

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	: Mortars	(i.e. Chapter 3)
Sec. IV	- Chap. 7 & 16	: Filling Foundation, R.C.C. & Form 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

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**SPECIFICATION OF MASONARY STRUCTURE & CONCRETE WORK FOR IRRIGATION PROJECTS
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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.

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 timer and fuel shall be properly stacked and handed over to the department, when asked for by the Engineer-in-charge. 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, if 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 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 materials is not completely removed and porous strata exposed.

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.

(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 tampers 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 shall be such and so laid out that regular flow of water is 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 from 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 or 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.

2.4.9.4. 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 refuse.

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 shall be filled with mortar of specified mix. The mortar shall be forced in to the joints with the help of 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 from the river and the bed. 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.

(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 of 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 being 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 over looked, 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.

(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 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 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 MORTARS

3.1. MATERIALS

3.1.1 Cement

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

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 a 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 180 days shall not be used for dams and that beyond 180 days shall not be used for structural members and hydraulic structures.

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 to 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 Designation	For use in masonry Mortar, percentage Passing by mass	For internal and external wall and ceiling plaster, percentage passing by mass
9.5 mm		100
4.75 mm	100	95 to 100
2.36 mm	90 to 100	95 to 100
1.18 mm	70 to 100	90 to 100
600 micron	40 to 100	80 to 100
300 micron	5 to 70	20 to 65
150 micron	0 to 15	0 to 15

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.

3.2.2.5 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.

3.4. CRITERIA FOR SELECTION OF MASONRY 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 preferably 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 the 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 weighing 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 its quantity shall be increased suitably to allow for bulking which shall be determined as per Para 3.1.3.

3.5.2.2. Preparation - Mixing shall be done preferably 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 hand 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 to 12 percent of air by volume of mortar.

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 "Stacking 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.

4.1.2.1. 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 alkalies 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 Substance		Method of test	Fine aggregate percentage by Weight maximum		Coarse aggregate percentage by weight maximum	
			Uncrushed	Crushed	Uncrushed	Crushed .
1	2	3	4	5	6	7
(i)	Coal and lignite	IS: 2386	1.00 (PT.II) 1977	1.00	1.00	1.00
(ii)	Clay lumps	-do-	1.00	1.00	1.00	1.00
(iii)	Materials finer than 75 micron IS Sieve	IS: 2386 (Pt.I) 1977	3.00	15.00	3.00	3.00
(iv)	Soft Fragments	IS: 2386 (Pt.II) 1977			3.00	
(v)	Shale	-do-	1.00			
(vi)	Total f percentage of all deleterious materials (except mica) including Sl. No. (i) to(v) for Col.4, 6 & 7 & Sl. No.(1)& (ii) for Col 5 only	5.00			5.00	2.00

NOTE 1:- The presence of mica in the fine aggregate has been found to reduce considerably the durability and compressive strength of concrete and further investigations are under way to determine the extent of the deleterious effect of mica. It is advisable, therefore, to investigate the 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.

TABLE- 2: MECHANICAL AND PHYSICAL PROPERTIES

S.No.	Test results	Specified limits of result	
		Concrete other than for wearing surfaces	Concrete for wearing surfaces
1	2	3	4
1.	Crushing value	shall not exceed 45%	shall not exceed 30%
2.	Ten percent fines Value	shall not be less than 5 tonnes	shall not be less than 10 tonnes
3.	Impact value by weight	shall not exceed 45%	shall not exceed 30%
4.	Abrasion value by losangles machine	shall not exceed 50%	shall not exceed 30%
5.	Flakiness Index	Not greater than 25%	As per col.3

SOUNDNESS OF 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 it 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 (Na_2SO_4) and 15 percent when tested with magnesium sulphate (MgSO_4)
- (b) For Coarse aggregate 12 percent when tested with sodium sulphate (Na_2SO_4) & 18 percent when tested with magnesium sulphate (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
Small, 20 to 4.75 mm	20 mm	90 to 100
	4.75 mm	0 to 10
	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.

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 dimension of Section (mm)	Maximum size of aggregate (mm)			
	Non reinforced well	R.C. walls beams & columns	Lightly reinforced or non reinforced slabs	Heavily cycled 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

4.1.2.5.1. - 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 outside the limits of any particular zone of sieves other than 600 micron IS Sieve by a total amount not exceeding 5% it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron IS Sieve or to percentage passing any other sieve size on the coarse limit of grading zone I or the lower 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

IS Sieve Designation	Percentage Passing for			
	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 any one 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 thereof shall be included in the accepted rate for the finished item of Work 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

IS Sieve	Percentage passing for All in Aggregate of	
	40 mm Nominal Size	20 mm Nominal size
80 mm	100	-
40 mm	95 to 100	100
20 mm	45 to 75	95 to 100
4.75 mm	25 to 45	35 to 50
600 micron	8 to 30	10 to 35
150 micron	0 to 6	0 to 6

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

S. No.	(Size of Stack in meters)			
	Material	Length	Breadth	Height
(i)	Soling Stone	5.0	2.0	0.50
	or	5.0	10	0.50
(ii)	Coarse aggregate	2.0	2.0	0.50
	or	5.0	5.0	1.00
	or	5.0	1.0	0.50
(iii)	Fine Aggregate	2.0	2.0	0.50
	or	5.0	5.0	1.00
	or	5.0	1.0	0.50

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 $1/3^{\text{rd}}$ 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.

(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 be 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 ²)
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/mm²

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.

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 past 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 Engineer-in-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.

TABLE 13: Proportions for Nominal Mix Concrete

Grade of per concrete	Total quantity of dry aggregates by Mass per 50 Rg. of Cement to be taken as the sum of the individual masses of fine and coarse aggregates Max Kg.	Proportion of fine aggregate to coarse aggregate (By Mass) Litre	quantity of water 50 kg of cement (Max)
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.

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 carryout check tests and order changes in the mix as may be necessary from time to time to maintain the specified quality of the work. No radical changes, substitutions and additions in the mix shall be made without such check tests and subsequent approval.

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.

- (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 through compaction as possible in the situation of placing and with the facilities of compaction.
- (d) It should be possible to obtain a satisfactory surface finish.

The above requirements of stability, mobility, 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 Workability	Value of workability
1	2	3
Concreting of shallow sections with vibration compaction factor	very low	20-10 seconds, vee-bee time or 0.75-80

Concreting of lightly reinforced sections with vibration	Low	10-15 seconds Vee-Bee time or 0.80-0.85 compaction factor
Concreting of lightly reinforced sections without vibration or heavily reinforced section with vibration	Medium	5-2 seconds, vee-bee time or or 0.85-0.92 compacting factor or 25-75 mm, slump for 20 mm aggregate.
Concretion of heavily reinforced sections with vibration Note -for smaller aggregate the value of slump will be lower	High	Above 0.92 compacting factor or 75-125 mm. slump for 20mm aggregate.

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 water-cement ratio, by ensuring a through 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

(4-13)

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 interlocked with the discharge gate of the batch hopper that timing does not start until the discharge gate is fully closed and all ingredients are in the drum. A suitable record shall be kept of the average time consumed in charging, mixing and discharging a batch during each run.

Excessive mixing, necessitating the addition of water to provide workability shall 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 or 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.

4.6.1.3 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 provided 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 comers 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 tests 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 remind from the site. The contractor shall replace such rejected units at his own cost.

(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 proper 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.

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 generated strength equal to double the stresses generated by the dead load plus live load of 200 Kg/m². 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 to a suitable depth and to firm rock along the side. Where excavation methods or the natural rock strata do not leave a sufficiently rough surface of contact, the bed shall be roughened by cutting steps, grooves, trenches or keyways into the soil rock. Scaly containing 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.

4.7.3.3 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 nay 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

concrete to be placed upon it and the consistency of the mortar shall be suitable for being spread uniformly and worked thoroughly into all irregularities of the surface.

For vertical and inclined joints (surfaces) which can not be covered with mortar shall be given a heavy coat of neat cement grout vigorously brushed into the interstices and hollows or neat cement slurry shall be applied on the surface before it is dry so as to provide 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 corners 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 until it has hardened to a considerable extent, it shall be left to set and cure for not less than 56 hours or longer if necessary until a strength greater than 35.21 g/cm² (500 PSI) has been attained, before completing the lift. The surface thus, interrupted shall be treated in same manner as described in Para 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 too 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 placing 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 slump 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 through the walls. Dewatering by pumping shall not be done while concrete is being placed or until 24 hours thereafter.

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 the following.

a) Tremie- When concrete is to be deposited under water by means of a tremie the top section of the tremie shall have a hopper large enough to hold one entire batch of the mix or the entire contents of the transporting bucket if any. The tremie pipe shall be not less than 200 mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably, flanged steel pipe of adequate strength for the job should be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding of the gunny 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 be below the top surface of the plastic concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of laitance layers, if the charge in the tremie is lost while depositing the tremie shall be raised above the concrete surface and unless sealed by a check valve, it shall be re-plugged at the top end, 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/mm²) 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.

4.10.1.1 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 shaft 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 satisfactorily 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.

4.10.4 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 pipes mechanical sprinklers or porous hoses or by any other suitable method, "Which will keep all the surfaces continuously (not periodically) wet. The period of 14 days specified above shall be increased to 21 days when pozzolana has been used in 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 clear curing compound may be required. Curing compound shall be applied to the concrete surfaces by spraying on one coat to provide a continuous uniform, membrane overall area. with a maximum coverage per 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

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 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.

4.11.5.3 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 from 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

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 present 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 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/cm² 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

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 from 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" or 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 discretion.

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 than 30 Attempts should be made to obtain the 30 test results, as early as possible when a mix is used for the first time the calculation of the standard deviation shall be brought up to 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 DEVIATION

Grade of concrete	Assumed S.D./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

$$\sqrt{\frac{\sum \Delta^2}{n-1}}$$

Where Δ = 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

$$\left[1.65 - \frac{1.65}{\text{no. of samples}} \right] \text{ time the standard deviation}$$

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

$$\left[1.65 - \frac{3}{\text{no. of samples}} \right] \text{ time the standard deviation}$$

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 adequacy 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 if it is porous or honeycombed: its placing has been interrupted without providing a proper construction joint: the reinforcement has been displaced beyond the tolerances specified: or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in Charge.

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.

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.

4.14.1.6 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 Mini Cement Content kg/m ²	Concrete Max Water cement ratio	Reinforcement concrete Min cement content kg/m ³	Max water cement ratio
1	2	3	4	5
Mild- For example, completely protected against weather, or aggressive conditions, except for a brief period of exposure to normal weather conditions during construction	220	0.7	250	0.65
Moderate- For example. Exposed sheltered from heavy and wind driven rain and against freezing, whilst saturated with water buried concrete in soil and concrete continuously under water	250	0.6	290	0.55
Sever-For example exposed to sea, water alternate wetting and drying and to freezing whilst wet subject to heavy condensation or corrosive fumes.	310	0.5	360	0.45

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 cm³ if it is lightly purred into the container to well over 1.60 gm per cm³ 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	Length, cm	inside measure 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 farm 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.

Then a mixer marching is used on the job it will be convenient to have lips on the sides on the farm, which can then be rested on the mixer hopper when the contents are being tipped in. Before concreting operations are started the farm volumes should be checked for specified quantities then filling the farms 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 farm should be stacked upside down to prevent any acculturation 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 farm for the sand made up to hold half of 88 litres (30x30x49cm) & fill it twice & for the coarse aggregate a 35 litres farm Which would be filled four times. Frames 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 mud) 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 undated 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 understand 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 weight the cement into a bucket suspended from as ordinary 50 kg spinning balance.

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

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

(4) Don't compact aggregate into the farm 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.

CHAPTER 5**5.1 UNCOURSED RUBBLE MASONRY I RANDOM RUBBLE I POLYGOONAL FACED MASONRY****5.1.1 MATERIALS.**

5.1.1 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.

5.1.3.5 BOND STONES Bond stones or through stones running right across the thickness of the wall shall be 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. In 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 0.03 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-

5.2.2.2 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 comers (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 baking of either brick work. Un-coursed rubble/coursed rubble masonry etc. In such cases the two portions shall be carefully bonded. The above specification shall apply to face work and the backing shall be governed by the appropriate specifications applicable to the type of backing used.

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-

All joints shall be pointed using mortar with admixture of pigment to match the Shaw of stone as specified. The pointing when finished shall be sunk from stone face by 5 mm or as specified. The depth of mortar in pointing shall not be less than 10mm.

5.2.5 CURING AND PROTECTION

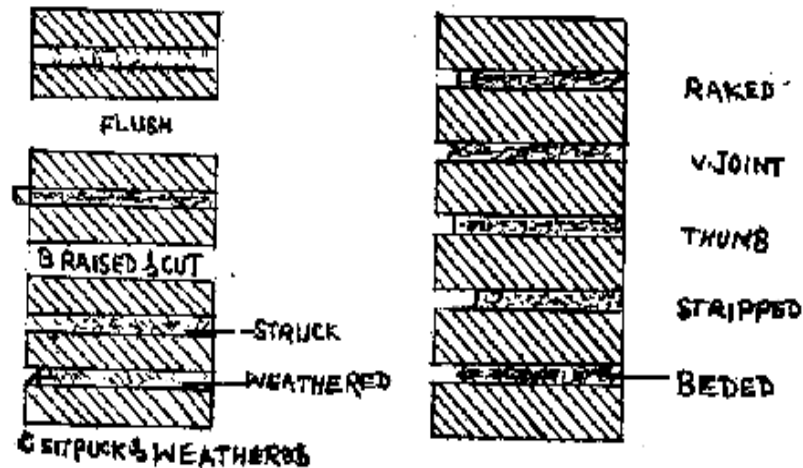
The masonry shall be cured in the same manner as describe in Para 8A.4.5. The work shall be suitably protected from damage during construction. .

5.2.6 SCAFFOLDING.

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.

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.

6.1.5.3 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.

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 15:432-1982 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 15:1566-1982 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 then 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 slacking 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	including	Up to and	Minus
	cm.	cm.		
For bent bars	-	75	3	5
	75	150	5	10
	150	250	6	15
	250		7	25
For straight bars	All lengths		25	25

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 Where splices are provided in the reinforced bars, they shall conform to the requirements contained 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 weldings 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 detected 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 I 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.

7.1.5.2.7 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 yield or proof stress as given in appropriate standards. The length of weld should be sufficient to transmit the design load in the bar, that is, the cross sectional area of (parent) bar $\times 0.87$ should be equal to effective length of weld \times throat thickness \times the shear strength of the filler material. The length of a run of weld should not normally exceed five times the size of the bar. If a longer length of weld is required. It should be divided in the sections and the space between runs made not less than five times 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 or 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 them 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 is 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.

(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 types 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 of 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: 3370- 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.

7.1.8.6. 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 tilt: normal tie spacing (112 tile minimum lateral size of tile member)

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

SL. No.	Type of Reinforcement	Nominal size of Bars	Characteristic strength Yield stress of 2 percent proof stress (mm)	Ultimate Tensile Stress (N/mm ²)	Composition of Steel conforming to IS No. (N/mm ²)	Elongation on Gauge length of 5.65 (area) 0.5 (%)
1	2	3	4	5	6	7
432 (part I) 1982	Mild Steel (Grade-I)	5,6,8,10 12,16,20		2:0		
		22, 25, 28, 32, 36, 40 45, 50	240	410	IS:226-1975	3
	Mild Steel (Grade-II)	5, 6, 8, 10 12, 16, 20		225		
		22, 25, 28 32, 36, 40 45, 50	215		370	Fe 410.0 3 (St 42,0) of (IS: 1977-1975)
	Medium Tensile Steel	5, 6, 8,10 12, 16		350		
		20, 22, 25 28, 32, 36 40, 45, 50	340	540	IS:%1-1975	(St 55-HTV) of
1786 1985	High Strength deformed Steel	6, 8,10,12,16 18, 20, 25 28,32,36,40 45,50	415 (for Fe 415	10% more than the actual 0.2% Proof Stress 8 % more than the actual 0.2% Proof Stress	C-0.30% S-O.06O% P-O. 060% S&P-O 11%	(Max) 14.5
			500 for Fe 500		C-O. 30% S-O. 055 % P-O. 005% S & P-O. 105%	12
1566 1982	Hard drawn steel fabric	(See Note)	As per IS 432 (part II) 1982			

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 flections 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/mm²

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

TABLE -A Value 'C'

S. No.	Type of steel yield Stresses INn/MM2 tensile	Nature of stress compressive	
1.	Tor -steel (415)	1.0	0.80
2.	Mild-steel (250)	1.40	1.12

TABLE -B: Value of 'K'

Grade of Concrete	M15	M20	M25	M30	M35	M40
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

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.

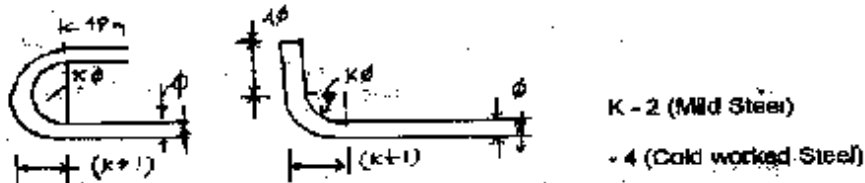


FIG-1: STANDARD HOOK AND BEND

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)

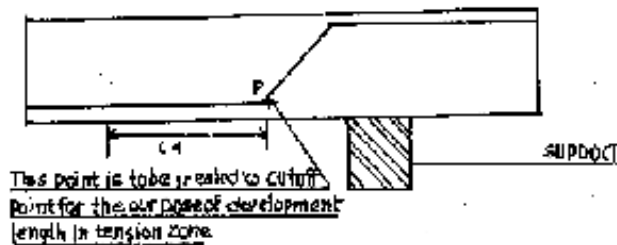


FIG-2 (a)

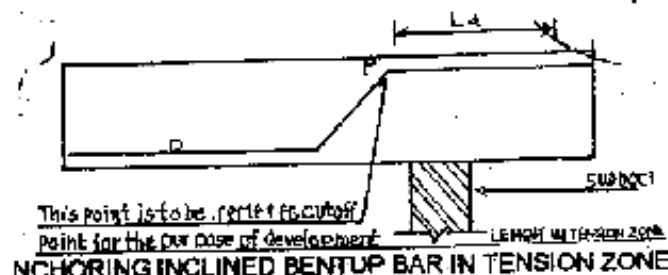


FIG - 2 (a) 2 (b) ANCHORING INCLINED BENTUP IN TENSION ZONE

(7-8)

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

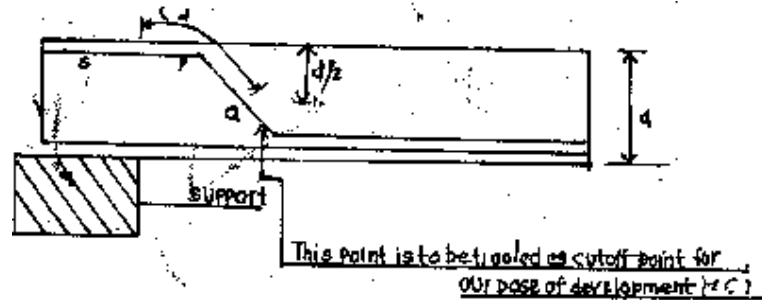


FIG.2 (c) ANCHORING INCLINED BENTUP BARS IN CONPRESSION ZONE

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 provided 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 Designed stress)	Percentage of bars spliced at one point	
	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.

(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 the 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.