SECTION - 1

CHAPTER-2

SURVEY AND INVESTIGATION

CHAPTER - 2

SURVEY AND INVESTIGATION

CONTENTS

CHAPTER-2
SURVEY AND INVESTIGATION

2.1 REFERENCES

IS:273-1983	Picks and beaters (third revision)
IS:1492-1970	Metric surveying chains (first revision)(with 2 amendments) (Reaffirmed 1987)
IS: 1759-1986	Powrahs (second revision)
IS: 1779-1961	4-MetrIc, leveling staff, folding type (Reaffirmed1986)
IS: 1842-1961	Surveying chain pins (arrows) (Reaffirmed 1986)
IS: 1955-1961	Prismatic compasses, liquid (Reaffirmed 1986)
IS 1957-1961	Prismatic compasses, non liquid (Reaffirmed 1986)
IS: 2288-1963	Ranging rods (Reaffirmed 1986)
IS: 2976-1964	Optical theodolite (Reaffirmed 1985)
IS:2988-1964	Vernier theodolite (with 3 amendments Reaffirmed 1986)
IS:4080-1967	Specification for vertical staff gauges
IS:4453-1980	Exploration by pits, trenches, drifts and shafts (first revision)(Reaffirmed 1987)
IS:4590-1980	Secondary level (first revision)(Reaffirmed 1986)
IS:5497-1969	Guide for topographical surveys for river valley projects
IS:5510-1969	Guide for soil surveys for river valley projects
IS:5529(ptl)1975	In situ permeability tests: part 1 tests in overburden
IS:5542-1969	Guide for storm analysis
IS:7784(PTL)-1975	Design of cross drainage works
IS:9110-1979	Specification for hand operated augers.
IS:9613-1980	Primary level)(Reaffirmed 1986)
IS:10442-1983	Specification for earth augers (spiral type)
	Investigation Manual for storage Reservoir,. VBIP publication No 58-1958

Unified schedule of rates for works of water Resources department Govt of M.P.

Specification for Irrigation Projects-Publication No.21Engineer-in-chief,water Resourced Department Government of M.P

Working Group Report, Govt. of India Ministry of Detailed project Reports of irrigation and Multipurpose projects 1980

C.W.C Guidelines for preparation of project Estimates for Irrigation and Multipurpose projects

T.C. Vol.1 (A) Engineer-in-chief, water Resources Department Govt. of M.P

Engineer- in-chief, water Resources Department Govt. of M.P. Guidelines for Diversion of Forest land for non -Forest purposes.

2.2 TERMINOLOGY

Coefficient of permeability- The rate of flow of water under laminar flow conditions through a unit a unit cross-sectional area of a porous medium under a unit hydraulic gradient and at a standard temperature of 27^0c.

Declination- The horizontal angle between the true north and the magnetic north.

Dip- The vertical angle between the horizontal plane and the plane of freely suspended symmetrical magnetic needle pivoted at its centre of symmetry. To over come this dip, a small weight is placed on one side of the needs so that it can be adjusted until the needle is horizontal.

Double packer Method- Method in which two packers are used in the drill hole. In this case the test section between the two packers.

Height-The height of a point above mean see-level is the length of the vertical between the mean see-level surface and the point.

Latitude-The latitude of a place is the angle between the direction of a plumb line at the place and the plane of the equator. It is marked north or south according to the place is north or south of the equator.

Least Count-Measure of the smallest unit which a vernier will resolve

Length of Chain- The overall distance between the outside surface of the handles when fully stretched.

Longitude-The longitude of a place is the angle between a fixed reference meridian called the prime or first meridian and meridian of the place. Longitude is measured from to 180 in eastward or westward and is marled E or WS

Magnetic Bearing- The horizontal angle measured from the magnetic north in a clockwise direction to desired line.

Mapping Units- Classification units that are shown on the maps. The kind of such units shown on the maps depends upon the scale of maps. In reconnaissance surveys these units may be series or association of series while in detailed surveys they will include types and phases of such soils.

Mean Sea Level- Mean sea-level is the average elevation of the sea surface which is determined by continuous observation of the varying level of the sea for as long a time as possible

Meteorological Homogeneity-A region is said to be meteorologically homogeneous if the stations therein have very nearly the same rainfall frequency distribution

Moisture Adjustment- Adjustment of observed precipitation in a storm by use of ratio of estimated maximum perceptible water, over the catchment under study perceptible water. calculated for particular storm.

Reconnaissance- The preliminary inspection of the area to be surveyed os called reconnaissance.

Scour Depth- Scour depth is the depth of stream bed material measured below highest flood level to indicate the limit up to which scour may due water flow.

Soil profile- Vertical section of a soil, showing the nature and sequence of the various layers, al developed by deposition or weathering both.

Soil Series- A group of soils that have soil horizons similar in their differentiating characteristics and arrangements in the profile except for the texture of the surface soil and are formed from a particular type of parent material. soil series is an important category in detailed soil classification

Surveying chain- A length-measuring device used for the purpose of obtaining surface distances between two points.

Tallies- Metallic tags or indicators of distinctive patterns fixed various distinctive points of the chain to facilitate quick reading on fractions of a chain in surveying measurements.

Traverse- The traverse consists of connected lined, the length and directions which are measured.

True Bearing-The horizontal angle measured from true north in a clockwise direction to desired line.

Vernier-It is a device for resolving divisions of a scale.

Water Table- The upper surface of ground water elevations at which the pressure in the water is zero with respect to the atmospheric pressure.

2.3 MATERIALS

2.3.1 Theodolite

It is an instrument for precise measurement of horizontal and vertical angles. These are mainly of two types- Optical and vernier theodolites. An optical theodolite is easy in manipulation, much lighter in weight and giving greater accuracy as compared to any other type. The vernier theodolite is not so precise as the optical one, but is still largely used due to lower cost and simplicity of design. The optical theodolite of specification conforming to IS:2976-1964 and the vernier theodolite conforming to specification of IS 2988-1965 shall be used.

2.3.2 Leveling Instrument For first /second order levelling operations, primary/ secondary levels or leveling instruments are respectively used. The primary levels and secondary levels conforming to specifications of IS:9613-1980 and IS:4590-1980respectively shall be used. Primary level is a high precision level used for height measurements for topographical maps, engineering works such as tunneling, installation of heavy machinery, hydroelectric projects etc.; height determination for geophysical purposes; quantity reductions and to record changes or height. Secondary level is a medium accuracy level used for second order levelling operations.These operations are undertaken for height determination for topographical works installation of machinery construction of roads, railways, building works etc.

2.3.3 Leveling staff

These confirming to specifications of IS:1779-1961 shall ve used

2.3.4 Prismatic compass

Prismatic compass, liquid and non liquid type conforming to specifications of IS:1955-1961 and IS1957-1961 respectively shall be used

2.3.5 Metric surveying chains

These shall conform to specification of IS:1492-1970

2.3.6 Ranging Rods

These conforming to specifications of IS:2288-1963 shall be used.

2.3.7 Vertical staff Gauges

For the measurement of the water level in streams, different types of gauges, recording and non recording are used The vertical staff gauge is the type most used because of its simplicity in installation and reading and because no mechanical device is involved in its simple design. The requirements of specifications Is:4080-1967 shall be followed for the vertical staff gauges.

2.3.8 Surveying chain pins (arrows) powrahs, axes,Axes and Hammer

Surveying chain pins conforming to specifications of IS:1842-1961 and powrahs confirming to specifications of IS:1759-1986shall be used. Pickaxes and beaters used shall confirm to specifications of IS:273-1983. Ordinary hammer and axe shall be used.

2.3.9 Auger

Augers are of two types-Head augers and Spiral augers. These conforming to IS:9110-1979 and IS:10442-1983 shall be used for hand and spiral augers respectively

2.3.10 Centre line Stone

Chisel dressed cut stone of size 150mm x150mmx600mm shall be 100mmx100mm x600mm shall be used. In case, cut stone is not available these stones may be made of R.C.C of size 100mm x100mm x450mm with nominal reinforcement.

2.3.11 M.S Plate with Anchor Bolts

Plate of size 120mm x120mm x6mm and anchor bolts of 10mm dia and 300mm length shall be used. These are to be used for standard benchmarks of type design given at plate 2-p/1.

2.3.12 Ordinary Bench Mark of stone or R.C.C.

The ordinary benchmark shall be as per type design given at plate 2-p/2.

2.3.13. Other Materials Like pegs, paints etc

Pegs may be made out of any ordinary jungle wood available near the site of work. The size of pegs normally may be 150mm long, 500-600 sq mm cross-sectional area at the top with lower 50mm long portion duly tapered to a point. Paints conforming to para 18.3.5 of painting shall be used. Material and procedure for the white washing of B.M stone shall be as per para 17.3 of chaprer-17 "whitewashing, colour washing and Distempring"

2.4 GENERAL

2.4.1 Reconnaissance and study of maps

2.4.2. Before reconnaissance it is necessary to thoroughly the need, extent and limitations of the project. And before field reconnaissance is started, all available data and maps detailed below shall be thoroughly studied to avoid waste and repetition of effort.

(1) Previous history of the area,
(2) Projects considered, investigated or constructed in the area.
(3) Topographical maps published by survey of India,
(4) Forest maps, from G.S.I and Maps and Data from Meteorological department, and
(5) Recent aerial photographs/ satellite imageries so as to furnish up-to date information on cultivated area, natural vegetation and growth, geological reconnaissance information and sources of construction materials. Areal photographs may be obtained from survey of India Dehradun and sattelite imageries from Indian Institute of Remote sensing, Balanagar, Hyderabed.

2.4.1.2 The reconnaissance for minor irrigation projects shall be carried out and its report prepared as specified at Appendix-I Appendix-II given the guide lines fir filling the check statement for medium and major projects shall be prepared on the basis of the check list appended at Appendix-III

2.4.2 Guidelines for Investigation of Minor, medium and major Irrigation Projects.

2.4.2.1 In order to ensure preparation of sound and economical project, it is necessary to have thorough and systematic investigations. The investigations shall include the study of various alternatives considered for type, and location of various features of the projects. The final alternative recommended shall be fully justified by recording the reasons for its choice as against the purpose are as below.

(i) Topographical surveys including preparation of survey plans to cater to the requirements of Appendix-IV
(ii) Geological and Foundation Investigations- C.W.C guide lined for foundation investigation of major projects are appended at Appendix-V

(iii) Meteorological and hydrological studies.
(iv) Pre-irrigation soil survey and drainage soil survey.
(v) Special surveys for hydro-electric projects.
(vi) construction Material Investigations- Guidelines for Investigations for suitability of constriction materials are appended at Appendix-VI.
(VII) Communication investigations.
(VIII) Construction planning
(ix) Other miscellaneous investigations for acquisition of land under submergence, rehabilitation measures if any, environment and ecology.

2.4.3 For chain and compass survey generally no jungle clearance is required to be done. However, when the alignments are passing through jungle other than the reserved forest, and its clearance is considered necessary by the Engineer-in-charge, then ordinary, medium and thick jungle clearance depending upon the type of jungle involved can be carried out be with prior sanction/permission from the competent authority, But such jungle clearance in widths not exceeding 1.5m for alignments and one metre for cross sections can only be done after obtaining prior specific sanction of the competent authority, which shall include the type of jungle clearance to be done in different lengths and widths as considered necessary. When it is necessary to survey through a reserve forest, prior sanction from the competent authority shall be required to be taken as per the Forest Conservation Act-1980.

2.4.4 Length of Survey

Length of the survey shall be measured along the lines on which particular type of survey is done. For chain and compass survey it would be the length along which chaining and compassing is to be done. For leveling, it would be the total length of the lines along which levels are to be taken.

2.4.5 Use of Theodolite

For survey and setting of curves for irrigation channels carrying discharge above one cumec and for layout of important structures, the use of theodolite shall invariably be made.

2.4.6 Chaining of Final Alignment

It shall be done with due precision after setting of curves.

2.4.7 Marking on Village Maps

The surveyed alignment and cross section shall also be marked on the concerned village maps. In case of catchment area survey, the ridge line/lines shall also be marked on the village maps. For command area survey, ridges and valleys shall also be marked.

2.4.8 Survey party for Double Levelling

The survey party for double levelling should invariably be headed by the sub- division officer concerned or an officer not below the rank of an Assistant Engineer.

2.4.9 The general instructions for carrying out systematic levelling work and making entries in the field/ level book as appended at Appendix - VII shall be followed.

2.5 DAG BAILLING IN ALL TYPES OF SOIL

Dag bailling shall only be done in all types of soil which can either yield to the ordinary application of pick and shovel, or to spade, rake or other digging implement, and or can be removed by this ordinary application after loosening with pick axe. This work in single spade stroke (minimum 75 mm deep) shall be carried out for all medium and minor irigation canal work, whereas the work in double spade 'V' shaped stroke (100 mm deep) shall be carried out for all major irrigation projects and all dam alignments.

2.6 SUB - SURFACE EXPLORATION

2.6.1 Exploration by pits/ Trenches/ Drifts /Adits and Shafts

Open test pits, trenches, drifts and are features accessible for visual examination in subsurface exploration and afford the most complete information on the ground penetrated. Location of pits, trenches, drifts and shafts shall preferably be decided in consultation with an engineering geologist; invariably to be followed for the medium and major irrigation projects.

2.6.1.1 Exploration by Test pits

2.6.1.1.1 Pits are dug manually but mechanical equipment may also be used for the purpose up to shallow depths. In dry ground, pits are economical in comparison to bore holes up to a depth of about 5m depending upon the location. As the depth increases, the cost of excavating a pit increases very rapidly and it is seldom that unsupported pits are dug to a depth exceeding 6 m except in the case of hard soils. The top of a pit shall be kept large enough so that dimension of the pit at the bottom may be at least 1.2 m X 1.2 m which are sufficient to provide necessary working space. Additional space for sheeting and timber support, hoisting arrangements and ladder, etc. shall be provided. A recommended Performa for the recording of information obtained from trial pits is given in Appendix (A).

2.6.1.1.2 For deep pits in soil, the walls shall be supported by timber. Typical sheeting and bracing to be adopted in such cases is shown in plate 2-p/3 Instead of sheeting and bracing, cribbing with 75x150 mm may be used and the arrangement is shown in plate 2-p/4. In loose materials, it is advisable to keep the space between the pit walls and the cribbing at a minimum and also to pack the space with hay or wood shavings, and to keep the bottom of cribbing close to the bottom of the pit. The material from such pits is removed by buckets operated from a hoist or windlass which should be equipped with a ratchet device for safety. During excavation, the pit should be kept fairly level and of full section so that each lift may represent the corresponding portion of the deposit in quality and quantity. The excavated material should be placed round the pits as stockpiles, separated when significantly different materials are encountered; and marked stakes should be driven in to the stockpiles to indicate the depth from which the materials were excavated in order to facilitate logging and sampling latter on. The excavated material should be placed round the pits in the manner it is received from the excavation, preferably in a clockwise direction. The deposits of excavated material from the pit at every change in strata should be dumped separately in the manner described above. Samples from these deposits should be taken as soon as material comes out of the pots and the natural water content of the excavation material determined.

2.6.1.1.3 Test pits left open for inspection shall be provided with covers or barricades for safety. Pits and trenches shall be suitably fenced. Trenches and pits should be filled back properly when exploration and physical inspections are completed and the relevant records have been obtained.

2.6.1.1.4 When water is encountered in a pit, suitable dewatering system may be required for further progress. Where suction pumps are used it is desirable that the suction hose be10 mm larger in diameter than the discharge opening on the pump and the suction head not more than 4.5 m. This requires resetting the pump in the pit (on a frame attached to the cribbing) at intervals of about 3.5 m. When an internal combustion engine is used in the pit, it would be necessary to lead the exhaust gases well away from the pit.

2.6.1.1.5 Undisturbed samples may be obtained from open pits from each stratum if the nature of the deposit permits. For this purpose, a pillar of suitable dimensions, say, 40 x 40 cm should be left undisturbed at the center of the pit to collect undisturbed samples of required size from each layer showing a change of formation. If the thickness of each layer exceeds 2m, a second sample may be taken. These undisturbed samples will be useful for the determination of several characteristics of the *in situ* material. Special care shall be taken to preserve the natural moisture content of the samples.

2.6.1.1.6 Open pits on dam axis shall be dug at every chain up to at least 1 m inside the rock level unless the rock level is very deep say more than 6 m in which case these shall be taken to a depth equal to (M.W.L. - G.L.)/2 or H/3 (H is the height of dam from the lowest nalla level to the T.B.L. of the dam) whichever is more. It is desirable to locate some pits on the probable cut off line.

2.6.1.17 For waste weir, pits at 2 chains apart, shall be dug to rock level or to hard strata. These shall be taken at every 2nd or 3rd chain of the spill channel, The maximum depth shall be restricted to 6 m and if rock or suitable hard strata is not met with within 6 m depth, pits on other alternative site shall be dug. For canals, pits shall be dug at every 150 m to a depth equal to full supply depth of the canal or 2 metre below the designed bed level (whichever is less). Separate pits at the location of structures shall be taken to a depth up to 1 m inside the rock or hard strata level (maximum depth 6 m).

2.6.1.2 ***Exploration by Trenches***

2.6.1.2.1 Test trenches are useful when a continuous exposure along a given line or section is desired. In general they serve the same purpose as the pit but have the added advantage of disclosing the continuity or limits of the formations or deposits in question and any vertical faults in the rock structured.

2.6.1.2.2 The field work consists of excavating an open trench from the top to the bottom of the slope to reach representative undisturbed material. Either a single slot trench down the face of the slope or a series of short trenches spaced at appropriate intervals along the slope may be excavated. Depending on the extent of the investigation required, use may be made of picks and shovels; bulldozers, ditching machines, back hoes or dragline. A trenching layout suitable for materials investigation is shown in plate 2-p/5.

2.6.1.2.3 All the instructions for pits given in para 2.6.1.1 shall apply to trenches.

2.6.1.3 ***Exploration by Drifts or Tunnels***

2.6.1.3.1 Drifts are normally employed to explore, at depth in the hill-sides the continuity, nature and structure of particular geological formations. They are most frequently used for establishing the minimum excavation limits to reach fresh and sound rock and the investigation of fault or shear zones as well as other zones of weakness and buried channels in the river section. Drifts are specially useful for in situ tests, like the plate bearing test, the jack test and shear test, to determine the modulus of elasticity, stress distribution and deformation characteristics of the formations encountered. This method is utilized only on major projects and when no other method provides the required information.

2.6.1.3.2 Drifts or tunnels are generally provided with a low out ward sloped of the floor so as to be self draining. A rectangular section with minimum clear dimensions of 1.5 m width and 2m height is adopted in hard rock, however, it will be advantageous to provide an arched roof with the dimensions as above.

2.6.1.3.3 Excavation of exploratory drifts in rock is often a slow and expensive process consequently, this type of investigation is utilized only on major projects and when no other method provides the required information. Ventilation by air from a compressor or a blower depending on the length of the drift may be resorted to for removing pockets of foul air or blast gases when explosives are used.

2.6.1.3.4 A typical mapping of a draft for a geologically simple environment is given in plate 2-p/6. For a complex geological environment and for major projects a three dimensional log, a typical example of which is given in plate 2-p/7, may be plotted.

2.6.1.4 ***Exploration by shafts***

2.6.1.4.1 Shafts are normally employed to reach either a particular formation at a greater depth (exceeding about 6 m) or to extend the exploration below river bed by means of tunnels.

2.6.1.4.2 Shafts may be rectangular or circular in section depending upon the ease of construction and should have minimum dimension of 2.4 m x 2.4 m or of 2.4 m diameter in case of circular in case of circular section, to provide space for movement of men, equipment and other accessories.

2.6.1.4.3 In hand dug shafts, the material are removed by buckets operated by hoists or windlass which should be equipped with a racket device for safety.

2.6.1.4.4 Deep shafts shall be ventilated to prevent accumulation of dead air or blast gases when explosives are used. For this purpose, connected length of stove pipe shafting slightly above the floor and extending one metre into open air above the mouth of the shaft have been found satisfactory. Air from a compressor or blower may also be used.

2.6.1.4.5 When water is encountered, a pumping system should be used to enable further progress. Electrical pumps should be preferred to ones with internal combustion engines to avoid pollution of air; otherwise it would be necessary to lead the exhaust gases well above the mouth of the shaft.

2.6.1.4.6 In weak and caving ground, the sides of the shafts shall be supported to prevent accident the spacing and the size of the support will depend on the nature of the strata. shafts left open for inspection shall be provided with covers grills or barricades for safety.

2.6.1.4.7 The shafts are mapped in the same way as drift giving the type of rocks encountered at various elevations, direction and magnitude of dip, extent and attitude of fault or shear zones, clay seems etc. A typical example of three-dimensional log of shaft is given at plate 2 -p/8.

2.6.2 *Exploration by Borings and Drilling*

2.6.2.1 Hand Auger Borings - Auger boring is the most common, economical and rapid method for relatively shallow exploration of fine - grained materials above the water - table. Hand augers become awkward and cumbersome beyond a depth of approximately 6 m. If the work is done carefully, the layers of different soils may be accurately located, identified classified and suitable distributed samples obtained.

In making auger borings it is often necessary to add water to soften a hard, dry, clayey soil so that the auger will penetrate the soil. Also, if dry sands or silts are encountered, the addition of water will make the soil slightly cohesive and easier to pick up by the auger. Cohesive soils can be augured successfully below the ground water table. However, if clean non-cohesive silts or sands are encountered below the water table, they are very difficult to extract from the hole and such material will cave unless the hole is cased.

2.6.2.2 ***Power Auger Borings -*** The most suitable type of power-auger for soil investigations is the one that will drill a hole at least 60 cm. in diameter (preferably 70 cm to 90 cm), which is large enough for a man to enter and make accurate inspection or sampling of the soil in place. These large-size augers will drill into slightly cohesive soils containing appreciable quantities of gravel up to 7.5 or 10 cm in size. Power-augers ate not satisfactory for use in bouldery materials.

Most augers permit boring of holes of about 2.5 m to 3.65 m depth. However, more recent equipment allow boring up to 6 m or even 12 m depths.

2.6.2.3.1 This type of exploration has to be resorted where the required strata or deposit in case of investigation of materials, cannot be reached by the methods mentioned above or where the compaction or the soil strata or presence of boulders and rock make it necessary. The various methods described under relevant para of chapter 22 - "Drilling and Grouting " shall be followed.

2.6.2.3.2 Use and Extent of Use-The Use and its extent for the various types of drilling is given below:

(a) Rotary Drilling- Rotary drilling may be used in firm clays, compact sands and silts to estimate the extent of overburden. Such drilling can be accomplished without casing the bore hole A drilling fluid is farced in to the sides of the hole through the rotating drill bit. This provides sufficient strength for the hole to be drilled without casing. The rotary drills employ some form of hardened steel core bits with a cutting edge. After rock is reached the rotary drilling should be replaced by diamond core drilling. The borehole in the overburden should be cased before commencing diamond drilling.

(b) Core Drilling-The two types of drills in common use are diamond drills and shot drills.

(i) Diamond Drill- This type is to be resorted to when rock is to be penetrated. Very deep holed at any angle may be readily drilled and rock of any hardness can be penetrated by this method. The cores, smaller ones also, can be recovered in good condition and cores from softer materials can also be recovered. But in this method the holes are too small to be explored readily with instruments and at times flexibility of rods causes deep holes to deviate from vertical.

(ii) Small Diameter Shot Drill-Use is similar as for diamond drill. But it shall be difficult to drill angle holed by this method and also cores are rough and not easy to examine. It shall not core small holes and softer materials. However, holes are large enough to be explored with instruments and method is cheaper than diamond drilling in loose rocks and boulders.

(iii) Large Diameter Shot Drill-This is not used for the same purpose as the diamond or small shot drill. It takes the place of hard-excavated shafts, drilling large holes to make visual inspection easy and reliable and also leaves the rock undisturbed. But this method is not suited for inclined holed and is expensive for small jobs.

2.7 FIXING BENCH MARKS

2.7.1 Standard and permanent Bench Marks

Type design No.7 and 8 of M.P Water Resources deptt. for permanent and standard B.M's shall be established as per the arrangement given at Plates 2-p/1 These Standard or permanent benchmarks adequate in numbers tentatively indicated with locations at Appendix-VIII duly connected G.T.S. by double leveling to be headed by an officer not below the rank of an Assistant Engineer, shall be established. The locations of these benchmarks shall be so selected by the Engineer-in-charge such that they do not get disturbed during construction. The top surface of the benchmark shall be truly horizontal and plane. The words 'B.M.' with its R.L. value shall be conspicuously carved and painted on the bench marks. The Sub-divisional officer shall himself lay out all important levels, all control points with respect to the standard or permanent bench mark connected with a specific shall be checked by the Engineer-in-charge.

2.7.2 Ordinary or Temporary Bench Marks-In the case of spread out works, several bench marks duly connected to standard bench marks or permanent bench marks by double leveling shall be constructed and fixed as per the type design No.6 of M.P Water Resources Department given at plate 2-p/2 The procedure for double leveling, selection of their locations and other specifications shall be the same as for the standard or permanent bench marks given at para 2.7.2 above. The tentative numbers and its locations are given at Appendix-VIII.

2.8 FIXING CENTRE LINE STONES

Centre line stones, conforming to specifications of para 2.3.10 shall be fixed on finally approved alignments and reference lined for setting out works only as directed by the Engineer-in-charge These shall be fixed as per the arrangement given at plate 2-p/10 or as directed by the Engineer-in-charge.

2.9 CONSTRUCTION OF TEMPORARY APPROACH ROADS

The necessity for the construction of a temporary approach road shall be got approved by the Superintending Engineer. Such a work shall be taken up only after his prior sanction of such a road indicating clearly the width (2.5M or 3.8) the type (non hilly or hilly terrain) including the details of the respective reaches with R.D.'s etc. Generally, such temporary approach roads shall not be constructed for survey works, if the existing village roads etc. shall be made good for plying by carrying out the minimum required repairs and maintenance after prior sanction of the Engineer-in-charge.

APPENDIX-I

RECONNAISSANCE SURVEY REPORT OF MINOR IRRIGATION PROJECTS

1. **Name of the Scheme**

2. **Basin/Sub-basin**

2.1 District/Tehsil/Block/Village

2.2 Assembly Constituency & Parliamentary constituency (Name & Number)

3. **Percentage of Irrigation in District/Tehsil/Block**

4. **Toposheet Study**

4.1 Toposheet No.

4.2 Latitude and Longitude

4.3 Whether the scheme is covered in master plan of the basin/sub-basin (reference be given)

4.4 Catchment area as per toposheet

4.5 Category of scheme:- Tank/Diversion/Stop dam/Lift

5. **Proposed Benefits**

5.1 Scheme already proposed or Contempleted on the upstream

5.2 Net catchment available at the site

5.3 Raingauge station/Average rainfall

5.4 Probable yield as per Bennie's table

5.5 Anticipated/Proposed irrigation

6. **Type of Scheme :** **Original/Extension and Improvement / Restoration /Restoration / Renovation / Modernisation**

6.1 Programme under which scheme is proposed to be taken up.

6.1.1 Plan Minor/C.D work/Tribal Welfare/Revenue sector/Tribal sub plan/T.D.P.P/D.P.A.P.

6.12 SC/ST benefisheries if any.

7. **Name of the Officer Inspecting Site:**

(Executive Engineer for schemes irrigating 200 hact.

Superintending Engineer for schemes irrigating more than 200 hect.)

7.1 Designation

7.2 Date of inspection

8. Field Data & Feasibility

8.1 Discharge of the site on the date of inspection

8.2 Has the site been found suitable with regard to:

8.2.1 Bund site

8.2.2 Waste weir site

8.2.2 Sluice and Head reach of canal

8.2.4 Nala closure point of view

8.3 Are construction materials available in adequate quatities and within economical lead?

Earth/ Sand /Metal/Stone

8.4 Is the percentage of submergence of cultivated land to the area proposed for irrigation less than 10%?

8.5 Forest submergence, if any

8.6 What is the probable

8.6.1 Tank capacity

8.6.2 Tank Percentage

8.7 Command

8.7.1 What is the crop cultivated in the command at present?

8.7.1.1 Khar if....................................Hact

8.7.1.2 Rabi.......................................Hact

8.7.2 What crop would be cultivated on availability of irigation?

8.7.2.1 Khar if....................................Hact

8.7.2.2 Rabi.......................................Hact

9. Is the Cost per Hact Likely to be reasonable?

10. Certificate of Revenue Authorities.

11. Remarks and Recommentations.

S.E (Field)

E.E (Field)

APPENDIX-II

GUIDELINES FOR FILLING UP THE CHECK STATEMENT FOR FEASIBILITY OF MINOR IRRIGATION SCHEME (C C A LESS THAN 2000 Ha)

1. The scheme should be named after the name of nallah, If any or more of village situated nearby or any sizable village in the command area or any other name approved by the Government.

2. The scheme should be verified as per approved/ proposed master plan of the basin/sub basin& whether the scheme is in concurrence with the master plan proposal.

The location with respect to revenue jurisdiction & election constituency should also be indicated.

The name of division & Sub Division which is to control the work should be given.

3. The percentage of irrigation in District/Tehsil/Block through water Resources Department & by other sources should be indicated covering all the schemes under progress.

4. Toposheet Study- The data which is to be collected from topoisheet rainfall record etc. should be recorded carefully before the inspection so as to correctly assess the scheme.

5. The information in respect of the work completed under progress & proposed on the stream should be thoroughly recorded from the office record & verified at field.

6. The probably yield and the benefits be then assessed.

6.1 Type of scheme proposed be decided as per toposheet study & field absorvations, as the case may be.

6.1.1 The proposal of financing of the scheme depending whether the scheme lies in tribal sub plan, Draught prone area or any other scheme should be verified.

6.12 the tribal /SC beneficaries in the village in command may also be broadly assessed.

7. No project should be submitted above the level of E.E. without complying the check statement & ensuring the general suitability of the project as enclosed.

8. Field Data and Feasibility

8.1 Rough assessment of the discharge in the stream at the site proposed on the date of inspection should be worked out and recorded.

8.2 suitability of the Site

Has the site been found suitable with regard to:

8.2.1	Bund site	All posible sites should be visited/
8.2.2	Waste weir site	Studied and suitability determined with
8.2.3	Sluice head reach of channel	References to the allied factors
8.2.4	Nallh closure point of view	(8.2.1 to 8.2.4)

8.2.1 Suitability of Bund Site

8.2.1.1 Suitability of Dam Base :- The over burden of the dam base should be studied by test pits. It should be sufficiently impervious and should have sufficient strength to sustain the weight of the dam. Heavy black soils are not very suitable.

8.2.1.2 Seating of Dam Base at Flanks :- Easy flank slopes, but not steeper than 2:1 are preferable for earthen dams.

8.2.1.3 Water Tightness of the Sub-strata Below the Proposed Dam and of the Tank Bed:- Obviously porous sites should be avoided. The extent of puddle cut off and grouting required should be foreseen. Positive cut off should be available at reasonable depth.

8.2.1.4 Length and Height of Dam:- Bearing in mind the earth work per cubic metre of storage, longer and low dams are preferable to shorter and higher dams for similar storage.

8.2.1.5 Drainage of the Downstream toe - This is an important factor and may affect the selection of the alignment.

8.2.1.6 Effect on Public Utilities Like Roads, Bridges, Railway, Downstream Ground Water Table :- Consideration of these factors may affect the site.

8.2.2 Suitability of Waste-weir Site :- Should be determined with reference to:

8.2.2.1 Availability of saddle at/above the F.T.L

8.2.2.2 Probable alignment and nature of sub-strata of spill channel

8.2.2.3 Other spillway requirements

8.2.2.4 Whether it would effect any valuable lands or property if flood are disposed off in any other valley.

8.2.2.5 How the total fall from F.T.L. to the nallah bed are proposed to be negotiated should be examined .

8.2.3 Head Reach of Channel:- Under this consideration should be given to:-

8.2.3.2 Suitable position of n Out Let - The sluice outlet should be in cutting and where sound foundation is available the required commanded areas should be dept in view..

8.3.2.2. Difficulties of the Channel to Reach up to the Command Line :- The quantity and nature of cutting or filling involved and the number of masonry works that will have to be constructed should . The consideration may lead to shifting of the dam site or provision of a pick-up further downstream.

8.2.3.3. Availability of Construction Materials:- Suitable construction mater ials should be available in adequate quantities within economic approchable leads provided that the quarries in the submergence are permitted by the forest department or else leads be given.

The criteria of economic leads will be as follows:

S.NO	Economic lead	Constriction Materials		
		Casing/hearting piddle	Pitching& boulder toe stones	Masonry stones
1.	Economic	Upto 1Km	Up to 5 Km	10 Km
2.	To be considered when other factors are favourable	Up to 1 to 3 Km	Up to 5 Km to 10Km	10 Km to

8.2.3.4 Percentage of submergence cultivated land to the net area proposed for irrigation .

The criterion of reasonability shall be as follows:

8.2.3.4.1 Submergence up to 10% is reasonable

8.2.3.4.2. Submergence from 10% to 15% should be given consideration when otherwise the scheme is found feasible.

8.2.3.4.3. Submergence more than 15% should out weigh other favourable factors and the scheme should not ordinarily be taken up.

8.2.3.5 Submergence of reserved or other forest if any should be indicated.

8.2.3.6 Adequacy of storage

8.2.3.6.1 The storage should be greater to the requirement for the proposed (available _ area for irrigation and provision should be made for adequate carry over and expansion .

8.2.3.6.2. Tank percentage and Adequacy of Storage- For kharif irrigation generally percentage between 60 to 80% is suitable to permit replenishment and in case of Rabi the percentage should be on 75% dependability.

8.2.3.7 Crop pattern and Availability of soil - it should be seen that the land under command :-

8.2.3.7.1 Is shown with the particular crop for which the tank is designed .

8.2.3.7.2. The sown area of this crop should be more than 60% of the land proposed for irrigation.

8.2.3.7.3. The soil is fit for irrigation from the point of view of salinity and other considerations .

9.

Has the cost per Hact. been checked and found reasonable	Economy is the primary consideration and should viewed on cost per Hact. basins.

The criteria for reasonability of the rate for irrigation scheme will be governed by G.O. M.P. circular No f / 22/90/TS/ /31 dated 4.4.80 or as may be modified from time by Government .

10. Certificate of Revenue Authority

Collectors certificate giving following details should be enclosed:-

10.1 Stipulating that there is keen demand for irrigation and that the beneficiaries are willing or otherwise to come under agreement and pay water rates and betterment lavy.

10.2 The approval of the district Advisory Committee.

10.3 ordinarily no new minor work can be proposed till work of extension improvement & repairs to the existing tanks in the district is completed.

10.4 In case where the scheme is proposed to be financed through Tribal sub -plan /DPAP/ Scarcity funds, the certificate to under take the scheme as per specific criteria should be verified, obtained and attached.

When a new work is proposed in preference to the work of extension improvement and reason should be explained.

11. Remarks & Recommendations

Site inspection report of SE/ E.E During the preliminary investigation/ projects anticipated cost mire than Rs.25 lakhs (corresponding 200 hact. CCA) should invariably be inspected by SE/E.W. should inspect all the schemes. Their inspection reports should cover the check lust and their firm opinion regarding the feasibility or other wise, of the scheme. The report accompanying the estimate must invariably contain dates of inspection of site by E.E/SE.s with their comments.

APPENDIX-III
CHECK LIST FOR RECONNAISSANCE REPOT FOR MEDIUM /MAJOR IPPIGATION SCHEME

Name of the Scheme...
District/Tehsil/Block...
Sub-Division ....

1 **River Basin / Sub Basin**

1.1 Toposheet No. & scale

1.2 Location of the scheme
Latitude
Longitude
1.2.1 Is any inter- state aspect involved ? Give details.
1.2.2 Is any inter-state agreement reached?

1.3 Catchment area

1.3.1 Is the scheme included in the master plan of the basin?
1.2.3. Upstream utilisation as per master plan under progress/ contemplated scheme.

1.4. The type to scheme:- Storage / Barrage

1.4.1 Is any gauge discharge site on the river established on U/s or D/s of the proposed site? if so, give details.

1.5 Is hydrology of any project in the adjacent basin/ sub basin finalised or under finalisation? if so , give details.

1.6 Is the scheme initiated to meet up irrigation / power/ industrial demand ? Give reference and details.

1.7 Does the scheme lie in tribal area of draught prone area?

1.7.1 Is any tribal area benefited by the project Is the commend area predominantly cover S/T or S/C beneficaries.

1.8 if any reserve forest area likely to go under submergence or other forest area going under submergence, the same along with details of floura and fauna getting due to submergence should be indicated.

2. Basic Information

2.1 Authority:

Note :- Under this head the authority i.e. No and date of the memo under which the reconnaissance survey has been ordered may be quoted.

2.2 Earlier reconnaissance , if any :

2.3 Name and designation of officer inspecting the site:

2.4 Date of inspection:

2.5 Access route to dam/ weir site.

(a) Existing
(b) Proposed, if any

Note:- Present condition of different reaches of existing and proposed approaches whether pucca , all unbridged jeepable or playable by foot etc. should be given in this report.

(c) Nearest railway station

B----------------km
M---------------km

2.6 Nearest G.T.S. Bench mark/ its location and level.

3. Topographical Features of Dam /Weir Site

3.1 Can the proposed site be considered as natural?

3.2 Have alter native sites been considered? Are they marked on the index map?

3.3 What is the area reconnoitered? Cam this be considered as satisfactory, considering the size of the project ?

Note: The extent of area reconnoitered should be clearly marked on the index max .

3.4 (a) What is the approximate width and average depth of river channel (s) to which the flow was confined on the date of reconnaissance ?

(b) What was the approximate velocity of flow in the river channel (s)?
(c) What is the approximate width of river at the proposed dam site?
(d) What is the approximate slope of the river bed ?
(e) Are there any falls or rapids un u/s or of the dam site ?
(f) Are the banks steeply rising if so, what is the approximate slope?
(g) Is there any deep still water pool at or near the site?

4 Surface Geological Conditions at Dam / Weir Site

4.1 (a) Is rock exposed at the ground surface ? If so in what reach can the quality of rock by visual judgment by considered as satisfactory for foundation both with regard to strength and also considering the fissures etc.

(b) Where rock is not exposed at Surface , what is the material at around surface.

(c) Are there any indications in favour of or against the availability of rock at shallow depths?

Note : The above information should cover:

(i) River bed
(ii) Left flank
(iii) Right flank
(iv) Waste weir site
(v) Approach channel
(vI) Spill channel up to its confluence with nala/river. Is a central spillway or a flank spillway indicated by the site conditions . (If flank spillway is recommended , it is presumed that rocky strata would be available for negotiating the proposed fall)

5 Hydrology

5.1 What raingauge stations exist within the catchment and the command ? for what period are the rainfall available? what do you consider as the average rainfall for (i) catcment area (ii) Command area?

5.2 Do you agree what the Rainfall 11/ Run-off figures computed in the office ? If no what other figures would you suggest? Are these supported by the performance of any adjacent existing reservoir or by any gauging done previously?

5.3 Is the site suitable for establishing a gauge discharge observation station ? If no what alternative site would you suggest.

5.4 What would you consider as the likely discharge on the day of inspection? what approximately would be the discharge in the river by the end of May or begining of june ?when does the river dry up normally?

5.5 What would you consider as the highest known flood level at site ? Have you checked the possibility of flood mark on any neighboring structure or is the H F L determined what reference to local enquires?

5.6 Is the river reported to be carrying comparatively heavy silt load? Would you suggest a silt gauging at the site ? If so where?

6 Submergence Under the Reservoir

6.1 Is it possible to check up the spread of the F.R.L.with reference to pointe for which levels are known?

Note : It is essential that this point may be particularly examined to check up the correctness of water spread marked on the index map.

6.2 How many villages are likely to be effected by submergence under the proposed reservoir ?
(i) Fully?
(ii) Partially?

6.3 What is the likely percentage of culturable / cultivated area under submergence? Is the percentage of submergence of cultivated land to the are proposed for irrigation less than 10% What would be the percentage of forest land going under submergence ? In general in what category would be forest lands come?

6.4 Is any reserve forest going under submergence? If so give details.

6.5 Whet would you consider the likely compensation cost per hectre of land of different classification?

(a) Cultivated land?
(b) Other culturable lands?
(c) Abadi lands

6.6 Are any important towns , roads or railway lines or minerals likely to go under submergence? Are any comtemplated roads or railways and transmission lines likely to be affected?

Note:- Sufficient details should b given so as to assess generally the impact of the submergnece on the cost of project.

6.7 Ate any monument of archeological importance (as maintained by archological dept) place of pilgrimage or any other structure of sentimental value likely to be affected?

7 Feasibility of Irrigation Canal/Power Channel/Power House

7.1 What is the nature of country through which the irrigation canal, power channel will pass in the initial reach? if the terrain is highly cut up and difficult, would you suggest any alternative arrangement?

7.2 Do you agree generally with the tentative alignment of tunnel (Where provided), penstock lines and location of power house of would you suggest any changes?

7.3 (a) Does your reconnaissance confirm the availability of head (shown by toposheets) for power generation?

7.3 (b) Does the topography permit construction of a underground power house?

8 Construction Materials

8.1 Have you satisfied yourself that construction material of requisite quality would be available in adequate quantities within economic leads?

8.2 What would be the approximate leads?

(i) Hearting material---Kms

(ii) Casing material---Kms.

(iii) Stones for rubble masonry ---Kms.

(iv) Stones for concrete and pitching---Kms.

(v) Sand---Kms.

Note: Replies to this question are to be given by personal judgment. No quality or quantity surveys are contemplated for replaying to this question.

9 Special Construction Features, if any

9.1 Do you think that the construction of the project will present any special problem and difficulty regarding diversion of river foundation treatment nallah closure, transport of equipment and essential materials etc. If so, these may be enumerated.

10 Irrigation Aspect

10.1 What is the broad crop-practice in the commanded area ?

(i) Kharif

(ii) Rabi

(iii) Perennials

(iv) Cotton.

10.2 What soils cover the major part of the commanded area?

10.3 Do you agree with the figures of culturable commanded area, irrigation intensity and crop pattern assumed by the office ? If so, what are your alternative proposals ? Is there any special feature which would command large scale sugarcane irrigation under the project?

10.4 Is there any possibility of water logging in any part of the commanded area?

Note : Local enquiry with regard to water levels of the wells, would help in answering this question.

11 Conclusion

11.1 After the reconnaissance of the area, are you satisfied with the prima-facia feasibility of the project, specially with reference to the following component works as broadly indicated in the map sent by the office? (give your comments).

(i) Dam- Masonry or earthen

(ii) Spillway approach and spill channel

(iii) sluice/Head regulator

(iv) Irrigation/Power canal in initial reach

(v) Tunnel/Penstock and power house.

Note : Strike out whichever is not applicable.

11.2 The report should be enclosed with:

(a) A contoured index map showing the approach road to dam site, commanded area/power house site and canals. Various alternative proposals made by the insecting officer for dam and power house etc. should also be distinctly indicated.

(b) A cross section of the river at dam site with levels connected with GTS. wherever possible. For this purpose levelling with the help of Abney level will do.

(c) Statement showing salient features revised in the light of reconnaissance.

(d) A certificate by the Superintending Engineer stating "The project appears to be promising and may be taken up for detailed survey"

(* If the reconnaissance survey confirms the prima facia feasibility of the project.)

(e) A brief note on incidential anticipated benefits such as Municipal/Industrial/Water supply /Power generation / Navigation / Transportation. etc.

Executive Engineer (Field)

Superintending Engineer (Field)

APPENDIX - IV
Topographical Surveys, Extent, Scales, Contour Interval, Etc.

S. No.	Description	Area to be covered/ Extent of Surveys	Scale		Contour interval	Remarks
			Horizontal	Vertical		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Catchment area survey					
	(a) Upto 2.50 Sq.km area	X-section-at every 90 m along the base line extending surfficiently below the ridge point to confirm the ride line	1:4000	-	-	-
	(b) For more than 2.50 Sq.km area	Topographical sheet be referred	-	-	-	-
2	River surveys	(i) L-Section				
	(a) Major project	Upstream L-section upto MWL +5m or to a point upto which the back wate effect is likely to extend from the axis of the structure, whichever is less. In case of any heed works situated upstream within MWL +5 m or far these points affected by back water, L-section to be taken upto head works.	1:10,000	1:100	-	Levelling at 50 m or less interval along the fair weather deep channel. Following items shall be indicated on the L-section: (i) Date of survey of the particular reach and water level on that day. (ii) Deep pool and rapids, rock out crops etc. (iii) Max. historical / observed HFL.
		Downstream - 10 km from the axis of structure or upto nearest head work whichever is less.	1:10,000	1:100	-do-	
		(ii) Cross section				
		Upstream-X-section @ 200 m interval upto MWL +5m or 1 km on either side of the firm bank whichever is less and for a distance of 2 km from the axis of the structure and thereafter at 1 km interval corresponding to the length of the L-section	1:2500	1:100	-	Levelling at 50 m or less interval. Following items shall be shown on the Cross-section : (i) Date of survey and water level on that day. (ii) Maximum water level. (iii) Rapids and Rock out crops etc.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Downstream-X-section @ 200 m inter - 1:2500 val upto historical / observed HFL + 1m on either side of firm bank for a distance of 2 to 5 km from the axis of the structure depending upon the mandearing nature of the river.	1:2500	1:100	-	-do-
		(iii) Along the axis of the structure	1:2500	1:100	-	-do-
	(b) Medium project	------------------------------Same as for Major Project 2 (a) above ------------------------------				
	(c) Minor project (i) L-Section					
		Upstream & Downstream - 5 km from the axis of the dam / structure	1:4000	1:50	-	Same as for item 2 (a) (i) above
		(ii) Cross-section				
		Upstream-X-section @ 100 m interval upto MWL +3m or 500 m either side of the firm bank whichever is less.	1:1000	1:50	-	Same as for item 2 (a) (ii) above
		Downstream - X-section @ 100 m interval upto MWL +3m or 500 m either side of firm bank for a distance of 1 to 3 km from the axis of the dam / structure depending upto the mandearing nature of the river.	1:1000	1:50	-	Same as for item 2 (a) (ii) above
		(iii) Along the axis of the dam / structure	1:1000	150	-	-do-
3.	Reservoir					
	(a) Major Project	Contour plan covering on area upto an elevation of MWL +5m	1:2500	-	1 or 2 or 3 m	Contour interval for slope less than 10* to horizontal - 1m, slope 10 to 30*, 2 m and slope more than 30*-3m.
	(b) Medium Project	Contour plan covering an area upto an elevation of MWL +5m	1:2000	-	1 or 2 m	Contour interval for slope less than 15* to horizontal 1m, slope more than 15* - 2m.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(c) Minor Project	Contour plan covering an area upto an elevation of MWL +3m	1:1000	-	0.5 m	
4	Dam and Dyke					
	(a) Major Project	Grid plan with contours of the site covering the area upto 250 m upstream and 500 m downstream of the axis extending upto an elevation of MWL +5m or more depending upon the site conditions (tail channel area shall be adequately covered)	1:2500	-	1 or 2 or 3 m	Contour intervals as per item 3 (a) above. Block levelling to be on 10 m grid basis.
	(b) Medium Project	Grid plan with contours of the site covering the area upto 250 m upstream and 250 m downstream of the axis extending upto an elevation of MWL +5m or more depending upon the site conditions (tail channel area shall be adequately covered)	1:1000	-	1 or 2 m	Contour intervals as per item 3 (b) above. Block levelling to be on 5 m grid basis.
	(c) Minor Project	Grid plan with contours of the site covering the area upto 200 m upstream and 200 m downstream of the axis extending upto a elevation of MWL +3m or more depending upto the site conditions (tail channel area shall be adequately covered)	1:500	-	0.5 m	Block levelling to be on 3 m grid basis.
5	Barrage/ weir	Grid plan with contours of the site covering an area upto 1 km on either side of the firm bank and 100 m from the upstream / downstream tip of the guide bunds parallel to the flow (tail channel area shall be adequately covered)	1:2500	-	0.5 m to 1 m	Block levelling on 50 m or less grid basis depending upon the slope of the land.
6	Canal & Water conductor system:					
	(a) Major project	(i) L-section	1:2500	1:100	-	Levelling at 50 m or less interval.
		(ii) Cross-section at 50 m interval	1:2500	1:100	-	-do-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
		(iii) Strip contour plan covering 150 m on either side of the centrel line of the canal or depending upon the requirement whichever is more	1:1500	-	1.0 m	Block levelling as per item (5) above.
	(b) Medium Project	(i) L-section	1:4000	1:100	-	Levelling at 30 m interval.
		(ii) Cross-section at 90 m interval	1:4000	1:100	-	-do-
		(iii) Strip contour plan covering 150 m on either side of the central line of the canal or depending upon the requirement whichever is more.	1:4000	-	1.0 m	Block levelling on 30 m grid basis.
	(c) Minor Project	(i) L-section	1:4000	1:100	-	Levelling at 30 m interval.
		(ii) Cross-section at 90 m interval	1:4000	1:100	-	-do-
		(iii) Strip contour plan covering 150 m on either side of the central line of the canal or depending upon the requirement whichever is more.	1:4000	-	0.5 m	Block levelling on 30 m grid basis.
7	Canal structures					
	(a) Major & Medium Project	(i) Grid plan with contours of the site to cover an area upto 300 m on either side of the central line of the canal - 200 m downstream of the point of exist of water and 200 m upstream of the point of water inlet.	1:2500	-	0.5 m	Block levelling as per item (5) above.
		(ii) Cross-section of the drain along the central line of the canal.	1:2500	1:100	-	Bed level / bank level and FSL of the canal and max. HFL of drain to be indicated on the cross-section.
		(iii) Drainage surveys for upstream and downstream of centre line of the canal for adequate length as required for hydraulic caculations.				
		For Plan	1:10,000			Refer item 2 above
		Longitudinal and cross sections	1:2500	1:100	-	Refer item 2 above
	(b) Minor Project	(i) Grid plan with contour of the site to cover an area upto 150m on either side of the central line of	1:4000-	-	0.25 m	Block levelling on 30 m or less grid basis depending upon the slope of the land.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
		the canal 60 m downstream of the point of exit of water and 60 m upstream of the point of water intel.				
		(ii) Cross-section of the drain along the central line of the canal extending sufficiently above the HFL.	1:4000	1:100	-	Bed level/bank level and FSL of the canal and max. HFL of drain to be indicated on the cross-section.
		(iii) Drainage syrveys for upstream and downstream of center line of the canal for adequate length as required for hydraulic calculations.				
		For plan	1:4000			Refer item 2 above.
		Longitudinal and cross sectins	1:4000	1:100	-	Refer item 2 above.
8	Command area survey including survey for drainage system :					
	(a) Major project and Medium project	(i) Contour plan of the area	1:10,000 or 1:15,000	-	0.5m	
		(a) Plains and plateau OFD works	1:2500	-	0.15 or 0.25 m	Block levelling on 50m or less grid basis. Contour interval
		(b) Hilly terrain OFD works	1:1250 or 1:625	-	0.25 or 0.50 or 1m	depeding upon the steepness of the country. Marshy land, depressions, if any, to be shown in the plan. 6 to 8 spot levels per hectare of area shall be minimum and high/low points of the field are not left out.
	(b) Minor project	Contour plan of the area	1:4000	-	0.25 or 0.5 m	Block levelling on 30m or less grid basis. Contour interval depeding upon the steepness of the country. Marshy land, high/Low poits to be shown in the plan.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
9.	Power House Switch Yard, Surge shaft, Tail race etc.	Contour plan of the site to cover full area of the component (s) and alternative layouts.	1:2500	-	0.5 or 1 or 2 or 3m	Contour intervals as per item 3 (a) above. Block leveling as per item 5 above.
10.	Plant and Colony	Contour plan of required area	1:2500	-	0.5m	Block levelling as per item 5 above
11.	Tunnel and Adit	(i) Contour plan of the area covering the length of the tunnel & 500m on either side of the central line of the tunnel/adit including approach portal and dump areas	1:2500	-	1 or 2 or 3m	Contour interval as per item 3 (a) above. Block levelling as per item 5 above in case of ground surveys.
		(ii) L-Section	1:2500	1:100 or 1:200 or 1:500 or 1:1000		Vertical scale depending upon the steepness of the slope and drop.
12.	Penstocks	(i) Contour plan of the area covering the length of the structures and 150m on either side of the central line of penstocks.	1:2500	-	1or 2 or 3 m	Contour inteval as per item 3(a) above. Block levelling as per item 5 above.
		(ii) L-Section	1:2500	1:100 or 1:200 or 1:500 or 1:1000		Vertical scale depending upon the steepness of the slope.
13.	Soil Conservation Survey	Plan of area subject to erosion. slides and slips.	1:10000 or 1:50000	-	10 m or less	This may be carried out for major and medium projects depeding upon the location of the area.
14.	Geological Maps	Reservoir and river valley structure (dams, Barrage, Tunnel, Power House Penstocks, Water Conductor System and important structures on Canal.)	Same as recommended under each item above or otherwise as stated in the Geological report.			
15.	Foundation Investigation Maps	Plan: Major Medium Minor	 1:2500 1:2500 1:1000	-	As specified above for the corresponding structure.	Showing location of Structures. bore holes pits, drifts and points where in-situ tests were conducted etc.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Cross section:				
		Major	1:2500	1:100	-	Showing longs of bore holes, trial pits, drifts etc. and other feature of the foundation.
		Medium	1:2500	1:100		
		Minor	1:1000	1:100		
16.	Borrow Area and Quarries	Plan:				
		Major	1:2500	-	0.5 or 1m	Showing location of different materials of construction pit/drill holes.
		Medium	1:2500		-do-	
		Minor	1:1000		-do-	
		Sections:				
		Major	1:2500	1:100	-	Showing profile along the grid lines upto the depth explored.
		Medium	1:2500	1:500		
		Minor	1:1000	1:100		
17.	soil Surveys	Plan:				
		Major	1:10,000 or 1:15,000			
		Medium	1:5000			

APPENDIX - V
LOCATION AND DEPTH OF EXPLORATORY HOLES/DRIFTS/PITS ETC.

Structure	Minimum Pattern of drilling	
	Spacing of Drill Holes/Pits/Drifts	Depth of Drill Holes/Pits/Drifts
(1)	(2)	(3)
(a) Earth and rock fill dam	Drill holes along the axis 150m or less apart, with intermediate pits to delineate weak and vulnerable strata with a minimum number of three to five holes in the gorge portion and additional two gorge portion and additional two on each abutment parallel to the flow.	Depth equal to half the height of dam at the elevation of the hole or 5m in the fresh rock (proved by the geophysical or any other suitable method) whichever is less. About two holes to be extended deep (equal to the maximum height of the dam in the abscence of rock at higher elevation) in the gorge portion and one each in abutments.
	drifts on each abutment at about 60 m elevation interval with a minimum of one abutment.	Drifts to be extended 5m in geologically sound strata for keying the dam in the absebce of rock.
(b) Masonry and concrete dam	Drill holes along the axis at 100m interval or less apart to delineate weak and vulunerable strata with a minimum number of three to five holes in the gorge portion and additional two on each abutment parallel to the flow.	10m in fresh rock (proved by geophysical or any other suitable method) About two holes to be extended deep (equal to the maximum height of the Dam in the abscence of rock at higher elevation) in the gorge portion and one each in abutments.
	Drifts on each abutment at about 60 m elevation interval with a minimum of one each abutment.	10m in fresh rock (proved by geophysical or any other suitable method.)
(c) Tunnels	Drill holes one at each of the portal and adit sites and additional at least one every 1-5km interval depending upon the, length of the tunnel.	Drill holes 5-10m below the tunnel grade of maximum possible depth. Wherever it is not possible to drill along the central line of the

(1)	(2)	(3)
	Drift, one each at the portal and adit sites.	tunnel the holes can be shifted. The explorations shall be so planned as to satisfactorily portray the geological structure and tunneling conditions.
(d)Barrage and Weirs	Drill holes along the axis, 150m or less apart with intermediate pits to delineate weak and vulnerable strata with a minimum of two additional holes one each abutment parallel of the flow.	Drill hole 1.5-2 times the maximum head or water below the average foundation level or 5m in the fresh rock whichever is less. Rock to be proved by geophysical or any other method.
(e) Power House	Two to four or more drill holes and /or drifts covering the area to satisfactorily portray the geological condition and delineate weak and vulneerable Zones, if any.	Drill hole one to two times the maximum width of the structure or 5-10m in the fresh rock (proved by geophysical or any other method) whichever is less. For underground power house the strata shall be examined by the explorations, with adequate number of drill holes. If found feasible and necessary according to the site conditions, one drift with cross cut may be excavated at the roof level to prove fresh rock conditions along the length and breadth of the cavity structures.
(f) Major canal structures.	Sufficient number of drill holes with a minimum of three (one on each bank and one in the bed)	Twice the width of the foundation of the biggest component of the structures below foundation level.
(g) Canal and Water Conductor system	Drill holes or pits 500m or less apart to depict the complete profile details.	Equal to the full supply depth of canal or one meter below the design bed level in rock which ever is less.

Note :- 1. A Minimum pattern of drilling holes and excavation of pits and drifts has been suggested above. Additional holes shall be drilled and pits/drifts excavated in consultation with the Geologist/Research laboratory to bring out clearly the foundation and abutment characteristics especially the weak zones requiring special treatment.

2. Distrbed and /or undisturbed soil samples, foundation of rock samples etc. shall be collected and tested at an interval of 1.5m tests shall be carried out in the selected drill holes in different strata at different elevations. Other in situ tests shear tests etc. shall be carried out in the holes or other suitable locations depending upon the nature of the strata and design requirements.

3. The bearing capacity test and in situ testing of the foundation rock shall be carried out for item (b) to (f) at average foundation level.

4. The plans and cross-sections shall be prepared on the scale as indicated in Appendix-IV.

5. The lops of the holes/pits/drifts shall be prepared as per Appendix V(A) to V(D) enclosed.

APPENDIX-V(A)
LOG OF TEST PIT BORROW AND FOUNDATION INVESTIGATIONS

Feature...................... Project.................... Test pit no ....

Area designation................... Co-ordinate.......................... Ground Elevation .... depth to ground water level"

Method of excavation .... Approximate dimentions of hole....... dates of excavation......... Hole logged by.................

Classification Symbol Letter Graphic	Depth (m)	Size and Type of Sample Taken	$Classification and description of Material(give Geological and in-place des-cription for Foundation investigation)	Volume of Hole Sampled (m)	Weight of O to 75mm Material in Sample	Percentage by Volume of o to 125mm material	Weight of 75 to 125 mm material in Sample (kg)	Percentage by Volume of 75 to 125mm Material	Weight of Plus 125 mm Material in Sample (kg)	Percentage by Volume of 75 to 125 mm Material	location of in situ Telts
Remarks @											

* Record after water has reached its natural level.

$This may be done as given in IS: 1498- 1970 Classification of soil for general Engineering purposes (first revision)

* (weight of rock sampled x 100)/ (Bulk specified gravity of rock) x(volume of hole sampled).

@ Record water test and density test data, if applicable, and also bulk specific gravity stating how obtained (measured of estimated) under remarks.

APPENDIX-V(B)

DAILY DRILL REPORT

Project............. Drill No. and type Coller elevation: date: Shift: From........ h to ....h: depth of Water level: At start of shift : At end of shift:	Location.............................	feature pump No. Capacity and pressure used: Hole No: Co-ordinates: Bearing of hole: Angle with vertical: depth drilled during the shift: from........... To...................

Run		length Drilled mm	Type and Size of Hole	Colour of Return water	Type of soil/ Rick	Water Loss with Depth	Core Recovery Length	percentage	SI. No of Cores	Rate of penetration mm/min	Remarks
from m	To m										
1	2	3	4	5	6	7	8	9	10	11	12

Supplies					Casing Lowered			Bits Used		
Petrol	Diesel	Motor Oil	Misc.	Size	From depth	To depth	Type and Size	From depth	To depth	Old or new with number

Drill Forman/Supervisor
Officer-in-Charge

Operator
Drill Observor

DRILL OBSERVERS REMARKS

(1) water loss during drilling may either be recorded as:

(i) Complete when no water is coming out; partial; or nil water loss; or

(ii) in percentage of return water {100 percent loss when no water is coming back and no water loss (o percent) when all the drilling water is coming back}

(2) Penetration speed in special zones (soft or broken zones); and other details of drilling like heavy vibration recorded during drilling.

(3) Reasons for heavy core loss as integrated with speed of drilling.

(4) Any special conditions not recorded: For example depth at which blasting was done while driving casing. Depth at which hole was ground, artesian water conditions (if any observed) during drillingl

(5) If water flows are encountered at the collar of the drill. Then the pressure head and discharge at the collar should be recorded. On completion of the hole, the pressure decline over a period of time should also be recorded.

APPENDIX -V (C)
CONSOLIDATED DRILLING LOG

Top R. L.

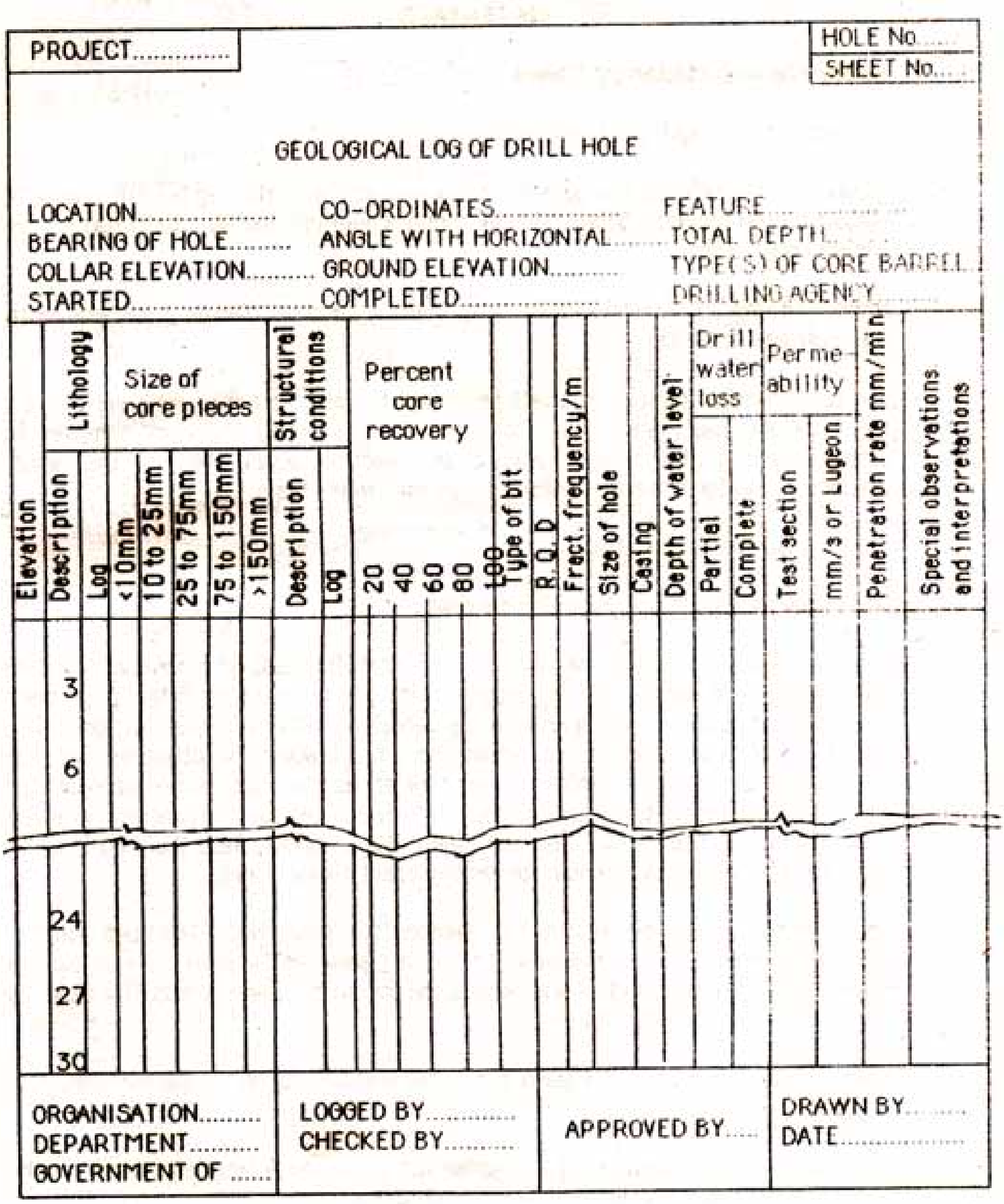
Project Site :
Hole No. :
Location :

Angle from vertical :
Bearing of angle hole :
Water table R. L. :

Machine :
Driller :
Logged by :

													Percolation Test								Penetration Test		
															Water Meter Reading								
Date and Time	Size of hole	Depth of casing	Depth of hole	Length drilled	Core run	Percent core recovery and RQD	Serial No. of cores	Wash water colour	Type of core barrel and bit used	Description of strata	Other drilling notes	Depth slab	Pressure in N/mm	Initial	Final	Loss in litres	Time in minutes	Loss in litres per minute	Lugeons	No. of blows	Penetration	Standard Promotion Test (S.P.T.) value
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

APPENDIX - V (D)
PROFORMA FOR PRESENTING DRILLING INFORMATION



PROJECT..............

HOLE No......
SHEET No......

GEOLOGICAL LOG OF DRILL HOLE

LOCATION.................... CO-ORDINATES.................. FEATURE..........
BEARING OF HOLE......... ANGLE WITH HORIZONTAL........ TOTAL DEPTH..........
COLLAR ELEVATION.......... GROUND ELEVATION.......... TYPE(S) OF CORE BARREL
STARTED.......................... COMPLETED.................... DRILLING AGENCY.........

Elevation	Lithology: Description	Lithology: Log	Size of core pieces: <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Structural conditions: Description	Structural conditions: Log	Percent core recovery: 20	40	60	80	100	Type of bit	R.Q.D	Fract. frequency/m	Size of hole	Casing	Depth of water level	Drill water loss: Partial	Drill water loss: Complete	Permeability: Test section	Permeability: mm/s or Lugeon	Penetration rate mm/min	Special observations and interpretations
	3																									
	6																									
	24																									
	27																									
	30																									

ORGANISATION.........
DEPARTMENT..........
GOVERNMENT OF ......

LOGGED BY.............
CHECKED BY..........

APPROVED BY.....

DRAWN BY.........
DATE..................

APPENDIX- VI

INVESTIGATIONS FOR ESTABLISHING SUITABILITY OF CONSTRUTION MATERILAS

1 Concrete and Masonry Dams

Following investigations shall be carried out :

(i) Geological and related characteriation of aggregates including type of deposits, classification and characteristics of rocks, chemical suitability of aggregates and strength tests.

(ii) Investigations for the availability of natural and artificial pozzolana with their characteristics.

(iii) The construction materials shall be tested for petrographic analysis of sand and rock samples, grading and physical tests of sand and rock samples to assess their suitability, presence of reactive aggregates in the area , pozzolanic materials and strength of permeability tests.

2 Earth and Rock fill Dams

Following investigations shall be carried out :

(i) The plans and sections of the borrow area shall be made on a scale of 1:2500 with contour interval of 1.50 m , showing the location and logs of test pits, bore holes spaced abut 150m apart and demarcating different types of soil. The lead for different types of soil from the site of work for different borrow areas shall also be indicated. The borrow areas shall be located as near the dam site as possible but not less than five times the head of water (H) away from the toe or heel of the dam for major dams and not less than 10 H away form the toe or heel of the dam for medium and minor dams

(ii) Soil samples shall be tested for mechanical analysis, Atterberg linits, Proctor compaction, permeability , triaxial shear tests with pore pressure measurements under O.M.C. and saturation conditions, and suitability tests in soils with nigh soluble content.

(iii) The sand and gravel to be used for filters shall be tested as for concrete aggregate.

(iv) Rock for rock fill dam shall be tested for porosity. compressive strength. durability , alkali reaction and hammer drop test.

(v) units of earth work sampling for suitability shall be taken as per the following table:

S.No.	Particulars	Minor project	Medium project	Major project
1.	Profile E/W quantity	140 Thousand cubic metre	140 Thousand cubic metre	Above 1400 Thousand cubic metre
2.	Borrow area E/W quantity	210 Thousand cubic metre	210 to 2100 Thousand cobic metre	Above 2100 Thousand cubic metre
3.	Units of profile E/W sampling	5.5 Thousand cubic metre	14 Thousand cubic metre	20 Thousand cubic metre
4.	Units of borrow	8.5 Thousand cubic metre	21 Thousand cubic metre	30 Thousand cubic metre
5.	Sampling - Number of samples	Minimum 10 samples	Minimum 25 samples	Minimum 100 and maximum 200 samples

APPENDIX-VII

INSTRUCTIONS FOR SYSTEMATIC LEVELLING

GENERAL

1. The same importance as prescribed for measurement books is to be given to Field/Level Books.
2 The date of first entry in the book is to be intimated to the DO/EE by the actual user.
3. The reducing of levels is to be done in the field immediately after leveling and the arithmetic check for each page conducted separately.
4. The k levels taken on a day are to be plotted the same day as far as possible or at least by the next day and, by the same person who conducted surveying /leveling and, a remark given in red ink in col. 8.i.e survey plotted on ....by...........
5 Before shifting of the survey camp, a certificate should be sent to the S. D. O. that all plotting work has been completed.
6. Every plotted sheet contain certificate as follows:

"Certified that survey was conducted by me /us using field books and level books bearing numbers.....................and......................issued by .... sub division (name of sub Division)"

The B.M.s are shown plotted in red ink and identifiable with the description shown. The levels are related to the nearest G.T.S. Bench Mark whose description is ....(Give particulars)

7. The level/field books shall be returned to the sub-division officer after plotting is done and index completed, unless of course required for another work.

Field Work

Before starting day's work, please write name of work, your own name date, instrument number and make (which is used) and the weather conditions in the space provided on the top of each page. In case the survey continued" concluded" etc. should also be written and cross reference given.

9. In the space for weather conditions, words like bright sun, cloudy, hazy are written those not applicable.
10. In case double leveling is done the name of person accompanying along with his designation shall also be written. In such a case, the level book should be countersigned by the person accompanying also, in token of having accompanied and the book number in which countersigning person has recorded levels wills also be mentioned.

11 While starting the day's work, mention clearly whether levelling with back-sight .

12. Give clear and sufficient description of the B.M. so that it can be located by any other person without difficulty.

13. Give clear and sufficient description of the B.M. so that it can be located by any other person with out difficulty.

14 In case leveling is started with reference to permanent B.M make sure that the description and R.L. is the same as shown in the B.M. register.

15 A systematic pattern of leveling should be adopted and illustrated where necessary by sketcher (using preferably the base line and coordinate system for grid surveys) so that another person can understand the scheme of leveling and plot it (on case such a need arises)

16. The entries should be made in indelible ink/dot pen in the first instance. Recording in pencil and inking over it is prohibited.

17 The day's survey should be ended on a permanent or temporary B.M. reliable established.

18 Pages left out inadvertently should be crossed out

19 A system of periodic review by Division officer and issue of review notes is prescribed in the W.D. Manual (1983),so that a vigorous compliance of these instructions will save avoidable correspondence /work, please note.

SAMPLES COMPUTATIONS IN A LEVELLING FIELD BOOK

Left hand page — Right hand page

(i) Name of person conducting survey.............. (IV) Instrument No........

(II) Name of work.................................. (V) Make................

(III) Date...........weather.............................

R.D	BACK Sight	I.S	F.S	Rise	Fall	Reduced level	Distance	Remarks
30m	4.235					100.00		B.M. whose description is
60m		4.320			0.085	99.915		
90m	3.215		3.215*	1.105		101.020		*Actually taken as I.S. but posted as F S and again as B S
120m	1.380		2.905	0.310		101.330		
150m			1.625			101.085		*Actually taken as I.S. but posted as F S column to facilitate arithmetic check independently for each page separately
	8.830		7.745	1.415	0.330			

Arithmetical Checks

Σ B.S - Σ F.S = ΣRise - Σ Fall = Last R.L. - First R.L.
8.830 - 7.745 = 1.415 -0.330 =101.085 - 100.000
= 1.085 =1.085 =1.085

The above method is also illustrated by height of collimation method below:

R.D	BACK Sight	I.S	F.S	Height of collimation	Reduced level	Distance	Remarks
30m	4.235			104.235	100.00		B.M whose description is
60m		4.320			99.915		
90m	3.215		3.215	104.235	101.020		Same remark as shown is Rise &Fall method
120m	1.380		2.905	102.710	101.330		...do...
150m			1.625		101.085		
	8.830		7.745				

Arithmetical Checks

Σ B.S - Σ F.S = Last R.L. - First R.L.
8.830 - 7.745 = 101.085 - 100.000
1.085=1.085

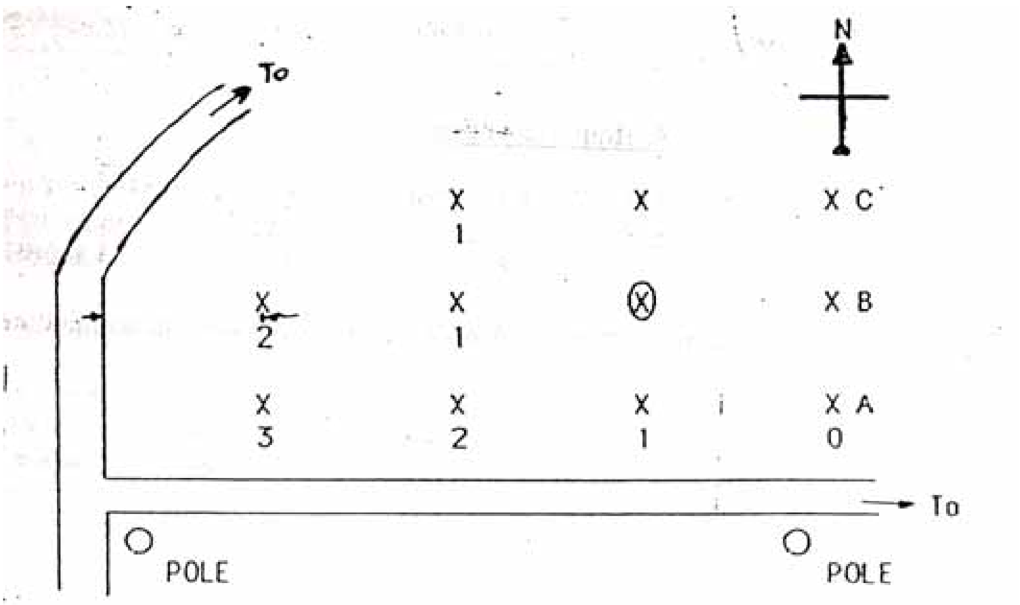
Singature

21. Reduce all levels at the field immediately after recording sights.

22. Perform arithmetic check for each page, at the end of the page it self and at the field To facilitate this, even if the instrument is not shifted (i.e. even if the sight is not taken on a change point) the intermediate may be posted as a presight at the end of the page post the same intermediate sight as a back sight and proceed. This will not after the values. The method is illustrated in sample computations.

23. Arithmetic check ensures the accuracy of reducing the back and fore sights only and not the intermediate . Therefore, cater the sights taken on S.M. as a foresights and again enter as back sight so that those levels (Bench Mark levels) are always involved in arithmetic check (see sample computations) circle the B.M .value in red ink for ready identification.

24. In grid surveys use a system of lettering/ numbering for easy location (see sketch below)

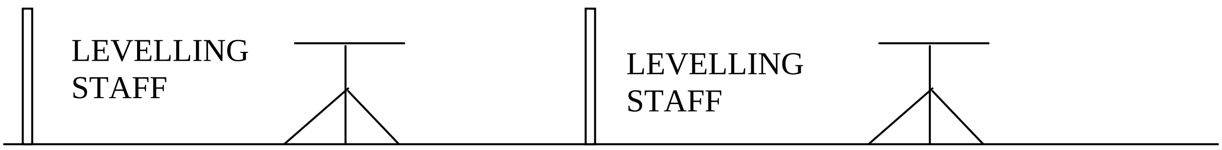


Note: Designation of points will be point indicated ⓧ as b1.

25. In some cases even elaborate desription may not be clear enough. In such cases, it is preferable to plot at the field itself after reducing levels.

26. The levelling instrument should not be shared with others. It is preferable to keep apart one instrument for one person only. However, if the instrument has to be shared, the adjustment for parallax should be done to suit the user's eye.

27 The last but not the least, the instrument should be in permanent adjustment, which should be verified, every day before going to field for levelling. It can be checked conveniently by establishing temporary bench marks approximately 60 m apart and verifying the difference of elevation of



A LEVEL INSTRUMENT B LEVEL INSTRUMENT

1st POSITION 2nd POSITION

these Bench marks first by keeping the instrument approximately in the middle, between A and B and then near to A or B as shown in sketch below. If there is difference in the elevations, as taken from the two position. the instrument is not in permanent adjustment, Adjust the instrument before going to the field.

Check as follows:

		Instrument in 1st position	Instrument in 2nd position
Reading on	A	4.25	4.85
	B	1.25	1.68

Difference	3.00	3.13

Error = 3.13-3.00=0.13

The instrument is not in adjustment.

APPENDIX-VIII

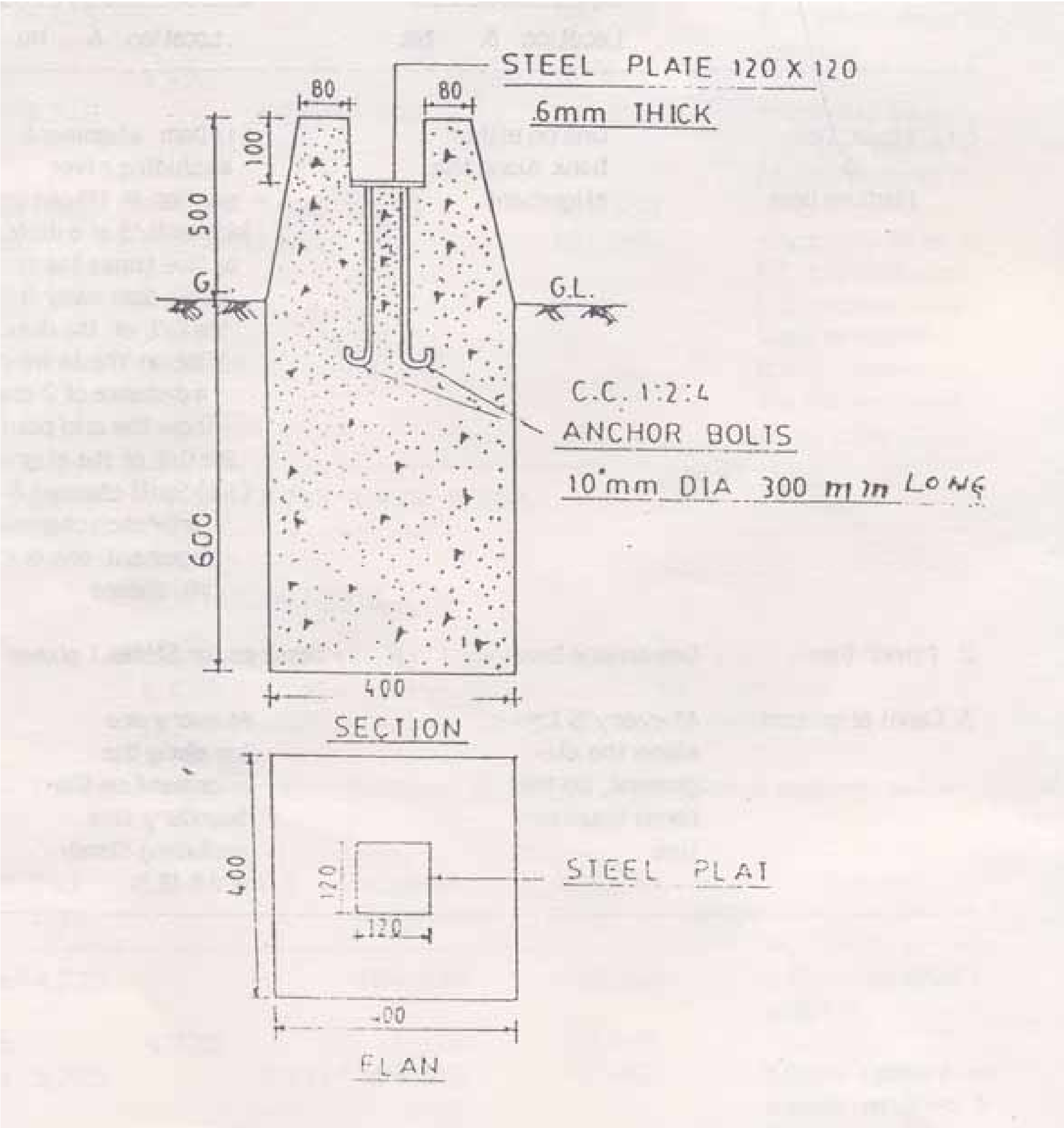
LOCATION AND NUMBER OF B.M

S. No.	Particulars	Standard/permanent B.M Location &No.	Ordinary or Temporary B.M. Location & No.
1.	Major Dam & Medium	One on either bank along the alignment	(i) Dam alignment excluding river portion @10 chains located D/s at a distant of five times the head of the dam away from the C/L of the dam. (ii) One on Waste weir at a distance of 2 chains from the mid pointed of the C/L of the alignment. (iii) Spill channel & approach channel alignment one @ every 10 chains.
2.	Minor Dam	One on one bank	Same as for Sl. No. 1above
3	Canal alignment	At every 5 km along the alignment, on the canal boundary line	At every one km along the alignment, on the boundary line excluding standard B.M.S.

STANDARD BENCH MARK

PLATE : 2-P/1

TYPE DESIGN - 8

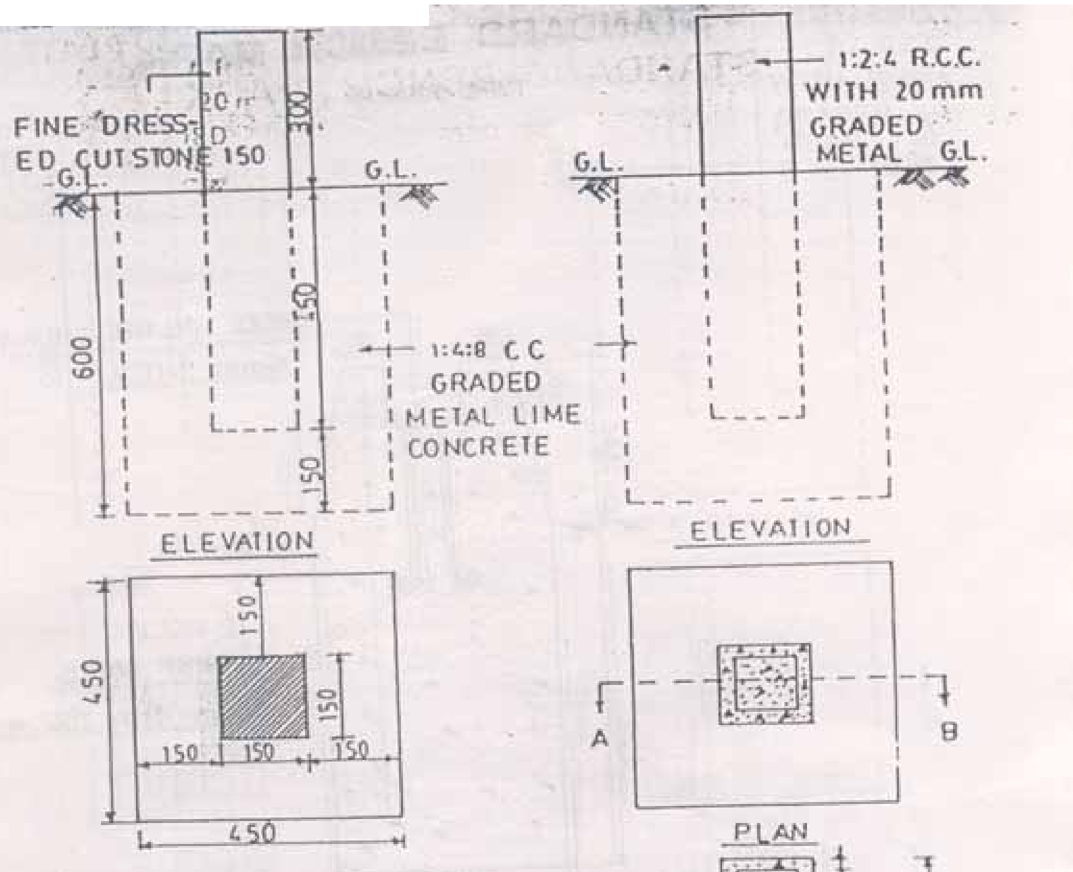


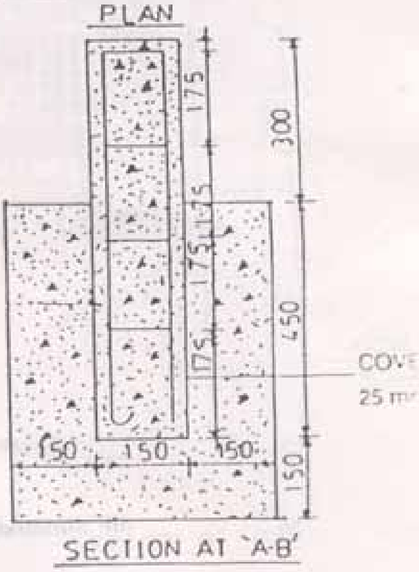
All Dimensions are in mm

Scale : - 10 mm = 10 cm

TYPE DESIGN 6 - ORDINARY BENCH MARK

PLATE : 2-P/2



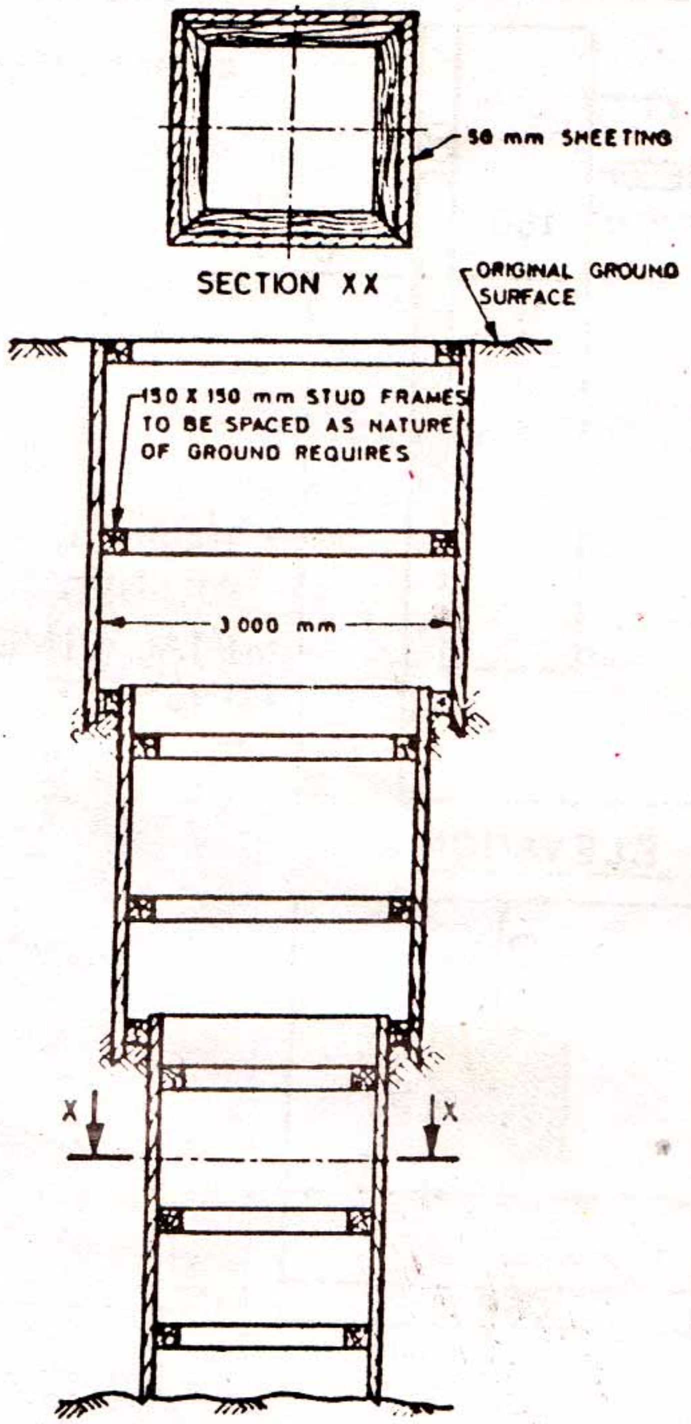


SCHEDULE OF REINFORCEMENT					
BAR NO	DIA IN mm	NO OF BARS	SHAPE OF BARS	LENGTH IN mm EACH BAR	TOTAL
1	6	2		1632	3264
2	6	3		496	1488
				TOTAL	4752

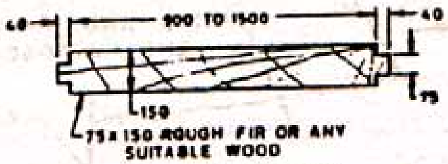
Wt. @ .22 Kg/m 1.045 Kg

SAY 1.05 Kg.

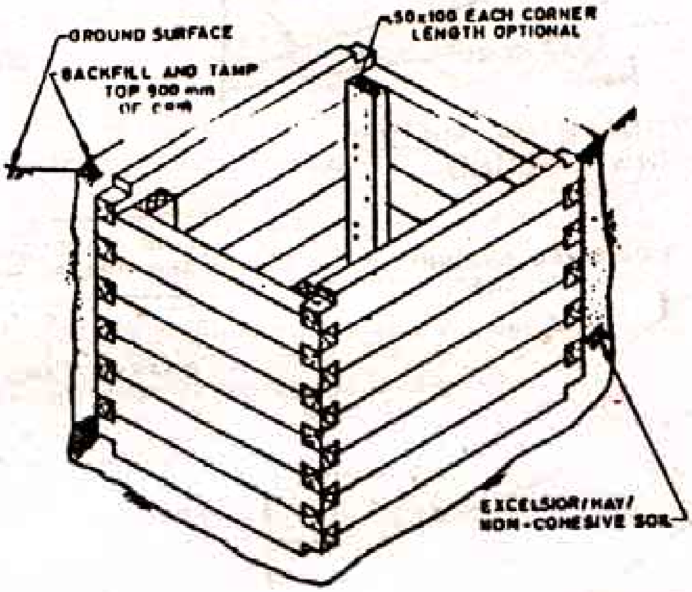
All Dimensions Are In mm



TYPICAL TEST PIT SHOWING ARRANGEMENT OF SHEETING AND BRACING (ILLUSTRATIVE SKETCH)



DETAIL OF CRIBBING

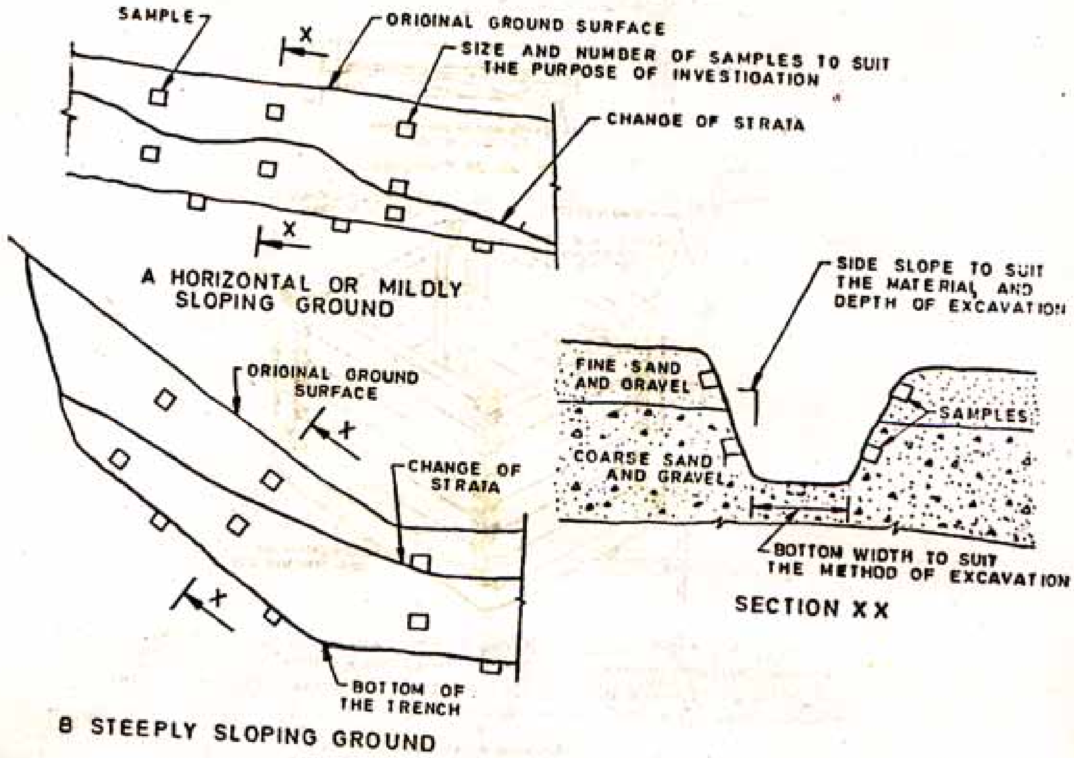


NOTE 1 — Space between cribbing and test pit walls to be backfilled with excelsior/hay/non-cohesive soil when exploring loose ground.

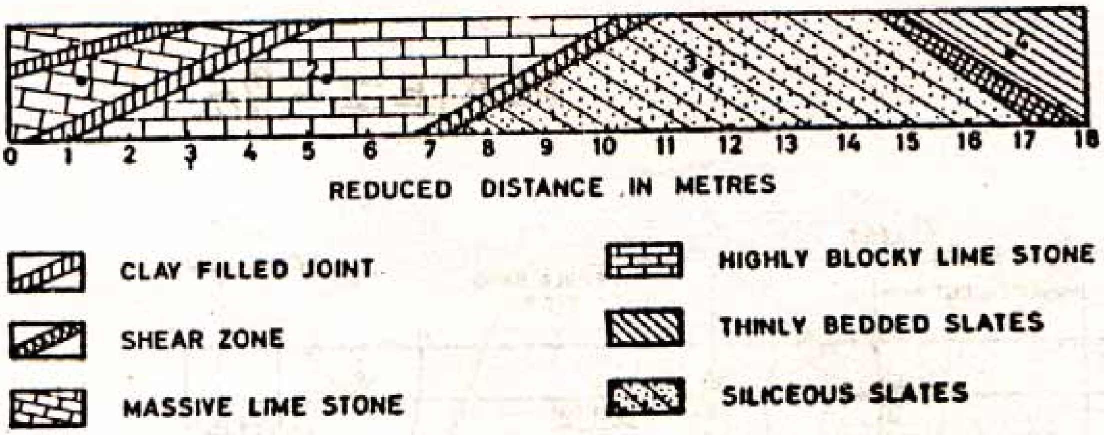
NOTE 2 — The crib need not always be blind. Wherever strata permits alternate blanks may be left or trellies arrangement may be used.

All dimensions in millimetres.

TYPICAL TEST PIT CRIBBING
(ILLUSTRATIVE SKETCH)



TYPICAL TRENCHING LAYOUT (ILLUSTRATIVE)



BEDDING DIPS : (Points 1 to 4 in the Section)

1. At RD........................ m dipping........................ due........................
2. At RD........................m dipping........................ due........................
3. At RD........................m dipping........................ due........................
4. At RD........................ m dipping........................ due........................

JOINTS :

1. Joint at RD........................m dipping .... due........................
2. Joint at RD ....m dipping........................ due........................
3. Joint at RD........................m dipping........................ due........................

RD = Reduced distance.

NOTE 1 — The gaps should be suitably filled in giving information about drift.

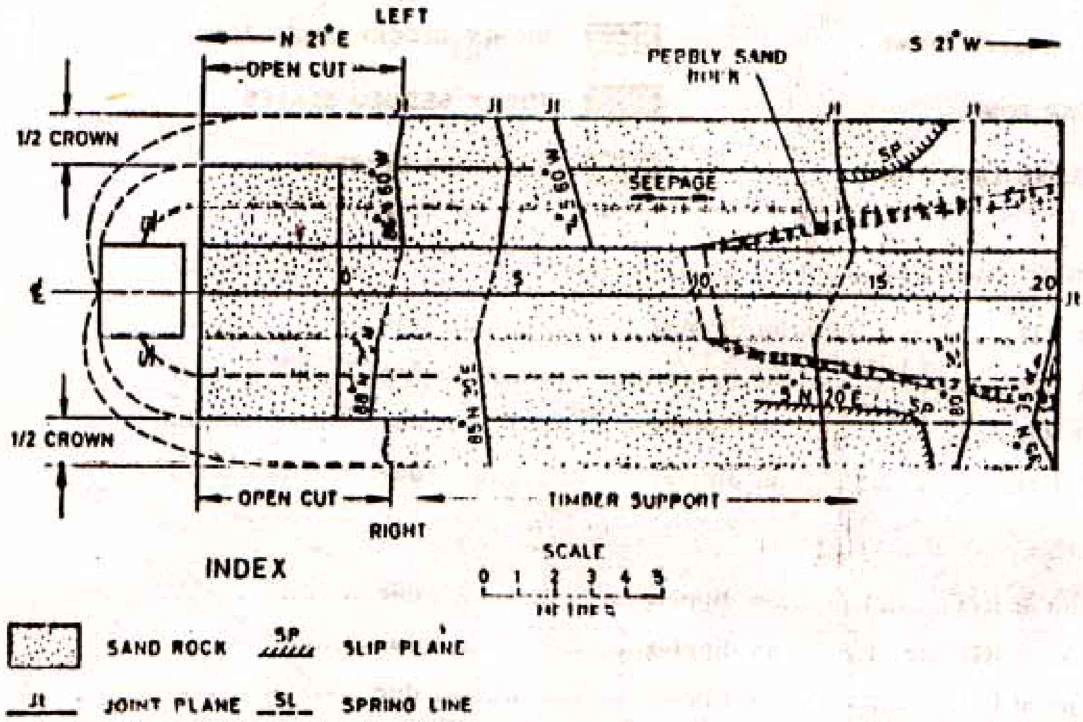
NOTE 2 — For purpose of representation a uniform height of drift should be assumed.

NOTE 3 — The wall of the drift which the geological cross-section represents should be specified.

NOTE 4 — The horizontal and vertical scales used should be specified.

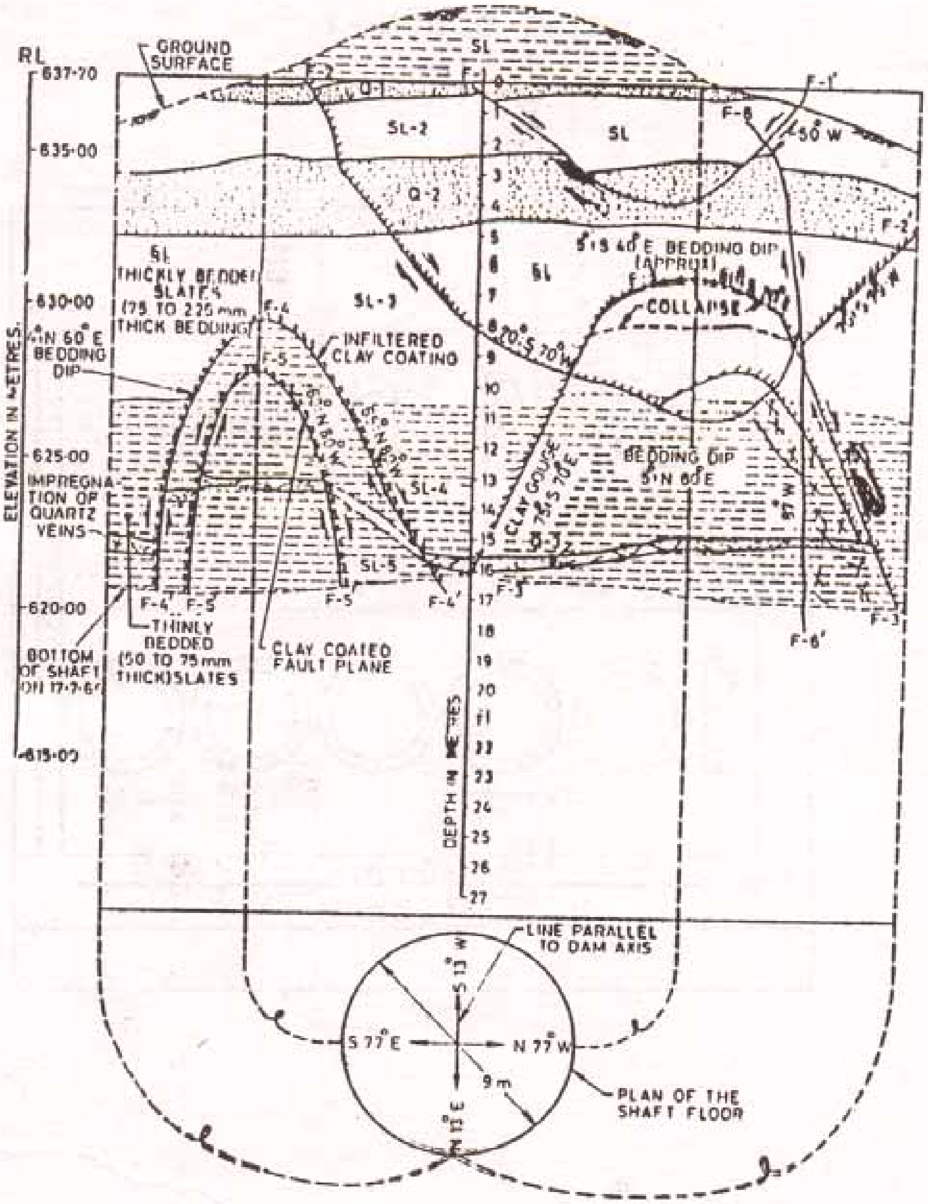
A TYPICAL GEOLOGICAL CROSS-SECTION OF THE WALL OF A DRIFT IN A GEOLOGICALLY SIMPLE ENVIRONMENT

PLATE : 2 - P/7



Typical Example of a Three-Dimensional Log in Exploratory Drift

PLATE : 2 - P/8



INDEX

Q	Quartzite (White)
SL	Quartzitic Shale (Thickly Bedded)
	Thinly Bedded Slate

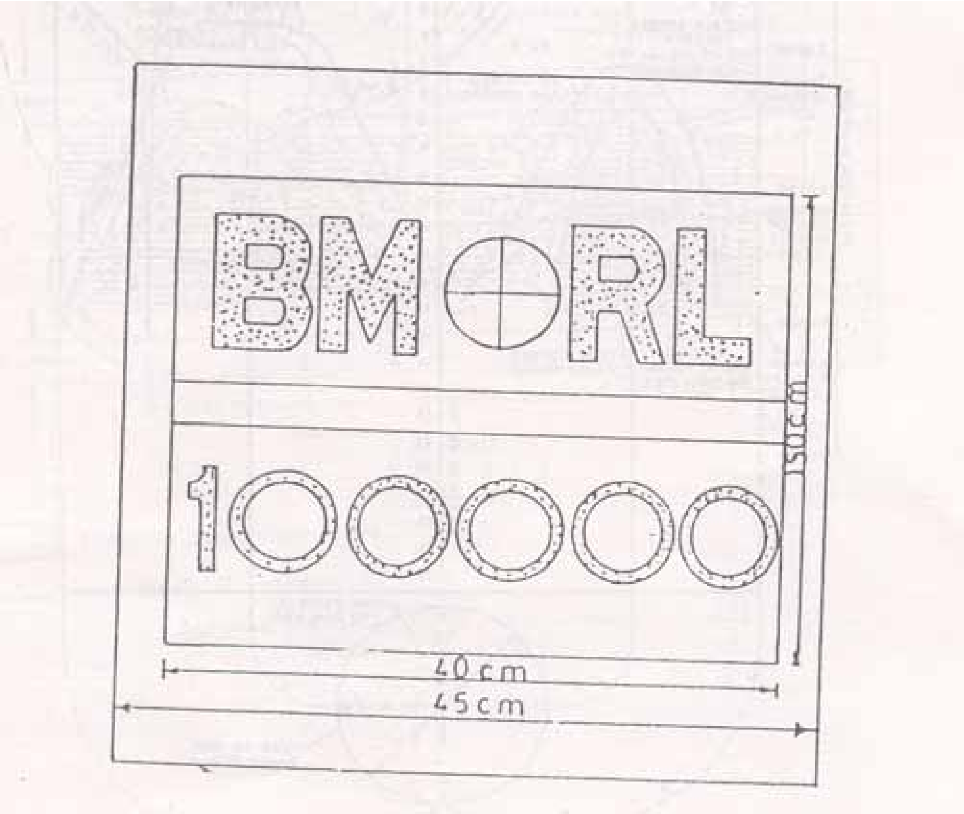
F-1, F-2, etc, indicate faults.
Q-1, Q-2, etc, indicate quartzite (white).
SL-1, SL-2, etc, indicate quartzitic shale.

NOTE — No groundwater was encountered in the shaft up to the depth illustrated.

A TYPICAL EXAMPLE OF THREE-DIMENSIONAL LOG OF A SHAFT

BENCH MARK ON MASONRY WORK Plate : 2 - P/9

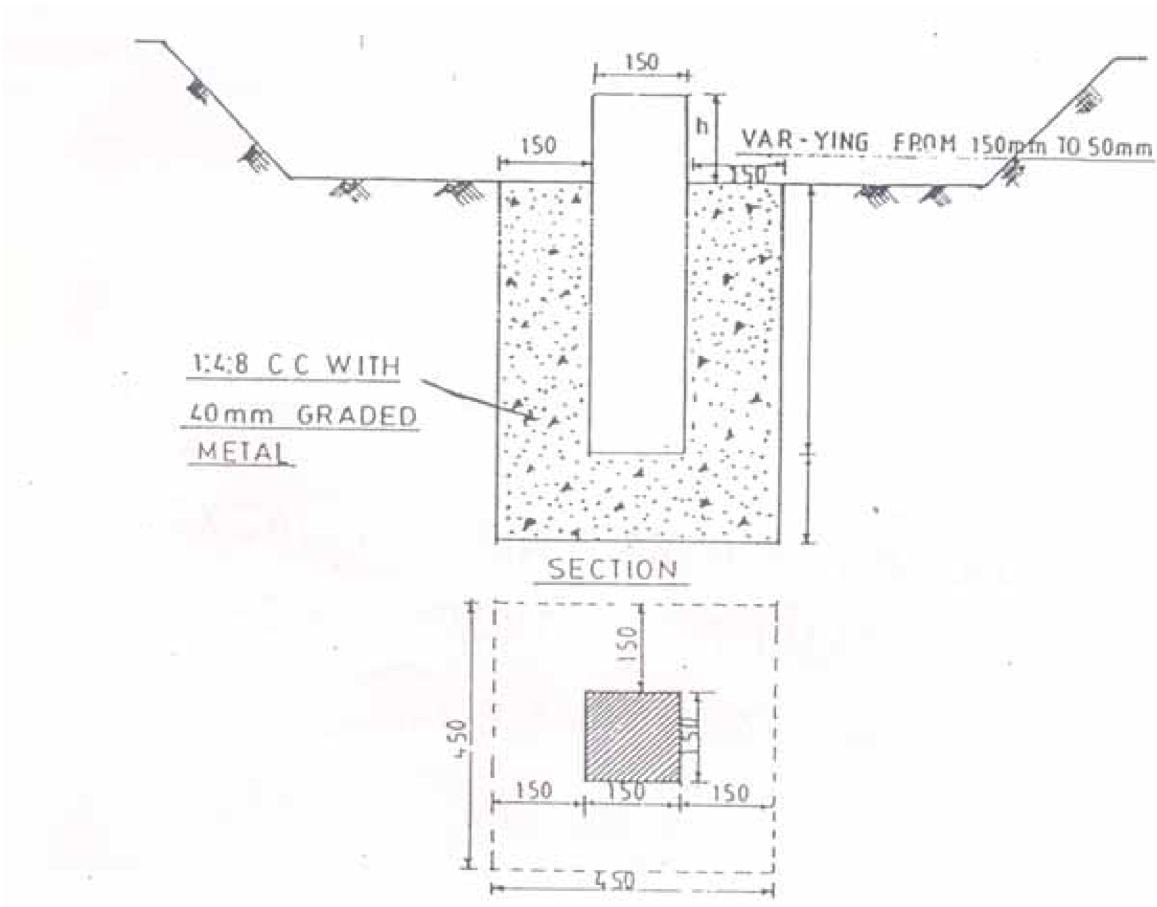
TYPE DESIGN - 7



BENCH MARKS ESTABLISHED ON MASONRY WORKS ARE INEXPENSIVE AND SERVE AS PERMANENT BM. THESE MAY BE ESTABLISHED EITHER NEAR THE EDGE OR IN THE CENTRE OR THE PARAPET CONSTRUCTED ON THE OUTER EDGE OF THE SERVICE ROAD. BMS SHOULD BE ESTABLISHED ON ALL IMPORTANT MASONRY WORKS ON A CANAL. THERE SHALL BE AT LEAST ONE BM AT EVERY KM DISTANCE.

NOT TO SCALE

TYPE DESIGN CENTRE LINE STONE



NOTES :- THE HEIGHT OF BED GRADE STONE ABOVE DESIGNED BED LEVEL SHALL BE 15 CM FOR DISCHARGE ABOVE 3 CUMECS 10 CM FOR DISCHARGE FROM 0.5 TO 3 CUMECS AND 5 CM BELOW 0.5 CUMEC.

All Dimensions are in mm

SPECIFICATION

For

Irrigation Projects

CHAPTER - 4
EXCAVATION AND EARTHWORK

AND

CHAPTER - 21
SPECIAL ITEM OF EARTH/MASONARY DAM AND CANALS

TABLE OF CONTENTS
Chapter 4 (Excavation & Earth work) &
Chapter 21 (Special items of Earth/Masonry dam & Canals)
As detailed in Volume - I, SECTION - II

TABLE OF CONTENTS (contd….)

CHAPTER - 4 EXCAVATION AND EARTHWORK
And
CHAPTER - 21 SPECIAL ITEMS OF EARTH/MASONRY DAM AND CANALS

4.1 REFERENCES:-

IS : 2720 (Pt. ll) - 1973	:	Determination of Water content (second revision)
IS : 2720 (Pt. XIV)- 1983	:	Determination of Density index (relative density) of cohesionless soils (first revision)
IS : 8237 - 1985	:	Code of practice for protection of slope for reservoir embankment (first revision)
IS : 8826 - 1978	:	Guide lines for design of large Earth and Rockfill dams
IS : 9429 - 1980	:	Code of practice for drainage system for Earth and rockfill dams
IS: 9556- 1980	:	Code of practice for design and construction of Diaphragm walls.
IS : 12200 - 1987	:	Code of practice for provision of Water stops at transverse contraction joints in masonry and concrete dams
	:	Specification for Irrigation projects in M. P. (1980)
	:	USR of Irrigation Works in M. P. & C.G. in force form 01.08.1984/ 01.4.1991/ 01.4.1998/ 01.12.2003
	:	Bombay PWD Specifications
	:	Specifications for Tawa Project.
	:	Specifications for Kolar Project
	:	CWC Specifications for masonry & earth dam of Rajghat Dam Project

4.2 TERMINOLOGY:-

Anchorage - Anchorage is a structure used to carry the lateral thrust of a wall. Ties to a series of concrete blocks or a continuous RCC beam, vertical or battered piles, inclined rock or soil anchors are generally used for this purpose.

Bentonite - A clay formed by alteration of volcanic ash and rich in montmorillonite clay mineral. Bentonite has exchangeable irons on the surface of particles. It swells in the presence of water and its suspensions are thixotropic.

Borrow area - The source of construction material required for earth and rockfill dam.

Casing - All zones other than the core in a zoned earth dam; also called shall or shoulder.

Core - A zone of impervious earth within zoned earth or rockfill dam.

Cut- off- A barrier to reduce seepage of water through foundation and abutments

(A) Full cut - off - A Cut - off taken to an impervious stratum.

Positive Cut - off - A full cut- off in the form of an open excavated trench and back filled with compacted impervious material.

NOTE - Full cut- offs also provided in the form of sheet piles, plastic diaphragm, concrete diaphragm, grouted cutoff, cutoff wall, etc.

(B) Partial Cut - off - A Cut - off which does not go down to impervious stratum.

Diaphragm wall - A wall constructed in situ by special trenching machines to act as cut - off wall or serve as a structural member. The standard widths rare 100-800 mm for cut - off wall, 450 to 1200 mm for structural member.

Guide wall - walls of shallow depth built on both sides of the centre line of a diaphragm wall to guide the grabbing or boring tool for trench making in order to prevent collapse or trench panels and contain bentonite slurry.

Horizontal filter - A layer of uniform or graded pervious materials placed horizontally.

Impervious blanket - An upstream impervious soil layer laid over a relatively pervious stratum and connected to the core.

Inclined or vertical filter - A layer of uniform or graded pervious materials, placed inclined or vertical.

Inner longitudinal drain - A trench filled with filter material and laid along the downstream toe of the core of dam to collect seepage from core of the dam.

Inner cross drain - A trench filled with filter material to collect seepage from inner longitudinal drain and carry it to toe drain.

Panel - Unit trench/ wall excavated or cast at a time.

Primary Panel - Panels made along the main axis of the wall in the first series; and leaving suitable gaps for other (secondary) panels. Primary panels are usually cast with two stop and pipes for inter locking with the secondary panels.

Secondary Panel - Panels made along the main axis of the wall inter locked with the panels to form an effective and reasonably leak proof joint resulting in a continuous diaphragm wall.

Riprap - It is the protection to the embankment material against erosion due to wave action, velocity of flow, rain wash, wind action etc., provided by placing a protection layer of rock fragments or manufactured materials. Riprap may be placed on slope either by hand or it may be simply dumped.

(i) Hand placed Riprap - it consists of natural stones quarried, laid flat or laid with projection, boulders or specially manufactured, material like cement concrete blocks and soil cement blocks, carefully placed by hand in a more or less definite pattern with a minimum amount of voids, its top surface reasonably uniform and free of loose stones or alternatively panel wise concrete slabs or precast concrete interlocking type blocks.

(ii) Dumped Riprap - It consist of boulders or blasted rock reasonably free from quarry fines and dumped in place by mechanical means.

Rock toe - A zone of free draining material provided at the toe of the dam.

Toe drain - A trench with filter material laid along the downstream toe of an earth or rockfill dam to collect seepage from horizontal filter or inner cross drain and take it to natural drain.

Trenching - Excavation for a panel carried out in situ. Use of drilling mud may be necessary to prevent collapse of sides.

Turfing - it is a cover of grass grown over an area to prevent erosion of soil particles by rain wash

Wale - This is a horizontal member fixed to the wall. Its function is to transfer the horizontal thrust of the wall to the tie rods / struts.

4.3 GENERAL SPECIFICATION:

4.3.1 Bench Marks:

4.3.1.1 Before starting any work, a permanent bench mark, reference line and check profiles at convenient positions approved by the Engineer - in - charge shall be erected. The Benchmarks shall be as per Type Design 6 and 8 of Department. The words "B.M" with R. L. shall be conspicuously carved and painted on the benchmark. The reference line shall comprise of a base line properly dog belled on the ground with number of masonry pillar. The check profiles shall be of such materials and shall be located at such places as to ensure execution of all slopes; steps and excavation to the profile or profiles indicated in the approved drawings or as directed by the Engineer - in - charge.

4.3.1.2. The Sub - Divisional Officer on behalf of the Engineer - in - charge shall himself lay out all important levels, all control points with respect to this bench mark and reference line and correlate all levels and locations with this bench mark and the reference line. Important levels shall be checked by the Executive Engineer. All assistance shall be given for the same by the agency executing the work.

In the case of spread out works, several bench marks, reference lines and check profiles may be necessary and shall be constructed as directed by the Engineer - in - charge.

4.3.1.3. Except the mathematical and surveying instrument which shall be provided by the department all materials and labour for setting out works including construction of bench marks, reference lines, check profiles and survey required for setting out works as may be required at the various stages of the construction works shall be supplied or made by the agency executing the work.

4.3.2. Cross Section

4.3.2.1. Immediately prior to the beginning of the work, cross - section of the existing ground level at suitable intervals, normal to the axis of the dam., canal alignment and other channels, sluice waste weir or other masonry structures , etc., shall be taken over the base and seating of the dam ,channels or other structures, etc. for sufficient distance outside the limits. Levels on this cross section shall be taken at suitable interval not exceeding 6 m or as directed by the Engineer - in- charge.

4.3.2.2. These cross - sections shall be taken and plotted in ink by the Departmental agency. These cross sections shall form the basis of all future measurements and payments on the area.

4.4 CLASSIFICATION OF STRATA:

4.4.1 Soft or Ordinary Soil - Generally any soil which yields to the ordinary application of pick and shovel or to spade, rake or other digging implement, such as vegetable or organic soil, turf, gravel, sand, silt, loam, clay pear etc.

4.4.2. Hard Soil - Includes all materials which can be removed with shovel or spade after loosening with pick axe such as clay soil mixed with lime kankar, black cotton soil for earthen bond, soft moorum etc.

4.4.3. Hard Moorum and Moorum mixed with boulders - Generally any material which required the close application or picks, jumpers or scarifies to loosen such as hard and compact moorum and soft shale. Moorum or soil mixed with small boulder not exceeding 25 % in quantity and each less than 0.014 cum (300 mm dia) but more than 0.004 cum in size.

Note - Boulder is rock fragment usually rounded by weathering, disintegration or abrasion by water or ice, found lying loose on the surface or embedded in river bed, soil talus, slope wash and terrace material of dissimilar origin.

4.4.4. Disintegrated Rock - Includes such strata which requires the close application of crow bars, picks, grating tools, scarifiers in suitable combination for its excavation such as soft laterite, soft conglomerate, hard shale, soft copra, hard and compact moorum mixed with small boulders exceeding 25% in quantity but each not exceeding 0.014 cubic metre in size.

4.4.5. Soft Rock - Soft rock comprises of the following: -

(i) Boulders (not greater than 0.5 cum. in volume) hard laterite, hard copra and hard conglomerate or other rock which may be quarried or split with crowbars with casual blasting, if required, for loosening of strata.

(ii) Any rock which in dry state may be hard, requiring blasting but when wet becomes soft and manageable by means other than blasting.

4.4.6. Hard Rock (Requiring blasting) - Any rock or boulder (more than 0.5 cum. in volume), which requires the use of mechanical plant or blasting for excavation or splitting.

4.4.7. Hard Rock (blasting prohibited) - Hard rock requiring blasting as described under 4.4.6 but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

4.4.8. Authority For Classification - The classification shall be decided by the Executive Engineer and his decision shall be final.

4.5 CLEARING, GRUBBING AND PREPARATION OF WORKS AREA -

(i) All excavation areas and dam embankment area including a 6 m wide strip measured beyond and contiguous to the limit line of the area as shown on the drawing shall be cleared and any roots etc. completely removed as specified. All trees down timbers, fencing, bush, rubbish; other objectionable materials and vegetation shall be cleared. All stumps and roots shall be excavated and removed. All roots over 50 mm. in diameter shall be removed to a depth of 90 cm below the original ground surface or as directed by the Engineer - in - charge. Materials thus removed will be burnt or completely removed from the site. All felled timber and fuel shall be properly stacking and handed over to the department when asked for by the Engineer - in - charge. Piling for burning shall be done in such a manner and in such location as to cause the least fire risk. All burning shall be thorough so that the materials are reduced to ashes. Special precautions shall be taken to prevent fire form spreading to the areas beyond limits or the areas specified and suitable equipment and supplies for preventing and suppressing fire shall be available at all times.

(ii) No trees shall be cut from outside of areas designated unless instructed in writing by the Engineer-in-charge and all trees designated outside of the areas actually occupied by the works shall be protected carefully from the damage.

4.6 STRIPPING AND BENCHING UNDER DAM EMBANKMENT:

(i) The entire area of embankment including a 3 m wide strip beyond and continuous with the area of embankment proper as showing in the drawing shall be stripped or benched to a sufficient depth as directed to remove all unsuitable materials. The unsuitable material to be removed shall include loose rock, vegetation, topsoil, sod, and organic silt swamp material and rubbish and any other objectionable materials below the ground surface.

(ii) At location where a river or stream crossed the embankment site, loose sand and gravel and loose boulders shall also be removed as directed.

(iii) Stripped materials shall be disposed off in a manner as may be directed by the Engineer - in - charge and in such a way as not to detract from the finished appearance of the project.

4.7 EXCAVATIONS OF CUT-OFF OR PUDDLE TRENCH UNDER DAM EMBANKMENT:

4.7.1. Procedure for Excavation - A cut off trench or puddle trench as shown in the drawings shall be excavated in the foundation of the dam at the location indicated. This trench shall be excavated to a depth of 0.6 m to 1.2 m. into rock (depending upon the permeability of the rock) or into other impervious stratum as may be approved by the Engineer - in - charge. Accurate trimming of the slopes or the excavation will not be required but the cutting in general shall follow lines as specified in drawings. The area to be excavated shall be unwatered. The water level shall be maintained below the level of excavation in the area and none of the excavation shall be performed in standing water.

4.7.2. Utilisation of Excavated Materials - Trench excavation shall preferably be started after the whole base of the dam or at least the substantial part of it is cleared, grubbed, benched or stripped as required by specifications so that suitable material out of trench excavation can be directly utilised for forming the bank, to maximum possible extent .

4.7.3. Blasting of Rock - No blasting of rock would be permitted for the excavation in hard rock when the excavation reaches within about 60 cm of final levels, if in the opinion of the Engineer - in - charge, such blasting will shatter and disturb the rock below foundation. He may also put similar restrictions, in cases, where damage is apprehened to works in neighbouring area existing or under construction. In such cases rock excavation shall be completed by chiseling and wedging etc.

4.7.4. Material received from Cut- Off Trench or Puddle Trench:

4.7.4.1. The materials, excavated form the trench shall, if suitable, be used in the embankment either immediately or after stock piling as convenient and directed by the Engineer - in - charge. The suitability or otherwise of the material and zone of the embankment in which it is to be placed will be specified by the Engineer - in - charge on the basis of laboratory tests.

4.7.4.2. Materials excavated from the trench shall not be placed in the embankment till foundation for the embankment has been cleared, stripped and prepared as specified and adequate arrangements made for watering and rolling the layers of earth fill in the embankment.

4.7.4.3. Materials excavated from the trench shall be subjected to the same degree of embankment control as material obtained from borrows pits.

4.7.4.4. The material excavated from the trench which are not suitable for use in the embankment shall be disposed off in a manner as may be directed by the Engineer - in - charge and in such a way as not to detract from the finished appearance of the project.

4.7.5. Cut - Off Trench Filling - Cut off trench shall be back filled with impervious material of the same specification and in the same manner as for the impervious hearting zone of the embankment of the dam in accordance with specifications under para 4.9 But before back filling is started foundation grouting in accordance with specification of Chapter 22 may be completed, where required, unless the Engineer - in - charge directs otherwise.

4.7.6. Puddle Filling:

4.7.6.1. Puddle:

4.7.6.1.1. The puddle shall consist of good retentive clay of best quality free from organic or other foreign material. It should be clean and tough and should be available near the sits as for as possible. The most suitable clay is of the description used for tile making Soft sludgy, peaty sandy, salt or puffy clay should be rejected.

4.7.6.1.2. The clay is to be worked out into puddle before use by turning it over and over again with phowras, watering and treading with men's feet into one plastic homogeneous mass of the toughest consistency until it gets plasticity.

4.7.6.2. Laying of Puddle.

4.7.6.2.1. The puddle shall than be made into balls and thrown into the trench or in any other position required. No more than 15 cm in thickness of puddle shall be deposited in the place at one time and it must at once be thoroughly kneaded by men's feet and incorporated with mass below it so that the whole will be uniform and not in layers.

4.7.6.2.2. The top of puddle shall be kept as level and uniform as possible and shall on no account be allowed to dry. If the surface cracks at any time it shall be dug up and puddle remade.

4.7.6.2.3. Vertical joints across the puddle wall and steps to its side shall be avoided. All joints shall be made by long inclined faces overlapping each other.

4.7.6.2.4. The whole width of puddle trench excavated shall be filled with puddle only so that the puddle gets thoroughly into the interstices of trench walls. The joint near the wall shall be thoroughly kneaded with men's heels.

4.7.6.2.5. On holidays and other days, when works are stopped, labour should be specially employed to keep the surface of puddle wet by sprinkling of water.

4.7.6.3. The puddle filling shall not be done in standing water. Water level in trench shall be kept below the working level by means of pumps, if required.

4.7.6.4. As the surface of the puddle layer dries up, it should be thoroughly consolidated with rammers before a new layer of puddle is laid the surface or the previous layer, if not newly made, should be lightly sprinkled with water by means of watering pots and kneaded.

4.7.6.5. When puddle is finished, it should be immediately covered up in the work or when, this is not possible, it should be covered with approved hearting soil and kept moist.

4.7.6.6. The surface soil if not conforming to approved hearting soil, is to be removed on both sides of the puddle trench for a breadth equal to that of the top of the trench, and for 0.60 m deep, and refilled with selected clay or other material used for the hearting and consolidated in the same way.

This filling is to be carried up with the puddle wall to a height of 0.6 m above ground level and joined with the hearting.

4.8 BORROW AREAS:

4.8.1. All materials required for the construction of impervious, semi pervious or pervious zones of embankment and backfill for cut off/ puddle trench which are not available form cut off/ puddle trench excavation or other compulsory excavation, shall be obtained from designated borrow areas as shown in drawings or as designated by the field laboratory.

The limits of each borrow areas to be used in the various zones of embankment shall be flagged in the field and materials from each borrow areas shall be placed only in the zones for which it has been specified.

The depth of cut in all borrow areas will be designated by the Executive Engineer and the cuts shall be made to such designated depths only. Shallow cuts will be permitted in the borrow areas, if unstratified material with uniform moisture contents are encountered. Each designated borrow area shall be fully exploited before switching over to the next designated borrow pits. Haphazard exploitation of borrow area shall not be permitted. The type of equipment used and the operations in the excavation of materials in borrow areas shall be such as will produced the required uniformity of mixture of materials for the embankment.

Borrow pits shall not be opened within a distance of ten times the height of the dam embankment from the upstream and downstream toes. Borrow pits shall be operated so as not to impair the usefulness or mar the appearance of any part of the work or any other property. The surface of wasted materials shall be left in a reasonably smooth and even condition. Care should be taken in working of the borrow areas in tank basin to ensure that existing impervious blanket material is not completely removed and porous strata exposed.

4.8.2. Preparation of Borrow Areas - All areas required for borrowing earth for embankment shall be cleared off all trees and stumps, roots, bushes, rubbish and other objectionable material. Particular care shall be taken to exclude all organic matter from the material to be placed in the dam embankment. All cleared organic materials shall be completely burnt to ashes or disposed off as directed. The cleared areas; shall be maintained free of vegetable growth during the progress of work.

4.8.3. Stripping of borrow Areas - Borrow area shall be stripped of top soil, sod and any other matter which is unsuitable for the purpose for which the borrow area is to be excavated. Stripping operations shall be limited only to designated borrow areas. Materials from stripping shall be disposed off in exhausted borrow areas or in the approved adjacent areas, as directed.

4.8.4. Borrow Area Watering - Borrow area watering if needed based on laboratory tests will be done by the department as decided by the Engineer - in - charge.

The placement moisture content for proper compaction of earth work should be as near as practicable to optimum moisture content as decided by laboratory tests. However, depending upon the site condition, the nature of the earth of the borrow area, the season of the year, the moisture content of the earth of borrow area will vary over a wide range. Thus it would be necessary to add water to bring the moisture content of borrow area earth to as near OMC as practicable. In Irrigation Projects, watering in borrow areas may be done where watering at the place of fill does not yield required results. Wherever practicable and specially during dry months periodical watering of the borrow area by tankers and mobile units may be done to the extent possible as decided by Engineer - in - charge.

4.9 Dam Embankment:

4.9.1. General - Certain instruments for measuring the performance of the dam during construction and afterwards are proposed to be installed by the department at locations as specified in the drawing or as decided by the Engineer - in - charge. Necessary facilities for the installation and observation of these instruments shall be extended by the agency executing the work. For installation and observation of instruments and for necessary soil tests near the installed instruments, necessary time shall be allowed within placement schedule.

The embankment shall be constructed (exclusive of pitching and backing of chips of filter below pitching) generally to the lines and grades shown on the drawings, but increased by such heights and widths determined as necessary to allow for settlement or shrinkage as specified in para .4.9.9. Also in order that proper compaction can be done upto the edges of the designed section duly increased for settlement and shrinkage as stipulated above, section will be further widened by 45 cm.. Subsequently after compaction it will be dressed by trimming the slopes to proper section so that the surface on the slopes is also as firm and compact as the top of embankment. The earth thus trimmed could however, be used in the embankment fill. Any material that is lost by rains weathering or other cause shall be replaced.

The dam embankment is divided into zones within which fill materials having different characteristics are to be placed. Placement of fill within these zones as shown in the drawings shall be performed in an orderly sequence and in efficient and workman like manner, so as to produce within each zone, fills having such qualities of density, strength and permeability as will ensure the highest practicable degree of stability and performance of the whole dam embankment.

No bushes, roots, sods or other perishable or unsuitable materials shall be placed in the embankment. The suitability of each part of the foundation for placing embankment materials there on and for all materials for use in embankment construction will be determine by the field laboratory.

The difference in elevations between core and shell zones of the dam embankment at any cross - section above the embankment foundation shall not exceed 0.6 m unless specifically authorised by the Engineer - in- Charge. The embankment for each zone shall be maintained in continuous and approximately horizontal layers in the reaches programmed for construction in that season. Where however, due to some constraints the dam has to be constructed in discontinuous portions or reaches, the slopes of the bonding surface parallel to dam axis between the previously completed portions of the dam embankment and the materials to be placed in each zone shall not be steeper than 3 to 1 in core, and 2 and 1/2 to 1 in other zones.

4.9.2. Preparation of foundation - Foundation preparation shall be done subsequent to stripping and excavation, if any. All portions of excavation made for test pits or other subsurface investigations and all other existing cavities found within the area to be covered by earth fill or of core and shall zones, which extend below the established lines of excavation for embankment foundation, shall be filled with earth fill of the corresponding zone of the embankments. All test pits within a distance of 10 times the dam embankment from the upstream toe shall be filled by impervious material. No material shall be placed in any section of the earth fill portion of the dam embankment until the foundation for that section is suitably prepared and has been approved by the Engineer - in - charge.

The surface of each portion of the Foundation immediately prior to receiving any material for the earth fill shall be moist and sufficiently cleaned to obtain a suitable bond with the embankment.

Pools of standing water will not be permitted in the foundation of the embankment and shall be drained out prior to placing the first layer of the embankment.

(a) Rock Foundation - The treatment of the rock surface under the dam shall be so done as to ensure a tight bond between the impervious core and foundation, for which the following procedure shall be followed.

(1) Before the grout curtain is installed, the area of the rock surface which is to be in contact with the impervious core of the dam shall be exposed with rough excavation. Hard rock projections and overhangs shall be removed. If blasting is to be resorted to, care shall be taken to avoid objectionable shocks to foundation rocks and abutments. As far as possible, the whole contact area of foundation rock and abutments after rough excavation shall be exposed at one time to enable examination of rock surface characteristics and planning the method or treatment. Curtain grouting where required shall be carried out in accordance with provision under relevant para of specifications of Chapter 22 **"** Drilling and Grouting "

(2) Cleaning and Shoveling - After the grouting operations are over, the rock surface shall be thoroughly cleaned. Pockets of sand and gravel and other soils shall be removed by hand shoveling and soft erodible seams and localised decomposition cleared out as deep as possible. Loose rock shall be removed by wedging and hand picking. Layers or grout spilled from grouting operation shall be chipped out and removed. Finally, the hand cleaned surface shall be thoroughly washed with powerful water jets to remove the fines which would have worked into the seams of the rock and obtain a clean surface. Compressed air jets shall be used as a final step in the clean up operation.

(3) Sealing cracks -Deep pot holes or pockets shall be filled with hand compacted soil or concrete. If the rocks surface in the bottom and sides of pot holes is cracked, the cracks should be sealed with cement grout. If the rock surface contains too many closely spaced pot holes, the entire rock surface shall be covered with concrete. A clay paste may be used in the smaller cracks. All the cracks and joints and shear seams or other incompetent materials that are exposed in the cut off trench shall be scooped out to the greatest depth practicable (Not less than twice their width at the surface) with the aid of trowels, bars and cleaned with air water jets and then filled with slush grout. Slush grout shall consist of cement and sand thoroughly mixed in a proportion, 1 part of cement to 2 parts of sand by volume with sufficient water to produce a highly plastic and buttery mix.

Foundation rock which is fairly impervious but has a very rugged surface shall be treated by laying core material at a moisture content slightly above the optimum in thin layers and compacted with mechanical equipment / small tampers to ensure that all irregular depressions in the rock surface have been filled with soil to create an effective / complete bond.

The moisture content and layer thickness shall be specified by the field laboratory. Any open crack in the rock surface shall be specified by the field laboratory. Any open crack in the rock surface shall be sealed with cement grout by appropriate means. Fault zones or larger cracks shall be dug out to a depth as determined by the Executive Engineer and backfilled with concrete.

(b) Soil Foundation - Soil foundation shall be scarified and loosened by means of a plough ripper or other methods to a depth of about 15 cms. to 20 cms. to the satisfaction of the Executive Engineer. Roots or other debris turned up during scarifying shall be removed from the entire foundation area for the fill. It shall then be moistened to slightly above the optimum moisture and compacted by required number of passed of the compaction equipment to the same percentage of compaction as the core. The purpose of higher than optimum moisture is to ensure forcing of the soil into any unseen soft zones just below the surface. The first few lifts of fill for the embankment shall be carefully placed, for the surface will still be rather irregular. If possible, heavy rubber tyred rollers should be used for compaction because they will follow the irregular surface and not bridge over small low areas, as other types of rolling equipment will do. Layers 10 cms to 15 cms thick with moisture content 1 to 2 percent above optimum moisture content must be used to ensure uniform compaction and a satisfactory intimate bond between the foundation soil and the fill materials especially under the central core. The layers shall be composed of the most impervious materials, under the central core zone.

(C) Sand Foundation - The foundation sand shall be tested for its natural relative density . In reaches where the relative density is less than 70%, the foundation sand shall be densified by any of the approved methods to obtain a minimum relative density of 70%. Until the foundation has been tested and the relative density found to exceed 70%, earth fill shall be not be allowed to be placed. This is necessary to minimise the effects of any structural readjustments in a loose foundation.

4.9.3. Earthfill Materials - The materials for the respective zones of embankment shall be obtained from borrow areas required for obtaining the desired gradation in the depth of cut in the barrow areas required for obtaining desired gradation in the materials. In general, all materials from a particular borrow area shall be a mixture of materials obtained for the full depth of cut. Where in a borrow area the sub - stratum occurs in well defined layer differing considerably in mechanical analysis, so that mixture is not suitable for any particular zone, the materials shall be excavated layer wise by scrappers or other suitable means and the materials placed in the zone for which it satisfies the requirements. Where it is not practicable to obtain a mixture of materials, the finest and most clayey material shall be placed in the cut- off trench and the central upstream portion of the embankment. The intermediate material shall be placed near the outer slopes of the embankment, No material containing a high percentage of plastic clay shall be used in the embankment without being mixed with coarser material.

Chemical and Physical tests of soils in embankment shall be carried out to ensure that the soil does not contain (a) soluble lime contents (b) soluble salt contents of cohesionless fines, in quantities harmful to the embankments.

4.9.4. Placing earthfill - The distribution and gradation of the materials throughout earth fill shall be as shown on the drawings or as directed. The fill shall be free from lenses, pockets, streaks or layers of materials differing substantially in texture or gradation from the surrounding materials. The combined excavation and placing operations shall be such that the material when compacted in the earth fill will be blended sufficiently to produce the best practicable degree of compaction and stability. Successive loads of materials shall be dumped on the earth fill so as to produce the best practicable distribution of the material. The various zones shall be clearly delineated on the embankment and the materials from the borrow areas placed accordingly.

The clay blanket shall be laid in a manner similar to clay core and compacted to same degree or compaction at optimum moisture content.

Particular care shall be taken to ensure that materials are not so placed as will be conducive to the formation of intermittent relatively impervious blankets in the shall zone, which will interfere with the satisfactory drainage.

No stone, cobbles or rock fragments having maximum dimensions or more that 10 cms. shall be placed in the earth fill (casing only). Such stones and cobbles shall be removed either at the borrow pit or after being transported to the embankment but before the materials in the earth fill are rolled and compacted. Such stone and cobbles shall be used in the riprap or rock toe of the dam embankment, if suitable or wasted as directed. The materials shall be placed in the earth fill in continuous horizontal layers not more than 15 cm in thickness after being rolled as herein specified Higher thickness or layers may also be permitted, if suitable compaction units such as vibratory compactors are used to give required density under optimum moisture content, but in no case the compacted thickness of the layer shall exceed 25 cm. The extent of layers shall be determined in the field by test section. During construction, a small transverse slope from centre towards edges should be given to avoid pools of water forming due to rains. If in the opinion of the Executive Engineer the surface of prepared foundation or the rolled surface of any layer of earth fill is to dry or smooth to bond properly with the layer of materials to be placed thereon, it shall be moistened or worked with harrow, scarifier or other suitable equipment, in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer or earth fill materials is placed. If the rolled surface of any earth fill is found to be toe wet for proper compaction of the layer of earth fill materials to be placed thereon, it shall be raked up and allowed to dry, or be worked with harrow, scarifier or any other suitable equipment to reduce the moisture content to the required amount, and than it shall be compacted before the next succeeding layer of earth fill materials is placed. The concrete or masonry surfaces against which earthwork is to be placed shall be cleared and moistened prior to placing of the earth fill, clay leaping of plastic consistency be adopted to ensure proper bond between the earth fill and the concrete / masonry. The foundation adjacent to the concrete structures shall be thoroughly cleared of loose materials and moistened. In placing the earth fill on rock foundation, the foundation shall first be prepared as detailed earlier. Care shall be taken in placing the first layer of the fill that no damage is caused by the hauling machinery, which will get concealed by the spread layer of the fill. The soil for the layer shall be at a moisture content sufficient to enable satisfactory bonding of the fill with the rock surface.

In case the whole length of embankment is not constructed simultaneously and only a portion of the embankment is constructed during one season the following procedure shall be adopted.

The incomplete ends of embankment shall be placed at a slope not steeper than 4:1 to permit satisfactory bonding with the portion of the embankment, which is constructed later. Old surface should be stripped or benched in accordance with the direction of the Engineer- in - charge.

4.9.5. Weather Conditions - The embankment material shall be placed only when the weather conditions are satisfactory to permit accurate control of the moisture content in the embankment materials. During that part of the construction period when the top surface of the embankment may be subject to rainfall causing cessation of work, It shall be graded and rolled with a smooth wheeled rollers to facilitate runoff. Prior to resuming work, the top surface should be slightly scarified and moistened or allowed to dry as necessary and approved by the Engineer- in - charge. If the cessation due to any reason, is for a considerable period, top layer shall be stripped to the required depth as may be directed by the Engineer - in - charge, so as to remove any vegetable growth, loose silt or sand washings or other objectionable matter.

4.9.6. Moisture Control - The water content of the earth fill material prior to and during compaction shall be distributed uniformly throughout each layer of materials between -2 to +1 of the optimum moisture content for casing material and between 0 to +2 for hearting material. Moisture determination of soil as well as needle moisture determination of soil shall be carried out as per IS : 2720 (pt. II) - 1973, Sec. 1 and designation E22 of USBR/ Earth manual 1968 respectively.

Laboratory investigations may impose some restrictions on the lower limits of the practicable moisture contents on the basis of studies on consolidation characteristics of soils in embankment. Hereinafter, the term range of optimum practicable moisture content shall refer to the value as described above. As far as practicable, the materials shall be placed at proper moisture content. If additional moisture is required it shall be added by sprinkling water before rolling of a layer. If the moisture is greater than required, the material shall be spread and allowed to dry before starting rolling. Moisture control shall be strictly adhered to. The moisture content shall be relatively uniform throughout the layer of material. If necessary, ploughing, disking, harrowing or blending with other materials may have to be resorted to, to obtain uniform moisture distribution, if the moisture content is more or less than the range of optimum practicable moisture content, or if it is not uniformly distributed throughout the layer, rolling and adding of further layer shall be stopped. Further work shall be started again only when the above conditions are satisfied.

The moisture content of the earth fill placed against any rock outcrop or any structure shall be slightly above the optimum to allow it to be compacted in to all irregularities of the rock and this shall be determined by the field tests.

4.9.7. Compaction and watering:

4.9.7.1. Compaction Equipments - While the specification below provide that equipment of a particular type & size is to be furnished and used, it is contended that the improved compaction equipment as may be most suited to the prevailing site conditions and the programme of construction shall be used. The broad details of the equipments are given below.

4.9.7.1.1. Tamping rollers / Vibratory compactors shall be used for compacting the earth fill .The sheep foot rollers shall meet the following requirements.

(I) Roller Drums - Each drum of a roller shall have an outside diameter of not less than 150 cm and shall be not less that 120 cm. not more than 180 cm in length. The space between two adjacent drums, When on a level surface shall not be less than 30 cm nor more than 38 cm. Each drum shall be free to pivot about an axis parallel to the direction of travel. Each drum shall be equipped with a suitable pressure relief valve to prevent excessive pressures from developing in the interior of the roller drum.

(II) Tamping Feet - Atleast one tamping foot shall be provided for each 65 sq. cm of drum surface. The space measured on the surface of the drum between the centres of two adjacent tamping feet shall not be less than 230 mm. The cross sectional area of each tamping foot shall be not more than 65 sq.cm. at a plane normal to the axis of the shank, 150 mm from the drum surface and shall be maintained at not less than 45 sq.cm. nor more than 65 sq.cm. at a plane normal to axis of the shank 200 mm from the drum surface.

(III) Roller Weight- The weigh of the roller when fully loaded shall not be less than 7,091 Kg and the ground pressure when fully loaded shall not be less than 40 kg/cm^2. required to obtain the desired compaction. Tractor used for pulling rollers shall be of 50 H.P. to 65 H. P., power to pull the rollers satisfactorily at a speed of 4 kms/per hour when the drums are fully loaded with wet sand ballast. During operation of rolling, the spaces between the tamping foot shall be kept clear of materials sticking to the drum which cold impair the effectiveness of the tamping rollers.

4.9.7.1.2 Rolling - (i) When each layer of material has been conditioned so as to have the proper moisture content uniformly distributed through the material, it shall be compacted by passing the tamping roller. The exact number of passes shall be designated by the field laboratory after necessary test. The layers shall be compacted in strips overlapping not less than 0.6 m. The rollers or loaded vehicle shall travel in a direction parallel to the axis of the dam. Turns shall be made carefully to ensure uniform compaction. Rollers shall always be pulled.

(ii) If the foundation surface is too irregular to allow the use of large roller directly against any structure or rock out - crop, the roller shall be used to compact the soil as close to the structure or the out crop as possible and the portion of the embankment directly against the rock or the structure shall be compacted with pneumatic hand tampers in thin layers. Sheep foot roller shall not be employed for compaction till the thickness of the layers compacted by other mean is greater by 30 cm than the depth of the foot of the roller drum.

4.9.7.1.3. Tamping -Rollers will not be permitted to operate within 1.00 metre of concrete and masonry structures. In location where compaction of the earth fill material by means of roller is impracticable or undesirable, the earth fill shall be specially compacted as specified herein at the following locations.:-

1. Portions of the earth fill in dam embankment adjacent to masonry structures and embankment foundation designated on the drawing as specially compacted earth fill.
2. Earth fill in dam embankment adjacent to steep abutment and location of instruments.
3. Earth fill at locations specially designated.

Earth fill shall be spread in layers of not more than 10 cm. in thickness when loose and shall be moistened to have the required moisture content as specified. When each layer of material has been conditioned to have the required moisture content, It shall be compacted to the specified density by special rollers, mechanical tampers or by other approved methods and all equipment and methods used shall be subject to approval based on evidence of actual performance and field compaction tests. The moisture control and compaction shall be equivalent to that obtained in the earth fill actually placed in the dam embankment in accordance with the specifications.

4.9.7.1.4. Watering - Watering of earthwork for consolidation shall be carried out by the department or by the contractor as per clubbed item of schedule. The arrangements for storage, pumping equipment and laying of suitable pipe lines of adequate capacity on upstream and downstream of the dam will be made. The connections will be provided at regular intervals in the main pipeline to connect to the off-take lines having valves to control the flow through rubber hoses. The whole system will be such and so laid out that regular flow of water is ensured on the dam at all times. The pipeline will be required to be raised as and when required with the raising of the earthwork on the dam.

4.9.8. Dressing Slopes. The outside slopes of the embankment shall be neatly dressed to lines and grades as placement of fill progress.

All humps and hollows varying more than 15 cm from the neat lines of the embankment shall be regraded. Material used to fill depression shall be thoroughly compacted and bonded to the original surface. Slopes shall be maintained until final completion and acceptance. Any material that is lost by rains, weathering or other cause shall be replaced at the cost of agency executing the work.

4.9.9. Settlement Allowance - In the earth fill embankment watered, rolled and compacted at optimum moisture content and at dry density expressed as percentage or Proctor's maximum dry density as given in Appendix - 1, settlement allowance of 1% and 2% of the designed height for unyielding (rock) and compressible (Soil) foundations respectively shall be provided. The base width of the dam will not be increased to maintain the design slopes indicated in the drawings for the additional height as settlement allowance, but the following procedure will be adopted.

Settlement allowance will be calculated at various levels. Where the slope is to be changed and elevations including settlement allowance will be derived. The embankment width at the designed levels remaining same. The edges of embankment at the increased elevation (including settlement), when joined with the point where the slope has changed earlier below shall give the slope to be adopted for construction.

If the embankment is raised in more than one season, provision for settlement shall be made in the last season's construction by slight steepening of slopes near the top.

4.10 TOE DRAINS -

Pitched toe drains with filter will be provided throughout the length of the dam at the downstream toe of earth dam as indicated in the drawings and as per the details shown therein. The layer of horizontal filter under the casing portion of dam shall be extended in the toe drains to specified thickness. The filter shall be watered and tamped with hand tampers.

The useful excavated material out of the toe drain shall be suitably utilised on the dam as directed by the Engineer - in - charge.

4.11 ROAD SURFACES AND PARAPETS -

(i) Road shall be constructed at the top of the earth dam and other locations as indicated in the drawing. The roadway shall be as indicated in drawing. The construction shall be as specified for the highway by I.R.C. or as directed by the Engineer - in - charge.

(ii) The parapets shall also be constructed after allowing sufficient time for the embankment to undergo the usual post construction settlement in order to avoid cracking of the walls due to differential settlement.

4.12. FILTER:

4.12.1 Base Filter Blankets:

4.12.1.1. Where indicated in the drawings, filter blankets shall be laid on the base under the downstream portion of the earth embankment. The number of layer in the filter blanket or seepage drains and thickness of such layer shall be as specified in the drawing. Filter shall be placed and tamped into place in such a manner that mixing of filter with foundation or backfill materials will not occur.

4.12.1.2. The filter material shall consist of clean, sound and well-graded aggregate. The material shall be free from debris, wood, vegetable matter, decomposed rock and other deleterious matter. The gradation of each filter layer shall meet the following requirements with respect to the material to be protected and also with respect to the adjacent filter layers.

(i) $$\frac{\text{D - 15 of the filter}}{\text{D - 15 of the base material}} = > 4 \text{ and } < 20$$

Provided the filter does not contain more than 5 percent of material finer than 0.07 mm (No. 200 sieve)

(ii) $$\frac{\text{D - 15 of the filter}}{\text{D - 85 of the base material}} = < 5$$

(iii) $$\frac{\text{D - 50 of the filter}}{\text{D - 50 of base material}} = < 25$$

(iv) The grain size curve of the filter shall be roughly parallel to that of the base material. In the above, D-15 is the size at which 15 percent of total soil particles are smaller, the percentage being by weight as determined by mechanical analysis. The D.- 85 size is that at which 85 percent of the total soil particles are smaller. It shall be laid in single layer or in layers as per the drawing if more than one filter layer is required, the same criteria shall be allowed. The finer filter is considered as the base material for selection of the gradation of the coarser filter.

(v) In order to prevent segregation and bridging of large particles, (the maximum) particle size shall not exceed 75 mm .

The requirement for grading of the filter shall be established by the field laboratory on the basis of mechanical analysis of adjacent materials.

The material brought to the site shall be subjected to the aforesaid tests in the laboratories at the project site. The result shall be final and binding and all material not conforming to the requirement so determined shall not be permitted, for use on the said works.

(vi) The following gradation is tentatively suggested but is subject to modifications after further laboratory tests: -

(a)	For filter material in contact with foundation or earth fill material	Well graded coarse sand & gravel passing 12 mm screen
(b)	For middle layer of filter blanket & for layers in contact with rock fill	Coarse gravel passing 75 mm screen and retained on 12 mm screen

4.12.1.3 Placing:

4.12.1.3.1. The foundation shall be cleared, stripped as specified in paras 4.5 and 4.6 and SC layers of specified thickness as shown in the drawing shall be laid wherever there is clay in the dam seat, before laying the base filter.

4.12.1.3.2. The filter material shall be deposited in horizontal layers of thickness not more than 15 cm after compaction to achieve relative density not less than 70 % . The thickness of filter layer shall be increased to 30 cm if compaction is performed by treads of crawler type tractors, Surface Vibrators, or similar equipment. Thickness of layer shall, however, not be more that the penetrating depths of the vibrators, if compaction is performed by internal vibrator. During or immediately prior to compaction, the material in each layer shall be thoroughly wetted.

4.12.1.3.3. The relative density of the compacted material shall be not less than 70 % as determined by relative density tests of cohesionless soils as per procedure given in IS: 2720 (Part XIV)- 1983.

4.12.1.3.4. Extreme care shall be taken in placing material in the filter zone as to obtain a fill, free form lenses, layers and streaks of segregated materials.

4.12.1.3.5. After compaction of the filter blanket, the earth fill material shall be placed in 10 cm, layers and tamped by hand at optimum moisture or compacted by smooth rollers or power compactors as directed by the Engineer - in - charge. Sheep foot rollers shall not be used till earthwork has been laid and compacted to a thickness of 60 cms over the filter blanket. However, the compaction of the earthfill in the initial 60 cm thickness shall be subject to the same quality control regarding to moisture content and dry density as for the rest of the embankment.

4.12.2. Chimney Filter - Vertical inclined filter of the dimension specified in drawing shall be constructed on the downstream face of impervious core. The thickness of chimney filter shall be as shown in the drawings. Materials used shall be clean, sound and durable and shall be free from silt roots, bush and other impurities. Filter materials shall be laid in 30 cm layers and shall be thoroughly wetted and compacted by pneumatic tyred rollers or other approved equipments. Materials for filter shall be compacted to obtain a minimum relative density of 70 %. The filter shall satisfy the filter criteria as given in para 4.12.1.2. for base filter blankets.

4.12.3. Seepage Drains - The seepage drains shall be excavated to the size and bed grade as shown in the drawings so as to allow for easy flow of seepage from the hearting toe to the open drains. These shall be refilled with layers of sand gravel or broken metal and boulders as shown in the drawings. In this case greatest care will have to be taken to see that filter medial do not get mixed up.

4.13 RIP - RAP ON THE UPSTREAM SLOPE OF EMBANKMENT:

4.13.1. Hand Placed Rip - Rap:

4.13.1.1. Rip - rap shall be hand placed on the upstream slope of the dam embankment over backing of specified filter layers .The thickness of Rip - rap layer shall be as indicated in the drawings.

4.13.1.2. Stone for Rip - rap shall be hard and durable and shall not crumble on long exposure to water frost and air.

4.13.1.3. Procedure for Placing Rip - Rap - The hand placed Riprap shall consist of one-man stones laid on edge. Starting at the bottom of the slope the stone shall be laid compactly with a minimum of joints and so matched and inter locked that they shall be keyed together with staggered joint space. Rock fragments and spall shall be driven into interstices to wedge the Riprap in place. The wedging shall be done with the largest chip practicable, each chip being well driven home with a hammer so that no chip can be removed by hand. Very irregular projection shall be knocked off so that the Riprap presents a reasonably uniform surface free of loose stones.

4.13.1.4. Hand placed Riprap should preferably be laid in one course such that the layer thickness is same as the stone size. However at least 80 percent of the area of Riprap should have stones weighing more than 45 kg. Such stone should be spread uniformly in the area, where such stones are not sufficient to cover the entire thickness of Riprap; the same may be laid in two layers.

If two layers of stones are used, header stones extending through both layer and spaced at about 1.5 m. shall be used. Also of the two layers, the top layer shall be of larger stones. The size of the smallest side of the header stone shall not be less than 150 mm and its length shall be equal to the thickness of the Riprap plus 150 mm., so that the header stone would project above the general top surface of the Riprap by about 150 mm.. Such a projection will break the wave force and would also facilitate easy identification of the headers stones. If header stones of full length are not available from the quarry, concrete blocks of necessary size, length and shape may be manufactured for the purpose.

In case, if stone of requisite size are not available and smaller stones / boulders locally available are required to be used; the Riprap should be laid in panels formed by constructing profile walls. A portion of the area between the panels may be grouted by pouring fluid cement mortar worked into the Riprap.

Hand placed Riprap may be laid flat or laid with projections (Needles) .

4.13.1.5. The Riprap shall be placed along with the fill so that a minimum of breakdown will occur during placing and spreading.

4.13.2. Dumped Rip-Rap:

4.13.2.1. The minimum thickness of dumped rock Riprap and average rock size shall be as shown in Table **1.** The thickness of Riprap shall in no case be less than 450 mm.

TABLE 1 : Minimum Thickness of Dumped Rip-Rap

Maximum wave height metre	Minimum average rock size (D_{50}) mm	Minimum Riprap Thickness mm
0 to 1.5	300	600
1.5 to 3.5	400	750
above 3.0	700	1000

4.13.2.2. The most important criteria in Table 1 is the minimum average rock size (D50)of Riprap. For example, for waves of waves of 2 m in height the Riprap should be composed of rocks, half of which by weight are equal to or larger than more or less equidimentional rock with average diameter of 400 mm. The rock used for Riprap shall be well graded from a maximum rock roughly equal to 1.5 times the average size to 50 mm.

4.13.2.3. Procedure for Placing Rip- Rap - Dumped Riprap shall consist of boulders or blasted rock fragments; it shall be dumped in place mechanically on a properly graded filter layer. The full thickness of dumped Riprap shall be dumped in one layer. It shall either be dumped over the upstream face from the embankment level as the embankment is being raised up or after the embankment had been completed. When placed during the construction, the Riprap layer should be kept a few meters lower than the construction surface. When placed after the embankment is completed, the rock should be taken to the crest of the dam in trucks and then lowered down the slope by suitable mechanical device. The rock shall not be allowed to drop down the slope in a cute or be pushed down the slope, since these operations result in excessive segregation. After dumping, the rock should be worked manually with bars or other equipment to achieve a well-packed and tidy surface.

4.13.3. Graded Filter Underneath Rip- Rap -

4.13.3.1. Graded filter shall consist of atleast two layers of filter material (coarse and fine). The thickness of each layer shall be as specified in the drawing.

4.13.3.2. The graded filter shall consist of sand and crushed stone as shown in the drawing Sang used shall be clean sound and durable and shall be free from silt roots, brush wood and other impurities. Sand used shall be of size passing 4.75 mm screen. Crushed stone used for filter shall consist of rock fragments reasonably graded upto 15 cm in maximum dimension.

4.13.3.3. Gradation requirement for the coarse filter material with respect to Riprap material should conform to the criteria that D85 size of the coarse filter material shall not be less than 1/10 of D15 size of the Riprap material. The gradation requirements for the fine filter with respect to embankment material should conform to the criteria that D15 size of the fine filter material shall not exceed 5 times the D 85 size of the retained embankment material .The two layers of filter shall also satisfy these criteria with respect to each other. Where the embankment material satisfy this criteria with respect to coarse filter fine filter could be omitted.

4.13.3.4. Before placing of filter material, The embankment shall be trimmed neatly to slope and grades as indicated on the drawing .The filter material shall be placed in layers of uniform thickness and care shall be taken to avoid segregation of coarse and fine material in each layer, formation of pockets and mixing of material of one layer with material of another layer or earth fill.

4.13.4. - Tolerance: The tolerance on the nominal thickness of Rip - rap enforced on the performed profile shall be 10 percent.

4.13.5. - Dry Stone Pitching:

4.13.5.1. - The quality stones for pitching shall be in accordance with para 4.13.1.2.

4.13.5.2. - The depth of stones shall be about equal to the specified thickness of pitching and shall generally be not less than 0.014 cum or 0.021 cum as specified in the appropriate item of USR or other sizes as ordered by the Engineer-in-Charge having regard to the nature of stones being quarried. The small size stones/ spalls required for pitching and wedging shall be brought to the site only to the required extent and they shall not to be used in two or more thickness as a substitute for the stones of full thickness. A large amount of the stones for pitching shall be obtained from the required excavation for other parts of the work. Additional rock as required shall be obtained from rock quarries.

4.13.5.3. Placing: -

4.13.5.3.1.- Backing of filter and/or spalls where specified on drawing shall be placed only after the underlying slope shall be trimmed neatly to the slopes and grades established on the drawings .The lowest course of pitching shall be started form the toe wall or the line of pinheaders at the toe of the slopes as may be specified on the drawing and the pitching laid course by course up the slope.

4.13.5.3.2.- Projecting corners shall be knocked off with the hammer so as to make a rough joint at the base. The stone shall be laid on end with broadest base down and length normal to the slope and carefully bonded in all directions and firmly bonded on the backing of filters where provided. The stones shall be packed with hammer of mallet closed against each other, their general line being approximately perpendicular to the slope of the underlying surface.

4.13.5.3.3. - After the stones have been fixed as above, the interstices shall be filled with well fitting chips driven home.

4.13.5.3.4. - The general face slope of the pitching when completed shall be as specified in the drawing subject to the tolerance as given in para 4.13.5.1. below . The final surface of the pitching shall be clear of all refuge.

4.13.5.4. - Tolerance - The provision in para 4.13.4 shall apply.

4.13.6. Grouted Stone Pitching:

4.13.6.1. - The specification of para 4.13.5.1. to 4.13.5.3. shall be followed except for the use of stone chips or quarry spalls as described in para 4.13.5.3.3.

4.13.6.2. - After the pitching stones are laid as described in para 4.13.5.3.2, the Interstices shall be filled with mortar of specified mix. The mortar shall be forced into the joints with the help of 6 mm. rods so as to ensure that the mortar reaches upto the base. The joints shall then be finished flush with the help of trowel.

4.13.6.3. - The surface of the pitching shall be cleaned of all loose mortar droppings, etc., The joints shall be cured for at least seven days after the initial setting time of one day.

4.13.7. Dry Picked Up Boulder Pitching:

4.13.7.1- The boulders used in this type of pitching shall consist of the rolled rock masses directly picked up in their natural form from the river or the nalla beds. The boulders shall be hard dense and resistant to abrasion. The size of the boulders in at least one direction should not normally be less than 22 cm. Also the least dimension of such boulders in any direction should not be less than 10 cm. The smaller size boulders/ gravels required for packing and wedging shall be brought to the site only to the required extent and shall not be used in two or more layers as a substitute for the boulders of full thickness.

4.13.7.2 - Placing:

4.13.7.2. 1. - Over the backing of filter as may be specified in the drawing, the boulders shall be placed such that the direction in which the size of boulder is around 22 cm is placed normal to the surface of under layer. Also the boulders shall be laid with broadest base down and carefully bonded in all directions.

4.13.7.2.2. - After the boulders have been fixed as above, the interstices shall be filled with well fitting smaller size boulders, gravel driven home.

4.13.7.2.3. - The provision of para 4.13.5.3.4. Shall be applicable here also.

4.13.8. Dry Quarried Boulder pitching:

4.13.8.1. - The specification as in para 4.13.6.1. shall be followed except that the boulders of required size shall be obtained by breaking big size boulders.

4.13.8.2. - Placing - The specifications as at para 4.13.6.2.1. to 4.13.6.2.3. shall be followed.

4.13.8.3. - Tolerance -The specifications as at para 4.13.4. shall apply .

4.14. ROCK TOE:

(i) The rock fill shall consist of free draining mixture of rock fragments of sizes from 75 mm to 250 mm. A large amount of material may be obtained from required excavation for other parts of the work. Additional as required shall be obtained from rock quarries.

(ii) Successive loads of material shall be dumped as to secured the best practicable distribution materials. The large rock fragments shall be placed on the outer slopes and the smaller fragment shall be placed towards the earth fill side. In general the downstream toe shall be placed in the manner to be approved by the Engineer - in - charge.

(iii) The rock fill shall be placed in horizontal layers not exceeding 90 cm in thickness. The completed fill shall be stable and no large unfilled spaces shall be present in the fill.

(iv) Large voids, shall be not be allowed on the downstream face of the rock - toe, so as to prevent choking by the spilling of earth, rain cuts etc. during and after construction. Such voids shall be properly packed with stone chips of suitable sizes. The surface of the rock - toe shall be kept clear of all earth and debris so as not to choke its full drainage capacity.

(v) The filter layers to be provided behind and below the rock - toe shall satisfy the requirements of para 4.12.1.2.

4.15 - INSPECTION AND TESTS:

4.15. 1 General - The Executive Engineer shall maintain and exercise thorough check on the quality of fill material delivered to the dam and shall arrange to obtain the data and in-situ proportion of the material after compaction with designed assumptions. To achieve these objectives, a program of fill testing and inspection shall be planned to affect quality control.

4.15.2. Scope of Testing and Inspection Required:

Field control of fill material will require visual and laboratory checks. The checks on the effectiveness of placement and compaction procedure will required to be made by field density - tests at prescribed intervals.

4.15.3. Before Compaction:

Materials delivered to the fill shall be visually examined and their properties estimated by way of inspection. These checks shall include.

(a) Borrow Areas:

(i) Excavation of borrow areas shall be limited in extent and depth as indicated on plans.

(ii) Estimation of moisture contents of materials by visual examination and feel.

(iii) Samples shall be taken for laboratory analysis in case the soil is of different characteristics.

These inspection checks shall be supplemented by sampling the materials at prescribed minimum intervals and by testing the samples in the laboratory for gradation and moisture conte**nt.**

(b) Embankment:

(i) Water content tests shall be carried out in the laboratory while placing the fill materials.

(ii) Moisture content shall be controlled by adding water or aerating the soil according to laboratory test.

(iii) It shall be ensured that the methods of dumping, spreading and moisture conditions are such that which results in reducing segregation and or variation of moisture content to a minimum.

4.15.4 During Compaction:

It is intended that the checks on operations during compaction shall verify.

(i) That the layer thickness of the materials is as specified.

(ii) That the fill is compacted by the specified number of passes of the specified machinery.

(iii) That no excessive rutting, weaving or a scaling of the fill occurs during compaction.

4.15.5. After Compaction:

The condition of the fill after compaction shall be observed and recorded particularly with respect of rutting or weaving. However, the properties of materials after compaction shall be determined primarily by field density tests. Dry density attained shall satisfy the compaction standards as per Appendix. I

4.15.6 Frequency of Testing:

4.15.6.1. The frequencies for various tests for earthwork shall be in accordance with Appendix 6.02 of the M. P., W. D. Manual 1983 Vol. Part II.

4.15.6.2 Special attention shall be given to the following locations where insufficient compaction is likely to occur: -

(i) The junction between areas of mechanical tamping and rolled embankment along abutments or cut off walls.

(ii) Areas where rollers turn during rolling operations.

(iii) Areas where too thick a layer is being compacted.

(iv) Areas where improper water content exists in a material.

(v) Areas where less than specified number of roller passes were made.

(vi) Areas where dirt - clogged rollers are being used to compact the materials

(vii) Areas where over sized rock which has been overlooked is contained in the fill.

(viii) Areas where materials have been placed when they contained minor amounts of frost, or at nearly freezing temperatures.

(ix) Areas that where compacted by rollers that have possibly lost part of their ballast.

(x) Areas containing materials differing substantially from the average.

4.15.7 Record and Reports - Record of borrow area materials and embankment placing operations be maintained in order to have a continuous check on the suitability and availability of fill materials and quality of the fill. Thus, it will be possible to have complete description of materials in any portion of the embankments. The records shall be maintained in the form specified in Appendix. - II.

4.15.8. Field Test Data - Records of field test data results should be presented in the form of statistical analysis sheets and summary sheets in order to provide control required for enforcement of statistical requirements of the specifications.

The test data summary sheets and inspection reports be used to form the basis of construction control report, which should be issued from the site at fortnightly intervals during construction season The report would contain narrative accounts of the progress and problems of fill construction, statistical analysis of test data and photograph of the fill operations.

4.15.9 Embankment Test Section - Placement of compaction methods specified will have to be verified by test embankment section to be built prior to starting of fill operations or at an early stage of dam construction. The initial stage of dam construction itself could be made to serve the purpose of test embankments. The test sections referred herein shall be used to establish:-

(a) Layer thickness of fills materials.

(b) Optimum practicable moisture content.

(c) Number of passes of the sheep foot roller, or weight of vibratory rollers vis -a vis number of passes for effective compaction.

When an appreciable change in material occurs, additional test sections shall be made during construction. The procedure for construction of the test embankment section is as follows.

(i) Select a location on the embankment where uninterrupted placing operations are being performed. This area 15 m by 30 m should be carefully worked and referenced so that its limits will be easily recognised. In order to expedite the determination of moisture contest to be used, more than one test section may be established on the embankment at the same time.

(ii) During construction of the test section which will most probably continue for several shifts, a complete record of the procedure should be kept . This record should include the number of layers placed, the spread thickness of each layer, the moisture content, at which the materials were rolled, the designated (No. 1, No. 2, etc.) of the rollers used the condition of the rollers (clean or dirty), the action of the materials being rolled (such as wavy under the rollers, the amount of penetration of the roller teeth after different number of roller trips etc.) and the borrow pit location from which the materials came.

(iii) Check the rollers to make certain that they met all the requirements of the specifications.

(iv) Determine the required spread thickness of layer that will compact to the specified thickness after rolling specified number of times and maintain this thickness as long as number of roller passes is kept the same.

(v) Using the available data from borrow pit investigations of the materials to be used in the test section, the optimum moisture content as determined by laboratory tests will be known and 3 percent less than this moisture content should be used in the first 3 or 4 layers rolled.

(vi) After 3 or 4 layers have been placed at 3 percent less than the laboratory optimum moisture content, field density test should be made throughout the section. These tests should be made for atleast each 93 sq.m. of test section area, and should be distributed over the area that they will detect the effects of different compaction conditions encountered during construction. For example, if the section is located near an abutment, certain parts of the area will receive more compaction from track travel than others, hence some tests should be made in the portion compacted only by the rollers and so reported.

(vii) The next step is to compact another 3 or 4 layers at the moisture content slightly higher (1 percent or 2 percent) then the moisture content previously used, maintaining the same rolled thickness of layer and number of roller passes as in above. Field density tests are again made over the test section.

(viii) If the resulting field dry densities (of materials passing the No. 4 sieve) from (vii) above shows an increase, with increase of moisture, again by another 1 percent or 2 percent, repeat the test. If an increase in moisture results in a decrease in field density, then place the next layers slightly dry of the original moisture content used and repeat the test. This procedure is nothing more than developing on the embankment a moisture density relation or compaction curve for a certain roller, thickness of layer, and a given number of roller trips. If special studies during investigation have indicated that, the material being tested should be placed within certain moisture limits, or if the moisture limits to be used have been specified, the procedure outline above should include tests at these moisture contents or at moisture contents both greater and smaller than the specified.

(ix) The roller compaction curve is now compared with the standard laboratory compaction curve If the field density of materials passing the No. 4 sieve (from the roller curve) is greater than the standard compaction density at the specified moisture content, the test section should be continued decreasing the number of roller trips while maintaining the specific desirable moisture content until the most economical compactive effort is determined. When the roller trips are decreased, the required spread thickness of layer that will compact to the specified thickness of compacted material should be reckoned.

(x) All works connected with the embankment test section will be done departmentally and shall be allowed without hindrance.

4.16. TURFING -

After the slope has been dressed to line, it shall be slightly roughened to bond and hold a surface dressing consisting of a 150 mm layer of good soil. The layer shall than be raked and lightly rolled with hand roller or hand tamped as directed by the Engineer - in - charge the entire slope surface shall then be covered with a layer of turf sod. The sod shall include a mat of roots and earth atleast 50 mm thick. Sod containing an excessive amount of obnoxious growth shall be excluded. Sods shall be carefully handled in transportation and transplanting so that a minimum amount of earth will be lost from the root mass. The strips of blocks of sod shall be laid on the slope in close contact and then tamped firmly in place so as to fill and close the joints between the blocks. The interval of time between cutting and laying shall be kept to a practicable minimum and sod shall not be permitted to dry out. Immediately after placing, the sodded slope shall be thoroughly wetted and kept moist for 10 days. The sodded slope shall be periodically moistened, if necessary for a sufficient period to re- establish the plant growth. Humus sod shall be transplanted only during an approved season. Alternatively the down stream slopes shall be topped with a 150 mm layer of good top soil and seeded with approved grass seed as directed.

4.17. ADDITIONAL SPECIFICATION FOR CANAL EARTH WORK:

4.17.1 Alignment and Layout of Canals:

No work will be started unless alignment including curves is set out, reference lines and check profile given in accordance with para 4.3 of the specification and edges of excavation and toes of banks etc., are dog - belled or otherwise suitably demarcated as directed by the Engineer - in - charge.

4.17.2 Canal in Cutting - General -

(i) Excavation shall be carried out according to design with accurately graded bed fall and sides properly sloped in accordance with drawings.

(ii) The excavation shall be done by first cutting a central trench with slopes having steps with 30 cm. rise and tread in accordance with the prescribed side slopes. When excavation is so completed upto bed level, sides will be finally trimmed to correct profile by knocking off the steps and dressing the slopes to as smooth a surface as the nature of soil permits. In cutting in hard rock smooth side cannot be obtained and it must suffice that the canal is excavated to the full section and depth. Trimming of slopes shall not be started unless excavation is completed to correct bed level in full width designed, and the work executed is accurately checked with respect to the reference line by the Engineer - in - charge. Finishing of slopes should be done neatly and free from buldges, dents and wavy and undulating surfaces. To obviate such defects, trimming of slopes in small lengths less than 60 m. should be avoided.

(iii) The classification of soils will be on the basis of classification visible at both the sides of the excavation, but ridges (addies) or deadmen (matamas) may be left at suitable intervals, if so directed by the Engineer - in charge for facility of classification of soils.

(iv) Excavated materials will be utilised in accordance with typical sections of canal given in the drawings, either (a) In forming the canal banks on either side or (b) In embankments in other filling reaches of the canal or (c) In spoil banks or (d) in any other suitable places as may be directed by the Engineer - in - charge in case of excavation in rock excavated stuff will be neatly stacked as directed by the Engineer-in-Charge and in such way that these can be easily removed or transported for other works. If so directed by the Engineer -in -charge the materials will be stacked separately according to their gradation like masonry stones, rubble, pitching stones, boulders chips etc.

4.17.3 Canals in Full Cutting:

(i) Excavated earth will be uniformly deposited in the canal banks or in the spoil banks so that the banks have a neat appearance.

(ii) In the case of canal service bank, which has to carry the service road for inspection earth should be deposited in uniform layers not exceeding 20 cm. Clods exceeding 10 cm in size will not be allowed without breaking them to proper size.

(iii) In non - service bank and spoil banks thickness of layer should not exceed 30 cm.

(iv) In case of all banks (Including spoil), more gravelly material will be deposited as for as possible on the top and in slopes and top of banks with slope as indicated in the typical sections.

(v) In ridge canals continuous stretch of spoil banks shall be broken by leaving a gap of 3 m or more at suitable intervals of 150 metres or as directed by the Engineer - in - charge to allow for drainage or passage of traffic etc. However, In case of contour canals such gaps will not be left in the upstream spoil bank so that drainage water from the sidelong ground does not enter the canal.

4.17.4. Canal in Partial Cutting:

(i) Relevant stipulations of the sub- paras 4.17.2. (i) and 4.17.2. (ii) above shall apply to this case also. Banks will be formed in uniform layers not exceeding 20 cm thickness or as may be directed by the Engineer - in - charge and no clods exceeding 10 cm will be allowed. Clods exceeding 10 cm size should be broken to proper size. In case, the embankment is more than 3 metre height, work of watering moisture control & compaction shall be done as per stipulations in Para 4.5., 4.8., 4.9. and 4.15..

(ii) Where the banks have to retain water, they shall be formed, if so directed, with core of impervious materials, firstly from the cutting of the canal and failing which from other borrow areas. Core will be covered with suitable semi - pervious or pervious material that may be available.

(iii) Before commencing of embankment the seat will be cleared and stripped and ploughed and furrowed or benched if so directed in accordance with para 4.17.7.

4.17.5. Canals in full Embankment not exceeding 3 m from Base to the Top - All relevant stipulations of paras 4.17.2. to 4.17.4. above will apply in this case also. Embankment shall be made in stretches not less than 100 m,

4.17.6. Canal in full Embankment exceeding 3 m height from Base to the Top - In this case construction of embankments shall follow, unless repugnant to the context, all the relevant specification for construction of an earth dam for a reservoir stipulated in paras 4.5, 4.8 to 4.16 and 4.17.7 subject to the modification stipulated in para 4.17.8 below.

4.17.7 Striping, Benching and furrowing and Ploughing:

4.17.7.1. The ground surface under all canal embankments excepting rock surface, where it is below full supply level in the canal be stripped, benched or furrowed and ploughed as per guidelines given below if not specified otherwise.

4.17.1.1. Benching - Benching should be provided only where the work is to be done on highly undulating stiff ground, steeply sloping ground or on existing canal embankments. Benching shall consist of excavation of triangular trenches with a slope of 1 In 12 with average depth of cutting as 15 cms, longitudinally below the embankment seat or in the form of steps with height of steps not more than 30 cms. The slope of trenches shall be towards the centre from the outer toes of the embankments.

4.17.7.1.2. Stripping and Ploughing and Furrowing - Recommended treatment on embankment seat for stripping and ploughing and furrowing under different situation should be as below:

S.No.	Type of vegetable growth on	Depth of stripping for				
		Q <3.0 cumecs		Q > 3.0 cumecs		
		H> 1.5 m	H< 0.6 m	H >0.6 m	H<0.6 m	H> 3.0 m
1.	Soil Containing grass cover	8 cm.	Nil only ploughing and furrowing	15 cm.	Nil only ploughing and furrowing	15 cm.
2.	Agricultural land	Upto depth of ploughing but not exceeding 15 cms	----do----	15 cm.	----do----	Upto depth of ploughing but not exceeding 15 cms

Note :

1. Where FSL in the channel is below the ground level, neither stripping, nor ploughing and furrowing shall be done.
2. None of the treatments described in the above table shall be done for seat under spoil banks.
3. Where the depth of stripping needed is more than 15 cms, it shall be carried out only after approval by the Engineer - in - charge.

The foundation for canal embankments shall be prepared in accordance with para 4.9.2 (a) to (c) depending upon the nature of foundation materials.

4.17.7.2. Disposal of materials - In all the items of benching / stripping and preparation of base on rocky strata, described in para 4.17.7.1. above, the material from excavation, shall be deposited in specified areas in a manner as may be directed by the Engineer - in - charge and in such a way as not detract from the finished appearance of the work.

4.17.8 Compaction - The dry density shall not be less than 90% of M. D. D. in case of unlined canal more than 3 m height of embankment and lined canal irrespective of the height of embankment. Work of watering, moisture control and compaction shall be done by the contractor, wherever it is so specified.

4.18 TRANSVERSE CONTRACTION JOINT IN DAM / BARRAGE:

4.18.1. General - Vertical transverse contraction joints shall be provided in the masonry and / or concrete of the dam/barrage for convenience in construction and to provide for contraction of masonry/ concrete. The location and details of these joint shall be as shown on the drawings. The joint shall extend through the full cross section of the dam profile and shall be started from the foundation. The contraction joint in the concrete portion shall be smooth, as obtained with plane surfaces of form works in the case of masonry, the edge of the block at the joint shall be built with selected stones and the surface plastered with cement mortar appropriate to the zone. The finish of end block of each contraction joint shall be such that an average thickness of 40 mm plaster gives smooth plumb surface.

The joint shall be sealed at the upstream face by installing water stops as described in para 4.18.2

4.18.2 Waterstops across Transverse Contraction Joint:

4.18.2.1. Materials:

(A) Metal Waterstop - The waterstop shall be made out of 1.5 mm thick strips of copper or stainless steel as specified on the drawing conforming to IS: 1972 - 1977 and IS: 6911 - 1972 respectively.

Subject to the provisions on the drawings, the waterstop shall have either of the two shapes viz. ‘Z’ and ‘M’ shapes shown in Fig. A of PLATE: 1/ CH-4*.

(B) Rubber/ PVC waterstop - The rubber Water stop shall be fabricated from natural rubber and shall meet the test requirement given in relevant parts of IS: 3660.

The PVC Waterstop shall be fabricated from a plastic compound, the basic resin of which shall be polyvinyl chloride and shall meet the test requirements given in relevant parts of IS: 8543

The Rubber / PVC Waterstop shall meet the requirements given in Table 2.

Table 2 : Performance Requirements of Rubber / PVC Waterstops.

SL. No.	Characteristics	Unit	Value
i)	Tensile strength	N/mm2	11.6 minm.
ii)	Ultimate elongation	%	300 minm.
iii)	Tear resistance.	N/mm2	4.9 minm.
iv)	Stiffness in flexure	N/mm2	2.46 minm.
v)	Accelerated extraction		
	(a) Tensile strength	N/mm2	10.5 minm.
	(b) Ultimate elongation	%	250 minm.
vi)	Effect of alkali (7 days).		
	(a) Weight increase.	%	0.25 maxm.
	(b) Weight decrease.	%	0.10 maxm.
	(c) Hardness change	Point	± 5
vii)	Effect of alkali (28 days).		
	(a) Weight increase.	%	0.40 maxm.
	(b) Weight decrease.	%	0.30 maxm.
	(c) Dimension change	%	± 1

Unless specified otherwise the shape and dimensions of Rubber/ PVC shall be as given in Fig B of PLATE; 1/CH-4*.

(C) Asphalt Waterstop - Recommended specifications of asphalt are given below: -

(a)	Density	...	1015-1065 Kg/m3
(b)	Penetration at 25^{o} C	....	200-300
(c)	Softening point (Ring and ball test)	.....	80-90^{o} C
(d)	Brittleness test on 22 mm^{2} specification		
	at 5^{o} C energy absorbed.	.....	0.97 Kg/m

The location, shape and dimensions of asphalt waterstop shall be as given in Fig. C of PLATE: 1/CH-4*

***For figures see specifications published by E- in - C.**

4.18.2.2. Installation of Waterstops :

4.18.2.2.1. The joints shall be sealed at the upstream face by installing. One line of metal waterstop and one line of Rubber / PVC Waterstop separated with one line of Asphalt water seal in between, as per general arrangement shown in Fig. C of PLATE: 1/CH - 4.* In addition one line of Rubber / PVC water stop across the joint around galleries/adits shall be provided as shown in Fig A of PLATE: 2/CH-4.*

4.18.2.2.2. The metal waterstops shall be erected in place with the help of anchor rods.

4.18.2.2.3. In the case of masonry dams, the surface adjacent to the block- outs (shown by dotted lines in Fig. C of PLATE: 1/CH-4.)* shall be irregular and the joints in the masonry shall be raked out when mortar is green, with some stones protruding beyond the dotted lines regularly in both directions. No such block - outs shall be provided in concrete dams where concreting on either side of the water seal is done along with the concreting of the rest of concreting block.

4.18.2.2.4. An asphalt waterstop, where specified, shall be constructed by forming a well of square opening with 125 mm side across the contraction joints. In this asphalt well, two 12 mm dia steam heating pipes (standard black welded steel) for reliquifying asphalt shall be installed. These pipes will be rigidly clamped in place and will be provided with threads and caps. The asphalt shall be poured in lifts corresponding to the concrete lift. The steam shall be passed through steam heating pipes after seal is completed upto top. It shall then be capped as in the drawing (Fig. B of PLATE: 2/ CH -4 AND Fig OF PLATE: 3 /CH-4)*

4.18.2.2.5. 25 mm dia dowel bars 1500 mm long (500 mm in concrete and 1000 mm in masonry) at the rate of 500 mm. centre to centre in both directions shall be provided at the concrete/ masonry interface of the block- out in case of masonry dam to prevent shrinkage cracks at the interface.

4.18.2.2.6 Adequate provision shall be made to support and protect the waterstops in position during the progress of work and adequate care taken while removing forms so that the bond between the seal and masonry of concrete is not broken. To provide good mechanical bond 10 mm dia M.S. bars of 500 mm length shall be brazed at one end to the sealing strip at 1 m vertical interval. The other end of this bar shall be hooked and tied around 20 mm dia bars embedded vertically in the block-out concrete.

4.18.2.2.7. The block- out shall be concreted in lifts not more than 1.5 m. Minimum grade of concrete used in block -out of one shall be concreted first and the joint face given a coat of coaltar black paint conforming to IS: 290 - 1961 and then only the block-out of the second block shall be concreted so as to have a clear contraction joint.

4.18.2.2.8. The concrete surrounding the waterstops shall closely follow the masonry in the block and at no time shall the top of concrete be lower than the general elevation of the masonry in the lower of the two adjacent blocks by more than 1.5 m.

4.18.2.2.9. Unless otherwise shown on the drawing, the details of waterstop arrangement (at contraction joint between two monoliths of a dam) near the top of a non-overflow section shall be as shown in Fig. B of PLATE : 2 /CH-4* and that near the crest of an overflow section as shown in Fig. of PLATE : 3/ CH-4* and near the bottom of the dam in Fig. of PLATE : 4/ CH-4*.

4.18.2.2.10. If not shown otherwise on the drawing Rubber/ PVC Waterstops shall be provided around galleries/adits at the contraction joint between two monoliths of a dam as shown in Fig A of PLATE 2/CH 4*.

4.18.2.3. Jointing:

4.18.2.3.1. Rubber/PVC Waterstops shall be jointed in straight reaches only. The waterstops shall be jointed carefully by heat sealing.

***For figures see specifications published by E- in - C .**

4.18.2.3.2. Jointing In Copper /Stainless Water seals shall be by careful brazing/ welding respectively so as to form a continuous watertight diaphragm.

4.19 DIAPHRAGM WALL:

4.19.1 Materials:

4.19.1.1. Cement - The cement shall be ordinary Portland cement conforming to IS : 269 - 1989 and blast furnace slag cement conforming to IS : 455 -1976 or pozzolana cement conforming to IS : 1489 - 1976. Other specifications for storage, testing etc., shall be as described under relevant paras of Chapter - 7 & 16.

4.19.1.2. Aggregate- All the aggregate (coarse and fine) shall conform to the specification laid down under relevant paras of Chapter 7&16. Unless specified otherwise well graded coarse aggregate of 20 mm size shall be used in reinforced cement concrete diaphragm wall . For plain concrete, plastic concrete or grout cut wall, (Sand, Bitumen, Cement mix) a smaller size of aggregate may be used.

4.19.1.3. Water- Clean water free from deleterious impurities as per specification laid down under relevant paras of Chapter - 7& 16 shall be used in concrete mixing. Water used for bentonite slurry shall be free from salinity and other deleterious impurities.

4.19.1.4. Admixtures - If required chemical admixtures in concrete shall be used as specified in IS: 456 - 1978.

4.19.1.5. Reinforcement - Mild steel and high tensile steel bars and hard drawn steel confirming to IS: 432 (Pt-1) - 1982, Cold twisted bars conforming to IS: 1786-1985 and hard drawn steel wire & fabric conforming to IS: 1566 –1982 shall be used and structural steel sections conforming to IS: 226-1975 shall be used.

4.19.1.6. Concrete- Concrete shall conform to detailed specifications laid down under relevant paras of Chapter 7 & 16 and Para 4.19.7.3. of this chapter.

4.19.1.7. Bentonite - Sodium based bentonite shall be used in preparing bentonite slurry. The concentration of bentonite slurry used shall confirm to requirements discussed under para 4.19.3. for sodium and chemically contaminated ground water condition. The slurry may be suitably processed with chemicals .

4.19.1.8. Grouts- In case of grouts walls, the cement, clay and chemical grouts used shall be designed and tested according to requirement of the structure.

4.19.1.9. Retarding Agents - Retarding agents and expansive additives may be added in the cement clay grout if required.

4.19.2. Equipment and Accessories:

4.19.2.1. Trenching Equipment - Depending upon the type of soil encountered soil encountered at the site and the depth, length and thickness of diaphragm wall to be constructed, suitable trenching equipment shall be chosen. The general trenching equipment shall include rotary boring rigs, percussion boring rigs, trenching bucket type shovels, mechanical grabs, hydraulic grabs with kelly bars, grabs controlled by suspended wire ropes of a crane winch, direct mud circulation boring rigs, reverse circulation rigs and submersible motor drills for trenching equipments. For gravelly soils, boulder deposits specially designed chiseling equipments shall be considered. When required methods using combination of above processes may be chosen.

4.19.2.2. Bentonite Slurry, Preparation an d Testing Equipments - Tanks of suitable sizes and slurry pumps of suitable capacity should be used for storage, mixing & circulation of bentonite for slurry at site. A separate water pump may be used for water supply to slurry tank. Equipment for sampling the slurry from deep trenches and testing its concentration, viscosity, PH value and hardness of ground water in which the bentonite slurry and concrete are prepared, should also be used. The tasting of slurry after contamination with soil or cement indicates the need of disposal or reuse as the case may be. Vibrating screens hydrocyclones, and centrifuges for cleaning the bentonite slurry for reuse may be employed.

4.19.2.3. Concreting Equipment - Concrete mixers, tremie pipes of suitable length and size and concrete pouring devices (manual or mechanical) shall be used according to the need of the work. The lifting arrangement for tremie pipes shall be capable of doing the works with desired speed.

4.19.2.4. Lifting Devices - Cranes of suitable capacity and boom length should be used in the case of precast wall panels for lowering them in the trenches. The same may be used for stacking the panels at site during casting the panels in the casting shed. The reinforcement cages of large depths and length of wall panels may be lifted by crane, derrick or any other suitable auxiliary rig. If the loads of the panel and reinforcement cage are small, this work may also be done by winch and pulley arrangement provided on the diaphragm-walling rig. Cranes or rigs with winches of adequate capacity may be used for operating the trenching grabs as necessary.

4.19.2.5. General Guidelines- Choice of rotary, percussion, grabbing equipment and equipment for direct or reverse circulation etc. , shall be made to suit the soil conditions . Vibrations and noise produced during construction should not have any damaging effect on the people and existing structures. Consideration shall be given in selection of equipment when they are required to work on a site with restricted space or headroom.

4.19.3 Specification of Bentonite Slurry:

4.19.3.1. Bentonite powder used for preparation of slurry will be tested for its liquid limit and the liquid limit shall not be less than 300 percent. This is normally prepared using 7% to 16% by weight of bentonite powder in water.

4.19.3.2. Following tests are normally carried out on freshly prepared bentonite slurry to be used in diaphragm walling:

Type of Test	Method of Test	Permissible value at 200 C
Density	Mud balance or hydrometer	1.04 to 1.10 g/ml.
PH Value	PH indicator paper Strips	9.5 to 12
Viscosity	Marsh cone method	30 to 90 seconds
10 minute gel Strength	Shearometer or vane Shear apparatus	1.4 to 10 N/m2 (14 to 100 dya / cm2)

4.19.3.3. The relationship between concentration "C" of bentonite slurry expressed as percentage by mass and the density Ys is give below.

$$Ys = 1.0 + 0.006\ C.$$

Note: - The above relation is valid for Indian bentonites and represents an average sample. There may be some variations of bentonites. Laboratory calibration may be prepared for the bentonite samples actually used.

4.19.3.4. Tests to determine density, viscosity, shear strength and PH value shall be carried out until a consistent working pattern is established, taking into account the mixing process, blending of freshly mixed bentonite slurry with previously used bentonite slurry.

4.19.3.5. When results show consistent behavior, the test for shear strength and PH value may be discontinued and only tests required to determine density and viscosity need be carried out.

4.19.3.6. The frequency of testing shall be on panel to panel basis where bentonite slurry becomes heavily contaminated with fine sand during its first use, and may be on a dally basis where contamination may be slight. In cases where a mechanical process is employed to remove contaminating solids from the slurry the frequency of slurry testing shall depend on equipment employed.

4.19.3.7. Prior to placing of concrete in any panel a bentonite slurry sample shall be taken (that is about 0.2 m from the trench bottom) and the same shall be tested for density. The sampling shall be done carefully by an appropriate method. The density thus determined shall not be greater than 1.25 g/ml to ensure satisfactory placing of concrete. If the slurry is found to have higher density the same shall be thinned by feeding in fresh bentonite slurry till the required density is achieved.

4.19.3.8. Suitable slurry pumps, submersible pumps or airlift shall be used in replacing the contaminated slurry at the bottom of trench by fresh bentonite slurry.

4.19.4. Bentonite Slurry and Additives:

4.19.4.1. Sodium based bentonite powder shall be mixed thoroughly with potable water to form a fully dispersed lump- - free homogeneous slurry. Suitable slurry taken shall be used for this operation. The use of a slurry pump with special nozzle (Fig. A of PLATE: 5/CH - 4)*. is suggested for preparing bentonite slurry. Use of paddle stirrers or other mechanical devices such as colloidal grout mixer (Fig. B of PLATE: 5/CH-4) *, may also be made for proper mixing of slurry, the temperature of water used and of the slurry used shall not be less than 5^0 C.

For proper stabilization of the trench walls by bentonite slurry, it is essential to allow adequate geletion period for bentonite slurry. For this purpose the slurry should not be used for a period of minimum 12 hours after it is mixed thoroughly.

4.19.4.2 Where saline or chemically contaminated ground water is present, special additives listed below may be used to render bentonite slurry fit for use. These additives are used in very small amount of 0.1 to 0.5 percent by mass of the slurry.

(i) Ferrochrome lignosulphonate in combination with soda ash or bichromate of soda may be used for effective bentonite hydration, If hardness of water exceeds 200 PP.

(ii) Sodium Carboxymethyl Cellulose (S. C. M. C.) is yet another additive some times used. It protects slurry against effects of electrolytes, accelerates filter cake formation, and reduces fluid loss by increasing the viscosity of slurry.

(iii) Cement contamination may be counteracted by phosphates. The Calcium gets removed and clay solids dispersed. Phosphates decrease PH value thereby lowering viscosity and yield value of slurry.

(iv) Carboxymethyl Cellulose, gums or pre-sheared asbestos may be used, to increase Viscosity and reduce filter loss.

(v) To remove fine silty solids and clay solids from the slurry, flocoulants may be used. Vinyl Acetate maleic anhydride co- polymer or polyacrylamides may be used. Gaur gum can flocculate clays, carbonates, etc.

(vi) Pregelatinised starch may be employed as a fluid loss control. It may also be used as a protective colloid against the effect of electrolytes.

(vii) Stability of slurry filled trenches should be worked out as per procedure described under Appendix - II.

***For figures see specifications published by E- in - C.**

4.19.5. Guide Wall / Pre-Trench:

4.19.5.1. RCC guide wall / per- trench shall be constructed prior to main slurry trenching operation.

4.19.5.2. Guide walls shall be 100 to 250 mm thick, 1 to 2 metre deep and made of lightly reinforced concrete (not inferior than M 10) and shall represent the reference lines. In soft ground or fill, guide walls may be taken deeper. When ground water is close to the surface, guide walls higher than the surface level shall be constructed to maintain slurry head. The top of per trench level will be minimum 1.5 m above the high water table.

4.19.5.3. The clearance between finished diaphragm wall & guide wall shall be 50 mm minimum for straight panels. The clearance shall be suitably increased when the panels are curved. The finished faces of the guide walls towards the trench shall be vertical. Guide walls after construction shall be suitably propped where necessary to maintain specified tolerance. Mesh or cage reinforcement shall be used in guide walls.

4.19.5.3.1 For heavy machinery, guide walls shall be constructed with suitable ground slab (on both sides of the wall).

4.19.5.4. Guide walls get support from adjoining panels and therefore, their construction shall be done continuously.

4.19.5.5. The trench shall be kept filled with bentonite slurry before the commencement of boring / grabbing operation for any diaphragm panel. The level of bentonite slurry in the trench shall be minimum 1.0 m above the ground water table . When the boring operation is in progress, the level of bentonite slurry will be maintained by addition of bentonite slurry.

4.19.6 Methods of Construction:

4.19.6.1. General - Cast - in - situ structural R. C. C. diaphragm wall shall be constructed by resorting to either successive panel method or alternate panel method. In successive panel method, a panel shall be cast by the side of another completed panel, so as to form a good joint and a continuous leak proof diaphragm wall. In alternate panel method, primary panels shall be cast first, leaving suitable gaps in between. Secondary panel shall then be cast, resulting in a continuous diaphragm wall. The panel lengths vary depending on the soil strata and depth of trenching and surcharging however lengths of 1.5 m to 6 m are usually adopted. .

4.19.6.2. Successive Panels Method - In this method a panel shall be cast in continuation of previously completed panel. Use of form tubes is generally a joint between primary panels and secondary panels. However, with longer width of diaphragm wall and greater depth of diaphragm wall it may not be possible to provide form tube due to handling, lowering and extraction difficulties. In such a case, special tools such as semi circular chisels are used to effect a joint between primary and secondary panel and in this case form tubes are eliminated. Form tubes of 1 m dia and 30 m length have been used successfully (Fig. of PLATE : 6/CH - 4)*.

4.19.6.3. Alternate Panel Method:

4.19.6.3.1. In this method primary panels shall be cast first leaving suitable gaps in between. Secondary panels shall then be cast in these gaps (Fig. of PLATE: 7/CH-4)*. Two stop end tubes are used at the ends of primary panels to support concrete and form suitable joints with the secondary panels.

***For figures see specifications published by E- in - C.**

4.19.6.3.2. The excavated length of secondary panels may be smaller than that of primary panels.

4.19.6.3.3. The shape of the secondary panel end should be such as to form a good joint with primary panels.

4.19.6.3.4. Other construction techniques are same for successive and alternate panel method, which are described below.

4.19.7 Stages of Construction:

4.19.7.1 Excavation of Trench (Boring Operation):

4.19.7.1.1 General - Excavation of each trench panel (Fig of PLATE: 6/CH-4)* shall be done with the help of suitable machinery. The trench panel shall be kept filled with bentonite slurry of suitable consistency & viscosity during the excavation period. Before commencement of boring, length of the panels will be properly demarcated on the pre-trench wall. Panel boring can be done either by direct circulation or reverse circulation method described below.

4.19.7.1.2 Direct Circulation Method:

(i) This method is used with rotary or percussion type rigs where drilling fluid (bentonite slurry) is pumped through the drilled rods. It can be used for successive panel or alternate panel construction. The stages of construction are shown in fig of PLATE: 8/CH-4*. Simple trenching rigs for excavation may be used. Special cutters (for cutting and jointing) and elliptical or circular concreting tremie pipes for backfilling the trench panel may be used.

(ii) The trench panel may be excavated in the ground by making over lapping boreholes with bentonite slurry jet in combination with percussion and to and from rotary motion of jetting pipe having a suitable cutter at the tip.

(iii) A special semi-circular cutter shall be used for providing appropriate shape at each panel end to form a suitable joint.

(iv) The operation of filling bentonite slurry in the trench shall be as described under para 4.19.7.2.

(V) For Thicker walls that is 40 cm and more,suitable modified semi-circular jointing cutter may be used.

(vi) This method is suitable for shallow depths and bringing up lighter cuttings.

4.19.7.1.3. Reverse Circulation Method:

(i) The reverse circulation method with in percussion shall be used to make trench panel in the ground as shown in Fig.A of PLATE: 9/CH-4*. Forward and backward movement of the rig from one end of the panel to the other end shall increase the depth of panel in a zigzag manner.

(ii) High capacity pumps shall be used to suck the loosened soil in the slurry filled trench, Separators or sedimentation tanks shall be used to retain the soil cuttings, and to pass the slurry for circulation and reuse.

(iii) This method is suitable for greater depths and to bring up heavier cuttings.

4.19.7.1.4. Other requirements during Boring operation:

(i) Solids in the setting tank shall be removed and kept along side. When the grabs or kelly method is used for boring, bored muck from the grab will be left along side.

(ii) For overcoming any under obstruction or boring through all types of rocks such as soft rock, weathered rock, disintegrated, rock, hard rock, boulder etc. the use of chisel grab will be made in case of grab type equipment. In case of reverse circulation equipment the cutting tool itself will execute chiseling operation in above-mentioned strata.

(iii) The width of cutting tool will be more or less as that of the diaphragm wall. The trench shall be finished upto founding level in the final stage of preparation by using a cutting tool having a width of not less than 600 mm before commencing placement of concrete.

(iv) Boring shall be continued in the manners described above upto founding level. Depth of the trench will be determined by taking sounding. Diaphragm wall shall penetrate about 0.6 meter into sound rock, which shall be ensured by careful soundings taken and certified by Engineer - in - charge. If there is difference of more than one metre or more in the rock level at two ends of the panel, suitable stepping as decided by Engineer - in - charge shall be provided.

(v) Before removing the equipment, the bottom of the trench will be cleaned by reverse circulation equipment.

(vi) Form tubes will be lowered at each end of primary panels in case of construction by alternate panel method and reinforcement cage shall then be lowered in the trench panel and suitably supported.

4.19.7.2. Reinforcement:

4.19.7.2.1. Method of Preparation - Method of preparation of reinforcement cage is as under: -

(i) Reinforcement in each panel should form a cage and the vertical ends of the cage should match with the type of joints of the panel. For ease of handing and good workmanship the cage should be made rigid. Clear distance between reinforcement bars should not be less than 100 mm for easy flow of concrete.

(ii) The length of the cage will be governed mostly by the depth of panel, and the length of rods available. The cage shall however, be built up preferably in two fabricated matching pieces but in no case in more then three pieces. Each subsequent reinforcement cage after the first cage shall be securely fastened and tack welded to the lower cage before the assembly is lowered to the trench. The steel reinforcement cages shall be clearly marked to indicate its correct orientation for proper insertion into the trench.

(iii) The gap in the main bars should not be staggered more than 50 cms to avoid difficulties in handling the cage and dropping the cage.

(iv) Suitable gaps in the reinforcement cage will be provided for accommodating the tremie required during concreting operation.

(v) The reinforcement cage will be suitably strengthened at regular intervals and generally the bars will be tack welded.

(vi) In case the reinforcement cage is heavy, angle iron frames may be utilised.

(vii) The concrete cover for reinforcement shall be maintained by the use of spacers. Circular roller cement concrete cover blocks using 1.1.1/2:3 cement concrete mix shall be provided at suitable intervals preferably one block per square meter on both sides of the cage and suitably staggered. The diameter of spacer block will depend upon clear cover required for the reinforcement.

Boxes are inserts for formation of recesses or for ground anchors shall be lowered along with the cage to correct position and levels. Circular cover blocks are considered essential to the reinforcement so that they will roll along the trench without damage and maintain adequate cover.

(viii) The hooks for lifting the reinforcement cage will preferably be of Mild steel, and diameter and number should be adequate to withstand the weight of the cage.

(ix) The reinforcement cage should be kept hanging over pretrench to provide a minimum cover of 10 mm at the bottom of trench and it shall be maintained in position during the concreting of each panel.

(x) Rock grout pipes shall be fixed with suitable spacer bars at specified intervals.

4.19.7.2.2. Jointing and splicing - Joints and splices in reinforcement shall be provided at positions shown on the approved drawing. This shall be dons as per detailed specification laid down under para 13.3.5. of Chapter 13 specifications for "Steel and iron work" The joints between main reinforcement bars, the links and other steel sections shall be properly welded with respect to design considerations and handling requirements. Welding shall be done according to relevant Indian Standard while using mild steel bars in concrete construction.

4.19.7.2.3. Reinforcement for Walls other than Structural Member - In case the diaphragm wall has not been designed as a structural member nominal reinforcement as per IS. 456 . 1978 shall be provided.

The usual provision is 16 mm dia to 20 mm dia bars at 300 mm to 325 mm centre to centre in both direction with a cover of 75 to 100 mm at faces and at ends of elements.

4.19.7.3. Concreting:

4.19.7.3.1. Concrete for the RCC diaphragm wall shall be composed of cement, sand, coarse aggregate, water and any other admixture as decided, all well mixed and brought to the consistency, Random samples from fresh concrete shall be taken as specified in IS : 1199-1959 and cubes shall be made, cured and tasted as described in IS 516 - 1959 . If required the mix should be modified to achieve the desired strength, workability, density and impermeability with maximum permissible economy. Concrete will be designated M -20, which means that 28 days cube strength will be 20 N/mm2 or 200 Kg/ cm2. The water cement ratio for concrete shall be governed by the requirement of strength, durability and workability, but it shall not be greater than 0.6.

The concrete shall be of uniform consistency and quality throughout any pour and for similar parts of the same structure. However, consistency and composition shall be such that the concrete can be worked out in all corners and angles of the forms (for cap work) and that concrete surrounds completely the reinforcement and embedded metal without causing segregation of the ingredients.

4.19.7.3.2 The control of concrete is based among other factors on maintaining a fairly uniform slump at the point of placement and holding the water cement ratio as closely as practicable to 0.6.

4.19.7.3.3. The slump should be measured in accordance with the method prescribed in IS: 1199-1959. The slump of concrete should be 150 mm to 200 mm for ensuring easy flow through for tremie pipe used in concreting.

4.19.7.3.4. The concrete mix shall be suitably designed for the required slump and ten percent extra cement added for under water work for laying concrete by other than tremie.

4.19.7.3.5. Concrete Classification:

4.19.7.3.6. Concrete classification is related to the specified 28 days compressive cube strengths and shall conform with the requirements set out in table below.

SI No.	Location	Classification	Slump
1	Concrete in R.C.C. Diaphragm walls	M. 20	150 to 200 mm
2	Concrete in R. C. C. Capping.	M 20	50 to 75 mm

Exact mix design however, shall be determined by laboratory tests.

4.19.7.3.7. A minimum of 3 tests specimens shall be made for each 120 cum. of each class of concrete. There shall be atleast 3 test specimens for one day of concreting even if only a few cubic metres of the particular concrete is manufactured in a day. Additional tests shall be carried out as and when directed.

4.19.7.3.8. The tests shall satisfy the criteria as prescribed under para 7.2 of Chapter 7 & 16.

4.19.7.3.9. Concrete materials, production of aggregate, batching, mixing, transporting and preparation for placing of concrete shall be done in accordance with the relevant paras of Chapter 7 & 16.

4.19.7.3.10 Placing and Compacting for Diaphragm Wall:

(i) The concreting shall be done by tremie pipes and the tremie diameter will be minimum 200 mm. It is preferable to use threaded tremie pipes in suitable lengths. The tremie pipes shall be clean & water tight. Depending upon the length of panels one or more tremie pipes should be used.The elliptical or oblong tremie pipe shall be used for concrete having aggregate of 20 mm and smaller . This shall be used for walls of 20 to 30 cm thickness. For walls of greater thickness a circular tremie pipe may be used.

(ii) Prior to placing concrete in any panel it should be ensured that heavily contaminated bentonite slurry has not accumulated in the bottom of trench, which can impair free flow of concrete. The contaminated bentonite slurry shall be identified by taking a sample of the slurry from near the bottom of the trench and carry out a density test on this using a mud balance. Density as measured shall not be greater than 1.25 gm/ml. Before pouring the concrete through tremie pipes, the bottom of the concreting funnel should be closed through a steel plate. The tremie should extend to the bottom of trench excavation prior to the commencement of concrete pouring and care shall be taken to ensure that bentonite slurry which may have entered the tremie is expelled from the tube during the initial charging process. After funnel is filled with concrete, the plate is removed and concrete is discharged. Thereafter concreting is done in a continuous manner upto required level. Care should be taken during placing to avoid contamination of the concrete where two or more pipes are used in the same panel. Simultaneously, care should be taken to ensure that the concrete level at each pipe is maintained.

4.19.7.3.11.For Cap Work:

(i) Before placing cap concrete extra concrete already placed during concreting of; the diaphragm walls above designed cut off level shall be removed by chiseling manually or by pneumatic tools. In case concrete below the designed cut off level is found to be inferior or contaminated not conforming to specifications, the same should also be removed until concrete of prescribed specifications is met with. Minimum 15 cms (6 inches) should preferably the removed. The chipping shall be done in such a manner as not to lossen, crack or shatter any part of the work beyond the approved levels at or below the cut-off level. The surface shall be cleaned thoroughly of all loose fragments, dirt, laitance and any other objectionable materials & shall be sound & hard in such conditions as to ensure good bond between the old and new concrete.

(ii) After the surface has been cleaned and dampened as specified, surface construction joints shall be covered wherever practicable with a layer of mortar approximately 15 mm to 20 mm. thick. The mortar shall have the same proportions of water, air entraining agent, cement and fine aggregate as the concrete mixture to be placed upon it. The water cement ratio of the mortar in place shall not exceed that of the concrete placed upon it, and the consistency of the mortar shall be suitable for being spread uniformly and worked, thoroughly into the irregularities of the surface. Concrete shall be placed immediately upon the fresh mortar.

4.19.7.3.12 As far as it is practicable, concrete shall be placed directly in its final position and shall not be caused to flow in a manner to permit or cause segregation. Methods and equipment employed in placing concrete in forms shall be such as will not result in clusters or groups of coarse aggregate being separated from the concrete mass.

Concrete shall be compacted to the maximum density; in such manner that it is free from pockets of coarse aggregates & is in intimate contact with surfaces of forms & embedded materials. Unless otherwise permitted all concrete shall be compacted by mechanical vibrator.

Compaction of concrete shall, wherever practicable be carried out by the use of adequate immersion type vibrators to be operated at speeds of at least 6,000 revolutions per minute when immersed in the concrete. Vibrators having vibrating head less than 100 mm in diameter shall be operated at speed of atleast 7,000 revolutions per minute in the concrete. Normally formwork shall be designed to provide for the insertion and operation of mechanical vibrators in the placed concrete. Form vibrators shall be used wherever internal vibration is not possible or would be inadequate.

During placing and until curing is completed, the concrete shall be protected against the harmful effects of exposure to sunlight, wind and rain, as directed.

A tension zone, close to the wall capping is created because of rigid wall. Hence 1.5 m thick clay cover over the top of concrete diaphragm wall should be provided and compacted at OMC, to act as a plastic cap to account for any deformation without under going any cracking.

4.19.8. Types of Joints:

Joints between the successive panels may be achieved in any of the different ways shown in Fig. B of PLATE: 9/CH-4*. In case of alternate panel method two stop end tubes are used at the ends of the primary panels to form suitable joints with secondary panels.

4.19.9. Wall of Precast RCC Panels:

The trench panels shall be made in the ground using normal machines or grabs. The trench shall be kept filled up with self-setting bentonite slurry. Specially designed precast RCC panels with provision for suitable jointing shall be lowered in the trench with help of crane. The panels shall be supported in the trench by using special supports.

Inside face of panels before lowering them into the trench shall be treated with specified compound.

The self-setting bentonite slurry shall be slow setting & should develop adequate strength & impermeability.

The precast panels used in the process shall provide an aesthetically pleasing surface of wall on excavation of soil. The quality of concrete in PRECAST RCC panels should be better than that achieved by tremie concrete method.

4.19.10. Grout Cut- off Walls:

4.19.10.1. Where structural strength is not required the self-setting, bentonite slurry may be used to provide an impermeable cut - off wall.

4.19.10.2. When so specified suitably designed clay concrete, or sand bentonite cement mix may be used for diaphragm walls, which are primarily meant as impermeable cut- offs.

***For figures see specifications published by E- in - C.**

4.19.11. Tolerances:

4.19.11.1. Guide walls - The finished faces of the guide walls towards the trench shall be vertical, there shall be no ridges or abrupt changes on the face of the guide wall. Variation from a straight line or a specified profile shall no exceed 25 mm in 3 mm.

4.19.11.2. Diaphragm Wall:

4.19.11.2.1. Verticality - The face of the wall and ends of the panel to be exposed shall be vertical within a tolerance of 1:80.

4.19.11.2.2. The effective trimmed final wall levels shall normally be taken as 250 mm below the top of guide wall when concrete is cast to the top of the trench. If water table is high and if required cut off is low and water table is also at depth, small concreting can be stopped at lower level. For trimmed final wall levels below this level, the vertical tolerance in profile of concrete cast shall be between 150 - 500 mm above the specified wall levels.

4.19.11.2.3. Where recesses are formed in walls, these shall be positioned within a vertical and horizontal tolerance of 150 mm.

4.19.11.2.4. In positioning of reinforcement, longitudinal tolerance of cage head at top of the guide wall measured along the trench shall be 75 mm and vertical tolerance at cage head in relation to top of guide wall shall be 50 mm.

4.19.12. Rock Grouting under the Diaphragm:

4.19.12.1. Specification for this work shall be as per Chapter 22.

4.19.12.1.1. 50 to 75 mm diameter pipes shall be embedded in the diaphragm wall at specified intervals. These pipes will be welded to the diaphragm wall reinforcement before it is lowered into position. This is done to avoid drilling through diaphragm wall concrete and reinforcement.

4.19.12.1.2. After the panel is completed drilling in rock will be done with pneumatic equipment.

4.19.12.1.3. After drilling for a depth of 2 metres in rock, the hole will be washed with water and water tested to find the water loss in " Lugeon " value. Normally the pressure is increased in steps of 1 Kg/cm^2 to the maximum grout pressure allowed for the particular position. While decreasing the pressure 2 to 3 readings will also be taken. This procedure will help to observe the flow in the particular rock media (laminar or turbulent.)

4.19.12.1.4. Generally the packer assembly with opening at the bottom and normally fitted with 2 numbers of cup type leather washers, will be lowered to the desired depth in the hole and water will be pumped at the required pressure. The duration of the test at any particular packer position at a particular pressure will be about 5 minutes. After noticing the flow in the media, the test at the particular packer position will be considered as completed.

A graph will be drawn showing the absorption of water in litres/ minute on abscissa and pressure on the ordinate scale .The Lugeon value is calculated by finding the absorption at 10 kg/cm^2 either by interpolation or extrapolation, per metre of the strata being tested for permeability.

4.19.12.1.5. In case of fine fissures neat cement grout will be used for rock grouting. However, if the fissures are bigger having a high lugeon value a stable grout consisting of cement bentonite and sodium silicate will be used. Bentonite in the mix will increase the injectability of cement in the rock fissures. Whereas sodium silicate will decrease its setting time and will avoid long travel of grout. This type of stable grout will be used only if it is found that consumption of neat cement grout is quite heavy and refusal pressures are not obtained even after continuous grouting for a long time .The type of mix will be decided only after conducting some trial eats at the site.

The pressure, which will be generally allowed for grouting will be as follows: -

1 PSI: For every foot of rock above the packer.

75 PSI: For every foot of overburden above rock

The grouting in rock will be done in suitable descending stages as directed by Engineer - in - charge. Criteria for the curtain grouting shall be as stated in para 3.6 & 3.6.1 of IS: 6066 -1971. **"Grouting of Rock Foundation in River Valley Projects".**

4.19.12.2. Grouting under the Diaphragm wall joints by Tube - A Manchette Method.

4.19.12.2.1. In order to prevent any leakage of water from the joints between the 2 panels of the diaphragm wall the area near the diaphragm wall joints will be grouted.

4.19.12.2.2. Boring in over- burden will be done by rotary- cum- percussion drilling equipment using the mud circulation process.

4.19.12.2.3. A manchette pipe will be lowered in the boreholes, this tube (A manchette pipe) consists of 1 - $^1/_2$" M .S. Pipe having openings at equal intervals (4 Nos. radial perforations every 33 cms) covered by rubber sleeve which acts as a one way valve.

4.19.12.2.4. The space between the borehole sides and the Tube -A Manchette' will be filled with plastic sheath grout, which after setting will seal the tube. A manchette with the grout and will prevent upward leakage. The grout will consist of bentonite, cement and water and is so designed that it is neither too hard nor too soft .The strength of the sheath grout after setting will be such that it will be punctured when the grouting starts but it will not be soft enough to allow upward leakage along the tube 'A' Manchette pipe.

4.19.12.2.5. Generally a coarse grout of cement, bentonite mix will be grouted through the Manchette pipes in the first stage. Chemicals, such as sodium silicate and monosodium phosphate may have to be used along with bentonite in the second stage. The first stage will be grouted at least to a pressure of 4 to 5 kg/ cm^2, whereas higher pressures can be allowed in the second stage grouting.

4.19.12.2.6. All necessary steps should be taken to ensure that the panel joints are grouted to required efficiency as may be prescribed by the Engineer - in- charge and also to the extent that grouting of sand between the two walls is not necessary.

4.19.13. Permeability Test For Concrete of the Diaphragm Wall:

4.19.13.1. In order to observe the permeability of the concrete in the diaphragm 50 to 75 mm diameter pipes will be provided at different levels in the diaphragm wall before concreting of the panel.

4.19.13.1.1. Drilling with appropriate size as may be decided by the Engineer - in-charge will be done through these pipes for a depth of 3 cms to 60 cms below the bottom of the pipe.

4.19.13.1.2. The test will be conducted by using " Le France's point permeability falling head method". The pressure corresponding to differential hydrostatic head when the work is completed can be applied while carrying out this test by using compressed air.

4.19.13.1.3. The computed permeability of the diaphragm concrete shall not be greater than 30 cm per year at pressure equivalent to a hydrostatic head of 40 metres.

4.19.14. Inspection of Works:

4.19.14.1 Test wells (inspection chambers) preferably of 3 m width x 2.5 m depth shall be constructed at suitable intervals as approved by the Engineer - in - charge to control workmanship quality and tolerance of the diaphragm wall. Adequate safety precautions shall be taken in construction and operation of these walls.

4.19.15. Testing Efficiency of Diaphragm Wall:

4.19.15.1 Efficiency of the diaphragm wall shall be tested by observing leakage through the diaphragm wall 'V' notches or other measuring devices shall be installed on the down stream wall and seepage measured all round the year.

APPENDIX - 1

CRITERIA FOR CONTROL OF COMPACTED DAM EMBANKMENT

Type of Material	Percentage of No. +4 fraction by dry weight of total material	Percentages based on minus No. 4 fraction					
		50 feet or less in height			Greater than50 feet height		
		Minimum acceptable density	Desirable average density	Moisture limits Wo - Wf	Minimum acceptable density	Desirable average density	Moisture limits Wo - Wf
1	2	3	4	5	6	7	8
Cohesive	0-25	D = 95	D = 98	-2 to +2	D = 98	D =100	2 to 0 (Note 2)
Soil	26-50	D=92.5	D = 95		D = 95	D = 98	
Controlled by The Proctor test	More than 50 (Note 1)	D = 90	D = 93		D = 93	D = 95	
Cohesionless	Fine sands with 0-25	Dd = 75	Dd = 90	Soils should Be very wet	Dd = 75	Dd = 90	Soils should Be very wet
Soils	Medium Sands with 0-25	Dd = 70	Dd = 85		Dd = 70	Dd = 85	
Controlled by the relative density test	Coarse sands and with 0-100 gravels	Dd = 65	Dd = 80		Dd = 65	Dd = 80	

Where -

Wo -Wf .... is the difference between optimum water content and fill water content in percent of dry weight of soil.

D .... is fill dry density divided by Proctor maximum dry density in percent .

Dd .... is relative density.

NOTES:

1 Cohesive soils containing more than 50 percent gravel sizes should be tested for permeability of the total material if used as a water barrier.

2 For high earth dams special instruction on placement moisture limits will ordinarily be prepared.

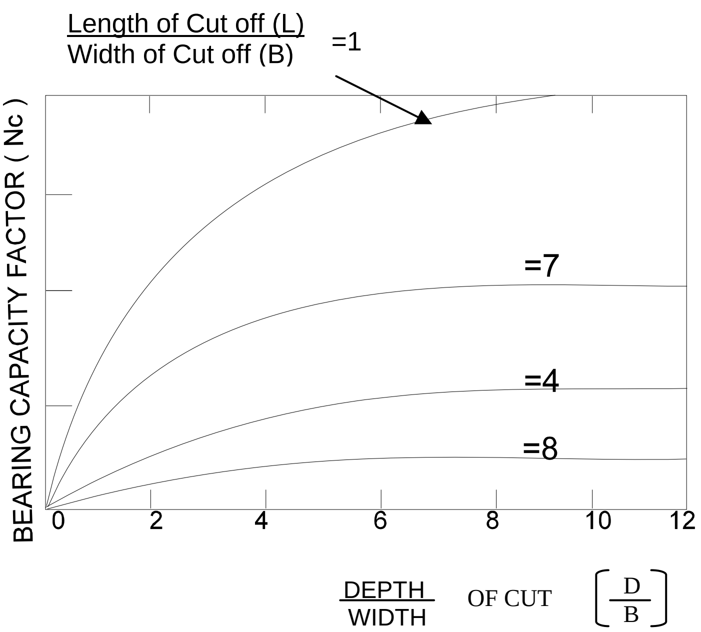
APPENDIX - II
[Para 4.19 A (vi)]
STABILITY OF SLURRY FILLED TRENCHES

The bentonite slurry filled in the trench imparts stability by mainly applying hydrostatic pressure on the wall, against the impermeable thin film formed along the wall. Secondly, The slurry filled in the trench provides passive resistance against failure of the trench, and thirdly, the shearing resistance of the slurry saturated zone and the plastering effects of the filter cake formed also contribute towards trench stability. The hydrostatic pressure along represents 65 to 80 percent of the total stabilizing forces. If the density of slurry used is such that it can provide a factor of safety of one due to hydrostatic pressure, then factor of safety of the actual trench shall be between 1.25 to 1.50. Therefore, taking only hydrostatic pressure and considering F = 1, the density of slurry may be calculated as indicated by the following formula. This formula should be used as a guide only.

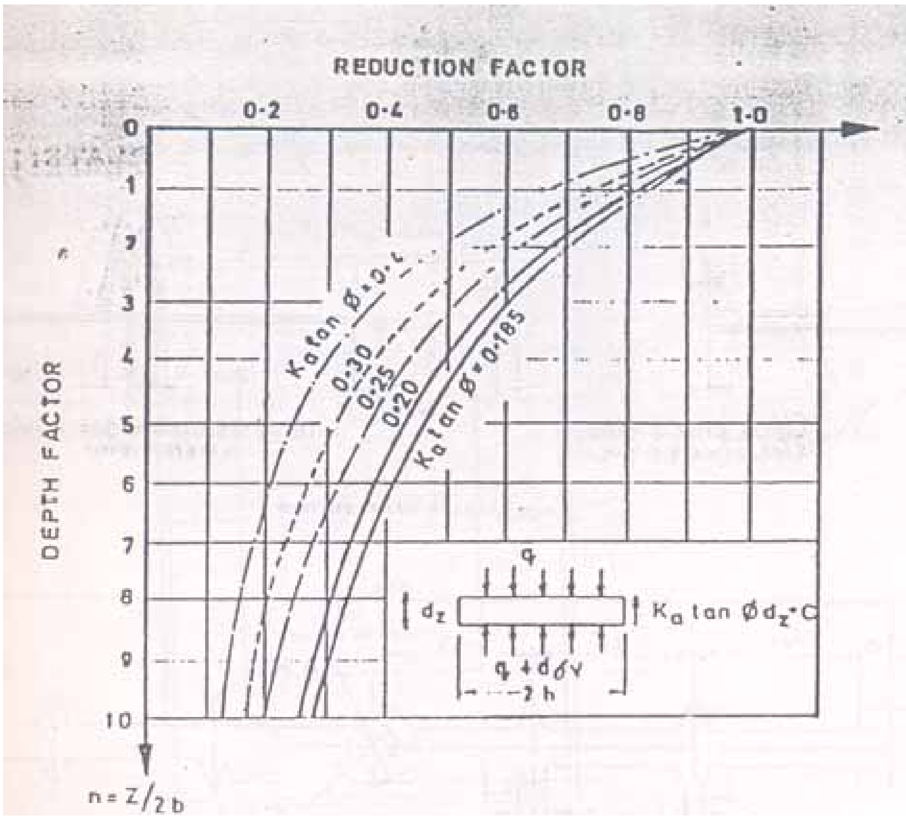
$$F = \frac{Nc\ Cu}{H(Y-Ys)}$$

Where -

H	=	depth of the trench,
Cu	=	undrained shear strength of clayey soil,
Y	=	natural density of saturated soil,
Ys	=	density of the slurry needed for the trench, and
Nc	=	bearing capacity factor which varies from 4 at the ground surface to 8 for deeper depths, depending upon D/B and L/B ratio of the trench. This factor accounts for arching action in horizontal as well as vertical directions - see figures below.



Stability Factor Nc for Rectangular Cuts in Clay (II)



Reduction Factor A for Earth Pressure in Trench of Length 2b (cd = O)

For sandy soils

Ys - YW + A (KaY)

Where,

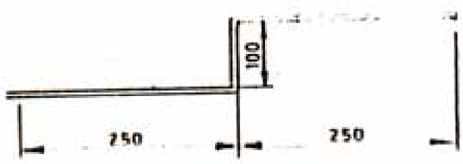
$$A = \frac{1-e^{-2n\,Ka\tan Ø}}{2n\,Ka\,\tan Ø}$$

Ka	=	$\tan^2 (45^0 - Ø/2)$
Y	=	effective unit weight of the sandy soil.
	=	Submerged weight - weight of water
	=	Y sat - Yw

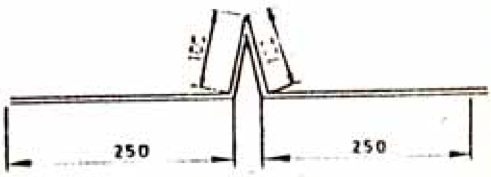
The value of A depends upon $n = \frac{\text{depth}}{\text{length}}$ ratio of the trench (see fig. above)

As a general rule, level of bentonite slurry in the trench shall be minimum 1.5m higher than the water level.

PLATE: 1/CH-4



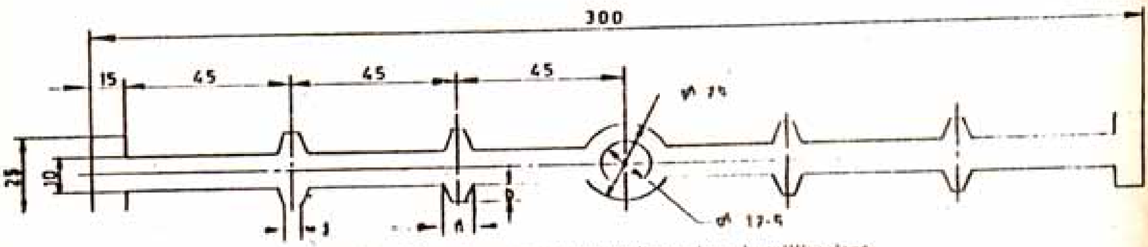
1A DETAILS OF Z-SHAPE METAL WATER STOP



1B DETAILS OF M-SHAPE METAL WATER STOP

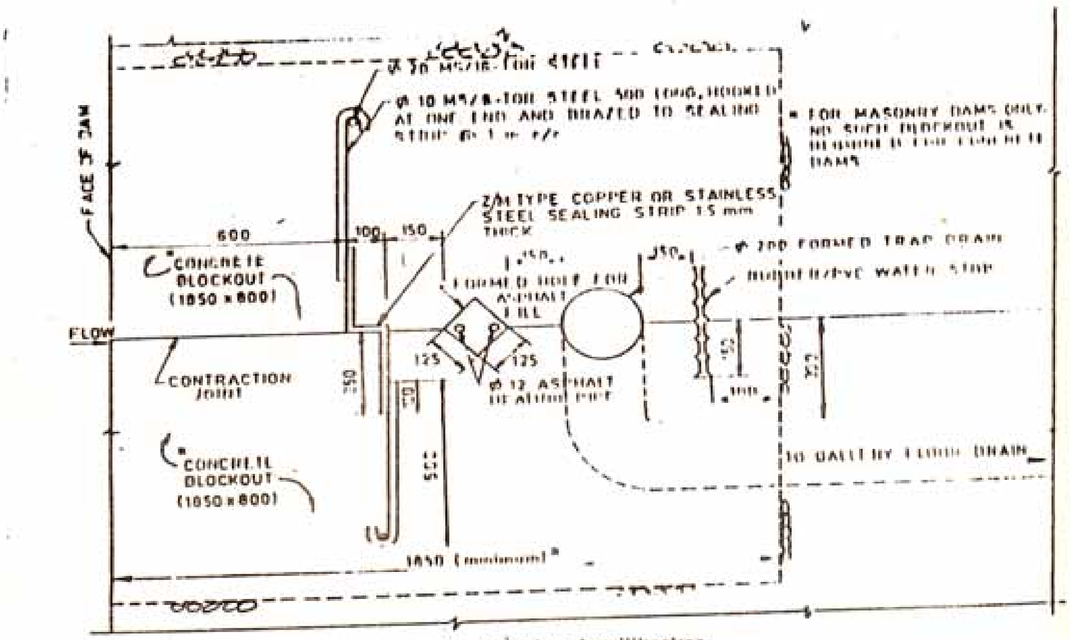
All dimensions in millimetres.

FIG. A METAL WATERSTOPS



Note — The above are minimum dimensions in millimetres.

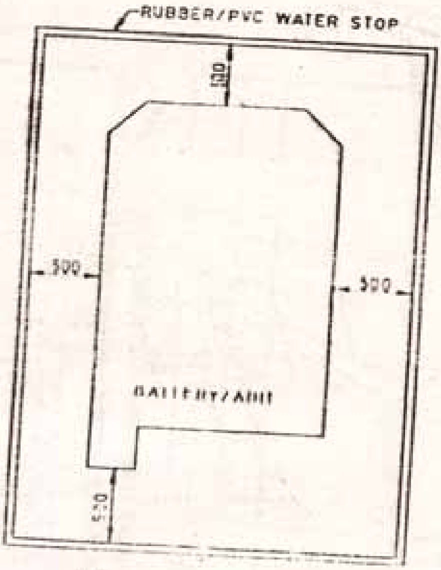
FIG. B DETAILS OF RUBBR/PVC WATERSTOPS



All dimensions in millimetres.

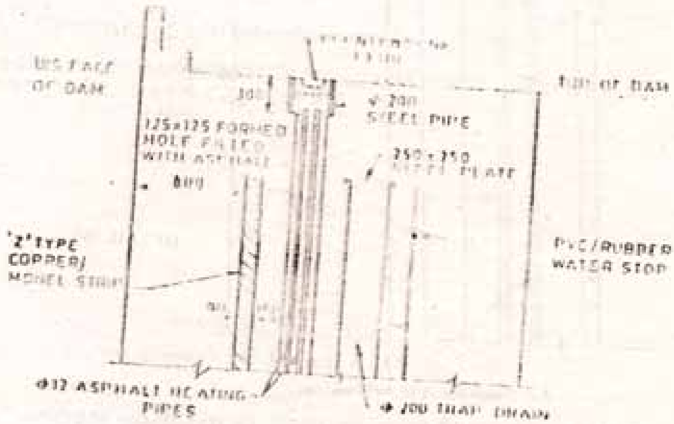
FIG. C SECTIONAL PLAN AT CONTRACTION JOINT [DOWEL BARS BETWEEN CONCRETE MASONRY FACE OF THE BLOCKOUT NOT SHOWN (*See Clause 7.5*)]

PLATE 2 /CH-4



All dimensions in millimetres.

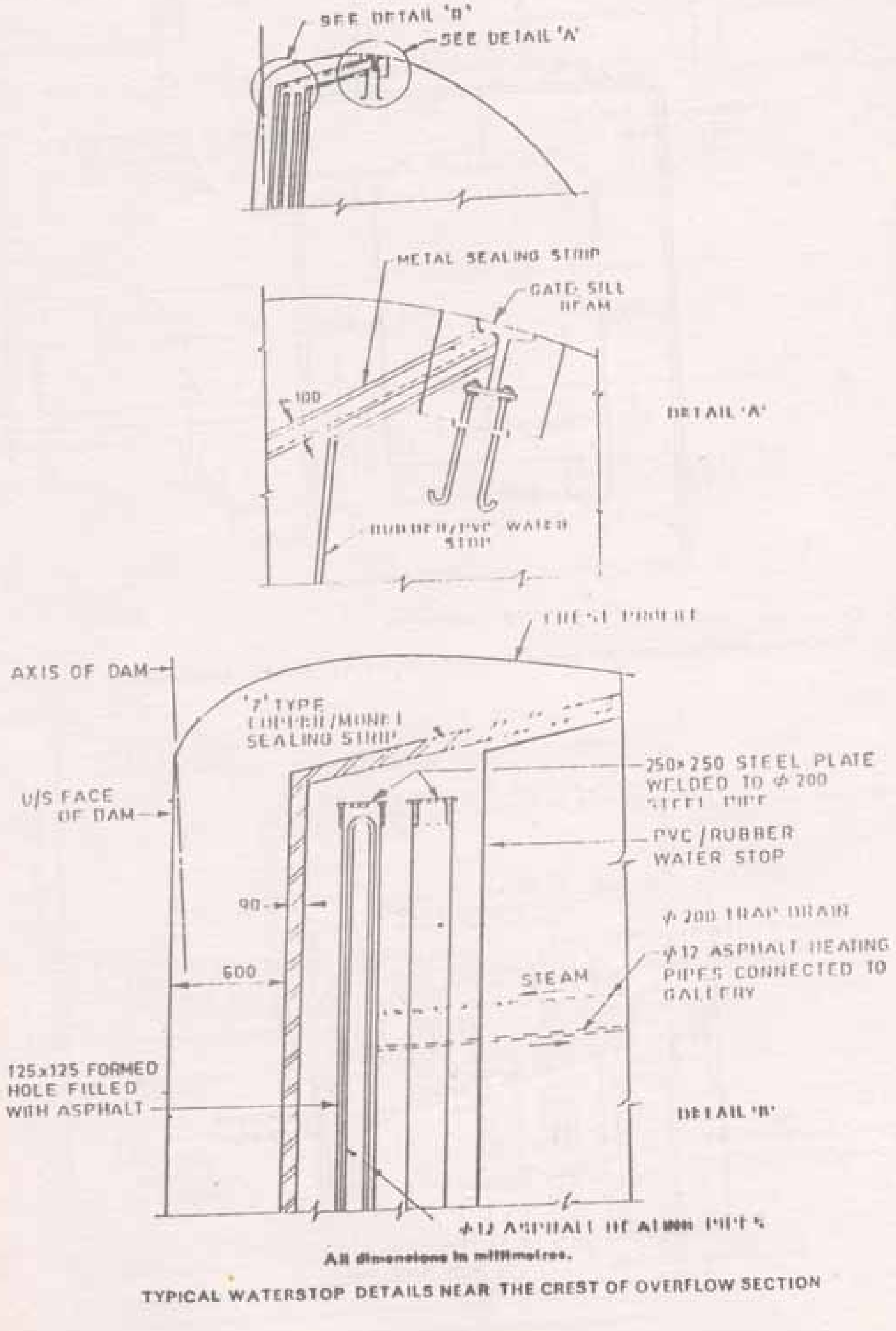
FIG. A RUBBER/PVC WATERSTOP AROUND GALLERY/ADIT AT CONTRACTION JOINTS



All dimensions in millimetres

FIG. B TYPICAL WATERSTOP DETAILS NEAR THE TOP OF NON-OVERFLOW SECTION OF DAM

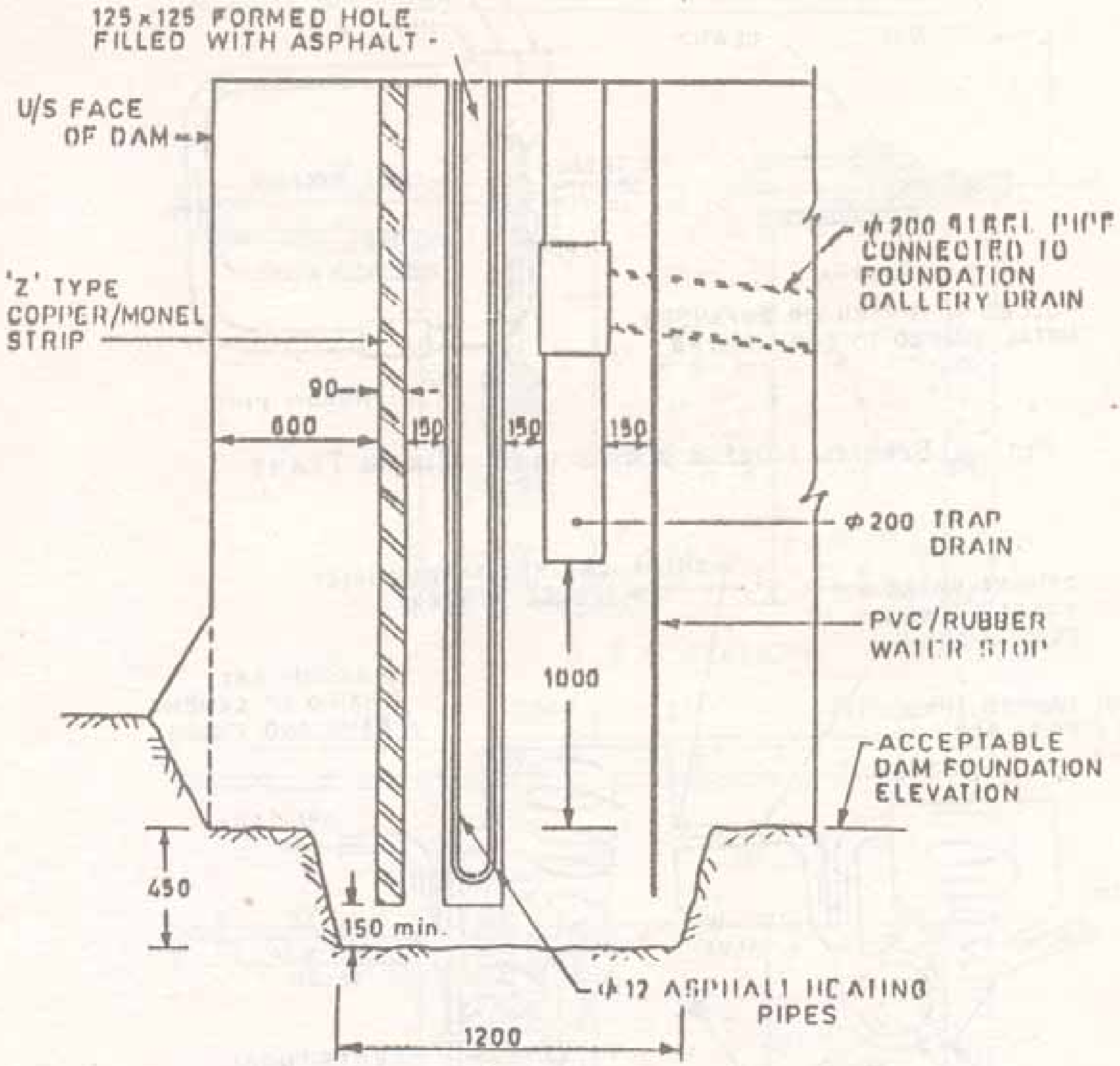
PLATE:3/CH-4



All dimensions in millimetres.

TYPICAL WATERSTOP DETAILS NEAR THE CREST OF OVERFLOW SECTION

PLATE: 4/CH-4



All dimensions in millimetres.

YPICAL WATERSTOP DETAILS NEAR BOTTOM OF DAM

PLATE: 5/CH-4

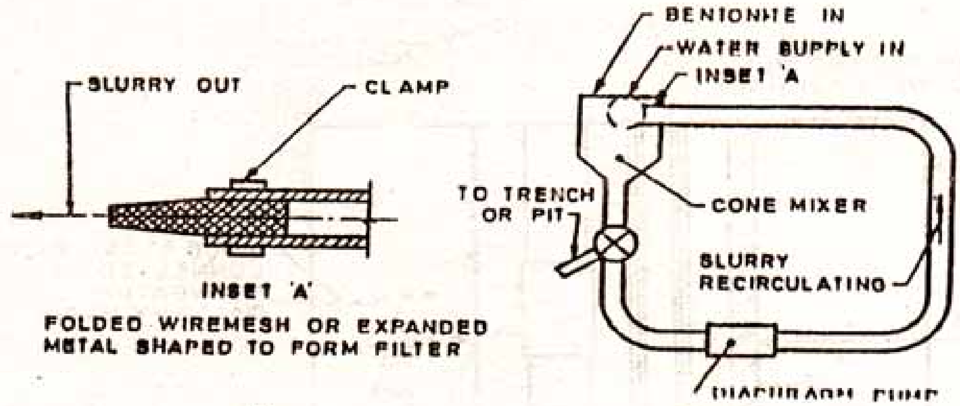


FIG. A SPECIAL NOZZLE AND SLURRY MIXING PLANT

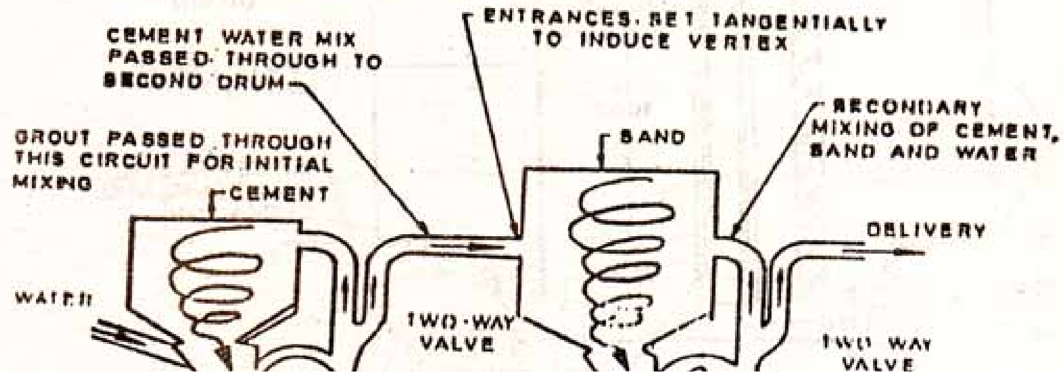
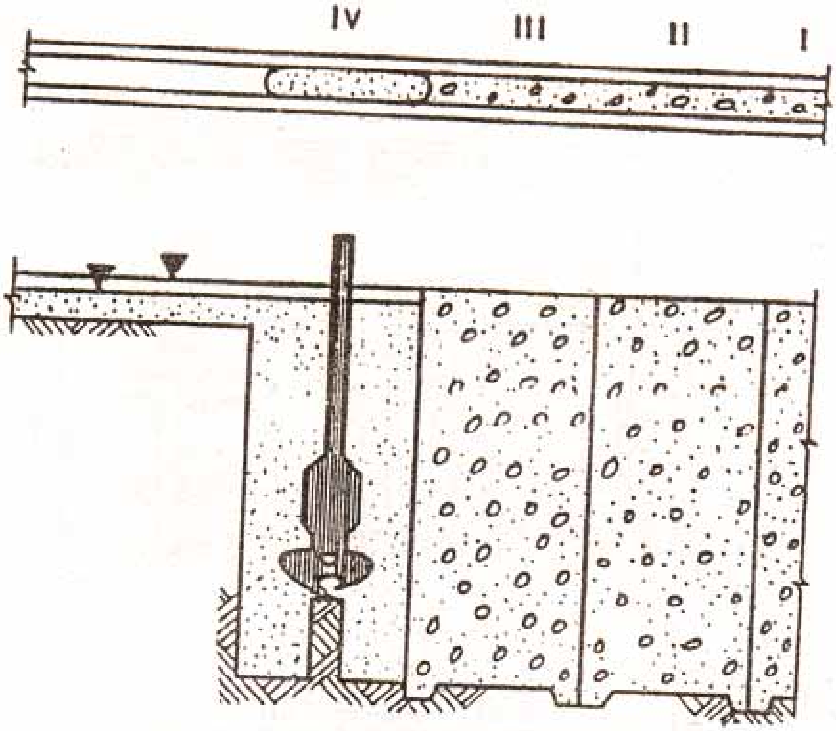
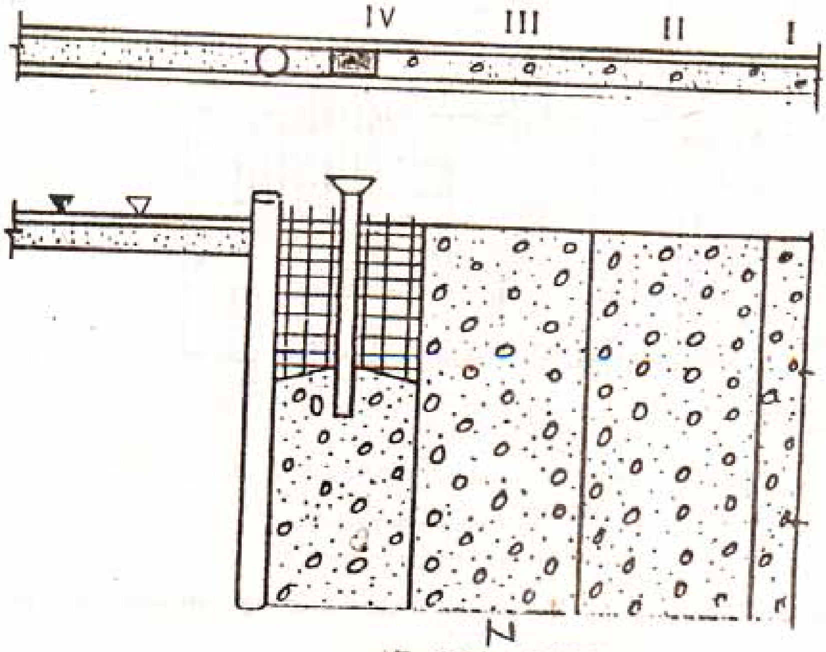


PLATE: 6/CH-4



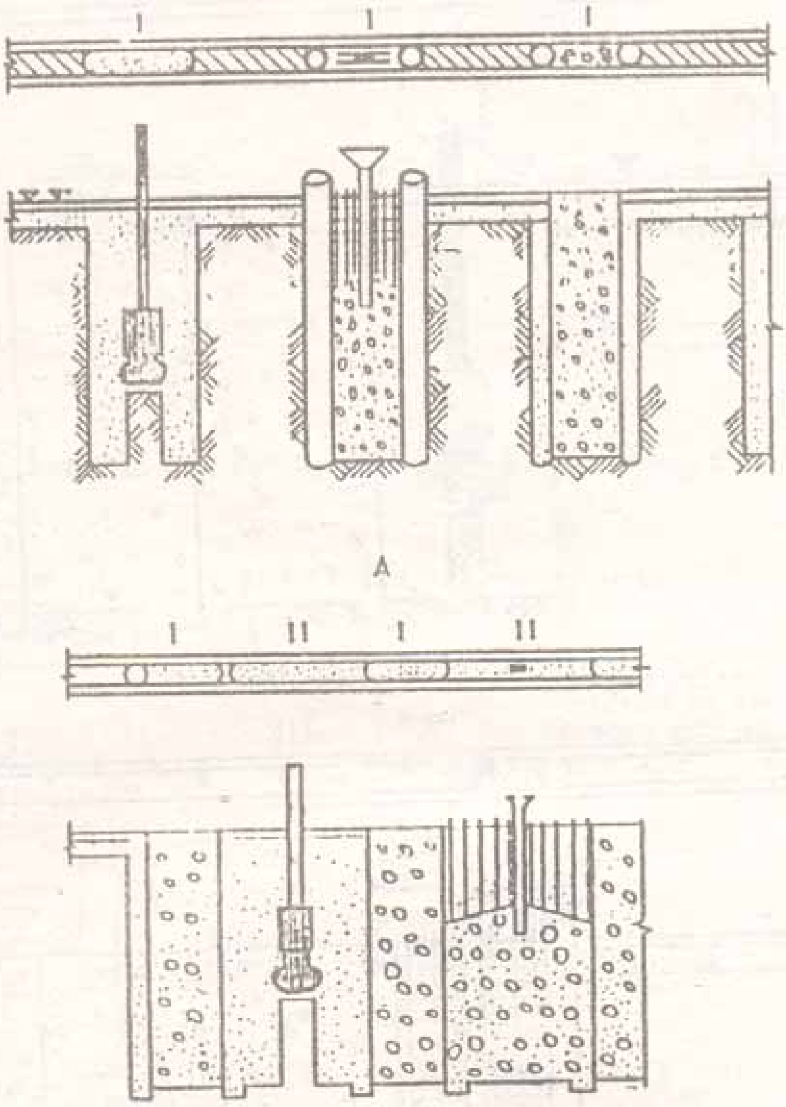
A EXCAVATION



B COLCRETING

SUCCESSIVE PANEL CONSTRUCTION (EXCAVATION AND CONCRETING)

PLATE:7 /CH-4



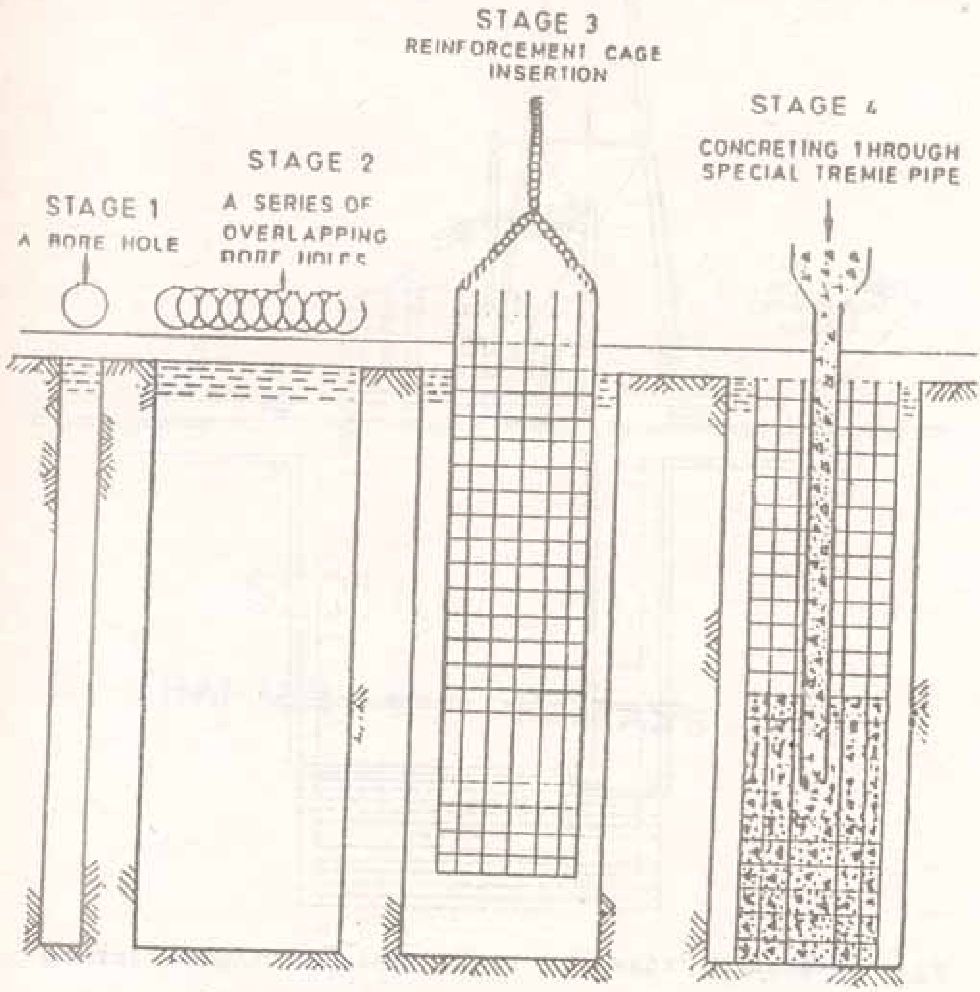
I — Primary panels

II — Secondary panels

NOTE — Due to space left by stop end tubes primary and secondary panels are of different sizes and panel end shape.

CONSTRUCTION OF PANELS

PLATE: 8/ CH-4



STAGES OF DIAPHRAGM WALL CONSTRUCTION BY DIRECT CIRCULATION METHOD

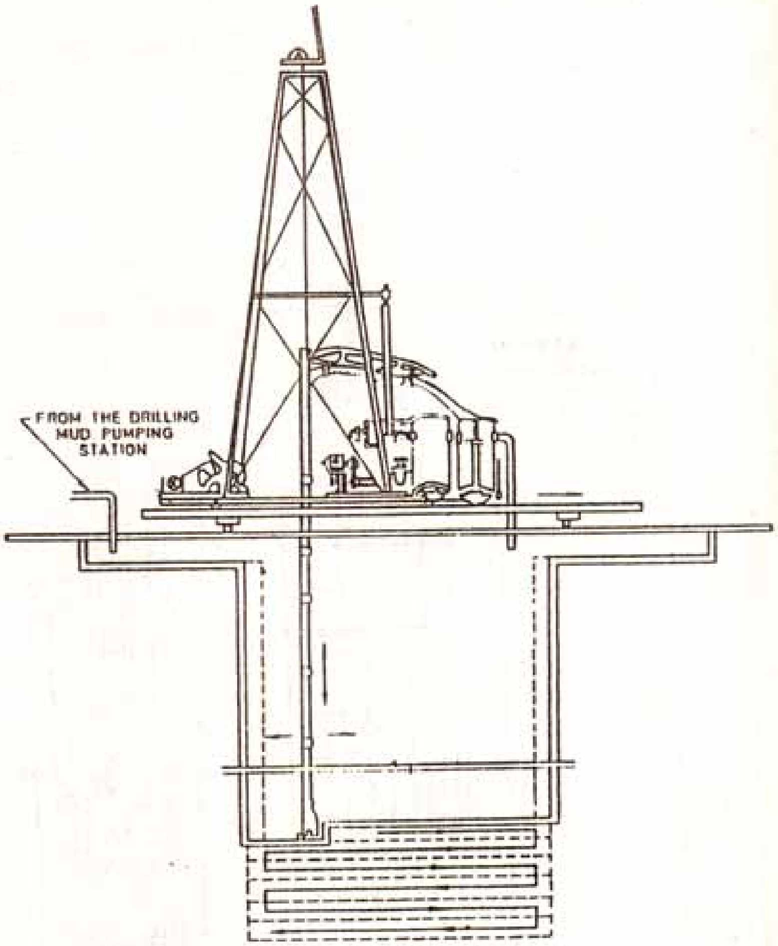


Fig A TRENCH EXCAVATION BY REVERSE CIRCULATION METHOD

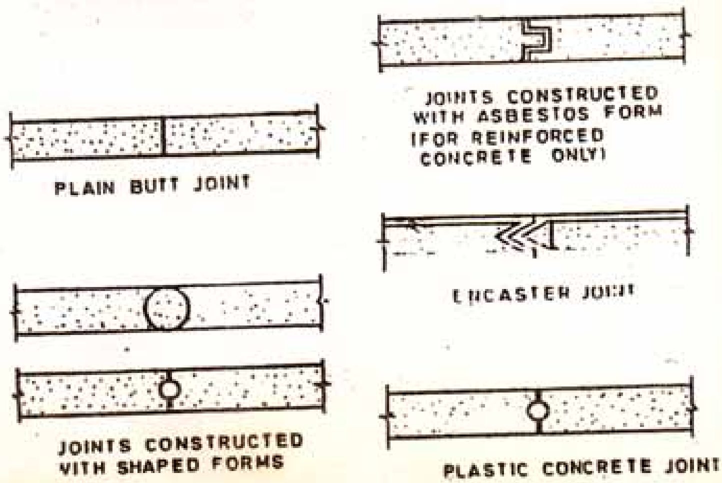


Fig B DIFFERENT TYPE OF JOINTS

SECTION – III

MORTARS

CHAPTER – 6 MORTARS

CONTENTS

CHAPTER 6 MORTARS

6.1 REFERENCES

IS: 269 – 1989	Ordinary Portland cement, 33 Grade (fourth revision)
IS: 455 – 1979	Portland stag cement (third revision) (with Amendment Nos. 1 to 6)
IS: 4 – 1978	Plain and reinforced concrete (third revision)
IS: 457 – 1957	General constructions of plain and reinforced concrete for dams and other massive structures.
IS:460(Pt.I&II)– 1984	Test sieves (third revision)
IS: 712 – 1984	Building limes (third revision)
IS. 1290 – 1973	Mineral gypsum (second revision)
IS: 1344 – 1981	Calcimined clay pozzolana (second revision)(with Amendment Nos. 1 to 6)
IS: 1489 – 1976	Portland Pozzolana cement (second revision)
IS: 1514 – 1959	Methods of sampling and test for quick lime and hydrated lime (Reaffirmed 1978)
IS: 1635 – 1975	Field slaking of building lime and preparation of putty (first revision)
IS: 1727 – 1967	Methods of test for pozzolanic materials (first revision)
IS: 2116 – 1980	Send for masonry mortars (first revision) (reaffirmed 1987)
IS: 2250 – 1981	Preparation and use of masonry mortar (first revisoin)
IS: 2386 – Pt. 1to VIII) – 1963	Methods of test for aggregates for concrete .
IS: 3466 – 1988	Masonry cement (second revision)
IS: 4082 – 1977	Stacking and storage of construction material at site (first revision)

IS: 4098 – 1983	Lime pozzolana mixture (first revision) (with Amendment No.1)
IS: 5512 – 1969	Flow table for use in tests of hydraulic cements and pozzolonic materials
IS: 6508 – 1988	Glossary of terms relating to building limes (first revision)
IS: 6932 – Pt.1 to 10) -1973	Methods of test for building limes
IS: 7969 – (Pt.11) - 1984	Methods of test for building limes
IS: 7969 – 1975	Handling and storage of building materials (Reaffirmed1987)
IS: 8041–1978	Rapid hardening Portland cement (first revision) With Amendments Nos. 1to 3)
IS: 9103 - 1979	Admixtures for concrete
	Engineer – in – Chief , irrigation Department publication No.21
	Specifications – 77 of " Central Public Works Department "
	Standard Specifications –77of " National Building Organization

6.2 TERMINOLOGY

Admixture- A material other than water, aggregates, and hydraulic cement, used as an ingredient of concrete or mortar and added to the batch immediately before or during its mixing to modify one or more of the properties of concrete in the plastic or hardened state.

Air-Entraining Admixture – An admixture for concrete or mortar which causes air to be incorporated in the form of minute bubbles in the concrete or mortar during mixing, usually to increase workability and resistance to freezing and thawing and disruptive action of de-icing salts.

Composite Mortar - A mortar containing cement and lime in addition to other ingredients.

Consistency – The working consistency of a mortar or plastering mix as judged by the worker from its behavior during application its assessment includes characteristics, such as initial fluidity, water retentively, etc.

Granulated Slag – Slag in granulated form is used for the manufacture of hydraulic cement. Slag is a non-metalic product consisting, essentially of glass containing silicates and alumino silicates of lime and other bases, in the case of blast furnace slag which is developed simultaneously with iron and blast furnace or electric pig iron furnace. Granulated slag is obtained by further processing a molten slag by rapidly chilling or quenching it with water or steam and air.

Hardening - The physio-chemical changes observed in a mortar due to the effect of one or more of the following phenomena :-

(a) Absorption of carbon.
(b) Recrystallization, and
(c) Chemical reactin.

Lime - A general term which includes the various chemical and physical forms or quick lime hydrated lime and hydraulic lime commonly obtained by calcination or calcination and hydration from one or other calcarious materials.

Building Lime - A lime whose chemical and physical characteristics and methods of processing make it suitable for construction purposes. Also known as “Construction lime”.

Eminently Hydraulic Lime - Lime containing some quantities of silica and alumina (and / or iron oxide) which are in chemical combination with some of the calcium oxide content. This gives a putty or mortar which has the property of setting and hardening under water.

Fat Lime - Connotes a pure non-hydraulic lime. It may be in quick hydrated or putty form.

Hydrated Lime – A dry powder obtained by treating quick lime with water enough to satisfy its chemical affinity for water under the condition of its hydration.

Hydraulic Lime – Lime containing small quantities of silica and alumina (with or without iron oxide) which are in chemical combination with some of the calcium oxide content giving a putty or mortar which has property of setting and hardening under water.

Kankar lime – The calcinate of Kankar. It may be hydraulic or semi-hydraulic in nature. Kankar is the impure earthy stone rich in concretious and nodules of calcium carbonate.

Lime Putty – A wet plastic paste consisting of hydrated lime and fee water.

Lime Slurry – A suspension of hydrated lime in considerable amount of fee water with a consistency similar to cream.

Milk of Lime – A suspension of lime in a large amount of water with a consistency similar to milk.

Magnesium Lime – Lime obtained from magnesium and dolomitic lime stones or dolostones which may contain more than 5 percent magnesium oxide (ignited basis).

Semi-hydraulic Lime – Lime containing small quantities of silica (with or without iron oxide) which are in chemical combination with some of the calcium oxide content, and therefore shows the property of setting and hardening under water. This is intermediate in composition between eminently hydraulic and fat limes.

Slaking – Slaking usually means addition of the requisite amount of water to quick lime so as to form dry slaked lime putty or slurry.

Unslaked Lime (Quick lime) – A calcined material, the major part of which is calcium oxide or calcium oxide in natural association with a lesser amount of magnesium oxide, capable of slaking with water.

Popping and Pitting – A type of unsoundness caused by particles of unhydrated or incompletely hydrated lime which hydrate and expand at some period subsequent to actual use. It manifests itself in the form of craters or blisters on plaster surfaces.

Portland Clinker – Clinker consisting mostly of fusion – a predetermined and homogeneous mixture of materials principally containing lime (CaO) and silica (SiO2) with a smaller proportion of alumina (Al2)3) and iron oxide (Fe2O3).

Portland Slag Cement – An intimately inter ground mixture of portland cement clinker and granulated slag with addition of gypsum and permitted additives or an intimate and uniform blend of portland cement and finely ground granulated slag.

Pozzolana – An essentially silicious material which while in itself possesing no cementitious properties will, in finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.

Calcined Clay Pozzolana – The calcined clay pozzolana is a reactive pozzolanic material manufactured under controlled conditions by cancellation of clay at suitable temperature and grinding the resulting product to the required fineness. This material can be used for manufacture of portland pozzolana cement for blending with hydrated lime to produce ready to use lime pozzolana mixture, and for part replacement of cement in unblended cement mortar and concrete and for use as an admixture.

Sand – A fine aggregate which is either natural sand or crushed stone sand or crushed gravel sand.

Crushed Gravel Sand – Fine aggregates produced by crushing natural gravel.

Crushed Stone Sand – Fine aggregates produced by crushing hared stone.

Natural Sand – Fine aggregates resulting from the natural disintegration of rock and which have been deposited by streams or glacial agencies.

Water Retentivity - The ability or mortars to retain water against suction and evaporatin in general. It is indirectly a measure of the workability or mortars. It is measured by the flow of mortar when tested on a standard flow before and after application of a specified suction.

6.3 MATERIALS

6.3.1 Cement

6.3.1.1 General – Unless otherwise specified cement shall conform to any of the Indian Standards, IS : 269 – 1989, IS : 455 – 1976, IS : 1489-1976, IS : 3466 – 1988, IS : 8041 – 1978 and IS : 8112 – 1976 (amended from time to time).

6.3.1.2. Stacking and Storage – As far as practicable no consignment of cement shall be received and transported during the monsoon period.

Cement shall be stored in dry and waterproof sheds and on a platform raised about 20 cm above ground level, and about 30 cm clear off the walls. Cement bags shall be stacked in such a manner as to facilitate their removal and use in the order in which they are received. When removing bags for use, apply the “First in first out” rule, that is take the oldest cement out first. For this purpose each consignment as it comes in shall be stacked separately and play cared bearing the date of arrival shall be pinned into the pile. Each consignment of cement shall also be stacked separately therein to permit easy access for inspection and facilitate removal. Cement bags shall not be stacked more than 12 bags high to avoid lumping up under pressure.

Cement shall be stored at the work site in such a manner as to prevent deterioration due to moisture. The number of bags shall be kept to a minimum preferably just sufficient for the day’s consumption. This manner of temporary storage shall not be adopted in wet weather.

Handling and storage facilities shall be such that no cement is stored before use for more than 120 days counted from the date of dispatch by the manufacturer. Cement stored beyond 120 days but not exceeding 180 days shall be tested and rejected if found defective in any way. Cement stored beyond 120 days shall not be used for dams and that beyond 180 days shall not be used for structural members and hydraulic strictures.

6.3.2 **Building Lime -** Lime shall conform to IS : 712 - 1984

6.3.2.1. **Classification –** Building lime shall be classified as follows :

Class – A Eminently hydraulic lime used for structural purposes.

Class – B Semi-hydraulic lime used for masonry mortars, lime concrete and plaster undercoat.

Class – C Fat lime used for finishing coat in plastering, white-washing, composite mortars, etc. and with addition of pozzolanic materials for masonry mortar.

Class – D Magnesium / Dolomitic lime used for finishing coat in plastering, whitewashing, etc.

Class – E Kankar lime used for masonry mortars.

Class – F Siliceous dolomitic lime used for under coat and finishing coat of plaster.

Note 1. Lime shall be available either in hydrated or quick form, except that of Class A and E which shall be supplied in hydrated form.

Note 2. Applications indicated are only suggestive.

6.3.2.2 Chemical requirements of building lime shall be as given in Table 1 of IS : 712-1984.

6.3.2.3 Physical requirements of building lime shall be as given in Table 2 of IS:712-1984.

6.3.2.4 **Supply and Storage -** The lime packages shall bear the type and class of lime, brand, name of manufacturer, date of manufacture and the net weight, in case of quick lime the slaking temperature shall also be indicated.

6.3.2.4.1 **Hydrated Lime –** Hydrated lime shall be supplied in suitable containers such as jute bags lined with polythene or HDPE woven bags lined with polythene or craft paper bags, preferably containing 50 kg of lime. It shall be stored in a building to protect the lime from dampness and to minimise warehouse deterioration.

6.3.2.4.2 **Quick Lime Before Slaking –** Quick lime shall be supplied in containers like metal container or similar suitable containers preferably containing 50kg of lime. Quick lime deteriorates rapidly on exposure by taking up moisture and carbon dioxide from atmosphere. It shall be slaked as soon as possible before deterioration sets in. If unavoidable, it may be stored in compact heaps having only the minimum of exposed area. The heaps shall be stored a suitable platform and covered to avoid direct contact with rain or being blown away by wind. In case quick lime is stored in a covered shed, a minimum space of 300mm shall be provided around the heaps to avoid bulging of walls. Unslaked lime shall be stored in a place inaccessible to water and because of the fire hazard shall be segregated from the combustible materials.

6.3.2.4.3. **Dry Slaked Lime –** If the lime is to be used within a few days it may be stored on a platform suitably covered for protection from rain and wind. If it is required to be stored for a longer period not exceeding 2 months it may be kept in a dry and closed godown.

6.3.2.4.4 **Putty –** The lime putty shall be stored under water. The putty of class C and D lime may be stored up to 15 days and putty of Class B and E lime shall be used as soon as after preparation.

6.3.2.5 Slaking Quick lime and Preparation of Putty

6.3.2.5.1 Preliminary Cleaning – The slacking receptacle or platform shall first be cleaned of all unslaked stones of lime and other materials left over from previous slaking.

6.3.2.5.2 Slaking Procedure – The slaking shall be done either in tanks by adding 'lime to water' or on platform by adding 'water to lime' as described below :

Tank Slaking – This method directly results in lime putty and is thus suitable when the product is required in this from. The tank shall be water tight and large enough to permit stirring of the mix. Its sides and bottom shall be lined with a material which is not attacked by lime. Brick lining is recommended. For providing continuous slaking operation, two tanks may be used, one 40 cm deep at a higher level above ground and the other about 75 cm deep at a lower level below ground. The slaking of the quick lime is done continuously in the higher tank and the resultant milk of lime allowed to flow, through a sieve if desired, into the lower tank where it will settle and mature into putty. To obtain a continuous supply of putty, two tanks instead of one may be provided at the lower level and used alternately so that when putty is being used from one, fresh putty may be formed in the other. The tank shall be filled with water to a depth of 25 to 30 cm quick lime shall be gradually added to it so as to cover the entire bottom of the tank to about half the depth of water. While quick lime is being added to water it shall be constantly stirred so as to break up the lumps and aid, the slaking process with minimum cooling of the mix. No part of the lime shall be allowed to get exposed above water. As lime slakes with the evolution of heat, the temperature of water will begin to increase. When a temperature near boiling point is reached, additions of lime and water shall be made in small quantities with constant stirring so as to maintain the required temperature. The operation shall be continuous until the requisite quantity of lime has been slaked. After the slaking is apparently over, the stirring shall be continued for some more time to ensure that all the time has been fully slaked. The slaked lime shall be allowed to stand undisturbed in the tank. Where only one tank is used, or run into a lower tank where one is provided, and allowed to mature into lime putty. The maturing period shall not be less than 3 days in the case of class C and D lime and not more than 2 days in case of Class B and E lime.

Platform slaking – This method provides dry slaked lime which can be used as it is or after converting it into putty (see para 6.3.2.5.3 below). Quick lime is spread in 15cm thick layer on a watertight masonry platform and water sprinkled over it in small quantities through a rose can or with a hose pipe until the lime disintegrates into a fine powder. Care shall be taken to see that only the minimum quantity of water required for complete and uniform slaking is added. It shall be periodically turned over. Slaking shall be allowed to continue further by itself for a period of at least 24 hours. The slaked lime shall then be screened through 250 micron is sieve.

6.3.2.5.3 **Preparation of putty** – The putty shall be obtained by adding dry slaked lime to water and stepping to the consistency of a thick cream, and allowing it to stand and mature for a period which shall be not less than 16 hours in the case of Class C and D limes and not more than 12 hours in the case of Class B and E before using it as slaked lime.

6.3.3. **Calcined Clay Pozzolana (SURKHI)**

The calcined clay pozzolana is reactive pozzolanic material, shall conform to IS:1344-1981.

6.3.3.1 Calcined clay pozzolana shall conform to the physical requirements given in Table 1 below when tested in accordance with IS:1727-1967.

Notwithstanding the strength requirements specified in Table I, mixes in which calcined clay is incorporated shall show a progressive increase in strength.

TABLE I – PHYSICAL REQUIREMENTS

S.No.	**CHARACTERISTIC**	**REQUIREMENT**	
		Grade I	Grade II
(1)	(2)	(3)	(4)
(i)	Finess – Specific surface in m2/kg by Blaine's permeability method, Min	320	250
(ii)	Lime reactivity – Average compressive strength in H/mm2, Min.	4.0	3.0
(iii)	Compressive strength at 28 days, Min. (Applicable in case of pozzolana to be used for manufacture of Portland pozzolana cement only)	Not less than 80 percent of the strength of corresponding plain cement mortar cubes.	
(iv)	Drying shrinkage Max.	0.15	0.10

6.3.3.2 **Supply and Storage –** The calcined clay pozzolana may be supplied in bags (jute laminated, multiply paper or polyethylene lined) bearing the manufacturer's name or registered trade marks, and the net mass of each bag shall be 50kg. The permissible tolerance on the mass of calcined clay pozzolana supplied in bags shall be ± 2.5 percent per bag with an overall tolerance of ± 0.5 percent per wagon of 20 to 25 tonnes. The calcined clay pozzolana shall be protected from main and dampness and shall be stored in such a manner as to permit easy access for proper inspection and identification of each consignment. It shall be stored site on a hard dry and level patch of ground; If such a surface is not available, a platform of planks or old corrugated iron sheets, or a floor of bricks, or a thin layer of lean concrete shall be made so as to prevent the admixture of clay, dust, vegetable and other foreign matter.

6.3.4 Sand

6.3.4.1 Quality of Sand

6.3.4.1. General – The sand shall consist of natural sand, crushed stone stand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than the limits specified under para 6.3.4.1.3 below.

6.3.4.1.2 Deleterious Material – The sand shall not contain any harmful impurities, such as Iron pyrities, alkalies, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form on in such quantities as to affect adversely the hardening, strength on durability of the mortar, or the appearance in case of plaster or applied decoration on to cause corrosion of metal lathing on the other metal in contact with the plaster.

6.3.4.1.3 Limits of Deleterious Materials and Other Impurities – Unless found satisfactory as a result of further tests as may be specified by the Engineer-in-charge, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the natural and crushed stone sand shall not exceed the following limits, when determined in accordance with IS:2386 (Part II) – 1963.

(a) Clay, fine silt and find dust not more than 5% by mass when determined in accordance with the procedure at Appendix – I;

(b) Organic impurities when determined in accordance with IS:2386 (Part II) – 1963. Colour of the liquid shall be lighter than that indicated by the standard solution specified in IS:2386 (Part II) – 1963.

NOTE - In particular cases, crushed stone sand with even higher proportions of fine dust than specified above may be satisfactory and the limit so permitted be subject to approval of Engineer – in – Charge.

6.3.4.2 Grading of Sand

6.3.4.2.1 The particle size grading of sand shall be as specified in Table II on masonry mortars and for plaster work for external as well as internal walls and ceiling.

TABLE II – GRADING OF SAND FOR USE IN MASONRY AND PLASTER MORTARS

I.S. : Sieve Designation	For use in masonry Mortar, percentage Passing by mass	For internal and external Wall and ceiling plaster, Percentage passing by mass
9.5 mm	-	100
4.75 mm	100	95 to 100
2.36 mm	90 to 100	95 to 100
1.18 mm	70 to 100	90 to 100
600 micron	40 to 100	80 to 100
300 micron	5 to 70	20 to 65
150 micron	0 to 15	0 to 15

6.3.4.2.2 The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

6.3.4.2.3 The required grading may often be obtained by screening and/or by blending together either natural sand or crushed stone screenings, which are, by themselves unsuitable.

6.3.4.2.4 The sand for masonry mortars whose grading falls out side the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening through a suitable sized sieve and / or blending with required quantities of suitable sizes of sand particles. Based on test results and in the light of practical experience with the use of local materials, deviation in grading of sand given in para 6.3.4.2.1 above may be considered by the Engineer – in – charge.

6.3.4.2.5 Sand for plaster where the grading falls out side the limits of grading zones of sieves other than 600 micron IS sieve by a total amount not exceeding 5 percent, it shall be regraded as falling within the grading. This tolerance shall not be applied to percentage passing the 600 micron IS sieve or to percentage passing any other sieve size on the finer limit.

6.3.4.2.6 For crushed stone sands for plaster, the permissible limit on 150-micron nominal aperture size sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted in para 6.3.4.2.5 applying the other sieve sizes.

6.3.4.3 Bulking of Sand – In the nominal mortar mixes specified by volume, sand is assumed to be dry. Dry and saturated sands have almost the same volume, but damp sand increases in volume. Bulking depends primarily upon moisture content and marginally on grading of sand. Due allowance for bulking of sand shall be made, while preparing the mortar mixes based on volume measurements.

The bulking allowance for any sample of sand shall be got determined in accordance with procedure given in Appendix – II. The following Table III gives the relation between the moisture content and percentage of bulking, which may be used as a rough guidance.

TABLE III

Moisture content Percentage	Bulking percent (Volume)
2	15
3	20
4	25
5	30

6.3.5. Soil

Soil for making mud mortar shall have suitable plasticity. The soil shall be free from vegetable roots, stone, gravel (particle size greater than 2mm) kankar; coarse sand and harmful and efflorescent salts. Soil shall not be collected from locality affected by white ants. The plasticity index of soil shall be between 6 and 10. The sulphate content shall not exceed 0.1 percent. Coarse material (coarser than 3.35mm) in soil shall not exceed 10 percent by weight.

6.3.6. Water

Water used for making masonry mortars shall be clean and free from injurious quantities of deleterious materials. Potable water is generally considered satisfactory for use in masonry mortar.

6.3.6.1. Permissible limits for solids shall be as give in Table IV below :

TABLE IV

Solids	Permissible Limit (Max.)
Organic	200 mg / L
Inorganic	3000 mg / L
Sulphates (as SO_4)	500 mg / L
Chloride (as Cl)	2000 mg /L
Suspended Matter	2000 mg / L

6.4 GRADE OF MORTAR

6.4.1 Masonry mortars shall preferably be specified by the grade in terms of their minimum compressive strength as given in Appendix – III. Masonry mortars in terms of mix proportion which gives the range of compressive strength (at the age of 28 days) values are also given in Appendix – III for guidance.

6.5 CRITERIA FOR SELECTION OF MASONRY MORTARS

6.5.1 The selection of masonry mortars from durability considerations will have to cover both the loading and exposure conditions of the masonry. The requirements for masonry mortar shall be as specified in para 88.3 of Chapter – 88 for "Dam and Appurtenant Works" and para 6.5.1.1 to 6.5.1.6 below for other works.

6.5.1.1 In the case of masonry exposed frequently to rains and where there is further protection by way of plastering or rendering or other finishes, the grade of mortar shall not be less than MM 0.7 but shall preferably be of grade MM 2. Where no protection is provided, the grade of mortar for external walls shall not be less than MM 2.

6.5.1.2 In the case of load bearing internal walls, the grade of mortar shall preferably be MM 0.7 or more for high durability but in no case less than MM 0.5

6.5.1.3 In the case of masonry in foundations laid below damp proof course, the grades of mortar for use in masonry shall be as specified below :

(a) Where soil has little moisture, masonry mortar of grade not less than MM 0.7 shall be used.

(b) Where soil is very damp, masonry mortar of grade preferably MM 2 or more shall be used. But in no case shall the grade of mortar be less than MM 0.7; and

(c) Where soil is saturated with water, masonry mortar of grade MM3 shall be used but in no case shall be grade of mortar be less than MM2.

6.5.1.4 For masonry in buildings subject to vibration of machinery the grade of mortar shall not be less then MM 3.

6.5.1.5 For parapets, where the height is greater than thrice the thickness, the grade of masonry mortar used shall not be less than MM 3. In the case of low parapets, the grade of mortar shall be the same as used in the wall masonry below.

6.5.1.6 The grade of mortar for bedding joints in masonry with large concrete blocks shall not be less than MM 3.

6.6 PREPARATION OF MASONRY MORTARS.

6.6.1 Proportioning

The mortar mix will be preferably specified by volume. Where the mix design is prescribed on weight basis but weigh batching is not practicable, the batching may be done by converting the design mix into equivalent volume on basis of unit weight of materials in loosely placed condition which shall be found by actual field measurement. Loose placed condition is achieved by pouring or filling the material in the container loosely, that is without giving any jerk to the container.

6.6.2 Cement Mortar

6.6.2.1 ***Proportioning*** – Cement shall be proportioned only by full bags. Sand in specified proportion shall be measured in boxes of suitable size on the basis of dry volume. In case of damp sand its quantity shall be increased suitably to allow for bulkage which be determined as per para 6.3. 4.3.

6.6.2.2 ***Preparation*** – Mixing shall be done preferably in a mechanical mixer. If done by hand, the operation shall be carried out on a clean watertight platform. Cement and sand shall be mixed dry in the required proportions to obtain a uniform colour. The required quantity of water shall then be aded and the mortar mixed to produce a workable consistency. In the case of mechanical mixing, the mortar shall be mixed for at least three minutes after addition of water; in the case of hand mixing, the mortar shall be hoed back and forth for 5 to 10 minutes with addition of water.

6.6.2.3 Generally, only as much quantity of cement mortar as would be sufficient for 30 minutes work, shall be mixed at a time.

6.6.2.4 The Engineer–in–charge shall if necessary specify the use of suitable air – entraining agents to improve the quality and workability of mortar. The amounts of air entraining agents used shall be such as will effect the entertainment of 8 percent to 12 percent of air by volume of mortar.

6.6.3 Lime Mortar

6.6.3.1 **Proportioning** – The ingredients in specified proportions shall be measured in boxes of suitable size. Sand shall be measured on the basis of dry volume and in accordance with para 6.6.2.1

6.6.3.2 Preparation

6.6.3.2.1 If lime is supplied in the form of quick time it shall be slaked and run into putty in accordance with para 6.3.2.5. putty and sand in the specified proportions shall be mixed with or without addition of water on a dry water proof platform or in a mixer. The mix shall then be fed into a mortar mill with the required addition of water to the required working consistency. The mortar shall be raked continuously during grinding, particularly in the angular edges of the mortar mill. The mixing shall be done for 180 revolutions for minimum of 3 hours; till every particle of aggregate is coated uniformly with the cementations material. Alternatively, a mechanical mortar mill may be used for or ending for 3 minutes.

6.6.3.2.2 If dry hydrated lime is used, the sand and lime in specified proportions shall be mixed dry first, and shall then fed into a mortar mill with required additions of water to the required working consistency. The mixing shall be done in accordance with para 6.6.3.2.1. above.

6.6.3.2.3 Generally, only as much quantity of lime mortar (except made with class A Lime) as would be sufficient for a day's work shall be mixed at a time. If eminently hydraulic lime (class A) is present as an ingredient, the mortar shall be used within 4 hours after grinding.

6.6.4 Lime Pozzolana Mixture Mortar

6.6.4.1 ***Proportioning*** – The ingredients in specified proportions shall be measured in boxes of suitable size. Sand shall be measured on the basis of its dry volume as indicated in para 6.6.2.1.

6.6.4.2 ***Preparation*** – Mortar using lime pozzolana mixture shall be prepared in the same manner as described in para 6.6.2.2.

6.6.4.3 Mortars with lime pozzolana mixture of type LP 20 and LP 40 as binder shall be used with in 4 hours from the time of mixing of the mortar, whereas mortars which have hydraulic lime (Class B) or fat lime (Class C) and pozzolana or lime pozzolana mixture of type LP 7 as ingredients, but do not have either Portland Cement or eminently hydraulic lime (Class A) shall be used within 12 to 24 hours from the time of mixing of the mortar.

6.6.5 Cement Lime Mortar –

6.6.5.1 ***Proportioning –*** Cement, lime putty / dry hydrated lime and sand shall be taken in proportions as specified in the item of work. The unit of measurement for cement is a bag. Lime in the form of putty in specified proportion shall be measured in accordance with para 6.6.3.1. Sand shall be measured on the basis of its dry volume in accordance with para 6.6.2.1

6.6.5.2 Preparation

6.6.5.1.1 Where coarse sand is used the lime putty and sand in the required proportions shall; after preliminary mixing on a watertight platform, with necessary addition of water, be ground in a mortar mill to the required working consistency taking care to rake up continuously the mortar particularly at the corners. The mixing shall be done for 180 revolutions or for minimum 3 hours till every particle of aggregate is coated uniformly with the cementitious material. This mix shall then be transferred to a mechanical mixer to which the required quantity of cement is added and the content mixed for at least 3 minutes.

6.6.5.1.2 Where fine sand is used the mixing operation shall be done in same manner as in 6.6.5.2.1, except that grinding may be omitted for preliminary mixing of lime putty and sand. When factory made dry hydrated lime conforming to IS: 712-1984 is used, grinding of lime and sand in the mortar mill is not necessary.

6.6.5.1.3 If the mixture of lime putty and sand is not used immediately for mixing with cement, it shall be kept protected from drying out till the time of use.

6.6.5.1.4 Where hand mixing is necessary cement and sand shall be mixed dry thoroughly on clean tight masonry platform or in troughs. Lime putty shall be mixed with water to make milk of lime, it shall be added to mixture of cement and sand. The mixture shall be kneaded back and forth for about 10 minutes with addition of milk of lime to obtain mortar of workable consistency.

6.6.5.2 Mortar shall be used as soon as possible after mixing and maximum within 2 hours. Mortar unused for more than 2 hours shall be rejected and removed from the site of work. Mixture of lime putty and sand can be kept for 72 hours for preparation of lime cement mortar in respect of class B and C lime and for 6 hours in case of class A lime provided it is kept damp and not allowed to dry.

6.6.6 Mud mortar

6.6.6.1 ***Preparation*** – Mortar shall be prepared from none but well tempered clay or good brick earth free from vegetation, gravel, kanker, efflorescencing sails, white ants and other rubbish etc. the dry soil shall be reduced to fine powdered state and mixed with water in a pit. Fibrous reinforcing material such as chopped straw not longer than 20 mm in the preparation of 30 to 35 kg/cum of soil shall be added while mixing. The mixture shall be allowed to mature for a period of not less than seven days. During this period, it shall be worked up at intervals with feet and spades so as to get pugged into a homogenous mass free from lumps and clods.

The mortar when ready shall be of such a consistency that it will readily slide off the face of trowel but shall not be so wet that the mortar parts into large drops while falling.

Normally the mortar made on a day shall be used as soon as possible.

6.6.6.2 At site of the work, normally, pits shall not be dug at or near the site of work for obtaining the soil. However, if under special circumstances, pits are allowed to be dug by the Engineer – in – Charge, these shall not be deeper than 1.50 metres and shall be filled and dressed properly as soon as possible. The top 60 cm shall be filled with good soil in 20 cm layers with clods broken, watered, rammed and consolidated. The bottom layers may be filled with building rubish mixed with soil laid in 20 cm layers watered, rammed and consolidated.

6.7 RETEMPERING OF MORTARS

In the case of mortar using cement, the mortar that has stiffened because of evaporation of water from the mortar may be retempered by adding water as frequently as needed to restore the requirements of consistency. But this retempering shall be permitted only within 60 minutes from the time of addition of cement. Mud mortar can be retempered by adding water and kneading any time if it dries up.

6.8 CONSISTENCY OF MASONRY MORTARS

6.8.1 The water shall be enough to maintain the fluidity of the mortar during application, but at the same time it shall not be excessive leading to segregation of aggregates from the cementitious material. The quantity of water needed for maintaining consistency or fluidity will also depend upon the masonry to which the mortar is used; for example, thinner joints will require greater fluidity; bed joints subjects to heavy pressure may require stiffer mortar. Also, the mortar shall be able to hold the water against suction by the masonry unit, particularly in the case of burnt clay and concrete products.

6.8.1.1 The consistency of mortars shall be measured in accordance with the procedure given in Appendix – IV and the following values of depth of penetration are recommended.

For laying walls with solid bricks	90 to 130 mm
For laying perforated bricks	70 to 80 mm
For filling cavities	130 to 150 mm

APPENDIX – I

DETERMINATION OF CLAY, FINE SILT AND FINE DUST IN SAND

(SEDIMENTATION METHOD)

(Para 6.3.4.1.3)

1. OBJECT

This is a gravimetric method for determining the clay, fine silt and fine dust, which includes particles upto 20 micron. Differences in the nature and density of materials or in the temperature at the time of testing may vary the separation point.

2. APPARATUS

The apparatus shall consist of the following :

(a) A watertight screw-topped glass jar of dimensions similar to a 1kg fruit preserving jar.

(b) A device for rotating the jar about its long axis, with this axis horizontal, at a speed of 80 $\pm$ 20 rev/min.

(c) A sedimentation pipette of the Andrason type of approximately 25ml capacity and of the general form as indicated in figure 1. This consists mainly of pipette fitted at the top with a two-way tap and held rigidly in clamp clamp can be raised or lowered as required, and which is fitted with a scale from which the changes in height of the pipette can be read.

The volume of the pipette A, including the connecting bore of the tap B, is determined by filling with distilled water; by reversing the tap, the water is run out into a bottle, weighed and the volume calculated.

(d) A 1000 – ml measuring cylinder.

(e) A scale or balance of capacity not less than 10 kg. Readable and accurate to one gram.

(f) A scale or balance of capacity not less than 250g, readable and accurate to 0.001 g.

(g) A well-ventilated oven, thermostatically controlled, to maintain a temperature of 100^0 to 110^0 C

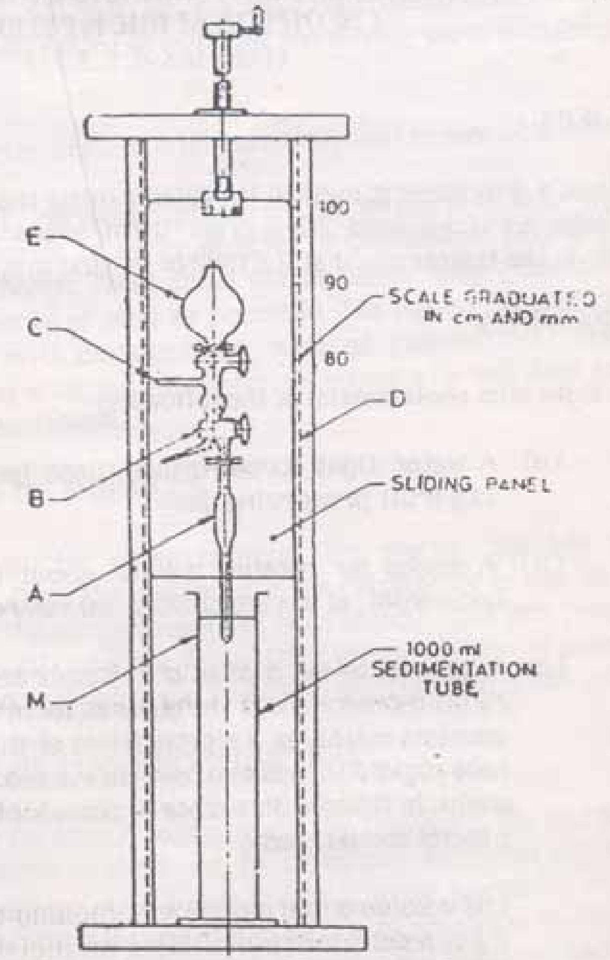


FIG. SEDIMENTATION PIPETTE FOR DETERMINATION OF CLAY AND SILT CONTENT

3. CHEMICALS

A solution containing 8g of sodium oxalate per liter of distilled water shall be taken. For use, this stock solution is diluted with distilled water to one tenth (that is 100 ml diluted with distilled water to one litre).

4. TEST SAMPLE

The sample for test shall be prepared from the main sample taking particular care the test sample contains a correct proportion of the finer material. The amount of sample taken for test shall be in accordance with Table below :

TABLE : WEIGHT OF SAMPLE FOR DETERMINATION OF CLAY, FINE SILT AND FINE DUST

Maximum Size present in Substantial Proportions (mm)	Approximate Weight of Sample for Test (Kg.)
63 to 25	6
20 to 12.5	1
10 to 6.3	0.5
4.75 or smaller	0.3

4.1 All in aggregates shall be separated into fine and coarse fractions by sieving on a 4.75mm IS Sieve and the two samples so obtained shall be tested separately.

5. TEST PROCEDURE

5.1 Method for Fine Aggregate - Approximately 300g of the sample in the air dry condition, passing the 4.75mm IS Sieve, shall be weighed and placed in the screw topped glass jar, together with 300ml of the diluted sodium oxalate solution. The rubber washer and cap shall be fixed, care being taken to ensure water tightness. The jar shall then be rotated about its long axis, with this axis horizontal, at a speed or 80 $\pm$ 20 rev/min for a period of 15 minutes.

At the end of 15 minutes, the suspension shall be poured into the 1000-ml measuring cylinder and the residue washed by gentle swirling and decantation of successive 150 ml portions of sodium oxalate solution, the washing being added to the cylinder until the volume is made up to 1000 ml. The determination shall be completed as described in after para below.

5.2 Method for Coarse Aggregate – The weighed sample shall be placed in a suitable container, covered with a measured volume of sodium oxalate solution (0.8 g per litre), agitated vigorously to remove all adherent fine material and the liquid suspension transferred to the 1000 – ml measuring cylinder. This process shall be repeated as necessary until all clayey material has been transferred to the cylinder. The volume shall be made upto 1000 ml with sodium oxalate solution and the determination completed as described in para below.

The suspension in the measuring cylinder shall be thoroughly mixed by inversion and the tube and contents immediately placed in position under the pipette. The pipette A shall then be gently lowered until the tip touches the surface of the liquid, and then lowered a further 10 cm into the liquid. Three minutes after placing the tube in position, the pipette A and the bore of a tap B shall be filled by opening B and applying gentle suction at C. A small surplus may be drawn up into the bulb between tap B and tube C., This shall be allowed to run away and solid matter shall be washed out with distilled water from E. The pipette shall then be removed from the measuring cylinder and its contents run to a weighed container, any adherent solids being washed into the container by distilled water form E through the tap B.

The contents of the container shall be dried at 100 to 110^0 C to constant weight, cooled and weighed.

6. CALCULATIONS

The proportion of fine silt and clay or fine shall then be calculated from the following formula :

$$\text{Percentage of clay and fine silt or fine dust} = \frac{100}{W1}\left(\frac{1000W2}{V} - 0.8\right)$$

Where,

W1	=	weight of the original sample in gram,
W2	=	weight of the dried residue in gram,
V	=	Volume in ml of the pipette, and
0.8	=	weight of sodium oxalate in one litre of the diluted solution in gram.

NOTE-No correction is made for water soluble salts which may be present in the sand since the amount of such salts shall be small.

7. REPORTING OF RESULTS

The clay, fine silt and fine dust content shall be reported to the nearest 0.1%

APPENDIX – II

FIELD METHOD FOR DETERMINATION OF BULKING OF SAND

1. OBJECT

This method of test covers the field method for determining the necessary adjustment for bulking of fine aggregate.

2. GENERAL

Sand brought on to a building site or other works may contain an amount of moisture which will cause it, when loosely filled into a container, to occupy a larger volume than it would occupy if dry. If the sand is measured by loose volume, it is necessary in such a case to increase the measured volume of the sand, in order that the amount of sand pyt into the concrete may be the amount intended for the nominal mix used (based on dry sand). It will be necessary to increase the volume of sand by the percentage bulking. The correction to be made is only a rough approximation because the system of measurement by loose volume is a rough method at the best, but a correction of the right order can easily be determined and should be applied in order to keep the concrete uniform.

3. PROCEDURE

3.1 The procedure to be adopted may be varied, but two methods are suggested in 3.2 and 3.3. Both depend on the fact that the volume of inundated sand is the same as if the sand were dry.

3.2 Put sufficient quantity of the sand loosely into a container until it is about two – thirds full. Level off the top of the sand and pushing a steel rule vertically down through the sand at the middle to the bottom, measure the height. Suppose this is h cm.

3.2.1 Empty the sand out of the container into another container where none of it will be lost. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6mm in diameter, so that its volume is reduced to a minimum. Then add the remainder of the sand and rod in the same way. Smooth and level the top surface of the inundated sand and measure its depth at the middle with the steel rule. Suppose this is h’ cm.

3.2.2 The percentage of bulking the sand due to moisture shall be calculated from the formula :

Percentage bulking = [h/h' -1] x 100

3.3 In a 250ml measuring cylinder, pour the damp sand (consolidated by shaking) until it reaches the 200ml mark. Then fill the cylinder with water and stir the sand well; the water shall be sufficient to submerge the sand completely. It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of Y ml. The percentage of bulking of sand due to moisture shall be calculated from the formula.

Percentage bulking = [200/V – 1] x 100

4. REPORT OF RESULTS

Report of percentage bulking of the sand to the nearest whole number.

APPENDIX – III
GRADE OF MASONRY MORTARS
(Para 6.4)

Sl. No.	Grade	MORTAR MIX (BY LOOSE VOLUME)					Compressive strength at 28 days (N/mm2)
		Cement	Lime	Pozzolana	Lime Pozzolana Mixture	Sand	
1.	2.	3.	4.	5.	6.	7.	8.
1.	MM 0.5	0	1 B or E	0	0	3	
2.		0	0	0	1 (LP-7)	1.25	0.5 to 0.7
3.		0	1 C or D	1	0	2	
4.	MM 0.7	0	0	0	1 (LP-20)	1.5	
5.		0	0	0	1 (LP-40)	2.25	
6.		1	3 C or D	0	0	12	0.7 to 1.5
7.		1	0	0	0	8	
8.		1	0	0.4*	0	10	
9.	MM 1.5	0	0	0	1 (LP-20)	1.25	
10.		0	0	0	1 (LP-40)	2	
11.		1	0	0	0	7	1.5 to 2
12.		1	0	0.4*	0	8.75	
13.		0	1 A	0	0	3	
14.	MM 2	0	1 A	0	0	2	
15.		0	1 C or D	3*	0	0	2 to 5
16.		1	2 C or D	0	0	9	
17.		0	0	0	1 (LP-20)	1	
18.		0	0	0	1 (LP-40)	1.75	
19.	MM 3	0	1 C or D	2*	0	0	
20.		1	1 C or D	0	0	0	
21.		1	0	0	0	6	
22.		0	1 A	0	0	1	
23.		1 $	0	0.21*	0	4.2	3 to 5
24.		0	0	0	1 (LP-40)	1.5	
25.		1	0	0.4*	0	7.5	3 to 5
26.		1	0	0	2 (LP-20)	12	
27.	MM 5	1	0 to ¼ B C .D or E	0	0	4	
28.		1	0	0	0	5	5 to 7.5
29.			0	0	1 (LP-40)	1	
				(LP-40)			
30.		1	0	0.4	0	6.25	
31.		1	0	0.4	0	5	

Sl. No.	Grade	MORTAR MIX (BY LOOSE VOLUME)					Compressive strength at 28 days (N/mm2)
		Cement	Lime	Pozzolana	Lime Pozzolana Mixture	Sand	
1.	2.	3.	4.	5.	6.	7.	8.
32.	MM 7.5	1	¼ Cor D	0	0	3	7.5 and above
33.		1	½ Cor D	0	0	4.5	
34.		1	0	0	0	4	
35.		1	0	0.2*	0	2.1	
36.		1	0	0	0	3	
37.		1	0	0.4*	0	3.75	
38.	MM 7.5	1	0	0	1 (LP-20)	8	

Note :-

1) A,B,C.D and E denote the classes of limes to be used (see para 6.3.2.1).

2) The strength values of lime mortars given in the table are after wet grinding of the mortar ingredients.

3) The compressive strength shall be determined in accordance with the procedure given in Appendix – A of IS : 2250 – 1981.

4) LP7, LP20 and LP40 are three types of pozzolana mixtures conforming to requirements specified in para 5 of IS:4098 – 1983.

5) Of minimum lime reactivity of 4N/mm2

By volume corresponds approximately to cement pozzolana ratio of 02 by weight. In this case, only ordinary Portland cement is to be used.

APPENDIX – IV

DETERMINATION OF CONSISTENCY OF MASONRY MORTAR

(Para 6.8.1.1)

1. OBJECT

To determine the consistency of masonry mortar.

2. APPARTUS

2.1 This shall consist of a standard cone weighing 300 $\pm$ 2g. 150 mm in height and a diameter at a base of 75mm. The cone is mounted on a vertical shaft fastened to in adjustable holder. The holder has a mechanism which releases the shaft. The apparatus has also on instrument dial which records the depth of penetration of the cone increase mortar mix kept in a conical container below. The conical container for mortar be 180mm deep with a diameter at top of 150 mm.

2.2 **Flow Table –** This shall be as given in IS : 5512 – 1969.

2.3 **Tamping Rod –** A metal bar 25mm square and 200 mm long.

3. PROCEDURE

The conical container shall be fixed with mortar mix to a level that is 1 cm below its nim. Mortar mix shall be placed in a conical mould in one continuous operation and shall be compacted by tamping rod. The mould filled with mortar mix is bumped 5 or 6 times over a flow table so as to level the surface of the mortar. The container shall be placed over the base below the penetration cone of the apparatus. The apex of the penetrating cone shall be brought first in contact with the surface of the mortar and the cone clamped in position. The instrument dial is set to be in contact with a cone at this position. The cone is then released and allowed to sink into the mortar mix. After the cone has stopped penetrating into the mortar, the dial is once more set to record the position of the cone and the difference between dial readings before and after penetration gives the depth of penetration of the cone into the mortar.

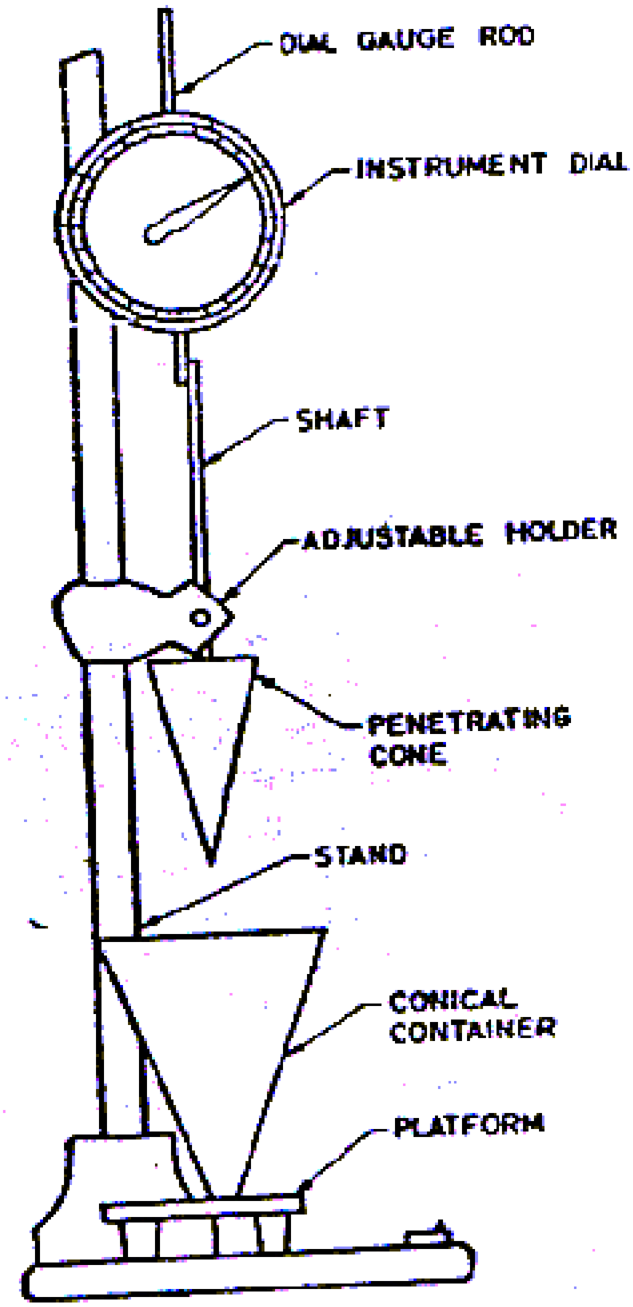
The test shall be repeated on another sample of the mortar.

4. REPORT

The average of the two determinations shall be reported as the consistency of the mortar.

5. FIELD TEST

For quick filed determination, the procedure may be further simplified. The shaft of the cone shall be field by hand in a perpendicular position so as to be in contact with the surface of the mortar and gently released to sink into the mortar taking care that the shaft remains vertical during penetration. The depth of penetration may be computed from the measurement of the wetted depth along the surface of the cone.



STANDARD CONE APPARATUS

FILLING FOUNDATION, RCC AND FORM WORK

CHAPTER - 7 & 16
FILLING FOUNDATION, R C C AND FORM WORK
CONTENT

7.1 REFERENCES

IS:269-1989	Specification for 33 grade ordinary Portland Cement (Fourth revision)
IS:383-1970	Specification for coarse & fine aggregate from natural source for concrete (Second revision)
IS:455-1976	Specification for Portland slag cement (Third revision) Amdt. No 1,2,3,4,5,6,7)
IS:456-1978	Code of practice for plain & reinforced concrete (second revision) (Amdt. No 1)
IS: 457-1957	Code of Practice for general construction of plain and reinforced concrete for dams and other massive structures
IS:516-1959	Method of test for strength of concrete (Amdt. No. 1)

IS:1199-1959	Method of sampling & analysis of concrete
IS:1334-1980	Code of practice for prestress concrete (first revision)
IS:1489-1976	Specification for Portland pozzolana cement (second revision) (Amdt.No 1,2,3,4,5,6 & 7)
IS:1791-1985	Specification for batch type concrete mixer (second revision)
IS:2386(Pt.I)-1977	Method of test for aggregates for concrete Part I particle size & shape (Amdt.No. 1)
IS:2386(Pt.II)-1977	Method of test for aggregates for concrete Part - 2 Estimation of deleterious material & organic impurities (Amdt. No. 1)
IS:2386(Pt.3)-1977	Method of test for aggregates for concrete part-3 Specific gravity, density voids, absorption & bulking.
IS: 2386(Pt.4)-1977	Method of test aggregates for concrete part-4 mechanical properties (Amdt. Nos. 1,2&3)

IS:2386(Pt.-5)-1977	Methods of tests for aggregates for concrete part-5 soundness
IS:2386(Pt.6)-1977	Methods of test for aggregates for concrete part-6, Measuring mortar making properties of fine aggregates (Amdt. No. 1)
IS:2386(Pt.7)-1977	Methods of test for aggregates for concrete part-7 Alkali aggregate reactivity
IS:2386(Pt.8)-1977	Methods of test for aggregates for concrete part-8 Petri graphic examination.
IS:2405(Pt.II)-1980	Specification for industrial sieve part-2 perforated plants
IS:2430-1986	Method for sampling of aggregates for concrete
IS:2505-1980	General requirements for concrete vibrators immersion type
IS:2506-1985	General requirements for screed board concrete vibrators
IS:2514-1963	Specification for concrete vibrating tables
IS:3535-1986	Methods of sampling hydraulic cements (first revision)
IS:3812-1981	Specification for fly ash for use as pozzolana and admixture (first revision)
IS:4031-1988 (Part 1 to pt. 13)	Methods of physical tests for hydraulic cement
IS: 4032-1985	Methods of chemical analysis of hydraulic cement (first revision)
IS: 4082-1977	Recommendation of stacking and storage of construction materials at site (First revision)
IS: 4634-1968	Methods testing performance of batch type concrete mixers.
IS: 4656-1968	Specification for from vibrators for concrete.
IS: 4925-1968	Specification for concrete batching and mixing plant.
IS: 6452-1972	Specification for high alumina cement for structural use (Amendment Nos. 1,2,3 & 3)
IS:6461-1972 (part 1 to 7)	Glossary of terms relating to cement concrete

IS: 6461- 1973 (Part 8 to 12)	Glossary of terms relating to cement concrete
IS:6909-1973	Specification for Supersulphate cement (Amdt. No. 1,2,3,4 & 4)
IS:7861(Pt.I) 1975	Code of practice for extreme weather concreting part 1 Hot weather
IS:8041-1978	Specification for rapid hardening Portland cement (first revision)(Amdt.No 1,2,3 & 4)
IS:8112-1976	Specification for 43 grade ordinary Portland cement (Amtdt. Nos 1,2,3,4,5 & 6)
IS:9103-1979	Specification for admixtures for concrete.
IRC:21-1972	Standard specification and code of practice for road bridges
SP:23-1982	Hand book or concrete mixes (based on Indians Standard (with amendment No. 1
SP:24-1983	Explanatory hand book on Indian Standard code for plain & reinforced concrete (IS:456-1978)
	- Specification for Road & Bridge Work (By Ministry of shipping & transport (road wing)
	-Gandhi sagar Dam specification.
	- Concrete Manual (US Department of the interior Water & power Resources Service)
	- Report of committee on cost control river valley project vol-iii Jan 1981 (Govt. of India Ministry of Irrigations

7.2 TERMINOLOGY

Abrahams Law - A rule stating that with given concrete materials and conditions of test the ratio of the amount of water to the amount of cement in the mixture determines the strength of concretes provided that mixture is of a workable consistency.

Absorbed Moisture - Moisture that has entered a solid material by absorption and has physical properties not substantially different from ordinary water at the same temperature and pressure.

Accelerator - A substance which when added to concrete, mortar or grout, increases the rate of hydration of the hydraulic cement, shortens the time of setting, or increases the rate of hardening or strength development.

Addition/Additive - A material that is interground or blended in limited amounts into a hydraulic cement during manufacture either as a "processing addition" to aid in manufacturing and handling the cement or as a "functional addition" to modify the use properties of the finished product.

Absorbed Water - Water held on surface of a material by electro chemical forces and having physical properties substantially different from those of absorbed water or chemically combined water at the same temperature and pressure.

Absorption - Development at the surface of a liquid or solid of a higher concentration of a substance than exists in the bulk of the medium; especially formation of one or more layers of molecules of gases, or dissolved substances, or of liquids at the surface of a solid, such as cement, cement paste, or aggregate, or of air-entraining agents at the air-water interfaces; also the process by which a substance is adsorbed.

Aggregate - Granular material, generally, inert, such as manufactured sand, gravel, crushed gravel, crushed stone, and air cooled iron blast furnace slag which when bound together into a conglomerated mass by a matrix forms concrete or mortar.

Aggregate- **All-in**- Material composed of a mixture of coarse aggregate and dine aggregate.

Aggregate Coarse - Aggregate most of which is retained on 4.75 mm, IS Sieve and containing only so much of finer material, as is permitted by the specification or alternatively (under differing circumstances). The portion of an aggregate retained on the 4.75 mm IS Sieve.

Aggregate, Dense Graded - Aggregates graded to produce low void content and maximum weight when compacted.

Aggregate (Fine) - Aggregates most of which passes 4.75 mm IS Sieve and containing only so much coarser materials as permitted for various grading Zones in the Specifications.

Aggregates, Gap Graded - Aggregates having a particle size distribution where one of more sizes are missing.

Aggregate graded - Aggregate comprising of a portion of all sizes from a given nominal maximum to 4.25mm. When these sizes are so proportioned as to give a definite grading, it is a well graded aggregate.

Aggregate Heavy Weight - Aggregates of high specific gravity such as barite, magnetite, limonite, ilemenite iron, or steel used to produce heavy concrete of high density concrete specially for shielding against unclear radiation.

Aggregate Light Weight - Aggregate of low bulk specific gravity, such as expended or sintered clay, slate, slag, fly ash vermiculite, or pumice or natural pumice and scoria used to produce light weight concrete.

Aggregate Maximum Size of - The largest size of aggregate particles present in sufficient quantity to influence the physical properties of concrete, generally designated by the standard sieve nearest to the sieve size on which over 10 percent weight is retained.

Aggregate, Reactive - Aggregate containing substances capable of reacting chemically with the products of solution or hydration of the Portland cement in concrete or mortar under ordinary condition of exposure, resulting in some cases in harmful expansion, cracking or staining.

Aggregate Blending - The process of intermixing two or more aggregates to produce a different set of properties; generally but not exclusively, to improve grading.

Air Content - The volume of air voids in cement past, mortar, or concrete, exclusive of pore space in aggregate particles, usually expressed as a percentage of total volume of the past, mortar or concrete.

Alkali - Salts of alkali metals, principally sodium and potassium specifically sodium and potassium occurring in constituents of concrete or mortar usually expressed in chemical analysis as the oxsides Na_2O and k_2O.

Alkali Aggregate Reaction - Chemical reaction in mortar or concrete between alkalies (sodium and potassium) from Portland Cement or other sources and certain constituents of some aggregates; under certain conditions, deleterious expansion of the concrete or mortar may result.

Alkali Reactivity (of aggregate) - Susceptibility of aggregate to alkali aggregate reaction.

Anchor - In prestressed concrete, to tock the stressed tendon in position so that it will retain its stressed condition, in precast concrete construction, to attach the precast units to the building frame; in slabs on grade or walls, to fasten to rock or adjacent structures to prevent movement of the slab of wall with respect to the foundation, adjacent structure of rock.

Acenoceous- Composed primarily of sand, sandy.

Argillaceous- Composed primarily of clay of shakes, clayey.

Ball Test- A test to determine the consistency of freshly mixed concrete by measuring the depth of penetration of a cylindrical metal weight with a hemispherical bottom.

Batch- Quantity of concrete of mortar mixed at one time.

Batch Box - Container of known volume used to measure constituents of a batch of concrete or mortar in proportions.

Batch Mixer - A concrete mixer for cyclic operation in which the ingredients for concrete are changed in batches; each new batch is charged in to drum of the mixer only when the proceeding batch has been discharged.

Batching Plant - An operating installation of equipment including batchers and mixers as required for batching or for batching and mixing concrete materials; also called mixing plant when mixing equipment is included.

Batching - Weighing or volumetrically measuring and introducing into the mixer the ingredients for a batch of concrete or mortar.

Blinding - The application of a layer or weak concrete or other suitable material to reduce surface voids, or to provide a clean dry working surface; also the filling or plugging of the openings in a screen or sieve by the material being separated

Bulking of sand - Increase in the bulk volume of a quantity of sand in a moist condition over the volume of the same quantity, dry or completely inundated.

Centering - Specialized form work used in the construction of arches, shells, and space structures, or any continuous structure where the entire false work is lowered (struck or decentered) as a unit to avoid the introduction of injurious stress in any part of the structure.

Chipping - Treatment of a hardened concrete surface by chiseling.

Chute - A sloping trough or tube for conducting concrete, cement, aggregate, or other free flowing materials from a higher to a lower point.

Coarse Aggregate Factor(b/bo) - Dry rodded bulk volume of coarse aggregate per unit volume of concrete; the ratio of the solid volume of coarse aggregate particle per unit volume of freshly mixed concrete to the solid volume of the coarse aggregate particle per unit volume of dry rodded coarse aggregate.

Cold Joint - A joint or discontinuity formed when a concrete surface hardens before the next batch is placed against it, characterized by poor bond unless necessary procedures are observed.

Compacing Factor - The ratio obtained by dividing the observed weight of concrete which fills a container size and shape when allowed of fall into it under standard condition of test by the weight of fully compacted concrete which fills the same container.

Consistency - The relative mobility or ability of freshly mixed concrete or mortar to flow, the usual measurements are slump for concrete and flow for mortar cement paste or grout.

Cube Strength - The load per unit area at which a standard cube fails when tested in a specified manner.

Curing - maintenance of humidity and temperature of freshly placed concrete during some definite period following placing, casting or finishing to assure satisfactory hydration of the cementitious materials and proper hardening of the concrete.

Durability - The ability or concrete to resist weathering action chemical attack, abrasion, and other conditions of service.

Early Strength - Strength or concrete or mortar developed soon after placement usually during the first 72 hours.

Expansion Joint - A separation between adjoining parts or a concrete structure which is provided to allow small relative movements such as those caused by thermal changes to allow small relative moments such as those caused by thermal changes to occur independently.

False work

(a) False work is the temporary structure erected to support work in the process of construction. It is composed of shores, form work for beams or slabs (or both), and lateral bracing.

(b) That part of formwork which supports is the forms usually for a large structure, such as bridge.

Final Set - A degree of stiffening of a mixture of cement and water greater than initial set, generally stated as an empirical value indicating the time in hours and minutes required for a cement past to stiffen sufficiently to resist to an established degree, the penetration of a weighed test needle; also applicable to concrete and mortar mixtures with use of suitable test procedures.

Final Setting Time - The time required for a freshly mixed cement past, mortar or concrete to achieve final set.

Flakiness Index - The flakiness index of an aggregate is the percentage of weight of particles in it whose least dimensions (thickness) is less than three fifth of their mean dimension.

Form (Shutter)

(a) That part of form which consists of sheeting and its immediate supporting or stiffening members.

(b) A temporary structure or mould for the support of concrete while it is setting and gaining sufficient strength to be self supporting.

Form Work - Complete system of temporary structure built to contain fresh concrete so as to form it to the required shape and dimensions and to support it until it hardens sufficiently to become self supporting. Form work includes the surface in contact with the concrete and all necessary supporting structure.

Grading (Particle size distribution) - The distribution of particles of granular material among various sizes; usually expressed in terms of cumulative percentage larger or smaller than each of a serie of sizes (sieve openings) or the percentage between certain ranges of sizes (sieve openings).

Grout - Mixture of cementitious material and aggregate to which sufficient water is added to produce pouring consistency without segregaton of the constituents, or mixtures of other compositions, such as containing PVC or epoxy resin or sodium silicate, but or similar consistency.

Grouting - The process of filling with grout.

Honeycomb - Voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse aggregate particles.

Hydration - Formation of a compound by the combining of water with some other substance, in concrete, the chemical reaction between hydraulic cement and water.

Hydraulic Cement - A cement that sets and hardens by chemical infraction with water and that is capable of doing so under water.

Initial Set - A degree of stiffening of a mixture of cement and water less than final set, generally stated as an empirical value indicating the time in hours and minutes required for cement paste to stiffen sufficiently to resist to an established degree, the penetration of a weighted test needle; also applicable to concrete or mortar with use of suitable test procedures.

Initial Setting Time - The time required for a freshly mixed cement past, mortar or concrete to achieve initial set.

Laitance - A layer of weak and nondurable material containing cement and fines aggregates, brought by bleeding water to the top of over wet concrete, the amount of which is generally increased by overworking or over manipulating concrete at the surface by improper finishing or by job traffic.

Lift - The concrete placed between two consecutive horizontal construction joints, usually consisting or several layers or courses.

Mass Concrete - Any volume of concrete in place (generally as a monolithic structure usually incorporating a high proportion of large coarse aggregate and a low cement content) and intended to resist applied load by virtue of its mess; it is distinct from other types of concrete because its dimensions are of such magnitude as to require that measures be taken to cope with the generation of heat and attendant volume changes.

Mix - A colloquial term designating a particular type of concrete mixture also commonly called mixture.

Mixing Speed - Rotation rate of a mixer drum or of the paddles in an open top, pan, trough mixer when mixing a batch expressed as revolutions per minute (rpm). or in peripheral feet per minute of a point on the circumference at maximum diameter.

Mixing Time - The period during which the constituents of a batch of concrete are mixed by a mixer; for a stationery mixer, time is given in minutes from the completion of mixer charging until the beginning of surcharge; for a truck mixer, time is given in total minutes at a specified mixing speed or expressed in terms of total revolutions at a specified.

Mould

(a) A device containing a cavity into which neat cement, mortar or concrete test specimens are cast; and

(b) A from used in the fabrication of precast mortar or concrete units.

No Fines concrete - A concrete Mixture containing little or no fine aggregate.

No- Slump Concrete - concrete with a slump of 25 mm or less.

Nominal Mix - The proportions of the constituents of a proposed concrete mixture.

Peeling - A process in which thin flakes or mortar are broken away from a concrete surface, such as by deterioration or by adherence of surface mortar to forms as forms are removed.

Penetration Resistance - The resistance, usually expressed in kg/mm^2 of mortar or cement past to penetration by a plunger or needle under standardized conditions.

Plum - A large random-shaped stone dropped into freshly placed mass concrete.

Plumb - Vertical or to make vertical.

Prestressed Concrete - Concrete in which internal stresses of such magnitude and distribution that the tensile stresses resulting from the service loads are counteracted to a desired degree; in reinforced concrete the prestress is commonly introduced by tensioning the tendons.

Proportioning - Selection of proportioning of ingredients for mortar or concrete to make the most economical use of available materials to produce mortar of concrete of the required properties.

Ramming - A form of heavy temping of concretes, grout, or the like by means of a blunt tool forcibly applied.

Retarder - An admixture which delays the setting of cement past, and hence of mixtures, such as mortar or concrete containing cement.

Retempering - Addition of water and remixing of concrete of mortar which has started to stiffen.

Rod Temping (Rodding) - A round, straight, steel rod, having one end rounded to a hemispherical tip.

Sandblast - A system of cutting or abrading a surface, such as concrete by a stream of sand ejected from a nozzle at high speed by compressed air; often used for cleanup of horizontal construction joints or for architectural exposure of aggregate.

Scaffolding - A temporary structure for gaming access to higher levels of the permanent structure during construction.

Scaling - Local flaking or peeling away of the near surface portion of hardened concrete or mortar.

Scour - Erosion of a concrete surface, exposing the aggregate.

Segregation - The differential concentration of the components of mixed concrete, aggregate, or the like resulting in non uniform proportions in the mass.

Separation - The tendency as concrete is caused to pass from the unconfined ends of chutes or conveyor belts, or similar arrangements for coarse aggregates to separate from the concrete and accumulate at one side; the tendency as processed aggregate leaves the ends of conveyor belts, chutes, or similar devices with confining sides, for the larger aggregate to separate from the mass and accumulate at one side; or the tendency for the solids to separate from the water by gravitational settlement.

Set - The condition reached by a cement past, mortar, or concrete when it has lost plasticity to an arbitrary degree usually measured in from of resistance to penetration or deformation initial set refers to first stiffening; final set refers to attainment of significant rigidity.

Shotcrete (Pneumatically Applied Mortar) - Mortar or concrete pneumatically projected at high velocity into a surface; also known as air-blown mortar, also pneumatically applied mortar or concrete, sprayed mortar and gunned concrete.

Shoulder - An unintentional offset in a formed concrete surface usually caused by bulging or movement of for work.

Sieve Analysis - Determination of the proportions of particles lying within certain size ranges in a granular material by separation on sieves of different size openings.

Slip form (Moving or Sliding Form Work) - A form which moves, usually continuously during placing of the concrete. Movement may be either horizontal or vertical.

Slump - A measure of consistency of freshly mixed concrete mortar, or stucco equal to the subsidence measured to the nearest 6 mm. of the molded truncated cone immediately after removal of the slump cone.

Slump Cone - A mould in the form of a truncated cone with a base diameter of 20 cm, top diameter 10 cm and height 30 cm, used to fabricate a specimen of freshly mixed concrete for the slump test.

Slump Test - The procedure for measuring Slump.

Slurry - A mixture of water and any finely divided insoluble materials, such as portland cement, slag or soil, in suspension.

Soundness - The freedom of a solid from cracks, Flaws fissures, or variations from an accepted standard; in the case of cement, freedom from excessive volume change after setting; in the case of aggregate, the ability to withstand the aggressive action to which concrete containing it might be exposed particularly that due to weather.

Spacer - Device which maintains reinforcement in proper position, or wall forms at a give distance apart before and during concreting.

Spall - A fragment, usually in the shape of a flake, detached from a large mass by a blow, by the action of weather, by pressure, or by expansion within the larger mass.

Specific Gravity - The ratio of the mass of a unit volume of a material at a stated temperature to the mass of the same volume of a gas free distilled water at a stated temperature.

Steam Curing - Curing of concrete or mortar in water vapour at atmospheric or high pressures and at temperatures between 30^o and 215^o centigrade.

Subgrade - The soil prepared and compacted to support a structure or a pavement system.

Surface Water - Free water retained on surfaces of aggregate particles and considered to be part of the mixing water in concrete, as distinguished from absorbed moisture.

Swelling - Volume increase cause by wetting or chemical changes or both: a function of time but not of temperature or of stress due to external load.

Tamper - A hand operated device for compacting floor toping or other unformed concrete by the impact caused by dropping it repeatedly from a small height; in preparation for strike off and finishing; contact surface often consists of open-mesh screen or a grid of bars to force coarse aggregates below the surface to prevent interference with floating or trowelling.

Tamping - The operation of compacing freshly placed concrete by repeated blows.

Temperature Cracking - Cracking due to tensile failure, caused by temperature drop in members subjected to external restraints or temperature differential in members subjected to internal restraints.

Test Strength or Sample - the test strength of the sample shall be the average of the strength of three specimens. The individual variation should not be more than $\pm$ 15 percent of the average.

Texture - The pattern or configuration apparent in an exposed surface, as of concrete or mortar; including roughness, streaking, striation, or departure from flatness.

Tolerance - The permitted variation from a given dimension or quantity.

Tremie - a pipe or tube through which concrete is deposited under water, having at its upper end a hopper for filling and a bail by means or which the assembly can be handled by a derrick.

Triaxial Compression Test - A test in which a specimen is subjected to a confining hydrostatic pressure and then loaded axially to failure.

Vibrator - An oscillating machine used to agitate fresh concrete so as to eliminate gross voids, including entrapped air but not entrained air, and produce intimate contact with form surfaces and embedded materials.

Water Cement Ratio - The ratio of the amount of water, exclusive only of that absorbed by the aggregates, to the amount of cement in a concrete or mortar mixture; preferably stated as a decimal by weight.

Wearing Course - A topping or surface treatment to increase the resistance of a concrete payment or slab to abrasion.

Weathering - Changes in colour, texture, strength, chemical composition of other properties of a natural or artificial material due to the action of the weather.

Workability - That property of freshly mixed concrete or mortar which determines the case and homogeneity with which it can be mixed, placed, compacted, and finished. It is the amount of energy to overcome friction and cause full consolidation.

Yield - The volume of freshly mixed concrete produced from a known quantity of ingredients; to total weight of ingredient divided by the unit weight of the freshly mixed concrete; also the number of product units, such as block, produced per bag of cement or per batch of concrete.

7.3 METERIALS

7.3.1 Cement

7.3.1.1 Unless otherwise specified cement shall conform to the following Indian Standard Specifications.

(a) Ordinary portland cement 33 grade conforming to IS:265-1989

(b) Low heat portland cement conforming to IS:12600-1989

(c) Rapid hardening portland cement conforming to IS:8041-1978

(d) Portland slag cement conforming to IS:455-1976

(e) Portland pozzolana cement conforming to IS: 1489-1976

(f) Ordinary portland cement 43 grade conforming to IS:8112-1989

7.3.12 **Precautions and Guidelines for Use of cement** - The type of cement to be used shall be specified by the Engineer- in -charge. Following guidelines are given for use of different types of cement.

(i) Low heat portland cement conforming to IS:12600-1989 shall be used with adequate precautions with regard to removal of form work etc.

(ii) High alumina cement conforming to IS:6452-1972 shall be used only under special circumstances when directed by the Engineer-in-charge.

(iii) Supersulphated cement conforming to IS:6909-1973 shall be used only under special circumstances when directed by the Engineer-in-Charge. Option to use this type of cement should be taken with caution.

(iv) The use of portland pozzolana cement is recommended as substitute for ordinary portland cement for plain and reinforced concrete work in general building construction. in addition to 7 days compressive strength, IS:1489-1976 specifies the minimum 28 days compressive strength of portland pozzolana cement. However, for the reasons cited the rate of development of early strength may need somewhat longer curing period under field conditions, delayed removal of form work, etc. Portland Pozzolana cement also has the advantage or lower heat of hydration and better sulphate resistance.

(v) Portland pozzolana cement is not allowed for RCC work of bridges and prestress concrete. Portland slag cement to be used for prestress concrete, the slag content should not be more than 50%.

7.3.1.3 **Stacking and storage** - Other specification for cement such as "Supply" "Stacking and Storage" shall be as described under para 6.3.1.2 of ch.6 "Mortars".

7.3.1.4 Test on Cement - The usual tests made on cement are fineness, setting time, soundness, heat of hydration, compressive strength and chemical composition. All physical and chemical composition tests are carried out in accordance with the procedures described in IS:4032-1985 and the results may be compared with standard as given in Appendix I for guidance.

The cement shall be tested also for adulteration. The frequencies of each of these tests shall be one per every 50 tones.

The number of test specimen and the method of sampling shall be in accordance with the specification for the type of cement being tested and IS:3535-1986.

7.3.2 Aggregates

7.3.2.1 General - Natural sands and gravels are by far the most common and are used whenever they are of satisfactory quality and can be obtained economically in sufficient quantity. Crushed rock is widely used for coarse aggregate and occasionally for sand when suitable material from natural deposits are not economically available, although production of workable concrete from sharp, angular, crushed fragments usually requires more vibration and cement than that of concrete made with well rounded sand and gravel. It shall consist of (1) coarse aggregates most of which are retained on 4.75mm IS sieve, but the actual size shall be in accordance with the provisions of the following clauses.

7.3.2.2 Quality of Aggregates - Aggregates shall consist of naturally accuring (crushed or uncrushed) stone, gravels and sand or combination thereof. Aggregates shall be hard, strong, dense, durable, clean and free from veins and adherent coating, and free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky, scoriaceous and elongated pieces should be avoided.

7.3.2.3 Deleterious Materials - Aggregates shall not contain any harmful materials such as pyrites, coal, lignite, mica, shale or similar laminated materials, clay, alkali, soft fragments sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Aggregates to be used for reinforced concrete shall not contain any material liable to attack the steel reinforcement Aggregates which are chemically reactive with alkalies of cement are harmful as cracking of concrete may take place,

The maximum quantity of deleterious materials shall not exceed the limits specified in table I as given below, when tested in accordance with IS: 2386- 1977. However the Engineer-in-charge at his decision, may relax some of the limits as a result of some further tests and evidence of satisfactory performance of the aggregates.

Table - 1

LIMITS OF DELETERIOUS MATERIALS

(Para 7.3.2.3)

			Fine aggregate percentage by Weight, maximum		Coarse aggregate percentage by weight, maximum	
			Uncrushed	Crushed	Uncrushed	Crushed
1	2	3	4	5	6	7
i)	Coal and lignite	IS:2386 (Pt.II) 19777	1.00	1.00	1.00	1.00
ii)	Clay lumps	- do -	1.00	1.00	1.00	1.00
iii)	Materials finer than 75- micron IS Sieve	IS:2386 (Pt.I)1977	3.00	15.00	3.00	3.00
iv)	Soft fragments	IS:2386 (Pt.II) 1977	-	-	3.00	-
v)	Shale	--do--	1.00	-	-	
vi)	Total of percentage of all deleterious materials (except mica) including Sl.No. (i) to (v) for col. 4, 6 and 7 and Sl.No. (i) and (ii) for col. 5 only.	-	5.00	2.00	5.00	5.00

NOTE 1- The presence of mica in the fine aggregate has been found to reduce considerably the durability and compressive strength of concrete and further investigations are under way to determine the extent of the deleterious effect of mica. it is advisable, therefore, to investigate the extent of fine aggregate and make suitable, allowances for the possible reduct8ion in the strength of concrete or mortar.

NOTE 2 - The aggregate shall not contain harmful organic impurities (tested in accordance with IS:2386 (part II)-1977) in sufficient quantities to affect adversely the strength or durability or concrete. A fine aggregate which fails in the test for organic impurities may be used, provided that, when tested for the effect of organic impurities on the strength of mortar, the relative strength at 7 and 28 days, reported in accordance with pare 7 of IS: 2386(Part Vi) - 1977 is not less than 95 percent.

7.3.2.4 Mechanical and physical Properties - Mechanical and physical properties shall be as describe in table 2 below:

Table:2

MECHANICAL AND PHYSICAL PROPERTIES

S.No.	Test result	Specified limits of result	
		Concrete other than for wearing surfaces	Concrete for wearing surfaces
(1)	(2)	(3)	(4)
1.	Crushing value	shall not exceed 45%	shall not exceed 30%
2.	Ten percent fines value	shall not be less than 5 tonnes	shall not be less than 10 tonnes
3.	Impact value by weight	shall not exceed 45%	shall not exceed 30%
4.	Abrasion value by losangles machine	shall not exceed 50%	shall not exceed 30%
5.	Flakiness Index	Not greater than 25%	As per col.3

soundness of Aggregate - For concrete liable to be exposed the action of frost, coarse and fine aggregates shall pass a sodium or magnesium sulphate accelerated soundness test specified in IS: 2386(Part V)-1977, the limits being set by agreement between the purchaser and supplier, except that aggregates failing in the accelerated soundness test may be used if they pass a specified freezing and thawing test as described in IS:2386(Pt-V)1977, satisfactory to the user.

As general guide it may be taken that the average loss of weight after 5 cycles shall not exceed the following:

(a) For fine aggregate	10percent when tested with sodium sulphate (Na_2SO_4) and 15 percent when tested with magnesium sulphate ($MgSO_4$)
(b) For coarse aggregate	12 percent when tested with sodium sulphate (Na_2SO_4), and 18 percent when tested with magnesium sulphate ($MgSO_4$)

7.3.2.5 Size and Grading of Aggregates

7.3.2.5.1 Size and Grading of Coarse Aggregate - Nominal maximum size of coarse aggregate shall be as specified in approved drawing of work. For any one of the nominal sizes, the proportion of other sizes shall be in accordance with table 4. Graded coarse aggregate may be used in the nominal size of 40 mm, 20mm, 16mm, 12.5mm, Grading of graded coarse aggregate shall be also in accordance with table 3.

For any one of the nominal of coarse aggregate for mass concrete works, the proportions of other sizes shall be as specified in table 4.

Table:4

SIZES OF COARSE AGGREGATE FOR MASS CONCRETE

Class and size	IS Sieve designation	Percentage passing
1	2	3
Very large, 150 to 80 mm	160 mm * 80 mm	90 to100 0 to 100
Large, 80 to 40 mm	80 mm 40 mm	90 to 100 0 to 10
Medium, 40 to 20 mm	40 mm 20 mm	90 to 100 0 to 10
Small, 20 to 4.75 mm	20 mm 4.75 mm 2.36 mm	90 to 100 0 to 10 0 to 2

* There being no I S Sieve having an aperture larger than 100 mm a perforated plate complying with I S: 2405-1980 and having a square aperture of 160 mm may be used.

However, if nominal maximum size of aggregate is not specified drawing, it may be adopted with the permission of Engineer-in-charge on basis of some guidelines given below:

TABLE:3 COARSE AGGREGATE

(para 7.3.2.5.1)

	Percentage passing for single- sized Aggregate of nominal size						Percentage passing fo	
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm
1	2	3	4	5	6	7	8	9

80 mm	100	-	-	-	-	-	100	-
63 mm	85 to 100	100	-	-	-	-	-	-
40 mm	o to 30	85 to 100	100	-	-	-	95 to 100	100
20 mm	o to 5	o to 20	85 to 100	100	-	-	30 to 70	95 to 100
16 mm	-	-	-	85 to 100	100	-	-	-
12.5 mm	-	-	-	-	85 to 100	100	-	-
10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55
4.75 mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10
2.36 mm	-	-	-	-	-	0 to 5	-	-

7.3.2.5.2 Guide lines

(i) The nominal maximum size of aggregate shall be as large as possible within the limits specified but in no case greater than one- fourth of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. For reinforced concrete work, aggregates having nominal size of 20 mm are generally considered satisfactory.

(ii) for heavily reinforced concrete members as in the case of ribs of main beams, the nominal maximum size of the aggregate should usually be restricted to 5 mm less than the minimum clear distance between the main bars or 5 mm less than the minimum cover to the reinforcement whichever is smaller. Where the reinforcement is widely spaced as in solid slabs limitations of the size may sometimes be as great as or greater than the minimum cover.

(iii) Following maximum nominal sizes of aggregate for different sizes of section and zone are given in table 5 & 6.

TABLE 5

Maximum Size of Aggregate recommended for Various Types of Construction

	Maximum size of aggregate (mm)

	Non reinforced well	R.C. walls beams and columns	Lightly reinforced of non reinforced Slabs	Heavily reinforced slabs
(1)	(2)	(3)	(4)	(5)
65 to 130	20	12 to 20	20 to 40	20 to 30
150 to 280	40	20 to 40	40 to 75	40
305 to 740	80	40 to 75	75	40 to75
750 to above	160	75 to 150	75 to 150	40 to 75

TABLE 6

Maximum Size of Aggregate for Dam and Appurtenant Works

S.No.	Location of use	Maximum aggregate size in mm
(1)	(2)	(3)
1	Filling crevices in foundation of non over flow and over flow section	40
2	Spillway and training wall sections (except exterior thickness shown in drawing)	75
3	spillway crest, glacis, u/s face of spillway, bucket, divide wall and water face of training wall (60 cm)	75
4	All around galleries, adits, sump well, pump chamber, contraction joint and other openings.	40
5	Sandwich concrete	75
6	Deck bridge	20
7	Top 60 cm of bucket	40
8	Bucket teeth	20
9	Block out concrete for embedded parts of gates,	20
10	Foundation for divide/training wall	75
11	R.C.C. wall curb, stening and piles	40
12	P.C.C well stening	63
13	Well cap of pile, solid type piers, abutments & wing walls & their pier caps.	40
14	R.C.C bearings	20

7.3.2.5.3 size and grading of fine aggregate (sand) - The grading of fine aggregate shall be within the limits given in table 7 and shall be described as fine aggregate, grading Zone I,II,III, IV where the grading falls out side the limits of any particular zone of sieves other than 600 micron IS Sieve by a total amount not exceeding 5%, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron IS Sieve or to percentage passing any other sieve size on the course limit of grading Zone I or the finer limit of grading Zone IV.

Very fine sands as included in Zone IV grading should not be used except when the concrete is closely controlled.

TABLE 7 FINE AGGREGATE

	Percentage passing for			
	Grading Zone-I	Grading Zone-II	Grading Zone-III	Grading Zone-IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 Micron	5-20	8-30	12-40	15-50
150 Micron	0-10	0-10	0-10	0-15

Note:1 - For crushed stone sands, the permissible limit on 150 - micron, IS Sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted under para 7.3.22.5.3 applying to other sieve sizes.

Note:2 - Fine aggregate complying with the requirements of any grading zone in this table is suitable for concrete but the quality of concrete produced will depend upon a number of factors including proportions.

Note:3 - Where concrete of high strength and good durability is required, fine aggregate conforming to any one the four grading Zones may be used, but the concrete mix should be properly designed. As the fine aggregate grading becomes progressively finer, that is, from Grading Zones I to Iv, the ratio of fine aggregate should be progressively reduced. The most suitable fine to coarse ratio to be used for any particular mix will however, depend upon the actual grading, particle shape and surface texture of both fine and coarse aggregates.

Note:4 - it is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless testes have been made to ascertain the suitability of proposed mix proportions.

7.3.2.5.4 ***All- in- aggregates*** - "All in-Aggregate" are generally not found suitable for making concrete of high quality. it shall be used only where specifically permitted by the Engineer-in-charge. If combined aggregate are available they need not be separated into the fine and coarse, but necessary adjustments may be made in aggregate" shall be in accordance with table 8.

TABLE 8

ALL- In-Aggregate Grading

	Percentage passing for All-in-Aggregate of	
	40 mm Nominal size	20 mm Nominal size
80 mm	100	-
40 mm	95 to 100	100
20 mm	45 to 75	95 to 100
4.75 mm	25 to 45	30 to 50
600 Micron	8 to 30	10 to 35
150 Micron	0 to 6	0 to 6

7.3.2.6 ***Bulking of sand -*** In volume batching, sand is assumed to be dry. Dry and saturated sands have almost the same volume, but damp sand increases in volume. Bulking depends primarily upon moisture content and marginally on grading of sand. Due allowance for bulking of sand shall be made, while preparing the concrete mixes based on volume measurement.

The bulking allowance of any sample of sand shall be determined in accordance with procedure given in Appendix II.

7.3.2.7 ***Handling and Storage*** - Aggregates shall be stored on a clean hard face and maintained free from loam and vegetable matter and exposure to dust or any other contamination. Aggregates of different types and Sizes shall be stored in separate heaps to avoid mixing up. On large job it is desirable to construct dividing walls to give each type of aggregate its own compartment fine aggregates shall be stocked in a place where loss due to the effect of wind is minimum. The aggregates shall be handled in such a manner as to minimize the breakage of particles. Unless specified otherwise or necessitated by site conditions stacking of the aggregate should be carried out in regular stacks. The suggested sizes for stacks are given in table 9.

TABLE- 9

			Size of stack (in meters)	
		Length	Breadth	Height
i)	Soling stone	5.0	2.0	0.50
	or	5.0	1.0	0.50
ii)	Coarse aggregate	2.0	2.0	0.50
	or	5.0	5.0	1.00
	or	5.0	1.0	0.50
iii)	Fine aggregate	2.0	2.0	0.50
	or	5.0	5.0	1.00
	or	5.0	1.0	0.50

7.3.2.8 ***Sampling and Testing*** - Sample of aggregates for use on a particular major work shall be sent to the laboratory at least 35 days before commencement for use in the works and used only after obtaining the approval.

If during the course of work the source or type of any material be changed the samples shall be tested and used only after approval by the competent authority

The method of sampling shall be in accordance with IS:2430-1986 and tests shall be carried out as described in IS:2386-1977.

7.3.3 **Plums**

7.3.3.1 All Plums shall be hard, durable, clean and free from soft materials or loose pieces or deleterious substances embedded in them and shall not have sharp corners. The plums shall be free from adhering films or coatings and the crushing value of plums shall not be less than that specified for coarse aggregate.

7.3.3.2 ***Size of Plums*** - In mass concrete members, stone plums from 150 mm to 300 mm size may be used. The maximum dimensions of these stones or plums shall not exceed 1/3red the least dimension of the member.

7.3.3.3 ***Storage*** - Materials shall be so stored as to prevent their deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

7.3.4 Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other Substances that may be deleterious to concrete or steel. Potable water (the exception being water containing sugar) is generally considered satisfactory for mixing concrete. As a guide the following concentrations represent the maximum permissible values.

(a) To neutralize 200 ml sample of water using phenolphthalein as an indicator, it should not require more than 2 ml of 0.1 normal Na OH.

(b) To neutralize 200 ml sample of water using methyl orange as an indicator, it should not require more than 10 ml of 0.1 normal HCI.

(c) Percentage of some impurities and solids shall not exceed the limits given in Table 10 and 11 respectively.

7.3.4.1 In case of regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests specified in 7.3.4.1.2 and 7.3.4.1.3.

7.3.4.1.1 The sample of water taken for testing shall represent the water proposed to be used for concreting, due account being paid to seasonal variation., The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.

7.3.4.1.2 Average 28 days compressive strength of at least three 15 mm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS:516-1959

7.3.4.1.3 The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by ± 30 minutes from the initial setting time of control test blocks prepared with the same cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of IS:4031-1988.

7.3.4.2 The PH value of water shall generally be not less than 6.

TABLE 10

CONCENTRATION OF SOME IMPURITIES IN MIXING WATER

WHICH CAN BE CONSIDERED AS TOLERABLE

Sl. No.	Impurity	Maximum Tolerable Concentration
1)	Sodium and potassium carbonates end bicarbonates	1000 ppm (total) (If this is exceeded. tests for setting time and 28 days strength should be made
2)	Sodium chloride	20000 ppm
3)	Sodium sulphate	10000 ppm
4)	Calcium and magnesium bicarbonates	400 ppm of bicarbonate ion
5)	Calcium chloride	2 percent by weight of cement in plain concrete
6)	Iron salts	40000 ppm
7)	Sodium iodate, phosphates, arsanate and berate	500 pmm
8)	Sodium sulphide	Even 100 ppm warrants testing
9)	Hydrochloric and sulphuric and other common inorganic acid	10000 ppm
10)	Sodium Hydroxide	0.5 percent by weight of cement if set not affected
11)	Silt and suspended particles	2000ppm

TABLE - 11

PERMISSIBLE LIMIT FOR SOLIDS

(para 7.3.4)

Solids	Permissible Limit, Max mg/1
Organic	200
Inorganic	30000
Sulphates (as SO)	500
Chloridess (as CI)	2000 for plain concrete work 1000 for reinforced concrete work
Suspended matter	2000

7.3.4.3 ***Storage of Water* -** Where water is to be stored for construction purposes this shall be done in proper storage tanks to prevent any organic impurities getting mixed up with it.

7.3.5 Admixtures

7.3.5.1 Admixtures may be used with the approval of the Engineer-in charge for special purpose or for imparting special characteristics to the concrete on satisfactory evidence that the use of such admixtures does not adversely affect the properties of concrete particularly with respect to strength,, volumes change, durability and has no deleterious effect on reinforcement and wherever so permitted the correct proportion and the method of use shall be as fixed by laboratory. the admixture shall conform to IS:9103-1979.

Materials permitted as admixtures shall have established merit for any of the following purpose:

(i) Improvement of workability

(ii) Reduction of heat evolution

(iii) Decrease in permeability

(iv) Increase in durability

(v) Accelerating of hardening, setting or strength

(vi) Increase in unit weight

(vii) Retardation of setting time

(viii) Increase in shear and bond

7.3.5.2 Before using an admixture in concrete its performance should be evaluated by comparing the properties of concrete with the admixtures and concrete without any admixture. The chloride content of the admixtures shall be declared by the manufactures. The physical requirements of an admixture shall be as per Appendix - III

7.3.5.3 **Information on Admixtures** - to facilitate approval of an admixture the following information is needed:

(a) The trade name of the admixture, its source, and the manufacture's recommended method of use;

(b) Typical dosage rates and possible detrimental effects of under and over dosage;

(c) Whether compounds likely to cause corrosion of reinforcement or deterioration of concrete (Such as those containing chloride in any form as an active ingredient) are present and if so,, the chloride ions by mass or expressed as equivalent anhydrous calcium chloride by mass of admixtures; and

(d) The average expected air content of freshly mixed concrete containing an admixture which causes air to be entrained when used at the manufacture's recommended rate of dosage.

7.3.6 Pozzolana

Pozzolanic materials conforming to relevant Indian Standards may be used with permission of the Engineer-in-Charge. Calcined pozzolana shall conform to IS: 13344-1981

7.3.7 Fly Ash

Fly ash may be used as an admixture or part replacement of fine aggregate or unblended cements (provided uniform blending with the cement is ensured) with the permission of Engineer-in charge. Fly ash shall conform to IS:3812-1981).

7.3.8 Reinforcement

Quality and other specifications of reinforcement shall be as laid down under Ch. 13 "Steel and Iron Work".

7.4 GRADE OF CONCRETE AND TYPE OF MIX

7.4.1 General

Concrete is composed of sand, gravel, crushed rock, or other aggregates held together by a hardened past of hydraulic cement and water. The thoroughly mixed ingredients, when properly proportioned, make a plastic mass which can be cast or moulded into a predetermined size and shape. Upon hydration of the cement by the water, concrete becomes stone like in strength and hardness and has utility for may purposes.

7.4.2 Grade of concrete

The concrete shall be in grades designated as per Table 12.

TABLE 12 GRADE OF CONCRETE

Grade designation	Specified characteristic compressive strength At 28 days (N/mm2)
M5	5
M7.5	7.5
M 10	10
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40

Note - In the designation of a concrete mix, latter M refers to the mix and the number to the specified characteristic compressive strength of 15 cm cube at 28 days, expressed in N/mm2.

Note2 - M5 and M 7.5 grades of concrete may be used for lean concrete bases and simple foundation for masonry wall. These mixes need not designed

Note 3 - Grades of concrete lower than M 15 shall not be used in reinforced concrete.

Note 4 - Grades of concrete lower than M 30 shall not be used in past tensioned prestressed concrete & M 40 for pretensioned prestressed concrete.

7.4.3 Classification of Concrete

Concrete can be classified either as "Nominal mix concrete" or "Designed Mix concrete" as specified below:

Designed Mix - Where the mix proportion are fixed by designing the concrete mixes is called "Designed Mix"

Nominal Mix - Where nominal concrete mix is adopted, such concrete shall be called "Nominal concrete mixes.

7.5 CONCRETE MIX PROPORTIONING

7.5.1 Mix Proportion

The mix proportion shall be selected to ensure that the workability of the fresh concrete is suitable for the conditions of handling and placing, so that after compaction it surrounds all reinforcements and completely fills the formwork. When concrete is hardened, it shall have the required strength, durability and surface finish.

7.5.2 Determination of proportions

7.5.2.1 The determination of proportion of cement, aggregates and water to attain the required strengths shall be made as follow:

(a) By designing the concrete mix

(b) By adopting nominal concrete mix

Design mix concrete is preferred to nominal mix. The nominal mix concrete should be restricted to works of minor nature in which the strength of concrete is not critical. If design mix concrete cannot be used for any reason on the work for grades of M20 or lower, nominal mixes may be used with the permission of Engineer-in-Charge.

7.5.2.2 ***Information Required*** - in specifying a particular grade of concrete, the following information shall be included.

(a) Type of Mix,, that is, design mix concrete or nominal mix concrete;

(b) Grade designation as specified in table 12

(c) Type of cement

(d) Maximum nominal size of aggregate;

(e) Minimum cement content (for design mix concrete);

(f) Maximum water cement ration;

(g) workability; and

(h) Mix proportion (for nominal mix concrete).

In appropriate circumstances, the following additional information may be specified.

(a) Type aggregate,

(b) Maximum cement content, and

(c) Whether an admixture shall or shall not be used and the type or admixtures and the conditions of use.

7.5.2.3 ***Design Mix Proportioning -*** The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in table 12.

As long as the quality of the materials does not change done earlier may be considered adequate for later work.

7.5.2.4 ***Nominal Mix Proportioning***

7.5.2.4.1 **Nominal Mix by weights** - The proportions of materials for nominal mix shall be as given in table 13 on the basis of weight of cement and aggregates.

TABLE 13

Proportions for Nominal Mix Concrete

Grade of	Total quantity of dry	Proportions of	Quantity or water per 50 kg of cement (Max)
concrete	Aggregates by Mass per 50 kg of cement, to be taken as the sum of the individual masses of fine and coarse aggregates, (Max) kg	fine aggregate to coarse aggregate (By Mass)	liter
1	2	3	4
M 5	800	Generally	60
M 7.5	625	1:2 but subject to	45
M 10	480	an upper limit of 1:1.5	34
M 15	350	and a lower limit of	32
M 20	250	1:2.5	30

NOTE - The proportion of the fine to coarse aggregates should be adjusted from upper limit ot lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used.

Example - for average grading of fine aggregate (that is Zone II of Table6 . the proportions shall be 1:1$^{1/2}$, 1:2 and 1:2 $^{1/2}$ for maximum size of aggregate 10 mm,, 20 mm and 40 mm respectively.

7.5.2.4.2 ***Nominal mix concrete by volume*** - mix proportion by volume under special circumstances, may be permitted by Engineer-in-Charge. A rough guide for the nominal mix proportions by volume will be 1:4:8, 1:3:6, 1:2:4 and 1:1:5:3 for M7.5 M10, M15 and M20 concrete respectively.

For cement which normally comes in bags and is used by weight, volume shall be worked out taking 50kg of cement as 0.035 cum in volume. The quantity of water per 50 kg (0.035 cum) of cement shall be as specified in table 13.

7.5.2.4.3 **Limitations of Nominal Mix Proportions** - The nominal mix proportion in para 7.5.2.4.1 and 7.5.2.4.2 shall be valid, provided that:

(1) Nominal maximum size of aggregate is 20 mm. For other sizes of aggregates, adjustments in the ratio of the weight/volume of coarse and fine aggregates will be necessary as indicated in the note below table 13.

(ii) The aggregate to be used shall be dry; if not, corrections for bulking of sand (is required only in case of nominal mix by volume) and surface water of aggregate shall apply.

(iii) In all cases of nominal mix, fine aggregates shall conform to the grading of Zone II or Zone III as described in table 7 of para 7.3.2.5.2 "Size and Grading of Fine Aggregate"

7.5.2.4.4 ***Guidelines for Nominal Mix Proportioning***

1) The cement content of the mix specified in table 13 for any nominal mix shall be proportionate by increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction. so that the water cement ratio as specified is not exceeded.

In case of vibrated concrete, the limit of quantity of water specified in table 13 may be suitably reduced to avoid segregation.

2) Allowance for bulking of sand is necessary only in case of volume batching as described in para 7.3.2.6. However allowance for surface water carried by aggregate should be made in all cases.

In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in table 14.

TABLE - 14

Surface Water Carried by Aggregate

	Approximate quantity of surface water	
	Percent by Mass	liter/cum
Very wet sand	7.5	120
Moderately wet sand	5.00	80
Moist sand	2.5	40
*Moist gravel or crushed rock	1.25 to 2.5	20 to 40

*Coarser the aggregate, less the water it will carry

3) if nominal mix concrete made in accordance with the proportions given for particular grade does not yield the specified strength, such concrete shall be classified as belonging to the appropriate lower grade. Nominal mix concrete proportioned for given grade in accordance with table 13, it shall not, however, be placed in higher grade on the ground that the test strength is higher than the minimum specified.

7.6 QUALITY OF CONCRETE

7.6.1 General

After materials have been selected and relative proportions determined, its use should be controlled to best advantage. Purpose of field control involves correct procedures of proportioning, missing, handling, placing and curing Field control governs quality, uniformity and ultimate economy of the structure. Much potential value of first class materials and optimum proportioning may be lost through ineffective control of these procedures. The poorer the quality of the ingredients, the greater the need for rigid control to attain satisfactory durability and strength and therefore maximum serviceable life.

7.6.2 Field Control

The quality of all concrete shall be strictly controlled throughout the job. The optimum proportion of all ingredients will be determined through extensive laboratory tests of concrete made from the type of cement and kind of aggregates proposed for the work.

In case of specified nominal mix, the proportion of ingredients shall be as described under para 7.5.2.4 "Nominal Mix Proportioning".

The preliminary tests shall be completed well before the beginning of concreting operations and a complete report on the concrete forming qualities and suitability of available aggregates as also recommendations for their use at the work shall be made and approved by the Engineer-in-Charge before actual concreting is started.

No substitutions in the materials used on the work or alterations in the established proportions (except correction made for bulking of sand in case of volume batching and content on surface of aggregate) shall be made unless additional tests have been conducted to show that the quality and strengths of the resulting concrete are satisfactory.

The Engineer-in-Charge may carryout check tests and order changes in the mix as may be necessary from time to time to maintain the specified quality of the work. No radical changes, substitutions and additions in the mix, shall be made without such check tests and subsequent approval.

7.6.3 ***Workability -*** From the stage of mixing till it is transported, placed in the formwork and compacted, fresh concrete should satisfy a number of requirements as mentioned below.

a) The mix should be stable, in that it should not segregate during transportation and placing. The tendency of bleeding should be minimized.

b) The mix should be cohesive and mobile enough to be placed in the form around the reinforcement and should be able to cast into the required shape.

c) The mix should be amenable to proper and through compaction as possible in the situation of placing and with the facilities of compaction.

d) It should be possible to obtain a satisfactory surface finish.

The above requirements of stability, mobility, compactability placeability and finishability of fresh concrete mentioned above are collectively referred to as "workability". Optimum workability or concrete varies from situation to situation and concrete which can be termed as workable for pouring into large sections with minimum reinforcement may not be equally workable for pouring in thin section with heavier concentration of reinforcement. A concrete may not be workable when compacted by hand but may be satisfactory when mechanical vibration is used.

7.6.3.1 **Measures of workability** - There are following three methods for measuring the workability.

a) Slump test

b) Compacting factor test

c) Vee - Bee consistency test

a) **Slump test** - This test is most widely used, primarily because of the simplicity of the apparatus required and the test procedure. Slump test is essentially a measure of consistency or witness of the mix. This test is suitable for concretes of medium to high workability i.e. slump 25 to 125 mm. For very stiff mixes zero, slump, the slump test does not indicate any difference in concretes of different workability.

b) **Compacting Factor Test-** it is the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete. This test is more accurate than slump test and it is suitable for concrete mixes of medium and low workability that is compacting factor of 0.9 to 0.8 This test is conducted as per procedure laid down in IS:1199-1959.

c) **Vee Bee Test** - This test is conducted with the Vee Bee apparatus and is measured in terms of time of Vibrations in seconds, required to transform the concrete sample from a truncated cone (remaining after removal of the cone) into a eight cylinder; the time is assumed directly proportional to the energy used in compacting sample. This test is preferred for stiff concrete mixes having low or very low workability. Detailed procedure of this test is given in IS:1199-1959.

7.6.3.3 The choice of workability depends upon the type of compacting equipment available, the size of the section and concentration of reinforcement. For heavily reinforced sections or when the sections are narrow or contain inaccessible parts of when the spacing of reinforcement makes placing and compaction difficult, concrete should be highly workable for full compaction to be achieved with a reasonable amount of effort. The table 15 gives ranges of workabilities required in term of slump, compacting factor and vee-bee time for concrete depending upon placing conditions at site. The nominal maximum size of aggregates makes a difference in degree of workability that may be suitable under a particular placing condition. The values in the table are only a guide notwithstanding the situation at hand and should be properly assessed to arrive at the desired workability in each case. Insufficient workability resulting in incomplete compaction may severely affect the strength, durability and surface finish of concrete and be uneconomical in the long run. The effectiveness of vibration equipment available should also be assessed.

However, for guidance suggested ranges of values of workability of concrete to some placing conditions, measured in accordance with IS:1199-1959 are give below:

TABLE : 15

Placing conditions	Degree of workability	Value of workability
(1)	(2)	(3)
Concreting of shallow sections with vibration	Very low	20-10 second, vee-bee time or 0.75-0.80, compacting factor
Concerting of lightly reinforced sections with vibration	Low	10-15 seconds Vee- Bee time or 0.80-0.85 compacting factor
Concreting of lightly reinforced sections without vibration,, or heavily reinforced section with vibration	Medium	5-2 seconds, vee-bee time or 0.85-0.92,compacting factor or 25-75mm, slump for 20mm aggregate
Concreting of heavily reinforced sections without vibration	High	Above 0.92, compacting factor or 75-125mm,, slump for 20mm aggregate

Note :- For smaller aggregate the values of slump will be lower.

7.6.4 Durability

The durability of concrete depends on its resistance to deterioration and the environment in which it is placed. The resistance of concrete to weathering, chemical attack, abrasion, frost and fire depends largely upon its quality & constituent materials . Susceptibility to corrosion of the steel is governed by the cover provided and the permeability of concrete. The cube-crushing strength alien is not a reliable guided to the quality and durability of concrete; it must also have an adequate cement content and a low water cement ratio

One of the main characteristics influencing the durability of any concrete is it permeability.. With strong, sense aggregates, a suitably low permeability is achieved by having a sufficiently low water-cement ratio, by ensuring as thorough compaction of the concrete as possible and by ensuring sufficient hydration of cement through proper curing methods. Therefore, for given aggregates, the cement content should be sufficient to provide adequate workability with a low water cement ratio that concrete can be completely compacted with the means available.

Appendix IV provides guidance regarding minimum cement content and permissible limits of chloride and sulphate in concrete.

7.7 PRODUCTION AND CONTROL OF CONCRTE

7.7.1 General

Salt, clay powdery coating soluble chemical salts and light weight materials are usually removable by washing. Aggregates should be washed before batching with clean water free from alkali, salt and other impurities.

7.7.2 Batching

7.7.2.1 ***Measurement of Materials -*** The method of measuring materials for concrete shall be such that the proportions are controlled and readily checked at any time during the progress of the work. Materials shall be measured as per procedure given below.

Weigh Batchers - All weighing devices shall be subject to approval and weigh batchers shall meet the following requirements:

a) The accuracy shall be of the order-set for the purpose and shall be such that indicated weight of any hopper full of material does not vary more than one percent from the required weight.

b) The weighing equipment shall be designed to permit ready and [roper adjustment of the proper of the mix.

c) The equipment shall be capable of so controlling the rate of delivery of each kind and size of materials the combined inaccuracy in feeding and measure during normal operations does not exceeds 3 percent of all aggregates, and 1 perfect fir water.

d) The operating mechanism measuring the amount of water shall be such that no leakage with the calves closed. The filling and discharge valves shall not be opened before the filling valve is closed.

e) Test scale weight shall be provided and periodic checks made of the accuracy of all weighing equipment.

7.7.2.2 To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant.

A competent person shall supervise all stages of production of concrete. Preparation of test specimens and site test shall be properly supervised.

7.7.2.3 In proportioning concrete, the quantity of both cement end aggregate should be determined by mass. Where the mass of cement is determined on the basis of mass of cement per bag, a reasonable number of bags should be weighed bags it should be weighed periodically to check the net mass. Where the cement is weighed on the site and not in bags it should be weighed separately from the aggregate. Water should be either measured by volume in calibrated tanks or weighed. Any solid admixture that may be added, may be measured by mass; liquid and paste admixtures by volume or mass. Batching plant where used should conform to IS:4925-1968.

7.7.2.4 Except where it can be shown to the satisfaction of the engineer-in-Charge that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate should be controlled by obtaining the coarse aggregate in different size and blending them in the right proportions when required, the different sizes being stacked in separate stock piles. The material should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge to ensure that the specified grading is maintained.

7.7.2 5 In case uniformity in the materials used for concrete making has been established over a period of time, the proportioning may be done by volume batching, provided periodic checks are made on mass/volume relationships of the materials. Where weight-batching is not practicable, the quantities of fine and coarse aggregate (but not cement) may be determined by volume with the permission of Engineer- in-charge. If fine aggregate is moist and volume batching is adopted, allowance shall be made for bulking in accordance with para 7.3.2 6 "Bulking of Sand"

A detailed not "How to batch concrete by volume" has been appended vide Appendix VI."

7.7.2.6 It is important to maintain the water cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregate shall be made as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge according to weather conditions. The amount of the added water shall be adjusted to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregate, IS:2386 (Part III) 1977 may be referred to. To allow for the variation in mass of aggregate due to variation in their moisture content, suitable adjustments in the masses of aggregates shall also be made.

Aggregate shall not be batched when free water is dripping from the aggregate.

7.7.3 Mixing

7.7.3.1 The mixing of concrete shall be done in a batch mixer of such approved type as will ensure the homogeneous distribution of all ingredients. The plant shall be so designed and operated that all materials entering the mixer including water can be accurately proportioned and readily controlled. The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete should be remixed.

The entire batch within the mixer shall be discharged before recharging. The volume of mixed material per batch shall not exceed the manufacturer's rated capacity.

7.7.3.2 ***Efficiency and Performance of Mixer***

7.7.3.2.1 The efficiency and performance of the mixer shall be periodically checked. The mixing efficiency, that is an index of the uniformity of the mixed concrete, can be evaluated by finding the percentage variation in quantity of cement, fine aggregate and coarse aggregate in freshly mixed batch of concrete. The percentage variation between the quantities of cement, fine aggregate and coarse aggregate (as found by weighing in water) in the two halves of the batch and the average of the two halves of the batch shall not exceed the following limits.

Cement	8 percent
Fine aggregate	6 percent
Coarse aggregate	5 percent

The mixer shall comply with 1S:1791-1985 and its performance should be tested according to IS:4634 -1968.

7.7.3.2.2 A mixer will be considered unsatisfactory if from three testes of any one batch a range in slump exceeding 25 mm or a range in air content exceeding one percent is given between reprehensive sample taken at different portions of the mixer discharge.

7.7.3.2.3 For any one mix. the variation in the air tree unit weights of three samples taken from the front, center and back of a batch of concrete in the mixer, shall not exceed the following:

For one batch	37.2 kg per cum
Average of 3 Batches	23.9 Kg per cum,
Average of 20 batches	1 9.4 Kg per cum
Average of 90 batches	14. 6 Kg per cum,

7.7.3.3 Method of Charging **-** The proper sequence of operations for the admission of aggregates into any type of mixer shall be ascertained by trial runs conducted in order to determine the method giving the best results. The following sequence of charging the mixer may be adopted:

a) Five to ten percent of the total quantity of water required for mixing adequate to wet the drum thoroughly, shall be introduced before the other ingredients in order to prevent any caking of cement on the blades or sides of the mixers.

b) All dry ingredients (cement and both fine and coarse aggregates) shall be simultaneously ribboned I to the mixer in such a manner that the period of flow for each ingredient is about the same, Eighty to ninety percent of the total quantity of water required for mixing shall be added uniformly along with the dry ingredients.

c) The remaining quantity of water shall be added after all the other ingredients are in the mixer.

d) Cobbles or a portion of the coarsest aggregate, however, may be added last this facilitates the clearance or the chutes and removes any fine aggregate or cement adhering to the sides.

7.7.3.4 ***Time of Mixing***

Unless otherwise permitted, machine mixing of each batch shall continue for not less than the period indicated in Table 16. During this period the drum shall be rotated at a speed recommended by the manufacturer. The mixing period shall be timed after all materials, including water, are in the drum.

TABLE - 16 TIME OF MIXING

	Time of mixing	
	Natural aggregate	Manufactured aggregate
One cubic meter or less	1 ¼ Minutes	1 ½ Minutes
Two cubic meters	1 ½ minutes	2 minutes
Three cubic meters or larger	2 minutes	2 ½ minutes

7.7.3.5 Each mixer shall have a mechanically operated timing device for signaling the completion of the required mixing period. The actual time of mixing shall be checked at least twice during each shift and the timing device shall be adjusted if in error.

The timing device shall be so interlocked with the discharge gate of the batch hopper that timing does not start until the discharge gate is fully closed and all ingredients are in the drum. A suitable record shall be kept of the average time consumed in charging, mixing and discharging a batch during each run.

Excessive mixing, necessitating the addition of water to provide workability shall avoided.

7.7.3.6 **Discharging -** The full contents of the drum shall be discharged quickly so as to avoid segregation.

When the mixer is stopped and has been out of use for more than 30 minutes before placing again any Ingredients in the mixer ell hardened concrete or mortar shall be removed from the inner surface of the mixer.

The first concrete batch at the start of the day's work snail be made richer by 10%, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregates.

7.7.3.7 ***Retempering*** - The retempering of partially hardened concrete or mortar requiring renewed mixing, with or without the addition Of cement, aggregate or water, shell not be permitted

7.7.4 **Hand Mixing**

Hand mixing shall be avoided In mess concrete construction. When hand mixing is permitted by the Engineer-in-Charge far small jobs or for certain other reasons, it shall be done on a smooth watertight platform large enough to allow efficient turning over or the ingredients of concrete before and after adding water. Mixing platform shall be so arranged that no foreign material shall get mixed with concrete nor does the mixing water flow out. Cement in required number of bags shall he placed in a uniform layer on top of the measured quantity of fine aggregate, which shall also be spread in a layer of uniform thickness on the mixing platform. Dry sand and cement shall then be mixed thoroughly by turning over to get a mixture of uniform colour. Enough water shall then be added gradually through a rose and the mass turned over till a mortar of required consistency is obtained. Measured quantity of coarse aggregate shall then be placed on the mixing platform and wetted till the mortar and mixture obtained is of uniform colour and required consistency. In hand mixing quantity of cement shall be increased by 10 percent more than the quantity provided in the mix designer nominal mix proportioning.

7.8 FORM WORK

7.8.1 General

7.8.1.1 Forms shall he used wherever necessary to confine the concrete and shape it to the required lines or to ensure against contamination of the concrete by material caving or soughing from adjacent surface left by excavations or other features of the work. All exposed concrete surfaces having slopes of 2 horizontal to I vertical or greater shall be formed.

7.8.1.2 Form work may be of timber, steel or precast concrete panels or of such other suitable materials or combination of such materials. Form work shall be substantially and rigidly constructed to the shapes, lines an dimensions required, efficiently propped and braced to prevent deformation due to placing, vibrating and compacting concrete, other incidental loads or to the effect of weather. If settlement or deflection of forms under the load of fresh concrete is to be expected allowance should be made in the original construction of the forms so that the finished. lines and dimensions of the structure are in accordance with those specified on the drawing.

7.8.1.3 The surfaces of formwork shall be made to produce surface finishes as specified and formwork joints space be tight enough to prevent loss of liquid from concrete. Joints between the form work and existing concrete structures shall also be ‘grout tight’ from work shall be arranged to facilitate easing and removing of the various parts in correct sequence, without jarring or damaging the concrete. Fixing blocks, bolts or similar devices may be embedded in the concrete, provided they do not reduce the strength or effective cover of any part of the structure below the required standard out the use of through holts shall be avoided wherever possible. Temporary opening shall be provided at all points necessary in the forms to facilitate clearing and inspection immediately before the placing of the concrete.

7.8.1.4 Forms shall overlap the hardened concrete in the lift previously placed by not more than 75 mm, and shall be tightened smugly against the hardened so that when concrete placement is resumed, the forms will not spread and allow offsets or loss of mortar at construction joints. Additional bolts or form ties shall be used as necessary to hold forms tight against hardened concrete. Particular attention shall be paid in setting and tightening the forms for construction joints so as to get a smooth joint free from sharp deviations or projections.

7.8.1.5 Moulding strips shall be placed in the corners of forms so as to produce chamfered edges as required on permanently exposed concrete surface.

7.8.2 Materials to be Used

7.8.2.1 Materials used for form sheathing end lining shall conform with the following requirements.

Required finish	Timber sheathing or lining	Steel sheathing or lining
1	2	3
F1	Any type and grade meeting the dimensional requirements of surface finish except that metal forms shall be used on surfaces of internal transverse and longitudinal joints in the dam.	Steel sheathing permitted, Steel lining permitted except on surfaces of internal transverse and longitudinal joints in the dam where steel sheathing is required
F2	Common grade timber or plywood sheathing or lining	Steel sheathing permitted. Steel lining permitted, if strongly supported.
F3	For plane surfaces, common grade timber or better T & S or plywood.	Steel sheathing permitted. Steel lining permitted, if strongly supported.
F4	For warped surfaces Timber which is free from knots and other imperfections and which can be cut and bent accurately to the required curvatures without splintering or splitting.	Steel sheathing permitted. Steel lining not permitted,

* Steel sheathing denotes steel sheats not supported by a backing of timber boards. Steel lining denotes steel sheats supported by a backing of timber boards.

7.8.2.2 Timber sheathing or lining shall be or such kind and quality or shall be so treated or coated that there will be no chemical deterioration of discoloration of the formed concrete surfaces. The type and condition of form sheathing and lining and the ability of forms to withstand distortion caused by placement, and vibration of the concrete, and the workmanship used in the form construction shall be such that the formed surfaces will conform with applicable requirements of this specification pertaining to finish of formed surfaces.

Forms for concrete surfaces required to receive F2 and f# finishes described under para 7.15.1.3.2, 7.15.1.3.3 shall be constructed so as to produce uniforms for these faces will not be permitted. The form sheathing on lining shall be so placed that all horizontal form marks are continuous across the 3ntire surface. Where finish F2 is specified, the sheathing or lining shall be placed so that the joint marks on the concrete surfaces will be in general alignment both horizontally and vertically and the form sheathing material used for such surfaces shall be restricted to one type in any one major feature of the work.

Forms for surfaces required to receive F4 finish as described under para **7.15.1.3.4** shall be constructed so as to conform accurately to the required curvature of the sections. Where necessary to meet requirements for curvature the form sheathing shall be built up of laminated splices cut to make right, smooth form surface. The forms shall be so constructed that the joint marks on the concrete surface shall in general, follow the line of water flow. After the forms have been constructed, all surface imperfections shall be corrected, all the nails shall be hidden, and any roughness and all angles on the surface of the forms caused by matching the forms material shall be dressed to curvature.

If temperate hard wood is used as a form lining, it shall be continuously supported with timber or plywood.

7.8.2.3 Embedded ties for holding forms shall remain embedded and except where F1 finish is permitted, shall terminate not less than two diameters or twice the minimum dimension of the tie or ten millimeters, whichever is greater, in the formed faces of the concrete. Where F1 finish is permitted, ties may be cut off flush with formed surface.

The ties shall be constructed so that removal of the ends or and fasteners can be accomplished without causing appreciable spelling at the faces of the concrete. Recesses resulting from removal of the ends of the form ties shall be filled in accordance with the provisions of para 7.16 on repairs of concrete.

7.8.3 Cleaning and Treatment of Forms

At the time concrete is placed in the forms, the surface of the form shall be fee from encrustations of mortar, grout or other foreign material. Before concrete is placed, the surfaces of the forms designated to produce F2, F3, and F4 finishes shall be oiled with a commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces. For timber forma, form oil should consist of pure refined pale paraffin mineral oil or other approved form oil. For steel forms, form oil shall consist of refined mineral oil suitably compounded with one or more ingredient, which are appropriate for the purpose.

Care shall be taken to keep form oil out of contact with reinforcement.

7.8.4 Removal of forms

7.8.4.1 Except as otherwise provided in this sub-clause forms shall be removed as soon as the concrete has hardened sufficiently to prevent damage by careful form removal, thus facilitating satisfactory progress with specified curing and earliest practicable repair of surface imperfections.

7.8.4.2 Forms on upper sloping faces of concrete, such as forms on the water sides of warped transitions, shall he removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be perform at once and followed immediately by the specified curing.

7.8.4.3 In order to avoid excessive stresses in the concrete that might result as fro swelling of the forms, timber forms for wall opening shall be loosened as soon as this con be accomplished without damage to the concrete.

7.8.4.4 Subject to approval, forms on concrete surface close to excavated rock surface may be left in place provided that the distance between the concrete surface and the rock is less than 400 mm and that the forms are not exposed to view after completion of the works.

7.8.4.5 From shall be removed with care so as to avoid injury to the concrete. Any concrete damage in form removal shall be repaired in accordance with the provisions of para 7.16 repair of concrete.

7.8.4.6 The following minimum intervals of time as per IS:456- 1978 will generally be allowed when using ordinary Portland cement between placing concrete and striking form work but the period shall be modified in case of wet weather and also at the option of the Engineer-in-Charge.

(a) Walls columns and vertical faces of all structural members	24 to 40 hours
(b) slabs (props left under)	3 days
(c) Beam (soffits)	7 days
(b) Removal of prop under-	
(i) slabs spanning upto 4.5 m	7 days
(ii) slabs spanning over 4.5 m	14 days
(e) Removal of props under beams and arches-	
(i) spanning upto 6 m	14 days
(ii) spanning over 6 m	21 days
(iii) spanning over 10 m	28 days

In some cases such as while using cements other than ordinary protland cement or when conditions are not normal, it may be necessary to estimate the strength of concrete at the time of removal of form work. Cubes if they are cast to determine the strength of concrete at the time of removal form work, should be cured along with the structure and not under standard condition s envisaged for sampling and strength tests of concrete. For rapid hardening cements 3/7 of the periods given for ordinary Portland cement will be normally sufficient, except that a minimum period of 24 hours is required.

Due regard is to be given to curing methods to be employed before the form work is removed.

When controlled concrete M20 and more strength is used, the forms of slabs may be removed when concrete has generated strength equal to double the stresses generated by the dead load plus live load of 200 kg / m^2.

In any case this period shall not be less than 96 hours on placing last batch concrete in the sleds.

7.8.4.7 ***Sequence of Removal* of Forms** in respect of complicated structure referred to in para 7.11.2 the sequence of removal of forms may be obtained form design office.

7.9 HANDLING AND CONVEYING

7.9.1 General

The method of transporting and placing concrete shall be approved by the Engineer - in - Charge. Concrete shall be so transported and placed that no contamination , segregation or loss of constituent materials takes place. Concrete shall be transported as rapidly as practicable without any slump loss exceeding 25 mm or a loss in air content more than 1% before the concrete is placed in the works.

Where the time of haul exceeds 20 minutes. Mixed concrete shall be transported under in cover protected from evaporation.

7.9.2 Buckets

Buckets used for conveying concrete shall be capable of prompt discharge of low slump, lean mix concrete of controlled quantity without splashing or segregation and shall be of such capacity that that there is no splitting of batches in loading buckets. Buckets shall be of the bottom dump type. permitting an even controlled flow into the forms or hopper without undue splashing or segregation cars, trucks and ships shall be designed to facilitate uniform delivery rather than quick dumping.

7.9.3 Chutes

Chutes used for conveying concrete shall be of such type and shape as to ensure a steady uniform flow of concrete in a compact mass without separation or loss of ingredients and shall be protected from wind and such necessary to protect loss of slump by evaporation and shall be furnished with a discharge hopper .The free fall or drop of concrete shall be limited to 150 cm .The chute sections shall be made of or lined with metal and all runs shall have approximately some slopes not flatter than l vertical to 21/2 horizontal. The required consistency of concrete shall not be changed in order to facilitate chatting if it becomes necessary to change the consistency, the concrete mix will be completely redesigned wherever there is a free fall within the conveying system , suitable baffle plates, splash boards or down spouts shall be provided to prevent segregation, splashing or loss of ingredients. Whenever it is necessary to sold the discharge of a chute more than three meter above the level of the fresh concrete, a flexible down spout will be used to break the fall and confine the flow. The lower end of the sop at shall be held close tithe place of deposit wherever depositing is intermittent, a discharge hopper will be provided all chutes shall be thoroughly cleaned before and after each run. All wash water and debris shall be washed outside forms.

7.9.4 Pumping

Where concrete is permitted to be conveyed into place by the application of pressure, the pump and piping shall be suitably designed and shall be of adequate capacity for the work. pumping shall be permitted only for conveying concrete containing aggregates less than 7.5 cm maximum size. The operation of the pumping system shall be such that a continue stream of concrete, without air pockets or interruptions, is delivered. At the run, all concrete remaining in the pipe line shall be rejected in such a manner as to avoid any segregation or lack of uniformity. The pump and line shall be thoroughly cleaned and all wash water and debris wasted.

7.9.5 Belt Conveyors

Where transportation by means of belt conveyors is permitted, a steady, uniform flow of concrete shall be maintained without any segregation of piling up on steep inclines or at transfer points. The conveyor shall be covered to prevent damage by rain, loss of heat during cold weather, evaporation or heating by the direct rays of the sun, or other detritions of the concrete shall not be discharged directly into the forms, unless the discharge end of the conveyor or pipe can be readily moved about with in the forms so to place the concrete in even layers as specified under 7.10.3 and 7.10.11. Otherwise, dutiable hoppers shall be provided, from which the concrete shall be dumped in place by means of bucket and short chutes or spouts.

7.9.6 Cleaning and Washing of Equipments

Equipment used for transporting concrete from mixer to the form shall be maintained free from deposit of stiff concrete and leafage of mortar Batch containers , transit mixers, chutes, concrete pumps, pipe lines and discharge hoppers shall be thoroughly cleaned after each run and wash water and debris wasted outside the forms,

7.10 PREPARATION FOR PLACING CONCRETE

7.10.1 Before depositing any concrete for the next lift or pour, the forms, shall not be retightened. The surface of contact shall be allowed to dry out between placing successive lifts of concrete. The top of the previously deposited concrete shall be thoroughly cleaned and prepared as specified under Para 7.10.4.

7.10.2 Rock Foundation

7.10.2.1 All rock surfaces against, which concrete is be placed shall be clean and free from mud, dirt, oil ,, organic deposits, or other foreign material which may prevent a tight bond between the rock and concrete. Seams shall be cleaned to a suitable depth and to firm rock along the side. Where excavation methods or the natural rock strata do not leave a sufficiently rough surface of contact. the bed shall be roughened by cutting steps, grooves, trenches,, or keyways into the solid rock. scaly coatings, hardened grout or concrete, construction debris , and other objectionable materials shall be removed. Seepage shall be properly controlled and diverted. The foundation bed and sides shall be carefully cleaned with stiff brooms, picks, jets of water and air applied at high velocity or other equally effective means, followed by thorough washing and before placing any concrete. water shall be removed from depressions and the rock surface shall be left uniformly damp if any drilled hole is the left in the foundation surface which is no longer needed the holes shall be cleaned and air water jetting and filled up completely with cement slurry.

7.10.2.2 All flat surfaces shall then be coated with mortar about 1.5 cm think in the case of concrete surfaces and 2 cm thick on rock surfaces. The water cement ratio for the mortar layer shall not exceed that for the regular concrete mixture. and the mortar shall be of such consistency that it can be spread evenly without flowing. It shall be thoroughly broomed and worked into all irregularities, cracks and crevices. The manner of spreading and working shall be such as not to cause any segregation and concrete shall be placed immediately upon the fresh mortar before it initially set.

7.10.2.3 No concrete shall be deposited until the foundation has been inspected and approve. Where the rock is dry enough to absorb water from the mortar layer. it shall be soaked for at least 24 hours prior to placing the concrete. Detailed instruction shall be issued for preparing scaly or cracked foundations requiring special treatment or grouting.

7.10.2.4 On very rough or broken surface the first few batches of concrete may, if so required, contain only about one half the regular proportion of coarse aggregate

7.10.3 Earth or shale Foundations

7.10.3.1 In the case of earth or shale foundations, all sort or loose mud and surface shall be scraped and removed .the surface shall be moistened to a depth of about 1.5 cm to prevent the sugared from absorbing water from the fresh concrete. Just before placing the concrete the surface of the earth shall be tamped or otherwise consolidate sufficiently to prevent contamination of concrete during placing. In general, concrete shall be deposited only upon material lying in natural undisturbed state.

7.10.3.2 Foundations of porous or free-draining materials shall thoroughly compacted by flushing and by subsequent temping rolling, if necessary. The finished foundation surface shall then be blanketed with a layer or tar paper or closely woven burlap carefully lapped and fastened down along the seams so as to prevent the loss of mortar from the concrete.

7.10.3.3 Unless otherwise specified, the under- drainage system for all foundations shall be blanketed as specified under para 7.10.3.2

7.11 PLACING OF CONCRETE

7.11.1 General

No concrete shall be placed until the place of deposit has been thoroughly inspected and approved by Engineer- in Charge, all reinforcement,, inserts and embedded metal properly secured in position and checked, and forms thoroughly wetted (except in freezing weather or oiled). Placing shall be continued without avoidable interruption while the section is completed or satisfactory construction joint made. The position and arrangement of construction joint shall be indicated by the designer.

If concreting is not started within 24 hour of the approval being given, it shall have to be obtained again from the Engineer-in-charge.

During cold weather, concreting shall not be done when the temperature falls below 4.50 c. The concrete placed shall be protected against frost by suitable coverings. Concrete damaged by frost shall be removed and work redone during hot weather, precaution shall be taken to see that temperature of wet concrete does not exceed 40^0 c.

7.11.2 Sequence of Concrete

In respect or complicated structures such as continuous bridges, balanced cantilever bridges, cantilevers canopies more than 3m, rigid framed structures, box type structures etc, the sequence of concreting must be stipulated in drawing. If this is not given in drawing it should be obtained from design office and concreting done accordingly.

7.11.3 Within Forms

Concrete shall be systematically deposited in shallow layers and at such rate as to maintain, until the completion of the unit, a plastic surface approximately horizontal throughout. Each layer shall be thoroughly compacted before placing the succeeding layer. In general, the thickness of layers shall not exceed the following limits:

a)	Vibrated mass concrete	45 cm
b)	Hard compacted mass concrete	30 cm
c)	Reinforced concrete	25 cm

The batches shall be deposited vertically in such a manner so as to avoid segregation, air pockets, or damage to other recently placed concrete, In so far as it is practicable, concrete shall be placed directly in its final position and shall not be caused to flow in a manner to permit or cause segregation. Method and equipment employed in placing concrete will ensure that aggregate is not separated from the concrete mass.

In placing mass concrete in a lift, successive batching of concrete shall be placed in a systematic arrangement in order to avoid long exposure of parts of the live surface to a concrete layer. Wherever necessary, both the forms and reinforcement shall be protected against plashing, and all accumulations of partially set, dried, or ceded mortar which may impair the bond or show in the finished faces shall be removed and wasted before commencing concreting operations.

7.11.4 Cleaning Joints

7.11.4.1 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean so as to expose sound concrete surface. The methods shall be by means of jets of air and water applied at high velocity with such additional roughening of the surface by means of stiff wire brushes as may be required. Brushing shall be done by jabbing and digging into the surface rather than by merely weeping. The whole process shall be conducted in such manner as not to loosen the coarse aggregates but vigorously enough to expose a fresh clean-cut concrete surface.

Immediately before depositing fresh concrete, the contact surface shall again be gone over and thoroughly washed to remove all debris and loose material. the final pick-up of loose materials shall be made near the centre of the joint and away from the outside edges of the masonry. Dry contact surfaces shall be kept saturated with water for not less than 24 hours, but all standing water shall be removed from depressions before spreading the layer of mortar or cement slurry.

For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15mm thick. The mortar will have the same proportions of water, air entraining agent, cement and fine aggregate as the concrete mixture which is to be placed upon it. The water cement ratio of the mortar in places shall not exceed that of the concrete to be placed upon it, and the consistency of the mortar shall be suitable for being spread uniformly and worked thoroughly into all irregularities of the surface.

For vertical and inclined joints (surfaces) which can not be covered with mortar shall be given a heavy coat of neat cement grout, vigorously brushed into all interstices and hollows or neat cement slurry shall be applied on the surface before it is dry so as to provide the best possible conditions for bond and impermeability. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing of the concrete.

7.11.4.2 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brush, care being taken to avoid dislodgement of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, a layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in the normal way.

7.11.4.3 Should the next lift be delayed the contact surface shall be kept wet and covered so as to minimize the evaporation of curing water which may cause an injurious coating on the joint. Where necessary all defective and undesirable concrete shall be removed by chipping and picking by hand or, if so required, by wet sand blasting the top to a depth just sufficient to expose a fresh, clean-cut surface over the entire area, which shall then be thoroughly flushed with water. Every precaution shall be taken to afford suitable bond for the succeeding lift.

7.11.4.4 If from any cause, the working surface is left exposed until it has hardened to a considerable extent, it shall be left to set and cure for not less than 56 hours or longer if necessary until a strength greater than 35.21 g/cm2 (500 PSI) has been attained, before completing the lift The surface thus, interrupted shall be treated in same manner as described in para 7.11.4.1.

Hardened surfaces of old masonry on which new concrete is to be placed, shall unless otherwise ordered, be prepared in the same manner as provided for rock foundations under para 7.10.2

7.11.5 Rate of Placing

Concreting shall be continued without avoidable interruption until the structure or section is completed or until satisfactory construction joints can be made. Concrete shall not be placed faster than the placing crew can compact it properly. In placing concrete in thin members and columns precautions shall be taken against too rapid a placement which may result in movement or failure of the form due to excessive internal pressure. An intervals of at least 4 and preferably 24 hours should elapse between the completion of columns and walls and the placing of slabs, beams or girders supported by them in order to avoid cracking due to settlement. All concrete shall be placed in approximately horizontal lifts not exceeding 150 cm in thickness except to expedite the placing of embedded materials. The interval between two lifts shall also be maintained as constant as possible, and the difference of elevation between any two adjacent blocks shall not be more than 900 cm and not less than 150 cm. A period of 5 days for 150 cm of concrete laid shall be allowed before the next pour unless heat dissipation methods warrant otherwise.

7.11.6 Placing "Plums in Concrete"

7.11.6.1 In mass concrete members, stone plums may be used, with a view to effect economy, in zones not subject to tensile stresses upto a maximum limit of 20 percent by volume of concrete when specifically permitted by the engineer-in-charge. While placing plums, care shall be taken that clear distance between any two plums is not less than either the width or thickness of either or the plums or 15 cms whichever is more. No stone shall be closer than 30 cm to an exposed surface. The stones shall not be dropped in place, but each stone shall be laid and carefully embedded so as to avoid any injury to forms or adjacent masonry and in such a manner that no planes of weakness or unnecessary seams occur in the structure.

7.11.6.2 During concreting, the first layer of concrete of the specified mix shall be laid to a thickness of at least two and a half times the thickness of the maximum size of plums to be used. The plums shall then be laid while the top portion of this concrete is still green but sufficiently stiff to prevent complete submergence of the plums under their own weight. These plums shall be about half embedded in the concrete and the remaining part exposed so as to form a key with the next layer of concrete. No plums shall be used for concrete laid under water.

7.11.6.3 If plums of stratified stone are used, they shall be laid on their natural bed. Stones with concave faces shall be laid with the concave face upwards.

7.11.6.4 The thickness of the next and successive layers of concrete shall be at least twice that of the largest plum.

7.11.7 In placing mass concrete, the exposed area of fresh concrete shall be maintained at the practical minimum by first building up the concrete in successive approximately horizontal layers to the full width of the block and to full height of the lift over a restricted area at the down stream and of the block and then continuing upstream in a similar progressive stages to the full area. The slopes formed by the unconfined upstream edges of the successive layers of concrete shall be kept as steep as practicable in order to keep its area minimum. Concrete along these edges shall not be vibrated until adjacent concrete in the layer is placed, except that it shall be vibrated immediately when weather conditions are such that the concrete will harden to an extent the later vibration may not fully consolidate and integrate it with more recently placed adjacent concrete.

7.1 1.8 In formed work, structural concrete placements shall generally be started with an over- sanded mix containing 20 mm maximum size aggregate and an extra bag of cement per cubic meter and having a 125 mm slump placed several centimeters deep on the joints at the bottom of the form. Concrete placement shall commence immediately thereafter.

7.1 1.9 If concrete is placed monolithically around opening having vertical dimensions greater than 0.6 meter, or if concrete in decks floor slabs, beams, girders, or other similar parts of a structure is placed monolithically with supporting concrete, the following instructions shall be strictly observed:

i) Placing of concrete shall be delayed not less than one hour nor more than three hours at the top of openings and at the bottom of fillets under decks, floor slabs, beams, girders or other similar parts of structures when fillets are specified and at the bottom of such structures, members when fillets are not specified but in no case shall the placing be delayed so long that the vibrating unit will not of its own weight readily penetrate the concrete placed before the delay. When consolidating concrete placed after the delay, the vibrating unit shall penetrate or vibrate the concrete placed before the delay.

ii) The last 0.6 meter or more of concrete placed immediately before the delay shall be placed with as low slump as practicable and shall be thoroughly compacted.

iii) The surfaces of concrete where delays are made shall be clean and free from loose and foreign materials when concrete placing is started after the delay.

iv) Concrete placed over openings and in decks, floors, beams girders and other similar parts of structures shall be placed with as low slump as practicable.

v) Concrete should be deposited at or near to final portion in the placement, eliminating the tendency to segregate when it has to flow laterally into place, sloping surfaces, concrete should he placed at the lower end of the slope first, progressing upward and thereby increasing natural compaction of the concrete. High velocity discharge of concrete, which may cause segregation of the concrete, which may cause segregation of the concrete should be avoided.

7.11.10 Large Blocks

In placing concrete in large blocks, the work shall in general proceed from the low side so that the working face is never excessively steep nor long.

However, for construction joints in dams, the work shall proceed from the high side to the low side so as to maintain in upward slope in the downstream direction, unless construction joints are otherwise shown on the drawings. Under no condition shall the slope be so steep as to cause the concrete to flow without working, or to cause any segregation. The concrete shall be deposited as nearly as practicable in final position and shall not be piled up in large masses at any point and then pushed, shoveled, or vibrated into space for long distances. It shall be brought up evenly around all large openings, conduits, or embedded metal so as to minimize unequal pressure and avoid displacement. For large blocks of concrete in dams and other massive structures, the sequence and rate of casting successive lifts and adjacent blocks shall be such as to facilitate the dissipation of the heat of hydration.

7.11. 11 Fissures

Where fissures in concrete are necessary to be produced (e.g. in bucket invert etc.) the use of fissure reinforcement concrete may be considered by the Engineer- in-Charge.

All concrete construction shall conform to the permissible tolerance and technical provisions as described in this section and to the detailed requirements of the following paragraphs. All structures shall be built in workman like manner and to the lines, grades and dimensions shown in the drawings or prescribed by the Engineer-in-Charge. The location of all construction joints shall be subject to the approval of the Engineer-in-Charge. The dimension of each structure shown on the drawings will be subject to such changes as may be found necessary by the Engineer-in-Charge to adopt structures to the conditions disclosed by the excavation or otherwise.

7.11.12 Concrete in the Dam (Up to Crest Level Including Concrete In Bucket/Stilling Basin)

This item of the schedule for concrete in dam includes all concrete in the main structure of the dam between the normal upstream and downstream faces of the dam upto crest level, including concrete in block outs but excludes concrete in spillway bridge piers (above crest level), elevator shaft (above crest level), training walls (above crest level), concrete in side walls, kerbs and parapets and concrete in shafts in foundation faults and seams. Concrete in upstream and downstream faces of the dam to a thickness to be prescribed by the Engineer-in-Charge may differ in mix proportions from the concrete in the interior of the dam and may contain more cement per unit volume of concrete. The concrete in the dam also includes the foundation of the trash rack structure, river sluices end irrigation sluices. All concrete in the dam shall be placed in horizontal lifts not exceeding 150 cm in thickness and shall be placed and built up to the full height of the lift in accordance with the provisions of relevant part of this section.

The forms of surfaces between adjacent blocks may be removed as soon as the concrete has hardened sufficiently to prevent the surface damage. Except as provided below, the placing of concrete in the dam shall be so regulated that the maximum differential height between adjacent blocks shall not exceed 9 m; unless relaxed by the Engineer-in-Charge.

The rate of placing concrete in any block of the dam shall be such that not more than one lift shall be placed in 72 hours. Every effort shall be made to obtain a regular periodic placement at successive lifts throughout the dam. All concrete in the dam shall be cooled as provided in the relevant part of this section. All outlets/galleries and other sizeable openings within mass concrete shall be closed or bulk headed at the faces of the cam and other exposed surfaces from the time, concrete is placed around the openings until the concrete surrounding the openings is completely cooled.

Plumb line walls shall be formed in the concrete where shown on the drawings or directed and plumb shall Be maintained within 12 mm.

7. 11. 13 Concrete In Dam (Above Crest Level)

The item of schedule for concrete in dam includes ail concrete above crest level in piers, abutments, elevator shaft, training walls, non-overflow portion of dam, power dam and block outs.

7.11.14 Concrete in Spillway Bridge, Side Walls. Kerbs and Parapets.

The Item of the schedule for concrete in spillway bridge, Kerbs and parapets include all concrete in the spillway bridge, Kerbs and parapets in full length of the masonry dam block outs.

Premoulded bituminous fiber type expansion joint, material shall be placed in the expansion joints.

Lighting recesses shall be constructed in the parapets as directed by the Engineer-in-Charge. Open joints or false joints shall be constructed as shown on the drawings or as directed by the Engineer- in-Charge. Preformed expansion joint filler shall be placed in the roadway and side walks where shown on the drawings or as directed by the Engineer-in-Charge.

7.11.15 Concrete in Blockouts

All concrete required to be placed in block outs to permit the installation and adjustment of mechanical and other equipments shall be included in the respective concrete as described above. The concrete surfaces of the blockouts shall be chipped and roughened as described hereinafter before the concrete is placed in the blockouts.Exceptional care shall be taken in placing the concrete in blockouts In order to ensure satisfactory bond with the concrete previously placed and to secure complete contact with all metal work in blockouts.

The roughening of the concrete surface of the blockouts shall be performed by chipping or sand blasting as approved by the Engineer-in-charge and in such a manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface. After being roughened, (he surface of the concrete shall be cleaned thoroughly of loose fragments, dirt and other objectionable substances and shall be sound and hard to ensure good mechanical bond between the existing and new concrete.

All concrete which is not hard, dense and durable shall be removed to the depth required to assure its surface satisfactory to the Engineer-in Charge.

7.11.16 Rejected Concrete

All concrete of inferior quality shall be rejected and removed from the site of operations, if possible, before placing fresh concrete; where concrete has already been placed if, found inferior, it shall be dug out and removed from the forms. Any batch, too stiff for proper placement or in such a condition that it cannot be properly compacted, shall be removed.

7.12 CONCRETING UNDER SPECIAL CONDITIONS

7.12.1 Work in Extreme Weather Conditions

During hot or cold weather concreting should be done as per the procedure set out in IS:7861 Part I or Part II.

7.12.2 Under Water Concreting

When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to and approved by the Engineer-in-Charge before the work is started. In no case shall such concrete be considered as 'Design mix concrete'.

The concrete shall contain at least 10 percent more cement than that required for the same mix placed in the dry condition, the quantity of extra cement varying with conditions of placing. The volume or mass of the coarse aggregate shall be not less than one and a half times, nor more than twice that of the fine aggregate. The materials shall be so proportioned as to produce a concrete having a slump of not less than 100 mm, and not more than 180mm.

Coffer-dams or forms shall be sufficiently tight to ensure still water If practicable, and in any case to reduce the flow of water to less than 3 m per minute through the space into which concrete is to be deposited Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the walls. Dewatering by pumping shall not be done while concrete is being placed or until 24 hours thereafter.

Concrete shall be deposited continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of seams avoided. The methods to be used for depositing concrete under water shall be one of the following:

a) ***Tremie-*** When concrete is to be deposited under water by means of a tremie, the top section of the tremie shall have a hopper large enough to hold one entire batch of the mix or the entire contents of the transporting bucket if any. The tremie pipe shall be not less than 200 mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably, flanged steel pipe of adequate strength for the job should be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding of the gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper, so that when concrete is forced down from the hoper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. It will be necessary to raise slowly the tremie in order to cause a uniform flow of the concrete, but the tremie shall not be emptied so that water enters the pipe. At all times after the placing of concrete is started and until all the concrete is placed, the lower end of the tremie pipe shall be below the top surface of the plastic concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of laitance layers. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface, and unless sealed by a check valve, it shall be re-plugged at the top end, at the beginning, before refilling for depositing concrete.

b) ***Drop Bottom Bucket*** - The top of the bucket shall be covered with a canvas flap. The bottom doors shall open freely downward end outward when tripped. The bucket shall be filled completely and lowered slowly to avoid backwash. The bottom door shall not be opened until the bucket rests on the surface upon which the concrete is to be deposited and when discharged, shall be withdrawn slowly until well above the concrete.

c) Bags of at least 0.028 cum capacity of jute or other coarse cloth shall be filled about two thirds full of concrete, the spare end turned under so that bag is square and securely tied. They shall be placed carefully in header and stretcher courses so that the whole mass is interlocked. Bags used for this purpose shall he free from deleterious materials.

d) **Grouting-** A series of round cages made from 50 mm mesh of 6 mm steel and extending over the full height to be concreted shall be prepared end laid vertically over the area to be concreted so that the distance between centers of the cages and also to the faces of the concrete shall not exceed one meter. Stone aggregate of not les than 50 mm nor more than 200 mm size shall be deposited outside the steel cages over the full area and height to be concreted with due care to prevent displacement of the cages.

A stable 1:2 cement-sand grout with a water cement ratio of not less than 0.6 and not more than 0.8 shall be prepared in a mechanical mixer and sent down under pressure (about 0.2 N/mm^2) through 38 to 50 mm diameter pipes terminating into steel cages, about 50 mm above the bottom of the concrete. As the grouting proceeds, the pipe shall be raised gradually up to height of not more than 600 mm above its starting level after which it may be withdrawn and placed into the next cage for further grouting, by the same procedure.

After grouting the whole area for a height of about 600mm, the same operation shall be repeated, If necessary, for the next layer of 600 mm and so on.

The amount of grout to be sent down shall be sufficient to fill all the voids which may be either ascertained or assumed as 55 percent of the volume to the concreted.

To minimize the formation of laitance, great care shall be exercised not to disturb the concrete as for as possible while it is being deposited.

7.13 COMPACTING

7.13.1 Method

Concrete shall be thoroughly compacted by means of suitable tools during and immediately after depositing. The concrete shall be worked around all reinforcement, embedded fixtures, and into the corners of the forms. Every precaution shall be taken to keep the reinforcement and embedded metal in proper position and to prevent distortion.

7.13.1.1 Compacting shall include rodding, spading, tamping, vibrating, treading, and such other operations except finishing, as are necessary to consolidate and mould the concrete properly. The rate of placing mass concrete or reinforced concrete in thin sections, whether mechanically or by manual labour, shall be clearly defined.

7.13.1.2 Accumulation of water on the surface due to bleeding, or other causes taking place during compacting shall be stopped as much as possible by adjustments in the mix. All free water on the surface shall be removed by sponging or mopping. Under no circumstances shall such accumulation of water be covered up with concrete or dry concrete used to soak up excess water.

7.13.1.3 Unless otherwise permitted, all concrete shall be compacted by mechanical vibration. The number and type of vibrators shall be subject to the approval of the Engineer-in-Charge. In general, only vibrators of the internal type shall be used. However in inaccessible places in the forms, where spading, rodding, or forking is impracticable, the concrete may be gently worked into place and compacted by light vibrating or hammering the forms.

7.13.2 Vibrating

7.13.2.1 Wherever practicable, concrete shall be internally vibrated within the forms, or in the mass, in order to increase the plasticity and to compact effectively to improve the surface texture and appearance, and to facilitate placing of the concrete.

7.13.2.2 The intensity and duration of vibration shall tie sufficient to cause complete settlement and compaction without any stratification of the successive layers or separation of ingredients. Preliminary experiments in vibrating shall be conducted under actual conditions of mix and placement in order to determine the optimum duration and method of vibration, as well as to develop the necessary skill.

7.13.2.3 Vibration shall be continued until the entire batch melts to a uniform appearance and the surface just starts to glisten. A minute film of cement paste shall be discernible between the concrete and the forms and around the reinforcement. Over vibration causing segregation, unnecessary bleeding or formation of laitance shall be avoided.

7.13.3 Internal Type Vibrators

7.13.3.1 Mass concrete shall be thoroughly compacted with the side of high frequency, mechanical vibrators of the internal type, having not less than 3 600 and preferably more than 5000 impulses per minute. Immediately after depositing the concrete, the vibrators shall be inserted into each pile, operated from 10 to 20 seconds in one spot and then moved to another not over 90 cm (or 3 ft) away. The operation shall be repeated over until the entire mass is thoroughly compacted and the pile, leveled down. Equal attention shall be paid to the edge of the pile and to the center. A sufficient number of two-man vibrators shall be used to compact each batch properly before placing the next one. A sufficient number of reserve vibrators in good conditions shall be kept on hand at all times so as to assure that there is no slackening or interruption in compacting.

7.13.3.2 The use of flexible shaft vibrators, if permitted, shall closely follow special instructions issued for the purpose.

7.13.3.3 Internal vibrators shall be allowed to penetrate as deeply as possible under their own weight and shall so consolidate the successive layers as to break up effectually all strata or seams. The vibrators shall be inserted and withdrawn slowly in such manner as not to leave voids in the plastic concrete. The entire operation shall be conducted in a systematic manner and each course or layer vibrated uniformly the method of dumping or depositing the loads shall be so arranged as to keep the vibrators working continuously during placing operations. The courses shall be kept approximately level, and the concrete even when deposited in thin layers, shall be as stiff as can be satisfactorily worked. However, concrete for which a slump greater than 10cm is specified shall not be vibrated unless otherwise ordered. Care shall be taken not to disturb a set of partially set layer. The vibrators shall be held vertical as far as possible.

7.13.3.4 Under no conditions shall internal vibrators strike the face of the forms, nor shall reinforcement steel or embedded metal be jarred with sufficient force to impair the bond between the concrete and the metal.

7.13.4 External Type Vibrators

7.13.4.1 Wherever so required, platform vibrators shall be used to embed all large stone or cobble projecting above the top of the lift, but such vibrators shall be used with caution and operated only in such manner for a depth of about 30 cm shall be thoroughly vibrated. Particular care shall be taken in making keyways and shear grooves. Where a raised key is required, the form shall be filled to overflowing and a platform vibrator used to compact the concrete and bond the key to the body of the lift.

7.13.4.2 Form vibrators shall be permitted only for special purpose specified under 7.13.1.3 and extreme care shall be exercised to avoid pumping air into the concrete.

7.13.5 Surface Voids

Large voids or air pockets, which may be left in the permanently exposed faces or the structure by vibration, shall be removed systematically spading the face in the following manner. Wherever practicable, a motor-driven, slowly revolving, square steel rod shall be held in a vertical position and moved slowly back and forth in short intervals along the entire face. Care shall be taken to avoid prolonging such spading to the point of leaving excess mortar in the face.

7.14 CURING OF CONCRETE

7.14.1 General

All concrete shall be cured by water in accordance with the requirement of para 7.14.3 of this clause or membrane curing in accordance with the requirements of para 7.14.4 of this clause. Concrete surfaces to be painted shall not be cured by membrane curing.

7.14.2 Curing of Unformed Surfaces and Piers

The unformed top surfaces of walls and piers shall be moistened by covering with water saturated materiel or by other effective means as soon as the concrete has hardened sufficiently to prevent damage by water. These surfaces and steeply sloping and vertical formed surfaces shall be kept completely and continuously moist, prior to and during form removal, by water applied on the unformed top surfaces and allowed to pass down between the forms and the formed concrete faces. This procedure shall be followed by the specified water curing and membrane curing.

7.14.3 Water Curing

Concrete cured with water shall be Kept wet for at least 14 days immediately following placement of the concrete or until covered with fresh concrete by covering with water saturated material or by a system of perforated pipes, mechanical sprinklers or porous hoses or by any other suitable method, which will keep all the surfaces continuously (not periodically) wet. The period' of 14 days specified above shall be increased to 21 days when pozzolana has been used in the concrete as part replacement of cement.

7.14.4 Membrane Curing

7.14.4.1 Membrane curing shall be by application of a suitable type of white pigmented curing compound which forms a water retaining membrane on the surface of concrete, provided that on concrete surfaces which will be permanently exposed to view clear curing compound may be required. Curing compound shall be applied to the concrete surfaces by spraying on one coat to provide a continuous uniform membrane overall area, with a maximum coverage per liter as prescribed by the manufacturer according to the roughness of the surface to be covered If necessary to cover the surface adequately a second coat of curing compound shall he applied by spraying at right angles to the direction a (which first coat was applied. Mortar encrustation and fins on surface for which finish F 4 is specified shall he removed prior to application of curing compound. Curing compound shall be applied to all areas of concrete surfaces except that those parts with surface imperfections shall be omitted until repaired.

7.14.4.2 When curing compound is to be used on formed concrete surfaces, application of the compound shall commence immediately after the finishing operations are completed.

7.14.4.3 When curing compound Is to be used on formed concrete surfaces the surface shall be moistened with light spray of water immediately after the forms are removed, and shall be kept wet until the surfaces will not absorb more moisture. As soon as the surface film of moisture disappears but while the surface still has a damp appearance, the curing compound shall be applied. There must be ample coverage with the compound at edges, corners and rough spot of formed surfaces. After application of curing compound has been completed and the coating is dry to the touch, any required repair of concrete surface shall be performed. Each repair after being finished shall be moistened and coated with curing compound in accordance with the foregoing requirements.

7.14.4.4 Traffic and other construction operations shall be such as to avoid damage to coatings of curing compound for a period of not less than 28 days after application of the curing compound Where it is impossible because of construction operations to avoid traffic over surfaces coated with curing compound, the membrane shall be protected by a covering of sand or earth not less than 25 mm in thickness or by other effective means. The protective covering shall not be placed until the sealing membrane is completely dry. Any sealing membrane that is damaged or that peels from concrete surfaces within 28 days after application shall be repaired without delay.

7.14.4.5 Curing compound if used, shall be of approved quality.

7. 15 FINISHING OF CONCRETE SURFACE

7.15.1 Classes of finish for Formed Surface

7.15.1.1 Allowable deviations from plumb or level and from the alignment, profile grades and dimentions shown on the drawings are defined as "tolerance" and are to be distinguished from the Irregularities in finish as described herein. The tolerance in concrete construction are specified in para 7.18.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawings or as hereinafter specified. In the event of finishing not being definitely specified herein or on the drawings the finishes to be used shall be directed. Finishing of concrete surfaces shall be performed only by skilled workmen.

Concrete surfaces will be tested where necessary to determine whether surface irregularities are within the limits hereinafter specified.

7.15.1.2 Surface irregularities are classified as "abrupt" or "gradual". Offset caused by displaced or misplaced from sheathing or lining or form sections or by loose knots or otherwise defective form timber will be considered as abrupt irregularities and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be one and a half meters for testing of formed surfaces and three meters for testing unformed surfaces.

7.15.1.3 The classes of finish for formed concrete surfaces are designated by one of the symbols Fl, F2, F3 and F4. Bag rubbing or sand blasting will not be required on formed surfaces. Grinding will not be required on formed surfaces, other than that necessary for the repair of surface imperfections. Unless otherwise specified or indicated on the drawings, the classes of finish which will apply are as follows:

7.15.1.3.1 ***Finish F1*** - This finish is applied to surfaces where roughness is not objectionable, such as these upon or against which fill material, masonry or concrete will be placed, the upstream face of the dam that will permanently be under water or surfaces that will otherwise be permanently concealed. The surface treatment shall be repaired of defective concrete, correction of surface expressions deeper than 25 mm and filling of tie rod holes. Form sheathing shall not leek mortar when the concrete is vibrated. Forms may be built with a minimum of refinement.

7.15.1.3.2 ***Finish F2*** - This finish is required on all permanently exposed surface for which other finishes F3 and F4 are not specified, such as in outlet works and open spillways, bridges and retaining wells not prominently exposed to public view and in the galleries and adits in the dam, except where Fl finishes are permitted Forms shall be built in a workmanlike manner to the required dimensions and alignment without conspicuous offsets of bulge surface, irregularities, shall not exceed 5mm for abrupt irregularities and 10 mm for gradual irregularities measured from a 1.5 m template.

7.15.1.3.3 ***Finish F3*** - This finish is designated for surfaces of structures prominently exposed to public view where appearance is of special importance. This shall include parapets, railings and decorative features on the dam and on the bridge. To meet the requirements for the F3 finish, forms shall be built in a skillful, workmanlike manner, accurately to dimensions. There shall be no visible offsets, bulges or misalignment of the concrete. At construction joints the forms shall be tightly set and securely anchored close to the joint. Surface Irregularities shall not exceed 3 mm for abrupt irregularities and 5 mm for gradual irregularities measured from a 1.5m template.

7.15.1.3.4 **Finish F4** - This finish is required for formed concrete surfaces at the spillway crest, glacis and bucket and inside sluices where accurate alignment and evenness of surface are essential for prevention of destructive effects of water action. The forms must be strong and held rigidly and accurately to the prescribed alignment. For warped surfaces, the forms shall be built up in section: cut to made right, smooth form surface after which the form surfaces are dressed and sanded to the required curvature.

When measured as described in this clause, gradual irregularities shall not exceed 5 mm. abrupt irregularities will not be permitted. The formations of air holes on the surface of the concrete designated to receive finish shall be minimized and where such air holes are found, they shall be repaired in accordance with relevant section.

7.15.2 **Classes of Finish for Unformed Surfaces**

7.15.2.1 **General**-The classes of finish for unformed concrete surfaces are designated by the symbols U1, U2, U3 and U4 unless otherwise specified or indicated on the drawings these classes of finish shall apply as follows.

7.15.2.2 **Finish U1**-This finish applies to unformed surfaces that will be covered by fill material, masonry or concrete, or where a screeded surface finish meets the functional requirements. Finish-U1 is also used as the first stage of finishes for U2 and U3. Finishing operations shall consist of sufficient leveling and screeding to produce even uniform surfaces. Surface irregularities measured as described in this section shall not exceed 10mm.

7.15.2.3 ***Finish U2*** - This Is a floated finish and applies to all out door informed surfaces not specified to receive finishes U1 or U3, it may be used for such surfaces as of spillways and aprons.

Finish U2 is also used as the second stage of finish for U3. Floating may be performed by use of hand or power driven equipment. Floating shall be started as soon as the screeded surface has stiffened sufficiently to prevent the formation of laitance, and shall be the minimum necessary to produce surface that is free from screed marks and is uniform in texture. If finish U3 is to be applied floating shall be continued until a small amount of mortar without excess water is brought to the surface, so as to permit effective trowelling. Surface irregularities measured as described in this section shall be lolled down where shown on the drawing or as directed.

7.15.2.4 **Finish U3** - This is a trowelled finish and may be specified for tops of parapets prominently exposed to view, and conduit invert immediately downstream of regulating gates and valves. When the floated surface has hardened sufficiently to prevent excess of fine materiel from being drawn to the surface steel trowelling shall be started. Steel trowelling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense uniform surface free from blemishes and trowel marks. Surface irregularities, measured as described in relevant part of this section, shall not exceed 5 mm. Where a hard steel trowelled finish is specified the regular U3 finish shall be trowelled again after the surface has nearly hardened using firm pressure and trowelling until the surface is hard and has a slightly glossy appearance.

7.15.2.5 **Finish U4**- This is a steel trowelled finish similar to finish U3 except that light surface pitting and light trowel marks such as obtained from the use of machine trowelling or lining machines will be acceptable, provided the surface irregularities do not exceed the limits specified for finish U3.

7.15.2.6 Unformed surfaces which are nominally level shall be sloped for drainage as shown on the drawings or as directed. Unless the use of other slopes or level surface is indicated on the drawings, narrow surface such as 35 tops of parapets, tops of walls and kerbs shall be sloped approximately one cm per 30 cm of width, broader surface such as roadways, platform and decks shall be sloped approximately half centimeter per 30 cm of width,

7.16 REPAIRS OF CONCRETE

7.16.1 General

Repairs of concrete shall be performed by skilled workers and in the presence of an Engineer-in-Charge. All Imperfections on the concrete surface as necessary to produce surfaces that conform with requirements of para 7.15 on formed concrete shall be completed as soon as practicable after removal of forms and within 24 hours after removal of forms Concrete that is damaged from any cause and concrete that is honey-combed, fractured or otherwise defective and concrete which because of excessive surface depressions excavated and built up to bring the surfaces to the prescribed lines. Shall be removed and replaced by dry pack mortar or concrete as hereinafter specified. Where bulges and abrupt irregularities protrude outside the limits specified in the para 7.15 on "Finishes & finishing of concrete surface", the protrusions shall be reduced by chiseling and grinding so that the surfaces are within the specified limits.

Dismantling of a part of hardened concrete of a structural element must not be done by hammering since this is likely to crack adjoining good concrete. This should be done slowly by pointed chisel or mechanically operated tool preferably by a skilled mason.

Before repairs are commenced, the methods proposed for the repair shall be approved by the Engineer-in-Charge. Routine curing should be interrupted only in the area of repair operations.

7.16.2 Methods of Repairs

For new works four methods are used.

7.16.2.1 Dry Pack Method

This method should be used for holes having a depth nearly equal to or greater than the least surface dimensions; for cone bolt, she bolt and grout insert holes and narrow slots cut for the repair of cracks. Dry Pack should not be used for relatively shallow depressions where lateral restraint can not be obtained for filling in back of considerable lengths of exposed reinforcements; non filling holes which extend entirely through the wall, beam, etc.

7.16.2.2 *Concrete Replacement Method*

Concrete replacement should be used when holes extend entirely through the concrete sections; when holes in unreinforced concrete are more than 1000 sq cm in area and 100 cm or more in depth and in holes in reinforced concrete are more than 500 sq cm in area and deeper than the reinforcement steel.

7.16.2. 3 Mortar Replacement Method

This should be used for holes too wide to dry pack and too shallow for concrete replacement and for all comparatively shallow depressions, large and small, which extend more deeper than far side of the reinforcement bars nearest the surface

7.16.2.4 Epoxies Method

A thermosetting plastic known as epoxy can be used as a bonding medium wherever long time curing of conventional concrete cannot be assured. Also epoxy mortars of fine sand as well as plain epoxy are suitable for concrete repair work and should be used whenever very thin patches are to be placed for immediate re-use of the area is required or where moist curing can not be effectively accomplished Preparation for epoxy bonded repairs should in general be identical to that for other concrete repairs except that every effort should be made to provide surfaces which are thoroughly dry. Drying of the immediate surface for at least 24 hours and warming to temperature between 18^{o}c to 27^{o} c are essential for proper application of epoxy bonded repaired. Preparation for the use of epoxy mortars should include thorough cleaning and drying of the areas to be repairs. A wash of dilute 1:4 muriatic acid rinsing with clean water and subsequent drying is desirable where feasible, if acid wash is not feasible, preparation may be accomplished as for other concrete repairs with final clean up being by means of sand blast method, followed by air water jet washing and thorough drying. Epoxy repairs shall be carried out only by trained personnel.

7.16.3 Preparation of Concrete for Repair

All concrete of questionable quality should be removed. It is better to remove too much concrete than too little because affected concrete generally continues to disintegrate and while the work is being done it costs but little more to dismantle to ample depth. Moistening, cleaning, surface drying and complete curing are of utmost importance when making repairs which must be thoroughly bonded, water tight and permanent Surface between trimmed holes should be kept continuously wet for several hours, preferably overnight prior to placing new concrete immediately before placement of the filling, the holes should be cleaned so as to leave a surface completely free of chipping dust, dried grout and all other foreign materials. A preliminary washing as soon as the chipping and trimming are completed is desirable to remove loose materials. Washing by water jet is useful to remove loose particles. Final cleaning of the surfaces to which the new concrete is to be bonded should be done by wet sand blasting followed by washing with air- water jet for thorough cleaning and drying with an air jet. Care should be taken to remove any loose materials embedded in the surface by chisel during the trimming and to eliminate all shiny spots indicating free surface moistures. Cleaning of steel if necessary should be accomplished by sand blasting. The prepared surface shall be approved by the Engineer- in-Charge.

7.16.3.1 Dry Pack of Concrete

For this method of repairs, the holes should be sharp and square at the surface edges but the corners within the holes should be rounded, especially when water tightness is required. The interior surfaces of holes left by cone bolts, she bolts, etc, should be roughened to develop an effective bond. Other holes should be under cut slightly in several pieces around the perimeter. Holes for dry pack should have a minimum depth of 25 mm.

7.16.3.2 Concrete Replacement

Preparation for this method should be as follows:

(a) Holes should have minimum depth of 100 mm is new concrete end the minimum area or repair should be 500 sq cm for reinforced and 1000sq cm for unreinforced concrete.

(b) The reinforcement bars should not be left partially embedded there should be clearance of at least 25 mm around each exposed bar.

(c) The top edge of the holes at the face of the structure should be cut to a fairly horizontal line. If the shape of the defect makes it advisable, the top of the cut may be stepped down and continued on a horizontal line. The top of the hole should be cut to 1 to 3 upward slope from the back towards the face of the wall or a beam. It may be necessary to fill the hole from both sides in which case the slope of the top or the cut should be modified accordingly.

(d) The bottom and sides of the hole should be cut sharp and approximately square with the face of the wall, when the hole goes entirely through concrete section spelling or feather edges shall be avoided by having chippers worked from both faces. All interior corners should be rounded to a minimum radius of 25 mm.

7.16.3.3 *Mortar Replacement - Guniting*

When mortar gun is used with this method, comparatively shallow holes should be flared outwardly at about 1:1 slope to avoid inclusion of rebound. Corners within the holes should be rounded. Shallow imperfections In new concrete may be repaired by mortar replacement if the work is done promptly after removal of the forms and while the concrete is still green V instance, when it is considered necessary to repair the peeled areas resulting from surface materials sticking to steel forms and surface, may be filled using mortar guns without further trimming or cutting. Wherever hand pieced mortar replacement is used, edges of chipped out areas should be squared with the surface leaving no feather edges.

7.16.3.4 *Use of Dry Pack Mortar*

The surface after preparing should be thoroughly brushed with a stiff mortar or grout barely wet enough to thoroughly wet the surface after which the dry pack material should be immediately packed into place before the bonding grout has dried. The mix of bonding grout is to be 1:1 cement and fine sand mixed to a consistency like thick cream. Under no circumstances should bonding coat be wet enough or applied heavily enough to make dry pack material more than very slightly rubbery. Dry pack is usually a mix (dry volume of weight) of one part of cement to 1½ part of sand that will pass a 1.18 mm I S Sieve. A mortar patch is usually darker than the surrounding concrete unless special precautions are taken to match darker than the surrounding concrete unless special precautions are taken to match the colours. Where uniform colour is important white cement may be used in sufficient amount to produce uniform colour is important white cement may be used in sufficient amount to produce uniform appearance. For packing cone bolt holes a leaner mix of 1:3 or 1:3½ will be sufficiently strong and will blend better with the colour of the wall. Only enough water should be used to produce a mortar which when used, will stick together on being moulded into a ball by slight pressure of hands and will not exclude water but will leave the hands damp. The proper amount of mixing water and proper consistency are those which will produce a filling which is at the point of rubbery when the material is solidly placed. Dry pack material should be placed and packed in layers having a compacted thickness of about 10 mm. The surface of each layer should be scratched to facilitate bonding with next layer. One layer may follow another immediately unless appreciable rubber iness develops in which case work on the repair should be delayed to 30 to 40 minutes. Under no circumstances should alternate layers of wet and dry materials be used. Each layer should be solidly compacted over its entire surface by use of a hard wood stick and hammer. Much of the tamping should be directed at a slight angle and towards the sides of the hold to assure maximum compaction in these areas. The holes should not be overfilled and finishing may usually be completed at once by laying the flat side of a hardwood placed against the fill and striking it several good blows. If necessary, a few light strokes with a rag sometime later may improve the appearance. Steel finishing tools should not be used and water must not be used in replacement of finishing tools should not be used and water must not be used in replacement of concrete.

7.16.4 Procedure of Replacement of Concrete, Curing of Repairs etc.

All procedures for replacement of concrete, mortar replacement, use of epoxies and curing of repairs shall be according to the provisions laid down herein before.

7.17 COOLING OF CONCRETE

Heat release during hydration of cement when large masses of concrete are being produced, poses two different problems viz.

(i) the thermal stability of concrete; and

(ii) the cracking of concrete.

The thermal stability is necessary for normal behaviour of the structure. So, suitable cooling system is to be adopted in the dam concreting in order to rapidly achieve thermal stability.

In order to control thermal stability arising out of the heat of hydration, the placement temperature of concrete should be adopted as directed by the Engineer-in-Charge.

7.18 TOLERANCE FOR CENCRETE CONSTRUCTION

7.18.1 General

(i) Permissible surface irregularities for the various classes of concrete surface finishes specified in the relevant portion of the section of "finishes and finishing of concrete surfaces" are defined finishes and are to be distinguished from "Tolerances" as described in this section. Deviations from the established lines, grades and dimensions will be permitted to the extent set-forth in this clause, provided that lesser tolerances than those tolerances set-forth in this clause, may be prescribed at site if such tolerances are considered to impair the structural action or operational action or operational function of the structure.

(ii) Where tolerances are not stated in the specifications or drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions of this clause.

(iii) Concrete work that exceeds the tolerance limits specified in this section shall be either remedied satisfactorily or removed.

7.18.2 Mass Concrete in Dams and Appurtenant Works

The following tolerances shall apply for concrete in dam and other larger mass concrete structures:

(i)	(a)	Variation of the constructed linear outlines from established position in plan.	In 6 meters in 12 meters	12 mm 20 mm
	(b)	Variations of dimension to individual structural features from established position.	In 24 meters or more In burried construction.	30 mm Twice the above amount.

(ii)	(a)	Variations from the plumb, from the specified batter or from the curved surfaces of all structures including the lines and surfaces of walls and vertical joints	in 3 metres	12 mm
			in 12 metres	30 mm
			or more in burried construction	Twice the above amount.
	(b)	Variation from the level or from the grades indicated on the drawings	in 3 metres	6 mm
			in 9 metres	12 mm
			or more in burried construction	Twise the above amount.
(iii)	(a)	Variation in cross sectional dimentions of columns, beams buttresses, piers and similar members and variation in the thickness of slabs, walls and similar members of concrete up to M 25 strength	Minus Plus	6 mm 12 mm
	(b)	For concrete M 35 and above	Minus Plus	3 mm 6 mm
(iv)		Variation from plumb and level for sills and side walls for radial gates and similar water tight joints	Not greater than a rate of 3 mm in 3 meters	

7.18.3 Placing Reinforcement Bar

The following tolerances shall apply for placing of reinforcement bars.

(i)	Variation of protective covering	Upto 50 mm cover	3 mm
		Upto 75 mm cover & over	12 mm
(ii)	Variation from indicated spacing of reinforcement	Variation upto 12 mm in spacing either way is acceptable but total area of steel in the component is not reduced.	

7.19 Porous Concrete

Porous concrete shall be used at locations shown on the drawings or as directed. Porous concrete shall be composed of one part of cement to five and half parts of aggregate by weight. The fines in the aggregate (viz. sand) may be permitted upto ten percent of the total aggregate. Only so much water shall be used in the concrete as is required to produce paste which will coat the particles and not fill the voids. In placing porous concrete, care shall be taken to ensure that it is not over tamped or compacted. The porous concrete as laid shall be pervious and free draining when it hardens. As soon as the concrete hardens (so that, paste cannot be washed away) it should be kept moist for a minimum of fourteen days. The compressive strength of porous concrete at 7 days as determined by test on 15cm by 30 cm cylinders should not be less than 70 kg/cm^2 and the porosity at 7 days be such that water shall pass through a slab of the concrete 30 cm thick at a minimum rate of 500 liters/min./Sq. meters of the slab with a constant 10 cm depth of water standing on the slab. The porous concrete blocks shall be laid as shown in the drawings or as corrected by the Engineer-in-Charge to form porous drains in the masonry dam.

7.20 STANDARD OF ACCEPTANCE

7.20.1 General

The standard of acceptance will be the same weather it is "Nominal Mix Concrete" or Design Mix Concrete. For relatively small and unimportant buildings and works in which quantity of concrete is less than 15 cubic meter, the strength tests may be waived by Engineer-In-Charge at his discretion.

Random samples from fresh concrete shall be taken as specified in IS:1199 & 1959 and cubes shall be made, cured and tested as described in IS:516-59. If required for some other purposes, for example, to estimate the time when the form work can be stripped, tests may be conducted at early ages also but the acceptance or otherwise is always on the basis of 28 days strength. The average of the strength of three specimens is the test strength of any sample. The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 test results, as early as possible, when a mix is used for the first time. The calculation of the standard deviation shall be brought up to date after every change of mix design and at least once a month. When significant changes are made in the production of concrete batches (for example changes in the materials used, mix design, equipment or technical control), The standard deviation value shall be separately calculated for such batches of concrete.

Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in table 17 below may be assumed.

TABLE : 17

Assumed Standard Deviation

Grade of concrete	Assumed S.D. N/mm
M 10	2.3
M 15	3.5
M 20	4.6
M 25	5.3
M 30	6.0
M 35	6.3
M 40	6.6

7.20.2 Determination of Standard Deviation

The Standard deviation of concrete of a given grade shall be calculated using the following formula from the results of individual tests of concrete of that grade obtained.

Estimated standard deviation S =

7.20.3 Acceptance Criteria

7.20.3.1 The concrete shall be deemed to comply with the strength requirements if:

a) every sample has a test strength not less then the characteristic

b) the strength of one or more samples though less than the characteristic value, is in each case not less than the greater of:

1) the characteristic strength minus 1.35 times the standard deviation; and

2) 0.80 times time the characteristic strength; and the average strength of all the samples is not less than the characteristic strength plus

7.20.3.2 The concrete shall be deemed not to comply with the strength requirement if:

(a) The strength of any sample is less than the greater of;

(i) The characteristic strength minus 1.35 times the standard deviation: and

(ii) 0.80 times the characteristic strength; or

(b) The average strength of all the samples is less than the characteristics strength plus

Concrete which does not meet the strength requirement as specified in 7.20.3.1 above but has a strength greater than that required by 7.203.2 may at the discretion of designer, be accepted as being structurally adequate without further tests. If the concrete is deemed not to comply pursuant to 7.20.3.2, the structural adequacy of the parts affected shall be investigated and consequential action as needed shall be taken.

7.20.3.3 Concrete of each grade shall be assessed separately.

7.20.3.4 Concrete shall be assessed daily for compliance.

7.20.3.5 Concrete is liable to be rejected if it is porous or honeycombed; its placing has been interrupted without providing a proper construction joint; the reinforcement has been displaced beyond the tolerances specified; or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-Charge.

7.21 FILLING FOUNDATION WITH MATERIALS OTHER THAN CEMENT CONCRETE

7.21.1 Filling foundation with lime concrete

7.21.1.1 ***Proportioning* -** The proportion of time mortar shall be as specified in the item of work and proportion of time mortar and coarse aggregate shall be one of time mortar and two of the coarse aggregate all by volume and measured in measuring boxes.

7.21.1.3 ***Mixing -*** coarse aggregate shall be free from all impurities and if dirty or dusty, should be thoroughly washed before being mixed with mortar Concrete shall be mixed on a level and impervious platform, with tight and close joints dimensions of the platform shall be as directed by Engineer-in-Charge.

The coarse aggregate shall be spread on the platform in a heap of uniform depth. It shall be wetted before mixing. The required quantity or mortar shall be spread over the whole surface of the coarse aggregate also to a uniform depth. The material shall then be thoroughly incorporated by being turned over and over backwards and forwards not less than three times, until every particle of the coarse aggregate is fully coated with mortar. Measuring boxes must be used for measuring both the aggregate and the mortar to ensure use of required proportion of mortar.

No more concrete shall be mixed than can be laid to place and rammed the same day. When it is necessary to give fluidity to concrete. This shall be effected by adding water to mortar and to the mixed concrete.

7.21.1.4 ***Form Work*** - Form work if necessary shall be as specified under para 7.8 and shall be removed only after concrete is set.

7.21.1.5 ***Laying*** - Before placing the concrete the bed of the concrete shall be cleaned of all loose stuff, moistened and rammed if necessary. Formwork, if used, shall be approved by the Engineer-in-Charge before laying.

Concrete shall be used while fresh. It shall be laid (and not thrown) in layers not exceeding 15 cm to 20 cm in thickness.

7.21.1.6 ***Compaction*** - Concrete shall be well compacted by ramming with wooden or iron rammers with area of ramming not exceeding 320 sq. cm. and weighing not less than 4.50 kg, before the next layer is laid. The consolidation shall continue for each layer with mortar creams upto the surface. No water or mortar shall be added during laying or ramming. If after adequate ramming, the mortar does not fill the interstices of the aggregate and cream upto the surface, the top surface should be grouted with thin mortar. No ramming shall be done after the concrete has begun to set. Ramming shall be done by one or more lines of men, ranged across the width of concrete with a lateral space of not more than 45 cm per man. After consolidation the surface must be kept damp.

If appreciable time passes between laying consecutive layers, the lower course should be made rough, cleaned and watered before the upper layer is laid

After formwork is removed, honey combed spots shall be finished with the lime mortar of the type used in the concrete.

7.21.1.7 **Curing** - All lime concrete is to be kept continuously wet for at least 14 days after it has been deposited in position or until it is built over. The wetting shall be done initially on signs of dryness by spreading hessien or straw and watering very frequently from a watering can through a perforated rose in moderate quantity and later directly on concrete after the mortar has set. All water used in mixing and curing of concrete shall be clean and for any injurious materials.

7.21.2 **Filling foundations with excavated materials, soil, sand or moorum**

7.21.2.1 **Preparation** - The ground over which filling has to be done shall be cleared of all grass, loose, stones, rubbish of all kind as well as tree roots, bushes, etc. If there is water it shall be pumped or bailed out.

The excavated material if to be used for filling should be properly stacked as per the direction of Engineer-in-Charge and shall be cleaned of all the rubbish, large stone, etc. and clods broken down to a size of 50 m.m. or less.

Materials to be brought from out side i.e. sand moorum or yellow soil shall also be cleaned of all rubbish and shall be used only after the approval of the Engineer-in-Charge.

7.21.2.2 **Laying -** The approved soil, sand or moorum shall be laid in 15 to 20 cm thick layers. Each layer shall be watered and compacted with heavy rammer's before the upper layer is laid, till the required level is reached so as to from a thoroughly compact base.

For filling in plinth watering and compaction shall be done in such a way as not to endanger the foundation columns, plinth wall etc. already built up.

Under no circumstances black cotton soil or similar greatly expansive and shrinkable soil shall be used for filling foundation or under the plinth.

APPENDIX - I

(Para 7.3.1.4)

PHYSICAL AND CHEMICAL REQUIREMENTS OF INDIAN STANDARD SPECIFICATIONS FOR DIFFRENT CEMENTS

Characteristic	Ordinary portland cement, (IS:269-1976)	Rapid Hardening portland cement (IS:8041-1976	Low heat portland cement (IS:12600-1989)	High strength portland cement (IS:8112-1976)	Portland pozzolana cement (IS:1489-1976	Port land slag cement (IS:455-1976)
1	2	3	4	5	6	7
Physical Requirements						
Fineness: specific surface (cm^2 /g Minimum	2250	3250	3200	3500	3000	2250
Setting time, vicat Initial setting time (minutes), Minimum	30	30	60	30	30	30
final setting time (hours), Maximum	10	10	10	10	10	10
Soundness: Le-Chatelier method, expansion (mm),Maximum	10[a], 5[b]	10[a], 5[b]	10[a], 5[b]	10[a], 5[b]	10[a], 5[b]	10[a], 5[b]
Autoclave expansion, *	0.8	0.8	0.8	0.8	0.8	0.8
Heat of hydration (cal/g), Maximum						
7 days	-	-	65	-	-	-
28 days	-	-	75	-	-	-

d - Where x is the declared percentage of pozzolana,

e - Air - entraining or other agents which have proved not be harmful

f - Lime saturation factor =

x - Declared percentage of pozzolana in the given portland pozzolana cement

* The test is to be performed if M_gO>3 percent

Appendix- II

DETERMINATION OF NECESSARY ADJUSTMENT FOR BULKING OF FINE AGGREGATE (FIELD METHOD)

1. Object

This method of test covers the field method for determining the necessary adjustment for the bulking of fine aggregate.

2. General

Sand brought on to a building site or other works may contain an amount of moisture which will cause it, when loosely filled into a container, to occupy a larger volume than it would occupy if dry. If the sand is measured by loose volume, it is necessary in such a case to increase the measured volume of the sand, in order that the amount of sand put into the concrete may be the amount intended for the nominal mix used (based on dry sand), It will be necessary to increase the volume of sand by the "percentage" bulking. The correction to be made in only a rough approximation, because the system of measurement by order volume is a rough method at the best, but a correction of the right order can easily be determined and should be applied in order to keep the concrete uniform.

3. Procedure

3.1 The procedure to be adopted may be varied, but two methods, are suggested in 3.2 & 3.3 Both depend on the fact that the volume of inundated sand is the same as if the sand were dry.

3.2 Put sufficient quantity of the sand loosely into a container until it is about two- thirds full. Level off the top of the sand and pushing a steel rule vertically down through the sand at the middle to the bottom, measure the height. Suppose this is h cm.

3.2.1 Empty the sand out of the container into another container where none of it will be lost. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6mm in diameter, so that its volume is reduced to a minimum. Then add the inundated sand and measure its depth at the middle with the steel rule. Suppose this is h' cm.

3.2.2 The percentage of bulking of the sand due to moisture shall be calculated from the formula.

Percentage bulking =m $[\,^{h}/_{h'} - 1]*100$

3.3 In a 250 ml measuring cylinder, pour the damp sand (consolidated by shaking) until it reaches the 200-ml mark). Then fill the cylinder with water and stir the sand well. (The water shall be sufficient to submerge the sand completely). It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark y ml. The percentage of bulking of the sand due to moisture shall be calculated from the formula:

Percentage bulking $= (\,^{200}/_{y} - 1) \times 100$

4. Reporting of Results - Report the percentage bulking of the sand to the nearest whole number.

APPENDIX - III

PHYSICAL REQUIREMENTS

(para 7.3.5)

Sl. No.	Requirement	Accelerating Admixture	Retarding Admixture	Water reducing admixture	Air-Entraining admixture
1	2	3	4	5	6
i)	Water content, percent of control sample, Max	-	-	95	-
ii)	Time of setting, allowable deviation from control sample, hours: Initial				
	Max	-3	+3	± 1	-
	Min	-1	+1		
	Final				
	Max	-2	+3	± 1	-
	Min	-1			
iii)	Compressive strength, percent of control sample, Min:				
	3 days	125	90	110	90
	7 days	100	90	110	90
	28 days	100	90	110	90
	6 months	90	90	100	90
	1 year	90	90	100	90
iv)	Flexural strength, percent of control sample, Min:				
	3 days	110	90	100	90
	7 days	100	90	100	90
	28 days	90	90	100	90
v)	Length change, percent increase over control sample, Max:				
	28 days	0.010	0.010	0.010	0.010
	6 months	0.010	0.010	0.010	0.010
	1 year	0.010	0.010	0.010	0.010
vi)	Bleeding, percent increase over control sample, Max:	5	5	5	2

APPENDIX - IV

REQUIRMENT FOR COCRETE EXPOSED TO SULPHATE ATTACK

	Concentration of Sulphates expressed as SO_3					
	In Soil					
	Total SO_3	SO3 in 2:1 water extract g/liter			Min cement content	Max Free/Water cement ratio
1	2	3	4	5	6	7
1.	Less than 0.2	Less than 30		Ordinary portland cement or portland slag cement or portland pozzolana cement	280kg/m	0.55
				Ordinary portland cement or portland slag cement or portland pozzolana cement	330	0.50
				Super Sulphate Cement	310	0.50
3.	0.5 to 1.0 1.9 to 3.1	120 to 250		Super sulphated cement	330	0.50

NOTE 1. - This table applies only to concrete made with 20 mm aggregates complying with the requirements of IS:383- 1970 * placed in near neutral groundwater's of pH 6 to pH 9, containing naturally occurring sulphates but not contaminants such as ammonium salts. For 40mm aggregate the value may be reduced by about 15 percent and for 12.5 mm aggregate the value may be increased by about 15 percent. Concrete prepared from ordinary portland cement would not be recommended in acidic conditions (pH 6 or less). Super sulphated cement gives an acceptable life provided that the concrete is dense and prepared with a water/ cement ratio of 0.4 or less, in mineral acids, down to pH 3.5.

NOTE 2. - The cement contents given in Class 2 are the minimum recommended. For SO_3 contents near the upper limit of Class 2, cement contents above these minimum are advised.

NOTE 3. - Where the total SO_3 in col.2 exceeds 0.5 percent, then a 2:1 water extract may result in a lower site classification if much of the sulphate is present as low solubility calcium sulphate.

NOTE 4. - For server conditions such as thin sections under hydrostatic pressure on one side only and sections partly immersed, considerations should be given to a further reduction of water / Cement ratio, and if necessary an increase in the cement content to ensure the degree of workability for full compaction and thus minimum permeability.

NOTE 5. - Portland slag cement conforming to IS:455-1976 with slag content more than 50 percent exhibits better sulphate resisting properties.

NOTE 6. - Ordinary portland cement with the additional requirement that C_3A content be not more than 5 percent and 2 C_3A + C_4AF (or its solid solution 4 CaO, AL_2O3, Fe_2O_3, + 2CaO, Fe_2O_3) be not more than 20 percent may be used in place of supersulphated cement.

APPENDIX - V

REQUIRMENTS FOR DURABILIY

MINIMUM CEMENT CONTENT REQIFD IN CEMENT CONCRETE TO ENSURE DURABILITY UNDER SPECIFIED CONDITIONS OF EXPOSURE

Exposure	Plain concrete		Reinforcement concrete	
	Mini cement content Kg/m^2	Max water cement ratio	Min cement content Kg/m^3	Max water cement ratio
(1)	(2)	(3)	(4)	(5)
Mild - For example, completely protected against weather, or aggressive conditions, except for a brief period of exposure to normal weather conditions during construction.	220	0.7	250	0.65
Moderate- For example, exposed sheltered from heavy and wind driven rain and against freezing, whilst saturated with water; buried concrete in soil and concrete continuously under water.	250	0.6	290	0.55
Sever- For example, exposed to seawater, alternate wetting and drying and to freezing whilst wet, subject to heavy condensation or corrosive fumes.	310	0.5	360	0.45

NOTE 1. - When the maximum water - cement ratio be strictly controlled the cement content in the above table may be reduced by 10 per cent.

NOTE 2. - The minimum cement content is based on 20 mm aggregate. For 40 mm aggregate, it should be reduced by about 10 per cent; for 12.5 mm aggregate, it should be increased by about 10 per cent.

APPENDIX - VI

HOW TO BATCH CONCRETE BY VOLUME

1 General

The proper & accurate measurement of all the materials used in concrete making is necessary to ensure uniformity of proportions & aggregate grading in succeeding batches. When concrete is batched by volume there is always a danger of variation between one batch and another. So if on any job batching is specified by volume, a certain amount of extra care is required to make sure that quantities are correct.

2 Gauging cement

Cement is often gauged by volume but this is most inadvisable except for small or unimportant jobs. The point against measuring cement by vol. (even when other materials are measured by vol.) is that it is difficult to secure accuracy in as much as actual volume of a given weight of cement depends upon how it is filled in to the gauge box and whether if is shaken down. The density of cement may vary form about 1.12 g per cm^3 if it is lightly poured in to the container to well over 1.60 gm per cm^3 if tamped down sufficiently hard. Invariably, there fore, the size of the concrete batch should be so determined as to require whole bags of cement, but should a fraction of a bag be required it should be weighed in to a bucket suspended from an ordinary 50 - kg spring balance.

3 gauging Aggregates by volume

Aggregates can be gauged by vol. and for this purpose wooden batch boxes called farmas are used.

The size of the farmas should be such as to measure the correct quantity of aggregates to be used with a whole bag of cement for the required mix. They should not be made so large as to be unwieldy; it is preferable to have a farma that will contain, say, half the required quantity of material, and to fill this twice over for each batch of concrete. Convenient sizes are indicated in Table given below:

The farma should be made of 30 cm thick prepared timber, which gives a good strong job. Joints should be tongued & grooved with the tongue on the inside of the box. This prevents any dirt getting in of the joints should open through shrinkage or rough handling. The faces of the joints should all be painted with red lead linseed oil before the farma is assembled.

Sizes of Farmas

Capacity liters	Inside measure		
	Length, cm	Breadth, cm	Height, cm
25	25	25	40
30	25	25	48
35	27	27	48
40	29	29	48
45	30	30	50
50	31	31	52

The farma should be made of 3 cm thick prepared timber, which gives a good strong job. Joints should be tongued & grooved with the tongue on the inside of the box. This prevents any dirt getting in if the joint should open through shrinkage or rough handling. The faces of the joints should all be painted with red lead linseed oil before the farma is assembled.

It is advisable to flash the top edge of the box with sheet metal to keep a clean level edge for striking off. The handles should be shaped to provide an easy grip.

When a mixer machine is used on the job it will be convenient to have lips on the sides of the farma which can then be rested on the mixer hopper when the contents are being tipped in.

When a mixer machine is used on the job it will be convenient to have lips on the sides of the farma which can then be rested on the mixer hopper when the contents are being tipped in.

Before concreting operations are started, the farma volumes should be checked for specified quantities. When filling the farmas the material should be thrown loosely into the box & struck off level; no compacting should be allowed. At the end of each day's work the farma should be stacked upside down to prevent any accumulation of rain water.

4 Calculating Batch volumes

A concrete mix is generally specified in parts by volume, as for example 1:1 1/2:3, 1:2:4, etc. meaning one part of cement to so many parts of sand to so many parts of coarse aggregate. Since it is proposed to use only whole bags of cement these proportions must be converted to suit this unit.

Take a mix specified as 1:$2^{1}/_{2}$:4. Now one 50 kg bag may be considered to hold 35 liters of cement, so above figures should be multiplied by 35. The mix will, therefore be : 50kg of cement to 88 liters of sand to 140 liters of coarse aggregate.

As these quantities of sand & aggregate are too large to be conveniently handled, the next thing, in this case, would be to have a farma for the sand made upto hold of 88 liters (30x3x49cm) & fill it twice, & for the coarse aggregate a 35 liters farma, which would be filled four times. Farmas much larger than 50 liters in size are rather inconvenient to use.

5 The Phenomena of Bulking

The figures given above are for dry sand but. the sand as delivered and used on the job quite frequently contains moisture which causes films of water to form on the suraface of the particles, fluffing them apart. This is called bulking and for a moisture content of 5 or 6 percent may be as 20,30 or even 40% depending upon the grading of the sand, fine sands bulk much than coarse sands Further addition of water tends to flood or pack the sand decreasing the amount of bulking and when the sand is completely inundated the volume is approximately the same as when measured dry & loose.

If allowance for bulking is considered when batching by vol. it will not only unease the cost of concrete by reducing the yield per bag of cement, but it will also have an undersanded mix which is harsh & difficult to place. An example given later will illustrate this point.

6 Measurement of water

Of even greater importance than the accurate measurement of cement & aggregates is the proper control of mixing water. The strength & other desirable properties of a concrete mix depends entirely upon the quantity of water used to the bag of cement, the concrete becoming weaker as more water is added just as the cementing property of glue is impaired as it is mixed with more & more water.

The prevailing method of gauging water "by the eye" with any odd tin can, direct into the mixer is most inaccurate & cannot be too strongly condemned.

The mix design gives together with the specified mix, the exact of mixing water to be used, as to many liters. per 50kg of cement. An exact 5 liter measurer is used to calibrated any other containers. This will ensure that the correct amount of mixing water is added to the concrete mix.

For determining surface moisture, table 15 and for determining absorption by aggregate following table can used:

TABLE

Approximate Absorption of Aggregate

S. No.	Aggregate	percent by weight
(i)	Average sand	1 Percent
(ii)	Gravel and crushed lime stone	1 Percent
(iii)	Trap rock and granite	0.5 Percent
(iv)	Porous sand stone	7.0
(v)	Very light and porous aggregate	25.0

The method of using these tables will be clear from the following example:

Example: Materials per bath

50kg of cement

88 litres of sand (saturated, surface-dry)

175 litres of coarse aggregate

The engineer has pacified 25 litres of water to be used per 50kg of cement. Correction for moisture: Suppose the sand used is moderately wet (surface water 65 gm per litre see table) and the coarse aggregate is also moist (surface water 30 g per litre)

Then the total surface water carried by the aggregate is

Sand = 65x88 = 5,720 g

Coarse aggregate = 30 x 275 =5,250 g
10,970 gm say 11 liters

Since this water is introduced into the mix with the aggregates, it must be deducted from the 25 litres specified by the engineer, that is to say, only 14 litres must be actually added to the bath at the time of mixing.

If neglected to make this correction, the concrete mix would have contained 36 litres per 50 kg of cement, causing a considerable reduction in its strength.

Correction for absorption: If not infrequently occurs in our hot climate that the sand and coarse aggregate being used is bone-dry & will actually absorb water from the concrete, thus reducing the water cement ratio.

Suppose the sand used weighs 1.60 gm per cm^3 when dry (absorption 1.0 percent by weight, see Table on pre-page) the coarse aggregate is trap rock and weighs 1.44 g per cm^3 (absorption 0.5 Percent by weight.)

Then the total water absorbed by the aggregate is

sand $= \frac{1 \times 88 \times 1.60}{100} = 1.41$ kg

Coarse aggregate $= \frac{0.5 \times 175 \times 1.44}{100} = 1.26$ kg

2.67 kg

Say 2.7 liters

This quantity must be added to the 25 liters specified by the engineer, that is to say 27.7 liters must be added to the batch at the time of mixing.

Loss of Water by Evaporation- In very hot weather it often happens that some of the water contained in the concrete mix is lost by evaporation during transporting & placing. An allowance may be made for this by a corresponding increase in the amount added at the mixer, prior approval of the engineer having been obtained.

Summary

The precautions that must be observed in the batching of concrete by volume can be summed up in a series of don'ts.

(i) Don't gauge cement by vol. except for the most unimportant jobs. Determine the size of your batch so as to required whole bags of cement, but should a fraction of a bag required weigh the cement into a bucket suspended from an ordinary 50 kg spring balance.

(ii) Don't gauge aggregate into any old container. Have special farmas made on each job, carefully calculating their dimensions to suit the field mix proportions.

(iii) Don't make farms larger than about 50 liters otherwise they become unwieldy. It is preferably to use a farma which contains, say, half the required quantity & fill it twice over.

(iv) Don't compact aggregates into the farm when filling them in. The aggregates should be loosely thrown into the box & struck off level.

(v) Don't neglect to make allowance for bulking of sand, if any. Use the bulking test to determine the correct volume of damp sand that should be batched, which will be more than volume of dry sand specified in the mix.

(vi) Don't gauge water "by the eye" with any odd tin can direct into the mixer. Measure the water carefully into a calibrated container.

(vii) Don't neglect to make allowance for the moisture that may already be present in the aggregates when gauging mixing water.

CHAPTER - 8A

STONE MASONERY AND BLOCK MASONRY
(OTHER THAN MASONRY IN DAMS)

CONTENTS

CHAPTER - 8A

STONE MASONRY AND PRECAST BLOCK MASONRY WORK

(STONE THAN MASONRY IN DAMS)

8A.1 SCOPE

8A.1.1 This chapter covers the specifications for construction of stone masonry for:

(i) Buildings,

(ii) Hydraulic structures with maximum height 10 m (from lowest foundation level), and

(iii) Precast block masonry.

8A.1.2 This chapter does not cover the specifications for masonry for dams and hydraulic structures more than 10m height for which specifications of chapter 8B shall apply.

8A.2 REFERENCES

IS: 269 - 1989	Ordinary portland cement, 33 Grade (fourth revision).
IS:383-1970	Coarse and fine aggregates from natural sources for concrete (second revision) (Reaffirmed 1980).
IS:455 - 1976	Portland slag cement (third revision) (with amendments no.1 to 6).
IS:456 - 1976	Code of practice for plain and reinforced concrete (Third revision) (with ammendment no. 1)
IS:1121	Methods of test for determination of strength properties of natural building stones.
IS:1121)Pt. I)-1974	Compressive strength (first revision) (with amendment no. 1) (Reaffirmed 1987).
IS:1121 (Pt.-II) - 1974	Transverse strength (First revision) (Reaffirmed 1987
IS:1124 - 1974	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones (First revision)
IS: 1127 - 1970	Recommendations for dimensions and workmanship of natural building stones for masonry work (first revision) (Reaffirmed 1987).
IS: 1129 - 1972	Recommendations of dressing of natural building stones (first revision) (Reaffirmed 1987).

IS:1489-1976	Portland pozzolana cement (second revision) (with ammendments no. 1to6).
IS:1597-1967	code of practice for construction of stone masonry.
IS:1597(Pt.I) - 1967	Rubble stone masonry.
IS:1597 (Pt.II) - 1967	Ashlar masonry (Reaffirmed 1987).
IS:1805-1973	Glossary of terms relating to stones: Quarrying and dressing (First revisio) (Reaffirmed 1987).
IS:2185	Concrete masonry units.
IS:2185(Pt. I) - 1979	Hollow and solid concrete blocks (second revision) with ammendment no. 1) reaffirmed 1987).
IS:2185 (Pt.II)- 1983	Hollow and solid lightweight concrete blocks (first revision).
IS:2402 - 1963	Code of practice for external rendered finishes.
IS:2645 - 1975	Integral cement waterproofing compounds (first revision)(with ammendment no. 1) Reaffirmed 1987).
IS:3812 -1981	Flyash for use aspozzolana and admixture (first revision).
IS:6042 - 1969	Code of practice for construction of light weight concrete block masonry.
IS:6909 - 1973	suppersulphated cement (with ammendments no. 1 to 3).
IS:8041 - 1978	Rapid hardenning porland cement (first revision) (with ammendments no. 1 to 3).
IS:8043 - 1978	Hydrophobic portland cement (first revision) with ammendments no.1 to 3).

IS: 9103 - 1979 Admixtures for concrete.

IS:9394 - 1979 Stone lintels (Reaffirmed 1987).

C.P.W.D. Specifications 1977, volume I.

All India Standard Schedule of Rates - 1977, I. Standard Specification of National Building Organisation.

Building Research Note No.7 of Central Building research Institute India "Precast stones Masonry Block Walling Scheme."

Maharashtra Specifications

8A.3 TERMINOLOGY

Ashlar - Stone masonry using dressed square stone blocks of given dimensions having faces perpendicular to each and laid in courses.

Bed Joint - The joint where one stone presses on another for example, a horizontal joint in a wall or a radiating joint between the voussoirs of an arch (see Figure 8-A/1)

Bond - an interlocking arrangement of Structural units in a wall to ensure stability.

Bond Stone (Through Stone)- selected long stones used to hold a wall together transversally (See Figure 8-A/2).

Corbel - stone bonded well into the wall with part of it projecting out of the face of wall to form a bearing surface.

Cornice - A horizontal moulded projection which crowns or finishes either a wall, any horizontal division of wall, or any architectural feature (See Figure 8-A/3A).

Courses - A layer of tones in a wall including the bed mortar.

Cramp - A small piece of metal or the hardest or toughest stone procurable, sunk in mortices and fixed across joints as additional ties. The ends of metal cramps are bent at right angles and stone cramps are dovetailed (See Figure 8-A/38).

Dowels - Dowels are small sections of metal, stone or pebbles bedded with mortar in corresponding mortice in bed or side joints of adjacent stones (See Figure 8-A/3C).

Hammer Dressing - Rough surfacing to a stone by means of a small hammer.

Jamb - The part of the wall at the side of an opening.

Joggle - A key between the stones by providing a groove in one stone to take a corresponding concealed projection in the edges on the other stone (See Figure 8 - A/3B.)

Natural Bed - The plane of stratification that occurs in sedimentary rocks.

Parapet - A solid or pierced uard wall for flat terrace or a balcony (or a bridge) or a curb wall at the lower part of a pitched roof, which is exposed to atmosphere on face, back and top (See Figure 8-A/3A).

Quoin - A quoin is the External angle of a wall or building. The term is also applied to a stone specially selected and neatly dressed for forming such angle.

Random - Of irregular sizes and shapes.

Reveal - The part of the jamb between the frame and the arise.

Rubble Masonry - Masonry built of stones either irregular in shape as quarried or squarred and only hammer dressed and having comparatively thick joints. Stones for rubble masonry are, as far as possible, angular.

String Course - A horizontal band, plain or moulded, usually projecting slightiy from the face of a wall (See figure 8 - A/3A)

Template or Bed Block - A block of Stone or concrete bedded on a wall to distribute the pressure from a concentrate load.

Plum Stone (Pin-Header)- Selected long stones embedded vertically in the interior of masonry wall to form a bond between successive courses.

Efflorescence - A powdery encrustment of salt left by evaporation. This may be visible on the surface or may be (5-1) [illegible]rface.

Hearting - The infilling which forms the core of a rubble wall.

8A.4 UNCOURSED RUBBLE MASONRY I RANDOM RUBBLE I POLYOONAL FACED MASONRY

8A.4.1 MATERIALS.

8A.4.1.1 STONE -The stone shall be of the specified variety (such as granite, trap stone, sand stone, quartzite etc.). The stone shall be obtained only from an approved quarry and shall be hard, sound, durable and free from defects like cavities, cracks, sand holes, flaws, injurious veins, patches of loose or soft material, etc. Stone with round surface shall not be used. The stone should not contain cryptocrystalline silica or chart, mica or any other deleterious material like iron oxide, organic impurities, etc. The water absorption shall not be more than 5 percent when tested in accordance with appendix -A. The minimum crushing strength of stone shall be 200 kg/sq cm unless higher minimum strength is specified in any particular case. All stone shall be obtained by quarrying large massive rock unless otherwise specified.

8A.4.1.1.1 SIZE OF STONE-Normally stones used in rubble masonry should be small enough to be lifted and placed by hand. The length of the stone shall not be less than its height and shall not exceed three times the height, and the breadth on base shall not be less than its height and shall not be greater than three fourths of the thickness of the wall nor less than 15 cm. The height of stone for Rubble masonry may be up to 30 cm and shall not be less than 22.5 cm for hydraulic structures and 15 cm in other cases.

8A.1.2 MORTAR -The mortar used shall be cement mortar/lime mortar/ lime pozzolana mortar/cement lime mortar/cement surkhi mortar of specified proportion or mud mortar. The detailed specification for mortar given under chapter 6 'Mortars' shall apply.

8A.4.2 DRESSING OF STONES - Face stone used for un-coursed of random rubble masonry work shall be hammer dressed on the side and beds in such a way as to close up with the adjacent stone in the masonry work as strongly as possible. The face stones shall be dressed in such manner as to give specified pattern such as polygonal facing, etc. The face of stones shall be so dressed that bushing on the exposed face shall not project by more than 40 mm from the general wall surface and on the face to be plastered it shall not project by more than 10 mm nor shall it have depressions more than 10 mm from the average wall surface. The hearting or interior filling shall be constructed of stones as they come from the quarry and no dressing shall be done except cutting of the Stones to there movably of inconvenient comers with a scabbing or spilling hammer.

8A.4.3 LAYING -

8A.4.3.1 All stones shall be sufficiently wetted before laying to prevent absorption of water from mortar. The wall shall be built truly plump (or true to required better when so specified). All connected walls in a structure shall normally be raised up uniformly and regularly However, if for any specific reason, one part of the masonry is required to be left behind, the wall shall be raked back at an angle not steeper than 45 degree. Toothed joints in masonry shall be allowed.

The work shall no be carried up regularly and masonry on any day shall not be raised by more than I metre in height.

8A.4.3.2 Stones shall be laid in an un-coursed fashion, or to produce specified Pattern such as polygonal facing random facing etc. However the masonry is required to be brought to level at various stages viz plinth level window sill level, lintel level roof level and any other level specifically shown in the drawing. This may be done by firstly adjusting the laying of stones to one level and than by providing a 40mm thick leveling course of cement concrete 1.6: 12 (1 Cement:6 Sand 12 graded stone aggregate of 30mm nominal size) If more thickness of leveling course is required than richer mix shall be used as specified by the Engineer-in-charge.

8A.4.3.3 Proper bounding shall be achieved by closely filling in adjacent stones as well as by using bond stones as described herein below. Face stones shall extend back sufficiently and bond well with the masonry. The stones shall be carefully set so as to break joints and avoid formation of vertical joints. The depth of stone from the face of the wall inward shall not be less than the height or the breadth at the face.

8A.4.3.4 All stones shall be carefully laid, hammered down by a wooden mallet into position and solidly embedded in mortar, 'chips of stone may be used wherever necessary to avoid thick mortar beds or joints, at the same time ensuring that no hallow space is 1 ft any where in the masonry. The chips shall not be used below hearting stones to bring these up to the level of face tones. The use of chips shall be restricted to the filling of inter sticks the adjacent stones in hearting. The chips used shall not be more than 20% by volume of masonry, and in the case of random rubble masonry or polygonal faced Masonry no spalls or chips shall be seen on the exposed face. The hearting shall be laid nearly level with the face stones except the at about one metre intervals vertical bond stones or plums projecting about 150 to 200mm shall be firmly embedded to from vertical bonding in masonry.

8A.4.3.5 BOND STONES Bond stones or through stones running right across the thickness of the wall shall provided in walls up to 600mm thick In thicker walls up to 2m bond stones of length not less than 2.5 times the height of the course shall be provided over lapping each other by at least 150mm There shall be at least one bond stone for every 0.5 sqm of wall surface. The bond stones shall be marked by a distinguishing letter during construction for subsequent verification and shall be laid staggered in subsequent layers I n walls thicker than 2m through bond stones are not required to be provided. However bond stone as specified above are required to be provided for face masonry. Where bond stones of suitable length are not available cement concrete block of 1.36 (1 Cement, 3 coarse sand, 6 graded metal, 2Omm size) conforming to size mentioned above shall be used.

8A.4.3.6 PLUM STONES Plum stones 45 cm. long or depth of two courses whichever is more shall be provided in hearting at the rate of one for every square metre of area in plan, for every course a new set of headers shall be introduced at this rate in a sagged pattern. The average sectional are of each should not be less than 003 sqm

8A.4.3.7. QUOIS The quoins or comer stones shall be selected stones neatly dressed with hammer and/or chisel to from the required comer angle and laid header and stretcher alternately. No quoin stone shall be smaller than 0.03 cum in volume and it shall not be less than 300mm in length 25% of them being not less then 500mm in length.

8A.4.3.8 JAMB STONES: The jambs shall be made with stones specified for quoins except that the stones the provided on the jambs shall have their length equal to the thickness of the wall for walls up to 600mm and a line of headers shall be provided for walls thicker than 600mm as specified for bond.

8A.4.3.9 JOINTS: All joints shall be completely filled with mortar and their width shall not exceed 20mm in face masonry and 35 mm In hearting masonry. When plastering or pointing is 'not required to be done the joints shall be struck flush and finished simultaneously while laying the stones. Otherwise the joints shall be racked to a minimum depth of 20mm by a raking tool during the progress of laying while the mortar is still green.

This type of masonry is illustrated in Figure No. 8-A/2.

8A.4.4 SCAFFOLDING

Single or double scaffolding shall be use. The scaffolding shall be strong and sound. The holes left in masonry for supporting scaffolding shall be filled and made good before plastering

8A.4.5. CURING AND PROTECTION

Green work shall be protected from rains by suitably covering the same. Masonry in cement mortar or composite mortar shall be kept constantly moist on all the faces of at-least seven days. The top of masonry shall be flooded at the close of the day. In case of fat lime mortar (with or without pozzoland) curing shall commence two days after laying of masonry and shall continue for seven days.

8A.5 COURSED RUBBLE MASONRY FIRST SORT/COURSED RUBBLE MASONRY SECOND SORT

8A.5.1 Materials

Same as for uncoursed rubble masonry/random rubble/polygonal faced masonry described under paras 8A.4.1.1 and 8A.4.1.2.

8A.5.2 Dressing of Stones

8A.5.2.1 For first sort coursed rubble masonry face stones shall be hammer dressed on all beds and joints so as to give them approximately rectangular shape. These shall be square on bed and side joints. The bed joints shall be rough chisel dresed for depth of at least 75 mm back from the face, and the side joints shall be dressed to a depth of at least 40 mm back from the face, such that no portion of the dressed surface is more than 6 mm from a straight edge held against the surface. The remaining portions of the respective surfaces shall not project above the chisel dressed bed and side joints. The bushing on the face shall not project by more than 40 mm on an exposed face and 10 mm on a face to be plastered.

8A.5.2.2 For second sort coursed rubble masonry the stones shall be dressed as for first sort masonry described in para 8A.5.2.1 above except that no portion of dressed surface shall show a depression of more than 10 mm (as against 6 mm for first sort) from the straight edge place against the dressed surface.

8A.5.3 Laying

8A.5.3.1 Coursed Rubble Masonry First Sort

8A.5.3.1.1 All stones shall be wetted before laying. the wall shall be built up truly plumb (or to required batter where so specified). All connected masonry in a structure shall normally be raised up uniformly and regularly. However if for any specific reasons one part of wall is required to be left behind such wall shall be raked back at an angle not steeper than 45 degrees, toothed joints in masonry shall not be allowed. The work shall be carried up regularly and masonry any day will not be raised by more than 1 meter in height.

8A.5.3.1.2 All courses shall be laid truly horizontal. The height of course shall not be less than 150 mm nor more than 300 mm However, the course height shall be uniform throughout the height of masonry. Face stones shall be laid in alternate header and stretcher fashion. They shall be so arranged as to break joints by at least 75. mm Stones shall be laid with grais horizontal so that the load is transmitted along the direction of their maximum crushing strength. The depth of stone from the face of well inwards shall not be less than the height. The breadth of a face stone shall also be not less than the height. Each face stone shall be of the same height in any given course.

The courses shall be built in perpendicular to the pressure which the masonry will bear. in case of battered walls (such as retaining walls) the beds of stone and the plane of courses shall be laid with their bed perpendicular to the battered face.

8A.5.3.1.3 The hearting or the interior filling of the wall shall consist of flat bedded stones carefully laid on their proper beds in mortar, chips and spalls of stone being used where necessary to avoid excessive use of mortar, care being taken to see that no hollow space is left anywhere in the masonry. Chips shall not be used below the hearting stone to bring these upto the level of face stones. The use of chips shall be restricted to the filling of interstices between the hearting stones but the volume of chips shall be limited to 10% of the total volume of masonry.

8A.5.3.1.4. Bond Stones - Bond stones shall be provided in the same manner as in the case of uncoursed rubble masonry described in para 8a.4.3.5 above except that in this case there shall be at least one bond stone for 1.5m to 1.8 m length of every course.

8A.5.3.1.5 Plum Stones(Pin Headers) - Specifications shall be the same as described in para 8A.4.3.6.

8A.5.3.1.6 Quoins- The quoins, which shall be of the same height as the course to which it belongs shall be formed from selected stone of at least 450 mm. length. They shall be laid square on bed as stretchers and headers alternatively. The beds shall be rough chisel dressed to a depth of at least 100 mm These stones shall have a minimum uniform chisel drafts of 25 mm width at four adges, all the edges being in the same plane.

8A.5.3.1.7 Joints - Except in case of battered wall bed joints shall be horizontal and all side joints shall be vertical. Face joints shall not be more than 10 mm thick for first sort and 15 mm for second sort masonry. all joints shall be properly and completely filled with mortar. On faces where no plastering nor

Pointing is required to be done, the joints shall be struck flush and finished sumultaneously while laying the stones. In other case the joints shall be raked to minimum depth of 20 mm by raking tool during the progress of work while the mortar is still green.

Theis type of masonry is illustrated in figure no.8-A/1.

8A.5.3.2 Coursed rubble masonry second sort - This type of masonry shall be constructed in the same manner as first sort masonry described above, except that no portion of dressed surface of joint shall show a depth of gap more than i cm from a straight edge placed on it and use of chips for filling of interstices shall be limited to 15% of the total volume of masonry and that it is permissible to have courses of varying heights. A course may be made up of single stones or two stones.

8A.5.4 Other Details

The specification for curing, protection and scaffolding shall be the same as for uncoursed rubble/random rubble masonry described in para 8A.4.4 and 8A.4.5.

8A.6 HAMMER DRESSED COURSED RUBBLE MASONRY

8A.6.1. Materials

Same as for uncaused rubble masonry as described in para 8A.4.1.1. and **8A.4.1.2.**

8A.6.2 Dressing of Stone

Face stone shall be hammer dressed on all beds and joints, so as to give them approximately rectangular shape. The bed and side joints shall be hammer dressed for 75 mm form the face. The bushing on the face shall not be more than 4 cm on the exposed face.

8A.6.3 Laying

For laying provision under para 8A.5.3.1 shall be followed.

8A.6.4 Band Stones

These shall be provided as specified in para 8A.5.3.1.4.

8A.6.5 Plum Stones (Pin Header)

These shall be provided as specified in para 8A.4.3.6.

8A.6.6 Quions

These shall be provided as specified in para 8A.5.3.1.6.

8A.6.7. Joints

Provisions as specified in para 8A.5.3.1.7 shall be followed except the thickness of face joint shall be 20mm.

8A.6.8. Scaffolding. Curing and Protection

The Provisions made in Para 8A.4.4 and 8A.4.5 shall be followed.

8A.7 TONE WORK IN PLAIN ASHLAR MASONRY

8A.7.1 MATERIALS

Materials to be used for ashlars masonry, shall be the same as provided in Para 8A 4. 1. 1 and 8 A.4.1.2

8A.7.2 DRESSING OF STONES

8A.7.2.1 DRESSING- Every stone shall be cut to the required size and shape. Chisel dressed on all beds and joints so as to be free from bushing. Dressed surface shall not show a depth of gap of more than 3mm from straight edge placed on it. The exposed faces and joints. 6mm from the face shall be fine tooled so that a straight edge can be laid along the face of the stone in contact with every point. All visible angles and edges shall be true and square and free from chippings. The comer stones (quoins) shall be dressed square and comer shall be straight and vertical-

8A.7.2.2 A Sample of dressed stone shall be prepared and kept on the work after approval from the Engineer-in-Charge.

8A.7.3.1 LAYING

8A.7.3.1 Stones shall be wetted before placing in position. They shall be floated on mortar and bedded properly and solidly in position with a wooden mallet.

8A.7.3.2 The wall shall be built truly vertical (or true to required better as specified). Stones shall be laid in alternate header/stretcher fashion. The headers shall be arranged in such a fashion so as to bring them centrally over the stretchers below and above stones shall break joints on the face for at least half the height of the course and the bond shall be carefully maintained throughout. The work shall be carried up regularly and masonry on any day will not be raised by more than one metre in height.

8A.7.3.3 The height of courses in a masonry work shall be uniform and shall not be less than 300mm unless otherwise specified. The width of stone shall not be less than height or less in length than twice its height unless otherwise directed by the Engineer-in-charge.

8A.7.3.4 All connected masonry shall be raised uniformly and regularly throughout but when a break is inevitable the joint shall be made in good long steps to avoid cracks.

8A.7.3.5 When necessary, jib crane or other mechanical appliances shall be used to hoist heavy pieces of stones and places them in correct position. They shall be handled carefully to avoid damage to edges and comers (which are more vulnerable to damage). No damaged stone shall be allowed to be used in work.

8A.7.3.6 A masonry work may be a composite one consisting of ashier stone facing with baking of either brick work. Un-coursed rubble/coursed rubble masonry etc. In such cases the two portions shall be carefully bonded. The above specification shall apply to face work and the backing shall be governed by the appropriate specifications applicable to the type of backing used.

8A.7.3.7 **BOND STONES-** Bond stones shall be provided in the same manner as in Para 8A5.4. In case of composite masonry (8A.7.3.6c.above) the bond stones shall run right across the combined thickness of the wall.

8A.7.3.8. **JOINTS-** All joints shall be uniform through out and not more than 6mm wide. A uniform recess of 15mm depth from the; face shall be made with the help of a steel plate to receive pointing to be later. .

8A.7.4. **POOINTING-**

All joints shall be pointed using mortar with admixture of pigment to match the Shaw of stone as specified. The pointing when finished shall be sunk from stone face by 5 mm or as specified. The depth of mortar in pointing shall not be less than 10mm.

8A.7.5. **CURING AND PROTECTION**

The masonry shall be cured in the same manner as describe in Para 8A.4.5. The work shall be suitably protected from damage during construction.

8A.7.6. SCAFOLDING.

Double scaffolding shall be adopted. Single scaffolding shall not be allowed. The scaffolding shall be built sufficiently strong and sound keeping in view the heavy load of solid and other materials likely to be carried by it.

8A.8 ASHLAR ROUGH TOOLED OR PUNCHED MASONRY

8A.8.1 Dressing of Stone

The dressing of stone blocks shall be similar to plain ashlar except that face exposed in view shall have a fine chisel draft 2.5 cm wide round the edges and shall be rough tooled between the draft such that the dressed surface shall not deviate more than 3mm from the straight edge placed over it.

8A.8.2 The requirements regarding laying, pointing, curing and scaffolding shall be the same as for plain ashlar masonry.

8A.8.9 ASHLAR ROCK OR QUARRY FACED MASONRY

8A.9.1 Dressing of Stone

The dressing of stone clocks in case of ashlar rock shall be similar to ashlar rough tolled except that the exposed faces of the stone between the drafts shall be left rough as the stone comes from the quarry; but no rock face or "bushing" shall project more than 7.5 c.m. from plane of drafts.

8.A.9.2 The requirements regarding laying, pointing, curing and scaffolding shall be the same as for plain ashlar masonry.

8A. 10. DRY RANDOM RUBBLE MASONRY

8A. 10.1 Materials

8a.10.1.1 Stone- The stone shall conform in all respects to specifications under para 8a.4.1.1. The stone shall not be less than 15.cm. in any direction except the packing stone. The face stones average breadth shall not be less than the height and average length not less than one and a half times the height for stones upto 20cm height and not less than one and one third times the height or 30 cm whichever is more, for stones exceeding 20 cm in height.

8A.10.1.2 Bond Stones - The bond stones shall run right across the wall and shall not be less than 300 sq cm in cross section at any point. In masonry wall thicker than 60cm two bond stones over lapping each other by at least 150 mm may be used in conjunction. The bond stones shall be provided @ 2 per square meter of front face area.

8A.10.1.3 The stones shall be knocked of so as to obtain as large bedding surface as possible.

8A.10.1.4 The thickness of joint of the front and rear face shall not be more than 30mm at any point.

8A.10.2 Laying

8A.10.2.1 The stones in the foundations shall be the longest available and shall be laid close to each other and packed by hand. The front and back stones shall be laid alternately as headers and stretchers as far as possible. The stones in the hearting shall be laid interlocking each other. The Stones shall break joints with the stones below.

8A.10.2.2 The bond stones shall be laid in a line from front to back over lapping each other at least 20 cm. The course shall be built perpendicular to the pressure with the masonry will bear. In case of battered (such as retaining walls), the beds of stone and the plane of course shall be laid with their bed at right angles to the battered face.

8A.11 PRECAST CEMENT CONCRETE BLOCK MASONRY

8A.11.1 Material

8A.11.1.1 **Cement** - Cement complying with any of the Indian Standards, IS:269-1389, IS:455-1976, IS:1489-1976, IS:6909-1973, iS:8041-1978, IS:8042-1978 and IS:8043-1978 (amended from time to time) may be used at the discretion of the manufacturer.

When cement conforming to IS:269-- 1989 is used, replacement of cement by fly ash conforming to IS:3812 (Part I)-1981 may be permitted upto a limit of 20%. However, it shall be ensured that blending of fly ash with cement is as intimate as possible, to achieve maximum uniformity.

8A.11.1.2 Aggregates - The aggregates used in the manufacture of blocks at the mixer or the mixing platform shall be clean and free from deleterious matter and shall conform to the requirements of IS:383-1970.

The grading of the combined aggregates shall conform as near as possible to the requirements indicated in IS: 383-1970. It is recommended that the fineness modulus of the combined aggregates shall be between 3.6 and 4.0

Fly ash conforming to IS: 3812 (part III) -1981 May be used for part replacement of fine aggregate upto a limit of 20%.

8A.11.1.3 Water- The water used used in the manufacture of concrete masonry units shall be free from matter harmful to concrete or reinforcement, or matter likely to cause efflorescence in the units and shall conform to the requirements of IS:456-1978.

(a) accelerating, water -reducing and air-entraining admixtures conforming to IS:9103-1979,

(b) fly ash conforming to IS:3812 (part II) - 1981,

(c) waterproofing agents conforming to IS:2645-1975,and

(d) colouring pigments.

Where no Indian standards apply, the additives or admixtures shall be shown by test or experience, to be not detrimental to the durability of the concrete.

8A.11.2 Dimensions

8A.11.2.1 Concrete masonry building units shall be made in sizes and shapes ato fit different construction needs. They include stretcher, corners, double corner or pier, jamb, header, bull nose, partition block and concrete floor units.

8A.11.2.2 Concrete Block - Concrete block, hollow (open or closed cavity or solid shall be reffered to by its nominal dimensions. The term "nominal" means that the dimensions includes the thickness of the mortar joint. Actual dimensions shall be 10 mm short of the nominal dimensions (or 6 mm short in special cases where finer jointing is specified).

The nominal dimensions of concrete block shall be as follows:

Length	400,500 or 600mm
Height	200 or 100 mm
Width	50, 75,100, 150, 200, 250, or 300mm

In addition, block shall be manufactured in half lengths of 200, 250 or 300mm to correspond to the full lengths.

The nominal dimension of the units are so designed that taking account of the thickness of mortar joints, they will produce wall lengths and heights which will conform to the principles of the modular coordination.

8A.11.3 Classification

8A11.3.1 Hollow (Open and Closed Cavity) Concrete Blocks- The hollow (open and closed cavity) concrete blocks shall conform to the following three grades:

(a) Grade A - These are used as load bearing units and shall have a minimum block density 1500 kg/m^3. These shall be manufactured for minimum average compressive strengths of 3.5, 4.5, 5.5 and7.0No/mm^2 respectively at 28 days.

(b) Grade B- These are also used as load bearing units and shall have a block density less than 1500 kg/m^3. These shall be manufactured for minimum average compressive strengths of 2.0, 3.0, 5.0 N/mm^2 respectively at 28 days.

(c) Grade C - These are used as non-load bearing units and shall have a block density less than 1500 kg/m^3 , but not less than 1000 kg/m^3, These shall be manufactured for minimum average compressive strength of 1.5 N/mm^2 at 28 days.

8A.11.3.2 Solid Concrete Blocks - Grade D - The solid concrete blocks are used as load bearing units and shall have a block density not less than 1800 kg/m^3. These shall be manufactured for minimum average compressive strengths of 4.0 and 5.0 N/mm^2 respectively.

8A.11.4. Manufacture

8A.11.4.1 Mix

8A.11.4.1.1 The concrete mix used for blocks shall not be richer than one part by volume of cement to six parts by volume of combined aggregates before mixing.

8A.11.4.1.2 In case of hand- moulded block where compaction is done manually, concrete mix should be sufficiently consistent to enable demoulding immediately after casting. The consistency of mix should be such that it may cohere when compressed in the hand without free water being visible. Too little water causes the mix to be friable, while too much water causes difficulty in the immediate withdrawal of the mould.

8A.11.4.1.3 In case of machine- moulded blocks, the web markings on the units as they come from the machine give a good indication as to whether the proper consistency of concrete has been used. In addition to the grading of the aggregate and the quantity of cement, the amount of water required for mix will depend to an extent on the type of machine of which blocks are produced. It is possible to judge the proper consistency by squeezing a handful of concrete mixture. When traces of mixture show on the outside of the squeezed mass it is usually considered to be suitable.

8A.11.4.2 Mixing

8A.11.4.2.1 Concrete shall normally be mixed in a mechanical mixture.

(a) Mixing shall continued until there is a uniform distribution of the materials, and the mass is uniform in colour and consistency.

(b) When hand mixing is permitted by the Engineer-in charge, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. 10% extra cement may be added when hand-mixing is resorted to.

8A.11.4.3 Placing and Compaction

8A.11.4.3.1 In the case of manual compaction, the mixture shall be placed into the mould in layers of about 50 to 75 mm and each layer thoroughly tamped with suitable tampers until the whole mould is filled up and struck off level with a trowel.

8A.11.4.3.2 In the case of mechanical compaction, the mould shall be filled up to overflow, vibrated or mechanically tamped and struck off level.

8A.11.4.3.3 After demoulding, the blocks shall be protected until they are sufficiently hardened to permit handling without damage.

8A.11.4.4 Curing

8A.11.4.4.1 The blocks hardened in accordance with para 8A.11.4.3.3 shall then be cured in curing water tank or curing yard, and shall be kept continuously moist for at least 14 days. When the blocks are cured in immersion tank, the water of the tank shall be changed at least every four days.

8A.11.4.4.2 Steam curing of blocks hardened in accordance with para 8A.11.4.3.3 may be adopted instead of methods specified in para 8A.11.4.4.1, provided the requirements of pressure or non-pressure steam curing are fulfilled.

8A.11.4.5 **Drying-** After curing, the blocks shall be bried for a period of four weeks before being used on the work. They shall be stacked with voids horizontal to facilitate through passage of air. The blocks shall be allowed to complete their initial Shrinkage before they are laid in a wall.

8A.11.5 Surface Texture and Finish

8A.11.5.1 Concrete masonry units can be given a variety of surface textures ranging from a very fine close texture to a coarse open texture by the proper selection, grading, and proportioning of aggregates at the time of manufacture. Textures may also be developed by treating the face of the units, while still green, by wire brushing or combing, by slightly eroding the surface, by playing a fine spray of water upon it, and by splitting (split block). Colour may be introduced by incorporating non-fading mineral pigments in the facing concrete, or by applying a coloured cement grout or paint to the face of the units soon after they are removed from the moulds. Selected coloured aggregates may also be used in the facing and exposed by washing with water or dilute hydrochloric acid.

8A.11.5.2 Well made concrete masonry may not require plaster in case of unimportant buildings in low rainfall area; two or three coats of a cement paints being sufficient to render it resistant to rain water. If, however, it is intended to plaster concrete masonry, the block shall have a sufficiently rough surface to afford a good day to the plaster.

8A.11.6. Mortar

8A.11.6.1 Cement lime sand mortar, cement sand mortar or lime pozzolana sand mortar etc., as specified shall be used. Detailed specifications for mortars given under Chapter-6 "Mortars" shall apply.

8A.11.6.2 Mortar shall not be spread so much ahead of the actual laying of the units that it tends to stiffen and loose its plasticity, there by resulting in poor bond. For most of the work, the joints, both Horizontal and vertical shall be 10mm thick. Except in case of extruded joint construction, the mortar joints shall be struck off flush with wall surface and when the mortar has started stiffening, it shall be compressed with a rounded or U-shaped tool. This compaction is important, since mortar, while hardening, has a tendency to shrink slightly and thus pull away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after the mortar has stiffened to effect intimate contact between the mortar and the masonry unit and obtain a water tight joint.

8A.11.7. Laying

8A.11.7.1 The blocks need be wetted before or during laying in the walls. In case climatic conditions so require, the top and the sides of block may only be slightly moistened so as to prevent absorption of water from the mortar and ensure the development of the required bond with the mortar.

8A.11.7.2 Operations of laying of precast cement concrete block masonry shall be carried out as under:

8A.11.7.2.1. First Course- The first course of concrete block masonry shall be laid with greed care, making sure that it is properly aligned, leveled and plumbed, as this may assist the mason in laying succeeding cou5rses to obtain a straight and truly vertical wall.

8A.11.7.2.1.1 Before laying the first course, the alignment of the wall shall be marked on the damp-proof course, The blocks for this course shall first be laid dry, that is without mortar along a string stretched between properly located corner of the wall in order to determine the correct position of the blocks including those of the cross walls jointing it and also adjust their spacing. When the blocks are set in proper position the two corner blocks shall be removed, mortar bed spread and these blocks laid back in place truly level and plumb. The string shall then be stretched tightly along the faces of the two corner blocks and the faces of the intermediate ones adjusted to coincide with the line. Thereafter each block shall be removed and relaid over a bed of mortar. After every three or four blocks have been laid, their correct alignment level and verticality shall be carefully checked.

8A.117.2.2 The construction of walls may be started either at the corners first or started from one end proceeding in the other direction. if the corners of the wall are built first, they shall be built four or five courses higher than the center of the wall. As. each course is laid at the corner, it shall be checked for alignment and level and for being plumb. Each block shall be carefully checked with level or straight edge to make certain that the faces of the block are all in the same plane. This precaution is necessary to ensure truly straight and vertical walls.

8A.11.7.2.2.1 The use of a storey-rod or course pole which is simply a board with markings 200 mm apart, provides an accurate method of finding the top of the masonry for each course. Each course, in building the corners, shall be stepped back by a half- block and the horizontal spacing of the block shall be checked by placing a mason's level diagonally across the corners of the block.

8A.11.7.2.3 When filling in the wall between the corners, a mason's line shall be stretched from corner to corner for each course and the top outside edge of each block shall be laid to this line. The manner of handling or gripping the block shall be such as position the block properly with minimum adjustment.

8A.11.7.2.3.1 To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as it will stiffen and lose its plasticity. As each block is laid, excess mortar extruding from the joints shall be cut off with the trowel and thrown back on the mortar board to be reworked into the fresh mortar. If the work is progressing rapidly, the extruded morta cut from the joints may be applied to the vertical face shells of the blocks just laid. If there be any delay long enough for the mortar to stiffen on the block, the mortar shall be removed to the mortar board and reworked. Dead mortar has been picked up from the scaffold or from the floor shall not be used.

8A.11.7.2.4 ***Closer Block*** - When 1nstalling the closure block, all edges of the opening and all four edges of the closure block shall be buttered with mortar. The closure block shall be careful1y lowered into place. If any mortar fal1s leaving an open joint, the closure block shall be removed, fresh mortar applied and the operation repeated.

8A.11.7.3 ***Quoins and Closers*** - Special quoin blocks (with 6 return face equal to length to half the normal face) shall be cast for all building and slabs for external work. Proper half length closers shall be cast and not cut from full size blocks. The returned ends of blocks for door and window reveals and quoins shall be finished with a fair face in the moulds.

8A.11.8 Scaffolding

Only double scaffolding shall be used. The scaffolding shall be strong and sound. No holes in the masonry for supporting scaffolding shall be allowed.

8A.11.9 Finishing

8A.11.9.1 The precast concrete blocks walls shall be suitably finished or pointed as explained in Chapter-11 "Plastering and Pointing".

8A.11.9.2 Rendering and other finishes for different types of concrete blocks. shall be carried as under:

8A.11.9.2.1 ***External Renderings*** - Lightweight concrete blocks are almost invariably not impervious and will become damp when exposed to rain. The exterior surface of a11 lightweight concrete blocks shall, therefore, be made waterproof by treating the walls with different types of renderings as explained below depending. upon the intensity of rainfal1, nature of exposure of other seasons. S me other points that shoo Id be considered are given below :

(a) Renderings shall not be applied to the walls when these are wet or in monsoon. The walls shall be treated only after they are dried.

(b) Satisfactory performance of any rendering depends entirely on the efficiency of the bond developed between the rendering and the well surface. Extreme care shall, therefore, be taken to ensure effective bond with the wall by preparing the surface, cleaning the surface of all loose particles and dust, and lightly moistening it with 'water just prior to applying the rendering to prevent absorption of water from it.

(c) The plaster finishes sho11 be applied in accordance with IS:2402-1963.

(d) The sand used for the plaster finish shall be graded from 3mm downwards. The plaster shall not be finished smooth, but provided with a coarse finish by means of a wooden float.

8A.11.9.2.1.1 In localities where rainfall is heavy or the walls are exposed to sea weather, concrete block masonry shall be rendered with two coats of plaster. First coat (backing coat) shall be of 15 mm thickness of 1:1:6 cement lime sand mortar or 1:6 cement sand mortar. Second coat (finishing coat) shall be of 5 to 10 mm thickness *of* 1:1:6 to 1:2:9 cement lime sand mortar or 1:6 cement sand mortar.

8A.11.9.2.1.2 In moderate rainfall areas, concrete block masonry shall be rendered with at least one coat of 10 to 15 mm thickness *of* 1:1:6 cement lime sand mortar (or 1:6 cement sand mortar) or two coats of cement paint may be applied directly on concrete block masonry to provide a reasonably impervious surface to withstand rain.

8A.11.9.2.1.3 In areas of scarce rainfal1, where it is desired from aesthetic considerations, the exterior surface of concrete block masonry need only be pointed with 1:1:6 cement lime sand mortar or 1:6 cement sand mortar.

8A.11.9.2.1.4 Where for architectural or other reasons it is necessary to have the concrete block surface exposed, the walls shall either be built with block having richer facing mixture or treated with two coats *of* approved quality of cement based paint. In either case the walls in heavy or moderate rainfal1 areas shal1 be, pointed with 1:3 cement mortar.

8A.11.9.2.2 Internal renderings -As machine made concrete blocks are of uniform size, wells built with them provide an even surface. Where it is desired to have the block surface exposed, the walls may only be flush pointed and painted with an approved quality of cement paint, emulsion paint or chlorinated rubber paint. Oil based paints are liable to be attacked by alkali from the blocks and mortar. Otherwise the interior surface on wells shall be plastered with one coat of 6 to12 mm thickness of 1:2:9 cement lime sand mortar or 1:6 cement sand mortar. Where a very smooth finish is desired. a second coat of 2 to 3 mm thickness of lime finish may be applied.

8A. 12 PRECAST STONE BLOCK MASONRY

8A. 12. 1 Materials-Stone Masonry Blocks

These shall be precast with concrete of specified mix and stone 5 to15 cm in size. Care should be taken that stone content in the block is around 30% by volume.

The stones shall be of specified variety such as granite, trap stone, sand stone, quartzite etc. These shall be obtained only from an approved quarry or approved river boulders and sha11 be hard, sound, durable and free from all defects.

The materials used for concrete shall conform to relevant specifications given in para 8A.11.1. The size of block shall be as follows:

	Nominal size (cm.)			Actual size (cm.)		
For Load Bearing Wall	30	20	15	29	19	14
For Partitions	30	10	15	29	9	14

Blocks of one-third and two-third of above sizes shall be used for bond purpose. The minimum average compressive strength of blocks shall be 50 kg/cm2.

The blocks shall be cast as per CBRI Technical Note No.7. The various steps in casting are as follows:

(i) Apply oil (grease and kerosene oil 1:4 ratio) on casting platform and place the moulds in row.

(ii) Arrange large size stone 12 cm size or so inside the mould, generally two or three stones w ill be laid.

(iii) Fill up the gaps between the stone pieces in the lower portion of the mould up to a height of about 5 cm with cement concrete of mix 1:5:8 (1 cement: 5 sand : 8 stone aggregate 20mm nominal gouge)/cement concrete 1:4:8 (1 cement 4 sand: 8 stone aggregate 20 mm nominal gauge/ cement concrete 1:5:10 (1 cement: 5 sand: 10 stone aggregate 20 mm nominal gauge) and compact by trowel. The cement concrete should have low water cement ratio so as to give a stiff mix.

(iv) Fill up the remaining portion by placing 60 to 75 mm pieces in gaps and again pour the same cement concrete mix upto top and compact by roding/tamping/vibrating.

(v) The demould1ng is done after 3 to 4 minutes of casting the block by putting a wooden piece on top of the block cast and pulling the mould up.

(vi) The next day of casting, the block are turned upside down and stone texture kept exposed. The blocks are removed and cured with water for two weeks and air dried for 3 weeks before using in masonry.

8A.12.2 Mortar

The cement lime sand mortar, cement sand mortar, lime pozzolana sand mortar etc. as specified shall be used. Detailed specifications for mortars given under relevant Chapter-6 "Mortars" shall apply.

8A.12.3 laying

The blocks shall be slightly wetted before or during laying in the wal1, one-third and two-third size blocks shall be used for completing the bond. The thickness of joints shall be I cm and it shall be ensured that all horizontal and vertical joints are completely filled with mortar without any void left in the masonry. The face joints shall be racked to a depth of 1 cm by rack1ng tool during the process of the work while the mortar is still green so as to provide proper key for plaster or to facilitate pointing to be done later. Where plaster or pointing is not requ1red, the joint shall be struck flush and finished side by side.

8A.12.4 Curing

Green work shall be protected from rains by suitable covering. Masonry work in cement or composite mortar shall be kept constantly moist on all the face for a minimum period of seven days. In case of fat lime mortar curing shall commence two days after the laying of masonry and shall continue for seven days.

8A.12.5 Scaffolding

Single or double scaffolding may be used. The scaffolding shall be strong and sound. In case of single scaffolding is used, the holes shall be careful1y made good as per directions of the Engineer- in-Charge.

8A. 13 STONE SHELVES. PLAIN COPINGS, CORNICES, STRING COURSE AND SILLS

8A.13.1 Stone used for shelves, copings, cornices, string courses, shall be of

the specified variety and shall be hard, sound, durable and of uniform colour and texture.

8A.13.2 Dressing

All exposed plane surfaces and sides shall be chisel dressed such that the dressed surface shall not vary by more than 1 mm at any point from a 600 mm long straight edge placed aginst it except in the case of shelves where a variation of 3 mm shall be allowed. All visible angles and edges shall be free from chippings. The surfaces to be burried in masonry shall be rough chisel dressed. Copings, cornices and si1ls shall be finished to the shape as shown in the drawing. The finished thickness of stone shelves shall be as specified with a permissible tolerance of 2 mm.

8A. 13.3 Laying and Fixing

laying and fixing of these items shall be done in cement mortar of specified mtx, in the manner shown in the drawing as directed by the Engineer-in -Charge.

8A.13.4 Other Details

Pointing, curing, protection, scaffolding etc., shall be done as specified for plain ashlar masonry work vide para 8A. 7.4, 8A. 7.5 and 8A.7.6.

8A.14 STONE LINTELS

8A.14. 1 Lintel are important structural part of a building. The strength of the stone used for lintels is of considerable Importance, and, therefore, due care should be taken while making their selection.

8A.14.1.1 General Requirements - The stone for the lintels shall be reasonab1y fine grained, hard end shall have a uniform texture and colour. They shall be free from weathering and decay. The stone shall be without any creeks, vents, fissures, clayholes or other similar source of weakness.

The lintels shall be so cut that when set in the building, the stone is laid on its natural bed or with the bed in the same direction as it was when the test for transverse strength was carried out.

8A. 14.2 Physical Properties

The physical properties of the stones used for lintels sha11 conform to the requirements given in 001.3 of Table below, when tested in accordance with the provisions of 100180 Standards given in given in col. 4:

TABLE -PHYSICAL PROPERTIES OF THE STONE USED FOR LI

Sl. No.	Characteristics	Requirements	Method of Test (Ref. to IS)
(i)	Specific gravity	2.6 Min	IS:1124-1974
(ii)	Water absorption, per cent	1.0 Max	IS:1124-1974
(iii)	Transvers strength, $N/mm.^2$	11.0 Min	IS:1121 (Part II) - 1974

8A.14.3 Dimension and Tolerance

The stone 11ntels shall be of rectangular cross-section. The width shall be equal to the thickness of the wall and the depth shall not be less than 100 mm. The length shall be limited to a maximum clear span of 2.65 metres. A tolerance of $\pm$ 1.5 mm shall be allowed on all dimensions of 1.2 m or less and $\pm$3 mm on all dimensions more than 1.2 m

8A.14.4 Lintel Bearing

Stone lintels shall be well bonded into the masonry on either s1de of the opening. The bearing length on either side shall not be less than the depth of the lintel or half the width of the supporting masonry whichever is more. The bearing length shall be increased for exceptionally:-heavy loads and for long spans. Bed blocks shal1 be provided if the clear span exceeds 2 m.

8A.14.5 Workmanship

The edges-of the stone lintels sha11 be dressed as specified 1n respective masonries. The exposed surface of the lintel shall be finished as specified.

8A. 15 STONE CHAJJA

8A. 1 5.1 Stone Slabs

Stone slabs shall be of specified variety and sha11 be hard, sound and durable. They shall be chisel dressed on all faces which are exposed to view and rough dressed at other surfaces. Angles shall be true and edge lines straight. The finished thickness shall be as stipulated with a permissible tolerance of 2 mm. The length of stone slabs shall not be less than 60 cm unless otherwise specified.

8A.15.2 Slopping Chajja

The slope, projection etc. shall be as indicated in drawing. The bearing on the wall being similarly sloped. The chajja shall have 8 minimum of 20 cm on the wall, measured hor1zontal1y. Each slab sha1l be anchored down by means of a steel bar 12 mm in diameter and 450 mm long the lower end being bent for fixing into the masonry joint. The steel bar shall pass through the hole dril1ed in the centre of the bearing of the stone slab.

8A.15.3 Horizontal Chajja

The stone shall be fixed horizontal1y with a slight outer slope of about 1:20. Holding down bolt shall be provided where so specified. The stone chajja shall have 8 mjnimum bearing of 20 cm

8A.15.4 Other Details

The specification for curing, protection, scaffolding, pointing etc. shall be the Same as for stone work in plain ashlar masonry detail under paras 8A.74., '8A.75 and 8A.7.6 and / or as specified in the work.

APPENDIX-A

TEST FOR WATER ABSORPTION OF STONE

(para 8A.4.1.1)

1. SELECTION OF SAMPLES

The sample shall be selected to represent a true average *of* the type or grade *of* stones under consideration.

The sample shall be selected from the quarried stone or taken from the natural rock as described below and shall be of adequate size to permit the preparation of the requisite number of test pieces.

Stone from ledge or quarry face of the stone shall be inspected to determine any variation in different strata. Differences in colour and structure shall be observed. Separate samples of stone weighing at least 25 kg each of unweathered specimens shall be obtained from all strata that appear to very in colour and structure. Pieces that have been damaged by blasting shall not be included in the sample.

Fie1d Stone and Bou1ders - A detai1ed inspection shall be made of the deposits of field and boulders over the area where the supply is to be obtained. The different kinds of stone and their conditions in the various deposits shall be recorded. Separate samples shall be selected of classes of stone that would be considered for use in construction as indicated by visual inspection.

When perceptible variations occur in the quality of rock, the purchaser shall select as many samples as are necessary for determining the range in properties.

2. TEST PIECES

The test pieces selected as above shall be crushed or broken and the material passing 20 mm IS Sieve and retained on 10 mm IS Sieve shal1 be used for the test.

3. APPARATUS

Cylindrica1 Measuring G1ass Jars - of 1000 ml and 100 ml capacity shall be used. The 100 ml capacity jar shall have graduation mark of 1 ml.

Glass vessel- of about 1.5 liter and two dry absorbent cloths of 0.5 sqm area each.

Balance - of Capacity 3kg with en accuracy of 1 g.

Desiccator

Oven.

4. PROCEDURE

The test piece weighing about 1 kg shall be washed to remove particles of dust and immersed in disti11ed water in a glass vessel at room temperature 20^0 to 30^0 C for 24 hours. Soon after immersion and again at the end of soaking period, entrapped air shall be removed by gentle agitation achieved by rapid clock-wise and anti-clock-wise rotation of the vessel. The vessel shall then be emptied and the test piece be allowed to drain. The test piece shall then be placed on a dry cloth and gently surface dried with the cloth. It shall be transferred to a second dry cloth when the first one removes no further moisture. It shall be spread out not more than one stone deep on the second cloth and left exposed to atmosphere away from direct sunlight or any other sources of heat for not less than 10 min until it appears to be completely surface dry. The sample shall then be weighed (B).

The water in the larger cylinder shall be drained and the sample shall be carefully taken out and dried in an oven at 100^0 to 110^0 C for not less than 24 hours. It shall then be cooled 1n a desiccators to room temperature and weighed (A). The room temperature during the test shall, be recorded.

5. EVALUATION AND REPORT OF TEST RESULTS

The water absorption shall be calculated from the following formula:

$$\text{Water absorption} = \frac{B - A}{A} \times 100$$

Where,

A = weight of oven dry test piece in g, and

B = weigh of saturated surface dry test piece in g.

The water absorption shal1 be expressed as percentage by weight of oven dry sample andshal1 be the average of three determinations.

Identification of the sample, date when sample was taken and type of stone shall be reported.

The size and shape of test pieces used in the tests sha11 be indicated.

A description of the way in which the test pieces were prepared shall be included. .

APPENDIX - B

TEST FOR COMPRESSIYE STRENGTH OF NATURAL BUILDING STONE

1. SELECTION OF SAMPLES

The sample shal1 be selected to represent 6 true average of the type of grade of tone under consideration. The sample shall be selected from the Quarried stone or taken from the natural rock, as described below and shall be of adequate size to permit the preparation of the requisite number" of test pieces.

Stone From Ledges or Quarries - The ledge or Quarry face of the stone shall be inspected to determine any variation in different strata. Differences in coloour. texture and structure shal1 be observed. Separate samples of stone weighing at least 25 kg each of the unweathered specimens shal1 be obtained from al1 strata that appear to very in colour, texture and structure. Pieces that have been damaged by blasting, driving, wedges, heating, etc, shall not be included in the sample.

Field Stones and Boulders - A detailed inspection of the stone 'and boulders over the area shall be made where the supply is to be obtained. The different kinds of stones and their conditions at various quarry sites shall be recorded separate samples for each class of stone that would be considered for use in construction as indicated by visual inspection shall be selected.

TEST PIECES AND CONDITIONING

Test pieces shall be made from samples selected in accordance with above and all be in the form of cubes or cylinders. They shall be cut or drilled from the sample. The diameter or lateral dimension (distance between opposite vertical faces) of a test piece shall not be Jess than 50 mm and the ratio of height to diameter, lateral dimension shal1 not be less than 1:1 (as shown later).

The load bearing surfaces shall be finished to as nearly true, parallel and perpendicular planes as possible by using rock cutting saws, grinding polishing heels or abrasive powder. The dimensions of the faces under loading shall be measured to the nearest 0.2 mm.

The load-bearing surfaces and the direction of the rift shall be carefully marked on each test piece after finishing.

Three test pieces shall be used for conducting the test in each of the conditions mentioned below. In each of these conditions, separate/tests shall be made for the specimen when the load is parallel to the rift and perpendicular to the rift. In all twelve test pieces shall be used.

The test pieces shall be immersed in water maintained at 20^0 to 30^0 C for 72 h before testing and shall be tested in saturated condition.

· The test pieces shall also be tested in a dry condition and shall be dried in an over, at. 105 $\pm$ 5^0 C for 24 hand col1ed in a desiccator to room temperature (20^0 to 30^0 C).

3. APPARATUS

A testing machine of sufficient capacity for the tests and capable of applying load at the

.

specified rate shall be used. The machine shall be equipped with two steel bearing plates with hardened faces. One of the plates (preferably the one that normally bears on the upper surface of the test pieces) shall be fitted with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the plate. The other compression plate shall be plain rigid bearing block. The bearing faces of both plates shall be preferably larger than the nominal size of the test piece to which load is applied. The bearing surface of the plates when new, shall not depart from a plane by more than 0.0125 mm at any point. The movable portion of spherically seated compression plate shall be held on spherical seat, but the design shall be such that it is possible to rotate the bearing face freely and tilt it through small angles in any direction.

4. PROCEDURE

The load shall be applied without Shock and increased continuously at a rate of approximately 140kg/cm2 of the area per minute until the resistance of the test piece to the increasing load breaks down and no greater load is sustained. The maximum load applied to the test piece shall be recorded and-the appearance of the stone and many unusual features in the type of failure shall be noted.

5. EVALUATION AND REPORT OF TEST RESULTS

The maximum load in kg supported by the test piece before failure occurs, divided by the area of the bearing face of the specimen in square cm shall be taken as the compressive strength of the specimen.

When the ratio of height to diameter (or lateral dimension) differs from unity by 25 percent or more, the result shall be calculated to that standard test piece as follows :

$$Cc = \frac{Cp}{0.778 + 0.222\ (b+h)}$$

Where

Cc = compressive strength of standard test piece,

Cp = compressive strength of the specimen having a height greater

than the diameter or lateral dimension.

b = diameter or lateral dimension, and

h = height.

The average of the three results in each condition separately above shall be taken for purposes of reporting the compressive strength of the sample

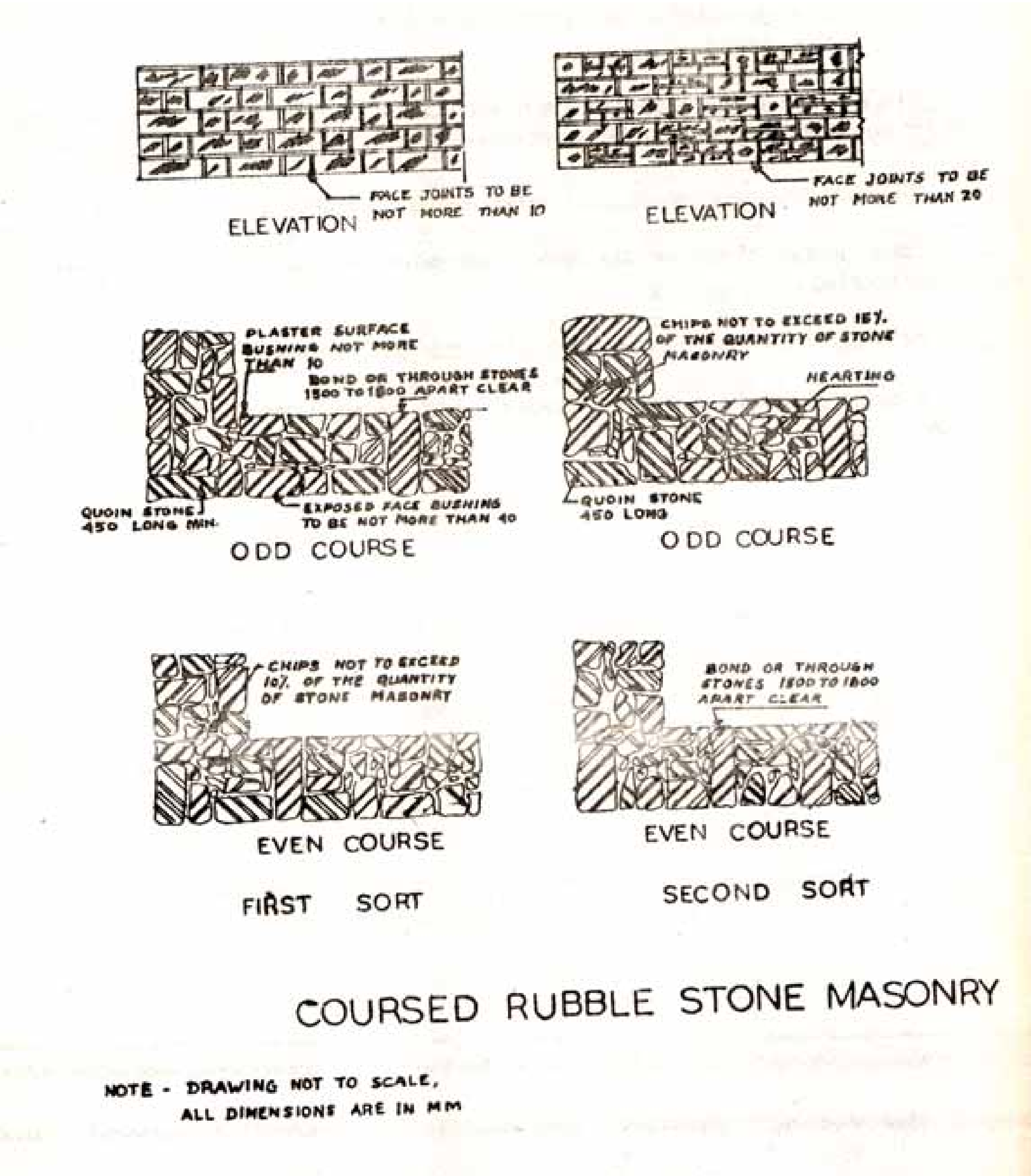
The compressive strength shall be expressed in kg/cm2

Identification of the sample, date, when sample was taken and type of stone shall be reported.

Size and shape of test pieces used in the tests shall be indicated.

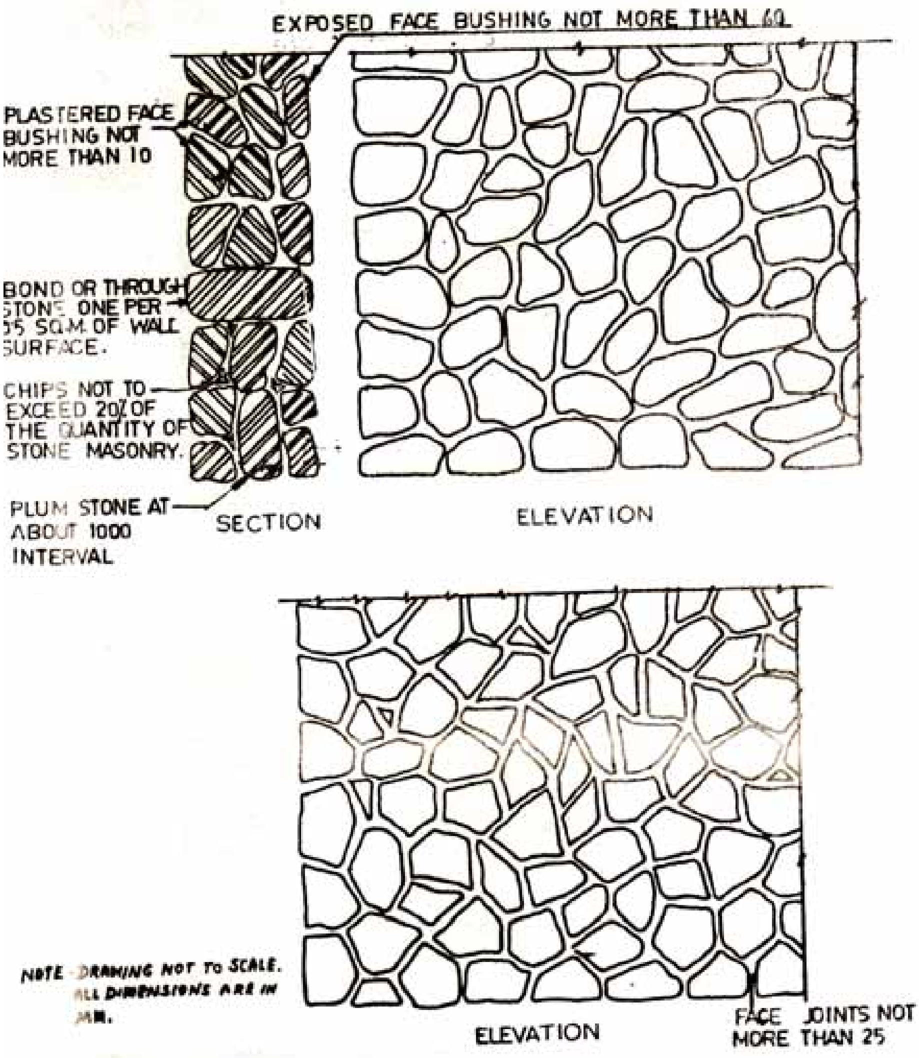
A description of the way in which the test pieces were prepared shall be included.

FIGURE : 8-A/1



FACE JOINTS TO BE NOT MORE THAN 10
ELEVATION
FACE JOINTS TO BE NOT MORE THAN 20
ELEVATION
PLASTER SURFACE BUSHING NOT MORE THAN 10
BOND OR THROUGH STONES 1500 TO 1800 APART CLEAR
QUOIN STONE 450 LONG MIN.
EXPOSED FACE BUSHING TO BE NOT MORE THAN 40
ODD COURSE
CHIPS NOT TO EXCEED 15% OF THE QUANTITY OF STONE MASONRY
HEARTING
QUOIN STONE 450 LONG
ODD COURSE
CHIPS NOT TO EXCEED 10% OF THE QUANTITY OF STONE MASONRY
EVEN COURSE
FIRST SORT
BOND OR THROUGH STONES 1500 TO 1800 APART CLEAR
EVEN COURSE
SECOND SORT
COURSED RUBBLE STONE MASONRY
NOTE - DRAWING NOT TO SCALE, ALL DIMENSIONS ARE IN MM

FIGURE : 8-A/2



RANDOM RUBBLE STONE MASONRY

FIGURE : 8-A/3

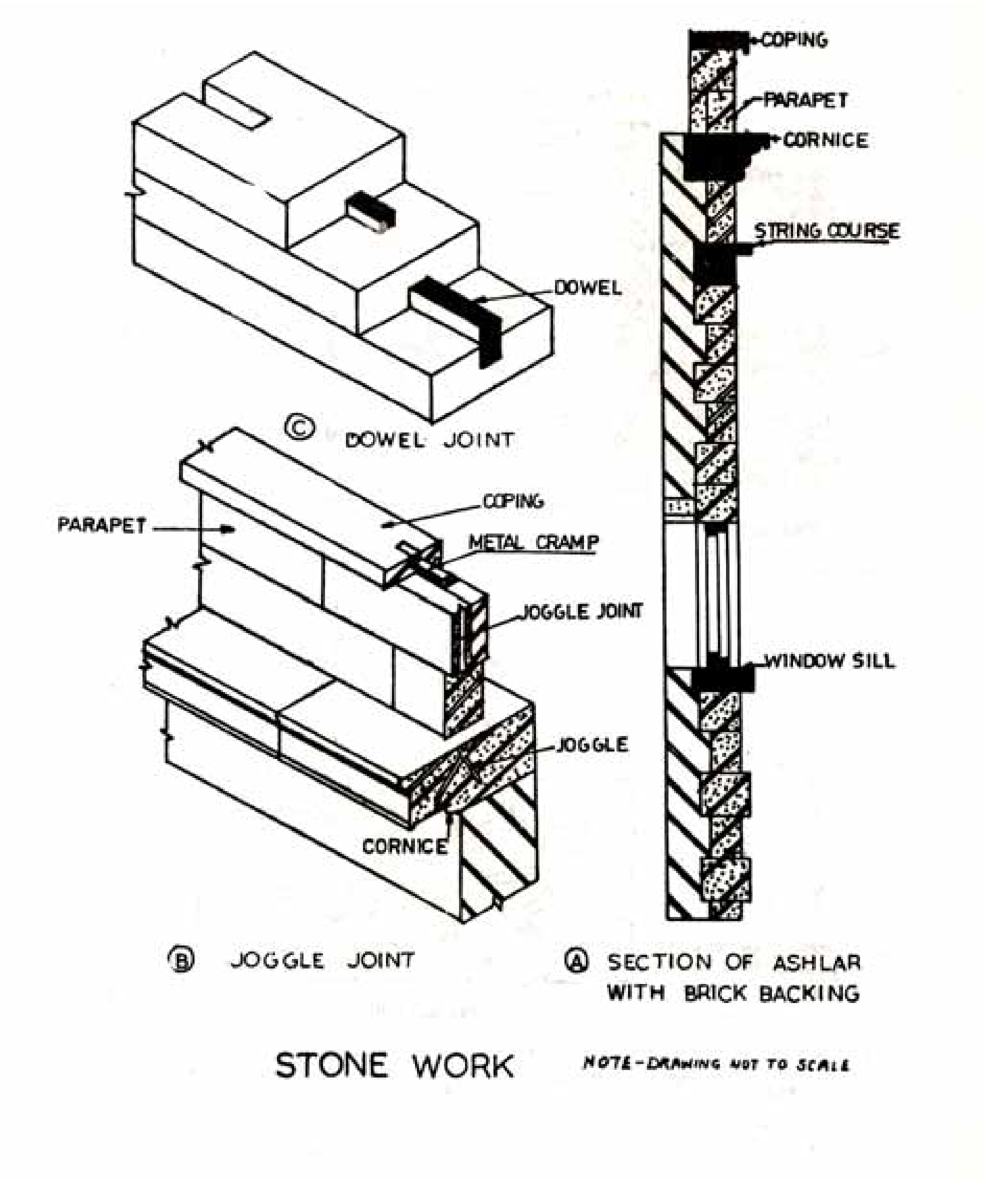
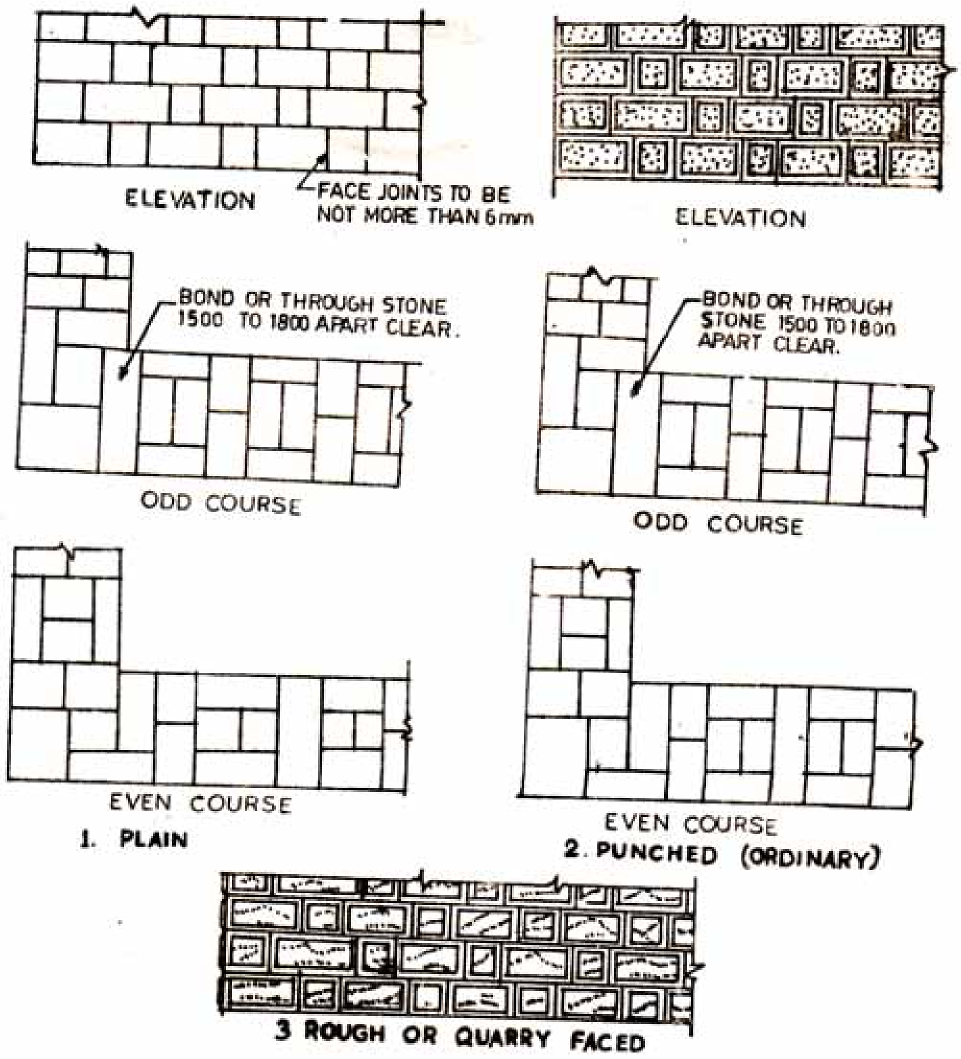

COPING
PARAPET
CORNICE
STRING COURSE
DOWEL
© DOWEL JOINT
COPING
PARAPET
METAL CRAMP
JOGGLE JOINT
WINDOW SILL
JOGGLE
CORNICE
Ⓑ JOGGLE JOINT
Ⓐ SECTION OF ASHLAR
WITH BRICK BACKING
STONE WORK
NOTE-DRAWING NOT TO SCALE

FIGURE : 8-A/4



ASHLAR STONE MASONRY

NOTE - DRAWING NOT TO SCALE
ALL DIMENSIONS ARE IN MM.

CHAPTER - 8 B

STONE MASONARY (IN DAM AND APPURTENANT WORKS)

CONTENTS

CHAPTER - 8 B

STONE MASONARY (IN DAM APPURTENAT WORK)

8B.1 REFERENCES

IS No.	Title
269-1989	Ordinary Portland cement ,33 Grade (Fourth revision)
455-1976	Portland slag cement (third revision)
456-1978	Code of practice for plain and reinforced concrete (third revision)
60-1985	Test sieves
1121(pt)-1974	Compressive strength (first revision)
1122-1974	Method of tests for determination of true specific gravity of natural building stone (first revision) (reaffirmed 1987)
1124-1974	Method of test for determination of water absorption, apparent specific gravity and porosity or natural building stones (first revision)
1126-1974	Method of test for determination of durability of natural building stone (first revision)
1344-1981	Calcined clay pozzolana (second revision)
1489-1976	Portland pozzolana Cement (second revision)
1727-1967	Method of test for pozzolanic materials (first revision)
2116-1980	Sand for masonry mortars (first revision)
2250-1981	Preparation and use of masonry mortars (first revision)
2386 (PtII-163)	Estimation of deleterious materials and organic impurities
2386 (Pt III) -181	Specific gravity, density , voids, absorption and bulking

3812-1981	Fly ash for use as pozzolana and admixture (First revision)
4082-1977	Recommendations on stacking and storage of construction materials at site (first revision)
5529(Pt II)-1985	Test in Bedrocks
6909-1973	Super sulphated cement
8605-1977	Construction of masonry in dams
9103-1979	Admixtures for concrete
11216-1985	Permeability test for masonry during and after construction
	Right dam project specification

8B.2 **OENERAL**

Masonry for the dam and appurtenant works shall be composed of stone placed in matrix of cement, sand , water and any other admixture as specified . Test shall be made on the masonry s\as well as on the mortar matrix at specified intervals during the progress of the works and the mixes modified as necessary in order to consistently secure the required strength, workability , density and impermeability together with maximum possible economy. It is contemplated that the mortar for masonry may range in character from a lean mix of strength 8N/mm2 to a rich mix of strength 18N/ mm2 .The water cement ration for the mortar will be regulated by the requirements of strength, durability , workability and permeability.

8B. 3 MASONRY CLASSIFICATION

Masonry classification is related to the type of work and the specified 28 days compressive strength of 50 mm cube of mortar to be used and shall conform with the requirements as set out in the Appendix-I. The grade of mortar will be defined by its compressive strength in N/mm at the age of 28 days. In case where approved pozzolana is used as part replacement of cement, the pozzolana mortar shall be designed to attain the same 365 days strength as would be attained at the end of 365 days by a corresponding neat cement mortar.

8B.4 MATERIALS

8B.4.1 Cement

8B.4.1.1 Portland cement, Portland slag cement , Portland pozzolana cement and super super suphated cement shall be used for plain and reinforced concrete work and stone masonry work in dams and other massive structures and shall comply with the requirements of IS:269-1989, IS: 455-176 IS: 1489-1976 and IS: 6909-1973 respectively. Special cements may also be specified for use in dam masonry.

8B.4.1.2 Portland cement, Portland slag cement and Portland pozzolana cement that has been in storage for more than 120 days counted after the date of dispatch from factory shall not be used without a special inspection and approval. Transport, storage, sampling and testing shall be governed by the specification for use of cement detailed in Chapter7.

8B.4.2 Water

Water used for mixing, Portland slag cement and also for washing the stone and curing masonry shall conform to the requirement of IS:456-1978. The water used shall be clean and free from injurious amount of oil, acid, salts and organic material or other substances that may be deleterious to mortar.

8B.4.3 Sand

8B.4.3.1 The term sand is used to designate fine aggregate with maximum size of particles 4.75 mm. The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall consist of hard, dense, durable, rock fragments and shall be free from injurious amounts of dust, lumps of clay, soft or flaky particles, shale , alkali loam mica and other deleterious substances. The amount of deleterious substances by weight shall not exceed the percentages given below :

S.No.	Deleterious Substances	Percentages (by weight)
(i)	Shale	1.0
(ii)	Coal & Lignite	1.0
(ii)	Clay lumps	1.0
(iv)	Cinders & clinkers	0.5
(v)	Materials passing I.S. sieve 8 (screen opening 0.075 mm)	3.0
(vi)	Total of other deleterious substances such as alkali, mica and coated grains flaky particles etc	2.0

The sum of the percentage of all deleterious substances shall not exceed 5 percent by weight. The sand shall also free from injurious amounts of organic impurities. The sand shall be tested for deleterious and organic impurities in the laboratory as per IS:2386(part II)-1963.

The sand used shall be of coarse category conforming to IS: 2116-1980. The sand or fine aggregate shall be investigated for sulphate content and it shall be ensured that it is free from this hazard. Where sand blended to ensure are being used at one mixer at the time, they shall be so blended to ensure uniform grading in successive batches. The sand as batched, shall be well graded within the limits specified below:

I.S. Sieve Designation	Percentage Passing Weight
4.75 mm	100
2.36 mm	90 to 100
1.18 mm	70 to 100
600 micron	40 to 100
300 micron	5 to 70
150 micron	0 t 15

8B.4.3.2 A sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening through a suitably sized sieve and / or blending with required quantities of suitable sizes of sand particles. Based on test results and in the light of practical experience with the use of local materials deviation in grading of sand given in table above may be considered by the Superintending Engineer.

8B.4.3.3 The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass. The mechanical analysis curve of sand shall indicate a uniform gradation without predominance of any one or more size fractions. The fineness modulus shall preferably lean towards the coarser range in the limit fixed. A gap graded sand requires more cement and may promote permeability if adequate care is not taken. Remedial measures as specified above shall be taken to ensure uniform gradation.

8.4.3.4 For natural sand the fineness modulus shall be greater than 2.2 and less than 2.8.

8B.4.4 Resistance to Sulphate Attack

8B.4.4.1 The following could be source of sulphate attack:

(a) Sulphate contained in the sand or fine aggregate used in the mortar.

(b) Sulphate from soil in the case of masonry in contact with soil .

(c) In exceptional circumstances sulphate derived from the calcine clay pozzolana.

8B.4.4.2 The cement in the mortar will undergo expansive reaction in the presence of sulphate, which will lead to cracks in the mortar. Where serious sulphate attack is expected, Portland slag cement. Other general precautions shall be taken as given in "Appendix G of chapter 7 concrete and chapter 16: RCC and form work "Necessary precaution should be exercised when opting for super sulphate cement .It should be borne in mind that sulphate attack is a hazard for which there is no satisfactory solution and the problem should rather be avoided than opting to use remedial measures.

8B.4.5 Admixtures

8B.4.5.1 Admixtures including pozzolanas, air-entraining agents. wetting agents, etc, shall be used only under specific authorization and wherever so permitted, the proportions and methods of use shall be specified by the Engineer - in - charge .

8B.4.5.2 Materials permitted as admixture shall have established merit for improving any specific quality of the mortar without causing deleterious effects.

8B.4.5.3 ***Air Entraining admixtures* -** Air entraining admixtures, satisfying the criteria in IS:9103 - 1979 shall only be use if permitted by the Engineer -in -charge . The percentage of air entrained shall be tested by the Engineer -in -charge or his designate. The percentage of entrained shall normally be 8 to 12% of cement mortar .

8B.4.6 pozzolana

8B.4.6.1 Fly ash pozzolana suitable for incorporation in cement mortar and concrete and in lime pozzolana mixture shall be grade II (as designated in IS:812-1981) and shall conform to IS:3812-1981.

8B.4.6.2 Calcined clay pzzolana suitable for incorporation in unblended cement mortar and in lime pozzolana mixture shall be grade II (as designated in IS: 134-1981) and shall be manufactured in a manner as specified in IS: 1344-1981

8B.4.6.3 pozzolana (Fly ash and calcined clay) shall conform to the physical requirements given in following table when tested in accordance with IS: 1727-1967.

TABLE

S. No.	Characteristics	Requirement
1.	Fineness - Specific surface in m^2/ kg by Blaine in/mm^2, min	250
2.	Lime reactivity - Average compressive strengh in N/mm^2, min	3.0
3.	Drying shrinkage, max	0.1

8b.4.6.4 Pozzoland shall be such that it will agree with the cement used and in no way promote increase attack.

8B.4.6.5 **Storage -** It shall be free from any admixture of clay dust, or foreign matter and shall be stacked on a brick , wood or other suitable platform so as to be adequately preotected from such admixture . storage of materials shall be in accordance with IS: - 1977.

8B.4.7 Stone

8B.4.7.1 **General -** The stone for masonry shall be hard dense, durable, tough, sound and clean. They should be free from decay, weathered faces, soft seams, adhering coating, holes, veins, flaws, cracks, stains and other defects and shall have, as far poddible, uniform colour and texture. Stone not uniform in colour, texture and/or with stains may be permitted after proper test.

8B.4.7.2 ***Stone For Random Rubble Masonry* -** The size of the stones shall normally vary from 0.05 to 0.01m^2 . No. stone larger than the maximum specified size of 0.05 cum should be used (in general) . The stones shall be taken from quarries approved from geological and engineering consideration. No stone shall weigh less than 25 kg. The stone used in the hearting shall be roughly cubical in shape. No stone weighing between 75 kg and 150 shall be less than 225 mm in any direction and no stone weighing between 25 kg and 75 kg shall be less than 150 mm in any direction.

8B.4.7.2.1` Spalls with minimum dimension of 200mm to 100 mm shall be used to wedge in to thick mortar spaces. They shall not normally exceed 10% of the volume of stone masonry.

8B.4.7.3 ***Stone For Chisel Dressed Coursed Rubble Masonry***

8B.4.7.3.1 The height of the stone for face work shall be uniform and is commended to be 300 mm including mortar joint . The length (parallel to axis) and depth (perpendicular to axis) of face stone shall not be less than the height of the stone. At least 50% of the stones shall have lenght more than. 1.5 times the height of the stone . At least one third of the remaining stones shall be bond stone projecting not less than two and half times the height in to the masonry. The remaining shall be header stones with depth not less than one and half imes the height of the stone.

8B.4.7.3.2 The stone shall be hammer dressed on face and one line chisel dressed on bed, top and sides for a minimum depth of 75 mm up to which the stones shall be true and rectangular. Beyond 75 mm depth, the stone may be tapered but the tail end of the stones shall have at least half the area of the face. Bushing on the faces of the stones shall not project more than 40 mm.

8B.4.7.3.3 **Header stones:-** Header stones shall not be less than 300 mm in length and one a half times the height in depth.

8B.4.7.3.4 **Stretcher Stones :-** The stretcher stones shall not be less than 450 mm in length and not than its height in depth.

8B.4.7.3.5 **Bond Stones :-** The bond stones shall not be less than 300 mm in length and two and a half times its height in depth.

8B.4.7.3.6 **Quoin Stone :-** Quoin stone shall be of the same height as the face stones, but true and rectangular on two faces with one line dressing for 75 mm depth in beds and sides. The stones shall be at least 300 mm long on one face and 450 mm on the other face.

8B.4.7.4 **Stone For Hammer Dressed Coursed Rubble Masonry**

8B.4.7.4.1 Stones for hammer dressed coursed rubble masonry shall meet the requirement of stones for chisel dressed coursed rubble masonry (see para 8B.4.7.3) except that be the stone shall be only hammer dressed. The stones shall be nearly rectangular.

8B.4.7.5 **Random Rubble Masonry With Selected Stones -** Stone for random rubble masonry with selected for work shall be with minimum dimension of 225 mm in length as height. The depth of at least 50% stone shall not be less than 225 mm. The depth of one - sixth stones shall not beless than 400 mm and depth of rest stones shall not be less than 150 mm. The stone need be hammer dressed on face.

8B.4.7.6 **Tests For Masonry Stones -** The following tests shall be carrtied out in accordance with Indian standards mentioned against each to ensure suitability of stones for masonry.

S. No.	Name of test	Relevant Indian Standard
i	Compressive strength test	IS: 1121 (pt.I)- 1974
ii	Specific gravity test	IS: 1122-1974
iii	Water absorption test	IS: 1124-1974
iv	Durability (Soundness) test	IS: 1126-1974

The compressive strength test shall be conducted with the load parallel absorption of stone samples shall not exceed 5%.

8B.5 CEMENT MORTAR

8B.5.1 General

8B.5.1.1 The cement mortar shall consist of cement, sand and other approved mixtures, as required, each complying with its respective specification in accordance with para 8B.4.1 to 8B.4.6 mixed in the proportions as may be defined. The proportions of material entering in to the mortar shall be based on laboratory studies. The moisture content of the sand and gradation, as available for use , shall be taken into account in proportioning the mix. Pozzolanic material may also be nixed, if directed, in proportions fixed by the Engineer - in - charge. If directed, suitable air entraining agent may be used to improve the quality and workability of the mortar, The exact proportions of air entrainment shall be determined by actual tests.

8B.5.2 All materials forming the mortar should be measured by weight except for water which may be by weight or by equivalent volume. Periodical calibration of the measuring instruments shall be carried out. where weigh - batching is not possible, due consideration to bulkage of sand and its water content be given.

8B.5.2 Batching

8B.5.2.1 The prescribed amount of various materials for mortar including water, cement, admixtures and sand shall be controlled within the limits of accuracy. The amount of cement and sand shall be determined by weighing, The quantity of water may be by weight or by equivalent volume. In case of sand, the surface moisture shall be determined in accordance with the method prescribed in IS:2386 (Pt III)-1963 as revised from time to time and taken into account. Where volume batching has been permitted, due consideration to bulkage of sand and its water contents shall be given.

8B.5.2.2 The proportion of the various materials shall be changed as directed in order to maintain the desired quality of mortar. The batching equipment shall be calibrated and operated so that the combined in feeding and measuring the materials will not exceed one and a half per cent for water cement or pozzoland and 2 per cent for sand .

8B.5.2.3 The operating performance of each scale or other measuring device shall be checked by tests weghts and the test shall cover the range of measurement involved in the batching operations. Tests of equipment in opraton shall be made at least once every fortnight and adjustments., repairs or replacements made as necessary to meet the specified requirements for accuracy of measurement.

8B.5.3 Mixing

8B.5.3.1 The mortar ingredients shall be mixed thoroughly in batch mixers of satisfactory type and size which are so designed as to ensure uniform distribution of all component materials throughout the mass at the mixer period. The plant shall be so designed and operated that all material entering the mixer can be accurately proportioned and readily controlled. The entire batch within mixer shall discharged before recharging. Mixers should not be loaded in excess of 10 % more than the manufacturer s rated capacity.

8B.5.3.2 The mixing time for each type of mixer shall be reckoned after all materials except the full amount of water are in the mixer. The thoroughness of mixing and adequacy of mixing time so as to give a uniform mortar shall be tested at the start of the job and at such intervals as may be considered necessary. The uniformity of mortar is reliable indication of the thoroughness of mixing and adequacy of mixing time. Retempering requiring the addition of water to preserve the required consistency shall be avoided. The minimum mixing time generally specified is as follows :-

Capacity of Mixer (m^3)	Time of Mixing (min)
1.50 or less	1.50
2.50	2.00
3.00	2.50
4.00	2.75
4.50	3.00

For any one mix, the variation in the free unit weights shall be exceed the following :-

For one batch	35 kg/m^3
Average of 3 batches	25 kg/m^3
Average of 20 batches	20 kg/m^3
Average of 90 batches	15 kg/m^3

8B.5.3.3 Use of mixer for different mortar mixes consecutively shall be avoided.

8B.5.3.4 The first mortar batch at the start of the work after every cleaning operation of the mixer drum shall be made richer by addition of 10 percent extra cement over and above that required for the mix.

8B.5.3.5 It should be preferable to use the mixer having a timing device for indicating the copletion of the mixing period. The actual time of mixing shall be checked at least twice during each shift and the timing shall be adjusted if in error. The timing device shall be so inter locked with the discharge gate is fully closed and all ingredients are in the drum. Strict manual control in recording the time should be followed where the mixers do not bear the time device. The RPM of the mixer shall be kept 16 to 20. The full contents of the drum shall be discharged quickly so as to avoid segregation. The minimum mixing periods are conditioned on the materials being fed into the mixer in a manner which will facilitate efficient mixing and on operation of the mixer at its design speed. The following sequence of charging the mixer shall be adopted.

(i) Five to ten percent of the total quantity of water required for mixing, adequate to wet drum thoroughly shall be introduced before the other ingredients in order to prevent any caking of the cement on the blades or sides of the mixer.

(ii) All dry ingredients (cement, pozzolana and sand) shall be simultaneously ribboned into the mixer in such a manner that the period of flow for each ingredient is about the same. Eighty to ninety percent of the total quantity of water required for mixing shall be added uniformly along with dry ingredients.

(iii) The remaining quantity of water shall be added after all the other ingredients are in the mixer.

(iv) Water shall be added prior to, during and following the mixer charging operations. Excessive over mixing requiring addition of water to preserve the required mortar consistency will not be permitted. Mortar which has been kept unutilized for more than 30 minuts after the addition of water shall be wasted unless mortar continues to be in such a workable condition that its use is specifically permitted.

(v) When the mixer is stopped, before placing again any ingredient in the mixer, or all hardend mortar shall be removed from the inner surface of the mixer.

(vi) The retempering of partially hardened mortar requiring renewed mixing with or without the addition of cement, sand or water shall not be permitted.

8B.5.4 Test and Acceptance Criteria

8B.5.4.1 Tests on mortar shall be regularly conducted and shall comprise compressive strength and permeability tests.

8B.5.4.2 Tests for compressive strength - Compressive strength of the mortar shall be tested in accordance with the procedure specified in IS : 2250-1981. In special cases where specimens of different sizes are used such as 15 cm x 30 cm cylinder / 15 cm cube, necessary corelation shall be established, and such tests may be adopted for quality control.

8B.5.4.2.1 The compressive strength of cement mortar used shall be as specified for the particular job. The strength of one sample shall be taken as the average of at least three test specimens taken from single batch of mortar . If the individual specimen result differs by more than $\pm$ 15 percent of the average of 3 specimens, the remaining two specimens shall be worked out or the test may be repeated . If the individual test results o two specimens of mortar do not come with in $\pm$ 15 percent of the average and where repeat tests are not possible, the whole set of results shall be rejected from the analysis . Over a given period of time, not more than 10 percent of percent of the specimen tested shall have a compressive strength les than 80 percent or the required strength and the average of all tests shall equal or exceed the required strength. The exact proportions for the, cement, sand and water for mortars shall be fixed atter conductiong tests for compressive strength .

8B.5.4.2.2 The frequency of sampling of mortar separately for each mix proportion shall be as follows:

(i) up to 100 m of masonry work per day , one sample per shift per mixer, and

(ii) For every additional 100 mm masonry work per day, one sample per shift per mixer.

8B.5.4.3 **Tests of permeability -** The permeability tests on motar specimen shall be coducted i accordance with the procedure specified in IS : 1727-1967 as described in brief in Appendix -II .Mortar as used on work shall not give a coefficient of permeability than 2.5 x 10 mm for rich mortar and 4.8x10 mm for lean mortar.

8B.5.5.5.1 **Transporting Mortar -**

8B.5.5.1 Mortar shall be transported from the mixer to the place in position as rapidly as practicable by methods that will prevent loss of ingredients or consistency , or in air content of more than two per cent, before the mortar is ;placed on the work .

Whenever the length of haul from the mixing plant to the place or deposit is such that the mortar unduly compacts, suitable agitators shall be installed in the conveying system.

8B.5.5.2 Where the time of haul exceeds 20 minutes, mixed mortar shall be transported under cover and protected from evaporation.

8B.5.5.3 Chutes used for conveying mortar shall be such size and shape as to ensure a steady uniform flow in a compact mass and shall be protected from wind and sun where necessary to prevent loss of consistency , evaporation and shall be furnished with a discharge hopper. The free fall or drop of mortar shall be limited to 150 cm. Buckets shall be the bottom drum type permitting an even controlled flow in to the site of placing or hopper without undue splashing or segregation. Cars and trucks shall be designed to facilitate uniform delivery father than quick dumping.

8B.5.5.4 The chute sections shall be made of or lined with metal and all runs shall have approximately the same slope not flatter than one vertical to two and a half horizontal. The required consistency of the mortar shall not be changed in order to facilitate cutting. Where it becomes necessary to change the consistency, the mortar will be completely redesigned. Where there is a free fall within the conveying system, suitable baffle plates, splash board's pr down spouts shall be provided to prevent segregation for loss of ingredients. All chutes shall be thoroughly cleaned before and after each run.

8B.5.5.5. Eqipment used for transporting mortar from mixer to the place of masonry shall be maintained free from deposits of the mortar and leakage of mortar.

8B.6 PREPARATION OF FOUNDATION/SURFACE FOR PLACINO MASONRY

8B.6.1 Masonry in Contact With Foundation

8B.6.1.1. After completion of rough excavation of foundation ,scaling and trimming for final removal of all slabby or drummy rock or any loosened mass shall be done by chiselling , picking , barring and weding . Any weathered or decomposed rock remaining should be removed; the doubtfus areas cleaned out to sufficient depth and back filled with concrete or masonry in richer mortar. if foundation conditions permit, consolidation grouting may be carried out before laying masonry In case steps are required to be provided in the foundation of any individual block, stepping should not exceed 5m with a maxinum difference in elevation of 10m .

8B.6,1.2 Masonry shall not be placed until embedded parts, if any are all installed and checked and surface prepared for placing. All surface of embedded mater ial that have before the surriunding or adjacent masonry is placed. No masonry shall be placed until the foundation has been inspected and approved.

8B.6.1.3 Immediately before placing masonry all surface of foundation upon or against which masonry is to be placed, shall be free from standing water, mud and debris. All surfaced of rock upon which or against which or against which masonry is to be placed shall in addition to the foregoing requirements, be cleaned and freed from oil, objectionable coating and loose semidetached or unsound fragments. The cleaning and roughening of the surface of rock shall be performed by the use of high velocity air-water jet, wet sand blasting, stiff brooms, picks or by other effective means. The washing and scrubbing process shall be continued until the wash water collecting in puddles is clear and free from dirt. in the final cleaning process the wash water may nave to be removed by sponged. if and drilled hole is left in the foundation surface which are no longer needed, with air water jetting and filled up, completely with cement slurry. The preparation of the foundation as specified above shall be done not earlier than 72 hours before starting masonry work on it .

8B.6.2.4 The surfaces of adsorptive foundation upon or against which masonry is to be placed shall be kept sufficiently wet for at least 24 hours immediately prior to pacing so that moisture will not be drawn from the freshly placed cement slurry and mortar.

8B.6.1.5. if for any reason construction on the foundation surface, thus prepared is delayed, the area shall be examined thoroughly for any defects and rectifications carried out The foundation shall then be kept moistened for 24 hours prior to masonry placement.

8B.6.1.6 Immediately preceding the placement of masonry on foundation rock, the cleaned up surface shall be moistened and coated with a thick layer of cement slurry (comprising one cement: about two thirds of water by volume). The slurry shall be spread only on a small area of about half a square meter at a time and the layer of mortar (which has to follow) shall be spread immediately thereafter but in case later than five minutes after the slurry coat is given in order to avoid stiffening up of cement slurry which may prevent satisfactory bonding The layer of the rich mortar 50 mm to 75mm thick shall be spread over the slurry and worked in the all the irregularities of the foundation surface be trowels , bare and brushes. The composition of this mortar shall be the same as used in the masonry work being placed over it. The stone of the first course of masonry shall be carefully pressed in to mortar immediatly so to force the mortar around the corers. The layer of mortar shall be made thicker if stones than 0.06 cubic metre are placed.

8B.6.1.7 Water from any springs or leakage through the surrounding area shall be kept out of the foundation area and from masonry toll the later has set. Where pumping is resorted to care shall be taken to ensure that no work already carried out is disturbed or damaged.

8B.6.2 **Masonry in Contact With Masonry**

Surface of masonry shall be treated as follows before laying fresh masonry over it. Loose stones , if any, shall be removed . Mortar joint shall be scraped with iron and the exposed faces of stone shall be wire brushed . The surface shall be cleaned with air-water jet . The water collected in the depressions of masonry shall be removed be sponge or cloth.

8B.6.3 Masonry in Contact with old Masonry

Surface of old masonry which has been exposed for a long time, that is more than 28 days, shall be treated as follows Loose stones, if any shall be removed old mortar joints shall be scraped to a depth of 15mm or wet sand blasted and washed with air- water jet . Immediately prior to placed masonry, the old masonry surface shall be treated in the same way as for foundation masonry described in para 8B.6.1.6

8B.6.4 The clean up of construction joints in running masonry, work can be aconplished with ease, if a freshly placed layer is gone over with air-water jet just after a lapse of 3 to 4 hours when the mortar will have set hard enough to withstand any erosion. The period may have to be varied to suit conditions arising from the type pf cement used and the weather

8B.7 MASONRY CONSTRUCTION

8b.7.1 General

8B.7.1.1 The masonry work shall be so arranged that a layer of masonry once laid is subjected to any disturbance either from the placement of subsequent layers or from any incidental traffic on the block from the time the mortar in the first layer has lost its plasticity (work ability) to at least 24 hours from its placement.

8B.7.1.2 The details of all openings , block outs measuring instruments embedded parts and piping shall be ascertained and all fixtures positioned in the area before the masonrywork is done in the area.

8B7.1.3 The structure shall be built true to level line, plumb or curved or as directed in a workman like manner, suitable aids like templates, scaffolding , etc, shall be used, The joints Masonry shall be kept wet. for at least 21 days after being built and at no time and on no account shell be allowed to be dry in this period. if stones, once kept, position, are to be adjusted they shall be lifted clear and reset they shall not be moved one over the other. Walkways are necessary to ensure that the green masonry is not disturbed before it sets.

8B.7.1.4 The maximum height of masonry allowed to be constructed at a time shall be 0.6 m in one or more layers. No fresh masonry shall be laid with in 24 hours over the masonry previously laid.

8B.7.1.5 In the same black (monolith) the difference in level of masonry layers should normally be not more then 1.5 m to be negotiated in steps 3H:iv. In no case the difference in level shall be permitted in rich cement mortar face and random rubble masonry work

8B.7.1.6 The quarried stones shall be thoroughly cleaned and washed before they are brought to the block for placement.

8B.7.1.7 The following rules shall be observed to ensure efficient construction :

(a) Do not place mortar which bleeds excessively:

(b) Keep the surface continuously moist :

(c) Clean the old masonry surface , prior to starting masonry on it by wet sand blasting or chiseling and washing

(d) Thoroughly and effectively broom in to the old surface a layer of mortar and build the masonry course on it immediately ;and

(e) Masonry work should invariably be done during day light hours .

8B.7.1.8 In case of long stoppage of work , suitable depressions of about 2m x2m should be left to a depth of one or two courses for proper keying and effective bondage with the new masonry. Work shall be started in these depressions.

8B.7.2 Face Masonry

8B.7.2.1 Coursed Rubble Masonry The face masonry shall be of selected stones and dressed , as described as described in para 8B.4.7.3 and 8B.4.7.4 The work shall be in parallel courses of about 300mm thickness . In each course stones shall be laid in header and stretcher fashion and joints in face work shall not be thicker than 15mm for single line chisel, dressed stoned or20 mm for hammer dressed stones Bond stone in each course shall be so provided that every 6 th stone or third header stones is a bond stone . The bond stone shall be staggered The face masonry work shall preferably be constructed simultaneously with the hearting masonry .The content of mortar in face shall not be less than 33% and not more than 35 mm .The stones of different depth shall be suitably staggered.

8B.7.3 Random Rubble Masonry With Selected Stones

The random rubble masonry with selected stones shall be of selected stones as specification in para 8B4.7.5 : and shall be laid in parallel courses of about 250 mm thickness . The joints shall break in courses above and below by at least half the height shall be suitably staggered.

8B.7.4 Random Rubble Masonry (Uncoursed Rubble Masonry)

8B .7.4.1 The hearting shall be of the random rubble masonry. The mortar used for each class and location of masonry shall conform to the particular specification for that class of mortar and the specification of the materials used therein.

8B.7.4.2 The stones as specified in para 8B .4.7.2. shall be set on their flat beds as received from the quarry and with out further dressing except knocking out weak corners and sharp edges.
Spalls as specified in para 8B.47.2.1 shall be used to wedge into thick mortar space and shall not exceed 10 percent in volume of the total stones utilized. All stones, etc, shall be washed with water jet and wire brushes before use to ensure clean surface for mortar to adhere to and water shall be sprinkled before actually pacing the stone in position in the work to prevent absorption of water from the mortar the mortar placed above the under lying course of masonry/ rock surface shall be worked out by a trowel to a quacky mass and the stone laid on flat bed shall be shaken by 1 m long 25 mm dia ;lain MS bar (one end o rod may be made slightly flat for proper insertion between two stones) to sink into mortar squeezing excess mortar from all sides. The other stones shall be filled with mortar . The stone should be carefully laid so as to beak joint as much as possible and solidly bedded with close joint . After placing at least two stones all around the central stone is manually vibrated in the direction by insertion of a vertically. Simultaneous to this operation of vibration the joint between the stones shall be packed by a packing rod (12 mm dia and 0.6 m long plain MS bar) and a trowel. This operation of lateral vibration shall be continued to the extent necessary to wedged in to mortar by hammering down by a wooden mallet so as to reduce the thickness of the mortar joint the chips shall not be put flat at the top as these tend to get dislodged but these should be driven end wise. Also these shall be as rough as possible to secure good bond between successive layers. Further the spells not be inserted in space between stones before it is filled up with mortar. The thickness of the joint shall not exceed 35 mm the content of mortar in random rubble masonry shall not be less than 40% and not more than 45% of the masonry.

8B.8 TRUNCATED CONSTRUCTION

Truncated of masonry section should be avoided. However if it is unavoidable, the following precautions shall be taken.

i) The truncated section should satisfy the design criteria adopted for full section for that particular at age of construction.

ii) Truncated faces shall be constructed in steps embedding enough dowel bars to ensure proper bonds between old and new masonry.

iii) The later construction on the truncated section shall be started after giving treatment to the truncated face in the same way as for masonry in contacty with old masonry described in 8B.6.3

iv) In case concrete is used for constructing truncated section, shear keys shall be provide in both horizontal and vertical feces of the truncated section ;and

v) The joint between old concrete and masonry constructed later shall be grouted after fainsing the masonry to sufficient height.

8B.9 PROTECTION OF MASONARY

The fresh masonry shall be protected against vibrations or any other movement which might injure it before it has reached its final set. Stones shall not be allowed to be dumped over the masonry which has not taken its final set. Mortars and fresh masonry shall be protected from fains.

8B.10 PERMEABILLTY TEST ON MASONRY

Permeability tests on masonry shall be carried out in accordance with Appendix - II (during and after construction) . The permeability shall be determined in "Lugeons " which shall be defined as the water loss in minute per metre depth of the drill hole under a pressure of 10 atmosphere maintained for 10 minutes in a drill hole of 46 to 76 mm diameter .

8B.11 WEATHER CONDITION

8B.11.1 Masonry work shall be temporarily suspended during excessively hot or weather when conditions are such that the masonry cannot be properly placed and cured.

8B.11.2 Wherever necessary exposed surfaces, of fresh masonry shall be shaded from direct rays of the sun and protected against premature setting of the mortar or drying by being cured under continuous sprays of water. All freshly placed masonry shall be covered and projected against surface wash.

8B.12 CURING

Arrangements shall be made to protect the fresh masonry against rapid drying and to cure the masonry. The masonry shall be cured after 8 to 12 hrs of construction and water shall be gently sprayed so as to avoid damage . All exposed surfaces of shall be kept continuously moist for a period of 21 days.

APPENDEX - I

MASONRY CLASSIFICATION AND LOCATION DETAILS

S. NO.	**Location of use**	**Classification details**	
		Type of Masonry	28 days minimum compressive strength of 50 mm mortar cube in N/mm ^{2}
(1)	(2)	(3)	(4)
1.	1. 0.60 m thickness in u/s face if over flow & non over flow sections.	Coursed rubble masonry consisting of face stone with one line chisel dressed stone 75 mm on all four sides.	(a) 14 (upto 50 m high dam) (b) 18 (for dam higher than 50 m)
2.	2.4 m thickness in u/s face of overflow and non overflow sections at the back of face work.	Random rubble masonry	(a) 14 (upto 50 m high dam) (b) 18 (for dam higher than 50 m)
3.	1.0 m depth of foundation for the full section of dam except area covered by items above in both over- flow and non - over flow section.	Random rubble masonry	a) 14 (upto 50 m high dam) (b) 18 (for dam higher than 50 m)
4.	Down stream face of non over flow section : (a) from one metre above foundation upto 0.5 m below wrap around line along the masonry face (thikness-0.30m)	(a) Random rubble masonry with selected stones.	10.50
	(b) above item 4 (a) (thickness - 0.45m)	(b) Hammer dressed coursed rubble masonry	10.50

(1)	(2)	(3)	(4)
5.	Hearting in both over flow and non- over flow sections.	Random rubble masonry	10.50
6.	Contraction joints.	Random ruble masonry with selected stones. (a) upto 50 m high dam	(i) 4 upto 3 m from u/s face. (ii) 10.5 beyond 3 m from u/s
		(b) for dam higher than 50 m	(i) 18 upto 3m from u/s face (ii) 10.5 beyond 3 m from u/s face.
7.	Training wall:		
	(a) 0.45 m thickness on water face	Hammer dressed coursed rubble masonry.	10.5
	(b) 0.45 m thickness on rear face from 0.5 m below the earth line along masonry face to top of masonry.	Hammer dressed coursed rubble masonry.	8.5
	(c) Other than (a) & (b)	Random rubble masonry	8.5

APPENDIX - II

PERMEABILITY TESTS AND STANDARDA OF IMPIRMEABILITY

1 PERMEABILITY TESTS

1.1 Frequency of tests

1.1.1 ***Masonry* -** permeability test for the masonry shall be conduces regularly and at frequent intervals to judge quality and maintain uniformity. The permeability tests for masonry shall be conducted every 6 to 8 m rise of each block very block where fresh masonry is laid shall be tested at lested at every year.

1.1.2 **Mortar -**permeability tests on mortar shall normally be carried out once in a week. Specimens 100 mm dia and 50 mm high or similar size prepared from mortar as used on work shall be used be used testing .

1.2 Testing Procedure For Masonry

Test holes 50 to 80 mm in diameter and of appropriate depth (say 6 to 8 m) shall be drilled on the built up masonry after 28 days hardening. Drilling shall be done by wet percussion method. However in special circumstances diamond drilling may be resorted to. The holes shall be kept 300 to 600 mm above the bottom level of the masonry to be tested. These holes shall be drilled vertically in two rows. One row shall be at 1.5 m from the axis of the dam. The second row shall be at about one - third of the width of the dam from the rear face excluding the front impervious face. The holes shall be provided staggered and it should be seen that at least one each in upstream and downstream portion in each block is provided. The holes may be closer if found necessary on the basis of the permeability test results. In locating the holes, position of any embedded parts, instruments galleries and other opening shall be kept in view. The these holes shall be subjected to a water lass test to determine "Lugeon" value. Notwithstanding the test pressures specified for lugeon values, the actual test pressures should not be so high as to cause disturbance to masonry depth. Then assuming linear variation of water loss with respect to the pressure applied, the water loss in lugeons may be interpreted. For details of procedure and test equipments reference may be made to IS 5529 (part 2) - 1985

1.2.1 When a concrete membrane is used on the upstream face of masonry dam, the upstream hole for water loss test shall be drilled one metre downstream of the junction of concrete membrane with masonry.

1.2.2 After the water loss tests the holes shall be grouted with neat cement and the results of grout intake recorded.

1.3 Testing Procedure For Mortar

Permeability tests on mortar specimen shall be conducted in accordance with the procedure specified in IS: 1727 - 1967

2. STANDARDS OF IMPERMEABILITY

2.1 Masonry

Standards of impermeability aimed at shall be a water loss of not more than 2.5 and 5 lugeons in the upstream and downstream portion of the dam respectivel.

2.1.1 Permissible water loss in holes drilled in accordance with 1.2 shall be not more than 2.5 or 5 lugeous depending on the mortar mix used for masonry at that location (rich or lean respectively)

2.1.2 The values of water loss obtained from the test is the over all value of masonry including loss into cracks, joints etc. It provides an approximate estimate of the possible leakage that may take place through specific zones of masonry.

2.2 Mortar

Mortar as used on work shall not give a coefficient of permeability greater than 2.5×10^{-8} mm /sec for rich mortar and 4.8×10^{-8} m /sec for lean mortar.

2.3 If test in a block indicate water loss greater than acceptable, measures in the from of adequate core drilling and grouting shall be done as directed by the Engineer- in - Charge.

SECTION – VI

CHAPTER - 9 BRICK WORK

CHAPTER 9 - BRICK MASONRY

CONTENTS

CHAPTER 9 - BRICK MASONRY

9.1 REFERENCES

IS: 1077-1986	Specification for common burnt clay bricks (third revision).
IS: 1081-1960	Code of practice for fixing and glazing of metal (Steel and Aluminum) doors, windows and ventilators (reaffirmed 1979).
IS: 1905 -1985	Code of practice for structural safety of *buildings, Masonry walls* (second revision).
IS:2212 -1962	Code of practice for brickwork (with amendment No. 1).
IS: 3414- 1968	Code of practice for design & installation of joints in buildings.
IS:3495 (Pt.l to IV)-1976	Methods of tests of burnt clay building bricks (second revision) (with amendment No. 1).
IS:5454 -1978	Methods for sampling of clay building bricks(first revision).
IS: 10440 -1983	Code of practice for design of RB & RBC floors and roofs.
SP20 (S&T) -1981	Explanatory Hand Book on Masonry Code.
SP 25(S&T) -1984	Hand Book on causes and prevention of cracks in buildings. Specifications - 77 of Central Public Works Department.
	Standard specification- 77 of National Building Organization.

9.2 DEFINITIONS

Arch.-A form of structure having a curved shape, used to support loads or to resist pressure (see fig of PLATE: 1 / CH-9).

Cavity wall.- A wall comprising two leaves, each leaf being built of structural units and separated by a cavity and tied together with metal ties or bonding units to ensure that the space between the leaves being either left a continuous cavity or filled with non-load bearing insulating and water proofing material (see fig. A of PLATE: 1 / CH-9).

Corbel.- Bricks projecting from 8 wall to support a load (see fig.D of PLATE:2/CH-9).

Cornice.- A horizontal projecting moulding decorating the top of building, window etc. (see fig. D of PLATE: 2/CH-9).

Closer.- Any portion of a brick used in constructing a wall, to close up the bond next to the end brick of a course (see fig. of PLATE 4 &5/CH-9.

Over, sailing course.- Brick course projecting from a wall for the sake of appearance only as distinct from corbels, which ere load carrying (see fig. D of PLATE:2/ CH-9).

Pier,- A thickened section forming integral part of the wall placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical concentrated load. The thickness *of a* pier is the overall thickness of the wall or when bonded into one leaf of a wall (see fig. B of PLATE:2/ CH-9).

Pillar,- Pillar means a detached masonry support. This can be rectangular, circular, elliptical, etc. In case of rectangular pillars, the breadth shall not exceed three times the thickness and thickness itself snail not exceed more than three bricks.(see C of PLATE:2/ CH-9 and PLATE: 3/CH-9).

Retaining Wall.- A wall built to support earth at a higher level on the one side than on the other.

Scaffolding- A temporary erection of timber or steel work used in the construction, alteration, demolition or repairs of a building to support or to allow of the hoisting or lowering of workmen, their tools and materials.

Sill.- A brick work forming the lower boundary of a door or window opening (see fig. D of PLATE:2/ CH-9).

Spandrel- The space between the haunches and the road decking of an arch (see fig. of PLATE: 1/CH-9)

String course.- A horizontal course projecting from a wall (usually introduced at every floor level or under windows or below parapets) for imparting architectural appearance to the structure and also keeping off the rain water (see fig. D of PLATE:2/ CH-9).

9.3 MATERIALS

9.3.1 Bricks

9.3.1.1 Bricks shall be hand-moulded or machine-moulded and shell be made from suitable soil They shall be free from cracks end flaws and nodules of free lime. Hand moulded bricks of 9 cm height, shall be moulded with a frog 10 to 20 mm deep on one of its flat sides; the shape and size of the frog shall conform to either fig. 1a or fig. 1B.

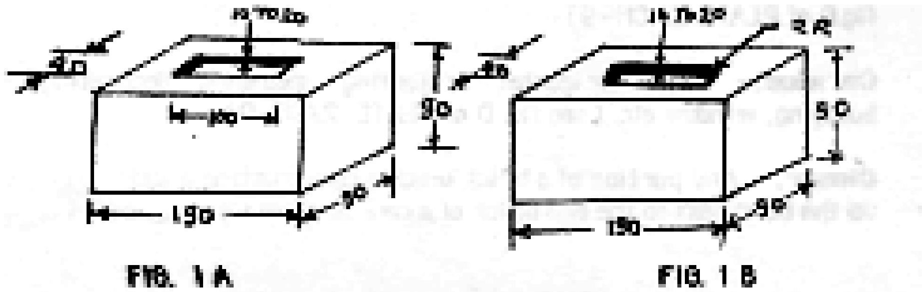


FIG. 1 A FIG. 1 B

ALL DIMENSIONS IN MILIMETRES

Each brick shall be marked (in the frog where provided) with the manufacturer's identification mark or initials.

9.3.1 .2 Bricks used shall be of the specified class and size. The standard sizes of common building bricks shall be as follows:

Type of Bricks	Nominal size	Actual size
Modular bricks	20x1Ox1O cm	19x9x9 cm

9.3.1.3 The common clay bricks shall be classified on the basis of average compressive strength as given in Table 1.

TABLE 1 : CLASSIFICATION OF BRICKS

S.No.	Type of Bricks	Class designation	Average compressive strength (N/mm^2)	
			Not less than	Not more than
1	First class table moulded (TM) Chimney kiln burnt brick/Grog or Ghol bricks.	5	5.0	7.5
2	Second class T.M. Chimney kiln burnt bricks.	3.5	3.5	5.0
3	Second class T.M. open bhatta or Pajawa burnt bricks.	3	3.0	3.5
4	Kumhar bricks burnt in Pajawa.	2	2.0	3.0

The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour.

9.3.1.4 **Dimensional *Tolerances***

The scale of sampling for dimensional tolerance shall be as under.-

No. of bricks in the lot	No. of bricks to be selected
2,001 to 10,000	40
10,001 to 35,000	60
35,001 to 50,000	80

The dimension of bricks when tested in accordance with para 9.3.1.5 shall be within the following limits per 20 bricks selected at random from the lot.

(i) *For Bricks of C/ass Designation 5 And 3. 5*

Length	372 to 388 cm (380 ±8 cm)
Width & height	176 to 184 cm (180 ± 4 cm)

(ii) *For Bricks of C/ass Designation 3*

Length	366 to 392 cm (380 ± 12cm)
Width & Height	174 to186 cm (180 ± 6cm)

(iii) *For Bricks of C/ass Designation 2*

Length Width	350 to 410 cm (380 ± 30 cm)
& Height	165 to 195 cm (180± 15 cm)

9.3.1.5 *Testing For Physical Characteristics*

9.3.1.5.1 *Sampling*:-For carrying out compressive strength, water absorption and efflorescence tests the samples of the bricks shall be taken at random according to the size of lot as given in Table 2.

TABLE 2 : SCALE OF SAMPLING FOR PHYSICAL CHARACTERISTICS

Lot size	Sample size for compressive strength, water absorption and efflorescence.	Permisible No. of defecives for efflorescence.
2001 to 10000	5	0
10001 to 35000	10	0
3500 1 to 50000	15	1

9.3.1.5.2 *Compressive Strength:-The* bricks when tested in accordance with the procedure laid down in IS : 3495 (Part 1)-1976 and given at Appendix-1 shall have a minimum average compressive strength for various classes as given in Table 1.

The compressive strength of any individual brick, shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 per cent.

In case of the test results for compressive strength exceed the upper limit of the class for the purpose, the upper limit of the class should be taken while averaging the result

9.3.1.5.3 *Water Absorption:-* The bricks when tested in accordance with the procedure laid down in IS:3495 (Part II)- 1976 and given at Appendix-II after immersion in cold water for 24 hours the average water absorption shall not be more than 20 per cent by weight.

9.3.1.5.4 *Efflorescence-* The bricks shall be tested for efflorescence when specifically so desired *by* the Engineering-in-Charge. The bricks when tested in accordance with the procedure laid down in IS:3495(Part III)-1976 and given at Appendix III, the rating of efflorescence shall not be more than "moderate".

9.3.1.6 ***Brick Bats**:*— Brick bats shall be obtained from well burnt bricks.

9.3.2 Mortar

Mortar as specified in the respective items shall be used. For specifications for mortars, refer Chapter 6 **-** "Mortars".

9.4 BRICK WORK - GENERAL

9.4.1 Bricks

The bricks shall be classified according to class designation of bricks used. Only Kumhar bricks shall be used for brick masonry in mud mortar.

9.4.2 Laying

Bricks used for masonry in cement mortar or composite mortar shall be thoroughly soaked in clean water for at least an hour immediately before use. (The absence of bubbling when the soaked brick is immersed in water is the test for thorough soaking). The soaked bricks shall be kept on a platform free from dirt, mud or any foreign element. Bricks required for masonry in mud mortar/fat lime mortar are not to be soaked.

Bricks shall be laid in English bond (with frogs upwards normally) as shown in Fig. of PLATE: 5 / CH-9 and PLATE: 6/ CH-9 unless otherwise specified. Half or cut bricks shall not be used except for closers which may be required to complete the bond. It shall be ensured that ell horizontal end vertical joints are completely filled with mortars without any void in brick work.

Brickwork shall be raised truely plumb (or true to required batter where so specified). All courses shall be laid truely horizontal. Vertical joints shell be truely vertical, and those in alternate courses shall be in the some vertical line. The thickness of brick courses shall be uniform (slight difference in dimension of bricks being adjusted in joint thickness). The levels of window sills, soffit level of lintels and such other important levels shall be kept as shown fn the drawing or otherwise specified and the course shall be so adjusted as to get complete number of courses up to these levels.

In case of one brick thick or half brick thick wall at least one face should be kept smooth and plain even if the other side is slightly rough (due to variation in size of brick). In age of walls of thickness greater then that of one brick, both the sides shall be smooth and plain.

All connected brickwork shall be raised uniformly and no portion of brickwork nil be left more than one metre below the rest of the work. Where this is not possible the work shall be raked back according to bond (and not left toothed) at an angle not steeper than 45 degrees.

At least one set of tools comprising of wooden straight edges, mason's spirit level, *we*, half metre rule, line and pins string and plumb line shall be available for each group of three (or less number of) masons working on a job for regular checking as the work progresses.

All iron fixtures, pipes, outlets of water, holdfasts of doors and windows, etc. which are required to be built into the wall, shall be embedded in cement mortar or in cement concrete as specified, in their correct position as the brick work is raised. Metal doors, windows or ventilators shall however be fixed into prepared openings. They shall not be built in as the wall go up as this practice often results in brickwork being brought right up to the frame with no clearance allowed and usually distorts the units and increases the likelihood of damage being done to the unit during subsequent building work. Iron holdfasts shall be given a protective coat of bitumen to avoid rusting. Wood-work faces in contact with brickwork shall be treated with wood preservative to prevent attack from insects and termites.

9.4.3 Joints

9.4.3.1 Bricks shall be so laid that all joints are full of mortar.

9.4.3.1.1 In brickwork the cross-joints in any course shall not be nearer than a quarter of a brick length from those in the course below or above it.

9.4.3.1.2 The thickness of bed joints shall be such that four courses and three joints taken consecutively shall measure equal to 39 cm.

9.4.3.1.3 The thickness of vertical joints shall not exceed 1.0 cm for brickwork of any class designation.

9.4.3.2 *Flinishing of Joints*

9.4.3.2.1 The face joints of brickwork may be finished by "jointing" or by "pointing" as may be specified in the drawings.

9.4.3.2.2 In jointing either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brickwork, or the joints shall be squarely raked out to a depth of 1 cm while the mortar is still green for subsequent plastering. The faces of the brickwork shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brickwork.

9.4.3.2.3 In pointing, the joints shall be squarely raked out to a depth of 1.5 cm while the mortar is still green and the raked joints shall be well brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give the required finish e.g. "flush", "tucked", "ruled", etc.

9.4.4 Precaution to prevent cracks

The precautions to be taken to prevent cracks in the brickwork are given at Appendix -1 V & shall be observed.

9.4.5 Protection & Curing

Green work shall be protected from rain by suitable covering. For proper setting up of mortar the brickwork shall also be protected from drying up by keeping it constantly, wet for at least seven days, except in the case of brickwork with mud mortar for which no such curing shall be done.

9.4.6 Scaffolding

For exposed brickwork, double scaffolding having two sets of vertical supports shall be provided. Only minimum number of holes (such holes shall be formed by omitting a header brick) shall be left in the brickwork for supporting horizontal scaffolding poles. No hole shall be permitted in pillars under one metre in width, or near the skewbacks of arches. The holes left in masonry shall be made good by fixing full bricks into the holes before plastering. The scaffolding shall be sound and strong and shall be properly maintained during construction.

Note:- In case of special type of brickwork, scaffolding shall be got approved from Engineer-in-charge in advance.

9.5 BRICKWORK-INDIVIDUAL ITEMS

Particular specification for individual items given below are in addition to the general specification for brickwork given above which shall apply to ell the following items in so far as they are applicable or unless otherwise specified.

9-5.1 Brickwork In Arches

9.5.1.1 ***Classification of Arches***.— Masonry in archwork may be either 'gauged' or "plain". Cut or specially moulded bricks shall be used in gauged archwork and ordinary (but selected) bricks shall be in plain archwork.

9.5.1.2 ***Circular Arches :-*** This term also includes curved arches other than conforming to arc of a circle such as parabolic or elliptical shaped arches. Circular plain arches shall be built in half-brick concentric rings, taking care to break joints transversely; circular gauged arches shall be built with proper binding using cut or specially moulded bricks. The two tiers of arch work is shown in Fig. of PLATE:7/ CH-9. The arch work shall be raised uniformly from both ends and closed carefully at the center using key brick(s). Thickness of joints shall not be less than 5 mm nor more than 15 mm. All bricks shall be carefully set with joints properly filled with mortar by pressing the bricks into position against the layer of mortar already applied to the bricks.

As soon as the arch is completed, the haunches shall be loaded by filling up the spandrels upto the crown level of the arch, care being taken to load the arch uniformly on both haunches.

When the face of the arch is to be pointed (and not plastered), the face bricks shall be cut to proper shape or specially moulded bricks used, so as to have the face joints not more than 5 mm thick uniformly. The joints shall be radial and through the full depth of the arch, but the voussoirs shall break joints (see Fig. of PLATE:7/ CH-9).

9.5.1.3 ***Flat Arches:***—Flat arches shall be gauged arches using cut or moulded bricks. The extrados shall be kept horizontal while the intrados shall be given a slight comber of one hundredth of span. The centre of the arch from which the joints shall radiate shall be determined by the point of intersection of the lines drawn from the end points of the intrados of the arch at the springing level of 60 degree to the horizontal (see Fig. of PLATE.-8/ CH-9).

In flat arehes bricks shall be laid with radial-through-joints to the full depth of arch, and voussoirs shall break joints with each other. The archwork shall be built from both sides uniformly and closed carefully at the centre using key brides. All bricks shall be carefully set with joints properly filled with mortar by pressing the bricks against the layer of mortar already applied to the bricks. The thickness of joints shall not exceed 5 mm.

9.5.1.4 ***Skew Backs :-*** Bricks forming skew backs shall be dressed or cut so as to give proper radial bearing to the end voussoirs. Defects in dressing of bricks shall not be made up by mortar or use of chips.

9.5.1.5 ***Spandrels: -*** The bricks of the spandrel wall at their junctions with the extrados of arch shall be cut to fit in the curvature of arch.

9.5.1.6 ***Centering And Shuttering*****:—**The centering and shuttering for the arch shall be strong enough to bear the load of the arch with the haunch fillings as well as the live loads that are likely to come upon it during construction without any settlement or deflection. The shuttering shall be tightened with wedges or sandboxes so that the same could be eased without any jerk being transmitted to the arch. The arrangement shall permit for all portions of the shuttering being released simultaneously. The shuttering shall be struck within 48 hours of completion of the arch but not before 24 hours. This shall be done after the spandrel and the haunches have been filled and the arch is loaded.

9.5.2 Half Brickwork-Plain or Reinforced

Half brickwork is built by laying bricks in stretcher courses. The thickness of such wall as the name implies shall be half the full length of the bricks. Half brick wall may be built independently or as (one or both) leaf/leaves of a cavity wall.

The description of items shall specify whether or not the brickwork is to be reinforced.

Reinforcement: - If reinforcement is specified, the same shall consist of one No.25 mm x 1.6 mm hoop iron embedded in cement mortar in every third course or two nos. 6 mm dia round bars similarly embedded in every fourth course. The hoop iron shall be properly joined by hooking at junctions or corners so as to form one continuous length in each continuous brickwork. The free ends of the reinforcement shall be keyed into the mortar joint of the main brickwork to which the half brickwork is joined. Round bars shall be properly overlapped staggering joints, and the free ends keyed into the main brickwall.

9.5.3 Brick Honeycomb Work

Brick honeycomb shall be done with specified class and size of bricks in specified mortar. All joints shall be struck flush to give an even surface. The thickness of honeycomb brickwork shall be that of half brick works unless otherwise specified.

Openings shall be equal and alternate with half brick laid with a bearing of 2 cm on either side. The honeycomb work shall present a uniform pattern.

9.5.4 Moulding and Cornices

Specified quality and class of bricks shall be used for the work. The bricks used for moulded work shall be either purpose moulded or cut to required shape.

Cornices shall not ordinarily project by more than 15 cm to 20 cm. This projection shall be formed by projecting each layer of brick by not more than one fourth of the length of brick. Where cornices of greeter then 20 cm is required special arrangements such as metal clomps shelf be used.

Corbelling shall be brought roughly to required shape by plastering with the specified mortar. The mouldings shall be then brought to shape using metal or wooden templates, while the mortar is still green. The mouldings shall be cured properly for seven days and the work shall be properly protected against damage by rain etc.

9.5.5 Brick drip course

Brick drip course shall be laid above the junction of the roof with the parapet wall (see Fig. Of PLATE:9/ CH-9).

Specially moulded bricks shall be used for drip course. When such special bricks are not available, bricks cut to shape may be permitted. The shape of drip course shall be as shown in the Fig. of PLATE:9/ CH-9.

The arrangement, shape etc. of lime concrete gola below the drip course to prevent water seepage through the j unction of roof and wall ere shown in Fig. of PLATE.-9/ CH-9 .

9.5.6 Joining Old Brick Work With New Brick Work

9.5.6.1 In case of old as well as new brick work in metric system, the old brickwork shall be toothed to the full width of the new wall and to the depth of quarter of a brick in alternate course. It shall be cleaned of all dust, loose mortar etc., and thoroughly wetted before starting new brick work. Thickness of each course of new work shall be made equal to the thickness of the corresponding course of the old work by adjusting thickness of horizontal mortar joints.

9.5.6.2 In case of old brick work in F.P.S. system and new work in metric system, the old brick work shall be toothed to the full width of new wall and to the depth of 5 cm in alternate stages of four courses. Four courses of old brickwork will be inserted to three course of new brickwork.

9.5.7 Cavity Walls

9.5.7.1 One or both leaves of a cavity wall may be of brick (the other being of concrete or other material). The two leaves of the cavity wall shall be tied by means of specially made wall ties spaced at not more than four brick length apart horizontally and not more than five brick courses vertically and staggered. Additional ties shall be used near opening. There shall be at least five ties per square metre of surface area of the wall. Ties shall be sloped away from the inner leaf of the cavity wall.

Ties shall be of mild steel flat iron, suitably twisted at the middle to prevent water flowing along it, or round bars bent to oval shape and twisted in the middle. Ties shall be given a bituminous or other anticorrosive coat before inserting into position.

9.5.7.2 ***Cleaning Out Holes*****:-**Small openings shall be left in the exterior leaf approximately 2 metres apart at the start of masonry so as to facilitate hand cleaning out by leans of a rake. These holes should *be* closed at the end of the construction of the wall after doing the necessary cleaning at the cavity.

9.5.7.3 ***Mortar Dropping:-*** During construction of cavity wall, mortar droppings are quite likely to fall into the cavity and get lodged over ties and become a constant source of transmittance of moisture. For preventing this, a wooden batten should be kept over ties during the construction of wall to catch any mortar droppings (see Fig. of PLATE:2/ CH-9).

The batten should be lifted up every time when the next row of ties is reached and the process repeated as the construction of wall proceeds. The inner surface of outer leaf of the wall should not encourage splash of dripping water that may penetrate through the outer leaf and thus transmit dampness to the inner leaf. To avoid this, projections from outer leaf extending in the cavity should not be allowed.

APPENDIX - I

TEST FOR COMPRESSIVE STRENGTH

(Para 9.3.1.5.2)

[Refer IS. 3495 (Part I)- 1976]

1. No. of Specimen.- The numbers of specimen as prescribed in table 2 of para 9.3.1.5.1 shall be taken at random from a lot to be tested. The dimensions shall be measured correct to I mm.

2. Apparatus. - A compression-testing machine, the compression plate of which shall have a ball seating in the form of portion of a sphere the center of which coincides with the center of the plate, shall be used.

3. Preconditioning - Remove unevenness observed in the bed faces to provide two smooth and parallel faces by grinding. Immerse in water at room temperature for 24 hours. Remove the specimen and drain out any surplus moisture at room temperature. Fill the frog (where provided) and all voids in the bed face flush with cement mortar (1 cement, 1 clean coarse sand of grade 3 mm and down). Store under the damp Jute bags for 24 hours followed by Immersion In clean water for 3 days. Remove, and wipe out any traces of moisture.

4. Procedure.- Place the specimen with flat faces horizontal, and mortar filled face facing upwards between two 3-ply plywood sheets each of 3 mm thickness and carefully centred between plates of the testing machine. Apply load axially at a uniform rate of 140 kg/cm^2 per minute till failure occurs and note down the maximum load at failure. The load at failure shall be the maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.

Note.- In place of plywood sheets plaster of Paris may be used to ensure a uniform surface for application of load.

5. Report.- The report shall be as given below:

$$\text{Compressive strength in kg/cm}^2 = \frac{\text{Maximum load at failure in kg.}}{\text{Average area of the bed faces in cm}^2}$$

6. The average of results shall be reported.

N.B.- In case of the test results for compressive strength exceed the upper limit of the class for the purpose, the upper limit of the class should be taken while averaging the result

APPENDIX-11

TEST FOR WATER ABSORPTION

(Para 9.3.1.5.3)

[Refer IS : 3496 (Part II) - 1976]

1. **No. of Specimen.-** The number of specimen as prescribed in table 2 of para 9.3.1.5.1 shall be taken at random from a lot to be tested.

2. **Apparatus. -** A sensitive balance capable of weighing within 0.1 per cent of the mass of specimen; and a ventilated oven.

3. **Preconditioning. -** Dry the specimen in a ventilated oven at a temperature of 105 to 115 ^{o}C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M_1). Specimen warm to touch shall not be used for the purpose.

4. **Procedure- -** Immerse completely dried specimen in clean water at a temperature 27 $\pm$ 2^0 C for 24 hours. Remove the specimen and wipe out any traces of water with a damp cloth and weigh the specimen. Complete the weighing 3 minutes after the specimen has been removed from water (M_2).

5. Water absorption, percent by mass, after 24 hour Immersion in cold water is given by the following formula:

$$\frac{M_2 - M_1}{M_1} \times 100$$

6. The average of results shall be reported.

APPENDIX III

EFFLORESCENE

(Para 9.3. 1. 5.4)

Refer IS: 3495 (Part III) – 1976]

1. No. of specimen.- The number of specimen as prescribed in table 2 of para 9.3.1.5.1 shall be taken at random from a lot to be tested.

2. Apparatus.- A shallow flat bottom dish containing sufficient distilled water to completely saturate the specimens. The dish shall be made of glass, porcelain or glazed stoneware and of size 180 mm x 180 mm x 40 mm depth for square shaped and 200 mm dia x 40 mm depth for cylindrical shaped.

3. Procedure.- Place the end of the bricks in the dish, the depth of immersion in water being 25 mm. Place the whole arrangement in a warm (for example, 20 to 30^0 C) well ventilated room until all the water in the dish is absorbed by the specimens and the surplus water evaporates. Cover the dish containing the brick with suitable glass cylinder so that excessive evaporation from the dish may not occur. When the water has been absorbed and bricks appear to be dry, place a similar quantity of water in the dish and allow it to evaporate as before. Examine the bricks for efflorescence after the second evaporation and report the results.

4. Report.- The liability to efflorescence shall be reported as 'nil’ 'slight’, 'moderate', 'heavy' or 'serious' in accordance with the following definitions:

(a) *Nil.*- When there is no perceptible deposit of efflorescence.

(b) *Slight.*- When not more than 10 per cent of the exposed area of the brick *is* covered with a thin deposit of sorts.

(c) *Moderate.*- When there is a heavier deposit than under 'slight' and covering upto 50 per cent of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.

(d) *Heavy.*- When there is a heavy deposit of salts covering 50 per cent or more of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface,

(e) *Serious.*- When there is heavy deposit of salts accompanied by powdering and/or flaking of the exposed surfaces.

APPENDIX-IV

PRECAUTION TO BE TAKEN TO PREVENT CRACKS IN BUILDINGS

(Para 9.4.4)

In order to minimise cracks in buildings, the following measures shall be adopted subject to the approval of the Engineer-in-Charge.

1. Horizontal Cracks in Masonry And Plaster At the Floor or Roof Slab Level.

(i) A smooth bearing for R.C.C. slabs and beams on the wall with 6 mm cement plaster 1:3 (1 cement : 3 fine sand), finished with a floating coat of neat cement shall be provided and then finished with a thick coat of lime wash or Kraft paper. The sides and top of slabs and beams in contact with wall shall be painted with thick coat of hot bitumen.

(ii) The slab shall not bear on full thickness of external wall. A gap of about 12 mm shall be kept between slab and external masonry and filled with bituminous filler or impregnated fiberboard in case of superior buildings and bituminous filler (80 kg. hot bitumen : 1 kg cement: 0.25 cubic metre coarse sand) in other building. The external masonry of wall beyond the expansion Joint shall not be less than 10 cm. (see Fig. of PLATE: 10/ CH-9 & of PLATE: 11/ CH-9).

(iii) A similar gap of 12 mm wide shall be provided and filled with Impregnated fiberboard or bituminous filler when two slabs butt against each other and bear on an intermediate wall. Such expansion Joints should always be provided at ridges (and not in valleys) as shown In Fig. of PLATE: 12/CH-9.

(iv) Ceiling plaster shall be done first and then the wall plaster. When the ceiling plaster Is done, it shall be finished with a chamfered edge at an angle at Its junction with the wall at bearings, with a trowel while the plaster is still green. Similarly when the wall plaster is being done it shall be kept separate from the ceiling plaster by a thin straight groove drawn with a trovel at an angle with the wall, while the plaster is still green. The arrangement is shown in Fig. Of PLATE: 10/ CH-9 to Of PLATE: 13/ CH-9.

(v) R.C.C. or plain cement concrete 1:2:4 bed plate with a smooth surface and a thick coat of lime wash or laid with Kraft paper shall be provided under the beams. The plaster of wall and the bed plate shall be kept separated from that of the beam as given in Fig. of PLATE: 13/ CH-9 Minimum thickness of R.C.C. bed plate shall be 10 cm and that of plain concrete 20 cm.

2. Horizontal Cracks At the Junction of Sun Shade with the Wall.

Wall plaster shall be kept separate from that of the R.C.C sun shade as in para 1 -(iv) above.

3. Inclined Cracks At the Junctions of Sun Shade With the Wall

(i) Flat brick arches shall be constructed for openings upto 1.2 meters

(ii) R.C.C. lintels shall be allowed to dry and shrink as much as possible before plastering the wall.

4. Vertical Cracks At the Bearings of R.C.C. Beam or Pillars.

These crocks occur when R.C.C. beam has an expansion joint over the masonry pillar. These can be avoided by designing a continuous beam on the pillar. Where however, expansion Joint In beams is essential a R.C.C. bed plate may be provided over the pillar for its full length and width.

5. Transverse Cracks In R.C.C. Slab In Sun Shades, Verandahs And Room

Expansion joints shall be allowed at 5 to 6 metres intervals in case of sun shades, 12 to 13 metres in case of covered verandah slabs and 12 to 15 metres in case of slabs continuous over rooms in a row of quarters.

To prevent cracks in the masonry, below or above the expansion joints, the following measures shall be taken:

(i) *Sunshades*- In this case, the expansion Joints shall not extend to the portion embedded in masonry but shall stop short of the face of the wall by 5 cm and the distribution reinforcement in the embedded portion and in the 5 cm portion of the chhajja slab where there is no expansion Joint, shall be increased to 40% of main reinforcement. The gap of the expansion joint in the projected portion shall not be filled with any material.

(ii) Verandah *Slabs*- In this case the expansion joint shall be a neat butt Joint which shall be finished straight. The joint shall be carried right through the portion embedded in the masonry also. It is desirable to provide a vertical butt Joint in the masonry supporting the verandah slab at the expansion joints right from plinth level. Where this is not possible, R.C.C. or plain cement concrete bed plates shall be provided on the bearing as shown in Fig. of PLATE: 13/ CH-9 . To prevent cracks in the masonry above, the longitudinal wall shall also have a butt joint with gap running in the same vertical plane as the joint in the slab. The gap can, in the case of roof slabs, be scaled by copper cradles.

(iii) *Room slabs* - In load bearing structures, expansion joint in room slabs shall be similar to that in verandah slabs. Where slab is combined with T-beams, the expansion joint shall be provided by substituting one of the T-beams, with rectangular beam and slabs as per sketch No.2 of Fig. of PLATE: 14/ CH-9.

In R.C.C. framed structure, the expansion joint is generally provided in conjunction with twin beams and twin columns as shown in sketches 1 & 2 of PLATE: 14/ CH-9 and sketches of Fig. of PLATE: 15/ CH-9 The expansion joint shall be provided with copper cradle and its top filled with bituminous material. The underside of the beam shall be provided with sheet of asbestos or any other suitable material, which shall be fixed on one side and shall be free to move on the other side within oval-shaped holes, in case of twin columns, the expansion joint is similarly covered on the inside and outside.

The gap between the twin columns and the gap below copper cradle in twin beams need not be filled with any bitumen filler but may be kept unfitted. Before, however, the Joints are covered on the outside with asbestos or any other suitable sheets, the gap should be cleaned thoroughly of all rubbish or mortar droppings etc.

6. Cracks At The Junction of New Buildings With Old

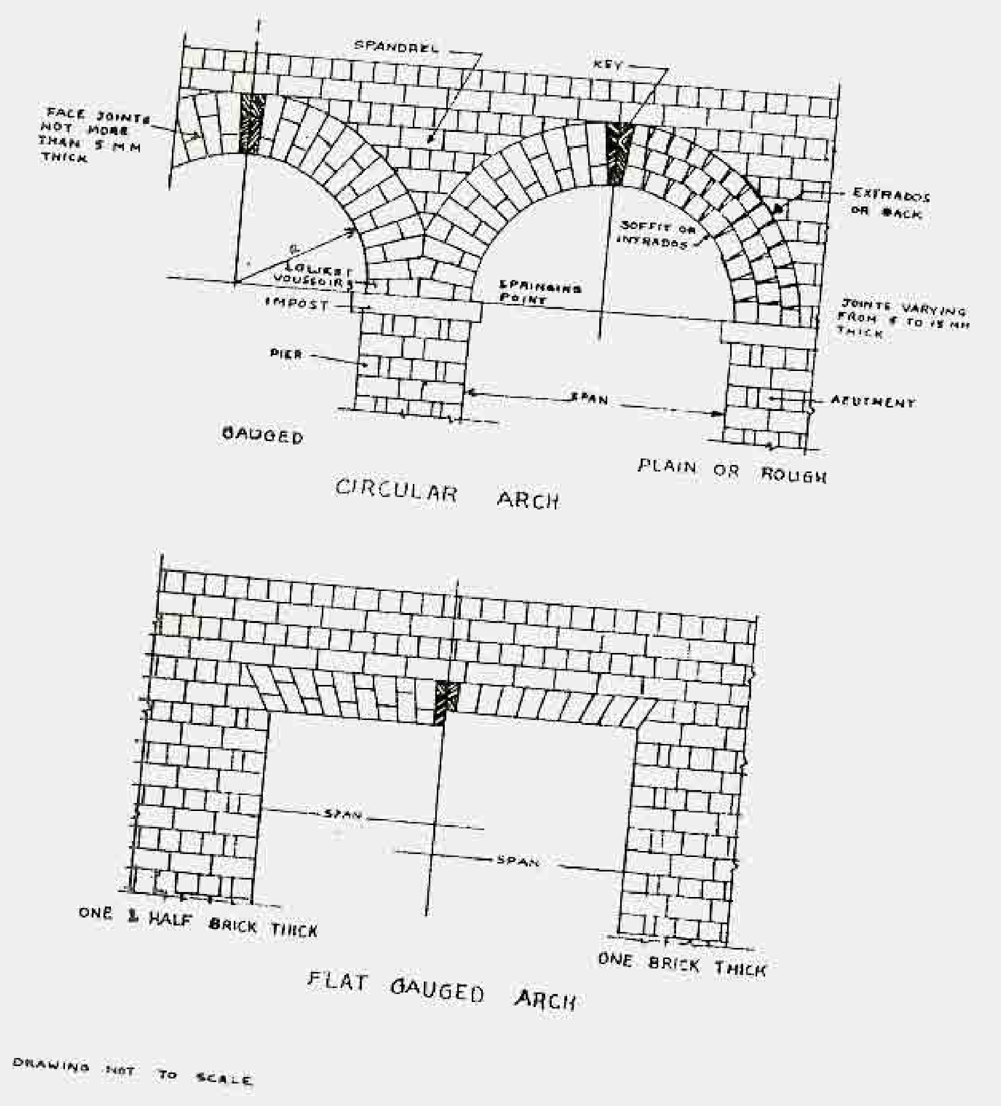
When making additions to on old building, if new masonry is toothed with old masonry, there is a likelihood of cracks occurring at the junction because of differential settlement. Toothing, therefore, shall be avoided and new masonry shall be laid with a slip joint for thick walls. Where tongued and grooved joint is not possible as in 20 cm walls, the joint shall be straight butt joint only.

7. Cracks In General

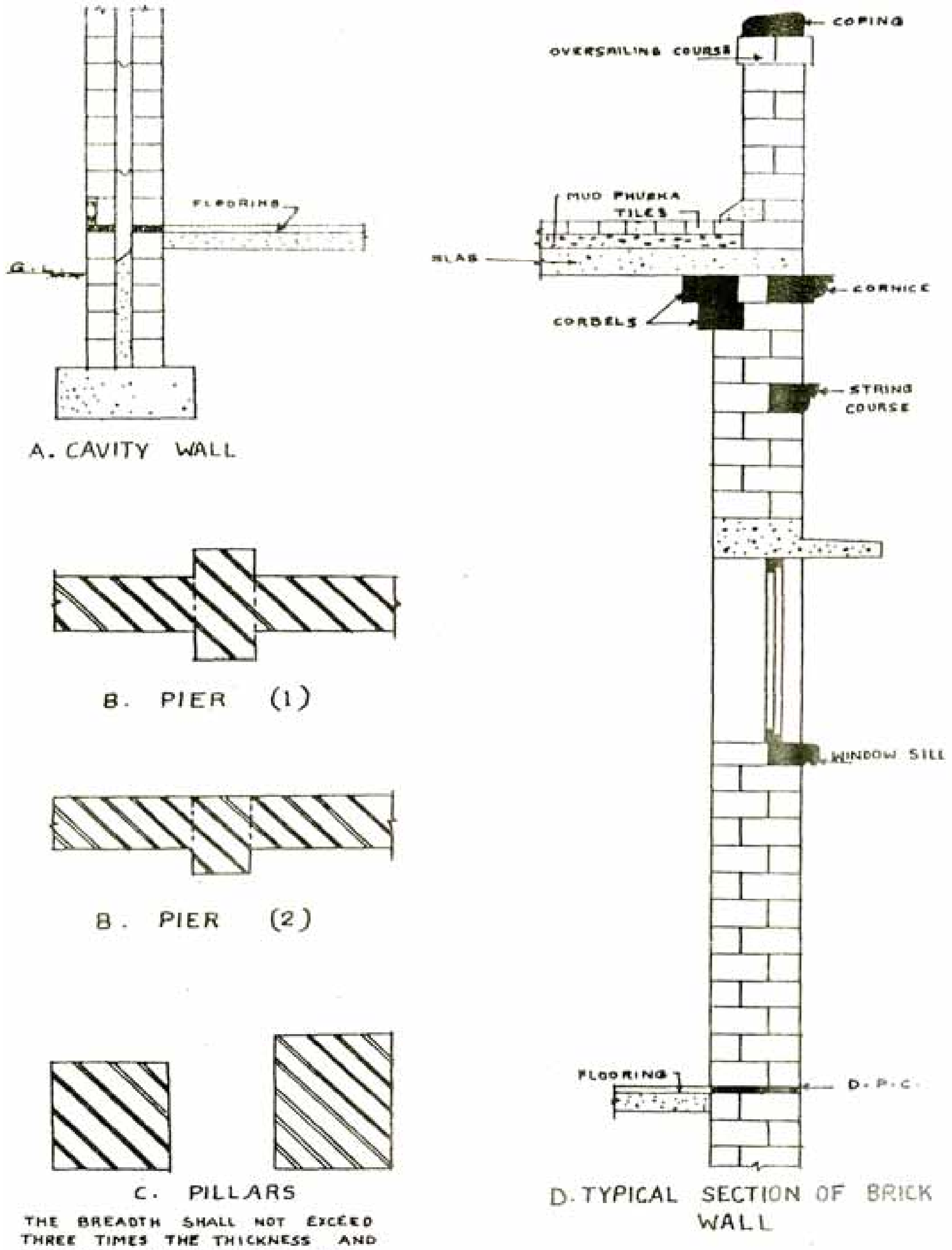
(i) Masonry work shall be proceeded systematically and uniformly at all levels.

(ii) The plasterwork on walls shall be deferred as much as possible so as to let shrinkage in R.C.C. and masonry take place before plastering.

BRICK WORK IN ARCHES



BRICK WORK

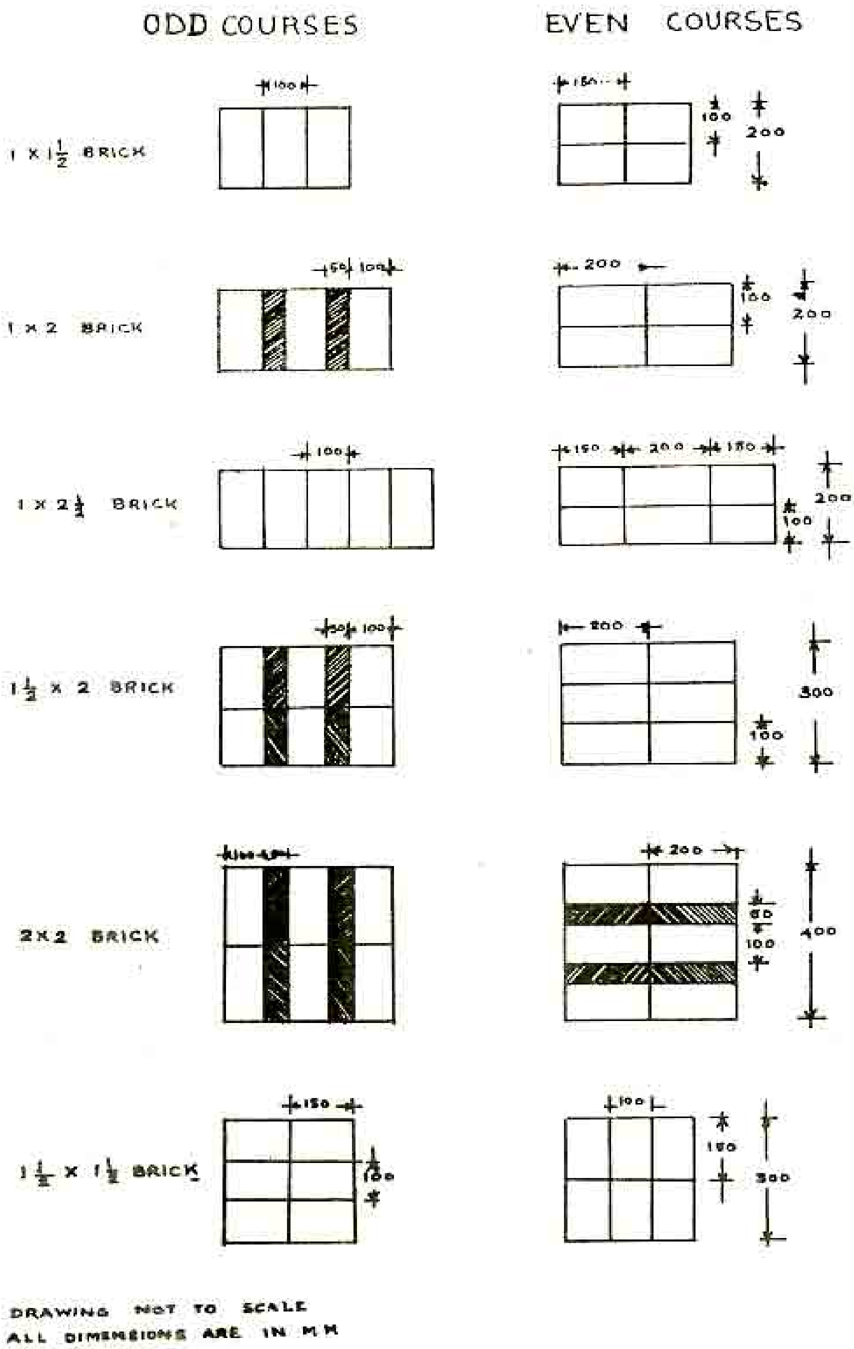


THE BREADTH SHALL NOT EXCEED THREE TIMES THE THICKNESS AND THICKNESS IT SELF SHALL NOT EXCEED MORE THAN THREE BRICKS

PLATE : 3/CH – 9.

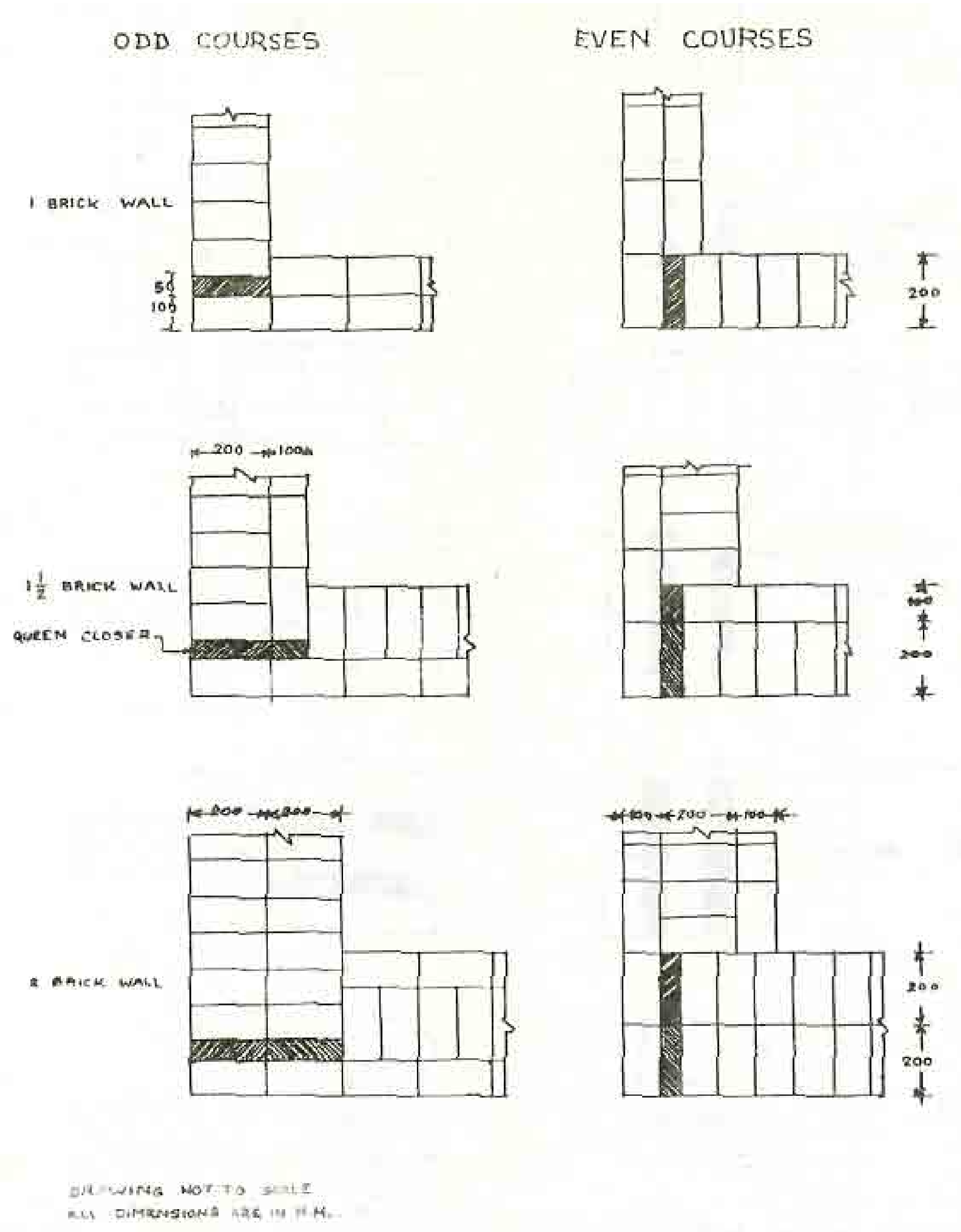
BRICK PILLARS

ENGLISH BOND



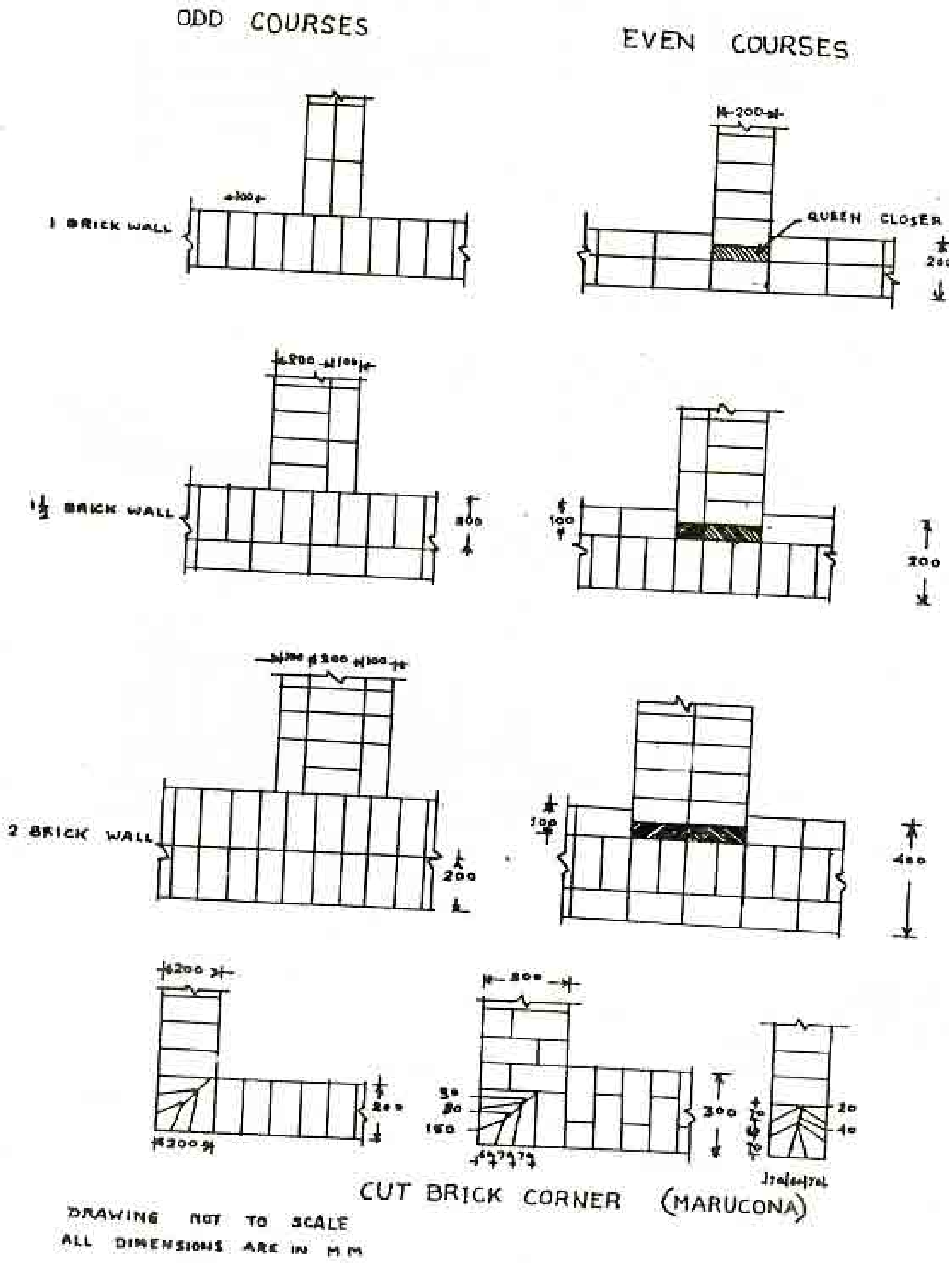
BRICK BONDS

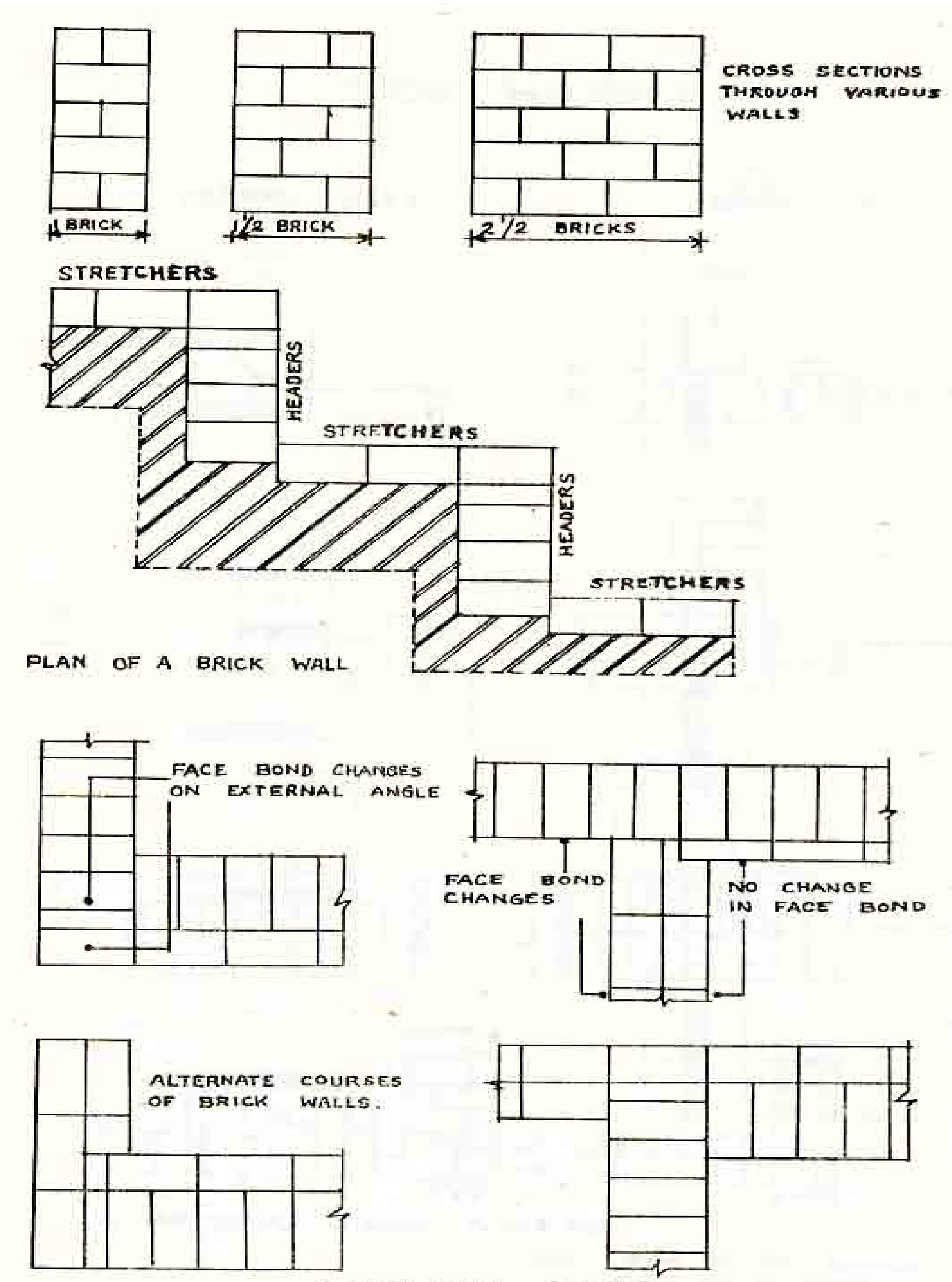
ENGLISH BOND



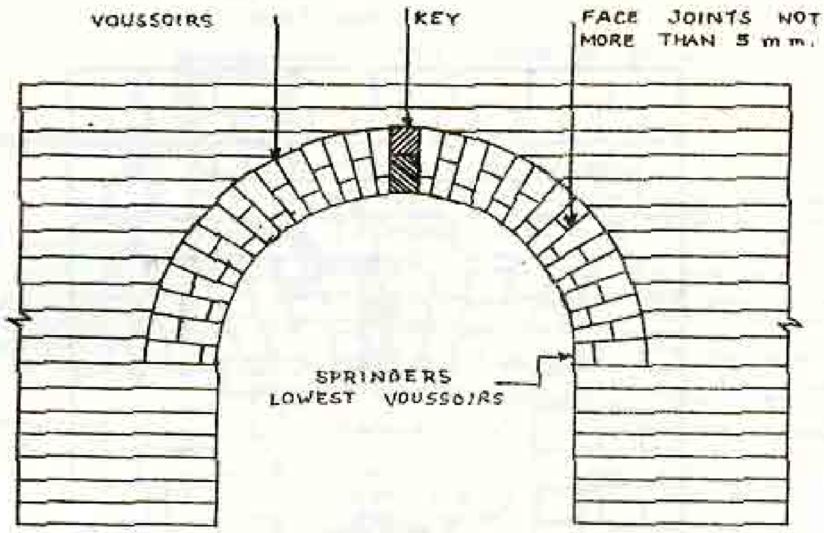
BRICK BONDS

ENGLISH BOND



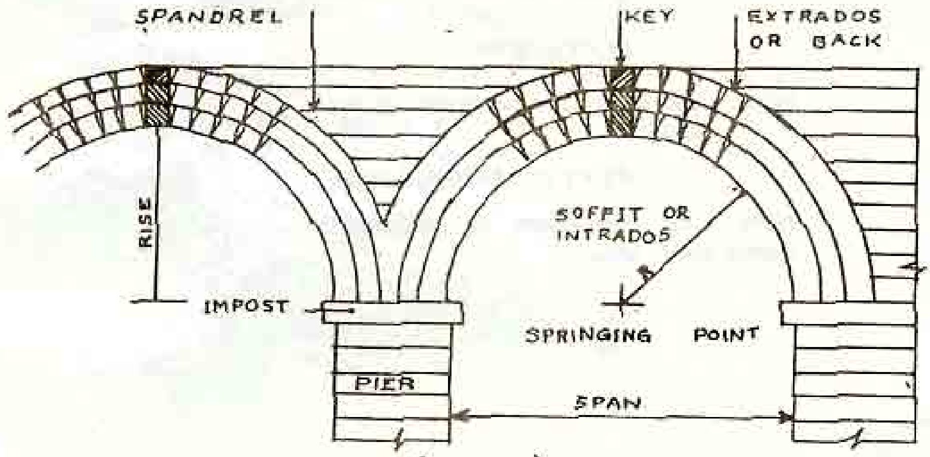


ENGLISH BOND



CIRCULAR ARCH (GAUGED) USING CUT OR MOULDED BRICKS
(WHEN THE FACE IS POINTED)

SKETCH - 1



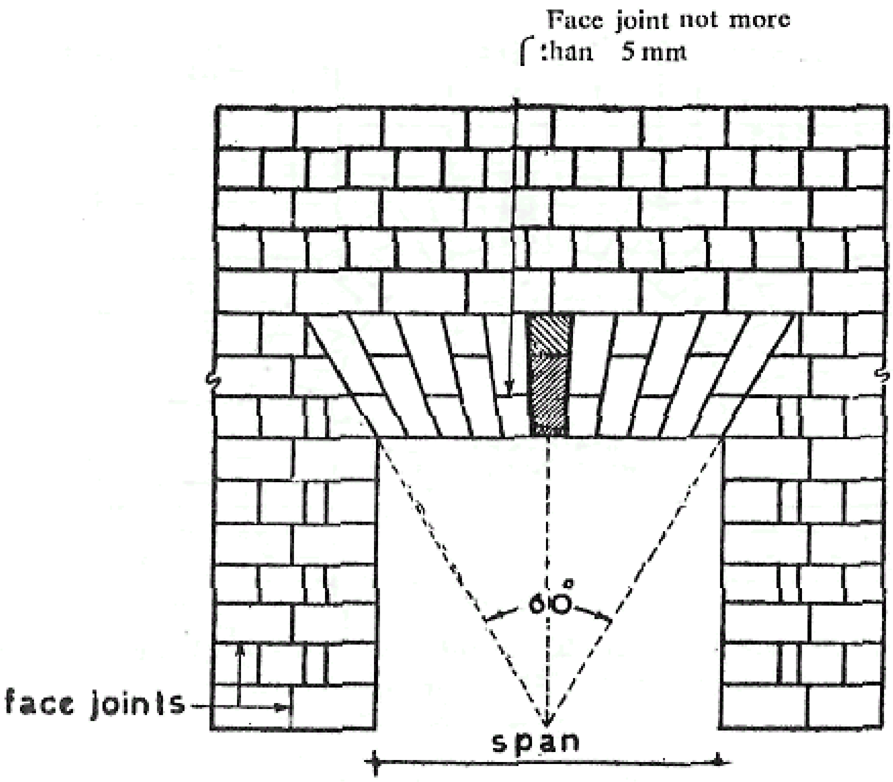
CIRCULAR (PLAIN) ARCH

(WHEN THE FACE IS PLASTERED) USING ORDINARY BRICKS WITH VARYING THICKNESS OF MORTAR JOINTS 5 mm TO 15 mm.

BRICK WORK IN ARCHES

NOTE :- ALL DIMENSIONS IN MILLIMETRE
SKETCH NOT TO SCALE

SKETCH - 2

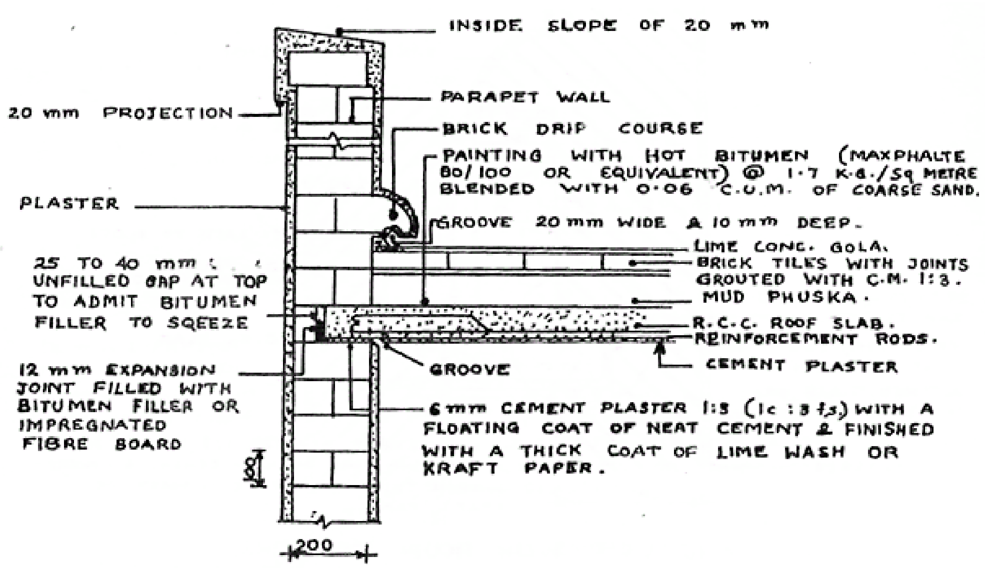


ELEVATION

Note : Camber = One hundredth of the span

FLAT (GAUGED) ARCH

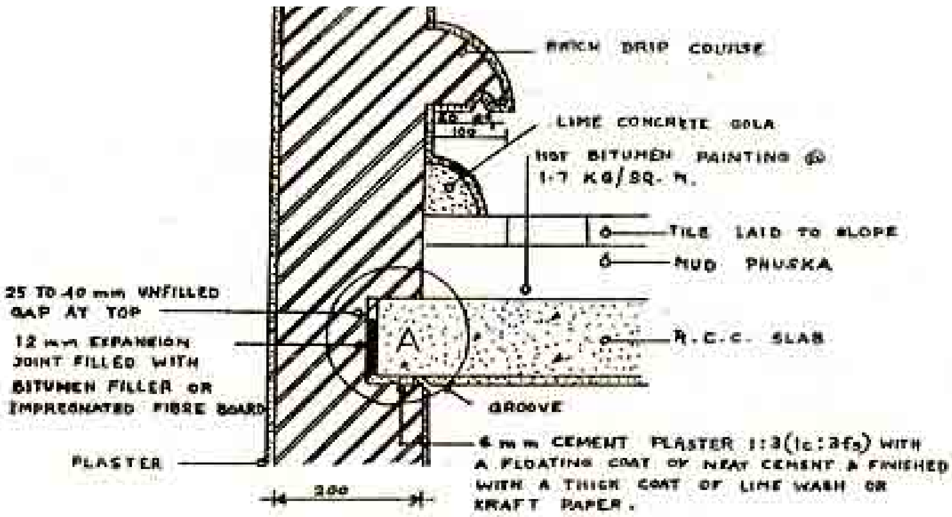
Note : All dimensions in millimetres
Figure not to scale



SECTION AT RIDGE

BRICK DRIP COURSE AND JOINT OF ROOF WITH WALL

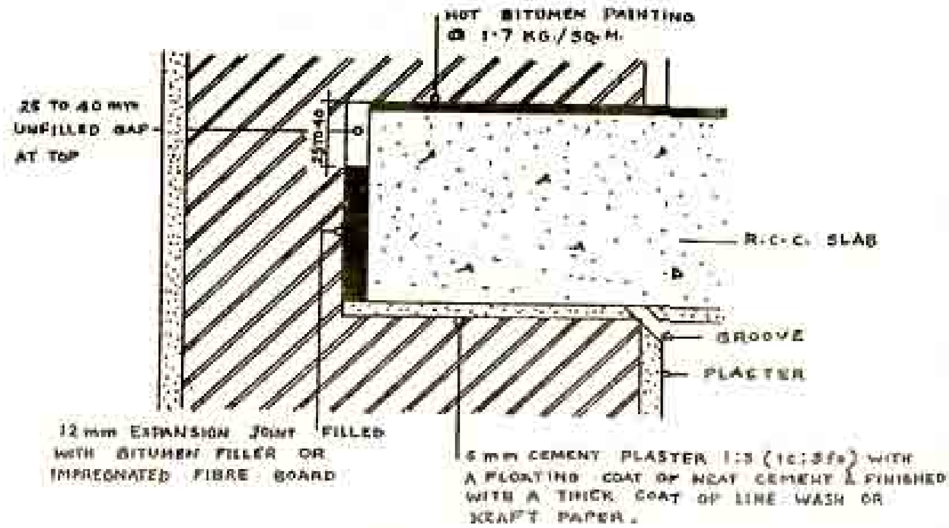
NOTE :— ALL DIMENSIONS IN MILLIMETRE
FIG. NOT TO SCALE.



END WALL WITH ROOF SLAB

SKETCH - 1

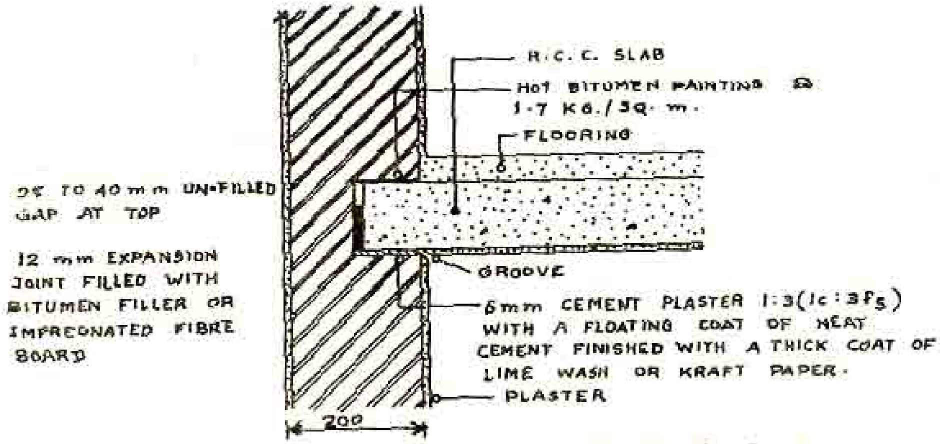
NOTE — ALL DIMENSIONS IN MILLIMETRE
FIG. NOT TO SCALE



DETAIL AT A

SKETCH - 2

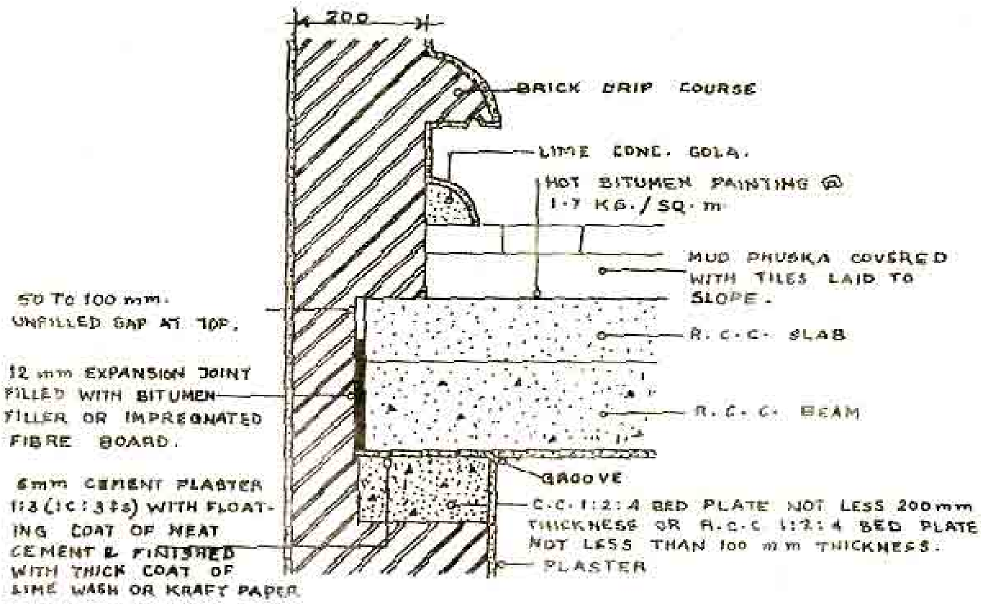
NOTE — ALL DIMENSIONS IN MILLIMETRE
FIG. NOT TO SCALE



END WALL WITH SUSPENDED FLOOR SLAB

SKETCH - 1

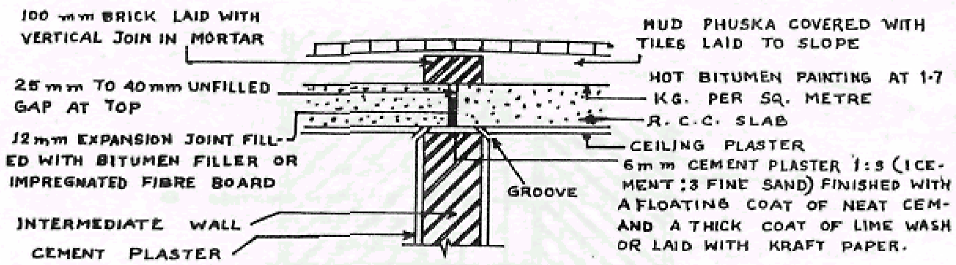
NOTE - ALL DIMENSIONS IN MILLIMETRES.
FIG. NOT TO SCALE



END WALL WITH ROOF BEAM.

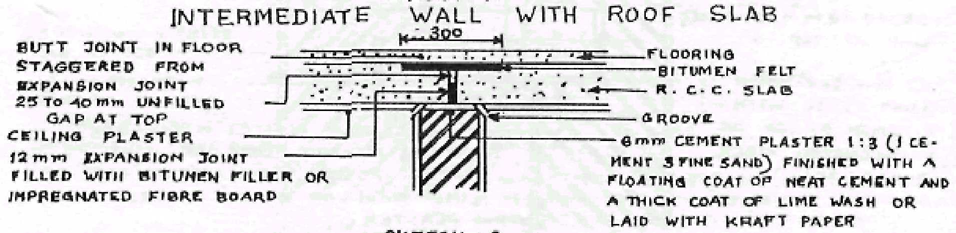
SKETCH - 2

NOTE ALL DIMENSIONS IN MILLIMETRE.
FIG. NOT TO SCALE.



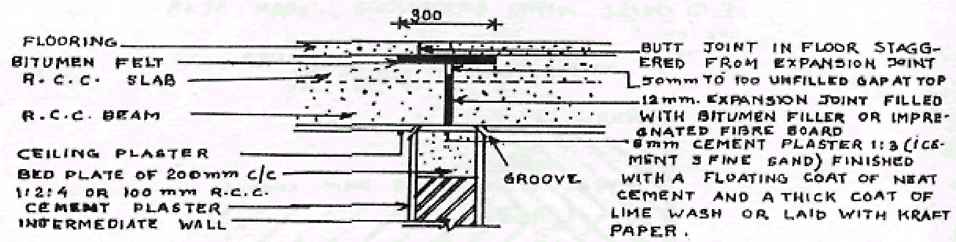
SKETCH - 1.

INTERMEDIATE WALL WITH ROOF SLAB



SKETCH - 2

INTERMEDIATE WALL WITH FLOOR SLAB

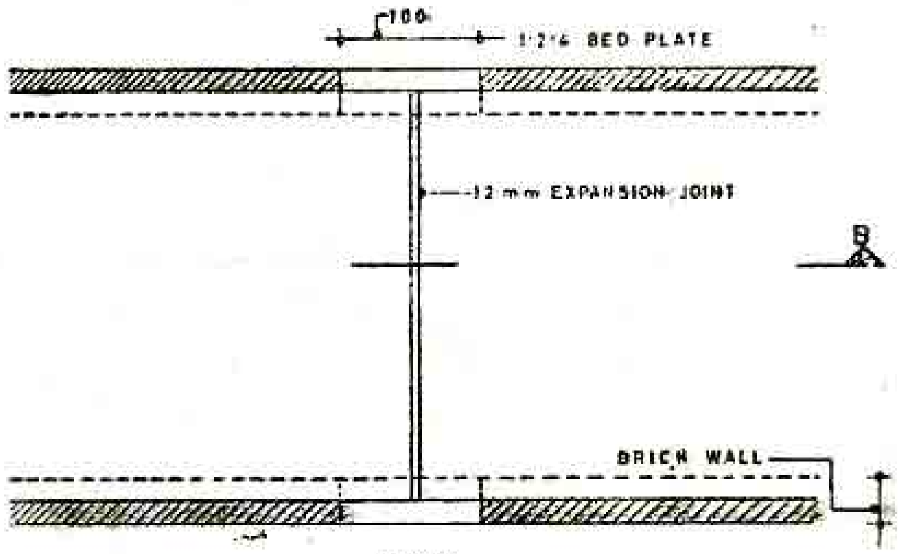


SKETCH - 3

INTERMEDIATE WALL WITH FLOOR BEAM

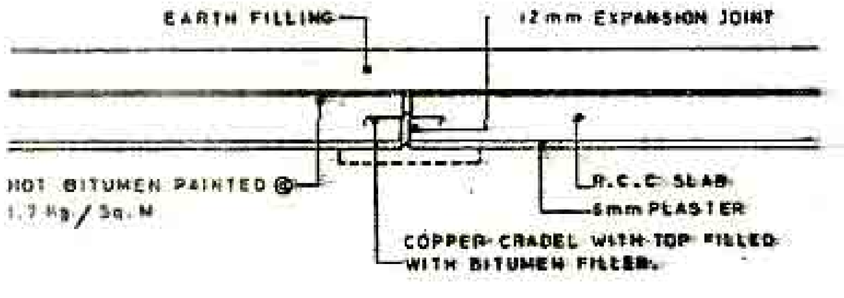
NOTE :- ALL DIMENSIONS IN MILLIMETRE
FIG. NOT TO SCALE

LONG WATER — RESERVOIR SLAB
(EXPANSION JOINT AT 12 to 15M CENTRES)



PLAN

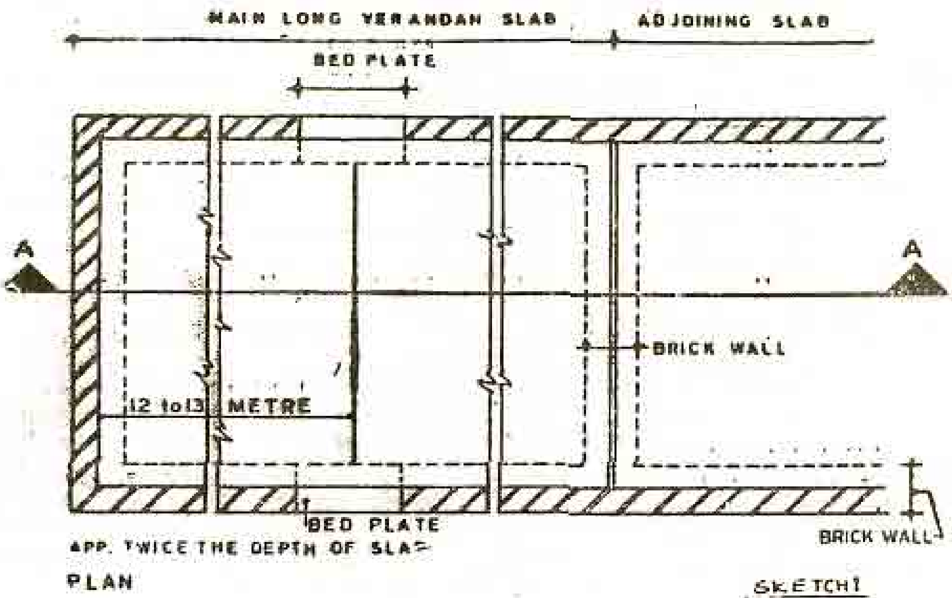
SKETCH 1

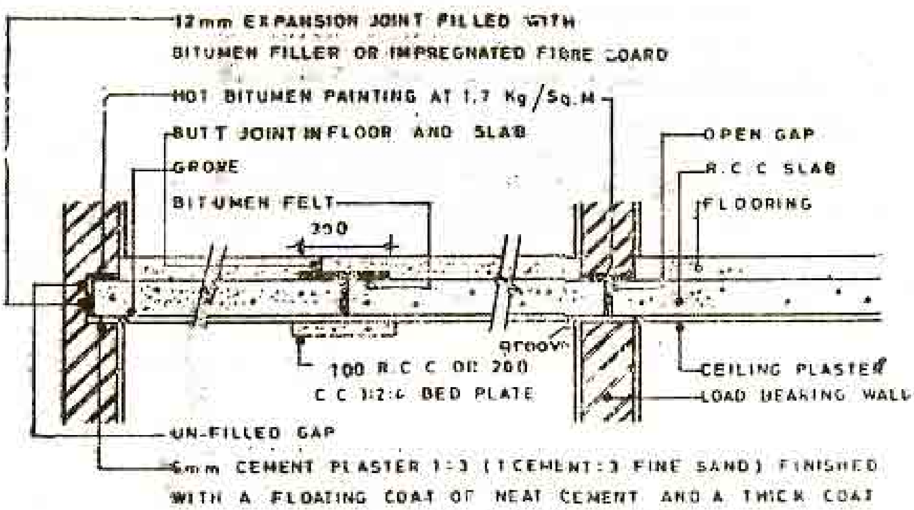


SECTION ON BB

NOTE FIG.NOT TO SCALE. ALL DIMENSIONS ARE IN MILLIMETRES SKETCH 2

(Contd.)

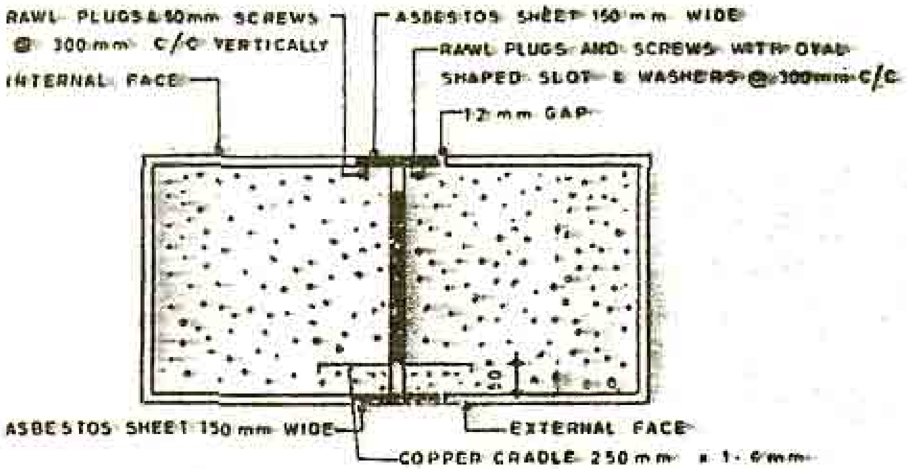




LONG VERANDAH SLAB

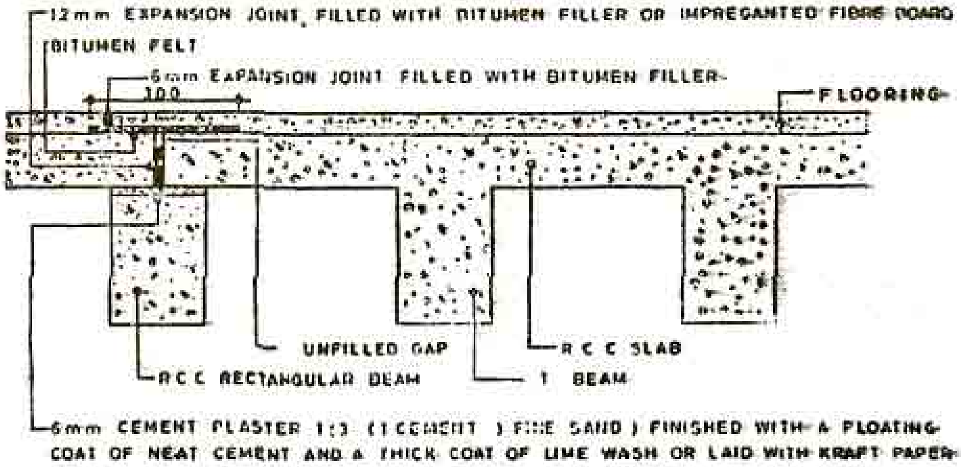
(BUTT JOINT AT 12 TO 13 METRE CENTRES)

NOTE :- all dimensions in millimetre.
fig. not to scale



TWIN COLUMNS
SECTIONAL PLAN

SKETCH-1



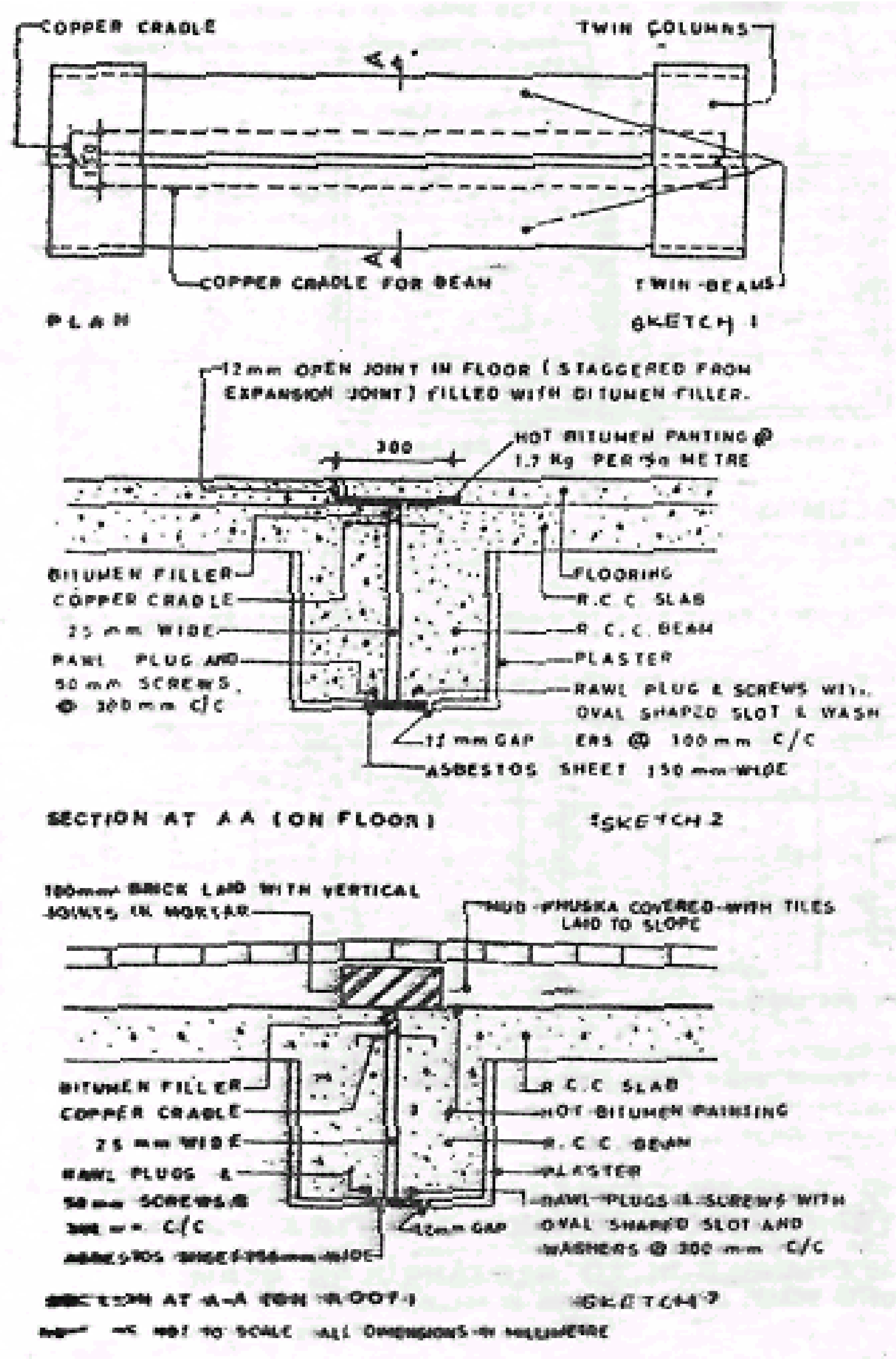
SKETCH-2

SLAB AND T-BEAM CONSTRUCTION OF LONG LENGTH WITH INTERMEDIATE EXPANSION JOINT (AT 12-15 M CENTRE)

T-BEAM CHANGED IN TO RECTANGULAR BEAM

NOTE:- FIG. NOT TO SCALE. ALL DIMENSIONS IN MILLIMETRE.

TWIN BEAMS WITH TWIN COLUMNS



GCPM ... BCBD - 28-8-87 - 1500

SECTION – VII

CHAPTER – 10 FLOORING

CHAPTER – 10

FLOORING

CONTENTS

CHAPTER –10

FLOORING

10.1 REFERENCES

IS: 777-1970	Glazed earthenware tiles (First revision with amendment No.1).
IS: 1237-1980	Cement concrete flooring tiles (First revision).
IS: 1443- 1972	Code of practice for laying and finishing of cement concrete flooring, tiles (First revision) (Reaffirmed 1987).
IS: 2114-1984	Code of practice for laying in-situ terrazzo floor finish (first revision).
IS: 2571-1970	Code of practice for laying in-situ cement concrete flooring (first revision) (Reaffirmed 1987).
IS: 3461- 1980	PVC (Vinyl) asbestos floor tiles.
IS: 3622-1977	Sandstone (slabs and tiles) (First revision).
IS: 5318-1969	Code of practice for laying of flexible PVC sheet and tile flooring (Reaffirmed 1978).
IS: 8237-1976	Protection of slope for reservoir embankment (Reaffirmed March 1981).
-- --	Standard Specification, Building &, Communication Deportment, Government of Maharashtra
-- --	"Specifications 77" of Central Public Works Department.
-- --	"Standard Specifications 77" of National Building Origination.

10.2 TERMINOLOGY

10.2.1 General Terms

Base-The prepared surface *an* which [he flooring is laid.

Base Concrete **-** The layer of concrete on which the cement concrete lopping is laid.

Efflorescence **-**Patches of whitish scum formed by deposition of soluble salts which appear on the flooring particularly by noticeable on Plain Tiles.

***Grout or slurry* -** Neat cement mixed with water to honey-like consistency; it may include pigments If used for grouting joints of tiled floor Sand, stone dust or any other aggregate shall not be added.

***Laitance* -**A thin layer consisting essentially of fine cement particles, which often forms a scum on the surface of freshly laid concrete. This layer may be formed by excessive surface trowelling of concrete immediately after it has been laid.

***Matrix* -** The binding constituent of the top layer of the tile which is chiefly Portland cement, either plain or mixed with pigments.

***Pin Holes* -** These are tiny air-cells in terrazzo tiles which open up during the polishing process and are too small to be filled.

***Pores* -** Holes appearing in the surface of the hardened terrazzo tile after the initial grinding.

Sub-base - The prepared surface on ground on which base concrete is laid.

***Sub-floor* -** The structural floor upon which the base is formed.

***Tiles* -** The term " tile " used in these specification shall apply to the following:

(a) Plain cement tiles;

(b) Plain coloured tiles,

(c) Terrazzo tiles;

(d) Chequered, embossed or specially manufactured non-slip cement tiles; and

(e) Precast staircase treads, risers, wall-slabs, etc.

***Terrazzo Floor* -** The floor finish where the wearing surface is normally composed of marble chips in a matrix of cement with or without pigments and mechanically or manually ground, processed and polished.

10.*2.2.* Tools And Accessories

***Screed* -** Narrow strips of wood, bands of plaster or pieces of tiles laid on the floor to act as guides for bringing the whole of the work to a true and even surface. The screeds shall be removed after laying all the floor area for which they have been applied as guides.

Screeding Board - *A* straight-edged wooden plank used for floating a plain surface. It is moved with a sawing action, the two ends resting on screeds or guides set at the correct height.

10.2.3 Site Operation

***Bedding* -** A layer of mortar applied to the base or sub-floor end brought to a defined level.

***Damp Proofing* -** Covering the sub-floor with a continuous layer of impervious material so as to prevent penetration of moisture.

***Filling* -** A plain or coloured cement paste with which the open pores of terrazzo tiles are filled or plastered after grinding. The term refers also to the operation of filling.

***Grinding* -** The process by which the aggregate of the tiles is exposed by' means of mechanical or manual grinding.

***Hacking* -** The roughening of solid backgrounds, by hand or mechanical methods, to provide a suitable key.

***Polishing* -** Rubbing of tiles mechanically or by hand with polishing stones after they have been laid, and bringing out their sheen.

***Raking* -** Removing mortar from masonry joints to provide suitable key for the plastering and pointing.

***Screeding* -** Bringing the floor to a true and even surface by means of screeding boards and screeds.

10.3 CEMENT CONCRETE FLOORING

10.3.1 Material

10.3.I.I ***Cement* -** Cement used for the floor finish work shall conform to IS:269 -1989 or to IS:455 -1978 or IS: 1489 -1 976 or IS: 12600 -1989.

10.3.1.2 ***Aggregates*** -Aggregates for cement *concrete* flooring mix shall conform to relevant para 7.3.2.4 of Chapter 7 & 16 Filling Foundation, R.C.C & Form Work Graded aggregate of maximum nominal size of 40 mm shall be used and grading shad be as described under para 7.3.2.5.1 of Ch. 7 & 16. The coarse aggregate shall generally be of the of the following sizes:

(a) Base concrete (lean cement concrete - Graded from 40 mm or below.
or lime concrete)

(b) Cement Concrete topping of thickness 40 mm and above.	-Graded from 16 mm and below
(c) Cement concrete topping of mm	-Graded from 12.5 mm and below) thickness 25
(d) Under layer of cement Concrete topping in two layers.	- Graded from 12.5 mm and below

10.3.1.3 ***Fine Aggregate (sand)* -** The grading of fine aggregate for cement concrete flooring mix shall be within the limits of one of the two zones i.e. Grading Zone I and II as given in table under para 7.3.2.5.3 of Ch. 7 & 16

10.3.1.4 **Water -** Water shall conform to relevant para 7.3.4 of Ch. 7 & 16.

10.3.2. Laying Concrete Flooring

10.3.2.1 **General -** Thickness, Mix proportion and Size of Panels shall be as specified in the description of item or as directed by Engineer-in-Charge. Broad guidelines are given under Appendix **-** I

10.3.2.2 ***Floor Finish Laid Monolithically with the Base Concrete on Ground***

a) *Preparation of sub-base*

(i) The ground or earth filling shall be thoroughly compacted so that there are no loose pockets left anywhere in the whole area. This shall then be covered with clean sand well consolidated to a thickness of not less than 100 mm. Great care is necessary in the preparation of the sub-base, as a settlement in the sub-base may cause the failure of the whole floor.

(ii) In situations, such as garages where wheeled traffic comes into contact with the flooring, sub-base shall consist of well compacted sand layer of 100 mm thick and an additional 100 mm thick well compacted hard core of dry brick or stone ballast (40 mm size) blinded with MOORUM (disintegrated rock) or coarse sand.

(iii) In case of expansive soils, like black cotton soil, stone ballast (40 mm graded aggregates) mixed with locally available yellow or red soil or soft MOORUM in 1:1 proportion shall be compacted to about 300 mm thickness and thoroughly saturated with water. This surface should be further covered with another 200 mm thick layer of soft MOORUM or cinder or sand and compacted properly before laying the base concrete. Special care is necessary in consolidation of the ground as otherwise the settlement of sub-base may cause cracking of the whole floor.

b) *Laying the Base*

(i) The area to be paved shall be divided into suitable panels keeping in view the limits as specified. This shall be done by fixing screed strips, the depth of which shall be equal to the combined thickness of the base concrete and the topping. Before being laid in position the screed strip shall preferably be coated with a thick coat of lime wash so as to prevent them from sticking to the concrete deposited in the panels.

(ii) The base concrete and the topping shall be laid in alternate panels, the intermediate panels being filled in alter one to two days depending upon the temperature and atmospheric conditions. The screed strips should be removed the next day after the concrete has been deposited in the panels and the edges of panels shall be examined for any honeycombing or undulation which, if found, shall be repaired straight and smooth by cement mortar. If the intermediate panels are not to be tilted the next day, the screed strips shall then be cleaned and put back against the edges of panels till the concrete in the alternate panels is to be deposited. When the concrete is being deposited In the alternate panels the screed strips shall be removed. When the concrete is being compacted in new panels, core shall be taken to avoid damage to the panels already laid. If glass strips are provided for effective separation of panels, the base concrete and the topping may be laid in all the panels simultaneously.

(iii) Before placing the base concrete, the sub-base shall be properly wetted. The concrete shall then be deposited between the screed strips, thoroughly tamped and the surface screeded uniformly below the desired finished grade of flooring to accommodate the required thickness of topping. Any slope desired in the floor finish shall be given in the base concrete. The surface shall not be finished smooth but kept rough to provide adequate bond for the topping.

(c) *Laying the Topping***-** On the clean, green surface of the base concrete, the topping shall be placed in position as soon as possible but generally not later than two or three hours of laying the base concrete depending upon the temperature and the atmospheric conditions. The base concrete at the time of laying the topping shall be still green but sufficiently firm to enable the workmen to work over it by placing planks on its surface.

The concrete mix for the topping shall be deposited on the base concrete in the screed strips already laid and thoroughly compacted to the finished thickness. Glass or aluminium stripes may be provided for effective separation of panels and to provide straight edges and corners for the panels where good workmanship is required. The mix for the topping shall be stiff enough to prevent accumulation of any excess water or laitance on the surface. If water or laitance rises to the surface when consolidating (which indicates that too much of water has been used in the preparation of concrete) the concrete should preferably be scraped and replaced by a fresh mix. If it is desired to absorb surplus water for any reason, it should be mopped up; it should, on no account, be absorbed by spreading dry cement. The topping shall then be floated with a wooden float to render the surface even and after the surface is slightly hardened, it shall be finished smooth as described in 10.3.2.2 (d).

(d) *Finishing the surfaces*

After the concrete has been fully compacted it shall be finished by trowelling or floating. Finishing operations shall start shortly after the compaction of concrete and shall be spread over the period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled three times at intervals so as to produce a uniform and hard surface. The satisfactory resistance of floor to wear depends largely upon the care with which trowelling is carried out. The object of trowelling is to produce as hard and close knit a surface as possible. The time interval allowed between successive trowelling is very important. Immediately after laying only just sufficient trowelling shall be done to give a level surface. Excessive trowelling in the earlier stages shall be avoided, as this tends to work a layer rich in cement to the surface. Sometime, after the first trowelling, the duration depending upon the temperature, atmospheric conditions and the rate of set of cement used, the surface shall be retrowelled to close any pores in the surface, and to bring to surface and scrape off any excess water in concrete or laitance (it shall not be trowelled back Into the topping). The final trowelling shall be done well before the concrete has become too hard but at such a time that considerable pressure is required to make any impression on the surface. Trowelling of a rich mix of dry cement and fine aggregate on to the surface shall not be permitted.

The junctions of floor with wall plaster, dado, or skirting shall be rounded off where so specified.

e) *Slipperiness* - The slipperiness of concrete flooring depends mainly upon the surface treatment; when highly polished this type of floor finish is likely to be slippery. A trowel-finished floor is reasonably non-slip. Non-slip surfaces may be obtained by trowelling the floor surface or by providing non-slip inserts.

Floor finish over ramps, stairs and other similar situations, specially if they are liable to get wet, shall be finished in chequered pattern to make them non-slip.

10.3.2.3 Floor finish Laid Separately on Hardened Concrete Base on Ground

a) *Preparation of sub-base*- The sub-base shall be prepared as described in 10.3.2.2 (a).

b) *Laying the Base Concrete*- The base concrete ma/be deposited a stretch. Before placing the concrete the sub-base shall be properly wetted and rammed. The concrete shall then be deposited between the forms, where necessary,, thoroughly tamped and the surface finished level with the top edges of the forms. The surface of base concrete shall be left rough to provide ad adequate far the topping. Two or three hours after the concrete has been laid in position, the surface shall be brushed with a hard brush to remove any scum or laitance and swept clean so that the coarse aggregate is exposed.

c) *Laying the Topping*- Before the operation for laying the topping is started the surface of base concrete shall be thoroughly cleaned of all dirt, loose particles, caked mortar droppings, and laitance, if any, by scrubbing with coir or steel wire brush. Where the concrete has hardened so much that roughening of surface by wire brush Is not possible, the entire surface shall be roughened by chipping or hacking. - Before laying the topping, the surface shall be soaked with water, at toast for twelve hours and surplus water shall be removed by mopping immediately before the topping is laid in position.

The screed strips shall be fixed over the base concrete dividing it into suitable panels as specified in the item. The screed strips shall be so arranged that the joints, if any, in the base concrete shall coincide with the joints in the topping. Before placing the concrete mix for topping, neat cement slurry shall be thoroughly brushed @ *9 2* Kg/lit/ Sqm into the prepared surface of the base concrete just ahead of the finish. The topping shall then be laid, very thoroughly tamped, struck off level and the surface floated with a wooden float. The surface shall be tested with the straight-edge and mason's spirit-level to detect any inequalities in the surface which, if any, shall be made good immediately. The finish shall be laid in alternate panels as described in 10.3.2.2 (b) (ii) for topping laid monolithic with the base concrete.

d) *Finishing the surface*- The surface shall be finished as given in 10.3.2.2 (d)

e) *Laying the Topping in Two layers*- Where the topping is to be laid in two layers to obtain very smooth and dense finish , the sub-base, base concrete and under-layer of topping shall be laid as described in 10.3.2.2 (a) with the exception that the surface of the concrete in the under-layer of topping shall not be finished smooth with a trowel but left rough after tamping it and leveling it with screed board.

The top 15 mm thick wearing layer of mix 1:2 to 3 cement concrete (depending upon the quality of fish and abrasive resistance desired) of consistency stiffer than that of under-layer-concrete shall then be immediately laid over the rough but green surface of under-layer and thoroughly tamped, struck off level, and the surface floated with wooden float. The surface shall then be tested with a straight-edge and mason's spirit level to detect any undulation in the surface which, if any, shall be made good immediately. The surface shall then be finished smooth in accordance with 10.3.2.2 (d)

10.3-2.4 ***Floor Topping Laid Directly Over the Hardened Structural / Suspended Slab***

(a) *Preparation of Surface of Structural /Suspended slab*- When the topping is to be laid separately but directly over the structural slab without any cushioning layer, the structural concrete, 3 to 4 hours after its laying in the forms, shall be thoroughly brushed with a coir or steel wire brush to remove any scum or laitance and swept clean to expose the coarse aggregates and leave the surface rough.

(b) *Laying Topping*- Before the operation of laying the topping is started the surface of structural slab shall be thoroughly cleaned of the dirt, loose particles, cake mortar droppings and laitance, if any, by scrubbing with coir or steel wire brush. Where the concrete has hardened so much that roughening of surface by wire brush is not possible, the entire surface shall be roughened by chipping or hacking.

The screed strips shall then be fixed over the structural slab dividing it into suitable panels as specified. Immediately before depositing the concrete for the topping, neat cement slurry shall be thoroughly brushed into the prepared surface of the structural slab, just ahead of the finish. The topping shall then be laid, thoroughly tamped, struck off level and surface floated with a wooden float. The surface shall then be tested with e straight-edge and mason's spirit-level to detect any inequalities and undulations in surface which, if any, shall be made good immediately. The finish shall be told in alternate panels as described in 10.3.2.3 (e) and other laying and finishing operations shall be done as in 10.3.2.3 (c) and 10.3.2.3(e) depending upon whether the topping is to be laid in single or two layers.

10.3.3 **Shuttering -**The panels shall be bounded by wooden/angle iron battens. The battens shall have the same depth as the concrete flooring. These shall be fixed in position, with their top at proper level, giving required slopes. The surface of the battens or flats, to come in contact with concrete shall be smeared with soap solution or non sticking oil (foam oil or raw linseed oil) before concreting. The flooring shall butt agains the masonry wall. which shall not be plastered.

10.3.4 **Concreting -** The concreting shall be done in the manner described under chapter 7-" Filling Foundations". The battens used for shuttering, shall be removed on the next day of the laying of cement concrete. The cods thus exposed shall be repaired, if damaged, with cement mortar 1:2 (1 cement 2 coarse sand) and al towed to set for minimum period of 24 hours. The alternate panels shall than be cleaned of dust, mortar droppings etc. and concrete laid. White laying concrete care shall be taken to see that the edges of the previously laid panels are not damaged and fresh mortar is not splashed over thorn. The joints between the panels should come out as fine and as straight lines.

10.3.5 **Precautions**

If water or laitance rises to the surface when consolidating (which indicates that too much of water has been used in the preparation of concrete), the concrete should preferably be scraped and replaced by a fresh mix. If ft is desired to absorb the surplus water
for any reason, it should be mopped up; it should on no account be absorbed by spreading dry cement.

Flooring in lavatories and both rooms shall be laid after fixing of water closet and squatting pans and floor traps. Traps shall be plugged while laying the floors and opened after the floors are cured and cleaned. Any damage done to W.C.'s squatting pans and floor traps during the execution of work shall be made good.

During cold weather, concreting shall not be done when the temperature falls below 4.5^0C. The concrete placed shall be protected against frost by suitable coverings. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed '40^0C. No concreting shall be laid within half an hour of the closing of the day, unless permitted by the Engineer -in-Charge.

The floor shall 1 be protected from any damage during the execution of work.

10.3.6 **Curing**

The curing shall be done for a minimum period of fifteen days. Curing shall not be commenced until the top layer has hardened. Covering with empty cement gunnies shall be avoided, as the colour is likely to be bleached with the remanents of cement mortar from the bags.

10.3.7 Cement Plaster in Risers of Stops Skirting And Dado.

A bond of plaster at the bottom of wall not exceeding 30 cm in height above the floor shall be classified as skirting and above 30 cm as dido. It shall be flush with wall plaster or projecting out uniformly by 6 mm from the wall plaster, as specified The work shall be preferably carried out simultaneously with the laying of floor. Its corners and Junctions with floor shall be finished neatly as specified.

10.3.7.1 Thickness - The thickness of the plaster specified shall be measured exclusive of the thickness of key i.e. grooves or open Joints in brickwork. The average thickness shall not be less than the specified thickness, here 6 mm. The average thickness should be regulated at the time of plastering by keeping suitable thickness of the gauges. Extra thickness required in daubing behind rounding of corners at Junctions of wall shall be Ignored.

10.3.7.2 *Preparation of Wall Surface.* - The joints shall be raked out to a depth of at least 15 mm in masonry walls, while the masonry is being laid. In case of concrete walls, the surface shall be roughened by hacking. The surface shall be cleaned thoroughly washed with water and kept wet before skirting/dado is commenced.

10.3.7.3 *Application* - Skirting /dado with specified mortar and to specified thickness shall be told immediately after the surface is prepared It shall be laid along with the border or adjacent panels of floor. The Joints in skirting/dado shall be kept true and straight in continuation of the line of joints in borders or adjacent panels. The skirting/dado shall be finished smooth and true, with top truly horizontal and Joints truly vertical except where otherwise indicated.

10.3.7.4 *Finishing* - The finishing of surface shall be done simultaneously with the borders of the adjacent panels of floor. The cement to be applied- in the form of slurry for smooth finishing shall be at the rate of 2 kg of cement per liter of water applied over an area of 1 sqm.

Where skirting/*dado* is flush with plaster a groove 10 mm wide and up to 5 mm deep shall be provided in the plaster at the Junction of skirting/dado with plaster.

10.3.7.5 Curing.**-** Curing shall be commenced on the next *day* of plastering when the plaster has hardened sufficiently, it shall be continued for a minimum period of fourteen days.

10.4 TERRAZZO FLOORING

10.4.1 Materials

10.4.1.1 *Cement concrete*.- For specification of cement concrete appropriate paras ofSpecifications of Chapter **-** "Filling Foundations may be referred.

10.4.1.2 *Aggregate For Terrazzo Topping.* - The aggregate used in topping shall be marble aggregates size varying from I mm to 25mm as may be specified in the schedule of item.

Marble powder used in terrazzo topping shall pass through I.S. Sieve 300. The marble chips shall be of plain white Makrana, Abu white marble, Abu Fanther marble, white venied Makrana marble. Black Bhainslana (plain black or black zebra), black zebra from Kishangarh, Abu and Narnaul and Mekrana Dhobi Doongri zebra marble, Green from Baroda, Abu Falna and Bundi, Pink variety from Makrana and Bar. Grey from Kumari and Bundi. Brown from Bar and Narnaul or as specified. It shall be hard, sound, dense end homogeneous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering.

Before starting the work, sample of marble chips shall be approved by the Engineer-in-Charge.

10.4.1.3 **Cement-** Cement used for the floor finish work shall be ordinary cement, white cement/coloured cement or cement with admixture of pigment to give the desired shade conforming to 15:269-1976, 1&455-1976, IS: 1489-1976, or IS: 8042 - 1978 as applicable.

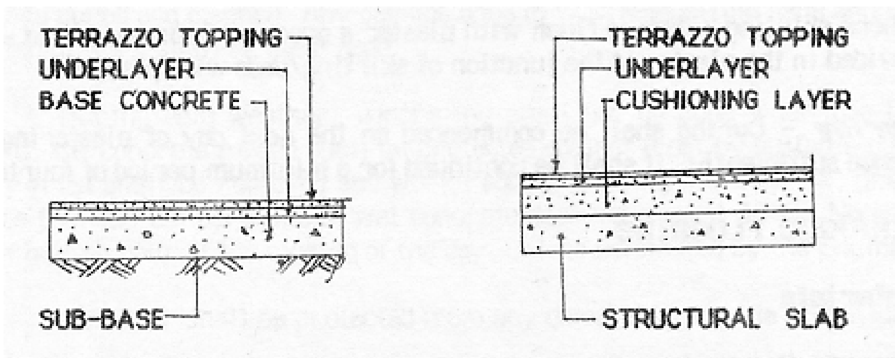
10.4.1.4 **Pigments-** Pigments incorporated in terrazzo shall be of permanent colour and shall conform to the requirements mentioned in table I

10.4.1.5 **Water.-** Specifications for water shall be same as in relevant para of chapter 6 ‘Mortar'.

10.4.1.6 **Dividing Strips-** These shall be of glass 4mm thick and 40mm wide.

10.4.2 **General Requirements**

10.4.2.1 Terrazzo finish shall be laid over a layer of base concrete in the case of ground floor. When the terrazzo floor is laid over R.C.C. slabs a cushioning layer shall be provided below the terrazzo floor. The terrazzo flooring shall consist of an under layer of cement concrete and a topping layer of terrazzo which shall be laid monolithically (refer fig. 1)



10.4.2.2 **Under layer -** The under layer shall be of cement concrete of mix 1:2:4. The maximum size of aggregate used shall not exceed 10 mm. Specification for cement concrete shall be as given in the relevant para of specifications of chapter 7 - "Filling Foundations”.

10.4.2.3 **Terrazzo Topping -**Topping shall have a mix of cement, marble powder, marble aggregates and water. Where coloured surface is required suitable pigment shall be added to the mix. The proportions of cement shall be inclusive of any pigments added to cement. Cement end marble powder shall be mixed in the ratio of 3:1 by weight. For every part cement marble powder mix, the proportion of aggregate by volume shall be as follows depending upon the size of aggregates:

Size of Aggregate (mm)	Proportion of Aggregate & Binder Mix (Parts)
1 to7	One & three-fourth
7 to 15	One & one-half
15 to 25	One & one-half

10.4.2.4 ***Thickness-*** The thickness of base concrete and cushioning layer shall not be less than 100 mm and 75 mm respectively. The combined thickness of the under layer and topping for flooring and dado /skirting shall be not less than 30 and 20 mm respectively. -The thickness of terrazzo topping shall be 6mm for chip size I to 2mm and 2 to 4 mm 9 mm for chip size 4 to 7mm and 12mm for chip size 7 to 10 mm. Where chips of size larger than 10 mm are used, the minimum thickness of topping shall be not less than one and one-third times the miximum size of chips.

TABLE : I - CEMENT PIEMENT PROPORTIONS FOR VARIOUS COLOURS OF MATRIX IN TERRAZZO WORK

(All proportions shall be by mass.)

Colour	Pigment to be used	Proportion or pigment	Proportion of cement	Proportion
(1)	(2)	(3)	(1)	(5)
Red	Red oxide of iron (see 2 or 3 of lS:44-1969).	1	15 to 20	nil
Black	Carbon black (see 1S:40-1971)	1	25 to 40	nil
Bottle Green	Green chromium wide (see IS:54-1974).	1	15 to 30	nil
Pink	Red oxide (see 2 or 3 of IS: 44-1969).	1	nil	100 to 300

(1)	(2)	(3)	(t)	(5)
Cream	Yellow oxide of Iron *(see 4* of IS:44-1969).	1	nil	100 to 400
Yellow	Yellow oxide of Iron see IS:44 - l979)	1	nil	25 to 75
Light Green	Green chromium oxide (see IS: 54-1975).	1	nil	50 to 150
French	- - - - - -	ni	1 to 2	1
Fawn	Yellow oxide of iron (see 4 of IS: 44-1969).	1	6	4

10.4.2.5 ***Panels*.-** The floor both while laying the under layer and topping shall be divided into panels not exceeding 2 sqm in area so as to reduce the risk of cracking due to differential shrinkage or expansion between the terrazzo and the sub floor. The joints shall be so located that the longer dimension of any panel does not exceed 2 m. The joints in flooring shall always coincide with expansion joint, if any, in the structural slab. The panels shall preferably be separated by means of dividing strips. However, where the butt joints are provided, the bays shall be laid alternatively allowing for an interval of atleast 24 hours between the laying of adjacent bays.

10.4.3 Mixing of Materials

With a view to avoid variation in colour, mixing shall be done in a trough or tub and the complete quantities of cement and pigment required for one operation shall be mixed at the beginning of the work. Coloured cement or cement and pigment mix shall be dry mixed with marble powder. The mix thus obtained shall be mixed with aggregate. Care shall be taken not to get the materials into a heap as this would result in coarser aggregates moving on to the sides and cement to the center. To the dry mix thus prepared, water shall be added in small quantities while materials are being worked to get a mix of proper consistency. The mixture shall be plastic but not so wet as to flow. The wet mix shall be used within half an hour of addition of water during preparation.

10.4.4 Laying

10.4.4.1*Laying of Under Layer*- The base shall be divided in panels with the help of dividing strips including the strips required for decorative design, up to the finished surface level of the floor. Screed strips shall be used where dividing strips are not used. The base shall be cleaned of ill dust, dirt, laitance and any loose material. It shall then be wetted with water, mopped and smeared with cement slurry 2 kg/lit/sqm. Under layer shall then be spread and leveled with a screeding board. The top surface shall be left rough to provide a good bond to the terrazzo.

10.4.4.2 ***Laying Of Torrozzo Topping-*** Terrazzo topping shall be laid while the under layer is still plastic but has hardened enough to prevent cement from rising to the surface; this is normally achieved between 16-24 hours after laying of the under layer. A cement slurry preferably of the same colour as the topping shall be brushed on the surface immediately before laying the tapping. The terrazzo mix shall be laid to a uniform thickness (slightly more than that specified in order to get finished thickness after rubbing) on the screed bed and be compacted thoroughly by tamping or rolling and trowelled smooth. Excessive trowelling or rolling in early stages shall be avoided as it results in working up cement to the surface which will produce a surface liable to cracking and will require more grinding to expose marble chips. The terrazzo surface shall be tamped, trowelled and brought true to required level by a straight edge and steel floats in such a manner that the maximum amount of marble chips come up and are spread uniformly over the surface and no part of the surface is left without the chips.

10.4.5 Borers And Decorative Design

Borders and decorative designs shall be laid before the main flooring and the procedure would be same as outlined for the main flooring. If in place of dividing strips, stencils or formwork of wood or metal are used, they shall be removed before the topping begins to harden and in a manner so as not to damage the material and edges. Any ragged edges left shall be made good before laying the main flooring.

10.4.6 Curing

The surface shall be left dry for air curing for a period of 12-18 hours. Thereafter water shall be allowed to stand overnight in pools for a period of minimum four days. The floor shall be prevented from being subjected to extreme temperature.

10.4.7 Grinding And Finishing

Grinding and polishing shall be done either by hand or by machine. In case of manual grinding the process of grinding shall begin after two days while in case of machine grinding, the process shall start after seven days after completion of laying.

First grinding shall be done with carborundum stones of 60 grit size. The surface shall then be washed clean and grouted with a cream like consistency grout of cement or/and colouring matter in same mix and proportion as the topping in order to fill any pinholes that appear. It shall then be allowed to dry for 24 hours and wet cured for four days in the same manner as in para 10.4.6.

The second grinding shall be done with carborundum stone of 80 grit size. The surface shall then be prepared as after first grinding. The third grinding shall be done with carborundum stone of 120 to 150 girt size. The surface shall then be washed again and allowed to dry for 12 hours and wet cured for four days as before. The fourth grinding shall be done with carborundum stone of 320 to 400 grit size. The surface shall again be washed clean and rubbed hard with felt and slightly moistened oxalic powder, at five grams per square metre of floor surface. After the finishing works namely, painting distempering, plumbing joinery work etc are over, the surface shall be washed with dilute oxalic acid solution and dried. Floor polishing machine fitted with felt or hessian bobs shall then be run over it until the floor shines.

During cold weather, concreting shall not be done when the temperature falls below 4.5^0C .The concrete placed shall be protected against frost by suitable coverings. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 40^0C. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer- in-Charge.

The floor shall be protected from any damage during the execution of work.

In case wax-polished surface is required, wax-polish shall be applied on the surface with the help of soft linen, over a clean and dry surface. Then the polishing machine fitted with bobs shall be run over it. Clean saw dust shall be spread over the floor surface and polishing machine again operated which will remove excess wax and leave glossy surface. Floor shall not be left slippery.

10.4.8 Laying Terrazzo Skirting And Dados

10.4.8.1 ***Materials-*** As for main flooring in para 10.4.1**.**

10.4.8.2 **Under layer-** The under layer for terrazzo on vertical surfaces like skirtings end dados shall be of stiff cement mortar 1:3(1 cement: 3 coarse sand) finished rough so as to give a good bond to the topping.

10.4.8.3 ***Thickness-*** Terrazzo topping shall not be less than 6 mm thick and the combined thickness of underlayer and topping shall be not less than 20 mm. Other details shall be same as for terrazzo flooring with the exception that grinding shall have to be done manually.

10.5. TERRAZZO TILE FLOORING

10.5.1 Terrazzo Tiles

10.5.1.1 **Terrazzo** tiles shall generally conform to IS:1237-1980. Requirements and methods of testing of tiles are described in appendix-11. The sizes of tiles shall be as given in Table 2.

The specific sizes of tiles to be used shall be as shown in the drawings or as required by the Engineer-in-Charge.

Table : 2

Length		Breadth		Thickness Not less than
Nominal	Actual	Nominal	Actual	
20 cm	19.85 cm	20 cm	19.85 cm	20 cm
25 cm	24.85 cm	25 cm	24.85 cm	22 cm
30 cm	29.85 cm	30 cm	29.85 cm	25 cm

10.5.1.2 **Tolerance-** Tolerance on length and breadth shall be plus or minus one millimetre and on thickness it shall be plus 5 mm. However, in one lot, the variation in thickness shall not exceed 3 mm.

10.5.1.3 The tiles shall be manufactured under hydraulic pressure of not less than 140 kg per sqcm and shall be given the first grinding before delivery at site. The backing of tiles shall be of cement aggregate in ratio of 1:3 by weight. Likewise the proportion of cement to marble chips aggregate in the wearing layer of the tiles and the proportion of pigment to be used therein shall not exceed 10% of weight of cement in the mix.

10.5.1.4 The finished thickness of upper layers shall not be less than 5 mm for size of marble chips up to 12 mm size and not less than 6 mm for size of marble chips upto 20 mm size.

10.5.2 **Laying**

10.5.2.1 General - Tiles shall be laid on a sub-grade of concrete of the R.C.C. slab and the specification shall be same as for terrazzo flooring.

10.5.2.2 ***Bedding***

10.5.2.2.1 ***Cement Mortar.-*** Cement mortar shall be of one part of cement and six parts of coarse sand by volume thoroughly mixed manually or by a mechanical mixer. The quantity of water added shall be the minimum necessary to give sufficient plasticity and workability for laying. A high water-cement ratio will produce a screeded bed with a high drying shrinkage and should be avoided.

10.5.2.2.2 ***Spreading of Cement Mortar.-*** Before spreading of cement mortar, it is essential to ensure that the base is well compacted and the surface is rough to form suitable key. The base shall then be cleaned of all scum, laitance or plaster droppings or any other loose foreign matter. It shall be properly wetted without allowing any water pools on the surface. The mortar shall then be evenly spread over the base for two rows of tiles and about three to five metres in length with thread level fixed at both ends to act as guide. The top of mortar shall be kept rough so that cement slurry can be absorbed. The thickness of the bedding shall normally be not less than 10 mm and not more than 30 mm in any one place. Immediately after, the laying of tiles shall start as described in para 10.5.2.3 below.

10.5.2.3 ***Laying Of Tiles-*** The bedding shall be allowed to harden for a day before the laying of tiles is started. Neat cement slurry of honey like consistency at 4.4 kg of cement per square metre shall be spread over the bedding to cover an area as would accommodate about 20 tiles. Tiles after having been washed clean shall be fixed in this grout one after other, each tile being gently tapped, with a wooden mallet till it is properly bedded. The joints shall be as thin as possible in straight lines of the required pattern. The joints shall normally be 1.5 mm wide.

The surface of the flooring shall be checked frequently with a straight edge at least two metre long so as to obtain a true surface with required slope.

Tiles which are fixed in the floor adjoining the wall shall go about 10 mm under plaster, skirting or dado. For that purpose wall plaster, skirting or dado shall be left unfinished for about 50 mm above the finished floor level and unfinished strip then left earlier shall be finished.

In places where full tiles cannot be fixed, the tiles shall be cut to size and smoothened at edges to give straight and true joints.

After the tiles have been laid, the surplus cement slurry and the Joints shall be cleaned and washed fairly deep before cement hardens.

The day after tiles have been laid, the joints shall be cleaned of grey cement grout with a wire brush to a depth of about 5 mm and then grouted with grey or white cement mixed with or without pigment to match the shade of the topping of the tile. The same cement slurry shall then be spread over the whole surface in a thin coat to protect the surface from abrasive damage and to fill pinholes that may exist on the surface.

10.5.3 Curing

The floor shall be kept wet for a minimum of 7 days so that bedding and joints set properly.

10.5.4 Grinding and Polishing

Grinding shall normally be commenced after 14 days of laying the tiles. Except for skirting or small areas machine shall be used for the purpose.

First grinding shall be done with carborundum stones of 48 to 60 grade grit fitted in the machine. Water shall be properly used during grinding. When the chips show up and the floor has been uniformly rubbed, it shall be cleaned with water baring all pin holes. It shall then be covered with a thin coat of gray or white cement, mixed with or without pigment to match the colour of the topping of the tile. Pin holes, if any, shall thus be filled. This grout shall be kept moist for a week. Thereafter second grinding shall be started with carborundum of 120 grit. Grouting and curing shall follow again. Final grinding shall be done when other works are finished. The machine shall be fitted with carborundum of grit 220 to 350 using water in abundance. The floor shall then be washed clean with water. Oxalic acid powder shall then be dusted at 33 grams per square metre on the surface and the surface rubbed with machine fitted with hessian bobs or rubbed hard with pad of woollen rags. The floor shall then be washed clean and dried with a soft cloth or linen. The finished floor shall not sound hollow when tapped with a mallet.

If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished.

10.5.5 Wax Polishing

Specifications same as in para 10.4.7.

10.5.6 Permissible Tolerance In Laying

The permissible deviation from datum depends on the area involved. For large open areas a deviation of upto 15 mm shall be tolerated. Localized deviation of 3 mm in any 3 m shall be accepted in a nominally flat floor.

10.5.7 Skirting/Dado Work And Staircase - Tread Work

10.5.7.1 Tile skirting, where required shall be fixed only after laying the tiles on the floor. If tiles are to be fixed on walls as dados, the portion of the wall to be so tiled shall be left un-plastered. Also, dado work shall be done only after laying tiles on the floor.

10.5.7.2 Before fixing tiles on brick or concrete wall, the wall surface shall first be wetted with clean water. Thereafter, in case of dado the wall surface shall be evenly and uniformly covered with about 10 mm thick backing of cement mortar (1 cement : 4 coarse sand). In the case of skirting, the tiles shall be directly fixed with cement mortar (1:4) without initial backing. Before the cushioning mortar has hardened, the back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet. The fixing shall be done from the bottom of the wall upwards. Each tile shall be fixed as close as possible to the one adjoining, and difference in the thickness of the tiles shall be evened out in the cushioning mortar or cement paste so that all the tile face are set in conformity with one another.

10.5.7.3 Wherever possible, skirting and dado shall be ground and polished just as for floor work with machine suitable for the purpose. Skirtings and dado may also be polished by hand.

10.5.7.4 Precast treads and risers for staircases shall be laid and polished as for flooring.

10.5.7.5 **Curing, Grinding And Polishing** - Specifications same as in para 10.5.3 and 10.5.4 except that polishing will be done manually.

10.6 GLAZED TILE FLOORING

10.6.1 White Glazed Tiles

The white glazed tiles shall be of nominal sizes 150 x 150 mm & 100 x 100 mm with actual sizes 149 x 149 mm & 99 x 99 mm. The thickness of the tiles shall 6 mm. The tiles shall be straight or cushion edge type. Half tiles for use as full tiles shall have dimension which shall be such as to make half tiles when joined together (with 1 mm joint) match with dimensions of full tile.

10.6.2 Coloured Tiles

Only the glaze shall be coloured as specified. The sizes and specifications shall be the same as for white glazed tiles.

10.6.3 Tolerances

10.6.3.1 **Facial Dimensions -** The length of all the four sides of tiles shall be measured to the nearest 0.1 mm. The average value shall not vary more than ± 0.8 mm from the actual size mentioned in para 10.6.1 above.

10.6.3.2 The variation of the individual dimension from average value shall not exceed ± 0.5 mm.

10.6.3.3 Tolerance on thickness shall be ± 0.5 mm.

10.6.4 Sub grade

Sub grade shall be of concrete or RCC slab.

10.6.5 Bedding

The specifications at para 10.5.2.2 and 10.5.2.3 shall be followed.

10.6.6 Laying

The specification at para 10.5.2.4 shall be followed.

10.6.7 Jointing and Finishing

The joints shall be cleaned of grey cement grout with wire brush or trowel to a depth of 5 mm. and all dust and loose mortar removed. White cement shall then be used for flush pointing the joint. The floor shall be cured for seven days. The surface shall then be washed and cleaned. The surface shall not sound hollow when tapped.

10.6.8 Glazed Tiles risers of Steps, skirting and dado

10.6.8.1 ***Glazed Tiles -*** The specifications shall be same as in para 10.6.1 and 10.6.2 for white glazed tiles.

10.6.8.2 The rest of the specification shall be the same as at para 10.5.7.

10.7 FLAG (SAND) STONE FLOORING (ROUGH DRESSED)

10.7.1 Red or white rough dressed sand stone slabs

The slabs shall be red or white as specified in the description of the item. The stone slabs shall be hard, sound, durable and tough, free from cracks, decay and weathering. In case of red sand stone, white patches or streaks and in case of white sand stone, red patches or streaks shall not be allowed. However, scattered spots upto 10 mm diameter will be permitted. Before starting the work samples of stone-slabs shall be approved by the Engineer-in-Charge.

The slabs shall be hand cut to the requisite thickness along planes parallel to the natural bed of stone and should be of uniform size if required.

The least dimension in plan of the flagstone slabs shall not be less than 15 cm. The thickness of flagstone slabs shall be within the range specified in the schedule of item.

10.7.2 Subgrade

Base concrete or RCC slab shall serve as subgrade. However, in case of flooring in open space, compacted moorum shall form as the grade for flag stone flooring.

10.7.3 Bedding

The bedding for the stone slabs shall be with cement mortar 1:5 (1 cement: 5 coarse sand) of 20 mm average thickness.

10.7.4 Dressing Of Slabs

Every slab shall be cut to required size and shape and rough chisel dressed on the top, so that the dressed surface shall not be more than 6 mm from the straight edge placed on it

The unevenness on the surface on account of depressions or projections snail be smoothed out by chisel dressing the edge in a slant The sides shall also be chisel dressed to a minimum depth of 20 mm so that the dressed edge shall at no place be more than 3 mm from the straight edge butted against it. Beyond this depth the sides maybe dressed slightly splayed so as to form an inverted ‘V’ shaped joint with adjoining slab. The surface shall be reasonably true and plane and all the angles & edges shall be square and free from chippings.

10.7.5 Laying

The surface of the subgrade concrete shall be cleaned, wetted and mopped. In case of moorum subgrade the surface shall be watered and rammed and covered by tar paper. The bedding of the specified mortar mix shall be spread under each slab to the specified thickness. The slab shall be washed clean before laying. It shall be then laid on top pressed and leveled so that all hollows underneath get filled and surplus mortar works up through the joint. The top shall be tapped and brought level to the adjoining slab. The thickness of the joint shall not exceed 5 mm. Subsequent slabs shall be laid in the same manner.

10.7.6 Curing And Finishing

Any surplus mortar on the surface of the slab shall be cleaned off and joints finished flush. Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado. The junction between wall plasters and floor shall be cured for a minimum period of seven days. The finished floor shall not sound hollow when tapped with wooden Mallet and the finished surface shall be true to levels and slopes as instructed by the Engineer- in-charge."

10.8 FLAG (SAND) STONE FLOORING (FINE DRESSED)

10.8.1 Red Or White Fine Dressed Sand Stone Slabs

The specifications shall be same as in para 10.7.1.

10.8.2 Dimensions

Refer para 10.7.1.

10.8.3 Subgrade And Bedding

Refer para 10.7.2 and 10.7.3.

10.8.4 Dressing Of Slabs

Every slab shall be cut to the required size and shape and chisel dressed on all sides to a minimum depth of 20 mm. The top shall also be fine dressed. The top and edges shall be so dressed as to make a full contact with a straight edge laid along.

10.8.5 Laying

Same as In para 10.7.6

10.8.6 Finishing

Some as in para 10.7.7 of Rough dressed sand stone flooring, except that even slight unevenness if any between the edges of the joints shall be removed by chiseling in a slant.

10.9 P.V.C. (VINYL) ASBESTOS TILE FLOORING

10.9.1 General

It shall be laid on a base that if finished even and smooth such as concrete, metal or timber boarding. Unevenness or undulations in the base will show badly on the surface and are liable to damage the P.V.C sheet / tiles.

10.9.2 Materials

The floor tiles shall consist of a thoroughly blended composition of thermoplastic binder; asbestos fibre; fillers and pigments. The thermoplastic binder shall consist substantially of one or both of the following:

(a) Vinyl chloride polymer

(b) Vinyl chloride copolymer.

The polymeric material shall be compounded with suitable plasticizers and stabilizers.

The floor covering may be backed with hessian or other woven fabric. The hessian used for backing shall conform to type 1 of IS : 2818 -1964 or it shall be an equivalent woven fabric.

10.9.3 Dimensions and Tolerances

10.9.3.1 The standard *size* of the tiles shall be 200 and 250 mm. Square. The thickness of tiles shall be 1.5, 2.0, 2.5 and 3.0 mm as specified in the schedule of item.

Note*:* -Tiles of size and shape other than those specified herein above may be supplied if agreed between the purchaser and the supplier.

10.9.3.2 The permissible tolerances on the dimensions specified in 10.9.3.1 shall be as follows:

Dimensions	Tolerances (mm)
On 200 mm	± 0.4
On 250 mm	± 0.5
On thickness	± 0.15

Note*:*- A Tolerance on length and width of ±0.2 % shall be taken for tiles other than specified in 10.9.3.1.

10.9.4 Adhesive

Rubber based adhesives are suitable for fixing P.V.C flooring over concrete. P.V.A. based adhesives shall be used for concrete sub-floors. P.V.A. based adhesives are not suitable for metallic surfaces and also for locations where there is constant spillage of water.

10.9.5 Preparation *of* subfloors

Before laying P.V.C. sheets/tiles, It Is essential to ensure that the base Is thoroughly dry and damp proof as moisture slowly rots the base and damages the adhesive resulting in P.V.C. sheet/tiles being separated from the base and curled up. In case of new work a period of 4 to 8 weeks shall be allowed for drying the subfloor under normal conditions.

Concrete subfloors shall be laid in two layers. The top of the lower layer of concrete shall be painted with two coots of bitumen (conforming to IS: 1580-1969) applied at the rate of 1.5 kg/Sq.m. The surface of the lower layer shall be finished smooth while laying the concrete so that the bitumen can be applied uniformly. The bitumen shall be applied after the concrete has set and is sufficiently hard.

Where it is expected that the dampness may find its way from the surrounding walls, the same shall also be effectively damp-proofed upto at least 150 mm above the level of the sub-floor and the damp-proof treatment below the floor shall be extended over the walls.

10.9.6 Laying and fixing

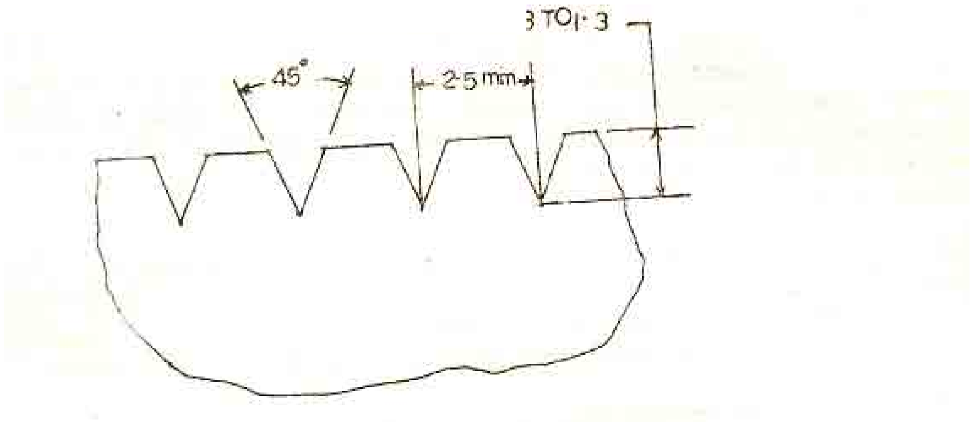
10.9.6.1 Prior to laying, the flooring shall be brought to the temperature of the area in which it is to be laid by stacking in a suitable manner within or near the laying area for a period of about 24 hours.

10.9.6.2 Where air-conditioning is installed, the flooring shall not be laid on the sub-floor until the conditioning units have been in operation for at least seven days. During this period the temperature shall neither fall below 20^0C nor exceed 30^0C. These conditions shall be maintained during laying and for 48 hours thereafter.

10.9.6.3 Before commencing the laying operation, the sub-floor shall be examined for evenness and dryness. The sub-floor shall then be cleaned with a dry cloth. The P.V.C. flooring shall not be laid on a sub-floor unless the sub-floor is perfectly dry. Methods of testing for dryness are specified in Appendix III

10.9.6.4 The lay out of the P.V.C. flooring on the sub-floor to be covered should be marked with guidelines. The P.V.C. flooring shall be first laid for trial, without using the adhesive, according to the required layout.

10.9.6.5 The adhesive shall be applied by using a notched trowel (see fig. below) to the sub-floor and to the back side of the P.V.C. sheet or tile flooring. When set sufficiently for laying, the adhesive will be tacky to the touch, but will not mark the fingers. In general, the adhesive will require about half an hour for setting. It should not be left after setting for too long a period as the adhesive properties will be lost owing to dust films and other causes.



10.9.6.6 … o that condens… under high humidit…

10.9.6.7 … upon local circumstances. In case of small room adhesive may be spread over the entire area but relatively small areas should be treated in a larger room.

10.9.6.8 When the adhesive is Just tack free, the P.V.C. flooring sheet shall be carefully taken and placed in position from one end onwards slowly so that the air will be completely squeezed out between the sheet and the background surface. After laying the sheet in position, it shall be pressed with suitable roller to develop proper contact with the sub-floor. The next sheet with its back side applied with the adhesive shall be laid edge to edge with the sheet already laid and fixed in exactly the same manner as the first sheet was fixed. The sheets shall be laid edge to edge so that there is minimum gap between joints.

10.9.6.9 The alignment should be checked after laying of each row of sheet is completed. If the alignment is not perfect, the sheets may be trimmed by using a straight edge.

10.9.6.10 The tiles shall be fixed in exactly the same manner as for the sheets, it is preferable to start laying of the tiles from the centre of the area. Care should be taken that the tiles are laid close to each other with minimum gap between Joints. The tiles should always be lowered to position and pressed firmly on to the adhesive. Care should be taken not to slide them as this may result in adhesive being squeezed up between the joints. P.V.C. tiles after laying shall be roiled with a light wooden roller weighing about 5 kg to ensure full contact with the underlay, Any undulations noticed on the P.V.C. surface shall be rectified by removing and relaying the tiles after thorough cleaning of the underside of the affected tiles. The adhesives applied earlier in such places shall be thoroughly removed by using proper solvents and the surface shall be cleaned to remove the traces of solvents used. Work should be constantly checked against guidelines In order to ensure that all the four edges of adjacent tiles meet accurately.

10.9.6.11 Any adhesive which may squeeze up between sheets or tiles should be wiped off immediately with a wet cloth before the adhesive hardness. If, by chance, adhesive dries up and hardens on the surface of the sheet or tile, it should be removed with a suitable solvent A solution of one part of commercial butyle acetate and three parts of turpentine oil is a suitable solvent for the purpose.

. **10.9.6.12** A minimum period of 2-4 hours shall be given after laying the flooring for developing proper bond of the adhesive. During this period, the flooring shall not be put to service. It is preferable to lay the P.V.C. flooring after the completion of plastering, painting and other decorative finish works so as to avoid any accidental damage to the flooring.

10.9.6.13 When the flooring has been securely fixed, it shall be cleaned with a wet cloth soaked in warm soap solution (two spoons of soap in 5 liters of warm water).

10.9.6.14 Where the edges of the P.V.C. sheets or tiles are exposed, as for example, in doorways and on stair treads, it is important to provide protection against damage of flooring material. Metallic edge strips may be used and should be securely fastened to the sub-floor to protect edges of the flooring.

10.9.7 Precaution for Maintenance

10.9.7.1 P.V.C. flooring subject to normal usage may be kept clean by mopping with soap solutions using clean damp cloth. Water shall not be poured on the P.V.C. flooring for cleaning purposes as the water may tend to seep between the joints and cause the adhesive to fail. To maintain o good wearing surface and a good appearance, the flooring may be periodically polished. When polish is applied frequently, a thick layer builds up which collects dirt and dust and Is tacky to walk on.

10.9.7.2 If the traffic is light, the floor shall be given frequently brushing, regular polishing and an application of new polish every 4 to 6 weeks, under moderate traffic conditions the floor shall be given an occasional wash with a wet mop but no detergents shall be used so that the polish is not removed. Application of polish may be done every one to three weeks. P.V.C. flooring should not be over-waxed, when this condition develops, the coatings should be cleared off with white sprit or paraffin and a light even coat of polish applied. When the P.V.C. flooring has been polished it will remain bright for a considerable period if dry mop is applied each day. It is this daily " dry polish " that maintains the glossy surface. After exceptionally heavy traffic, P.V.C. flooring should be swept with a hair groom, rubbed with a mop or cloth frequently rinsed in Glean water and finally rubbed dry:

APPENDIX-I

RECOMMENDED SPECIFICATIONS FOR DIFFERENT TYPES OF CEMENT CONCRETE FLOOR FINISHES

The required thickness and mix proportion of concrete depends upon the expected load and wear on the floor and the fact whether the topping has to be laid monolithic with the base or separately on a set and hardened ban. Broad guidelines for required thickness and mix proportion are given in table below:

Type	Sub-Base	Base Concrete		Topping		Remarks
		Min. Thick-ness	Mix Proportion	Min. Thick-ness	Mix Proportion	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A Concrete Flooring Laid Over Ground						
I	Thoroughly consoli-dated ground cover-ed with 100 to 150 mm well rammed (preferably coarse) sand	100	Cement concrete 1:4:8 (cement: fine aggregate: coarse aggregate of 40 mm and below by volume)	20	Cement concrete 1:2 to 3 (cement : stone aggregate of size 4.75 mm and below by volume)	See Fig. of PLATE:1/CH -10 concrete topping shall be laid monolithic with the base concrete.
IA	100 mm thick hard core of well consolid-ated dry brick or stone aggregate blinded with MOORUM (disintegr-	100	do	25	Cement concrete 1:2:4 (cement: fine aggregate:co-arse stone aggreg-ate of size 12.5	In places such as ga-rrages where wheeled traffic comes into con-tact with the flooring the sub-base shall ha-

(Continued)

Type	Sub-Base	Base Concrete Min. Thick-ness	Base Concrete Mix Proportion	Topping Min. Thick-ness	Topping Mix Proportion	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A Concrete Flooring Laid Over Ground						
I	Thoroughly consoli-dated ground cover-ed with 100 to 150 mm well rammed (preferably coarse) sand	100	Cement concrete 1:4:8 (cement: fine aggregate: coarse aggregate of 40 mm and below by volume)	20	Cement concrete 1:2 to 3 (cement : stone aggregate of size 4.75 mm and below by volume)	See Fig. of PLATE: I/CH-10 concrete topping shall be laid monolithic with the base concrete.
IA	100 mm thick hard core of well consolid-ated dry brick or stone aggregate blinded with MOORUM (disintegr-	100	do	25	Cement concrete 1:2:4 (cement: fine aggregate:co-arse stone aggreg-ate of size 12.5	In places such as ga-rrages where wheeled traffic comes into con-tact with the flooring the sub-base shall ha-

(Continued)

Type	Sub-Base	Base Concrete		Topping		Remarks
		Min. Thick-ness	Mix Proportion	Min. Thick-ness	Mix Proportion	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A Concrete Flooring Laid Over Ground						
I	Thoroughly consolidated ground covered with 100 to 150 mm well rammed (preferably coarse) sand	100	Cement concrete 1:4:8 (cement: fine aggregate: coarse aggregate of 40 mm and below by volume)	20	Cement concrete 1:2 to 3 (cement : stone aggregate of size 4.75 mm and below by volume)	See Fig. of PLATE: I /CH -10 concrete topping shall be laid monolithic with the base concrete.
IA	100 mm thick hard core of well consolidated dry brick or stone aggregate blinded with MOORUM (disintegr-	100	do	25	Cement concrete 1:2:4 (cement: fine aggregate:coarse stone aggregate of size 12.5	In places such as garrages where wheeled traffic comes into contact with the flooring the sub-base shall ha-

(Continued)

Type	Sub-Base	Base Concrete		Topping		Remarks
		Min. Thick-ness	Mix Proportion	Min. Thick-ness	Mix Proportion	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A Concrete Flooring Laid Over Ground						
I	Thoroughly consoli-dated ground cover-ed with 100 to 150 mm well rammed (preferably coarse) sand	100	Cement concrete 1:4:8 (cement: fine aggregate: coarse aggregate of 40 mm and below by volume)	20	Cement concrete 1:2 to 3 (cement : stone aggregate of size 4.75 mm and below by volume)	See Fig. of PLATE: I /CH -10 concrete topping shall be laid monolithic with the base concrete.
IA	100 mm thick hard core of well consolid-ated dry brick or stone aggregate blinded with MOORUM (disintegr-	100	do	25	Cement concrete 1:2:4 (cement: fine aggregate:co-arse stone aggreg-ate of size 12.5	In places such as ga-rrages where wheeled traffic comes into con-tact with the flooring the sub-base shall be-

(Continued)

y the
the season in
ompared to
han that of
iolithically
s its breadth.

10-29

APPENDIX - II

TEST REQUIREMENTS AND PROCEDURE FOR PRECAST CEMENT CONCRETE TERRAZO TILES

(Par8 10 5.1.1)

1. SAMPLING

The tiles required for carrying out test described below shall be taken by 'random sampling'. Each tile sample shall be marked to identify the consignment from which it was selected. -

The number of tiles selected from each consignment of 2000 tiles or part thereof shall be as follows:-

(a) For conformity to requirements on shape and dimensions, wearing layer, and general quality. — 12 tiles

(b) For transverse strength test:

(1) For dry test Stiles — 6tiles

(2) For wet test Stiles. — 6 tiles.

(c) For resistance to wear test — 6 tiles.

(d) For water absorption test — 6 tiles.

Note- (1) The tests on the tiles shall not be carried out earlier than 28 days from the date of manufacture.

(2) The tiles selected for (a) may as well after verification of requirements, be used for (b).

2. TRANSVERSE STRENGTH

2.1 Not less than six full-size tile shall be tested separately far the determination of dry and wet transverse strength, as described below and their average breaking loads, applied at mid span, shall be not less than the values specified in table below:-

TABLE

Size of tiles Cm	Span Cm	Breaking load	
		Wet test Kg.	Dry Test Kg.
20 x 20	15	71	106
25 x 25	20	80	120
30 x 30	25	99	149

Note- Based on a modulus of rupture of 30 kg. per sq cm for dry test and two third of value for wet test.

10-30

2.2 Dry Test.- Full size tiles in the air-dry state shall be used as test specimens. The specimen shall be placed horizontally on bearers with its wearing surface upper most and its sides parallel to the bearers. The load shall be applied at mid-span by means of a steel bar parallel to the bearers. The length of the bearers and of the loading bar shall be longer than the width of the tiles and their contact faces shall be rounded to a diameter of 25 mm. The span shall be as mentioned in table above. A plywood packing, 3 mm thick and 25 mm wide, shall be placed between the tile and the bearers and between the tile and the loading bar. The loading bar and one of the bearers shall be self-aligning. Starting from zero, the load shall be increased steadily and ' uniformly at a rate not exceeding 200 kg per metre (width measured along the bearer) per minute-upto specified maximum load, which shall be maintained for at least one minute. The testing machine shall ensure an accuracy of ± 2 per cent in the applied load.

2.3 Wet Test.- The tiles shall be Immersed in water for 24 hours and then taken out, wiped dry and tested as described in 2.2.

3. RESISTANCE TO WEAR

3.1 Not less than twelve specimens shall be prepared as described in 3.2 from the tiles selected in accordance with 1. When tested in the manner specified in 3.3.1 to 3.3.4 their average wear shall hot exceed 2.5 mm, and the wear on any individual specimen shall not exceed 3 mm.

3.2 Preparation Of Test Specimen.- The test specimens shall be square in shape and of size 7.06 x 7.06 (i.e. 50 sq cm in area). They shall be sawn off one only from each tile, preferably from the central part of the tile. The deviation in the length of the specimen shall be within ± 2 per cent. The surface to be tested shall be ground smooth and filling removed.

3.3 Apparatus And Accessories

3.3.1 ***Abrasion Testing Machine*.-** The abrasion of specimens shall be carried out in B machine conforming essentially to the requirements described in IS : 1237-1959. The abrasive powder used for the test shall conform to the specification given below.

The abrasive shall have an aluminium oxide content of not less than 95 per cent by weight. The grains shall be of rounded shape and shall generally pass through IS Test Sieve 25 and be retained on IS Test Sieve 20. The combined content of larger grains retained on IS Tests Sieve 25 and of smaller grains whose fineness is not limited, shall not exceed 10 per cent. The specific gravity of the grains shall be between 3.9 and 4.1. The grains shall generally have a hardness of 9 in Moh's scale.

3.3.2 ***Measuring Instruments-*** A suitable instrument capable of measurements to accuracy of 0.01 mm shall be used for determining the change in the thickness of the specimen after abrasion.

10-31

3.3.3 ***Procedure of rest-*** The specimens shall be dried at 110 degree C for 24 hours and then weighed to the nearest 0.1 gm. The specimen after initial drying and weighing shall be placed in the thickness measuring apparatus with its wearing surface upper most arid the reading of the measuring instrument taken.

The grinding path on the disc of the abrasion testing machine shall be evenly strewn with 20 gm of the abrasive powder. The specimen shall then be fixed in the holding device with the surface to be ground facing the disc and loaded at the center with 30 kg. The grinding disc shall then be put in motion at a speed of 30 rpm. After every 22 revolutions, the disc shall be stopped, the abrased tile powder and the remainder of the abrasive powder shall be removed from the disc and fresh abrasive powder in quantities of 20 gm applied each time. After 110 revolutions, the specimen shall be turned about the vertical axis through an angle of 90 degree and then the test continued under the same condition until 220 revolutions have been completed altogether. The disc, the abrasive powder and the specimen shall be kept dry throughout the duration of the test. After the abrasion is over, the specimen shall be reweighed to the nearest 0.1 gm. It shall be placed in the thickness measuring apparatus once again in the identical manner and the reading taken with the same position and setting of the dial gauge as for the measurement before abrasion.

3.3.4 ***Determination of Wear.-*** The wear shall be determined from the difference in readings obtained by the measuring instrument before and after the abrasion of the specimen. The value shall be checked up with the average loss in thickness of the specimen obtained by the following formula:-

$$t = 10 \times \frac{(W1 - W2)\ V1}{W1 \times A}$$

Where, t = Average loss in thickness, in mm;

W1 = initial weight, in gm of the specimen;

W2 = Final weight, in gm of the abraded specimen;

V 1 = initial volume, in C.C., of the specimen; and

A = Surface area, in sqcm, of the specimen.

4. **WATER ABSORPTION**

4.1 At the time of delivery to the site of the work, not less than six full tile specimens, selected in accordance with 1, shall be prepared and when tested as described below, their average percentage of water absorption shall not exceed ten.

4.2 **Preparation Of Specimens.-** Full size tiles shall be used for this test. They shall be immersed in water for 24 hours, then taken out, wiped dry and tested for water absorption.

4.3 **Procedure Of Test.-** Each tile shall be weighed immediately after saturation and wiping as in 4.2. The tile shall be oven dried at a temperature of 65 degree C for a period of 24 hours, cooled to room temperature and reweighed.

10-32

4.4 Determination Of Water Absorption.- The water absorption for each tile shall be determination as follow:

$$\text{percent. by weight (on oven dry basis)} = \frac{(W\ I - W2) \times 100}{W2}$$

Where, W 1 = Weight in gm of the saturated specimen; and
W2 = Weight in gm of the oven dried specimen.

The average value for percentage water absorption shall be calculated for the whole number of tiles tested.

10-33
APPENDIX - III DETERMINATION OF SUB-FLOOR DRY NESS
(Para 10.9.6.3)
(Refer IS: 5318-1969, Appendix-A)

1. GENERAL

1.1 Three tests for determining concrete subfloor dryness are given in this appendix. It is intended that the first test should be carried out as a preliminary test as it is an approximate method only, and, while adequate to separate very wet slabs from those which are dry or nearly dry, will not discriminate satisfactorily between the latter two conditions. Should this preliminary test indicate that the floor is 'dry' confirmatory-tests should be made by one of the other two procedures given in 3 and 4.

2. PRELIMINARY TEST

2.1 Materials. - The following materials are required:-

(a) A sheet of glass about 30 x 30 cm or rubber mat or a sheet of polyethylene (not less than 0.1 mm. thick) or the PVC flooring material of about 60 x 60 cm; and

(b) Putty, adhesive plasticine or other suitable mastic for seating the edges of the shoot material.

2.2 Procedure

2.2.1 A sheet of glass, rubber or plastic material shall be placed oh the concrete floor slab to

be tested, and sealed thoroughly around all edges, using the mastic material.

2.2.2 After a period of not less than 24 hours, the covered portion of the concrete slab shall be inspected for signs of dampness. If this area is even slightly darker in colour than the remainder of the slab the floor shall be considered too wet. A careful inspection is require, as in conditions of good ventilation, the difference in colour may rapidly disappear after the sheet has been lifted.

2.2.3 The test shall be made in several places on the slab. and repeated at regular intervals until no sing of dampness appears. The floor should then be tested at Several points by either the surface hygrometer method or the electrical resistance method until satisfactory results of floor dryness are obtained before the floor should be considered sufficiently dry.

3. HYGROMETER TEST

3.1 **Apparatus.-** A hygrometer is so constructed that when sealed to the floor with mastic or by other- suitable means, the relative humidity of a small quantity of air confined between the slab and the case of the instrument is measured.

3.2 **Procedure.-** The case of the hygrometer shall be carefully sealed to the slab and left for a period not less than 16 hours. The relative humidity reading shall then be taken.

3.3 **Results.-** The dryness of the concrete slab shall be considered satisfactory for conditions of laying the PVC flooring if the relative humidity reading does not exceed 70 %.

Note- The instrument shall be so placed that sunlight does not fall on it, as this may produce a false low reading.

4. **ELECTRICAL RESISTANCE TEST**

4.1 **Apparatus.-** The apparatus shall comprise the following:-

(a) ***Resistance meter.-*** One of suitable range to be calibrated in terms of the moisture content of the slab in the range of 4 to 8 per cent, and having sufficient sensitivity to clearly distinguish changes of 0.5 %

(b) ***Electrodes-*** Suitable to be inserted into 25 mm deep holes drilled in the concrete slab at a fixed distance apart.

(c) ***A suitable contact medium of Conductive Jelly-*** For placing into the electrode holes.

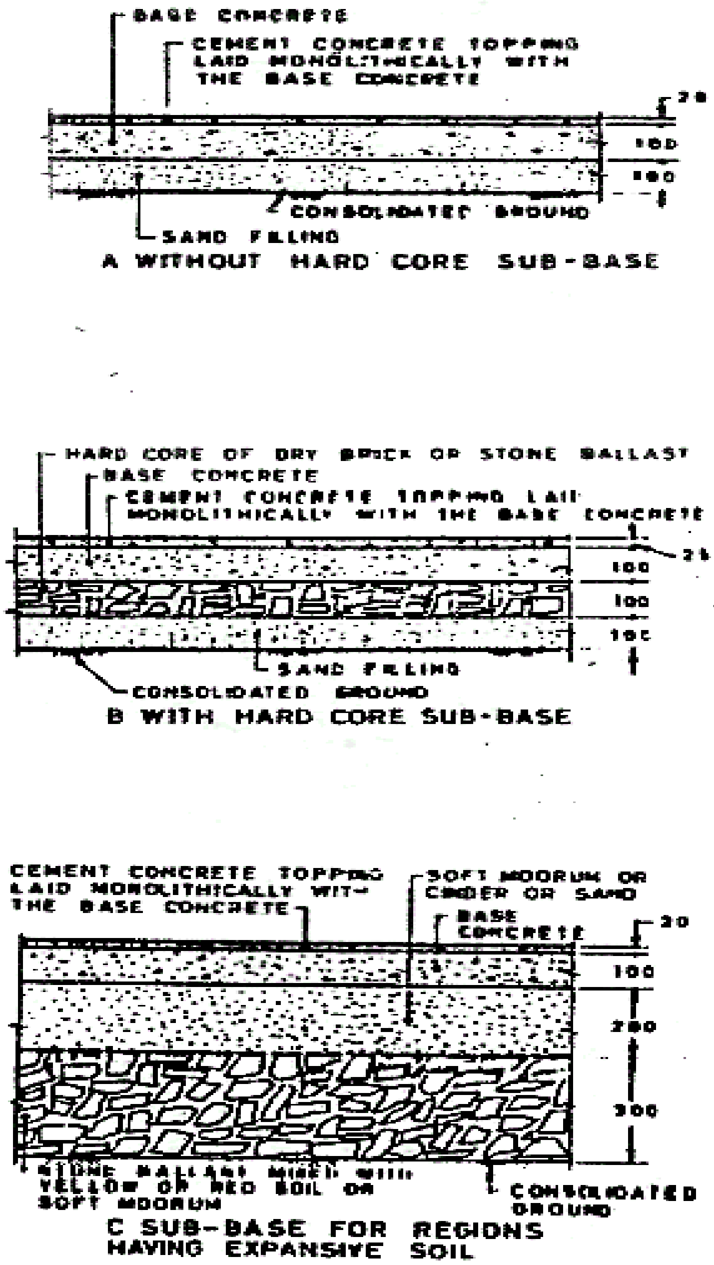
4.2 **Procedure.-** After drilling holes 25 mm deep in the concrete slab at a fixed distance, set the electrodes in the holes using the conductive jelly and connect to the electrical resistance meter. The moisture content of the floor shall then be read off to the nearest 0.5 per cent from the resistance meter. Reading shall be taken from several widely distributed locations on the concrete slab.

4.3 **Results.-** The concrete shall not be considered sufficiently dry if any one of the readings taken exceeds the following:- \

Vinyl asbestos flooring 6.5 percent.

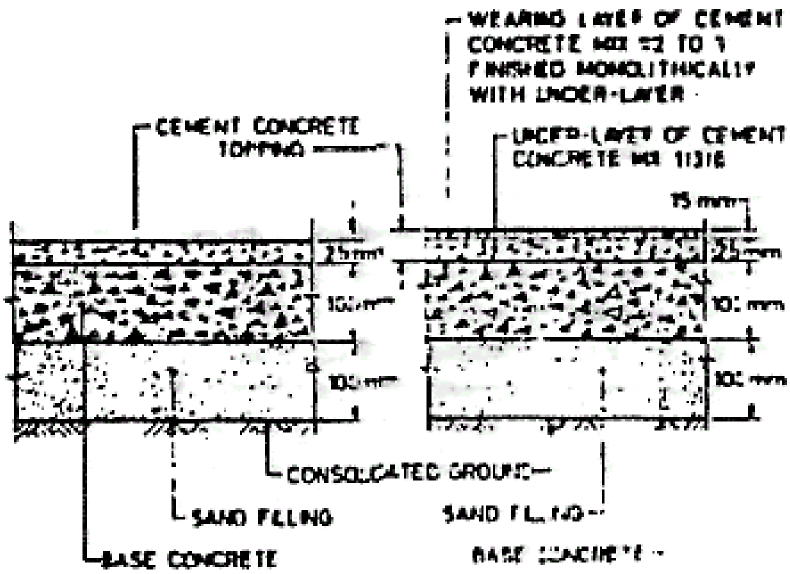
Other types of flooring 5.5 percent.

PLATE –1/CH - 10



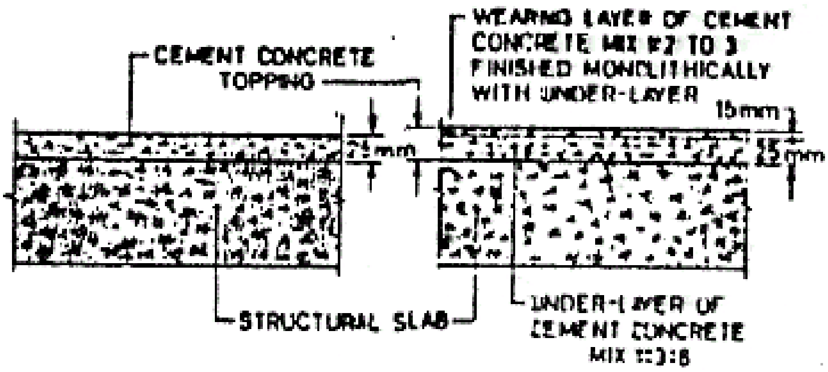
All dimensions in millimetres.

MONOLITHIC FLOOR FINISH (OVER GROUND)



Topping Laid in Single Layer Topping Laid in Two Layers

FIG. A BONDED FLOOR FINISH OVER GROUND



B Topping Laid in Single Layer C Topping Laid in Two Layers

BONDED FLOOR FINISH OVER STRUCTURAL SLAB