

NIT No. **01** /SAC/e-procurement / 2026-27 Dated **05-06-2026**System Tender No. **192409**  
(FIRST-CALL)**GOVERNMENT OF CHHATTISGARH**  
**WATER RESOURCES DEPARTMENT****VOLUME-III****TECHNICAL SPECIFICATION****CONSTRUCTION OF SOLAR POWERED LIFT IRRIGATION SCHEME FOR  
IRRIGATION FROM KHAIRI ANICUT CONSTRUCTED ON AAGAR RIVER  
DIST. MUNGELI (C.G.)**

Construction of Pressurized Pipe Distribution Network Lift Irrigation Scheme to supply water for irrigation to deliver at farmers field up to 1 ha with a duty of 0.70 lit/sec/ha and maintained up to 4 ha chak, keeping the discharge of minimum 3 times the duty at one hectare and at least 20 Meter Residual Head at 1 Ha for Pressurized Irrigation by rotation in village Kapua, Block -Patharia ,Dist. -Mungeli in **160 Ha. in kharif (Right side of KHAIRI Anicut as indicated in Index Map)**, out of total gross command area **270 hectare** fully covering the entire compact, contiguous possible arable area beyond 500m from submergence line (FTL line) of **KHAIRI Anicut** as indicated in the index map for Irrigation System without exceeding total power requirement for **Solar pumps with solar panel of 100 KWp**. It includes all activities starting from survey, investigation, designing, estimating costing, procurement, construction, laying, installing, energizing, etc. of pumping system, rising and gravity mains, main line, branch lines, distribution network, controlling and regulation system , SCADA work with automation etc. for supply of filtered water for irrigation under pressure. The work also includes construction of chowkidar quarter, pump house, installation of Solar power plant and sub station with transformer of required capacity by liasoning with CSEB, Management, Operation and Maintenance (MOM) and defect liability (DL) for the period of 05 years after completion and MOM and DL period run simultaneously and work also including foundation stone laying ceremony and inauguration ceremony and as directed by Engineer-in-Charge as per details given in scope of work.

**EXECUTIVE ENGINEER**  
**E/M H.E.M. DIVISION WRD**  
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**CONTAINS FOLLOWING SPECIFICATION**

<b>S.NO.</b>	<b>SPECIFICATION</b>
1	EARTHWORK
2	MASONRY

# **SPECIFICATION**

For  
**Irrigation Projects**

CHAPTER - 4  
**EXCAVATION AND EARTH WORK**

AND

CHAPTER - 21  
**Special Items of Earth /Masonry Dam & Canals**

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991****TABLE OF CONTENTS****Chapter 4 (Excavation & Earth work) &****Chapter 21 (Special items of Earth/Masonry dam & Canals)****As detailed in Volume - I, SECTION - II**

Clause Particulars Page

No.

Clause Particulars Page

No.

1 2 3 1 2 3

4.1 References 4/1 4.9.5 Weather Conditions 4/8

4.2 Terminology 4/1 4.9.6 Moisture Control 4/8

4.3 General Specification 4/2 4.9.7 Compaction and Watering 4/8

4.3.1 Bench Marks 4/2 4.9.8 Dressing Slopes 4/9

4.3.2 Cross Sections 4/2 4.9.9 Settlement Allowance 4/9

4.4 Classification of Strata 4/2 4.1 Toe Drain 4/10

4.4.1 Soft or Ordinary Soil 4/2 4.11 Road Surfaces and Parapets 4/10

4.4.2 Hard Soil 4/2 4.12 Filter 4/10

4.4.3 Hard Moorum and Moorum mixed

with Boulders

4/3 4.12.1 Base Filter Blankets 4/10

4.4.4 Disintegrated Rock 4/3 4.12.2 Chimney Filter 4/10

4.4.5 Soft Rock 4/3 4.12.3 Seepage Drain 4/11

4.4.6 Hard Rock (requiring blasting) 4/3 4.13 Rip-rap on the Upstream Slope of Embankment

4/11

4.4.7 Hard Rock (blasting prohibited) 4/3 4.13.1 Hand Placed Rip-Rap 4/11

4.4.8 Authority for Classification 4/3 4.13.2 Dumped Rip-Rap 4/12

4.5 Clearing, Grubbing and Preparation

of Work Area

4/3 4.13.3 Graded Filter underneath

Riprap...

4/12

4.6 Stripping and Benching under Dam

Embankment

4/3 4.13.4 Tolerance 4/12

4.7 Excavation of Cut-off or Puddle

Trench under Dam Embankment

4/3 4.13.5 Dry Stone Pitching 4/12

4.7.1 Procedure for Excavation 4/3 4.13.6 Grouted Stone Pitching 4/13

4.7.2 Utilisation of Excavated Materials 4/4 4.13.7 Dry Picked up Boulder Pitching 4/13

4.7.3 Blasting of Rock 4/4 4.13.8 Dry Quarried Boulder Pitching 4/13

4.7.4 Material received from Cut-off

Trench or puddle Trench

4/4 4.14 Rock Toe 4/13

4.7.5 Cut-off Trench Filling 4/4 4.15 Inspection and Tests 4/14

4.7.6 Puddle Filling 4/4 4.15.1 General 4/14

4.8 Borrow Areas 4/5 4.15.2 Scope of Testing and Inspection

required

4/14

4.8.1 General 4/5 4.15.3 Before Compaction 4/14

4.8.2 Preparation of Borrow Areas 4/5 4.15.4 During Compaction 4/14

4.8.3 Stripping of Borrow Areas 4/5 4.15.5 After Compaction 4/14

4.8.4 Borrow Area Watering 4/5 4.15.6 Frequency of Testing 4/14

4.9 Dam Embankment 4/5 4.15.7 Record and Reports 4/14

4.9.1 General 4/5 4.15.8 Field Test Data 4/15

4.9.2 Preparation of Foundation 4/6 4.15.9 Embankment Test Section 4/15

4.9.3 Earth Fill Materials 4/7 4.16 Turfing 4/16

4.9.4 Placing Earthfill 4/7 4.17 Additional Specifications for Canal

Earth Work

4/16

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991****--2--****TABLE OF CONTENTS (contd.....)**

Clause Particulars Page

No.

Clause Particulars Page

No.

1 2 3 1 2 3

4.17.1 Alignment and layout of Canals 4/16 4.19.4 Bentonite slurry and Additives 4/21

4.17.2 Canal in Cutting - General 4/16 4.19.5 Guide wall/Pre-Trench 4/21

4.17.3 Canal in Full Cutting 4/16 4.19.6 Methods of construction 4/22

4.17.4 Canal in Partial Cutting 4/16 4.19.7 Stages of construction 4/22-24  
 4.17.5 Canal in Full Embankment not exceeding 3 m from Base to the Top  
 4/17 4.19.8 Types of Joints. 4/25  
 4.17.6 Canal in Full Embankment exceeding 3 m from Base to the Top  
 4/17 4.19.9 Wall of precast RCC Panels. 4/25  
 4.17.7 Stripping, Benching and Furrowing and Ploughing  
 4/17 4.19.10 Grout cut-off walls. 4/25  
 4.17.8 Compaction. 4/17 4.19.11 Tolerances. 4/26  
 4.18 Transverse Contraction Joint in Dam/Barrage.  
 4/17 4.19.12 Rock Grouting under the Diaphragm.  
 4/26  
 4.18.1 General 4/17 4.19.13 Permeability test for Concrete of the Diaphragm Wall  
 4/27  
 4.18.2 Water Stops across Transverse Contraction Joint.  
 4/18 4.19.14 Inspection of Works 4/27  
 4.19 Diaphragm Wall. 4/19 4.19.15 Testing Efficiency of Diaphragm Wall  
 4/27  
 4.19.1 Materials. 4/19 Appendix - I 4/28  
 4.19.2 Equipment and Accessories. 4/20 Appendix - II 4/29-30  
 4.19.3 Specifications of Bentonite slurry 4/20 Note:- PLATE: 1/CH-4 to PLATE: 9/CH-4 referred these Specifications are not enclosed. These be seen in the Specifications published by E-in-C, Water Resources Deptt.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/1**

## **CHAPTER - 4 EXCAVATION AND EARTHWORK**

**And**

### **CHAPTER - 21 SPECIAL ITEMS OF EARTH/MASONRY DAM AND CANALS**

#### **4.1 REFERENCES: -**

IS : 2720 ( Pt. II ) - 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 ions 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 shell 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 rabbing 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/2**

**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 kanker, black cotton soil for earthen bond, soft moorum etc.

#### **Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/3**

**4.4.3. Hard Moorum and Moorum mixed with boulders** - Generally any material which required the close application or picks, jumpers or scarifiers 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.



\*4.5.1 Compliance of Provisions of Construction and Demolition waste management Rules-2016 shall be observed during the whole construction period by the contractor and a certificate before the final payment of the work shall be obtained by the contractor from the concerned local body/bodies i.e. Gram Panchayat(s)/Nagar Panchayat(s)/Municipal Council(s)/Nagar Palik Nigam(s) etc. as applicable regarding having complied, the provision of the said rules. Certificate to this effect be submitted. **As per Annexure-T.**

#### **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.

#### **Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/4**

**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 apprehended to works in neighbouring area existing or under construction. In such cases rock excavation shall be completed by chiselling and wedging etc.

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

**4.7.4.1.** The materials, excavated from 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 site as far 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/5**

**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.

#### **Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/6**

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 shell 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/7**

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 passes 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 borrow 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 scrapers 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 cohesion less 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 than 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

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/8**

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 too 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 then 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 than 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/9**

**(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<sup>2</sup>. 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/10**

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.

D - 15 of the filter

(i) ----- = > 4 and < 20

D - 15 of the base material

Provided the filter does not contain more than 5 percent of material finer than 0.075 mm (No. 200 sieve)

D - 15 of the filter

(ii) ----- = < 5

D - 85 of the base material

D - 50 of the filter

(iii) ----- = < 25

D - 50 of base material

(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

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/11**

(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 than 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 from 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 oneman 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/12**

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 (D50 )  
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 equidimensional 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 chute 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. Grade 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 Sand 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 be used in two or more thickness as a substitute for the stones of full thickness. A large amount of the stones

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/13**

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 from the toe wall or the line of pin headers 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.

**4.13.5.3.5. - 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

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/14**

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 content.**

**(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 were 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/15**

**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 content 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 at least 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) than 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 drier 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.

#### **Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/16**

(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 then 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 at least 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 downstream 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 far 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:**

#### **Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/17**

(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

#### **Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/18**

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/mm<sup>2</sup> 11.6 minm.

ii) Ultimate elongation % 300 minm.

iii) Tear resistance. N/mm<sup>2</sup> 4.9 minm.

iv) Stiffness in flexure N/mm<sup>2</sup> 2.48 minm.

v) Accelerated extraction

(a) Tensile strength N/mm<sup>2</sup> 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  $\pm$  5

vii) Effect of alkali (28 days).

(a) Weight increase. % 0.40 maxm.

(b) Weight decrease. % 0.30 maxm.

(c) Dimension change %  $\pm$  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/m<sup>3</sup>

(b) Penetration at 25o C .... 200-300

(c) Softening point (Ring and ball test) ..... 80-90o C

(d) Brittleness test on 22 mm<sup>2</sup> specification  
at 5o 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

#### **Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/19**

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.

**4.182.2.7.** 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/20**

**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 and 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-wall rig. Cranes or rigs with winches of adequate capacity may be used for operating the trenching grabs as necessary.

**4.19.2.5. General Guide lines**- 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/m<sup>2</sup> (14 to 100 dya / cm<sup>2</sup>)

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

$$Y_s = 1.0 + 0.006 C.$$

**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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/21**

**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 daily 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 stirres 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 50 C.

For proper stabilisation of the trench walls by bentonite slurry, it is essential to allow adequate gelation 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, flocculants 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/22**

**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:**



**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/23**

- (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 handling 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 than 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/24**

**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 done 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 tested 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/mm<sup>2</sup> or 200 Kg/ cm<sup>2</sup>. 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.

Sl 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

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/25**

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 be removed. The chipping shall be done in such a manner as not to loosen, 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 at least 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/26**

**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 not 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<sup>2</sup> 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<sup>2</sup> 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 tests 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.

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/27**

**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<sup>2</sup>, 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.

• □ • □ • □

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/28**

**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 than 50 feet height  
Minimum  
acceptable  
density  
Desirable  
average  
density  
Moisture  
limits  $W_o$   
-  $W_f$   
Minimum  
acceptable  
density  
Desirable  
average  
density

Moisture  
limits  $W_o$   
-  $W_f$   
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  
Soil 26-50  $D = 92.5$   $D = 95$   $D = 95$   $D = 98$  (Note 2)  
Controlled  
by The  
Proctor test  
More than 50  
(Note 1)  
 $D = 90$   $D = 93$   $D = 93$   $D = 95$   
Cohesionless  
Fine sands  
with 0-25  
 $D_d = 75$   $D_d = 90$  Soils  
should  
Be very  
wet  
 $D_d = 75$   $D_d = 90$  Soils  
should  
Be very  
wet  
Soils Medium  
Sands with  
0-25  
 $D_d = 70$   $D_d = 85$   $D_d = 70$   $D_d = 85$   
Controlled  
by the  
relative  
density test  
Coarse  
sands and  
with 0-100  
gravels  
 $D_d = 65$   $D_d = 80$   $D_d = 65$   $D_d = 80$   
Where -  
 $W_o - W_f$  .... 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 .  
 $D_d$  .... 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.

Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/29

**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.

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.

Length of Cut off (L)

Width of Cut off (B) =1

DEPTH (D)

#### **Stability Factor Nc for Rectangular Cuts in Clay ( II )**

**Volume – 1, Section – II ] Specification for Irrigation Projects, Nov. 1991 [4/30**

For sandy soils

$Y_s = Y_w + A (K_a Y)$

Where,

$A = 1 - e^{-2n K_a \tan \phi}$

$2n K_a \tan \phi$

$K_a = \tan^2 (45 - \phi/2)$

Y = effective unit weight of the sandy soil.

= Submerged weight - weight of water

=  $Y_{sat} - Y_w$

The value of A depends upon n = 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.

# SPECIFICATION

for  
Irrigation Projects

## MASONRY STRUCTURE & CONCRETE WORK

### Containing Covering of Volume - I

Sec. II	- Chap. 4	: Excavation	(i.e. Chapter 1 & 2)
Sec. III	- Chap. 6	: Foundation for masonry structure & Mortars	(i.e. Chapter 3)
Sec. IV	- Chap. 7 & 16	: Filling Foundation, R.C.C. & Farm Work	(i.e. Chapter 4)
Sec. V	- Chap. 8 A	: Stone, Masonry & Precast Block Masonry (Other than masonry in Dams)	(i.e. Chapter 5)

### & Volume - II

Sec. I	- Chap. 11	: Pointing	(i.e. Chapter VI)
Sec. III	- Chap. 13	: Steel & Iron Work - Reinforcement	(i.e. Chapter VII)

OF UNIFIED SCHEDULE OF RATES FOR WORKS OF WATER RESOURCES DEPARTMENT

**TABLE OF CONTENTS SPECIFICATION OF MASONRY STRUCTURE & CONCRETE WORK**

Containing Covering of Volume-I, Sec. II-Chap. 4:Excavation (i.e. Chapter 1 & 2), Sec.III-Chap.6, Mortars (i.e.Chapter-3), Sec.IV-Chap.716: Filling Foundation, R.C.C. & Form work, (i.e.Chapter-4) Sec. V-Chap.8A: Stone Masonry & Pre cast Block Masonry (other than masonry in Dams)(i.e. Chapter-5) & Volume II, Sec.1 Chap. II Pointing (i.e. Chapter VI), Sec.III-Chap.13: Steel & Iron work Reinforcement (i.e. Chap. VII) of Unified Schedule of rates for Works of M. P. Water Resources, Deptt.

**Specification Contents Page****No. Specification Contents Page****No.****1 2 3 1 2 3****CHAPTER 1 GENERAL** 1-1 2.5.6. Frequency of Testing 2-5

1.1 Bench Marks 2.5.7. Embankment Test Section

**CHAPTER-3**3.1 to 3.2.3 **FOUNDATION FOR MASONRY****STRUCTURE**

3-1

1.2 Cross Section

**CHAPTER-3 MORTARS**

1.3 Payments 3.1 Material 3-1

**CHAPTER-2 EXCAVATION/EARTH WORK** 1-1 3.1.1. Cement

2.1 Classification of Strata 3.1.2. Sand

2.1.1. Soft or Ordinary Soil 3.1.3. Bulking of Sand 3-2

2.1.1.1. Hard soil 3.1.4. Soil

2.1.1.2. Hard Moorum &amp; Moorum Mixed 3.1.5. Water 3-3

with Boulders 3.2. Grade of Mortar

2.1.1.3 Disintegrated Rock 3.3. Criteria for Selection of Masonry

2.1.1.4 Soft Rock 2-1 Mortars

2.1.1.5 Hard Rock (Requiring Blasting) 3.4 Preparation of Masonry Mortars

2.1.1.6 Hard Rock (Blasting Prohibited) 3.4.1. Proportioning

2.1.1.7 Authority for Classification 3.4.2. Cement Mortar.

2.2.1 Payments **CHAPTER 4 CONCRETE & FORM WORK**

2.3.1. Borrow Areas 4.1 Materials 4-1

2.3.2. Preparation of Borrow Areas 4.1.1. Cement

2.3.3. Stripping of Borrow Areas 2-2 4.1.2. Aggregates

2.3.4. Borrow Areas Watering 4.1.3. Plums 4-6

2.3.5. Payments 4.1.4 Water

2.4 Compaction and Watering 4.2 Grade of Concrete &amp; Type of Mix

2.4.1 Compaction Equipments 4.2.1. General

2.4.2. Tamping Feet 4.2.2. Grade of Concrete

2.4.3. Roller Weight 4.2.3. Classification Concrete 4-8

2.4.4. Rolling 4.3 Concrete Mix Proportioning

2.4.5. Tamping 2-3 4.3.1. Mix Proportion

2.4.6. Watering 4.3.1.1. Determination of Proportions

2.4.7. Dressing Slopes 4.3.1.2. Information Required

2.4.8. Dry Stone Pitching 4.3.1.3 Design Mix Proportioning

2.4.9. Placing 4.3.1.4 Nominal Mix Proportioning

2.4.10. Grouted Stone Pitching 2-4 4.4. Quality of Concrete 4-10

2.4.11 Dry picked up Boulder pitching 4.4.1. General

2.4.12 Dry Quarried Boulder Pitching 4.4.2. Field Control

2.5. Inspection &amp; Tests 4.4.3 Workability

2.5.1. General 4.4.4. Durability 4-12

2.5.2. Scope of Testing &amp; Inspection

Required

4.5.1. Mixing

1

**Specification Contents**

**Page****No. Specification Contents Page****No.****1 2 3 1 2 3**

2.5.3. Before Compaction 4.5.2 Efficiency &amp; Performance of Mixer

2.5.4. During Compaction 4.5.3. Method of Charging

2.5.5. After Compaction **CHAPTER 5**

4.5.4 Time of Mixing 4-13

4.6. Form Work

4.6.1. General

5.1 Un coursed Rubble Masonry/

Random Rubble/ Polygonal

Faced Masonry

5-1

4.6.2. Cleaning &amp; Treatment of Forms 4-14 5.1.1. Materials

4.6.3. Removal of Forms 5.1.1.1. Stone

4.7 Preparation for Placing Concrete 4-15 5.1.10.2. Size of Stone

4.7.2. Rock Foundation 5.1.1.3. Mortar

4.7.3. Earth of Shale Foundation 5.1.2. Dressing of Stones

4.8 Placing of Concrete 5.1.3. Laying 5-2

4.8.1. General 5.1.4. Scaffoldings

4.8.2. Sequence of Concrete 4-17 5.1.5. Curing and Protection

4.8.3. Within Forms 5.1.6. Payment

4.8.4. Cleaning joints

4.8.5 Rate of Placing 4-18

5.2. Stone Work in Plain Ashlar

Masonry

5-3

4.9. Concreting Under Special 5.2.1. Materials

Conditions 5.2.2. Dressing

4.10 Compacting 4-19 5.2.3 Laying

4.10.1 Method 5.2.4 Pointing

4.10.2 Vibrating 4-20 5.2.5. Curing and Protection

4.10.3 Internal Type Vibrators 5.2.6 Scaffolding

4.10.4 External Type Vibrators

4.11 Curing of Concrete

4.11.1 General

4-21 **CHAPTER 6 POINTING ON BRICK WORK &****STONE WORK**

(Other than-Dam)

4.11.2 Curing of Unformed Surfaces Piers 6.1.1. Preparation of Surface 6-1

4.11.3 Water Curing 6.1.2. Mortar

4.11.4 Membrane Curing 6.1.3. Application &amp; Finishing

4.11.5 Repairs of Concrete 6.1.4 Curing 6-2

4.12 Finishing of Concrete Surface 6.1.5.3. Ruled Pointing

4.12.1 Classes of Finish for Formed 6.1.5.4. Cut or weather struck pointing

Surface 6.1.5. Payment

4.12.2 Porous Concrete **CHAPTER 7 REINFORCEMENT**

4.13 Standard of Acceptance 7.1 General 7-1

4.13.1 General 7.1.2 Quality of Reinforcement

4.13.2 Determination of Standard 7.1.3 Stacking &amp; Storage

Deviation 7.1.4. Cutting &amp; Bending

4.13.3 Acceptance Criteria 4-25 7.1.5 Joint &amp; placing 7-2

4.14 Filling Foundation with Materials 7.1.6 Binding &amp; Pl

other than Cement Concrete

4-26

7.1.7 Substitution 7-4

4.14.1.1. Proportioning 7.1.8 Bundling of Bars

4.14.1.2. Lime Mortar Preparation

4.14.1.3. Mixing

7.1.9 Physical Properties of Reinforcing



Bars

7- 5

4.14.1.4. Form Work 7.2. Development (Bond) Length 7-6

4.14.1.5 Laying 7.3. Anchoring Reinforcing Bars 7-7

4.14.1.6 Compaction 7.4 Reinforcement Splicing 7-8

4.14.1.7 Curing

4.14.1.8. Preparation

7.4.1 General arrangements &

Provisions

4.15 Requirements for Durability 4-27 7.4.2 Lap Splices 7-9

4.16 How to Batch Concrete by Volume 7.4.3 Welded Split

2

## **SPECIFICATION OF MASONRY STRUCTURE & CONCRETE WORK FOR IRRIGATION PROJECTS**

### **NOV. 91**

#### **1. General:-**

**1.1 Bench Mark:** 1.1.1 Before starting any work, a permanent 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 works "B.M." with R.L. shall be conspicuously carved and painted on the benchmark. The reference line shall comprise of a base line properly dag 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.

1.1.2. The Sub-Divisional Officer on behalf of the Engineer-in charge shall himself layout all important levels all control points with respect to this bench mark and reference line and coral ate 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 benchmarks reference lines and check profiles may be necessary and shall be constructed as directed by the Engineer-in-charge.

1.1.3. 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.

**1.2. Cross Section:** 1.2.1. Immediately prior to the beginning of the work, cross- sections 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 these cross-sections shall be taken at suitable interval not exceeding 6 m or as directed by the Engineer in charge.

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

1.2.3. Payments - No payments shall be made for items of these works except for stripping or overburden in excess of 60 cm. (2ft.) thickness, as these will be covered in the overall rate of earthwork in the dam embankment.

## **2. EXCAVATION/ EARTH WORK**

### **2: 1.1. Classification of Strata:**

**2.1. 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 peat, etc

**2.1.1. 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 bund, soft Moorum, etc.

**2.1.1.2. Hard Moorum and Moorum Mixed with Boulders:** Generally any material which requires the close application of picks, jumpers or scarifies to loosen such as hard and compact Moorum and soft shale, Moorum or soil mixed with small boulders 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 exfoliation 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.

**2.1.1.3. Disintegrated Rock:** Includes such strata which requires the close application of crow bars, picks, grafting tools, scarifies in suitable combination for its excavation such as soft late rite, soft late rite, 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 meter in size.

(1-1)

**2.1.1.4. Soft Rock:** Soft rock comprises of the following:

(i) Boulders (not greater than 0.5 cum in volume), hard late rite, hard copra and hard conglomerate or other rock which may be quarried or spilt with crowbars, with casual blasting, If required, for loosening of - strata

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

**2.1.1.5. 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.**2.1.1.6. Hard Rock (Blasting prohibited) :** Hard rock requiring blasting as described under 4.46 but where blasting is prohibited for any reason and excavation has to be carried but by chiseling wedging or any other agreed method.**2.1.1.7. Authority for classification:** The classification shall be decided by the Executive Engineer and his decision shall be final.**Clearing Grubbing And Preparation Of Works Area;**

(i) All excavation areas and dam embankment area including a 6m 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 of 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 stacked and handed over to the department, when asked for by the Engineer-incharge.

Pilling for burning shall be done in such a manner and in such location as to cause the least fire risk.

All the burning shall be thorough so that the materials are reduced to ashes. Special precautions shall be taken to prevent fire from spreading to the areas beyond limits of 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.

**2.2.1. Payments:** - Payment shall be according to measurements of the actual work done per 100 sq meters or 1,000 sq. feet and will include all items indicated above except trees of over 90 cm (3 feet) girth which shall be counted and recorded before following and paid for separately, on the basis of girth measured at 90 cm (3feet) above the ground level. This item shall be payable only for the seating of the dam dykes and banks including areas contiguous to it and for other appurtenant works but shall not be payable for the borrow areas and quarries where the site clearance shall be included in the earthwork rate.**2.3. Borrow Areas:** 2.3.1. All materials required for the construction of impervious, semi previous or previous zones of embankment and backfill for cut of puddle trench which are not available from cut off/puddle trench excavation of 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 material from each borrow area shall be placed only in the zones for which it has been specified. The depth of cut in all borrow area will be designated by the Executive Engineer and the cuts shall be made to such designed depths only Shallow cuts will be permitted in the borrow area, it un stratified materials with uniform moisture contents are encountered. Each designated borrow area shall be full 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 operations in the excavation of materials in borrow areas shall be such as will produce 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 of mar the appearance of any part of the work or any other property. The surface of wasted materials shall be loft 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 materials is not completely removed and porous strata exposed.

(2-1)

**2.3.2.Preparation of borrow Areas:** All areas required for borrowing earth for embankment shall be cleared off all trees and slumps, roots, bushes, rubbish and other objectionable materials. Particulars card 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 the work.

**2.3.3. Stripping of Borrow Areas:** Borrow area shall be stripped of top soil, so 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 of in the approved adjacent areas as directed.

**2.3.4. Borrow Area Watering:** Borrow area watering if needed based on laboratory test will be done by the department as decided by the Engineer-in-charge. The placement moisture content for proper compaction of earthwork 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.

**2.3.5. Payments:** No payments shall be made for these works except for stripping or overburden in excess of 60 cm (2 ft.) thickness, as these will be covered in the overall rate of earthwork in the dam embankment.

## **2.4. COMPACTION AND WATERING:**

### **2.4.1. Compaction Equipments:**

While the specification below provide that equipment of a particulars 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 program of construction shall be used. The broad details of the equipment are given below.

Tamping rollers/vibratory compactors shall be used or 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 than 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 not 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. .

**2.4.2. Tamping feet:** At least one tamping foot shall be provided for each 645 Sq cm of drum surface. The space measured on the surface of the drum between the centers of the adjacent tamping feet shall not be less than 250 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 or more than 65 sq cm. at a plane normal to the axis of the shank 200 mm from the drum surface.

**2.4.3. Roller weight:** The weight of the roller when fully loaded shall not be less than 7091 kg. and the ground pressure when fully loaded shall not be less than 40 kg/ cm required to obtain the desired compaction. Tractor used for pulling rollers shall be 50 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 could impair the effectiveness of the tamping rollers.

### **2.4.4. Rolling:**

(i) When each layer of materials has been conditioned so as to have the proper moisture content uniformly distributed through the materials, 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 over lapping 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.

(2-2)

(ii) If the foundation surface is too irregular to allow the use of large roller directly against any structure or rock outcrop, the roller shall be used to compact the soil as to dose 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 tempers in thin-layer. Sheep foot roller shall not be employed for compaction till the thickness of the layers compacted by other means is greater by 30 cm than the depth of the foot of the roller drum.

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

1. Portion of the earth fill in dam embankment adjacent to masonry structures and embankment foundations 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. Then each layer of materials has been conditioned to have the required moisture content, it shall be compacted to the specified density by special rollers, mechanical tampers or by others 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.

**2.4.6. Watering:-** Watering of earth work for consolidation shall be carried out by the department.

The arrangements for storage, pumping equipment and laying of suitable pipe lines of adequate capacity on upstream and down stream of the dam will be made. The connections will be provided at regular intervals in the main pipe line to connect to the off take lines having valves to control the flow through rubber hoses. The whole system 111 be such and so laid out that regular flow of water in ensured on the dam at all times. The pipe line will be required to be raised as and when required with the raising of the earthwork on the dam.

**2.4.7. Dressing Slopes:** The out side 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 regarded' 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 his cost of agency executing the work.

**2.4.8. Dry Stone Pitching:**

**2.4.8.1.** The quality of stones for pitching shall be hard and durable and shall not; crumbled on king exposure to water, post, and air.

**2.4.8.2** The depth of stones shall be about equal to the specified thickness of pitching and shall generally be not less than 0.014 cum and 0.021 cum as specified in the appropriate item of used or other size 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 be use 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 form rock quarries.

**2.4.9. Placing:**

**2.4.9.1.** 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 from the toe wall or the line pin headers at the toe of the slope as may be specified on the drawing and the pitching laid course by course up the slope.

**2.4.9.2.** Projecting comers shall be knocked off with the hammer so as to make a rough joint at the base. The stones shall be laid on end with broadest base down and length normal to the slope and carefully bonded in all direction 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 under lying surface.

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

(2-3)

**2.4.9.4.** The general face slope of the pitching when completed shall be as specified in the drawing subject to the tolerance on the nominal thickness of riprap enforced on the performed profile shall be 10%. The final surface of the pitching shall be clean of all refuge.

**2.4.9.4.1, Tolerance:** The tolerance of the nominal thickness of rip-rap enforced on the performed Profile shall be 10 percent.

**2.4.10. Grouted Stone Pitching:**

**2.4.10.1** The specifications of Para 2.4.8.1, 2.4.8.2&2.4.8.3 be followed except for the use of stone chips or quarry spalls as described in Para 2.4.9.3.

**2.4.10.2** After the pitching stones are laid as described in Para 2.4.9.2. the interstices snail be filled with mortar of specified mix. The mortar shall be forced in to the joints with the help 0.6 mm rods so as to ensure that the mortar reaches up to the base. The joints shall then be finished flush with the help of trowel.

**2.4.10.3.** 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.

**2.4.11. Dry picked up Boulder Pitching:** The boulders used in this type of pitching shall consist of the rolled rock masses directly picked up in their natural form the river are the nail a beds. The boulder shall be hard dense and resistant to abrasion. The size of the boulder in at least one direction should not normally



be less than 22 cm. Also the least dimension of such boulder in any direction should not be less than 10 cm. The smaller size boulder/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 boulder of full thickness.

**Placing:** over the backing of filter as may be specified in the drawing, the Boulder 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 boulder shall be laid with broadest base down and carefully bounded in all direction. After the boulders have been fixed as above, the interstices shall be filled with well fitting smaller size boulder/ gravel driven home.

The provision of Para 2.4.9.4 shall be applicable here also.

**2.4.12 Dry Quarried Boulder pitching:** The specification as in Para 2.4.10.1 shall be followed except that the boulder of required size shall be obtained by breaking big size boulders.

**Placing:** The specification as at Para 2.4.10.2 & 2.4.10.3 shall be followed.

**Tolerance:** The specifications at Para 2.4.9.4 shall be followed apply.

## **2.5 INSPECTION AND TESTS:**

**2.5.1 General:** The Executive Engineer shall maintain and exercise thorough check on the quality of fill materials delivered to the dam and shall arrange to obtain the data and in situ properties of the materials after compaction for comparison with designed assumption. To achieve these objectives, a program of field-testing and inspection shall be planned to affect quality control.

**2.5.2 Scope of testing and Inspection Required:** Field control of fill materials will require visual and laboratory checks. The checks on effectiveness of placement and compaction procedure will require to be made by filled density tests at prescribed intervals.

**2.5.3 Before Compaction:** Materials delivered to the field shall be visually examined and their properties estimated by the inspection. These checks shall include.

**(a) Borrow Area:** (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 as prescribed minimum intervals and by testing the samples in the laboratory for gradation and moisture content.

**(b) Embankment:** (i) Water content test 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 the laboratory test.

(2-4)

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

**2.5.4 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.

**2.5.5 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 test. Dry density attained shall satisfy the compaction standards as per appendix.

## **2.5.6 Frequency of Testing:**

**2.5.6.1** The frequencies for various tests for earthwork shall be in accordance with appendix 6.02 of the M.P.W.D Manual 1983 Vol. II part II.

**2.5.6.2** 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 of cut of 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 materials.

(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 oversized rock, which has been overlooked, is contained in the fill.

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

(ix) Areas that were compacted by roller that have possibly lost part of their ballast.



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

**2.5.7. 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 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 fill materials (b) Optimum practicable moisture content. (c) Number of passes of sheep foot rollers, 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 test embankment sections is as follows.

(i) Select a location on the embankment where uninterrupted placing operations are being performed. The 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 content 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 earth layer, the moisture content; at which the material were rolled, the designation (No.1, No.2 etc.) of the rollers used, the conditions of the rollers (clean or dirty), the action of the material 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 material came.

(iii) Check the rollers to make certain that they meet all the requirements of the specification.

(iv) Determined 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.

(2-5)

(v) Using the available data from borrow pit investigations of 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 laboratory optimum content, field density test should be made throughout the section. These tests should be made for at least each 93 sqm 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 other, and 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 to 2 percent) than 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) The resulting field dry densities (of material passing the No.4 sieve) from (vii) above shown 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 drier of the original moisture content used and repeat the test. The 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 rollers 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 outlined 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 material 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.

## **CHAPTER - 3 FOUNDATION FOR MASONRY STRUCTURE**

### **3.1. EXCAVATION OF FOUNDATION ITS PREPARATION**

#### **3.1.1. GENERAL :**

(i) Excavation of foundation of the sluice, waste weir, falls on spill channel or other masonry works on head works or canals shall be made to sound firm rock free from weathered materials, cleared and open seams and creniers and shall be shaped, roughly stepped as to produce the desired surface of contact between the concrete and rock as shown on the drawings or as directed by the Engineer-in-charge.

If rock is not available at reasonable depth excavation may be done up to any firm strata like hard moorum hard shale, etc. as may be directed by the Engineer-in-charge.

(ii) The excavation shall be open cut excavation shall be made to the dimensions required and shall be finished to the full dimensions required and shall be finished to the specified lines and grades in a work manlike manner, except the sharp points of undisturbed ledge rock will be permitted to extend within the prescribed lances not more than 150 mm ( 6 inches).

**3.1.2. Side Slope** - All excavation work will be influenced in general by the nature and structure of materials in which the excavation is made the side slopes of the excavation shall be as steep as the soil would stand with safely as decided by the Engineer-in-charge. If the slopes established are found to be made flatter by removing the additional materials and stable established.

**3.1.3 Consolidation of foundation :**

(i) The bottom and side slopes of common excavation upon or against which concrete is to be placed shall be finished accurately to the dimensions shown on the drawings or prescribed by the Engineer-in-charge and surfaces so prepared shall be moistened with water and tamped or rooled is so required by the Engineer-in-charge, with suitable tools or equipment for the purpose of thoroughly compacting them and forming firm foundations upon or against, which to place the concrete structures. If at any point in ordinary soil excavation materials is excavated beyond the lines required to receive the structures, over excavation shall be filled either with is elected material in layers not more than 150 mm ( 6 Inches) thick moistened, and thoroughly compacted by tamping or rolling, as may be directed by the Engineer-in-charge. If at any point in ordinary soil excavation, the natural foundation material is (3-1)

disturbed or loosened during excavation process or otherwise, it shall be consolidated by tamping or rolling or it shall be removed and replaced with selected materials which shall be thoroughly compacted or filled with concrete as may be directed by the Engineer-in-charge. No payment will be made for over excavation and its refilling or for removal and treatment of loosened foundation unless in the opinion of the Engineer-in-charge such extra work was unavoidable for reasons beyond control.

(ii) All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavation in the soundest possible conditions.

(iii) Water from any spring or leakage through the coffer dams shall be kept out of the foundation area and from any masonry till the latter has set, where pumping is resorted to care shall be taken to see that it does not lead to disturbance of work already completed.

**3.1.4. Shoring :**

(i) Shoring or protective arrangements shall be provided wherever necessary to stabilize the slope if they are likely to slip. Such arrangement shall be the full responsibility of the contractor but the Engineer-in-charge may direct the contractor to strengthen or extend any such arrangement if he finds the same to be inadequate and the contractor shall immediately comply with such instructions.

(ii) Every possible precautions shall be taken to prevent slips of slopes, but should slips occur the slipped material shall be removed to the designed grades and slopes.

**3.1.5 Berms :** Suitable berms shall be left at appropriate place with necessary approach ramps provided, for installation or dewatering pumps and other machinery required for removing spoil.

**3.1.6 Excavation in rock :**

(i) Where concrete is to be placed upon or against rock and average minimum thickness is down the excavation shall be sufficient to provide for the minimum thickness of concrete at all points and the prescribed average thickness shall be exceeded, as little as possible, measurement for payment of such excavation shall be limited to the excavation required for the prescribed average thickness of the concrete.

(ii) Where concrete is to be placed upon or against rock and the thickness of concrete is not shown on the drawings, the excavation shall be made to the lines prescribed by the Engineer-in-charge. Measurements for such excavation shall be made as for actual work done.

**3.1.7. Excavation by biasing :**

(i) The excavation of rock requiring blasting shall be done with explosives of such quantity and mode rate power as will not open seams, crack or damage the rock outside the prescribed lines of excavation. Whenever blasting is likely to injure the rock uppn of against which concrete is to be placed, the use of explosive shall be discontinued and excavation completed by, wedging chiselling, bprring or other suitable methods. No blasting that might injure the rock will be permitted and any damages done to the rock by blasting including the shattering of the materials beyond the required excavation lines shall be repaired at the expense of any by the contractor in a manner satisfactory to the Engineer-in-charge.

(ii) Similar restrictions on blasting as above shall be placed if required, by the Engineer-in-charge to prevent any damage to adjacent structures of work, existing or under construction.

**3.1.8. Over excavation :**

(i) All cavities in rock excavation upon or against which concrete is to be placed, formed by careless excavation as determined by the Engineer-in-charge shall be filled solidly with concrete of the mix and specification is as the foundation concrete entirely at the expense of the contractor including the cost of all materials required therefore.

(ii) Any and all excess excavation or over excavation performed by the contractor for any purpose or reason except as may be ordered in writing by the Engineer-in-charge and whether or not due to the fault of the contractor, shall be at the expenses of the contractor.

**3.1.9. Fencing and lighting** -All the excavation areas, particularly in the river bed shall be heavily fenced and adequately flood lighted to the satisfaction of the Engineer-in-charge where work is in progress during the night shifts. This is in addition to the general lighting of the works area as specified in the General condition of contract parts of intensive and vulnerable work shall further be provided with special light and brilliant illumination as may be necessary to the satisfaction of the Engineer-in-charge.

**3.1.10. Inspections** : When the excavation for the foundations has been completed to the approximate grades specified all loose rock and other excavated materials shall be removed and the surface if rocky, shall be cleaned with an air water jet under high pressure, for purpose of inspection if the foundation is found to be unsatisfactory, additional excavation shall be made as directed and surface, against cleared for inspection. The procedure shall be repeated until satisfactory foundation is reached.

**3.1.11. Disposal of excavation materials :**

(i) Before and excavation is started, the deposition of spoil shall be carefully planned. The excavated materials shall be dumped sufficiently clear of the edges of excavation permitting ample space for possible widening or foundation if necessary ample space for railway tracks, paths, installations of lifting and dewatering machines and pumps, stacking construction materials. The excavated materials shall be transported to coffer dams, rock toes, flood banks, canal banks. In forming stock piles the useful materials shall be stocked with reference to the nature of the material. Steps shall be taken to keep the material clean as subsequent cleaning will be difficult and imperfect.

(ii) Suitable materials from excavation shall be used in the dam embankment, filters, rock toes, rip rap and masonry works etc. So far as practicable and as determined by the Engineer-in-charge. Materials suitable for the purpose shall be selected separately from the materials to be wasted and suitable materials shall be segregated by load from excavations and shall be transported and placed in the designated final locations directly from the excavation or shall be placed in temporary stock piles and latter placed in the designated locations as directed by the Engineer-in-charge. Waste materials from the excavation shall be disposed off as directed by the Engineer-in-charge. No spoil banks shall be left in such a condition that they will detract from the finished appearance of the project and all work shall be done with reasonable neatness.

(iii) All excavation materials shall be the property of department and adjustment and recovery shall be made from the contractor for the materials from excavation used on other items of the works and may be specified in the contract at specified rates. If the rates are not specified in the contract, these shall be settled with the department, before the materials are used.

**3.1.12. Test** : An adequate number of representative sample shall be taken from the foundation and abutment rock, as well as of the cores taken from the cores drilled and tested for compressive strength, both in dry state and after prolonged exposure to water, durability, hardness permeability and absorption properties as well as their suitability for concrete aggregates or masonry stones. The tests shall be conducted in the laboratory by the department at its own cost. No charge shall be made on or payment to the contractor for such test but contractor shall be bound by the results certified by the Engineer-in-charge and shall supply all labour for sampling and carriage of samples to the laboratory free of cost.

**3.1.13. Payments :**

(i) Final cross section shall be taken on completion of excavation and plotted on sections previously taken vide specifications para 1.15 and 1.1.6 volumes shall then be computed for materials excavated under different classification, where more convenient and suited to the nature of work, the Engineer-in-charge may direct the measurement to be taken directly by the pit or trench and contents worked out accordingly.

(ii) All grades of materials whether in cut or fill will be measured in the excavation. but when it is not practicable to take pit measurements and sections measurements of banks have to be taken a deduction as given below shall be made from the section measurements to reduce them to pit measurements.

S.No. Soils other than rock % Shrinkage allowance

(a) Work rolled and watered (light rolling and watering). 10%

(b) Work rolled but not watered (light rolling). 15%

(c) Work neither rolled nor watered. 20%

(d) Work neither rolled nor watered in case of clayey soil i.e. kanhar 25% soil or black collow soil.

(e) Work rolled and watered and compacted at optimum moisture 4% contents to maximum dry desity.

(iii) In case measurement of rock in pit excavation are not possible measurements shall be taken by stack measurements the materials being properly stacked by the contractor at his expense as directed by the Engineer-in-charge. Deduction shall be made for voids at the rate of 40% of the volume of stack measurements of reduce them to pit measurements.

(iv) The rate shall include in general all items as described in the above specification wide part 3.1 and in particular as described in the schedule of quantities under relevant items or excavation.

(v) \*Extra rates for excavation in wet soli when specified will be payable only for excavation below subsoil water level and where the material is sufficiently wet and slusly so as to cause difficulty in excavation and handling.

#### **3.1.14. Authority for classification :**

(i) The clasificate on of excavation shall be decided by the Engineer-in-charge and his decision shall be classification unless blasting is clarify necessary in the opinion of the Engineer-in-charge. Over breakage and payment. In cutting in rock, bed and slopes shall be dressed to the designed dimensions as best the starta permits. All excavation shall be done according to lince, levels dimensions shown on the drawings. Over breakage and excess excavations shall be carefully avoided as for as possible. No extra payment for any over breakage and extra slope shall be payable.

(ii) Useful excavated soil shall be directly utilished in accordance with the typical section of the canal given in the drawing and as specified by the Engineer-in-charge. Materials and soils on the spoil bank shall only be laid under the written orders of the Engineer-in-charge and in such 2 way that can be easily removed and transported for masonry fill grand other works of the projects if so directed. Materials will be stacked separately according to the graduation like masonry stone, rubble pitching stone, boulder chips etc.

(iii) In case of canal banks which have to carry water earth should be deposited in layers not exceeding 15 cm clods exceeding 10 cm in sizes will not be allowed without breaking them to size proper.

### **3.2. ANCHORE BARS IN ROCK**

**3.2.1 Drilling holes for anchore bars :** Wherever shown on the drawing or as directed, holes shall be drilled in to the rock to receive bars for anchoring concrete or masonry walls and ground mats to the rock. The dimensions of the anchor bars and the location, diameter and depths of the anctive bar holes shall be as shown on the drawings or as directed. The diameter of anchor bai holes shall be not less than 1 1/2 times the diameter or greatest transverse dimension of the anchor bar specified for the hole, subject to minimum of 13 mm (1/2") over the bar dimensions.

**3.2.2 Placing anchor bars and grouting :** Anchor bars shall be cleaned thoroughly before being placed. The holes shall be cleaned thoughly and kept flagged untill placing the bars and shall be filled completely and compactly, with grout or mortar mixed in the proportion and to the consistency specified by the Engineer-in-charge. All water shall be removed from the hole when the anchor grout is placed.

The anchor bars shall be forced into place before grout or mortar has taken its initial set and where practicable, shall be vibrated or rammed until the entire surface of the embedded portions of the bars in intimate contract with the grout special care shall be taken to ensure against movements of the bars which have been placed. Anchor bars shall be placed not less than 6 days in advance to concrete operations to allow the grout to become set anchor bars found loos after setting shall be replaced by and at the expense of the contractor.

**3.2.3 Measurement and Payment :** Measurement for payment for drilling holes for anchor bars and grouting bars in please will be based upon the length of the holes required to be drilled beyond the surface of the excavation or rock surface of the excavation or rock surface payment for drilling holes for anchor bars and grouting bars in place will be made at the unit price per linearmetre tendered therefore in the schedule which unit price shall include the cost of furnishing grout, drilling the holes and grouting the bars in place. Payment for furnishing and placing the bars will be able at the unit price per kg. (Pound) tendered in the schedule for furnishing and placing reinforcements bars.

## **CHAPTER-3 MORTARS**

### **3.1. MATERIALS**

#### **3.1.1 Cement**

**3.1.1.1 General** -Unless otherwise specified cement shall confirmed 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)



**3.1.1.2 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 card 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 jumping 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 structures.

(3-1)

## **3.2 Sand**

### **3.2.1. Quality of Sand**

**3.2.1.1 General -** The sand shall consist of natural sand, crushed stone or crushed stone sand 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 contain the amount of clay, silt and fine dust more than the limits specified under Para 31.1.3

**3.2.1.2 Deleterious Material -** The sand shall not contain any harmful impurities. Such as Iron pyrites alkalies, salt, coal or other organic impurities, mica, shale or similar laminated materials, soft fragment sea shells in such form or in such quantities as to affect adversely the hardening, Strength or durability of the mortar, or the appearance in case of plaster or applied decoration or to cause corrosion of metal lathing or the other metal in contact with the plaster.

**3.2.1.3 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 if) accordance with IS 2386 (part II) 1963.

(a) Clay fine silt and fine dust not more than 5% by mass when determined in accordance With the Procedure at Appendix-1.

(b) Organic impurities when determined accordance with IS 2386 (part 11) - 1963 color 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 to permitted may be subject to approval of Engineer-in-Charge.

### **3.2.2 Grading of sand**

3.2.2.1. The particle size grading of sand shall be as specified In Table II for 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**

IS: Sieve For use in masonry For internal and external  
Designation Mortar, percentage wall and ceiling plaster,  
Passing by mass 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

**3.2.2.2.** The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

**3.2.2.3** The required grading may often be obtained by screening and/or by blending together either natural sand or crushed stone screenings, which are, by them selves unsuitable.



**3.2.2.4** 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 3.1.2 above may be considered by the Engineer-in-Charge.

(3-2)

**3.2.2.5** 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 regarded 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.

**3.2.2.6** 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 3.1.2.5 applying the other sieve sizes.

**3.2.3. 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 by weight Bulking percent (Volume)

2 15

3 20

4 25

5 30

**3.2.4 Soil:** Soil for making mud mortar shall have suitable plasticity. The soil shall be free from vegetable roots, stone, gravel, (particle size greater than 2 mm) 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 materials (coarser than 3.35 mm) in soil shall not exceed 10 percent by weight.

**3.2.5. Water:** Water used for making masonry mortars shall be clean and free from injurious quantities deleterious materials. Portable water is generally considered satisfactory for use in masonry mortar.

3.1.5.1. Permissible limits for solids shall be as given 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

### **3.3 GRADE OF MORTAR**

3.3.1. 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.

(3-3)

### **3.4. CRITERIA FOR SELECTION OF MASONARY MORTARS**

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 8 B 3 of Chapter- 8B for "Dam and Appurtenant Works and Para 3.3.1 to 3.3.3.3 below for other works.

**3.4.1.** 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 MM2.

**3.4.2.** In the case of load bearing internal walls, the grade of mortar shall preferable be MM 0.7 or more for high durability but in no case less than MM 0.5.

**3.4.3.** 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 MM2 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 the grade of mortar be less than MM 2.

**3.4.3.1.** For masonry in buildings subject to vibration of machinery are grade of mortar shall not be less than MM 3.

**3.4.3.2.** 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.

**3.4.3.3.** The grade of mortar for bedding joints in masonry with large concrete blocks shall not be less than MM3.

### **3.5 PREPARATION OF MASONRY MORTARS**

**3.5.1. 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. Loosely placed condition is achieved by pouring or filling the material in the, Container loosely, that is without giving any jerk to the container.

#### **3.5.2. Cement Mortar**

**3.5.2.1. 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 it s quantity shall be increased suitably to allow for bulkage which shall be determined as per Para 3.1.3.

**3.5.2.2. Preparation** - Mixing shall be done preferable in 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 uniform color. The required quantity of water shall then be added 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 and mixing, the mortar shall be hoed back and forth for 5 to 10 minutes with addition of water.

**3.5.2.3.** Generally, only as much quantity of cement mortar as 'would be sufficient for 30 minutes work, shall be mixed at a time.

**3.5.2.4.** 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 entrainment of 8 percent of 12 percent of air by volume of mortar.

(3-4)

## **CHAPTER 4 -CONCRETE & FORM WORK**

### **4.1. MATERIALS:**

#### **4.1.1. CEMENT:**

**4.1.1. 1.** Unless otherwise specified cement shall conform to the following Indian standard specifications.

- (a) Ordinary Portland Cement 33 grade conforming to IS: 269-1939.
- (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) Ordinal Portland cement 43 grade conforming to IS: 8112-1989.

#### **4.1.1.2 Precautions and Guidelines for Use Cement:**

The type of cement to be used shall be specified by the Engineer-in-Charge. Following guidelines are given for used 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 formwork etc.
- (ii) High alumina cement conforming to IS: 645-1972 shall be used only under special circumstance when directed by the Engineer-in-Charge.
- (iii) Super sulphated cement conforming 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 to 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 rates of development of early strength may be some what lower concrete made with Portland pozzolana cement may need some what longer curing period under field conditions, delayed removal of form work etc. Portland pozzolana cement also has the advantage of lower heat of hydration and better sulphate resistance.
- (v) Portland pozzolana cement is not allowed for R.C.C. work of bridges and pre stress concrete. Portland slag cement to be used for pre stress concrete the slag content should not be more than 50%.

**4.1.1.3. Stacking and Storage** -Other specifications for cement such as supply "Stocking and Storage" shall be as described "under Para 3.1.1.2 of Chalk Mortars".

**4.1.1.4. 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 but in accordance 'with the procedures described in .IS: 4031-1988 and IS: 4032-1985 and the results may be compared 'with standard as given in Appendix 1 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.

#### **4.1.2. AGGREGATES:**

**4.1.2.1. 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 aggregates 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 4.75 mm IS Sieve, but the actual size be in accordance with the provisions of the following clauses.

(4-1)

**4.1.2.1. QUALITY OF AGGREGATES:** Aggregates shall consists of naturally occurring (crushed or uncrushed stone, gravels and sand or combination there of Aggregates shall be hard, strong, dense, durable dean and free from veins and adherent coating and free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substance. As far as possible, flaky, scoriaceous and elongated pieces should be avoided.

**4.1.2.2. DELETERIOUS MATERIALS:** Aggregates shall not contain any harmful materials such as pyrites, coal, lignite mica shall or similar laminated material, clay, alkali, soft fragments sea shale and organic impurities in such quantity as to affect the strength or durability of the concrete. Aggregates to be used for reinforced shall not contain any material liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkalis of cement and 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 discretion 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**

S. No. Deleterious Method of test Fine aggregate Coarse aggregate

Substance percentage by percentage by

Weight maximum weight maximum

Uncrushed Crushed Uncrushed Crushed .

1 2 3 4 5 6 7

(i) Coal and lignite IS: 2386 1.00 1.00 1.00 1.00

(PT.II) 1977

(ii) Clay lumps -do- 1.00 1.00 1.00 1.00

(iii) Materials finer than IS: 2386 3.00 15.00 3.00 3.00

75 micron IS Sieve (Pt.I) 1977

(iv) Soft Fragments IS: 2386 3.00

(Pt.II) 1977

(v) Shale -do- 1.00

(vi) Total f percentage of all 5.00 2.00

5.00 5.00

deleterious materials (except mica)

including Sl. No. (i) to(v) for Col.4,

6 & 7 & Sl. No.(1)&

(ii) for Col 5 only

**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 mica content of fine aggregate and make suitable allowances for the possible reduction in the strength of concrete or mortar.

**NOTE 2:-** The aggregate shall not contain harmful organic impurities (tested in accordance with IS: 2386 (part 11-1977) in sufficient quantities to affect adversely the strength or durability of concrete. A fine aggregate impurities 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 Para 7 of IS 2386(Part VI) 1977 is not less than 95 percent.

**4.1.2.3. MECHANICAL AND PHYSICAL PROPERTIES:** Mechanical and physical properties shall be as describe in table 2 below.

(4-2)

**TABLE- 2: MECHANICAL AND PHYSICAL PROPERTIES**

Specified limits of result

S.No. Test results

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

Los Angeles machine

shall not exceed 50% shall not exceed 30%

5. Flakiness Index Not greater than 25% As per col.3

**SOUNDNESS OF AGGREGATES** - For concrete liable to be exposed the actions 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 if may be taken that the average loss of weight after 5 cycles shall not exceed the following:

(a) For fine aggregate 10 percent when tested with sodium sulphate ( $\text{Na}_2\text{SO}_4$ ) and 15 percent when tested with magnesium sulphate ( $\text{MgSO}_4$ )

(b) For Coarse aggregate 12 percent when tested with sodium sulphate ( $\text{Na}_2\text{SO}_4$ ) & 18 percent when tested with magnesium sulphate ( $\text{MgSO}_4$ )

**4.1.2.4 SIZE AND GRADING OF AGGREGATES:**

**4.1.2.4.1. SIZE AND GRADING OF COARSE AGGREGATE** -Normal maximum size of coarse aggregate shall be as specified in approved drawing of work. For anyone of the nominal sizes, the proportion of other sizes shall be in accordance with table 4 shall be also in accordance with table 3.

For anyone 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

Very large, 150 to 80mm 160 mm 90 to 100

80 mm 0 to 100

Large, 80 to 40mm 80 mm 90 to 100

40 mm 0 to 10

Medium, 40 to 20mm 40 mm 90 to 100

20 mm 0 to 10

20 mm 90 to 100

4.75 mm 0 to 10

Small, 20 to 4.75 mm

2.36 mm 0 to 2

There being no IS Sieve having an aperture larger than 100 mm a perforated plate complying with IS: 2405-1980 and having a square aperture of 160 mm may be used.

(4-3)

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.

**4.1.2.5 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 beam, the nominal maximum size of the aggregates should usually be restricted to 5mm 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**

Minimum Maximum size of aggregate (mm)

dimension of

Section (mm) Non reinforced well R.C. walls beams & columns

Lightly reinforced or

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

305 to 740 80 40 to 75 75 40 to 75

750 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 Aggregates

1 2 3

1 Filling crevices in foundation of non over flow & over flow section 40

2 Spillway and training wall section (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, and 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, elevators, instrumentations etc.

20

10 Foundations 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

(4-4)

**4.1.2.5.1. - SIZE & 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 particulars 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 coarse limit of "grading zone 1 or the liner 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

IS Sieve

Designation Grading Zone-I Grading Zone-II Grading Zone-III Grading Zone-IV

10mm 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 4.1.2.5.1 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 anyone of the four grading zones may be used, but the concrete mix should be properly designed. As the fine aggregate grading becomes progressively fine, that is, from Grading Zones 1 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 aggregate.

**NOTE: - 4** it is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

**PAYMENTS - All** classifying storing in grades, screening, washing, batching or other operations of the coarse aggregate shall be done by the contractor and the cost there of shall be included in the accepted rate for the finished item of Mark in which the aggregate is used.

**4.1.2.5.2. ALL IN AGGREGATE** - "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 adjustment may be made in the grading by the addition of single-sized aggregates. The grading of the "all in-aggregate" shall be in accordance with table 8:

**TABLE 8: ALL-IN-AGGREGATE GRADING**

Percentage passing far All in Aggregate of  
 IS Sieve 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 35 to 50  
 600 micron 8 to 30 10 to 35  
 150 micron 0 to 6 0 to 6

(4-5)

**4.1.2.6. BULKING OF SAND:** In volume batching, sand is assumed to be dry. Dry and saturated sands have almost the same volume, but damp sand increase 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.

**4.1.2.7. HANDLING AND STORAGE:** Aggregates shall be stores on a clean heard surface and maintained free from loan 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 diving walls to give each type of aggregate its own compartment. Fine aggregates shall be stacked in a place where loss due to the effect of wind is minimum. The aggregates shall be handled in such a manner as to minimise 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)

S. No.

Material Length Breadth Height

(i) Soling Stone 5.0 2.0 0.50  
 or 5.0 10 0.50

Coarse aggregate 2.0 2.0 0.50  
 or 5.0 5.0 1.00

(ii)

or 5.0 1.0 0.50

Fine Aggregate 2.0 2.0 0.50

or 5.0 5.0 1.00

(iii)

or 5.0 1.0 0.50

**4.1.2.8. SAMPLING AND TESTING** -Samples 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 use 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.

#### **4.1.3. PLUMS**

**4.1.3.1.** All plums shall be hard durable, dean and free from soft materials or loose pieces or deleterious substance embedded in then and shall not have sharp comers. 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.

**4.1.3.2. 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  $1/3$ rd the least dimension of the member.

**4.1.3.3. STORAGE** -Materials shall be so stored are to prevent their deterioration of intrusion of foreign matter and to ensure the preservation of their quality and fitness for the 'work.

#### **4.1.4. 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.

(4-6)

(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 NaOH.

(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 HCL.

(c) Percentage of some impurities and solids shall not exceed the limits given in Table 10 and 11 respectively.

**4.1.4.1.** In case of doubt regarding development of strength, the suitability of water for making concrete shall of ascertained by the compressive strength and initial setting times tests specified in 4.1.4.1.2. and 4.1.4.1.3.

**4.1.4.1.1.** The sample of water taken for testing shall represent the water proposed to be used for concreting, due account being paid to seasonal variations. 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 used out with similar water.

**4.1.4.1.2.** Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similarly concrete cubes prepared distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS: 515-1959.

**4.1.4.1.3.** 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, block 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.

**4.1.4.2.** The PH value of water shall generally be not less than 6.

### **4.2. GRADE OF CONCRETE AND TYPE OF MIX**

#### **4.2.1. GENERAL**

Concrete is composed of sand, gravel, crushed rock, or other aggregates held together by a hardened paste 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 a strength and hardness and has utility for many purposes.

#### **4.2.2. 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 / mm<sup>2</sup>)

M5 5

M7.5 7.5

M10 10

M15 15

M20 20

M25 25

M30 30

M35 35

M40 40

**NOTE - 1:** In the designation of a concrete mix, letter M refers to the mix and the number to the specified Characteristic compressive strength of 15 cm cube at 28 days, expressed in N/mm<sup>2</sup>

**NOTE - 2:** M5 and M7.5 grades of concrete may be used for lean concrete and simple foundations for masonry wall. These mixes need not be designed.

(4-7)

**NOTE - 3:** Grades of concrete lower than M15 shall not be used in reinforced concrete.

**NOTE - 4:** Grades of concrete lower than M30 shall not be used in pre tensioned pre stressed concrete M40 for pre tensioned pre stressed concrete.

#### 4.2.3. CLASSIFICATION OF CONCRETE

Concrete can be classified either as "Nominal mix concrete" or "Designed mix concrete" as specified below:

**DESIGNED MIX:** Where the mix proportions 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 mix"

#### 4.3. CONCRETE MIX PROPORTIONING

##### 4.3.1. MIX PROPORTION

The mix proportions 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 form work. When concrete is hardened, it shall have the required strength, durability and surface finish.

##### 4.3.1. DETERMINATION OF PROPORTIONS

4.3.1.1 The determination of proportions of cement, aggregates and water to attain the required strengths shall be made as follows.

(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 Engineering Charge.

**4.3.1.2. 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 ratio

(g) Workability and

(h) Mix proportion (for nominal mix, concrete)

In appropriate circumstances, the following additional information may be specified.

(a) Type of aggregate

(b) Maximum cement content and

(c) Whether an admixture shall or shall not be used and the type of admixtures and the conditions of use.

**4.3.1.3. DESIGN MIX PROPORTIONING** -The mix shall be designed to produce the grade of concrete having the required workability and a characteristic strength not less than appropriate values given in table 12.

As long as the quality of the materials does not change a mix design done earlier may be considered adequate for later work.

##### 4.3.1.4. NOMINAL MIX PROPORTIONING

**4.3.1.4.1. 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.

(4-8)

#### TABLE 13: Proportions for Nominal Mix Concrete

Grade of Total quantity of dry aggregates by Proportion of quantity of water per

concrete Mass per 50 Rg. of Cement to be fine aggregate to coarse 50 kg of cement

taken as the sum of the individual aggregate (By Mass) (Max)

masses of fine and coarse aggregates

Max Kg. Litre

1 2 3 4

M5 800 Generally 60

M7.5 625 1.2 but subject to 45

M10 480 an upper limit of 1:1:5 34

M15 350 and a lower limit of 32

M20 250 1: 2: 5 30

**NOTE** -The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregate becomes large Graded coarse aggregate shall be used.

**EXAMPLE** -For an average grading of fine aggregate that is Zone II of Table 6 the proportions shall be 1:1:5, 1:2 and 1:2.5 for maximum size of aggregate 10 mm, 20 mm and 40 mm respectively.

**4.3.1.4.2. NOMINAL MIX CONCRETE BY VOLUME:** - Nominal 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 M 7.5, M10, M15 and M20 concrete respectively.

For cement which normally comes in bags and is used by weight, volume shall be 'worked out taking 50, kg 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.

**4.3.1.4.3. LIMITATION OF NOMINAL MIX PROPORTIONS** -The nominal mix proportion in Para 4.3.1.4.1. and." **4.3.1.4.2.** Shall be valid provided that:

(i) 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 4.1.2.5.2. Size and Grading of Fine Aggregate.

#### **4.3.1.4.4. GUIDE LINES FOR NOMINAL MIX PROPORTIONING**

(i) The cement content of fine mix specified in table 13 for any nominal mix shall be proportionate by increase if the quantity of water in a mix has to be increase to overcome the difficulties of placement and compaction, so that the water cement ratio as specified is not exceeded. In case vibrated concrete, the limit of quantity of water specified in table 13 may be suitably reduced to avoid segregation.

(ii) Allowance for bulking of sand is necessary only in case of volume batching as described in Para 4.1.2.6. 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.

(4-9)

#### **TABLE 14: Surface Water Carried by Aggregate**

Aggregate Approximate quantity of surface water

Percent by Mass Litre/Cum.

Very wet sand 7.5 120

Moderately we sand 5.00 80

Moist sand 2.5 40

\* Moist gravel or creshed rock 1.5.to 2.5 20 to 40

\* Coarser the aggregate, less the water it will carry

(iii) 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.

### **4.4. QUALITY OF CONCRETE**

#### **4.4.1. 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, mixing, 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.

#### **4.4.2. 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 4.3.1.4. Nominal Mix Proportioning.

The preliminary tests shall be completed well before the beginning of concreting operation 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-Charges 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 moisture content on surface of aggregate) shall be made unless additional tests have been conducted to show that the quality and strength of the resulting concrete are satisfactory.

The Engineer-in-Charge may carry out 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.

**4.4.3. WORKABILITY** - From the stage of mixing till it is transported, placed in the form work and compacted fresh concrete should satisfy a number of requirements mentioned below.

(a) The mix should be stable, in that it should not segregate during transportation and placing. The tendency of bleeding should be minimised.

(4-10)

(b) The mix should be cohesive any 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 thorough 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, compatibility place ability and finish ability of fresh concrete mentioned above are collectively referred to as "workability." Optimum workability of 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.

**4.4.3.1 MEASURES OF WORKABILITY** - There are following three methods for measuring the workability:

(a) Slump test (b) Compaction 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 25 125 mm. For, very stiff mixes having zero slump, the slump test does not indicate any difference in concretes of different workabilities.

(b) **COMPACTION 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. Detailed procedure of this test is given in given 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 right 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: 1119-1959.

**4.4.3.2** The choice of workability depends upon the type of compacting equipment available, the size of the section and concentrate on the reinforcement. For heavily reinforced sections or when the sections are narrow or containing - accessible part or 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 work abilities required interim of slump, Compacting factor and vee-bee time for concrete depending upon placing conditions at site. The nominal maximum size if aggregates make a difference in degree of workability that may be suitable under a particular placing condition. The values in the table are only a guide not withstanding the situation at hand and should be properly assessed to arrive at the desired workability in each case. In sufficient workability resolution 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 given below.

**TABLE 15**

Placing conditions Degree of Value of workability



**Workability**

1 2 3

Concreting of shallow sections with vibration very low 20-10 seconds, vee-bee time or 0.75-80 compaction factor

(4-11)

Concreting of lightly reinforced sections Low 10-15 seconds Vee-Bee time with vibration or 0.80-0.85 compaction factor

Concreting of lightly reinforced sections Medium 5-2 seconds, vee-bee time or without vibration or heavily reinforced or 0.85-0.92 compacting factor section with vibration or 25-75 mm, slump for 20 mm aggregate.

Concretion of heavily reinforced sections High Above 0.92 compacting factor with vibration or 75-125 mm. slump for

Note -for smaller aggregate the value of 20mm aggregate.

slump will be lower

**4.4.4. 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 depend 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 alone is not a reliable 'guide 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 its permeability with strong dense aggregates a suitably low permeability is achieved by having a sufficiently low watercement ratio, by ensuring a thorough compaction of the concrete as possible and by ensuring sufficient hydration of cement through proper curing methods. Therefore, for given aggregates, the cement contents should be sufficient to provide adequate workability with allow water cement ratio so that concrete can be completely compacted with the means available.

**5 MIXING:-**

4.5.1.6 The mixing of concrete shall be done in a batch, mixer of such approved type as will ensure the homogeneous distribution off 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 color 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.

**4.5.2. EFFICIENCY AND PERFORMANCE OF MIXER:**

4.5.2.1 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 weighting In water ) in 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

4.5.2.2.1 The mixer shall comply with IS: 1791-1985 and its performance should be tested according 4634-1968

4.5.2.2.1 A mixer will be considered unsatisfactory if from there tests of anyone batch a range in slump exceeding 25 mm or a range in air content exceeding one percent is given between representative sample taken at different portions of the mixer discharge.

4.5.2.3.2 For anyone mix, the variation in the air free unit weights of three samples taken from the front centre and back of batch of concrete in the mixer. shall not exceed the following.

For one batch 37.2 kg. per cum

(4-12)

Average of 3 batches 23.9 kg. per cum

Average of 20 batches 19.4 kg. per cum

Average of 90 batches 14.6 kg. per cum

**4.5.3 METHOD OF CHARGING-** The proper sequence of operations of 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 and 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 introduced 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 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 coarse aggregate. However may be added last: this facilitates the clearance of the chutes and removes any fine aggregate or cement adhering to the sides.

#### **4.5.4. 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**

Capacity of Mixer Time of Mixing

Natural aggregate Manufactured aggregate

Cone cubic meter or less 1.1/4 minutes 1.1/2 minutes

Two cubic meters 1.1/2 minutes 2 minutes

Three cubic meters or larger 2 minutes 2.1/2 minutes

4.5.4.1 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 inter locked 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 be avoided.

#### **4.6 FORM WORK:**

##### **4.6.1 GENERAL:**

4.6.1.1 Forms shall be 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 sloughing from adjacent surface left by excavations or other features of the work. All exposed concrete surface having slopes of 2 horizontal to 1 vertical or greater shall be formed.

4.6.1.2 Form work may be of timber, steel or pre cast concrete panels or of such other suitable materials or combination of such material. Form work shall be substantially and rigidly constructed to the shapes, lines and 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 drawings.

(4-13)

4.6.1.3 The surfaces of form work shall be made to produce surface finishes as specified and form work joints space is tight enough to prevent loss of liquid from concrete. Joints between the formwork and existing concrete structures shall also be grout tight. Formwork 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 providing they do not reduce the strength or effective cover of any part of the structure below the required standard but the use of through bolts 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.

4.6.1.4 Forms shall overlap the hardened concrete in the lift previously placed not more than 75 mm. and shall be tightened snugly against the hardened so that when concrete placement is resumed, the forms will not spread and allow off sets 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 deviation or projections.

4.6.1.5 Moulding strips shall be placed in the corners of forms so as to produce chamfered edges as required on permanently exposed concrete surface.

##### **4.6.1.6 PAYMENTS:-**

No separate payment will be made to the contractor for morally erection, striking and removal of forms. The rate for the same shall be included in the rate of concrete of the particular item.

##### **4.6.1.7 PRECAST CONCRETE WORKS:**

- (i) The requirements of clauses relating to concrete and reinforced concrete shall be observed in the case of pre cast concrete works, in so far as they are applicable, as well as the following requirements relating to the recast concrete works in particular
- (ii) PRECAST UNITS -The pre cast units shall be cast in-on their shutters supported from suitably prepared level and holding panel areas.
- (iii) Shutter shall be strong, constructed closely joined and smooth and shall be such as to ensure their sharp edges and a perfect surface as stated in the drawings. Shutters are to be so designed that they can be taken and re-assembled readily.
- (iv) The casting tolerance, unless otherwise ordered or directed shall be within 3 mm of true dimensioned surface line deformation due to pre stress shall be allowed for while checked dimensions.
- (v) The method and time of casting of unit, of striking the side shutter shall be subject to approval of the Engineer-in Charge. In the event of any other causes the unit or units concerned will be liable of rejection and to replacement by the contractor at his own cost.
- (vi) (a) The top of sides of shall be kept covered in a damp condition for at least 14 days after casting or for such periods as the Engineer-in Charge may decide.
- (b) Accelerated curing of pre cast members, if deemed necessary by the Engineer- in-Charge shall be done in a mechanical way i.e. other by a vapor or by electrical system and the process of curing shall be approved by the Engineer-in-Charge. The contractor shall assure that the pre cast unit shall gain the desired maturity before placing it in store yard without sacrificing the architectural appearance as shown and specified.
- (vii) Fitting and stacking of pre cast unit shall be undertaken with out causing shock, vibration, or under stress to the units. Pre cast units shall not be lifted transported or used in the works until they are sufficiently mature. The crushing tests on the test tube, which are to be kept with the pre cast units will be used to assess the maturity of the units. The contractor shall satisfy the Executive Engineer that the method he purposes for lifting, transporting and setting the pre cast units will not overstress or damage due to 'whatever cause, the units condemned will be liable to rejection. And if so rejected unit shall be immediately broken up and removed from the site. The contractor shall replace such rejected units at his own cost.

(4-14)

- (viii) The contractor shall ensure that all pre cast units are properly marked in clear and legible manner with reference No. and dates of casting The information shall be clearly visible 'when the units are stacked. Reinforced pre cast member shall be clearly marked to indicate the top surface.
- (ix) For full and accurate records of the materials of all pre cast work, every unit shall have reference No. 1 date of casting date of removal from the bed and date and position of packing shall be recorded.

#### **4.6.2 CLEANING AND TREATMENT OF FORMS:**

At the time concrete is placed in the forms, the surface of the forms shall be free from encrustations of mortar, grout other foreign material. Before concrete is placed, the surfaces of the forms designated to produce F2, F3 and 4 finishes shall be oiled with a commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces. For timber forms, 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.

#### **4.6.3 REMOVAL OF FORMS:**

- 4.6.3.1. Except as otherwise provided in this sub-clause form shall be removed as soon 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 imperfection.
- 4.6.3.1 Forms on upper sloping faces of concrete, such as forms on the water sides of warped transition, shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging any needed repairs or treatment required on such sloping surface shall be performed at once and be followed immediately by the specified curing.
- 4.6.3.2 In order to avoid excessive stresses in the concrete that might result from swelling of the forms, timber forms, for well opening shall be loosened as soon as this can be accomplished without damage to the concrete.
- 4.6.3.4.. 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 the less than 400mm and that the forms are not exposed to view after completion of the work.
- 4.6.3.5. Forms shall be removed with care so avoid injury to the concrete any concrete in damage in form removal shall be repaired in accordance with the provision of Para 7. 16 repair of concrete.
- 4.6.3.6. The following minimum intervals of time as 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 all structural members. 24 to 40 hours

- (b) Slabs (props left under) 3 days
- (c) Beam (Sophist) 7 days
- (d) Removal of props under (i) Slabs spanning up to 4.5 m 7 days
- (ii) Slabs Spanning over 4.5 m 14 days
- (e) Removal of props under beams (i) Spanning up to 6m 14 days
- and arches (ii) Spanning over 6m 21 days
- (iii) Spanning over 10m 28 days

In some cases such 'while using cements other than ordinary Portland cement or when conditions are not normal, it may be necessary to estimate the strength of concrete at the time of form work. Cubes if they are cast to determine the strength of concrete at the time of removal of formwork should be cured along with the structure and not under standard conditions 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.

(4-15)

Due regard is to be given to curing methods to be employed before the form work is removed.

Then controlled concrete of m 20 and more strength is used, the forms of slabs may be removed when concrete has generate strength equal to double the stresses generated by the dead load plus live load of 200 Kg/m<sup>2</sup>. In any case this period shall not be less than 96 hours on placing last batch concrete in the slabs.

**4.6.3.7 SEQUENCE OF REMOVAL OF FORMS:** In respect of complicate structure referred to under water concreting the sequence of removal forms may be obtained from design office.

#### **4.7. PREPARATION FOR PLACING CONCRETE**

4.7.1 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

##### **4.7.2 Rock Foundation.**

4.7.2.1 All rock surfaces against which concrete is to be placed shall be clean and free mud, dirt, oil organic deposits or other foreign materials which may prevent a tight bond between the rock and concrete. Seams shall be cleaned 10 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 soil rock. Scaly contenting hardened grout or concrete, construction debris, and other objectionable materials shall be removed. Seepage shall be properly controlled and inverted. The foundation bed and sides shall be carefully cleaned with stiff brooms, picks, jets of water and air applied at high velocity or them equally effective means followed by thorough washing. After washing and before placing any concrete, water shall be removed from depressions and the rock surface shall be left uniformly damp. If any drilled holes are left in the foundation surface which is no longer needed, the holes shall be cleaned with air water jetting and filled up completely with cement slurry.

4.7.2.2 All flat surfaces shall then be coated with mortar about 1.5 cm thick 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 boomed 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 its initial set.

4.7.2.3 No concrete shall be deposited until the foundation has been inspected and approved. 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 instructions shall be issued for preparing scaly or cracked foundations requiring special treatment of grouting.

4.7.2.4 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.

##### **4.7.3. Earth or Shale Foundation:**

4.7.3.1: In the case of earth or shale foundations, all sort or loose mud and surface debris shall be scraped and removed. The surface shall be moistened to a depth of about 15cm to prevent the sub grade from absorbing water from the fresh concrete. Just before placing the concrete the surface of the earth shall be tamped or otherwise consolidated sufficiently to prevent contamination of concrete during placing. In general, concrete shall be deposited only upon material lying in natural undisturbed state.

4.7.3.2 Foundation of porous or free-draining materials shall be thoroughly compacted by flushing and by subsequent tamping or rolling, if necessary. The finished foundation surface shall then be blanketed with a layer of 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.

(4-16)

4.7.3.3 Unless otherwise specified, the under drainage system for all foundations shall be blanketed as



specified under Para 4.7.3.2.

#### **4.8 PLACING OF CONCRETE:**

4.8.1 General: No concrete shall be placed until the place of deposit been thoroughly inspected and approved by Engineer-in-charge, all reinforcement, inserts and embedded metal property 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 hours of the approval being 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 45 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, precautions shall be taken to see that temperature of wet concrete does not exceed 40 C.

4.8.2 Sequence of Concrete: In respect of 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.

4.8.3 Within Forms: Concrete shall be systematically deposited in shallow, layer and at such rates as to maintain, until the completion of the unit, a plastic surface approximately horizontal throughout. Each layer shall be through compacted before placing the succeeding layer. In general the thickness of layer shall not exceed the following limits.

- a) Vibrated mass concrete 45cm.
- b) Hard compacted mass concrete 30cm.
- c) Reinforced concrete 25cm.

The batches shall be deposited vertically in such in 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 part of the live surface .of a concrete layer. Wherever necessary both the forms and reinforcement shall not be protected against splashing and all accumulation of partially set dried, or caked mortar which may impair the bonder show in the finished faces shall be removed and wasted before commencing concreting operations.

#### **4.8.4 Cleaning Joints:**

4.8.4.1 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept dean so to expose sound concrete surface. The method 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. Bruising shall be done by Jabbing and digging Into the surface rather than by manly sweeping. The whole process shall be concrete in such manner as not to loosen the coarse aggregates but vigorously enough to expose a fresh dean cut concrete surface. .

Immediately before depositing fresh concrete, the contact surface shall again be gone over and through washed to remove all debris and loose material. The final pick up of loose material shall be made near the center 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 depression 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 proportion of water air entraining agent cement and fine aggregate as the concrete mixture which is to placed upon it .The water cement ratio of the mortar in places shall exceed that of the (4-17)

concrete to be placed upon it and he 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 de interstices and hollows or neat cement slurry shall be applied on the surface before it is dry so as to provided the best possible condition for bond and impermeability. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing of the concrete.

4.8.4.2. 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. This 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 comers and close, spots, work thereafter shall proceed in the normal way.

4.8.4.3 Should the next lift be delayed the contact surface shall be kept wet and covered so as to minimise 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.

4.8.4.4 If from any cause, the working surface is left exposed unit 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/cm<sup>2</sup> (500 PSI) has been attained, before completing the lift. The surface thus, interrupted shall be treated in same manner as described in Para 4.8.4.1.

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 foundation under Para 4.7.2

4.8.5 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 to rapid a placement 'which may result in movement or failure of the form due to excessive internal pressure. An interval of at least 4 and preferably 24 hours should elapse between the completion of columns and wall 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 lacing of embedded material. 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.

#### **4.9 CONCRETING UNDER SPECIAL CONDITIONS**

4.9.1 Work in extreme weather Condition: During hot or cold weather concreting should be done as per the procedure set out in IS: 7861 part I or part II

4.9.2 .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 test 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 column 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 slumps of not less than 100 mm, and not more than 180 mm.

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. Cofferdams or forms in still water shall be sufficiently tight to prevent loss of mortar though the walls. Dewatering by pumping shall not be done 'while concrete is being placed or until 24 hours thereafter.

(4-18)

Position and to prevent distortion 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 he following.

**a) Tremie-** When concrete is to be deposited under water by means of a tremie the top section of the tremie shall be 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 with stand 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 stacking or other approved material before delivering the concrete to the tremie pipe through the hopper. so that when the concrete is forced down from the hopper 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 he below the top surface of the plastic concrete. This will cause the concrete to build up from below instead following 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, as 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 down ward and outward when tripped. The bucket shall be filled completely and lowered slowly to avoid backwash. The bottom doors shall not be opened until the bucket rests on the surface upon which the concrete is to be deposited and when discharge 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 be free from deleterious material.

**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 and 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 less 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<sup>2</sup>) 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 600 mm, 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 be concreted.

To minimise the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

#### 4.10. COMPACTING

**4.10.1 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.

(4-19)

4.10.1.1 Compacting shall include rodding, spading, tamping, vibrating, treading, and such other operations finishing, as are necessary to consolidate and mould the concrete properly. The rate of placing mass concrete or enforced concrete in thin sections, whether mechanically or by manual labour, shall be clearly defined.

4.10.1.2 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 circumstance shall such accumulation of water be covered up with concrete or dry concrete used to soak up excess water.

4.10.1.3 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 place 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.

#### 4.10.2 Vibrating.

4.10.2.1 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.

4.10.2.2 The intensity and duration of vibration shall be 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.

4.10.2.3 Vibration shall be continued until the entire batch melts to uniform appearance and the surface just 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.

#### 4.10.3. Internal Type Vibrators

4.10.3.1 Mass concrete shall be thoroughly compacted with the aid of high frequency, mechanical vibrators of the internal type having not less than 3600 and preferably more than 5000 impulses per minute.

Immediately after depositing the concrete, the vibrators shall be inserted into each pipe, operated from 10 to 20 seconds in one spot and then moved to another not over 90 cm (or 3ft) away.. The operation shall be repeated over until the entire mass is thoroughly compacted and the pipe, 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.

4.10.3.2 The use of flexible shift vibrators, if permitted, shall closely follow special instruction issued for the purpose.

4.10.3.3 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 satisfactory worked. However, concrete for which a slump greater than 10 cm is specified shall not be vibrated unless otherwise ordered. Care shall be taken not to disturb a set layer. The vibrators shall be held vertical as far as possible.

4.10.3.4 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.

(4-20)

#### **4.10.4 External Type Vibrators**

4.10.4.1 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 platform vibrator used to compact the concrete and bond the key to the body of the lift.

4.10.4.2 Form vibrators shall be permitted only for special purpose specified under 4.10.1.3. and extreme care shall be exercised to avoid pumping air into the concrete.

4.10.5 Surface Voids: Large voids or air pockets, which may be left in the permanently exposed faces of 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.

#### **4.11 CURING OF CONCRETE**

4.11.1. General: All concrete shall be cured by water in accordance with the requirement of Para 4.11.3 of this clause or membrane curing in accordance with requirements of Para 4.11.4. of this clause. Concrete surfaces to be pointed shall not be cured by membrane curing.

4.11.2 Curing of Unformed Surfaces And Piers: The unformed top surfaces' off walls and piers shall be moistened by covering with water saturated material 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 informed top surfaces and allowed to pass down between the formed concrete faces. This procedure shall be, followed by the specified water curing and membrane curing.

4.11.3. 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 popes 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 concretes as part replacement of cement.

##### **4.11.4. Membrane Curing**

4.11.4.1 Membrane curing shall be by application of suitable type of white pigmented curing compound "Which forms a water retain membrane on the surface of concrete, provided that on concrete surfaces "Which will be permanently exposed to view dear curing compound may be required. Cutting 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 litre as prescribed by the manufacture according to the roughness of the surface to be covered. If necessary to cover the surface adequately a second coat of curing compound shall be applied by spraying at right angles to the direction at which first coat was applied. Mortar encrustation and fins on surface or which finish F4 is specified shall be removed prior to application of curing

compound Curing compound shall be applied to all areas of concrete surface except that those part with surface imperfection shall be omitted until repaired.

4.11.4.2 When curing compound is to be used on formed CONCRETE SURFACES. APPLICATION OF THE COMPOUND SHALL COMMENCE immediately after the finishing operations are completed.

4.11.4.3 When curing compound is to be used on formed concrete surfaces, application of the compound shall commence immediately after the finishing operation are completed.

4.11.4.3 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 during compound shall be applied.

There must be ample coverage with the compound at edges, comers 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

(4-21)

concrete surface shall be performed. Each repair after being finished shall be moistened and coated with curing compound in accordance with the foregoing requirements.

4.11.4.4 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. There it. Is impossible be Cause 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 proactive 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 with cut delay.

4.11.4.5 Curing compound if used shall be of approved quality.

#### **4.11.5 REPAIRS OF CONCRETE**

4.11.5.1 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 honeycombed, fractured or otherwise defective and concrete which because of excessive surface depressions excavated and built up to bring the surface to the prescribed line, 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.

4.11.5.2 Methods of Repairs: For new Works four methods are used.

4.11.5.2.1 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, nor filling holes which extend entirely through the wall beam etc.

4.11.5.2.2. Concrete Replacement Method: Concrete replacement should be used when holes extend entries through the con rate sections, when holes in un reinforced 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 Sqm in area and deeper than the reinforcement steel.

4.11.5.2.3. 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 depression, large and small, which extend more deeper than far side of 'he reinforcement bars nearest the surface.

4.11.5.2.4 Epoxies Method: A thermosetting plastic known as epoxy can be used as a bonding medium wherever long time curing of conventional concrete can not be assured. Also epoxy mortars of fine sand as well as plain epoxy are suitable for concrete repair work and should be used whenever vary 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 C to 27C 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 repaired. A wash of dilute 1:4 meiotic 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.

(4-22)

#### **4.11.5.3 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 almost 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 through cleaning and drying with an air jet. Care should be taken to remove any loose materials embedded in the surface by chisels 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.

#### **4.12. FINISHING OF CONCRETE SURFACE:**

##### **4.12.1. CLASSES OF FINISH FOR FORMED SURFACE.**

4.12.1.1 Allowable deviations from plumb or level and form the alignment, profile grads and dimensions shown on the drawings are defied 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 (Vol. I. specification)

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 as directed, finishing of concrete surfaces shall be performed only by skilled workmen.

Concrete surfaces with be tested where necessary to determine whether surface irregularities are within the; limits hereinafter specified.

4.12.1.2 Surface irregularities are classified as 'abrupt' offset caused by displaced or misplaced From sheeting or lining or from sections or by loose knot are otherwise detective from time be 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 of use of template, consisting of a straight edge or the equivalent there of for curved surfaces. /the length of template will be one and half meters for formed surfaces and three meters for testing unformed surfaces. .

4.12.1.3 The classes of finish for formed concrete surface are designated by one of the symbols F1, 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 then that necessary for the repair of surface imperfection. Unless otherwise specified or indicated on the drawings, the classes of finish, which apply, are as follows. FINISH F1 -This finish is applied to surfaces where roughness is not objectionable such as those 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 depressions deeper than 25 mm and filling of tried holes, Form sheathing shall not leak mortar ~en the concrete is vibrate~ Forms may be built with a minimum of refinement.

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 walls not prominently exposed to public view and in the galleries sand admits in the dam, except where F1 finished are permitted. Forms shall be built in a workmen like manner to the required' dimensions and alignment. Without conspicuous offsets of bulge surface, irregularities. shall not exceed 5 mm for abrupt irregularities and 10 mm for gradual irregularities measured from a 1.5 template.

FINISH F3 -This finish is designated for surfaces of structures permanently exposed to public view where appearance is of special importance. This shall include parapets, railings ad decorative features on the dam and on the bridge. To meet the requirement for the F3 finish, forms shall be built in a skilful, workman. like manner, accurately to dimension. There shall be no visible offset bulges of misalignment of the concrete.

At construction, of

(4-23)



joints the forms shall be lightly set and securely anchored close to the joint. Surface irregularities shall not exceed 3 mm for abrupt irregularities and 5 mm gradual irregularities measured from a 1.5 mm template. **FINISH F4** -This finish is required for formed concrete surfaces at the spillway crest, glacis and bucket and inside sluices where accurate alignment evenness of surface are essential for prevention of destructive effects of water action the must be strong and held rigidly and accurately to the prescribed alignment for warped surfaces the forms shall be built up in sections cut to made right. Smooth surface after which the form surfaces are dressed and sanded is 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 minimised and where such air holes are found, they shall be repaired in accordance with relevant section.

#### **CLASSES OF FINISH FOR UNFORMED SURFACES**

**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 drawing these classes of finish shall apply as follows:

**FINISH U1**- This finish applies to unformed surfaces that will be covered by fill material, masonry or concrete or where a screened surface finish meets the functional requirements. Finishing U is also used as the first stage of finishes for U2 and U3. Finishing operations shall consist of sufficient leveling and screening to produce even uniform surfaces. Surface irregularities measured as described in this section shall not exceed 10 mm.

**FINISH U2**- This is a floated finish and applies to all out door unformed 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 screened 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 troweling. Surface irregularities measured as described in this section shall be tolled down where down on the drawing or as directed.

**FINISH U3**- This is a trowel led finish and may be specified for tops of parapets prominently exposed to view, and conduct invert immediately downstream of regulating gates and valves. When the floated surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface steel trowel ling shall be started. Still trowel ling 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 trough marks. Surface irregularities, measured as described in relevant part of this section, shall not exceed 5 mm. Where a hard steel trowel led finish is specified the regular U3 finish shall be trowel led again after the surface has nearly hardened using firm pressure and trowel ling until the surface is hard and has a slightly glossy appearance.

**FINISH U4**- This is a steel trowel led finish similar to finish U3 except that light surface pitting and light trowel marks such as obtained from the use of machine trowel ling or lining machines will be acceptable, provided the surface irregularities do not exceed the limits specified for finish U3.

Unformed surface which are nominally level shall be sloped for drainage as shown on the drawings or as directed. Unless the use of other slope or level surface is indicated on the drawing. Narrow surface such as tops of parapets, tops of walls and keys shall be sloped approximately one cm per 30 cm of width, border surface such as roadways, platform and decks shall be sloped approximately half centimeter per 30 cm of width.

**4.12.2. 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 of five and half parts of aggregate by weight. The fines in the aggregate (viz. sand) may be permitted up to 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 at 7 days as determined by test on 15cm by 30cm cylinders should not be less than 70Kg/cm<sup>2</sup> and the porosity at 7 days be such that water shall pass through a slab of the concrete 30cm thick at a minimum rate of 500 litres /min./Sq. metres of the slab with a constant 10cm depth (4-24)

of water standing on the slab. The porous concrete blocks shall be laid as shown in the drawings or as directed by the Engineer-in-Charge to form porous -drains in the masonry dam.

#### **4.13 STANDARD OF ACCEPTANCE:**

4.13.1 GENERAL: The standard of acceptance will be the same whether it is "Nominal Mix Concrete"

of Design Mix Concrete. For relatively small and unimportant buildings and 'works in which quantity of concrete is less than 15 cubic metre. The strength tests may be waived by Engineer-in-Charge, at his description.

Random samples from fresh concrete shall be taken as specified in IS: 1199-1959 and cube shall be made cured and tested as described in IS: 516-59. It 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 then 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 the data 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 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. There sufficient test results 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 DEVIATIO**

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

4.13.2. DETERMINATION OF STANDARD DEVIATION: The standard deviation of a given grade shall be calculated using the following formula from the results of individual test of concrete of that grade obtained.

Estimated standard deviation

Where = Deviation of the individual test strength from the average strength of n samples and

n=Number of sample test results.

4.13.3 ACCEPTANCE CRITERIA: The concrete shall be deemed to completed with the strength requirement if:

4.13.3.1.(a) every sample has a test strength not less than the characteristic value :or

(b) The strength of one or more samples through less than the characteristic value; is in each case not less than the greater of : (1) The characteristic strength minuses 1.35 times the deviation; and (2) 0.80 times the characteristic strength; and the average strength of all the samples is not less than the characteristic strength plus

(4-25)

1.65

**[ 1.65-- \_\_\_\_\_ ]** time the standard deviation

no. of samples

4.13.3.2 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 time the standard deviation; and (ii) 0.80 times the characteristic strength or

(b) The average strength of all the samples is less than the characteristic strength plus

3

**[ 1.65-- \_\_\_\_\_ ]** time the standard deviation

no. of samples

Concrete which does not meet the strength requirement as specified in 4.13.3.1. above but has a strength greater than that required by 4.13.3.2 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 4.13.3.2.the structural adequate of the parts affected shall be investigated and consequential action as needed shall be taken.

Concrete of each grade shall be assessed separately.

Concrete shall be assessed daily for compliance.

Concrete liable to be rejected of 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.

#### 4.14 FILLING FOUNDATION WITH MATERIALS OTHER THAN CEMENT CONCRETE

##### 4.14.1 FILLING FOUNDATION WITH TIME CONCRETE:-

4.14.1.1 Proportioning:- The proportion of lime mortar shall be as specified in the item of work and proportion of lime mortar and coarse aggregate shall be one of lime mortar and work of the coarse aggregate all by volume and measured in measuring boxes.

4.14.1.2 Lime Mortar Proportion -Lime mortar shall be prepared in accordance with the specification laid down under Para 6.6.3 of Chapter '6' Mortar'

4.14.1.3 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 joint. 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 of mortar concrete 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 coat 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 that can be laid to place and rammed the some day when it is necessary to give Fluidity to concrete, this shall be effected by adding water to mortar and to the mixed concrete.

4.14.1.4 Form 'Work -Form 'Work if necessary shall be as specified under Para 7.8 and shall be removed only after concrete is set

4.14.1.5 Laying- Before placing the concrete, the head of the concrete shall be cleaned of all loose stuff, moistened and rammed if necessary. Form 'Work if used shall be approved by the Engineer-in-Charge, before lying.

Concrete shall be used while fresh. It shall be laid (and not thrown) in layers not exceeding 15 cm to 20 cm in thickness.

(4-26)

4.14.1.6 Compaction -Concrete shall be well compacted by ramming with wooden or on rammers with area of ramming not exceeding 320 sqcm and weighting not less than 4.50 kg before the next layer is laid. The consolidation shall continue for each layer with mortar creams up to 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 up to the surface, the top surface should be grouted within mortar. No ramming shall be done after the concrete has begun to set. Ramming shall be done by one or more lines of men, raged 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 ten laying consecutive layers 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.

4.14.1.7 Curing- All time 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 cession or straw and watering very frequently form 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

free for any injurious materials. Filling Foundation with excavated materials, Soil, Sand or Moorum-

4.14.1.8 Preparation -The ground over which filling has to be done shall be cleared of all grass. Loose stones, rubbish of all kinds as well as tree roots bushes, etc. If there is water it shall be pumped or billed 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 stones, etc and clods broken down to a size of 50 mm or less. Materials to be brought from out side i.e. sand, moorum or yellow soil shall also be clean of all rubbish and shall be used only after the approval of the Engineer-in-Charge.

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 rammers before the upper layer is laid, till the required level is reached so as to form 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 expensive and shrinkable soil shall be used for filling foundation or under the plinth

#### 4.15 REQUIREMENTS FOR DURABILITY

##### MINIMUM CEMENT CONTENT REQUIRED IN CEMENT CONCRETE TO ENSURE DURABILITY

## UNDER SPECIFIED CONDITIONS OF EXPOSURE

Exposure Plain Concrete Reinforcement concrete

Mini Max Min Max

Cement Water cement water

Content cement content cement

kg/m<sup>2</sup> ratio kg/m<sup>3</sup> ratio

1 2 3 4 5

Mild- For example, completely protected against weather, or aggressive conditions, 220 0.7 250 0.65

except for a brief period of exposure to normal weather conditions during construction

Moderate- For example. Exposed 250 0.6 290 0.55

sheltered from heavy and wind driven rain

and against freezing, whilst saturated with

water buried concrete in soil and concrete

continuously under water

Sever-For example exposed to sea, 310 0.5 360 0.45

water alternate wetting and drying and

to freezing whilst wet subject to heavy

condensation or corrosive fumes.

(4-27)

NOTE: When the maximum water cement ratio can be strictly controlled the cement in the above table may be reduced by 70 percent.

NOTE: The minimum cement content is based on 20 mm aggregate. For 40 mm aggregate. It should be reduced by about 10 percent: for 12.5 mm aggregate, it should be increased by about 10 percent.

**4.16 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 properties & aggregate grading in succeeding batches. Then 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 must inadvisable except for small or unimportant jobs, The point against measuring cement by volume (even when other materials are measured by vol.) is that is difficult to secure accuracy in as much as actual volume of a given weight of cement depends upon how it is filled into the gauge box and whether it is shaken down. The density of cement may vary from about 1.12 per cm<sup>3</sup> if it is lightly purred into the container to well over 1.60 gm per cm<sup>3</sup> if tamped down sufficiently hard invariably, therefore 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 weighted into a bucket suspended from an ordinary 50 kg string balance.

3. GAUGING AGGREGATES BY VOLUME- Aggregate can be gauged by volume not this popish wooden" batch boxes called frames are used.

The size of the farms 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 farm that ~ll 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 farms should be made of 3 cm thick prepared timber which gives a good strong job. Joints should be tongued & grooved ~the the tongue on the inside of the box. This prevents any dirt getting in if the joints should be through shrinkage or rough handling. The faces of the joints should all be painted ~the red lead linseed oil before the frames is assembled.

**SIZES OF FARMAS**

Capacity litres 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 farm 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 joints

should open through shrinkage or rough handling. The faces of the joints should all be painted with red lead linseed oil before the form is assembled.

It is advisable to flash the top edge of the box with sheet metal to keep as clean level edge for striking off. The handles should be shaped to provide an easy grip.

(4-28)

Then a mixer machine is used on the job it will be convenient to have lips on the sides on the form, which can then be rested on the mixer hopper when the contents are being tipped in. Before concreting operations are started the form volumes should be checked for specified quantities then filling the forms the material should be thrown loosely into the box & struck off level on compacting should be allowed. At the end of the each days work the form should be stacked upside down to prevent any accumulation of rainwater.

4. Calculating batch volumes. : A concrete mix is generally specified in parts by volume, as for example 1 : 1/2 : 3, 1 : 2 : 4 etc, meaning one part of cement, of to so many part of sand to so many of sand to so many parts of coarse aggregate. Since it is proposed to use only whole bags of cement those 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 litres of cement, so above figures should be multiplied by 35. The mix will therefore be: 50 kg of cement to 88 litres of sand to 140 litres 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 form for the sand made up to hold half of 88 litres (30x30x49cm) & fill it twice & for the coarse aggregate a 35 litres form which would be filled four times. Forms much larger than 50 litres in size are rather inconvenient to use.

5. The Phenomenon 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 surface of the particles, fulfilling them apart This is called bulking and for a moisture content of about 5 or 5 percent may be as much as 20.30 or even 40% depending upon the grading of the sand, (fine sands bulk more 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 in undrained the volume is approximately the same as when measured dry & loose. If allowance for bulking is not considered when batching by vol. it will not only increase the cost of concrete by reducing the yield per bag of cement but it will also have an unbalanced 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 depend 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 proportion glue is imparted 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 accurate & cannot be too strongly condemned.

The mix design gives together With the specified mix, the exact quantity of mixing water to be used, as to many litres per 50 kg of cement. An exact 5 litre measure is used to calibrate 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 be used

7. Summary: The precautions that must be observed in the batching of concrete by volume can be summed up in a series of don'ts

(1) Don't gauge cement by volume 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 be required weigh the cement into a bucket suspended from an ordinary 50 kg spring balance.

(2) Don't gauge aggregate into any old container. Have special forms made on each job carefully calculating their dimensions to suit the field; mix proportions.

(3) Don't make forms large than about 50 litres otherwise they become unwieldy. It is preferably to use a form which contains, say half the required quantity & fill it twice over.

(4) Don't compact aggregate into the form when filling them in. The aggregates should be loosely thrown in to the box & struck off level.

(5) 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 the volume of dry sand specified in the mix

(6) Don't gauge water "by the eye" With any odd tin can direct into the mixer. Measure the water carefully into a calibrated container.

(7) Don't neglect to make allowance for the moisture that may already be present in the aggregates when gauging mixing water.

(4-29)

## CHAPTER 5

### 5.1 UNCOURSSED RUBBLE MASONRY I RANDOM RUBBLE I POLYCONCRETE FACED MASONRY



**5.1.1 MATERIALS.**

**5.1.1.1 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.

**5.1.1.2 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.

**5.1.1.3 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.

**5.1.2 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.

**5.1.3 LAYING -**

**5.1.3.2** 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 1 metre in height.

**5.1.3.2** 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.

**5.1.3.3** 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.

**5.1.3.4** 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.

(5-1)

**5.1.3.5 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, 20mm size) conforming to size mentioned above shall be used.

**5.1.3.6 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 area of each should not be less than 003 sqm

**5.1.3.7. QUOINS** The quoins or corner stones shall be selected stones neatly dressed with hammer and/or chisel to form the required corner 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 than 500mm in length.

**5.1.3.8 JAMB STONES:** The jambs shall be made with stones specified for quoins except that the stones 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.

**5.1.3.9 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 raked to a minimum depth of 20mm by a raking tool during the progress of laying while the mortar is still green.

#### **5.1.4 SCAFFOLDING**

Single or double scaffolding shall be used. The scaffolding shall be strong and sound. The holes left in masonry for supporting scaffolding shall be filled and made good before plastering

#### **5.1.5 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 pozzolana) curing shall commence two days after laying of masonry and shall continue for seven days.

#### **5.1.6 PAYMENT:**

(i) The volume of masonry will be calculated from the overall outside dimensions inclusive of face work up to the joint, as shown in the drawing or directed in writing by the Engineer-in-Charge and will be paid for at the tendered unit rate for the particular item.

(ii) Double faced masonry shall be payable only for works not exceeding 120 cm (4ft) in width where the width exceeds 120cm (4ft.) - face masonry shall be payable limited to only 60 cm (2ft) width on each face. There specification on face masonry differ from those of hearting rate for face masonry will be payable only up to 60cm (2ft) from the face.

(iii) Generally the rates for masonry shall include all loads and lifts of materials unless otherwise specified in the contract No extra load shall be payable for water. The contractor shall arrange at his own cost for the supply storage, pumping etc. of water required for the construction and curing of the masonry.

### **5.2 STONE WORK IN PLAIN ASHLAR MASONRY**

#### **5.2.1 MATERIALS**

Materials to be used for ashlar masonry, shall be the same as provided in Para 8A 4. 1. 1 and 8 A.4.1.2

#### **5.2.2 DRESSING OF STONES**

**5.2.2.1 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 corner stones (quoins) shall be dressed square and corner shall be straight and vertical-

(5-2)

5.2.2.2 A Sample of dressed stone shall be prepared and kept on the work after approval from the Engineer-in-Charge.

#### **5.2.3 LAYING**

5.2.3.1 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.

5.2.3.2 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.

5.2.3.3 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.

5.2.3.4 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.

5.2.3.5 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 corners (which are more vulnerable to damage). No damaged stone shall be allowed to be used in work.

5.2.3.6 A masonry work may be a composite one consisting of ashier stone facing with backing 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.

5.5.7 **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.

5.2.3.8 **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. .

#### 5.2.4 **POINTING**

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.

#### 5.2.5 **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. .

#### 5.2.6 **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.

(5-3)

### **CHAPTER -6-**

#### **6.0 POINTING ON BRICK WORK AND STONE WORK (OTHER THAN DAM )**

Pointing shall be of the type shown in figure below:

#### **POINTING**

##### **6.1.1 PREPARATION OF SURFACE:**

6.1.1.1 The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scraping. The surface then thoroughly washed with water, cleaned and kept wet before pointing is commenced.

6.1.1.2 The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunken surface of the finished pointing or from the edge of brick shall not be less than 12 MM.

##### **6.1.2 MORTAR:**

Mortar of specified mix shall be used. It shall be, as specified under "Chapter 6 Mortar~".

##### **6.1.3 APPLICATION AND FINISHING:**

6.1.3.1 The mortar shall be pressed into tile raked out joints, with a pointing trowel, either flush, sunk or raised, according to the type of pointing required. The mortar shall not be spread over the corner, edges or surface of the masonry. The pointing shall be finished with the proper tool. in the manner described below.

**6.1.3.2 FLUSH POINTING** -The mortar shall be pressed into the joints and shall be finished off flush level with the edges of the bricks. or stones so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge.

**6.1.3.3 RAISED AND CUT POINTING** -Raised and cut pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm raised and width 10 mm more as directed.

6. 1.3.4 The superfluous mortar then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned off all mortar. The finish shall be such that the pointing is to the exact size and shape stipulated arid the edges are straight neat and clean.

##### **6.1.4 CURING:**

6.1.4.1 The pointing shall be kept wet for seven days. During this period it shall be suitably protected from all damages.

6.1.4.2 The pointing lines shall be truly horizontal and vertical except where the joints are slanting as in random rubble masonry. Lines of joints from different directions should meet neatly at the junctions instead of crossing beyond.

(6-1)

**6.1.5.3 RULED POINTING"** The joints shall be initially formed as for flush pointing and then while the mortar

is still green, a groove of shape and size as Shown in drawing or as instructed, shall be formed by running a forming tool, straight along the center line of the joints. This operation shall be continued till a smooth and hard surface is obtained. The vertical joints shall also be finished in a similar way. The vertical lines shall make true right angles at their junctions with the horizontal lines and shall not project beyond the same.

**6.1.5.4 CUT OR WEATHER STRUCK POINTING** -The mortar shall first be pressed into the joints. The top of the horizontal shall then be neatly pressed back 3 mm or as directed with the pointing tool so that the joints are sloping from top to bottom: The vertical joints shall be ruled pointed. The junctions of vertical joints with the horizontal joints shall be true right angles.

#### **6.5 PAYMENT:**

(i) The volume of masonry will be calculated from the overall outside dimensions inclusive of face work up to the joint, as shown in the drawing or directed in writing by the Engineer-in- Charge and will be paid for at the tendered unit rate for the particular item.

(ii) Double faced masonry shall be payable only for works not exceeding 120 cm. (4 ft) in width. Where the width exceeds 120 cm (4 ft) face masonry shall be payable limited to only 60 cm (2 ft) width on each face. Where specification of face masonry differ from those of hearting, rate for face masonry will be payable only up to 60 cm (2 ft) from the face.

(iii) Generally the rates for masonry shall include all leads and lifts of material unless otherwise specified. The contractor shall arrange at his own cost for the supply storage, pumping etc. of water required for the construction and curing of the masonry.

(6-2)

### **CHAPTER 7**

#### **7.0 REINFORCEMENT**

##### **7.1 GENERAL:**

7.1.1 This work shall consist of furnishing and placing steel reinforcement of the shape and dimensions indicated in the drawings and as specified in these specifications.

All steel used for reinforcement shall be clean. free from oil. grease, paints, dust mortar, scales, kinds rust or any rolling defects or bands other than those required as per drawings or as per directed by Engineer-in-Charge.

##### **7.1.2 QUALITY OF REINFORCEMENT:**

7.1.2.1 The steel reinforcement shall be any of the following as may be specified for the job in question.

(a) Mild steel and medium tensile steel bars conforming to IS: 432-1982 as amended from time to time.

(b) Cold-twisted bars conforming to IS: 1786-1985 as amended from time to time.

(c) Hard drawn steel wire fabric conforming to IS: 1566-1982 as amended from time to time.

7.1.2.2 The ultimate tensile stress, yield stress and percentage elongation of reinforcing steel shall be as given in Appendix 7.1.9.

7.1.2.3 In case of material purchased from re-rollers or other than authorized suppliers of manufacturer, the supplier shall furnish manufacturers certificate containing the results of all the required tests on samples taken from the delivered material. For each bundle/coil of bars, a tag shall be attached indicating cast No. lot No. grade & size.

##### **7.1.3 STACKING AND STORAGE:**

Steel reinforcement shall be stored in such a way as to prevent distortion, deterioration and corrosion.

Reinforcing bars shall not be left in direct contact with the ground, but they shall be stacked on top of an arrangement of timber sleepers or the like -suitable racks shall also be used for stacking reinforcement in tiers. Bars of different classifications, size and lengths shall be stored separately to facilitate issues in such sizes and lengths as to minimize in cutting from standard lengths.

##### **7.1.4 CUTTING AND BENDING:**

7.1.4.1 Bars bent during transport or handling shall be straightened before being used on work: they shall not be heated to facilitate bending.

7.1.4.2 Reinforcement bars shall be of the size prescribed and shall accurately cut to length and bent to shape and fixed in positions as shown on the drawings or as directed by the Engineer-in-Charge and shall conform to IS: 2502-1963 as revised from time to time. The tolerances for bending and cutting shall be as given in.

#### **TABLE-I PERMISSIBLE BENDING AND CUTTING TOLERANCES**

Length - Tolerance

Over Up to and Plus Minus  
including

cm. cm. m.m. m.

For bent bars - 75 3 5

75 150 5 10

150 250 6 15



2S0 7 25

For straight bars All lengths 25 25

(7-1)

7.1.4.3 Reinforcement bars shall be bent cold, but bars larger than 10mm. in size may be bent hot at cherry red heat (not exceeding 850 c) except- those bars which depend for their strength on cold 'working'. Hot bars shall not be cooled by quenching. Bars shall not be straightened or bent in a manner that will injure or weaken the material.

7.1.4.4 Bars of 10mm. diameter and under may be bent by simple tools such as a dawn. For bars up to 16 mm, a simple hand machine (without gears) is recommended. For larger diameter, a geared bar bending machine (hand operated) Will be suitable. For bars 36 mm. and where large quantities of bars are to be bent, power operated benders may be used advantageously.

7.1.4.5 Unless otherwise specified all type hook shall invariably be provided at the end of each bar.

The radius of the bend shall not be less than twice the diameter of the round bar and the length of the straight part of 4" the round bar. Deformed bars may be used without hooks.

## 7.1.5 JOINT AND SPLICING

### 7.1.5.1 LAPPED SPLICES

7.1.5.1.1 All reinforcement shall be furnished in full length indicated in the drawings as bar as possible Splicing bars, except as shown in the drawings shall not be permitted without written approval of Engineer-in-charge.

7.1.5.1.2 There splices are provided in the reinforced bars, the shall confirm the requirements contain in Design Series Technical Circular No. 24 appended at Appendix II 7.1.10

### 7.1.5.2 WELDED SPLICES

7.1.5.2.1 Reinforcement in structure shall not be welded except where shown in the drawing. All procedure shall be subject to the prior approval of the Engineer-in-Charge.

7.1.5.2.2. Welding of reinforcement shall be done in accordance with the recommendations of the Indian Standards.

(a) IS: 2751-1979 gives the requirements of wildings of mild steel round and deformed bars conforming to grade I of IS: 432 (Part I) 1982 and IS: 1786-1985.

(b) IS: 9417-1979 gives requirements of welding of cold 'worked steel bars conforming to IS: 1786-1985

(c) The M.S. electrodes used for welding shall conform to IS: 814-1974

7.1.5.2.3 Joint welding procedures which are to be employed shall invariably be established by a procedure specification and shall be qualified prior to use by tests as prescribed in IS: 2751-1979 and IS 9417-1979. All welders and welding operators to be employed shall have to be qualified by tests prescribed in IS: 2751-1979 IS: 9417-1979. Inspection of welds shall conform to IS: 822-1970 and destructive and non-destructive

testing may be undertaken when deemed necessary. Joints With weld defects detested by visual inspection or dimensional inspection shall not be accepted.

7.1.5.2.4 Reinforcement bars up to and including 10mm. in diameter should be lap welded and those l than 10mm. diameter should be butt-welded.

As far as possible, in concrete structures subjected to large numbers of repetitions of substantial loads welding should be avoided.

7.1.5.2.5 Welds shall be avoided at bends or in curved parts of the reinforcing bars and shall be located at least at a distance of 50 times the diameter from bends.

7.1.5.2.6 The design strength of welded splice or mechanical connection shall be taken as equal to 80 percent of the design strength of the bar for tension splices and 100 percent of the design strength for compression splices: However, 100 percent of the design strength may be assumed in tension when the spliced area forms not more than 20% of the total area of steel at the section and the splices are staggered at least 60 cm.

**Note:** Welded joints or mechanical connections in reinforcement may be used but in all cases. of important connection, tests shall be made to prove that the joints are of the full strength of bars connected.

(7-2)

7.1.5.2.7 Deformed bar shall not be lap welded at splices except where lap welding is shown on the drawings or otherwise specifically approved. In the welds of lapped joints, the shear strength of the filler materials should be taken as 0.38 times its vied or proof stress as given in appropriate standards. The length of weld should be sufficient to transmit the design load in tile bar, that is, the cross sectional area of (parent) bar X 0.87 should 'be equal to effective length of weld X throat thickness X the shear strength of the filler material. The length of a un of weld should not normally exceed five times the size of the bar. If a longer length of weld i required. It should be divided in the sections and the space between runs made not less than five the size of the bar.



7.1.5.2.8 But welding of reinforcement bars shall be performed under cover from the weather and may be performed either by the gas pressure of the flash pressure welding process or by electric arc methods. The following shall apply for all welding of reinforcement bars including butt welding and the preparation of welded reinforcement mats:

(i) The ends of the bars to be butt welded by gas pressure or flash pressure welding shall be squared off by an abrasive disc cutter. Any accumulation of dirt or oxide film formed after their cutting operation shall be removed by sand blasting or butting prior to welding. Ends of bars to be joined by flash pressure welding shall be cleaned off all rust and projections on the end faces and for a distance of about 15 cm from the ends. If necessary to prevent arching, care shall be taken in aligning and separating the ends of the bars to be joined by this welding and the ends of the bars shall be matched accurately and shall be retained firmly in position during the welding operations. For pressure welding, the bars shall be accurately held in position with the prescribed pressure applied prior to heating and during heating welding.

(ii) Where bars are to be joined by electric arc welding the weld metal shall be deposited in successive layers and each layer shall be thoroughly cleaned before subsequent layer is deposited.

(iii) All structural welds shall have complete fusion and freedom from imperfection. Defective pressure welded joints shall be separated by flame cutting and reworked.

Defective arc welds shall be chipped to sound metal and resulting cavities shall be filled in the same manner as the original grooves were filled or the bars shall be flame cut and reworked.

(iv) Tack welding of reinforcement bars, for fixing bars in place or for preparation of mats shall be carried out by competent operators using appropriate techniques. The work shall be so performed that there are no short discontinuities or loss of cross section in the jointed bars at or adjacent to the weld.

#### **7.1.6. BINDING AND PLACING**

7.1.6.1 Before reinforcement is placed the surface at the reinforcement and the surfaces of any metal supports shall be cleaned of heavy flaky rust, loose mill scale, dirt grease coats of paints, oil or other foreign substances which may destroy or reduce bond. Heavy flaky rust can be removed by rubbing with gunny (burlap) or equivalent treatment. A note on rust over reinforcement is given at Appendix III for general guidance.

7.1.6.2 Reinforcement bars shall be placed accurately in the positions indicated in the drawings and maintained in these positions. When delay occurs between assembling the steel and depositing the concrete, the placing of the reinforcement shall be again carefully checked immediately prior to concreting.

7.1.6.3 Reinforcement after being placed in position shall be maintained in a clean condition until completely embedded in concrete. Special care shall be exercised to prevent any displacement of reinforcement in concrete already placed.

7.1.6.4 When reinforcement bars are bent aside, at construction joints and afterwards bent back into their original positions, care should be taken to ensure that at no time the radius of the bend is less than 4 bar diameters for plain mild steels 6 bar diameters for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bars is not damaged.

7.1.6.5 Bars crossing each other should be secured by annealed binding wire of size not less than 0.90mm and conforming to IS 280-1978 in such a manner that will not slip over each other at the time of fixing and concreting.

7.1.6.6. The bars shall be kept in position by the following materials: -

(a) In case of beam and slab construction, pre cast cover blocks in cement mortar 1:2 (1 cement 2 sand) about 4cmx4cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering so as to secure and maintain the requisite cover of concrete over reinforcement.

(7-3)

(b) In case of cantilevered and doubly reinforced beams or slabs the vertical distance between the horizontal bars shall be maintained by introducing chain spacers or support bars of steel at 1m. or at shorter spacing to avoid sagging.

(c) In case of columns and walls the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them or with block of cement mortar (1:2) suitably tied to the reinforcement. If templates are used they shall be removed after the concreting has progressed to level just below them.

(d) In case of R.C.C. structures such as arches, domes, curved profiles of spillways falls training walls etc. cover blocks, spacers and templates shall be used as directed by Engineer-in-Charge.

7.1.6.7. Chairs, spacers, hangers supporting wires or other approved devices at sufficiently close intervals may also be used as approved by Engineer-in-Charge. All materials used for positioning the steel shall be non-corrodible material. Support shall not extend to the surface of concrete except where shown on drawings.

7.1.6.8. All the bars protruding from concrete and to which other bars are to be spliced and which are

likely to be exposed for an indefinite period shall be protected by a thick coat of neat cement grout.

7.1.6.9. Reinforcement will be inspected for compliance with requirement as to size shape length spacing and position after it has been placed.

#### **7.1.7 SUBSTITUTION**

7.1.7.1. Substitution of size of bars different from specified in the drawing shall be allowed only with the permission of Engineer-in-Charge. Substitution of the same type and grade such as plain bars and deformed bars of various grades say F415, F500 shall be used as main reinforcement in a structural member. However, Simultaneous use of two different type of steel for main and secondary reinforcement respectively is permissible. Guidelines for substitution are given in appendix .IV.

While permitting substitution of bars the Engineer-in-Charge shall satisfy himself regarding the design requirements in respect bond spacing between bars and minimum cover etc. as given in IS: 456-1978 and IS: 3370 (pt ii) 1% 5. The relevant clauses are given below for guidance.

(i) Bond 25.2 of IS: 456-1978

(ii) Spacing 25.3 of IS: 456-1978

(iii) Cover 25.4 of IS: 456-1978 and 7.2 of IS: 3870- 1963

#### **7.1.8 BUNDLING OF BARS**

7.1.8.1. The bundles of bars may be provided in the original design/drawing or may be necessitated as a requirement of substitution. The bars shall be bundled in shapes of triangular, square or L-shaped to act as one unit of reinforcement. The bar diameters in bundle shall be limited to two nearest sizes. Bundled bars shall be tied together to ensure the bars remaining together. Bars larger than 36 mm dia. shall not be bundled except in columns.

7.1.8.2. CURTAILMENT. Bars in a bundle shall terminate at different points spaced apart by not less than 40 times the bar diameter except for bundles stopping at a support.

When all bars in a bundle are carried to the support, the increased development length (based on single bar) for bundles as given in Para 2.2 of Appendix IV should be used for checking of the development of stress.

7.1.8.3. Diameter of bundled bars -Where spacing limitations and minimum concrete cover are based on bar diameter, a group of bars bundled in contact shall be treated as single bar of diameter derived from total equivalent area.

7.1.8.4. The minimum free distance between groups of bundled bars should be at least the maximum of the following:

(i)  $C + 1.5$  cm. Where, C = maximum size of aggregate (cm)

(ii) The diameter of the largest size of bar used.

(iii) 3 cm.

7.1.8.5. If more than one layer of bundled bars are used then the groups should be placed One over the other.

(7-4)

7.1.8.6. Bundles shall not be used in a member without stirrups.

7.1.8.7. For column where large amount of bundled bars are used (2 to 3 %) the spacing of the bundle bars should be reduced to half the normal tie spacing (112 the minimum lateral size of tile member)

#### **7.1.9. PHYSICAL PROPERTIES OF REINFORCING BARS (Para 7.1.2.2.)**

SL. No. Type of Nominal Character Ultimate Composition Elongation

size of elastic strength Tensile of Steel on Gauge

reinforcement Bars Yield stress of Stress conforming to length of

2 percent IS No. 5.65

proof stress (area) 0.5

(mm) (N/mm<sup>2</sup>) (N/mm<sup>2</sup>) (%)

1 2 3 4 5 6 7

432 Mild 5,6,8,10 2:0

(part I) Steel 12,16,20

1982 (Grade-I)

22, 25, 28, 240 410 IS:226-1975 3

32, 36, 40

45, 50

Mild 5, 6, 8, 10 225

Steel 12, 16, 20

(Grade-II)

22, 25, 28 215 370 Fe 410.0 3

32, 36, 40 (St 42,0) of

45, 50 (IS: 1977-1975)

Medium 5, 6, 8, 10 350  
 Tensile 12, 16  
 Steel  
 20, 22, 25 340 540 (St 55-HTV) of  
 28, 32, 36 IS: %1-1975 IS: %1-1975  
 40, 45, 50 330 -do-  
 1786 High 6, 8, 10, 12, 16 415 10% more C-0.30% (Max)  
 1985 Strength 18, 20, 25 (for Fe than the S-O. 060% 14.5  
 deformed 28, 32, 36, 40 415 actual P-O. 060%  
 Steel 45, 50 0.2% S & P-O 11%  
 Proof Stress  
 500 8 % more C-O. 30% 12  
 for Fe 500 than the S-O. 055 %  
 actual P-O. 005%  
 0.2% S & P-O. 105%  
 Proof Stress  
 1566 Hard (See Note) As per IS  
 1982 drawn 432 (part II)  
 steel 1982  
 fabric  
 (7-5)

Notes 1. Mild steel bars are supplied on the following grades:

(A) Mild steel bars Grade -1 Steel OR Mild steel reinforcement bars Grade -1 Shall be manufactured and have the chemical composition in accordance with the requirements of steel St 42 of IS: 226-2975. Para St -42 5 shall be used for all the type of structures including those subjected to dynamic loadings and where fatigue wide flection's of stress, reversal of stresses and great restraint are involved as for example range gentry girders, road and railway bridges etc.

(B) Mild steel Bars Grade -1 Steel for mild steel reinforcement cement bars grade -II shall be manufactured and have the chemical composition in accordance with the requirements of steel IS -420, IS : 1977 -1975. The grade II quality of steel designated as St-42-0 shall be used for structures, not subjected to dynamic loadings, other than wind load, where welding is not employed or/and structures not situated in earthquake zones or/and design has not been based on plastic Theory.

(C) ORDINARY QUALITY STEEL: - Ordinary Quality Steel shall be manufactured and have the chemical composition in accordance with the requirements of steel St-32-O 15:1977-1975. The ordinary quality steel designated as St-32-0 shall be used for door, windows, window frames, window bar, grills, steel gates, hand grilling, fencing posts, tie bars etc.

## 2. DEVELOPMENT (BOND) LENGTH

2.1 For a safe design of RCC member, it is necessary that the designed tension or compression at any section in any reinforcing bar shall be balanced by the equal bond strengths developed by the sufficient length of the bar embedded in the concrete beyond that section on either side. The length thus, required is known as bond length or development length.

Bond length or development length  $L_d$  (in mm) is given by the following depression

$$L_d = C.K.N.$$

Where, C = Constant depending upon the grade of steel & nature of stress (i.e. tension or compression)

K = Constant depending upon the grade of concrete.

N = Diameter of bar @ in mm X maximum permissible stress at section in N/mm<sup>2</sup>

Value of C & k should be adopted from Table A & B respectively.

### TABLE -A Value 'C'

S. No. Type of steel yield Nature of stress

Stresses IN n/MM<sup>2</sup> tensile compressive

1. Tor -steel (415) 1.0 0.80

2. Mild-steel (250) 1.40 1.12

### TABLE -B: Value of 'K'

Grade of M15 M20 M25 M30 M35 M40

Concrete

Value of 'K' 0.30 0.22 0.20 0.18 0.16 0.15

2.2 Bars bundled in contact: The development length of each bar of bundled bar shall be that for the individual bars as calculated in Para 2.1, increased by 10% for bars contact, 20% for three bars in contact, and 33% for four bars in contact.

### 3. ANCHORING REINFORCING BARS:

3.1 Anchoring Bars in Tension -Hooks should invariably be provided for plain bars in tension. Deformed bars may be used without end anchorages provided development length requirement is satisfied. In case this (7-6)

requirement is not satisfied deformed bars may be provided with end hooks. While calculating the anchorages length of bars in tension, the hook/bend should be ignored and only the anchorage values as specified in Para 3.1.1 below should be adopted.

3.1.1. Bend And Hooks -Bend & Hooks should conform to shape & dimensions given in FI G -I. The anchorage value of bend and hooks should be considered as follows-

- (i) Bends -The anchorage value of bend should be taken as 4 times the diameter of the byre for each 15 bend subject to maximum of 16 times the diameter of the bar.
- (ii) Hooks -The anchorage value of a standard U type hook should be equal to 16 times the diameter of the bar.

#### FIG-1: STANDARD HOOK AND BEND

3.2 Anchoring Bars in Compression -The anchorage length for straight bars in compression should e equal to the development length of bars in compression as specified if Para 2 above. The projected length of hooks bends and straight beyond bend, if provided, for a bar in compression should be considered for development length.

3.3. Mechanical Devices for anchorage -Any mechanical or other device capable of developing the strength of the bar without damage to concrete may be used as anchorage with the approval of the designer.

3.4. Anchoring Shear Reinforcement.

3.4.1 Inclined Bars -The development length shall be as for bars' intension this length shall be measured under.

- (i) In tension zone from the-end of the sloping of inclined portion of the bar (see FIG (a) & (h)

FIG - 2 (a) 2 (b) ANCHORING INCLINED BENTUP IN TENSION ZONE

(7-7)

- (ii) In the compression zone forms the mid depth of the beam (see FIG-2 (c)

FIG.2 (c) ANCHORING INCLINED BENTUP BARS IN CONPRESSION ZONE

3.4.2 Stirrups -In case of secondary reinforcement, such as stirrups and transverse ties, complete development lengths and anchorages shall be deemed to have been provided when the bar is bent through an angle of at least 90 round a bar of at least its own diameter and is continued beyond the end curve for at length of at least eight bar diameter.

Note: Thin concrete cover over the 90 hold in a stirrup more lead to spilling of cover concrete as the 90 hook has a tendency to straight en out under over load. To avoid this type of failure, a civet of at least twice the die of stirrup bar shall provide where this is impracticable; the hook shall have a 135 bend.

### 4. REINFORCEMENT SPLICING:

4.1. General Arrangements and Provision -As far as possible, bars of full length as per drawing should be used. In case this in not possible, overlapping in bars in the manner prescribed below should provided.

- (i) Then practicable, over lapping bars should not touch each other, but be kept apart by concrete between them by 25 mm or 1.25 times the maximum size of the coarse aggregate whichever is greater.
- (ii) Then arrangement as per 4.1 (i) above is not practicable over-lapping bars should be bound with annealed steel wire not less than 0.9. mm (20 SING) thick twisted tight.
- (iii) Splices in tension zone of flexible members should, as far as possible:-
  - (a) Be away form the section of maximum stress and be staggered.
  - (b) Should not be at section where the bounding cement is more than 50 percent of the cement of resistance and not more than half bars shall be spliced at a section.
- (iv) In tension zones, where more than one half of the bars are splices at a section or where splices are made at points of maximum stress, special precautions should be taken, such as increasing the length of lap as per Table -C using specials or closely spaced stirrups around the length of the splice.

#### TABLE - C: PERCENTAGE INCREASES IN LAP LENGTH

Splice stress Percentage of bars spliced at one point  
(Percentage of Designed stress) 50 or less More than 50

(a) 50% or less 0 30

(b) More than 50% 30 70

(v) In compression zone, all the compression bars may be lapped at the same section.

4.2. Lap splices:

(a) Lap splices shall not be used for bars larger than 36 mm; for large diameters, bars may be welded; in case where welding is not practicable, lapping than 36 mm diameter may be permitted, in which case additional spirals should be provided around the lapped bars.

(7-8)

(b) Lap splices shall be considered as staggered. if the centre to centre distance of the splices in to less than

1.3 times the lap length calculated as described In Para (1.2. (c). the Individual splices of bars within he bundle should be staggered by 1.3 times the increased. Lap lengths as per Para 4.2 (c) read with Para 2.2.

(c) Lap length including anchorage value of hook in flexural tension shall be  $L_d$  or 30 dia not be less than 15 or 20 cm. (0 denotes diameter of reinforcing bar and  $L_d$  denotes development length as per Para 2 suitable; modified as per Para 41. (iv). splice in tension in members should be enclosed in special made of bars not less than 6mm diameter With pitch not more than 100 mm and the spliced bars should and in hooks even in the case of ribbed or deformed bars

(d) The lap length in compression shall be equal to the development length in compression, calculated as described in Para 2 but not less than 24 dia.

(e) When bars of two different diameters are to be carried out, lap length shall be calculated on the basis of diameter of the smaller bar.

(f) When splicing of welded wire fabric is to be carried out, lap splices of wires shall be made so that over lap measured between the extreme cross Wires shall be not less than the spacing of cross Wires plus 10 mm as detailed in (FIG-3)

### **FIG -3 : LAP SPLICING OF WELDED WIRE FABRICS**

#### **3. WELDED SPLICES**

Welding should not usually be preferred in splicing of the bars. Chiefly because of the difficulty may be referred.

5. This circular supersedes instructions and all other circulars and Technical Memorandum issued on this subject in the past

#### **HUME PIPES**

R.C.C. Pipes will often be cheapest form of culvert. The diameter of the pipe chosen depends upon available head less is least in culverts when they are flowing about 80% full. Culverts should not be set to flow less than 80% full, so that they can be installed as low as possible thus minimising the depth of soil covering and minimising the chances of breaking pipe wall thickness should be designed to provide sufficient strength to ensure against breakages. Thickness of the soil cover should be such that weight is more evenly distributed to the pipe and less pipe strength is required. At least 60 cm of soil shall cover any culvert used for Circular traffic. Preparing in 'f even rock free bed for the pipe and compacting the replace soil at the side will reduce the changes of cracks as well as the possibility of water washing out soil along the pipe. Hume pipe of Np-2 for culvert on roads & VRBs structures. Rates include handling laying and filling joint With cement mortar (NP3).

The items not covered in the above part of specifications, shall be followed as per M.P. Irrigation specification of 1991. All relevant S.I. specification as mentioned in each Chapter of CSR shall be part & parcel of this specification.