SECTION V (2)

STRUCTURAL TECHNICAL SPECIFICATIONS

1. GENERAL

1.1 The work under this contract shall be carried out in accordance with Schedule 'A', particular specifications, drawings forming part of this contract and other provisions in MES/CPWD/Central government & state government Schedule of Rates.

The Employer may engage some other agency/ agencies to execute some work on the same site. The contractor is expected to work in close coordination with other agencies engaged by the Government including making/ allowing connection of services lines, matching/ coordinating in site grading/ road works etc.

1.2 The term "General specification" referred to in para 1.1 above as well as referred to in General Conditions of Contracts shall mean specifications contained in MES/CPWD/Central government & state government Schedule issued along with tender documents.

1.3 General Rules, Specifications, Special Conditions and all preambles in the MES/CPWD/Central government & state government Schedule shall be deemed to apply to works under this contract, unless mentioned otherwise in these tender documents, in which case specifications in these tender documents shall take precedence over the aforesaid provisions in the MES/CPWD/Central government & state government Schedule.

1.4 The notes on the drawings (if any) to the effect that foundations are based on specified Safe Bearing Capacity of the soil are for guidance only.

1.5 All works as shown in the drawings, specifications, conditions of contract and Schedule 'A' shall be deemed to have been covered in the prices quoted and nothing extra shall be payable to the contractor for any reason whatsoever unless specifically stated otherwise in the contract.

1.6 If specifications for any item of work or material are not available either in Schedule ‘A’ MES/CPWD/Central government & state government Schedule or in this Particular Specification, relevant IS specification or National Building Code shall be followed.

1.7 Any drawing which is mentioned/referred to as a drawing forming part of the contract but not specifically mentioned in the list of drawings shall be deemed to be forming part of the contract. The tenderer shall see such drawings/details in the office of PM, DEPMC/ Accepting Officer

1.8 All works shall be carried out as per Modern Project Management Practice, IS Codes, IE rules and MES/CPWD SSR.

1.9 SAMPLES OF MATERIALS

1.9.1 All materials to be provided shall be ISI marked. In cases where ISI marked materials are not available, materials superior or conforming to BIS standards and approved by the Project Manager shall be used. Materials for which manufacturers names have been mentioned in contract, makes as approved from list of manufacturers mentioned in contract shall be provided. The manufacturer's having ISI marked material shall be preferred.

1.9.2 Approval of samples of all materials which shall be used in the project is mandatory. No order for materials shall be placed by the contractor prior to approval of samples. The contractor shall produce the samples of all the materials / equipment and obtain approval in writing from the PM before he places bulk orders for the materials / equipment for incorporation in the work. In respect of materials for which samples are not kept or detailed specifications are not given hereinafter, the materials / equipment shall comply with relevant IS specifications. However, prior approval from the Project Manager shall be taken before finalizing the make. The contractor shall supply General Specifications, original test certificates from the manufacturers whose equipment are proposed to be incorporated in the work under this contract. Original test certificate will be retained by the department and bills will be returned after defacing.

1.9.3 A consolidated list of approved makes of various materials are appended in this document. The tenderer shall quote his rates on the basis of the price of best quality of the make stipulated in the item of works as described in specification as well as in the list of approved makes and as approved by the PM.

1.10 MAKING GOOD

The contractor shall cut, leave or form holes, recesses, chases etc. in concrete, brick work, walls, ceilings, floors and in any other situations as required or as directed by the Project Manager and make good in cement and sand mortar (1 :3)/PCC (1 :3:6) as directed by Project Manager and Finish to match the adjoining surfaces and the cost of same is deemed to be included in the lump sum cost of respective items.

1.11 SHOP DRAWINGS

1.11.1 Shop/fabrication drawings shall be prepared by the contractor for all specialist items of work as indicated in the specifications before starting manufacturing of the equipment. These shall be carefully prepared in accordance with the specifications and drawings and best trade practices and shall contain all the relevant information required.

1.11.2 Unless otherwise mentioned, the Contractor shall submit the shop drawings at least 6 weeks before the commencement of works for the prior approval of the PM. Before submission, the Contractor shall check the shop drawings and ensure that these are correct and complete and drawn in required scale and fully coordinated with all relevant disciplines.

1.11.3 The Contractor shall also ensure that any amendments to drawings and other information are made in accordance with comments of the PM, and shall re- submit these

drawings and other information for formal approval by the PM. The Contractor shall submit three sets of the finally approved shop drawings to the PM. The shop drawings are to be updated / revised if there is any change in the scope of work as instructed by the PM. Any manufacturing done prior to the approval of drawing from the PM in writing shall be rectified in accordance with the approved drawings by the Contractor at his own cost and equipment shall be supplied within the stipulated period.

1.11.4 Care shall be taken to ensure that all subsequent works are carried out as per the approved shop drawings only.

1.11.5 Shop drawing shall be prepared by the contractor for the following works unless specified otherwise: -

(i) Structural steel works
(ii) Internal and External Plumbing Works.
(iii) Internal Electrical Works.
(iv) Tile works
(v)

1.12 SOIL INVESTIGATION REPORT

BLANK

2. SCOPE OF WORK

The contract includes for the full, final and entire completion of the items of work described in Sch 'A' Section I to X catered for in General summary all as shown in drawings including notes thereon and/or as specified in these particular specifications.

3. BUILDING WORKS (EARTHWORK)

3.1.1 LEVELLING OF SITE AROUND BUILDINGS AND FOR BUILDINGS

The site around 3 meters from the edge of plinth protection of the building shall be dressed and levelled as directed by the PM. However, where distance around plinth protection is less than 3 meters, no price adjustment shall be made on this account. Lumpsum amount quoted by the contractor for the buildings against Section-1 shall be deemed to include for the same.

3.1.2 The site is fairly levelled, however ground levels will be taken and average ground level for each Block shall be considered for deciding plinth level as approved by PM.

3.2 EXCAVATION AND EARTHWORK

3.2.1 Unit rates for buildings in Section-I shall be deemed to include for excavation and earthwork in any type of soil (i.e. loose/soft/hard/dense). However, in the event of any deviations involving building works of Sch 'A', Part-I, the pricing for any type of soil shall be based on the mean rate of MES Schedule of rates for 'Soft / loose' and 'Hard / Dense" soil subject to contractor's percentage applicable as mentioned elsewhere in this contract as for Schedule "A" Section-I. If rock (soft/disintegrated/hard) is met with at the site, it shall be excavated by chisel cutting or by use of mechanical plant or by any other suitable method/techniques which have been evaluated by contractor

as ordered, in lieu of blasting by a prior written approval of PM. Blasting of hard rock by using explosives shall not be permitted. Payment shall however, be made as per respective items of SSR, subject to the percentage to be applicable as mentioned elsewhere in the document. Excavation in any type of soil/rock shall be carried out to the exact dimensions shown in drawings or as ordered. Any extra excavation done by the contractor on his own shall be made good with PCC (1:3:6) using stone aggregate at the bottom without any extra cost to the owner.

3.2.2 Loose pockets of Disintegrated rock/ soil if encountered shall be completely removed and backfilled with lean concrete (1:3:6) type C-2/1 using stone aggregate as per the direction of the P.M.

3.2.3 (a) In the event of any deviation involving excavation in soft/disintegrated/hard rock the same shall be paid as deviation at the applicable rates of MES Schedule for soft/disintegrated/hard rock subject to the percentage to be applicable as mentioned elsewhere in the document.

(b) Hard rock met with during excavation shall be taken out and stacked and accounted and credited as described here-in-after. Soft / Disintegrated rock shall also remain Govt. property and shall be disposed off/ removed in filling as and when permitted by the PM. The contractor may use the Hard rock obtained from excavation in the work for building stone, hard core, soling, WBM if approved by PM in writing.

3.2.4 **METHOD OF MEASUREMENTS OF EXCAVATION**

(i) Where soft/loose soil, hard/dense soil, soil/disintegrated rock and hard rock are mixed, the measurement for the total quantity shall be made by taking levels of the ground as directed by PM and the total quantity of excavation shall be computed from these levels. The soft disintegrated rock and the hard rock excavated shall then be stacked separately and measured in stacks. The quantity of soft/disintegrated rock and hard rock so measured shall be reduced by 50% to allow for voids. These reduced quantities of soft/disintegrated rock and hard rock shall be admissible for payment under item of excavation of soft/disintegrated rock and hard rock respectively. From the total quantity of the mixture the quantity of soft/disintegrated rock and hard rock excavated thus arrived at shall be deducted to work out the quantity of soil (i.e. soft/loose/hard dense soil) excavated.

(ii) Where only soft disintegrated rock and hard rock are mixed, the measurement for the total quantity shall be made by taking levels of the grounds as directed by PM and the total quantity of the excavation shall be computed from these levels. The hard rock excavated shall then be stacked and measured in stacks. The quantity of hard rock so measured shall be reduced by 50% to allow for voids. This reduced quantity of hard rock shall only be admissible for payment under item of excavation of hard rock. From the total quantity of the mixture, the quantity of hard rock excavated thus arrived at, shall be deducted to work out the quantity of soft/integrated rock excavated.

(iii) All excavation shall be measured in successive stages of 1.5 metres depth

starting from the commencing level. In case of excavation in rocks, if the depth of successive stage slightly exceeds 1.5 metres the levels shall betaken at that stage but excavated rock though obtained from the deeper depth, shall be measured in the previous successive stage only.

(iv) Hard rock obtained from excavations shall become property of the contractor for which he will be charged at the rate of Rs. 439.44 per cum for the quantity of hard rock admissible for excavation payment. The method of measurements shall be as laid down in clause 3.1 of SSR-2020 Part-II/CPWD. The measurement shall be properly recorded in MB and signed by the Project Manager and Contractor. Nothing extra shall be paid for stacking and removal of Hard Rock from the site of work.

3.2.5 In case timbering for excavation is required and specially ordered by the PM in writing this shall be paid as a deviation.
3.2.6 The contractor's lumpsum price shall include for dewatering / pumping / bailing out water, if met with during excavation due to high water table and no extra payment shall be admissible to the contractor on any such account.

3.3 EARTH FILLING

3.3.1 Earth obtained from excavation and approved by PM shall be used for filling around foundations, under floors and other situations to make up levels and shall be watered and well rammed in layers not exceeding 25 cm thick. Use of vegetable soil/turf/peat in filling is prohibited.

3.3.2 Earth obtained from surface excavations / surface dressing shall not be used for filling purposes for works under this Contract and shall be removed from the site filled in low lying areas or at locations directed by PM without any extra cost.
3.3.3 Contractor’s tendered lump sum against Schedule ‘A’ Part-I shall include for the following: -

(a) Contractor shall quote his lump sum taking into consideration that entire quantity of earth obtained from excavation excluding the soil obtained from surface excavation & surface dressing shall be utilized for filling purposes like returning filling in trenches etc to achieve plinth height as shown on drawing including removal of surplus soil and bringing in approved earth to make up shortage, from outside MoD land without any extra cost to Govt if any.

(b) The excavated soil obtained can be used as refill below floors if found suitable and approved by the Project Manager. Grass, roots, leaves or any other organic matter obtained in excavation shall not be used for refill below floors, the surplus soil & unusable soil shall be removed and deposited at a distance exceeding 250 metres and not exceeding 500 metres when directed at a level not exceeding 1.5metres above the ground level. This disposed soil shall be spread and levelled and compacted as directed by the PM. The cost of excavation and its disposal as mentioned above is included in the lump sum cost quoted by the Contractor for Schedule A Part I and nothing extra is admissible on this account.

(c) In case of excavation for foundation in black cotton soil for blocks as mentioned in Schedule A Part I, the complete excavated soil shall not be reused for filling under floors and shall be disposed off as mentioned below. The balanced soil within the floor of the building and upto a distance of 3.0 Metre beyond the external fall of the wall shall be excavated to depth of 1.5 Metre from ground level.

(d) The complete excavated soil as mentioned in Clause 3.3.3(c) above shall be removed to a distance exceeding 500 Metre and not exceeding 1.5 Km where directed at a level not exceeding 1.5 Metre above the ground level. The disposed soil shall be spread, levelled and compacted as directed by the Project Manager. Approved earth/moorum from outside ACDS Land shall be brought by the Contractor for refilling under floors and excavated area outside the building as mentioned in Clause 3.3.3(c) above Filling under floors and foundation trenches shall be carried out as per Clause 3.19 of Standard Schedule of Rates 1991. The cost of excavation, disposal of soil and excavation in borrow pits for approved soil/moorum, its transportation and filling under floors, foundation trenches etc. as mentioned in Clause 3.3.3(c) above is included in the lump sum cost quoted by the Contractor for Schedule A Part I

3.4 REMOVAL OF SPOIL

The surplus spoil(loose/soft/ hard/dense soil, soft/disintegrated rocks) obtained from excavation in normal soil in respect of Schedule A Part I shall be removed and disposed off at a distance exceeding 250 mt & not exceeding 500 mt at a level not exceeding 1.5 mt above ground level as directed by PM. The disposed soil shall be spread, levelled & compacted as directed by the PM. The cost of removal & disposal as mentioned shall be deemed to be included in the cost of lump sum quoted by the Contractor for Schedule A Part I. In case of black cotton soil, the disposal of soil is as mentioned in Clause 3.3.3.(c), (d) above

3.5 HARD CORE

Hard core where shown on drawings shall be broken hard stone (trap/basalt/Granite) of gauze not exceeding 63mm all as specified under para 3.27 on serial page 47 of SSR Part-I. Consolidation shall be done by well ramming and watering. The thickness of the hard core shown in the drawings shall be the consolidated thickness.

3.6 CONCRETE FILLING / CINDER FILLING

Concrete filling/cinder filling in sunken areas, if shown on drawings or specified elsewhere, shall be PCC (1:3:6) type C2/1 with brick aggregate not exceeding 40/20mm gauze. Brick aggregate shall be well graded so that after consolidation, it provides a dense and compact sub base.

3.7 ANTI-TERMITE TREATMENT TO FOUNDATIONS AND GROUND FLOOR

3.7.1 Anti-termite treatment shall be carried out in strict compliance with IS 6313 (Part II) of 1981 for pre-construction treatment using chemical CHLOROPYRIOPHOS EC20 and LINDANE EC20 emulsifiable concentrate.

3.7.2 The scope of work pertaining to Anti-termite treatment shall be restricted to the

provision i para 6.2.1, 6.2.2, 6.2.3, 6.4, 6.5 and 6.6 of IS : 6313 (Part II). The provisions of chemical in other paragraphs of the said IS shall also apply to the extent they are applicable to the items of works, specified in various para of IS mentioned above. The rate of application for different locations shall be as given in respective paras of IS.

3.7.3 A record of chemicals obtained in sealed containers shall be maintained in the measurement book duly signed by Project Manager and the contractor.

3.7.4 The work of anti-termite treatment shall be executed by the contractor through an approved agency (as approved by PM) who is a member of IPCA holding valid license as per clause 12 of Insecticides Act 1968 and persons employed to do the Anti-termite treatment shall be qualified as per rule 1991. The cost of anti-termite treatment is also deemed to be included in the unit rate quoted for buildings under Sch-'A' section I.

3.7.5 With reference to paras 6.2.2 and 6.3 of the IS : 6313 (part-II) the contractor shall note that earth filling to be done by him shall be carried out in layers not exceeding 25 cms each, watered and rammed as specified.

3.7.6 To check validity of guarantee, the following information will be inscribed on each building on a plate of 450 mm x 300 mm size prepared by plastering the brick surface with 20 mm thick cement and sand mortar (1:4) at such a place and in such a manner as approved by the PM. Date of expiry of guarantee shall be calculated or computed from the physical date of completion of the buildings as certified by the PM.

Anti-termite treatment carried out during _____

Chemical used _____

Agency who executed the work _____

Guarantee expires after **10 Years form** the date of Handover

The guarantee shall be given in Proforma

3.7.7 The unit rates quoted for buildings in Sch 'A' Sec I shall be deemed to be inclusive of this provision.

4. CONCRETE

I. COARSE AGGREGATE

Coarse aggregate shall be broken / crushed stone with the specifications given in clause 4.4 on pages 52 to 54 of MES Schedule Part I. However, in case of controlled quality concrete the provisions made in IS-456 shall be applicable.

II. Grading of coarse aggregate unless otherwise specified shall be as follows:

(a)	For all reinforced cement concrete of thickness not	-	20 mm graded as specified in para 4.4.7.1 on page No. 53 of MES

	less than 80 mm		Sch (Part-I)
(b)	For all reinforced cement concrete of thickness less than 80 mm	-	12.5 mm graded as specified in para 4.4.7.1 on page 53 of MES Sch (Part-1)
(c)	For plain cement concrete 65 mm thick and over	-	40 mm graded as specified in para 4.4.7.1 on page No. 53 of MES Sch (Part-1)
(d)	For plain cement concrete less than 65 mm thick.	-	20 mm graded in concrete 40 mm thick and above (but less than 65 mm thick) and 12.5 mm graded stone aggregate in concrete below 40 mm thick, both as specified in para 4.4.7 on page No. 53 of MES Sch (Part-1).
(e)	Where due to less thickness of concrete the use of 20 mm graded aggregate is not possible, the aggregate shall be of 12.5 mm grading as specified in para 4.4.7.1 on page 53 of MES Sch (Part-1) without any price adjustment.		

4.1 **CEMENT**

4.1.1

(a) The flowing types of cement can be used in structural/ Non structural works of ACDS.

(i) Ordinary Portland Cement Grade 43 (IS:8112-1989)

(II) Ordinary Portland Cement Grade 53 (IS:12269-1987)

(III) Portland Pozzolana Cement (IS:1489-1991 Part-I) with fly ash content of grade 43 and 53)

(b) (i) **Structural work**:- Only one type of cement will be used in one building. Mixing of various types of cement will not be allowed in one building. However, different types of cement can be used in different buildings.

(ii) **Non Structural works:-** As far as possible only one type of cement will be used in one building for structural and Non structural work. However in exceptional cases different types of cement can be used in same building for non structural work such as plaster, flooring, PCC etc, with prior permission of PM (ACDS)

(c) **Use of PPC:-** While using PPC, the following conditions will generally be met:-

(i) Strength criteria for PPC cement will be as per IS:8112-1989.

(ii) Stripping time shall be a minimum 14 days.

(iii) Para 4.1 (b) (i) & (ii) shall be enforced.

(iv) Mandatory certificates of testing and quality assurance will continue to submitted with fly as content as per IS: 1489-1991, part-I

4.1.2 **PROCUREMENT**

Cement shall be procured by the contractor from the main producers of cement enumerated as per list of approved makes / agencies.

The particulars of the manufacturer/supplier of cement along with the date of manufacture shall be produced by the contractor for every lot of cement separately. The original

documents in support of the purchases of cement shall be produced before the Project Manager for verification.

4.1.3 **TESTING**

The contractor shall submit the manufacturer's test certificate in original along with the Test Sheet giving the result of each physical test as applicable and the chemical composition of the cement or authenticated copy thereof, duly signed by the manufacturer with each consignment clearly bringing out lot No. The Project Manager shall record these details in the cement acceptance register (Appx 'B') after due verification. The Project Manager shall also organize independent testing of random samples of cement drawn from various lots from the National Test House, SEMT, Regional Research Laboratories, Government approved laboratories as per IS: 3535 - 1986 (Method of sampling Hydraulic cement), IS: 4031 (Method of Physical test for Hydraulic Cement) and IS: 4032-1985 (Method of chemical analysis of Hydraulic cement).

Following mandatory tests shall be carried out for cement procured by the contractor:

(i) Initial and final setting time.
(ii) Soundness test.
(iii) Compressive strength test at 3, 7 & 28 days as specified in relevant IS code.

The cement shall conform to chemical requirements and physical requirements as specified in relevant IS. The test carried out as per provisions of IS codes specified herein before shall be the criteria for acceptance of cement by Project Manager. If samples from a lot/lots are not within the acceptance limits of Indian Standard the lot/lots shall be rejected without any claims or compensation to the contractor for the lot/lots purchased. The contractor shall replace the lot/lots with the fresh one, which shall be tested again for acceptance. The cost of all tests carried out on cement before acceptance for incorporation in the work shall be borne by the Contractor whether the results are acceptable or not.

4.1.4 STORAGE

(a) Refer clause 4.3.1 on page-51 of SSR Part-I
(b) Cement shall be stored over dry platforms at least 20 cm high in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter. In case of store rooms, the stock should be at least 20 cm above from floors and away from walls. Inspections shall be carried out once a day by the DEProject Manager consultant and every week by the Project Manager. It shall be ensured by the Project Manager that tested and untested cement are segregated and stored separately with distinct identification. The cement godown shall be provided with two locks on each door. The key of one lock at each door shall remain with the Project Manager or his representative and that of the other lock with the contractor's authorized representative at site of works so that cement is removed from the godown only according to daily requirements with the knowledge of both the parties
(c) OPC grade 43 and PPC (Fly ash based) shall be stored in different storage

rooms for structural and non structural work. A record shall be kept showing the location and type of cement used. Different type of cement shall not be mixed together

(d) Maximum period of storage of cement for structural work shall be two months and for all other works three months

4.1.5 DOCUMENTATION

The Contractor shall submit original vouchers from the manufacturer for the total quantity of cement supplied under each consignment to be incorporated in the work. All consignments received at the work site shall be inspected by PM and documents verified before acceptance. The original vouchers and Test Certificates shall be defaced by PM, signed by Contractor and kept on record in the office of PM duly authenticated and with cross reference to the Control Number recorded in the Cement Acceptance Register. This Register will be signed by JE, DEPMC representative, PM and Contractor. The Accepting Officer may order a Board of Officers for random check of cement and verification of connected documents. The entire quantity of cement shall also be suitably recorded in the Measurement Book (not to be abstracted) for record purposes before incorporation in the work and shall be signed by the DEPMC, Project Manager and the Contractor. These documents shall be produced to all visiting officers from HQ ACDS.

4.1.6 SCHEDULE OF SUPPLY

Schedule of procurement of cement shall be finalized by the contractor with “Project Manager & DEPMC or his authorized representative” and shall be incorporated in the CPM chart so that procurement is in accordance with the progress contemplated in the CPM chart. The complete requirement of cement shall be worked out before making any RAR payment and procurement of cement by the contractor shall be completed sufficiently in advance of the execution of work.

4.2 FINE AGGREGATE (SAND)

Fine aggregate for all concrete work shall be best available river sand conforming to samples, complying with the requirement as specified in para 4.4.7.2 for grading zone I / zone-III on page 53 of MES schedule-2009 (Part I)..

4.3 All mixes of concrete except design mix concrete and mortar mentioned in this tender document shall be by volume except design mix concrete confirming to IS: 456 of 2000 for which all the ingredients shall be proportioned and mixed by weight.

4.4 MIX OF CEMENT CONCRETE

4.4.1 Cement concrete wherever shown on drawings or specified shall be of the following mix unless otherwise mentioned in these tender documents:

(a)	PCC lean concrete in foundations column footing, brick walls, brick	-	PCC (1:4:8) type D2 (by volume)

	pillars under brick steps and lean concrete not mentioned in (b) below.		
(b)	Sub base of floors except as mentioned.	-	PCC (1:3:6) type E-2 (by volume)
(c)	Lean concrete under floors for cycle shed & ramp as mentioned.	-	PCC (1:3:6) type E-2 (by volume)
(d)	PCC in Damp proof course	-	PCC (1:2:4) type B0 (by volume)
(e)	PCC blocks for hold fasts, PCC cills, PCC kerbs, coping, benching and any other PCC item not specifically mentioned elsewhere.	-	PCC (1:2:4) type B-1 (by volume)

4.4.2 Unless otherwise mentioned elsewhere, all RCC work in buildings covered under schedule 'A' Section-I shall be M-25 (Design mix).

4.5 MIXING AND CONSOLIDATION OF CONCRETE

4.5.1 All cement concrete work e.g. in footing, walls, column, beams, slabs, etc. shall be with **ready mix concrete (RMC)** from approved RMC manufacturer or from automatic batching plant installed at site with tested and calibrated water meter, control panel and of capacity 10-30 Cum per hrs. The mixing procedure supplying, conveying, placing, etc. shall comply with the specification mentioned under para 4.11 here in after. For smaller quantity i.e. for concreting to lintels, chajjas, shelves, etc., mechanical mixer and weigh batcher shall be used with approval of the PM and mixing of concrete shall be as per clause 10.3 of IS: 456-2000.

4.5.2 Mechanical vibrators shall be used for consolidation/ compaction to consolidate all reinforced cement concrete. Consolidation by tamping may be resorted to with prior permission of the PM in writing in locations where it is not practicable in the opinion of the PM to operate the vibrator. Care shall be taken to ensure that concrete is not over vibrated so as to cause segregation/ bleeding.

4.6 CASTING OF CONCRETE

PCC cills, RCC lintels (except those with chajjas), RCC shelves and fins may be **cast-in-situ or precast** at the discretion of the contractor without any extra cost. In the event of any deviation with regard to these items, pricing shall be done at applicable rates in MES/CPWD Schedule for cast-in-situ concrete.

4.7 DESIGN MIX CONCRETE

4.7.1 Where concrete is specified by grade that is M-25 & M-35 the same shall be of design mix all as per clause 9.2 of IS-456 - 2000, IS-10262-1982, SP-23 (S&T) 1982 and as specified herein after.

4.7.2 As soon as possible, after receiving the order to commence the work, the contractor shall procure sufficient quantities of the aggregate and cement and submit samples to any approved laboratory for testing and mix design. Also the RMC plant was identified and the design mix got approved by the PM.

4.7.3 The optimum mix to achieve the Target mean strength shall be determined in the laboratory conditions. The concrete shall conform to IS specifications:

4.7.4 MIXING BY VOLUME / WEIGHT

For controlled quality concrete of mix M-25 & M-30 only weigh batching will be adopted. No volume batching will be allowed for mix M-25 & M-30 grade of concrete.

4.7.5 MINIMUM CEMENT CONTENT

Minimum Cement, whichever is more for M-25 & M-35 grade of concrete shall be as per mix design or 300 Kg/cum & 340 Kg/cum respectively. The minimum cement content as mentioned above shall be provided even if the laboratory mix design gives a lesser quantity of cement. If the actual quantity of cement used as per mix design is more than the above minimum required, no price adjustment shall be made.

4.8 BATCHING

4.8.1 In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass and in accordance with clause 10.2 and sub clauses of IS-456: 2000.

4.8.2 TRIAL MIXES

The actual mix proportion will be arrived at by means of a number of trial mixes by changing the water cement ratio proportions of fine and coarse aggregate, fineness module of aggregate by changing their grading and preparations etc. Attempts shall be made to make the mix design as economical as possible.

4.9 SAMPLING

The sampling procedure and the frequency of sampling shall be as per clause 15.2 of 1S:456-2000.

4.9.1 TEST SPECIMEN

All test specimens shall be 150mm cubes. For each sample, six cubes shall be cast out of which three cubes each shall be tested for 7 days and 28 days compressive strength respectively. The specimen shall be tested as described in IS: 516-1959.

4.9.2 ACCEPTANCE CRITERIA

The acceptance criteria of the test results shall be as laid down in clause 16 of 1S:456-2000.

4.9.3 **WORKABILITY**

The workability of the concrete shall be checked frequently as per IS: 1199: 1959 (Methods of sampling and analysis of concrete).

4.9.4 **CHANGE OF MIX DESIGN**

During the progress of work, mix design will have to be changed if the quality of the ingredients of the concrete changes due to any reason.

4.9.5 **PACKING AND TRANSPORTATION OF SAMPLES**

The contractor must, at his own expenses, properly, pack the samples. The contractor shall bear the cost of transportation of the samples required to be tested, from site of work to the laboratory as directed by PM.

4.9.6 **SITE LABORATORY**

A state of the art Testing Laboratory shall be established at the site by the contractor at his own expense, which shall include the following minimum machinery and testing apparatus. Contractor shall establish separate laboratories for each and every station

(a) Concrete Cube Testing Machine of minimum capacity 100 Tons
(a) Cube Moulds: 15cm x 15cm x 15cm –12Nos.
70.6mm x 70.6 mm x 70.6mm-9 Nos.
(c) Slump Cone, Tamping rod
(d) Vicat's Apparatus
(e) Slandered Sand
(f) Moisture Meter
(g) Digital Balance (With Battery Backup)- 10 kg to 0.001 gm accuracy
(h) Digital Balance- 50kg to 0.001 kg accuracy
(i) Core cutter.
(j) Hot Air Oven – Temperature range 500 C to 3000 C
(k) Measuring Cylinder- 2000ml, 1000ml, 500ml, 100ml
(l) Sieves Coarse: 30cm Dia
(25mm,20mm, 16mm, 12.5m, 10mm, 6.3mm, 4.75mm, Pan & lid)
Fine: 20cm Dia
(4.75mm, 2.36mm, 1.18mm, 600mic, 150mic, Pan & lid)
(m) Thermometer- 00 C to 1000 C with accuracy of 10 C
(n) Megger and earth resistance tester
(o) Pumps and pressure gauges for hydraulic testing
(p) Curing Tank (Min. 2000 Lit. Capacity)

(q) Miscellaneous Sand Scoop, Spatula, Straight Edge Gauged Trowel, Steel foot rules, Scale, Mortar Pans, Spade, Shovels, Filter Paper and Wax

(r) Other equipment for site test as outlined in BIS

Test in addition to above shall be carried out at recognized test centres as catered in Appendix 'C' and / or desired by PM without any extra cost to Govt.

4.10 CONCRETE MIX PROPORTIONING

The mi x proportion shall be selected to ensure the mix workability of the fresh concrete is suitable for the conditions of handling and placing so that after compaction it surrounds all reinforcements and completely fills the formwork. When concrete is hardened, it shall have the required strength, durability and surface finish as per relevant clauses of IS: 456-2000. The compaction of concrete in RCC roof and floor slabs shall be done with plate vibrators.

4.11 READY MIX CONCRETE

4.11.1 Ready mix concrete (RMC) shall conform to IS:4926. For RMC, the contractor shall submit the following to the PM and obtain approval of RMC Plant.

(i) Mix design including names of suppliers from whom raw materials are to be procured.
(ii) Technical details of the batching plant.
(iii) Location of batching plant and details of transportation of concrete by transit mixers.
.
(iv) Brief details of projects where RMC. have been used from the proposed manufacturer.

Mixing: - Thorough mixing is essential for production of uniform concrete. Equipment and methods used shall be capable of effectively mixing concrete materials to produce uniform mixes of the lowest slump practical for the work.

Mixers both stationary and truck mounted shall be so charged that there is a preblending of the ingredients as the stream flows into the mixer.

Water shall enter the mixer first, but must continue to flow while other ingredients are entering the mixer. Water charging pipes shall be of proper design and of adequate size so that water enters at a point well inside the mixer. Water charging shall be complete within the first 25% of the mixing time.

Cement shall be charged along with other materials, but it shall be ensured that cement enters the stream after approximately 10% of the aggregate is in the mixer. When it is necessary to charge cement into truck mixers separately, additional mixing time shall be allowed to obtain desired uniformity to mix.

Admixtures shall be charged to the mixer at the same time in the mixing sequence for every batch. Liquid admixtures shall be charged with the water. Powdered admixtures shall be sprinkled into the mixer with other dry ingredients. When more than one admixture is used,

they shall be batched separately and they shall not be premixed before entering the mixer.

Mixer performance checks shall be made at regular intervals to ensure uniformity of the concrete. Visual examination of the concrete shall be one of the aids for maintaining and checking mixer performance.

Results of tests on air content, slump unit weight of air free mortar shall be guide lines on mixer performance.

Mixing time shall be measured from the time all ingredients are in the mixer.

Mixing time shall be established from mixer performance tests conducted at frequent intervals throughout the period of the works. However, as an initial guide, the mixer manufacturer's recommendation may be followed. Other guide lines being 1.33 min. for 1 cum capacity of mixer and 0.33 min for every additional 1 cum of mixer capacity.

Mixer shall be designed to have audible indicators and combination inter locks which prevent mixer discharge prior to completion of a preset mixing time. The mixer shall also be designed to start and stop operation with full load.

Provided that design water - cement ratio is not exceeded, small increments of retempering water may be added to mixed batches to obtain the desired slump.

Addition of water in excess of designed water - cement ratio to compensate for slump loss resulting from delays in delivery or placing of concrete shall not be permitted.

Batch to batch uniformity of concrete with regard to slump, water requirement and air content is dependent on temperature of concrete. It shall, therefore, be ensured that the maximum and minimum temperatures of concrete throughout all seasons of the year do not vary beyond the limits given below:
Maximum: 30°C
Minimum: 20°C

Necessary measures shall be taken to lower or raise the temperature of water to maintain the mixed concrete between the specified temperature limits.

Mixer shall be capable of and handled properly so that concrete of lowest desired slump can be effectively discharged without causing segregation.

Ready - Mix concrete may be :
- mixed in a central plant and transported to the job in agitating or non-agitating truck bodies.
- mixed entirely in transit.
- mixed entirely after reaching the job site.
- mixed partially in a central plant and completed in transit or after reaching the job site (shrink mixing).

In ready mix concrete, special attention shall be given to the addition of mixing water

quantity, which if incorrect, shall result in reduction of concrete quality.

Concrete consistency (Slump) is also affected by amount and rate of mixing, length of haul, time period for unloading and temperature conditions.

In cool weather or short haul and with prompt delivery, concrete quality may not be significantly affected. But with reverse conditions, the quality of concrete may be significantly affected.

Addition of water to compensate for slump loss shall not exceed that quantity necessary to compensate for a maximum 25mm slump loss. However, by this additional quantity of water, the design water cement ratio shall not be exceeded.

Loss in workability in warm weather shall be minimised by expediting delivery and placement, and by controlling the concrete temperature.

If it becomes necessary to use retarders to prolong the time the concrete will respond to vibrations after placement, prior approval shall be obtained from PM for their use.

In hot weather conditions or delays in delivery/placement, use may be made of the procedure of withholding some of the mixing water till the mixer arrives at the job site. In such cases, after addition of the balanced (withheld) quantity of water, an additional 30 revolutions of mixer at mixing speed shall be given to adequately incorporate the additional water into the mix.

When loss of slump or workability cannot be controlled by measures stated above, complete mixing shall be done at the job site using centrally dry batched ingredients.

4.11.2 **Supply and placing of ready-mix concrete(RMC)**

Responsibility of in-place quality of ready-mix concrete shall be shared by the manufacturer/ supplier of ready mix concrete and the placing contractor. They shall work in close coordination. The placing crew shall be in direct radio/telecommunication contact with the batching plant to ensure:

Avoidance of delay in dispatching concrete from batching plant:- inform batching plant delays to formwork, reinforcement work, handling or placing units.

The placement contractor shall give in writing his requirement of a particular batch of concrete to the supplier.

The ready-mix concrete manufacturer/supplier shall, along with each batch of concrete delivered to the placement contractor, give him a concrete delivery ticket. The supplier shall give copies of all such delivery tickets to the PM for his record and also shall get duplicate copies of all such delivery tickets duly received and signed from the placement contractor.

Ready mixed concrete as supplied by the manufacturer and as placed by the contractor

shall in no way be different from the specifications of concrete as approved by the PM.

Fresh concrete can be transported to the placement area by a variety of methods. Common among them are :-Mixer trucks.

Stationary truck bodies with or without agitators:- Buckets hauled by trucks. Conveyor belts. Hose or pipe line by pumping. Each type of transportation has specific advantages and limitations depending on the condition of use, mix, accessibility and location of placing.

Transportation by mixer trucks

These are essentially revolving drums mounted on truck chassis. Truck mixers used in the job shall be labeled permanently to indicate the manufacture specifications for mixing like:

- Capacity of drum.
- Total number of drum revolutions required for complete mixing.
- Mixing speed
- Maximum time limit before completion of discharge and after cement has entered the drum.
- Reduction in time period of discharge.
- Due to warm weather or other variables.
- All above information shall only form guidelines for the manufacture/producer of concrete.

Fulfillment of the stipulated number of revolutions or elapsed time shall not be an acceptable criterion. As long as the mixing water limit is not exceeded and the concrete has satisfactory plastic physical properties and is of satisfactory consistency and homogeneity for satisfactory placement and consolidation and is without initial set, the concrete shall be acceptable.

When the concrete is totally mixed in transporting trucks or in case of shrink-mix concrete, the volume of concrete being transported shall not exceed 63% of the rated capacity of the drum. In case the concrete is totally mixed in the central batching plant, the transporting truck may be loaded upto 80% of the rated capacity of the drum. In this case the drum shall be rotated at charging speed during loading and reduced to agitating speed after loading is complete.
When transporting concrete by truck mixers, delivery time shall be restricted to 1.50 hours from the time cement has entered the mixer to completion of discharge.

Transporting by agitating/non-agitating trucks

Transporting ready mix concrete by this method shall consist of truck chasis mounted with open top bodies. The metal body shall be smooth and streamlined for easy discharge. Discharge may be from the rear when the body is mechanically tilted. Body of the truck shall have a provision of discharge gate. Mechanical vibrators shall be installed at the discharge gate for control of discharge flow.

Agitators, if mounted, also aid in the discharging of concrete from the truck in addition to

keeping the concrete alive.

Water shall not be added to concrete in transport in this system.

Bodies of trucks shall be provided with protective covers during period of inclement weather.

Delivery period, when adopting this system of transporting, concrete shall be restricted to 30 minutes from the moment all ingredients including cement and water enters in the mixer to completion of discharge.

Transporting by buckets

This method of transportation is very common for transportation of centrally mixed concrete. Buckets of suitable capacities may be fitted with concrete which is totally mixed in the central plant and hauled to the job site. Buckets then may be conveyed to the actual point of placement either with the help of crane/ hoist or they may be carted.

As in the case of open truck transportation, water shall not be added to concrete transported in buckets. Concrete shall be protected from inclement weather by necessary covering arrangements. Also, the maximum delivery period for this system of transportation from the time cement is introduced into the mixer to completion of discharge shall not exceed 30 minutes.

Before loading concrete in either truck mixer, open bodied trucks or buckets, the containers shall be thoroughly cleaned, washed and dried, so that there is no water or moisture in the container which may affect the designed water content of the concrete.

Other methods of transportation

Transportation of concrete either by belt conveyors or by pumping is envisaged in this work.

If, however, producer/manufacturer/purchaser of ready mix concrete desires to use such methods of transportation, they may do so provided their scheme and complete specifications are submitted to the **PM** for his record and approval.

Method of transportation used shall ensure
Efficient delivery of concrete.

- No significant alteration of properties with regard to water cement ratio, slump, air content and homogeneity.

All variables in transportation, considering type and accessibility of placement locations, distance, time interval etc. shall be carefully studied before arriving at the method used.

4.11.3 **Placing Concrete by Pumping Methods**

Concrete conveyed by pressure through either rigid pipes or flexible hoses and discharged directly into the desired area is termed as pumped concrete. The method of conveying the concrete through pipe lines is dealt with in these specifications.

The method of applying pressure to concrete is by pumps. Pumps to be used shall be either of the two types as mentioned below:

(a) Piston type pumps
(b) Squeeze pressure type pumps.

The piston pump to be used in the works shall consist of a receiving hopper for mixed concrete, an inlet valve, an outlet valve, and the pump shall be a twin - piston pump. The two pistons shall be so arranged that one piston retracts when the other is moving forward and pushing concrete into the pipeline to maintain a reasonably steady flow of concrete. Single piston pumps shall not be acceptable.
Inlet and outlet valves shall be anyone of the following types :
Rotating plug type Sliding plate type Guided plunger type Swing type Flapper type or any combination of the above.

The pistons shall be mechanically driven using a crank or chain or hydraulically driven using oil or water.

The receiving hopper shall have a minimum capacity of 1.0 cum and the hopper shall be fitted with remixing rotating blades capable of maintaining consistency and uniformity of concrete. The primary power for pumps may be supplied by gasoline, diesel, or electric motors. The primary power unit and the pump unit may be truck, trailer or skid mounted.

Squeeze pressure pumps shall consist of a receiving hopper fitted with re-mixing blades. Re-mixing blades shall be such that these can push the concrete into the flexible hose connected at the bottom of the hopper.

The flexible hose shall pass through a metal drum around the inside periphery of the drum and come out through the top part of the drum.

The drum shall be maintained under a very high degree of a vacuum during operation. The drum shall be so fitted with hydraulically operated metal rollers, which when rotating, create a squeeze pressure on the flexible hose carrying concrete and force the concrete out into the pipe line.

Effective range of pumps to be used in the work shall be decided by the contractors after studying the site conditions. However, the minimum horizontal range shall not be less than 150 metres and minimum vertical range shall not be less than 50 metres.

Selection of pumps based on discharge capacity shall be decided by the contractors after studying the requirements for the project. Discharge capacity shall be worked out by the contractors and approval obtained from the PM. As a guide line figure the contractors may assume a discharge capacity of 15 cubic metre/hour/pump.

4.11.4 **Pipe Lines**

All concrete carrying pipe lines shall generally be rigid pipe lines. Flexible pipe lines may only be used at bend curves in lines or at discharge ends if required. Placements of flexible

units shall be done judiciously and connected to the pipe lines only when it meets the approval of the PM.

Rigid Line/Hard Line/ Slick Line: Such Lines shall be made either of steel or plastic. Aluminium alloy pipes shall not be used.

Minimum pipeline diameter shall be 100 millimeters and shall have normal maximum length of 3 metre in each section connected through couplers.

Flexible Pipe Line: Flexible lines shall be made out of rubber or spiral wound flexible metal or plastic. The pipe shall again be such that they are in Sections of 3 metre length each and connected through couplers. These pipes shall be such that they are interchangeable with rigid lines. While installing flexible units, care shall be taken that there are no links in the pipeline, which is a normal tendency with these pipes having diameters 10mm and above

Couplers to be used for connecting pipeline sections (either hard or flexible) shall have adequate strength to withstand stresses due to handling, misalignments, poor support to pipe lines etc.

For horizontal runs of pipes and for vertical runs up to 30-metre height the couplers shall be rated for a minimum pressure of 35 kg/cm square. Couplers used for rising runs between 30 metre and 50 metre heights shall have a minimum pressure rating of 50 kg/cm square. Couplers shall be designed to allow for replacement of any pipe section without displacing other sections. These shall provide for the full internal cross section with no constructions or service, which may disrupt the smooth flow of concrete. For pipelines of size 150mm and above, double logged type coupler with a thick rubber gasket and secondary wedge-takeup is recommended. Types of couplers that may be used shall be any of the following:

- Grooved end coupler
    - One piece extended lever swing type couplers
    - And full flow oil line type couplers.

Other Accessories

Other accessories which shall be catered for, are as under: -

- Rigid and flexible pipes of varying lengths
- Curved sections of rigid pipes
- Swivel joints and rotary distributors
    - Pin and gate valves to prevent back flow in pipelines
    - Switch values to direct the flow into another pipeline
    - Connection devices to fill forms from the bottom up
- Splints, rollers, and other devices for protection of conduit over rock concrete Reinforcing steel and form and to provide lifting and lashing points in the pipe line. '
- Transitions for connecting different sizes of pipe sections Air vents for downward pumping.
- Clean out equipment.

For concreting of columns, walls and scattered small placements, recommendation is made for special cranes or power controlled booms carrying pipelines with a pendant type concrete delivery hose.

Lubricating of Pipe Line

Before pumping concrete into the pipeline, the line shall be lubricated with a properly

designed mortar/grout lubricant. This shall be ensured by starting the pumping operation with a properly designed mortar, or with a batch of regular concrete with the coarse aggregate omitted. The quantity of mortar required as lubricant is dependent on the smoothness and cleanliness of the pipelines. As a guide line, for a 100mm diameter pipe line of 100metre length, 0.08 cum to 0.10 cum of mortar should normally be adequate, but this shall not be taken as specified, and the contractor shall establish his requirement.

The quantity of mortar that comes out of the delivery end of the pipeline shall not be used in place of the concrete work. However, with the approval of the PM, this mortar may be used as bedding mortar against construction joints. The rest of the mortar shall be wasted.
Lubrication shall be maintained as long as the pumping of concrete continues.

Proper planning of concrete supply, pump locations, line layout, placing sequence and the entire pumping operation will result in savings of time and expense.

The pump shall be placed as near the placement area as practicable. The surrounding area of the pump shall be free of obstructions to allow for movement of concrete delivery trucks. The surface must be strong enough to withstand the loaded trucks operating on it. If the surface is a suspended slab, the truck route shall be adequately supported in consultation with the PM.

Pipe lines from the pump to the placing area shall be laid with a minimum number of bends. For large placement areas, alternate lines shall be installed for rapid connection when required. A flexible pipe at the discharge end will permit placing over a large area directly without re-handling of pipelines. The pipeline shall be firmly supported.

If more than one size of pipe must be used, the smaller diameter pipe shall be placed at the pump end and the larger diameter at the discharge end.

When pumping downwards, an air release valve shall be provided at the middle of the top bend to prevent vacuum or air buildup. Similarly, while pumping upwards, a no-return valve shall be provided near the pump to prevent the reverse flow of concrete during the fitting of clean up equipment or when working on the pump.

It is essential that direct radio/telecommunication be maintained between the pump operator and the concrete placing crew. Good communication between the pump operator and the batching-plant is also essential. The placing rate shall be estimated by the pump operator so that concrete can be ordered at an appropriate delivery rate.

The pump shall be started for a check run and operated without concrete to ensure that all moving parts are in operation properly. Before placing concrete, the pump shall be run with some grout/l mortar for lubricating the line.

When concrete is received in the hopper, the pump shall be run slowly until the lines are completely full and the concrete is steadily moving. Continuous pumping must be ensured, because, if the pump is stopped, concrete in the line may be difficult to move again.

When a delay occurs because of concrete delivery or some form repair works or for any other reason, the pump shall be slowed down to maintain some movement of concrete in the pipeline. For long delays, concrete in the receiving hopper shall be made to last as possible by moving the concrete in the lines occasionally with intermittent strokes of the pump. It is sometimes essential to run a return line back to the j pump so that concrete can be re-circulated during long delays.

If after a long delay, concrete cannot be moved in the line, it may be necessary to clean out the entire line. However, quite often only a small section of pipeline may be plugged and required cleaning. The pump operator who knows such details as the length of line, age of concrete in the line etc., should be, dependent upon to aid in deciding the appropriate section to be cleaned.

When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a "go-devil" inserted at the appropriate time so that concrete ahead of the go-devil shall be forced completion of the work. The go-devil shall be forced through the pipeline to clean it out. Use of water pressure is a safer method. The go-devil shall be stopped at the -discharge end to ensure that water does not spill on the placement area. If air pressure is used, extreme care shall be taken and the pressure must be carefully regulated. A trap shall be installed at the end of the line to prevent the go-devil being ejected as a dangerous projectile. An air release valve shall also be installed in the line to prevent air pressure build up.

It is essential to clean the line after concrete placing operation is complete. Cleaning shall be done in the reverse direction from the form work end to the pump-end where the concrete in the line can be dumped in a bucket. After removal of all concrete, all pipe lines and other equipment shall be cleaned thoroughly and made ready for the next use.

4.12 **CONCRETE SURFACING**

4.12.1 Exposed surfaces of all RCC work such as soffit of roof/floor slab, slabs & bottom of beams, lintels, seismic bands, shelves & RCC railing / parapets etc. unless otherwise specified hereinafter in particular specification shall be provided with a coat of 5mm thick plaster in cement and sand mortar (1 :3) finished even and smooth. In case this thickness of plaster exceeds 5mm at places due to local unevenness, no extra payment is admissible. The exposed surfaces of columns, beams, lintels and the like coming in conjunction with plastered surfaces shall be plastered as specified in the plastering section. Sand for plaster shall be as specified. The term exposed surfaces does not include the surfaces hidden under earth filling etc. and in such cases irregularities, protruding form work marks shall be removed and air holes, if any, shall be stopped with cement and sand mortar (1: 3). Cost of above provisions shall be deemed to be included in the contractors quoted rates.

4.12.2 Drip course of 20mmx10mm size on the outer edge or bottom of RCC/PCC cill projection etc. shall be provided irrespective of whether shown on drawings or not.

4.13 **STONE CILL**

Polished Kota stone sills shall be provided in all window even if not shown on drawings. The thickness of Kota stone shall be 25mm and shall be in one piece with 200mm bearing on either side.

4.14 PLINTH PROTECTION

4.14.1 Plinth protection shall be 75mm thick in cement concrete (1 :3:6) type C-2 over 75mm thick hard core of 40mm graded stone aggregate and well compacted over rammed earth and shall be finished even and fair with steel trowel without using extra cement. Plinth protection shall be laid to a slope of 1 in 24 in alternate bays system., Each bay shall not exceed 3 metre in length. 12mm wide and 7.5 cms deep joint shall be formed between the bays which shall be filled with mastic filling to full depth, comprising a mixture of one part of heated hot blown bitumen 85/25 Penetration and two parts of heated coarse sand (by volume). The width of plinth protection irrespective of what is shown on drawings shall be 1500 mm. The toe of plinth protection of size 75mm deep and 75mm wide shall also be of PCC 1: 3:6 type C-2 and shall be provided in buildings irrespective of whether shown on drawings or not. Plinth protection shall be provided to all buildings irrespective of whether shown on drawings or not.

4.15 CONSTRUCTION JOINTS/ EXPANSION JOINTS

All construction joints/ expansion joints shall be as per clause 13.4 of 1S:456-2000 and 1S:11817. Concreting shall be carried out continuously upto the construction joint and prior to start of concreting written approval shall have to be obtained from the PM.

“At the construction joints, the concrete surface shall be cleaned properly and a coat of Nitobond (FOSROC) shall be applied before placing fresh concrete. The rate of application shall be as per manufacturer’s instruction. For slabs & beams of one Qtr, the concreting shall be done continuously till completion. No construction joints shall be permitted.”

4.16 WORK IN EXTREME WEATHER CONDITIONS

Work in extreme weather conditions (hot or cold) shall be carried out as per clause 14.2 of IS:456 - 2000.

4.17 DAMP PROOF COURSE

The damp proof course shall consist of a layer of 40mm thick PCC (1 :2:4) type B0 and shall be mixed with water proofing compound conforming to IS:2645 liquid grade as per manufacturer specification and laid as specified in para 5.42 on page 101 of MES Schedule (Part I)/CPWD. Water proofing compound shall conform to IS2645. It shall be mixed with concrete in the proportion and in the manner as given in manufacturers instructions. Deviations if any shall be priced on the basis of water proofing compound actually incorporated in the work.

Damp proof course shall be provided on all brick walls, PCC walls and brick pillars for their full length and width at the ground floor. Damp proof course shall also be provided

under openings/door opening at depressed level including vertical faces of depressed level and including vertical faces of depressed portion of opening as per requirement of clause 5.8.1.3 of IS - 2212. However, damp proof course shall not be provided over dwarf walls/RCC columns.

“Damp proof course shall be provided on masonry walls at floor level wherever plinth beams are not provided.

4.18 BLANK

4.19 **PCC BENCHING**

PCC Benching shall be provided at the junction of parapet wall and roof even if not shown in the drawing. The radius of PCC benching shall be 75mm and shall be cast in PCC 1:2:4. The entire surface of benching shall be plastered in CM 1:4 15mm thick.

4.20 **FORM WORK**

4.20.1 Formwork shall be as per clause 11 of of IS-456-2000 & IS: 14687. The level of forms shall be adjusted to keep the difference in thickness of the **flooring of Kota stone and ceramic tile floors.**

4.20.2 Formwork shall be of minimum 12mm water proof plywood or steel of adequate strength. However, the form work to be used for surfaces specified in these specifications to be plastered shall be such that after application of the specified thickness, a fair finished surface is achieved as specified herein. Wall thickness shall not be made use of as formwork. The wall shall be built after the columns are casted. In the event of deviation, rates in the MES /CPWD schedule for clean sawn formwork will be applicable. **In** this connection also refer to para 14.14.3 on page 314 of SSR Part – I/CPWD Manual. steel tubular scaffolding telescopic type shall only be used. Form work shall be preferably of steel.

4.20.3 The contractor shall excavate for the RCC footings, walls to their exact size after accounting for formwork to sides. If the excavation is more than required size, extra excavation shall be made good as mentioned in clause 3.13.4 on page 39 and sub clause 3.15.5 on serial page No. 39 of SSR Part - I. However, form work shall be provided to vertical sides of column pedestals as necessary and as directed by Project Manager. Slopped portion and RCC column footing if any, under masonry work shall be filled with **PCC (1 :3:6)** type C2/C1 to maintain continuity and level of masonry work and lumpsum quoted by the contractor shall be deemed to include for the same.

4.20.4 The form work for Soffits of suspended slabs such as roof slabs, floor slabs, landings and similar work, shall be of steel and vertical supports shall be of adjustable type steel props. Wooden bullies shall not be used.

4.20.5 Shuttering of RCC 'cantilever canopy / chajja shall not be removed unless counter balancing load has been imposed.

4.21 MIX OF LEAN CONCRETE

Wherever lean concrete has been specified /shown on drawings except as mentioned in clause 4.4.1 hereinbefore it shall be PCC (1 :5: 10) type E-2/1.

4.22 CURING

Curing of RCC / PCC shall be as per clause 13.5 of IS:456-2000.

4.25 Design Mix Concrete - Pricing of deviation

For the purpose of pricing deviation in M-25, M-30 Grade design mix concrete the rates in SSR Part –II subject to contractor percentage shall be applicable.

5. BRICK WORK

5.1 MATERIALS

5.1.1 Bricks to be used in the Building work shall be best available kiln burnt clay bricks of size 230 x 115 x 75 mm with frog size 100x40x10-20mm having minimum compressive strength of 75 Kgs per sqcm and shall comply with the requirements of Sub Class 'B' as specified in IS-1077. All bricks in any of the work coming below ground level shall also be best available kiln burnt clay bricks. Bricks to be used in other sections under this contract shall be best available kiln burnt clay bricks of size 230 x 115 x 75 mm with frog size 100x40x10-20mm having minimum compressive strength of 75 Kgs per sqcm and shall comply with the requirements of Sub Class 'B' as specified in IS-1077.

5.1.2 Common burnt clay building bricks shall conform to the requirements laid down in IS 1077-1992. Bricks shall have minimum compressive strength of 75 Kg/Cm^2 (Class designation 75). The brick shall have smooth rectangular faces with sharp corner & slight round edges, and shall be well burnt, uniform in colour, free from cracks, flaws, nodules of lime and emit clear ringing sound when struck.

5.1.3 **Sampling and tests**. Samples of bricks shall be subjected to the following tests.

a) Dimensional tolerance.

b) Water absorption.

c) Efflorescence.

d) Compressive strength.

5.1.4 Sampling for carrying out the above tests, shall be done as per IS: 5454 at random according to the size of lot given in Table below. The sample thus taken shall be stored in a dry place until tests are made.

5.1.5 Samples shall be taken as per details given below:-

Sampling from a stack. The brick stack, shall be divided in to a number of real or imaginary sections and the required number of bricks drawn from each section. Sampling from trucks shall be as per IS: 5454.Scale of sampling and criteria for conformity for visual and dimensional characteristics: -

No. of bricks in a lot	For characteristics specified for individual bricks		No. of bricks to be selected for dimensional characteristics
	No. of bricks to be selected	Permissible no. of defective bricks in the sample	
2001-10000	20	1	40
10001-35000	32	2	60
35001-50000	50	3	80

b) **Visual characteristics**. The number of bricks to be selected from a lot and shall be in accordance of col. 1 & 2 of Table for visual characteristics in all cases and dimensional characteristics if specified for individual bricks. All the bricks selected above in accordance with col. 1 & 2 of Table shall be examined for visual characteristics as specified in col 2. If the number of defective bricks found in the sample is less than or equal to the corresponding number as specified in col. 3 of table , the lot shall be considered as satisfying the requirements of visual characteristics, otherwise the lot shall be deemed as not having met the visual requirements.

c) **Dimensional characteristics**. The number of bricks to be selected for inspecting the dimensions and tolerance shall be in accordance with col. 1 & 4 of Table 1. These bricks will be divided into groups of 20 bricks thus formed will be tested as per IS: 1077 for all the dimensions and tolerance as given below

i) Type of bricks – Non modular bricks

ii) Nominal size _ 230X114X75mm

iii) Actual size – 230X111X70 mm

iv) Dimension for group of 20 bricks

Length 442 to 478 cm (460 ± 18 cm)

Width 213 to 231 cm (222 ± 9 cm)

Height 134 to 146 cm (140 ± 6 cm)

A lot shall be considered having found meeting the requirements of dimensions and tolerance if none of groups of bricks inspected fails to meet the specified requirements.

Scale of sampling and criteria for physical characteristics shall be as per IS: 5454.

The Lot, which has been found satisfactory in respect of visual and dimensional requirements, shall be next tested for physical characteristics like compressive strength, water absorption, and efflorescence.

5.1.6 The physical requirements of the bricks shall be tested as per IS: 3498 (Part I to IV)

The bricks shall have physical characteristics as specified here under:-

a) Water absorption - 20% Max

b) Compressive strength - 75 Kg/sq cm

c) efflorescence - Nil to Slight sign of efflorescence i.e. 0-10% of surface area of the brick should show a thin deposit of salt

To eliminate the efflorescence the bricks are required to be soaked in water mixed with chemical for 24 hours before use on the work & no extra payments shall be made for this.

5.1.7 A lot shall be considered having satisfied the requirements of physical characteristics if the condition stipulated herein are all satisfied:

a) The average compressive strength shall satisfy the requirements specified in Para 5.1.6 (b) above.

b) The compressive strength of any individual brick tested in sample shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 %

c) Average water absorption shall be as specified in Para 5.1.6 (a) above.

d) The Number of bricks failing to satisfy the requirements of the efflorescence specified in Para 5.1.6 (c) should not be more than the permissible in IS: 5454

5.1.8 Handling and storage of bricks shall be as per Cl 5.6.9 of SSR Part-1

5.1.9 The general quality of brick shall be as per Cl. 5.6.5 of SSR Part-I.

5.1.10 Construction of manholes & underground structure shall invariably be done by using burnt clay bricks class B with compressive strength 75 Kg/cm^2 & water absorption lesser than 15%.

5.1.11 **FLY ASH CEMENT BRICKS-- BLANK**

5.2 WORKMANSHIP

5.2.1All brick work unless mentioned otherwise in particular specifications shall be built in CM (1:6) except half brick walls, brick on edge walls, brick pillars (isolated), brick steps, brick fins which shall be built in cement and sand mortar (1:4).

5.2.2Unless otherwise shown on drawings all brick work in half brick walls shall be built from sub floor level in ground floor and from RCC slabs in subsequent floors shall be reinforced with 2 Nos. 8mm dia for steel at every fourth course starting from 20 cm above DPC / floor slab. These bars shall be extended into the junctions with adjoining walls / columns for a minimum length of 75mm. Laps shall be 300 mm

5.2.2.1. For half brick walls, continuous RCC bands shall be provided at cill level, lintel level, and roof level whether shown in the drawing or not. The size of the band shall be 115(width)x75mm (depth) and shall be reinforced with 2/8 dia TMT bars and 8mm dia TMT links @150clc. Grade of concrete shall be M-25.Wherever doors and window openings are there, separate lintel has to be provided as per drawings and specification.

5.2.3 Nominal width of brick shall be considered 230mm for one brick wall & 115 mm for half brick wall.

5.2.4 For half brick walls more than 3000 mm in length vertical RCC bands of size 115mm x thickness of the wall shall be provided at maximum 3000 mm c/c spacing. The vertical bands shall be reinforced with 4 Nos 8mm TOR reinforcement bars with 8 mm TOR links at 100 mm/cc. No foundation shall be provided for these vertical bands. The vertical 8 mm for the bar shall, however, be anchored into the slabs / beams / lintels both at the top and at the bottom. The anchorage length shall be 200 mm minimum..

5.2.5 2 Nos. 12 mm TMT bars shall be provided longitudinally in RCC floor slabs where half brick walls are supported on them directly.

5.2.6 Bearings of all slabs on masonry walls shall be for the full thickness of wall.

5.3 THICKNESS OF BRICK WALL/PILLAR & CONCRETE MEMBERS

5.3.1 Width of concrete lintels, beams, cills, columns and the like coming in conjunction with Brick walls/pillars shall be kept to the actual width of Brick work unless off sets have been specifically shown, in which case width as shown on drawings shall be maintained.

5.3.2 The walls shall be laid out strictly as per drawings. Before carrying out the Brick work the layout shall be done and got approved by the PM and changes instructed incorporated.

5.3.3 Mortar bed joints shall be such that four courses of Brick work and three joints taken consecutively shall measure 3 to 4cm in addition to the combined height of the Brick. Accordingly, the provision under clause 5.26 on page 95 of SSR (Part I) shall not be made applicable to this contract and no price adjustment shall be done on this account. However, in the case of half Brick walls where reinforcement has been specified herein above such four courses will be selected between the horizontal joints having the reinforcement.

5.3.4 Thickness of Brick walls/pillars shown on drawings as 115mm, 230mm and 345mm for half Brick wall, one Brick wall and one and half Brick wall respectively, shall be deemed to have been amended to the thickness obtainable with the use of Bricks as specified herein before without adjustment in prices.

5.3.5 Centre line dimensions of rooms, Verandah etc as shown in drawings shall be maintained. Internal and overall dimensions if at variance, then too, centre line dimensions shall be adhered to and drawings shall be deemed to have been amended accordingly.

5.3.6 All scaffolding for brick work shall be of double legged steel (Independent staging)

6. WOODWORK (CARPENTERS WORK)

6.1 The timber to be used in various situations (except flush shutters, veneered particle boards, block boards and timber for formwork) unless otherwise specified elsewhere in

particular specifications shall be as under:

(a) Wooden frames/chowkhats for door,: IInd class Hard wood Cup boards
Hollock / Bonsum /Mirantee (BEN TEAK)

(b) Cleats, chock stops, fillets, battens :IInd class Hard wood etc.
Hollock / Bonsum /Mirantee (BEN TEAK)

Edging Beading to particle board / block :1st class Hard wood teak board etc.

6.1.1 Maximum permissible moisture content in timber used for various purposes is 12%. The contractor shall get the timber (except that required for temporary use such as formwork etc.) klin seasoned to ensure that permissible moisture content is not exceeded.
6.1.2 No price adjustment will be made either to the unit rates quoted for the buildings in Schedule 'A' Section I while pricing any deviation on account of kiln seasoning as specified hereinbefore, as this element is deemed to be included in the rates.

7. Post tensioning Slab

7.1 l General

The Post Tensioning bonded Flat slab system shall consist of High Tensile strands of 12.90 mm (0.5“dia) /15.20 mm dia (0.6 “ dia) and contained in a flat slab GI duct of 80 mm x 20 mm .Each strand in anchored by means of wedge and individually stressed by means of a mono strand Jack. The prestressing force is transferred to the concrete by a flat anchorage. By use of flat duct the static depth of slab is more efficiently utilized compared to a round

2 Prestressing systems

The pre-stressing system is incorporating strands with 12.90 mm dia strand /15.20 mm dia strand.

3 Materials

Strands	0.5”	0.6”
Nominal Diameter	12.9mm	15.2mm
Nominal Area	98.7mm2	139mm^2
Nominal weight	0.785 kg/m	1.112 kg/m
Tensile strength	1860 N/mm^2	1860 N/mm^2
Modulus of elasticity	195000 N/mm^2	195000 N/mm^2
Min breaking load of strand	184kN	260kN

Strand quality in accordance with	IS 14268	IS 14268

3.1 Ducts

The sheathing consists of corrugated spiral ducts made from galvanized steel strips of 0.3 mm thick.

3.2 Anchorages

The type of anchorages commonly used is Flat Anchorage (FA), Multiplane Anchorages (MA), Bond Head (Dead End) Anchorages. The purpose of the anchorages are when the strands are stressed, the tendon force would be transferred to the concrete. Bursting reinforcement is provided behind the anchorage to distribute the stressing force.

4 Design data for friction / elongation calculation

Friction of coefficient u	:	0.2 } or as per the consultants recommendation
Wobble factor k	:	0.0017/m } design parameters
Draw in of wedge	:	6mm (approximately)
Stressing anchorage	:	Type FA, MA
Loss in jack	:	Varies from 0 to 2.0% for various type of jacks

5 Handling and storage of materials

- The pre-stressing strands shall be free of grease and corrosion enhancing properties.
- No flame cutting of strands is allowed
- Care should be taken during handling of construction work in order to avoid mechanical damage to the strands.
- Strands should be raised above ground level to prevent ingress of soil.
- Suitable ropes or slings shall be used for loading and unloading in order to avoid mechanical damage to the strand coil.
- The component must be handled and stored such that any contamination, mechanically damage or corrosion can be avoided.

6. General Working Procedures

- Generally the prestressing tendons are installed in accordance with the “Approved Drawings issued for Construction”.

- Install bottom slab reinforcement when the slab formwork is ready.
- Provide sufficient cover to the bottom slab reinforcement in accordance to the shop drawings.
- Install tendons after the completion of the bottom slab reinforcement.
- As for beam construction, install bottom / side reinforcement and links (without internal & external capping links in the beam).
- Install tendons in accordance to the shopdrawings.
- Install top reinforcement and capping links of the beam.

7. **Guidelines for Tendons Installation**

- Tendon alignment and height shall take precedent over reinforcement whenever there is a clashing point.
- All dimensions measured shall be based on the formwork level. Therefore an accurate formwork level is necessary.
- The tolerances of formwork shall be ±5mm or in accordance to the specifications.
- The Multiplane Anchor is fixed to the end formwork by support bars to avoid any displacement during concreting.
- The Multiplane Anchor must be orientated perpendicularly to the cable axis and with the grout connection at the top of the duct.
- If the side formwork is to be erected early, the main contractor has to arrange for hole protrusion to be made for each anchorage to accommodate protruding duct and strands.
- Tolerances for vertical tendon profiles are ±10mm for all high and low points.

  Tolerances for horizontal profiles are ±150mm (to avoid small M&E openings or other obstructions). Specialist designer shall be consulted for tolerances bigger than ±150mm.
- Handle ducts with care to avoid damage.
- Support bars and bar-chairs are placed at intervals of each 1m (approx) and secured with binding wire to avoid any movement during concreting.
- Duct joints are sealed with tape.

- Care should be taken during concreting to avoid grout hoses from being embedded in concrete or removed completely.
- Avoid stepping on ducts placed.
- Care should be taken to avoid damaging ducts with tie bars of the formwork.

8. Stressing

Stressing shall not commence unless the main contractor has confirmed that the concrete for the pour to be stressed has achieved the minimum cube strength of 28 N/mm^2.

Preparation for stressing

- Removal of formwork and polyfoam / plastic blockout from the anchorage blackout.
- Placing of wedge plate and wedges. It is important that this operation be carried out after concreting so that the anchorage is not fouled by grout or dirt.
- Ensure that the protruding strand length is sufficient for stressing.

8.1 **For Multistrand Jacks (Multiplane Anchor)**

- At the beginning of stressing the strands are locked in the jack pulling head.
- The pressure of the manometer and the measured elongation are recorded in the stressing report.
- When the jack has reached the end of its stroke or the desired force has been obtained, the pressure in the jack is released and the strands become locked uniformly by the wedges in the wedge plate.
- The jack piston returns.
- Stressing is continued in as many stages as are necessary to obtain the required force.

8.2 **For Monostrand Jack (Flat Anchor)**

- Initial stressing of 25% of the total designed force can commence anytime after the concrete has minimum cube strength of $8N/mm^2$. The purpose of initial stressing is to take the slack of the strands in the tendon.
- A spray mark is made on the strands.
- Proceed with the full 100% stressing of the total designed force after the concrete has attained its minimum strength as per the specifications.

- Measure the difference in length from the spray mark to the wedge plate. This will reflect the elongation per strand from 25% to 100%. (Assume this to be X mm in length.)

- Add the wedge draw in which is approximately 6mm to the elongation.

- By extrapolation the full measurement can be calculated and compared against theoretical elongation.

  Therefore the full elongation for one-end stressing will be

$$= (X + 6mm) \times \frac{100}{75} \% = = (X + 6mm) \times 1.3333$$

Similarly for tendons with two ends stressing, the tendons may be stressed from one end followed by another. Sum of elongations from both ends is then compared with total theoretical extension.

Assuming the far end elongation is Y.

The total elongation will be:

$$\{(X + 6mm) + (Y + 6mm)\} \times \frac{100}{75} \%$$

Sample of Stressing Reports are as shown in Appendix A.4

- After approval by consultants / main contractor the protruding strands are to be cut off to a minimum of 10mm from the wedge plate.

- All stressing results shall be tabulated on a stressing record and submitted for approval by the engineer. The pressure gauge and jack no's shall also be indicated.

- If the average stressing result of the whole pour is within ±8% it shall be deemed as satisfactory.

- In accordance to the Federation Institute of Prestressing (FIP) code, the average shall be within ± 8%.If any individual tendon of a pour falls outside this, then the average extension over the whole respective pour should be checked and this falls within the tolerance of ±8%, then the stressing operation is considered satisfactory.

- Stripping of formwork can be carried out after full stressing of beam / slab is completed.

- Stripping of form work shall be carried out only upon receiving the written confirmation from the Post tensioning agency 24 hours after stressing. Stripping of form work at Pour strip area 1m on both side should be carried only after achieve the concrete strength at pour strip and approval from PT designer.

9. **Grouting**

Proposed grout mix

- Cement in standard 50kg package (Ordinary Portland cement)
- Water = 0.45 x 50kg = 22.5 kg
  = 22.5 liters
- Admixture = 0.4% weight of cement (50 kg) = 200gm
  Conplast Fosrac or Cebex 100 fosrac

Mixing sequence = water – cement - additive
Min mixing time = 3-4 min

Terms & Conditions:

A) Scope of the work :

The scope of your work under this Tender shall include:

i) Detail design and Engineering of the Flat Slabs /Beam slab by post tensioning system in accordance with the design parameters specified by the Consultants, the codal requirements of ISI (Indian Standard Institute) latest versions , National Building Code and the relevant B.S. Standards.

ii) To prepare detail shop drawings for the post tensioning work to be carried out by showing clearly all the dimensions , spacing and other constructions details and obtaining approvals of same from RCC Consultants well in advance to have sufficient time for procurement and delivery of material and equipment is afforded to your construction team to carryout the work in accordance with the requirement of our overall construction schedule.

iii) To assist and guide the civil contractor for any works directly or indirectly related to or consequential to the post tensioning of the flat slabs.

iv) Prepare and submit three sets of As Built drawings for each post tensioned slab showing clearly the profile and location of each tendon

Eligibility criteria for PT Vendor

1. The PT Agency should have minimum 10 (Ten) years experience in post – tensioning works.
2. The PT Agency may be either a registered partnership firm or a company limited by shares having experience in similar construction and the design Engineer should have minimum 10 years of design experience.
3. The PT Vendor Should Posses Design Experience & Execution Experience More than 10 Years in India.
4. The PT Systems (Anchorages) should be in use for more than 10 years and it should be validated by systems performance test conducted in a registered laboratory (IIT).

a) Anchorage efficiency
b) Load transfer test

5. PT agency should have the Proprietorship of their systems and their assembly.

6. Similar kind of PT Projects Completed in the last 3 years shall form part of the qualification.

Approved PT Agency Utracon Structural Systems pvt Ltd, Tech 9 pvt.Ltd , **Navani PT systems** or equivalent to be approved by the engineer in charge,.
The average consumption of HT Strand as per design.

8. FLEXIBLE PAVEMENT

The structural design of pavements in Army College of Dental Sciences consists of determining both the overall pavement thickness and thickness of the component parts of the pavement. There are a number of factors which influence the thickness of pavement required to provide satisfactory service. These include the volume of traffic, the concentration of traffic in certain areas, and the quality of the subgrade soil and materials comprising the pavement structure.
This design basis is intended to be an overview of information for the preparation of structural designs and drawings for Flexible Pavement.

Bitumen (Binder) Grade grades are 60/70 and 80/100, penetration grades.
Viscosity: Should meet standards like IS 73 (Indian Standard).
Softening Point: between 40°C to 60°C.
Penetration: Should match required levels to ensure optimal durability and performance.

Aggregates
Coarse Aggregates: Clean, hard, durable particles free from impurities such as clay, dust, or organic material.

Fine Aggregates: Properly graded to meet the specified particle size distribution.
Aggregate Grading: Follows specifications such as IS 383 (Indian Standard) for crushed stone or gravel.

Shape: Angular or cubical aggregates are preferred for improved strength and stability.

Filler Materials
Fine materials such as limestone dust or hydrated lime can be used to improve the binding properties.

Mix Design

Type of Mix: Hot Mix Asphalt (HMA), Warm Mix Asphalt (WMA), or Cold Mix Asphalt.

Mixing Process:

Aggregates and bitumen are mixed in a heated condition (typically 150°C to 180°C).
The amount of bitumen used varies based on the aggregate size and the design type.
Mixes are designed based on the Marshall Stability method or Super pave mix design system.
Composition: Coarse aggregates mixed with bitumen, providing support to the surface and binder course.

Prime Coat and Tack Coat
Prime Coat: A bituminous solution or emulsion applied to the base before laying the bituminous mix (e.g., bitumen emulsion).
Tack Coat: A thin layer of bitumen applied between layers of the bituminous pavement to ensure adhesion.

Preparation of Subgrade: The subgrade should be leveled, compacted, and free of organic materials.
Base Layer: Constructed using well-graded aggregate with adequate compaction.
Prime Coat Application: Before the laying of the binder course, a prime coat (like a bituminous emulsion) is applied to ensure proper bonding.
Laying Bituminous Layer: The hot bituminous mix is laid using a mechanical paver.
Compaction: Compaction is done using rollers while the bituminous layer is still hot (85–100°C for binder course and 100–120°C for wearing course).
Cooling and Curing: After compaction, the surface should be allowed to cool and set properly.

5. **Testing and Quality Control**

Marshall Stability Test: Ensures the stability and flow of the mix.
Density:
The mix should be compacted to a density that achieves the desired stability.
Moisture Content: Should be checked to prevent the mix from being too wet or too dry.
Bitumen Content: Must be consistent with the mix design (generally 4-7% by weight of the mix).
Aggregate Gradation:
The mix should conform to the required gradation to ensure proper performance.
Smoothness:
The finished road surface should meet the specified smoothness standards (measured in terms of ride quality).

6. **Performance Criteria**

Durability:
The road should be resistant to cracking, rutting, and moisture damage.
Skid Resistance: The surface should provide adequate friction to avoid skidding.
Load-Bearing Capacity: The bituminous road should support the traffic load without significant deformation.
Drainage:
The road should ensure proper water runoff through the cross-slope and camber design.

7. **Maintenance and Rehabilitation**

Crack Sealing: Cracks should be sealed promptly to prevent water infiltration.
Overlay: For roads showing signs of wear, a new layer of bitumen may be laid over the existing surface (referred to as a bituminous overlay).

Routine Inspection: Regular inspection and maintenance should be carried out to ensure the road remains in good condition.

Flexible pavements are so designated due to their flexibility under load and their ability to withstand small degrees of deformation. The design of a flexible pavement structure is based on the requirement to limit the deflections under load and to reduce the stresses transmitted to the natural subsoil.