(English Medium)

All India

IS CODE BOOSTER

Indian Standard Code

CIVIL ENGINEERING

Useful for

BTSC JE, DSSSB JE/AE, SSC JE (Pre & Mains), PGCIL, NHPC-THDC, ISRO, BARC, Andaman & Nicobar (AE/JE), UPSSSC JE, Rajasthan AE/JE, UPPSC AE, UP Jal Nigam AE/JE, Uttrakhand AE/JE, Assam AE/JE, DMRC/LMRC/JMRC AE/JE, Coal India AE/JE, Bihar PSC AE/JE, Haryana AE/JE, Punjab AE/JE, UPPCL, UPRVUNL AE/JE, SJVNL JE, DDA JE, GATE, PSU, IES and All India AE/JE Exams.

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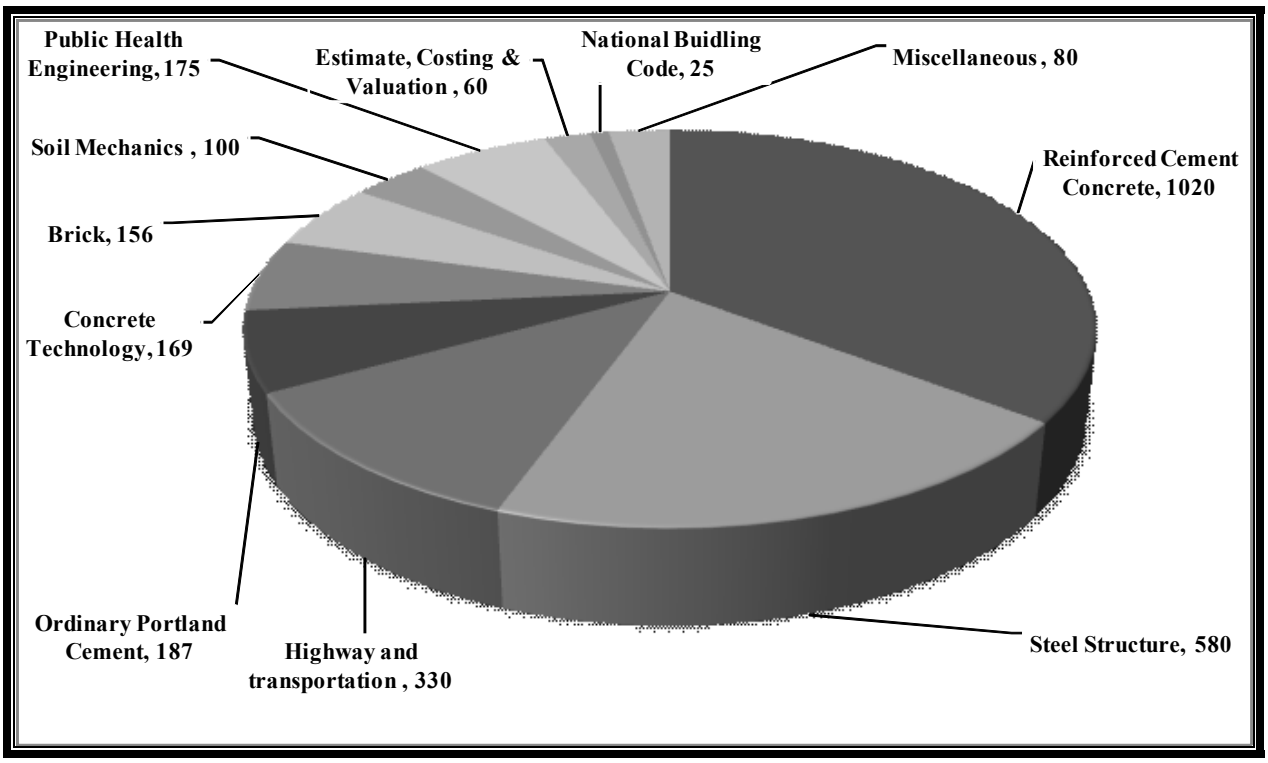
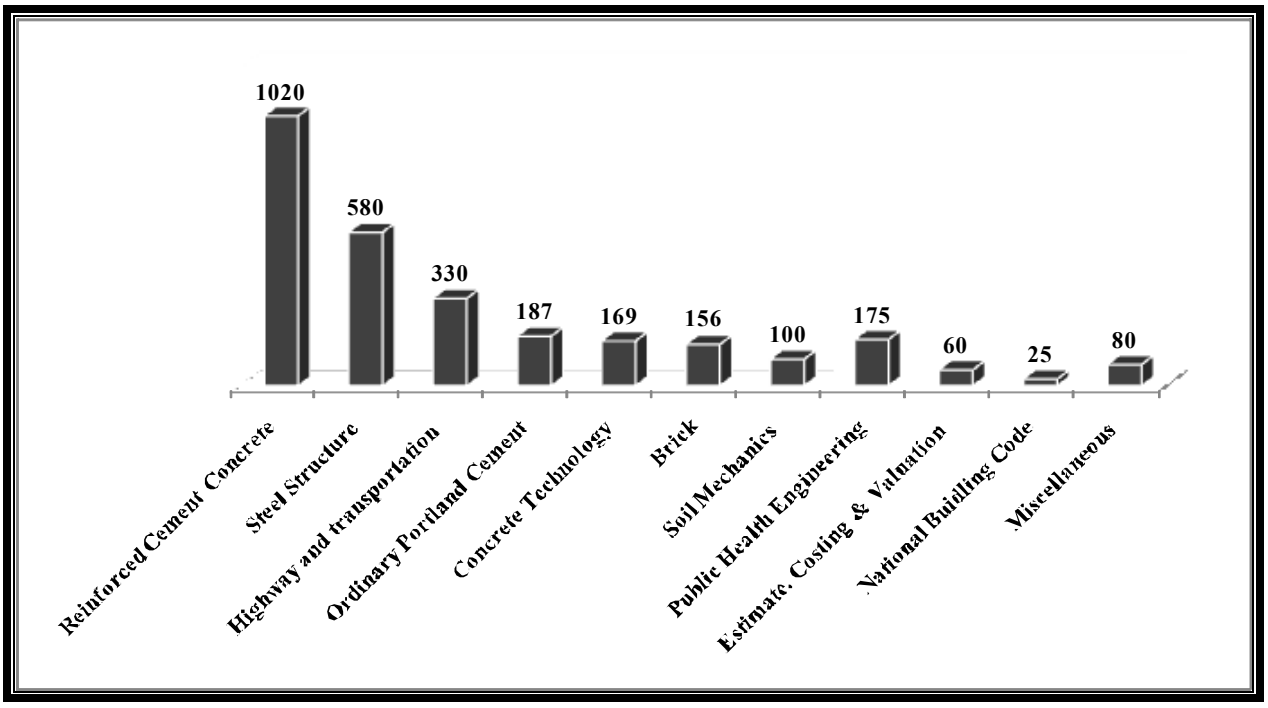
Trend Analysis of previous year JE/AE Approximate questions from IS CODE through bar graph and Pie chart.





Some Important Books, Test and Relative to IS Code

RCC (Reinforced Cement Concrete)					
1	**IS 456 : 2000**	Code of practices for plain and reinforced concrete. **SSC JE-22-01-2018,Shift-I UPSSSC JE-31-07-2016 Rajasthan JE-2015**	6	**IS 1893 : 2002 (Part-1)**	Zone factor for sever seismic intensity. **UPPCL 2020**
2	**IS 516 : 1959**	Method of Tests for strength of concrete. **DSSSB Tech. Asst. 23-10-2021**	7	**IS 432:1982 (Part-1)**	Mild steel and medium tensile steel bars. SSC JE-2014
3	**IS 1199 : 1959**	Method of sampling and Analysis of concrete.	8	**IS 1786**	Specification high strength deformed steel bars and wires for concrete reinforcement
4	**IS 10262 : 2009**	Guidelines for concrete mix proportioning. **Chhattisgarh Vyapam ITIR building -22-06-2023 UPPCL JE. 21-02-2022 Shift. 1 UP Awas Vikas 2022**	9	**IS 1343:1980**	Code of practice for prestressed concrete **MP Sub Engg.-02-09-2018 (2:00 PM)**
5	**IS 1893 : 2002**	Provides criteria for earthquake resistant design **UPPCL 2020**			

STEEL STRUCTURE					
1	**IS 800 : 2007**	Code of practice for general construction in steel. **UPSC ESIC JE (08.10.2023) UPPCL-2020 MP Sub Engg.04-09-2018 (9:00 AM) NBCC JE-2018 UPPCL JE -22-06-2022**	7	**SP6 : 1972 (Part-6)**	Hand book for structural Engineers. Application of plastic theory in Design of steel structures.
2	**SP 6 : 1964 (Part-1)**	Hand book for structural Engineers. (Structural steel section)	8	**SP 6 : 1972 (Part-7)**	ISI (Indian Standard Institution) book for structural Engineers. (Simple welded girders)
3	**SP 6 : 1962 (Part-2)**	Hand book for structural Engineers. (Steel beam and plate girders)	9	**SP 16 : 1980**	Design Aids for reinforced concrete.
4	**SP 6 : 1962 (Part-3)**	Hand book for structural Engineers. (Steel columns and struts)	10	**SP 34 : 1987**	Hand book on concrete reinforcement and detailing
5	**SP 6 : 1969 (Part-4)**	Hand book for structural engineers use of high strength friction grip bolts.	11	**SP 38 : 1987**	Hand book of typified design for structural with steel roof trusses (with and without cranes)
6	**SP 6 : 1980 (Part-5)**	Hand book for structural engineer. Cold Formed light gauge steel structures.			

DESIGN LOAD					
1	**IS 875 : 1987 (Part-1)**	Code of practice for design loads (other than earthquake) for building and structures (Dead load). **JKSSB Draftsman (24.09.2023) JKSSB JE (05.12.2022) Shift-II SSC JE-2010**	4	**IS 875 : 1987 (Part-4)**	Code of practice for design loads (other than earthquake) for building and structures – (Snow Load). **AIIMS RISHIKESH AE (30.09.2023) ISRO IPRC Tech. Asst. -20-09-2023 JKSSB JE (06.12.2022) Shift-II**
2	**IS 875 : 1987 (Part-2)**	Code of practice for design load (other than earth quake) (live load) **JKSSB JE (06.12.2022) Shift-II**	5	**IS 875 : 1987 (Part-5)**	Code of practice for design loads (other than earthquake) for building and structures – (Special loads and combinations).

3	**IS 875 : 2015 (Part-3)**	Code of practice for design loads (other than earthquake) for building and structures – (Wind Load). **OLICL JE 21.06.2023 WBPSC JE Civil -30-07-2023 SSC JE-23-09-2019**	6	**IS 13920 : 2016**	Code of practice for ductile detailing of reinforced concrete. (Structures subjected to seismic forces). **DSSSB AE -27-09-2021, Shift II**

HIGHWAY AND TRANSPORTATION

1	**IRC 37 : 2018**	Guidelines for the design of flexible pavements. **SJVN Jr. Field Engg. 22-06-2023**	10	**IRC 55:1974**	Recommended Practice for sand bitumen base course.
2	**IRC 58 : 2002**	Guideline for the design of plain jointed rigid pavements for highway.	11	**IRC 94:1986**	Specification for dense bituminous mecadam
3	**IRC 73 : 1980**	Geometric Design standards for rural (Non-urban) highway.	12	**IRC SP-42:1994**	Guidline on Road drainage.
4	**IRC 81: 1997**	Guideline for strengthening of flexible road pavement using (Benkelman beam Deflection Technique).	13	**IRC 65:1976**	Recommended practice for traffic rotaries.
5	**IRC SP-23:1983**	Vertical curve for Highway.	14	**IRC 103:1988**	Guidelines for pedestrian facilities.
6	**IRC 25:1967**	Type design for boundary stone.	15	**IS 3098 : 1980**	The noise pollution (Regulation and control) rules **SJVN field engineer civil-18-03-2023**
7	**IRC 67:2001**	Code of practice for Road Signs.	16	**IS 1203 : 1978**	Penetration value of bitumen **DSSSB technical Asist. -23-10-2021**
8	**IRC SP-44:1994**	Highway saftey code	17	**IS 73 : 1961**	Specification for paving bitumen **JSSC JE Civil. -03-11-2022**
9	**IRC 75:1979**	Guideline for the design of Highway Embankment.			

CEMENT

1	**IS 269 : 1989**	Specification for 33 grade ordinary Portland cement	23	**IS 12269 : 1987**	Specification for 53 grade OPC
2	**IS 650 : 1991**	Standard sand for Testing of cement.	24	**IS 12600 : 1989**	Specification for low heat Portland cement
3	**IS 1489 : 1991 (Part-1)**	Specification for port land pozzolana cement (Fly Ash based)	25	**IS 455 : 1989**	Specification for port land slag cement
4	**IS 1489 : 1991 (Part-2)**	Specification for Portland pozzolana cement (calcined clay based)	26	**IS 12330 : 1988**	Specification for sulphate resisting cement **DSSSB JE teir I civil -27-06-2022 Shift-III**
5	**IS 3535 : 1986**	Method of sampling for hydraulic cement.	27	**IS 8042 : 1989**	Specification for white portland cement
6	**IS 4031 : 1988 (Part-1)**	Method of physical Test for hydraulic cement (determination of fineness by dry sieving)	28	**IS 8043 : 1991**	Specification for hydrophobic portland cement LMRC JE 2015
7	**IS 4031 : 1988 (Part-2)**	Method of physical Test for hydraulic cement (determination of fineness by Blaine air permeability.	29	**IS 6452 : 1989**	Specification for high Alumina cement
8	**IS 4031 : 1988 (Part-3)**	Method of physical Test for hydraulic cement (determination of soundness)	30	**IS 6909 : 1990**	specification for super sulphated cement

9	**IS 4031 : 1988 (Part-4)**	Method of physical Test for hydraulic cement (determination of consistency of standard cement paste)	**31**	**IS 3536 : 1986**	Method of sampling for hydraulic cement
10	**IS 4031 : 1988 (Part-5)**	Method of physical Test for hydraulic cement (Determination of initial & final setting times.)	**32**	**IS 3466 : 1988**	Specification for masonry cement
11	**IS 4031 : 1988 (Part-6)**	Method of physical Test for hydraulic cement. Determination of compressive strength of hydraulic cement (other than masonry cement)	**33**	**IS 2430 : 1986**	Methods for Sampling of aggregate for concrete
12	**IS 4031 : 1988 (Part-7)**	Method of physical Test for hydraulic cement (Determination of compressive strength of masonry cement)	**34**	**IS 2502 : 1963**	Code of Practice for Bending and fixing for bar concrete reinforcement
13	**IS 4031 : 1988 (Part-8)**	Method of physical Test for hydraulic cement (Determination of Transverse and compressive strength of plastic mortar using prism.	**35**	**IS 3370 : 1967 (Part-3)**	Code of practice for concrete structures for storage of liquids (Pre-stressed concrete structures) IES-2002
14	**IS 4031 : 1988 (Part-9)**	Method of physical Test for hydraulic cement (Determination of heat of Hydration)	**36**	**IS 4925 : 2004**	Concrete batching and mixing plant
15	**IS 4031 : 1988 (Part-10)**	Method of physical Test for hydraulic cement (Determination of drying shrinkage)	**37**	**IS 4926 : 2003**	Code of practice for ready mixed concrete
16	**IS 4031 : 1988 (Part-11)**	Method of physical Test for hydraulic cement (Determination of density)	**38**	**IS 9012 : 1978**	Recommended practice for shot creating
17	**IS 4031 : 1988 (Part-12)**	Method of physical Test for hydraulic cement (Determination of air content of hydraulic cement mortar)	**39**	**IS 9013 : 1978**	Method of making, curing and determining compressive strength of acclerated cured concrete test specimens.
18	**IS 4031 : 1988 (Part-13)**	Method of physical Test for hydraulic cement (measurement of water retentivity of masonry cement)	**40**	**IS 9103 : 1999**	Specification for concrete admixtures
19	**IS 4031 : 1988 (Part-15)**	Method of physical Test for hydraulic cement (Determination of fineness by wet sieving)	**41**	**IS 13311 : 1992 (Part-1)**	Method of non – Destructive Testing of concrete (Ultra-sonic pulse velocity test)
20	**IS 4032 : 1985**	Method of chemical analysis of hydraulic cement	**42**	**IS 13311 : 1992 (Part-2)**	Method of non – Destructive Testing of concrete (Rebound hammer test)
21	**IS 8041 : 1990**	Specification for rapid hardening portland cement.	**43**	**IS 10080 : 1982**	Specification for vibration machine
22	**IS 8112 : 1989**	Specification for 43 grade OPC	**44**	**IS 8229 : 1986**	Specification for Oil well cement

CONCRETE TECHNOLOGY

1	**IS 5512 : 1983**	Specification for flow table for use in tests of hydraulic cement and pozzolanic materials.	**9**	**IS 6461 : 1972 (Part-2)**	Glossary of terms relating to cement concrete (Materials other than cement and aggregates)
2	**IS 5513 : 1996**	Specification for vicat Apparatus DSSSB JE teir I civil -28-06-2022 Shift-II	**10**	**IS 6461 : 1972 (Part-3)**	Glossary of terms relating to cement concrete (Concrete Reinforcement)
3	**IS 5514 : 1996**	Specification Apparatus used in Le-chatelier Test	**11**	**IS 6461 : 1972 (Part-4)**	Glossary of terms relating to cement concrete (Type of concrete)

4	**IS 5515 : 1983**	Specification compacting factor Apparatus	**12**	**IS 6461 : 1972 (Part-5)**	Glossary of terms relating to cement concrete (Form work for concrete)
5	**IS 5816 : 1999**	Method of Test splitting tensile strength of concrete.	**13**	**IS 6461 : 1972 (Part-6)**	Glossary of terms relating to cement concrete (Equipment, tools and plant)
6	**IS 5516 : 1996**	Specification variable flow type air permeability apparatus.	**14**	**IS 6461 : 1973 (Part-8)**	Glossary of terms relating to cement concrete
7	**IS 5517 : 1993**	Steel for Hardening and tempering.	**15**	**IS 6491 : 1972**	Method of sampling of fly ash
8	**IS 6461 : 1972 (Part-1)**	Glossary of terms relating to cement concrete (Concrete aggregate)	**16**	**IS 7320 : 1974**	Specification of concrete slump test apparatus

BRICK

1	**IS 1077 : 1992**	Common burnt clay building bricks. **DDA JE 29-03-2023** **Chandigarh Housing Board Jr. Dr. 04.02.2023** **MPSC Mains 23-04-2023** **J & K PSC AE 02.10.2023**	**12**	**IS 3952 : 1988**	Burnt clay hallow bricks for walls and partitions
2	**IS 3495 : 1992 (Part-1)**	Method of Test for burnt clay building bricks. (Compressive strength of brick) **DSSSB JE-23-12-2019**	**13**	**IS 2691 : 1988**	Specification of burnt clay facing bricks
3	**IS 3495 : 1992 (Part-2)**	Method of Test for burnt clay building bricks. (Water absorption of brick) **WBPSC JE 30-07-2023**	**14**	**IS 3583 (B) : 1988**	Specification for burnt clay paving bricks
4	**IS 3495 : 1992 (Part-3)**	Method of Test for burnt clay building bricks. (Efflorescence Test) **SSC JE 09-10-2023 Shift-I**	**15**	**IS 4885 : 1988**	Burnt clay sewer bricks
5	**IS 3495 : 1992 (Part-4)**	Method of Test for burnt clay building bricks. (Determination of warpage) **PCMC JE 28-05-2023**	**16**	**IS 5779 : 1986**	Burnt clay soling bricks
6	**IS 5454 : 1978**	Method of sampling of clay building bricks.	**17**	**IS 6165 : 1992**	Dimensions for special shapes of clay bricks **SSC JE (23-09-2019) Evening**
7	**IS 3535 : 1986**	Method of sampling for hydraulic cement	**18**	**IS 2212 : 1991**	Code of practice for brick works **J & K PSC AE 02-10-2023**
8	**IS 3466 : 1988**	Specification for masonry cement	**19**	**IS: 3102 : 1992**	Strength based classification at bricks is made on the basis **SSC JE (morning) 2014**
9	**IS 2430 : 1986**	Method for sampling of aggregate for concrete	**20**	**IS 5454 : 1978**	Method for sampling of clay building bricks
10	**IS 2180 : 1988**	Specification for heavy duty burnt clay building bricks. **Gujrat Engg. Service 24-01-2023** **OLICL AE Civil 21-06-2023**	**21**	**IS 3102 : 1971**	Classification of burnt clay solid bricks (strength) **SSC JE (morning)-2014**
11	**IS 2222 : 1991**	Specification for burnt clay perforated building bricks.			

MASONRY MORTAR

1	**IS 1542 : 1992**	specification for Sand for plaster	**4**	**IS 2116 : 1980**	Specification for sand for masonry mortars
2	**IS 2116 : 1980**	Specification for sand for masonry mortars.	**5**	**IS 2250 : 1981**	Code of practice for preparation and use of masonry mortars.
3	**IS 2250 : 1981**	Code of practice for preparation and use of masonry mortar.			

COARSE / FINE AGGREGATE

1	**IS 383 : 1970**	Specification for coarse and fine aggregates from natural sources for concrete.	6	**IS 2386 : 1963 (Part-5)**	Methods of Test for aggregates for concrete (Soundness)
2	**IS 2386 : 1963 (Part-1)**	Methods of Test for aggregates for concrete (Particle size and shape.) **UPPCL JE-21-02-2022 (Shift-I)**	7	**IS 2386 : 1963 (Part-6)**	Methods of Test for aggregates for concrete (Measuring mortar making properties of fine aggregate)
3	**IS 2386 : 1963 (Part-2)**	Methods of Test for aggregates for concrete (estimation of Deleterious Materials and Organic Impurities)	8	**IS 2386 : 1963 (Part-7)**	Methods of Test for aggregates for concrete (Alkali aggregate reactivity)
4	**IS 2386 : 1963 (Part-3)**	Methods of Test for aggregate for concrete (Specific gravity, density, voids, absorption & bulking).	9	**IS 2386 : 1963 (Part-8)**	Methods of Test for aggregates for concrete (petrographic examination.)
5	**IS 2386 : 1963 (Part-4)**	Methods of Test for aggregates for concrete (Mechanical Properties)			

STONE

1	**IS 1127 : 1970**	Recommendations for dimension and workmanship of natural building stones for masonry work	5	**IS 3620 : 1979**	Specification for laterite stone block for masonry
2	**IS 1128 : 1974**	Specification for limestone (slab and tiles)	6	**IS 3622 : 1977**	Specification for sandstone (slabs and tiles)
3	**IS 1130 : 1969**	Specification for marble (block, slabs and tiles)	7	**IS 6250 : 1981**	Specification for roofing slate tiles.
4	**IS 3316 : 1974**	Specification for structural granite	8	**IS 1121 : 1974 (Part-II) - (Reaffiremed 2003)**	Methods of test for determination of strength properties of natural building stones **JSSC JE Civil-31-10-2022**

TIMBER

1	**IS 399 : 1963**	Classification of commercial timbers and their zonal distribution	9	**IS 1708 : 1986**	Method of testing of small clear specimens of timber.
2	**IS 190 : 1991**	Specification for coniferous sawn timber (baulks and scantlings)	10	**IS 10701 : 2012**	Specification for structural plywood
3	**IS 1326 : 1992**	Specification for non-coniferous Sawn timbers (baulks and scantlings)	11	**IS 303 : 1989**	Specification for plywood for general purposes.
4	**IS 4891 : 1988**	Specification for preferred cut sizes of structural timber.	12	**IS 3129 : 1985**	Specification for low and medium density wood particle boards
5	**IS 287 : 1993**	Recommendation for permissible moisture content for timber used for different purposes.	13	**IS 1658 : 2006**	Specification for fibre hardboards
6	**IS 401 : 2001**	Code of practice for preservation of timber	14	**IS 1659 : 2004**	Specification for block boards
7	**IS 1141 : 1993**	Code of practice for seasoning of timber. ***SSC JE (24.01.2018) Evening Jharkhand SSC JE 2016***	15	**IS 1328 : 1996**	Specification for veneered decorative plywood.
8	**IS 1734 : 1983**	Method of test for plywood	16	**IS 4990 : 2011**	Specification for plywood for concrete shuttering works.

BITUMEN, ASPHALT, TAR

1	**IS 73 : 2006**	Specification for paving bitumen	4	**IS 4365 : 1967**	Code of practice for application of bitumen mastic for water proofing of roofs.
2	**IS 702 : 1988**	Specification for industrial bitumen	5	**IS 1322 : 1993**	Specification for bitumen felts for water proofing and damp proofing
3	**IS 216 : 2006**	Specification for coal tar pitch			

PLASTIC					
1	**IS 3462 : 1986**	Specification for unbacked flexible PVC flooring	3	**IS 4985 : 2000**	Specification for UPVC pipes for potable water supplies
2	**IS 12701 : 1996**	Specification for rotational moulded polyethylene water storage tanks.	4	**IS 3076 : 1985**	Specification for low density polyethylene pipes for potable water supplies

GLASS					
1	**IS 1761 : 1970**	Transparent sheet glass for glazing and framing purpose	3	**IS 5437 : 1994**	Specification for figured rolled and wired glass
2	**IS 2835 : 1987**	Specification for flat transparent sheet glass			

POZZOLANA					
1	**IS 4305 : 1967**	Glossary of terms relating to pozzolana	3	**IS 1344 : 1981**	Specification for calcined clay pozzolana.
2	**IS 3812 : 2003**	Specification for pulverized fuel ash	4	**IS 1727 : 1967**	Methods of test for pozzolanic materials.

LIME					
1	**IS 712 : 1984**	Specification for building limes	3	**IS 6932 : 1973**	Method of test for building limes (Laboratory Test) **DMRC AE-26-02-2020 (Shift-I)**
2	**IS 1624 : 1986**	Methods of field testing of building lime			

FERROUS METALS					
1	**IS 1230 : 1979**	Specification for cast iron rainwater pipes and fittings specifications.	8	**IS 806 : 1968**	Code of practice for use of steel tubes in general building construction.
2	**IS 1536 : 2001**	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.	9	**IS 1038 : 1983**	Specification for steel doors windows and ventilators.
3	**IS 1786 : 2008**	Specification for high-strength deformed steel bars and wires for concrete reinforcement.	10	**IS 1079 : 1994**	Specification for hot rolled carbon steel sheets and strips.
4	**IS 1691 : 1980**	Specification for cast iron and mild steel flat pulleys	11	**IS 1529 : 1971**	Specification for blast furnace refractories for steel plants.
5	**IS 226 : 1975**	Specification for structural steel (Standard quality)	12	**IS 432:1982 (Part-1)**	Specification for mild steel and medium tensile steel bars and hard-drwan steel wire for concrete reinforcement. (mild-steel and medium tensile steel bars.) **MP Sub Engg.-04-04-2016** **SSC JE-2014**
6	**IS 2062 : 1999**	Specification for steel for general structural purposes.	13	**IS 808:1989**	Dimensions for hot rolled steel beam, column, channel and angle sections **MP Sub Engg.-2015**
7	**IS 801 : 1975**	Code of practice for use of cold - formed light gauge steel structural members in general building construction.			

TILES

1	**IS 2690 : 1993 (Part-1)**	Specification for Burnt Clay Flat Terracing Tiles (Machine Made)	5	**IS 1464 : 1992**	Specification for Clay Ridge and Ceiling Tiles
2	**IS 2690 : 1992 (Part-2)**	Specification for Burnt Clay Flat Terracing Tiles (Hand Made)	6	**IS 1237 : 2012**	Specification for Cement Concrete Flooring Tiles
3	**IS 1478 : 1992**	Clay Flooring Tiles	7	**IS 13712 : 2006**	Ceramic tiles classification and characteristics **JSSC JE GE-03-07-2022** ***LMRC JE 13.08.2018 Shift I***
4	**IS 3461 : 1980**	PVC Asbestos Floor Tiles **SJVN Field Engg. 18-03-2023**			

EXTRA BUILDING MATERIAL (B.M.) IMPORTANT CODE

1	**IS 459 : 1992**	Specification for corrugated and semi-corrugated asbestos cement sheets	5	**IS 3792 : 1978**	Guide for heat insulation of non-industrial buildings
2	**IS 1626 : 1994**	Specification for asbestos cement building pipes and pipe's fittings, gutters and gutter fittings	6	**IS 4139 : 1989**	Specification for calcium silicate bricks
3	**IS 848 : 2006**	Specification for synthetic resin adhesives for plywood (phenolic and amino plastic)	7	**IS 3590 : 1966**	Specification for load bearing blocks light - weight concrete.
4	**IS 851 : 1978**	Specification for synthetic resin adhesives for construction work (non-structural) in wood	8	**IS 5482 : 1969**	Specification for autoclaved cellular concrete blocks.

SOIL

1	**SP 36 : 1987 (Part-1)**	Compendium of Indian standards on soil engineering (Laboratory testing of soil for civil engineering)	15	**IS 2720 : 1987 (Part-16)**	Laboratory determination of CBR
2	**SP 36 : 1988 (Part-2)**	Compendium of Indian standards on soil engineering (Field testing of soil for civil engineering purposes)	16	**IS 2720 : 1986 (Part-17)**	Laboratory determination of permeability.
3	**IS 1888 : 1982**	Method of load test on soils.	17	**IS 2720 : 1992 (Part-18)**	Determination of field moisture equivalent
4	**IS 2131 : 1981**	Method for standard penetration test for soils. **MP Sub Engg.04-09-2018 (2:00 PM)**	18	**IS 2720 : 1992 (Part-19)**	Determination of centrifuge moisture equivalent.
5	**IS 2720 : 1983 (Part-1)**	Preparation of dry soil. Sample for various tests.	19	**IS 2720 : 1992 (Part-20)**	Determination of linear shrinkage.
6	**IS 2720 : 1973 (Part-2)**	Determination of water content.	20	**IS 2720 : 1987 (Part-26)**	Determination of pH value.
7	**IS 2720 : 1980 (Part-3) (Sec-1)**	Determination of specific gravity Fine grained soils	21	**IS 2720 : 1977 (Part-39) (Sec.-1)**	Direct shear test for soils containing gravel (Laboratory Test).
8	**IS 2720 : 1980 (Part-3) (Sec-2)**	Determination of specific gravity (Fine medium and coarse grained soil)	22	**IS 2720 : 1979 (Part-39) (Sec.-2)**	Direct shear test for soils containing gravel (In situ shear Test).
9	**IS 2720 : 1985 (Part-4)**	Grain size analysis	23	**IS 2720 : 1977 (Part-40)**	Determination of free swell Index of soil.
10	**IS 2720 : 1985 (Part-5)**	Determination of liquid and plastic limit.	24	**IS 2720 : 1977 (Part-41)**	Measurement of swelling pressure of soil.

11	**IS 2720 : 1972 (Part-6)**	Determination of shrinkage factors.	**25**	**IS 2950 : 1981 (Part-I)**	Practice for design and construction of raft foundation **GSECL JE 07-09-2022 Shift-1** **UPPCL JE 2020**
12	**IS 2720 : 1986 (Part-13)**	Direct shear Test **BHEL Er. Trainee 24-08-2023**	**26**	**IS 6403 : 1981**	Practice for determination of bearing capacity of shallow foundations. **UPPCL JE 2020**
13	**IS 2720 : 1983 (Part-14)**	Determination of density Index (relative density) of cohesionless soil.	**27**	**IS 1498 :1970**	Classification and identification of soils for general engineering purposes **DSSSB JE teir I civil -28-06-2022 Shift-II**
14	**IS 2720 : 1986 (Part-15)**	Determination of consolidation properties.	**28**	**IS 6955 : 2008**	Specification for subsurface exploration for earth and rock fill dams. **DSSSB Tech. Asst. 23-10-2021**

PHE (Public Health Engineering)

1	**IS 10500:2012**	Specification of drinking water ***UPPCL JE 2020*** ***UPPCL AE 2019*** ***LMRCL Asst. Man.-15-05-2018***	**9**	**IS 8413 : 1977 (Part I)**	Requirements for biological treatment equipment (Trickling filters)
2	**IS 1172 : 1993**	Code of basic requirements for water supply, drainage and sanitation **JKSSB JE 05-11-2023** **UK Comb. AE-Paper-II-2012**	**10**	**IS 8413 : 1982 (Part II)**	Requirements for biological treatment equipment (Activated sludge process and its modifications.)
3	**IS 1742 : 1983**	Code of practice for building drainage	**11**	**IS 10500:1991**	Specification of drinking water (Total Hardness) **DFCCIL 2018**
4	**IS 3114 : 1994**	Code of practice for laying of cast iron pipes.	**12**	**BIS 1172:1963**	Water required per head per day average domestic purposes **SJVNL 2018**
5	**IS 4127 : 1983**	Code of practice for laying of glazed stoneware pipes	**13**	**IS 7634 : 1975 (Part-I)**	Code of practice for plastics pipe work for potable water supplies **Andman & Nicobar Asst.Arch 06-03-2023 Shift-II**
6	**IS 6280 : 1971**	Specification for sewage screens	**14**	**IS 458:2003**	Specification for precast concrete pipes (with and without reinforcement) **DSSSB AE 27-09-2021 Shift-II**
7	**IS 7232 : 1974**	Method for imhoff cone test	**15**	**IS 18001:2002**	Occupational health and safety management system requirements with guidance for use. **JKSSB JE 05-11-2023**
8	**IS 9234 : 1979**	The preparation of solid waste sample for chemical and microbiological analysis. **SJVN Field Engg. 18-03-2023**	**16**	**IS 3025 : 1987**	Methods of sampling and test (Physical and chemical) for water and wastewater (sampling) **GPSC AE Class 2 (GMC) 26-09-2021**

IRRIGATION ENGINEERING

1	**IS 10430 : 2000**	Criteria for Design of Lined Canals and Guidance for Selection of Type of Lining	**3**	**IS 5968 : 1987**	Guide for Planning and layout of canal system for Irrigation
2	**IS 7112 : 2002**	Criteria for design of cross-section for unlined canals in alluvial Soils.	**4**	**IS 3873 : 1993**	Laying cement concrete/ stone slab lining on canals Code of Practice.

ESTIMATING, COSTING AND VALUATION					
1	**IS 1200**	Methods of measurement of building and civil engineering works.	**3**	**IS 3861 : 2002**	Method of measurement of plinth, carpet and rentable areas of buildings.
	Part-I (1992)	Earthwork			
	Part-II (1974)	Concrete			
	Part-III (1976)	Brickwork			
	Part-IV (1976)	Stone masonary			
	Part-V (1982)	Formwork			
	Part-VI (1974)	Refactory work			
	Part-VII (1972)	Hardware			
	Part-VIII (1993)	Steel work and iron work			
	Part-IX (1973)	Roof covering (including cladding)			
	Part-X (1973)	Ceiling and linings			
	Part-XI (1977)	Paving, floring, finishing, dado and skirting			
	Part-XII (1976)	Plastering and pointing			
	Part-XIII (1994)	White washing, colour washing, distempering and painting of building surface			
	Part-XIV (1984)	Glazing			
	Part-XV (1987)	Painting, polishing, vernishing etc.			
	Part-XVI (1979)	Laying of water and sewer lines including appurtenant items			
	Part-XVII (1985)	Road work including airfield pavements			
	Part-XVIII (1974)	Demolition and dismentaling			
	Part-XIX (1981)	Water supply, plumbing and drains			
	Part-XX (1981)	Laying of gas and oil pipe lines			
	Part-XXI (1973)	Wood work and joinery			
	Part-XXII (1982)	Materials			
	Part-XXIII (1988)	Piling			
	Part-XXIV (1983)	Well foundation			
	Part-XXV (1971)	Tunneling			
	Part-XXVI (1987)	Acid resistance lining			
	Part-XXVII (1992)	Earthwork done by mechanical appliances			
	Part-XXVIII (1992)	Sound insulation work			
2	**SP 27 : 1987**	Handbook of method of building works. **MPPGCIL JE 24-04-2023 Shift- 1**	**4.**	**IS 1661:1972**	Code of practice for application of cement and cement-lime plaster finishes. **SSC JE-22-01-2018 (Morn.)**

EARTHQUAKE ENGINEERING

1	**IS 1893 : 2002 (Part-1)**	Indian Standard Criteria for Earthquake Resistant Design of Structures **AIIMS Rishikesh AE 30-09-2023** **UPPCL-27-02-2020**	4	**IS 1833 : 2000**	Indian standard specification for ditazinon, technical. **GETCO Vidyut Sahayak JE 05-01-2022**
2	**IS 4326 : 1993**	Indian Standard Code of Practice for Earthquake Resistant Design & Construction of Buildings.	5	**IS 13828 : 1993**	Indian Standard Guidelines for improving Earthquake Resistance of Low Strength Masonary Buildings
3	**IS 13827 : 1993**	Indian Standard Guidelines for improving Earthquake Resistance of Earthen Buildings	6	**IS 13935 : 1993**	Indian Standard Guidelines for Repair and Seismic Strengthening of Buildings

MISCELLANEOUS

1	**IS 11664 :1986**	Folding of drawing prints **TNPSC Road Inspector 07-05-2023** **Andman & Nicobar draftsman Gr. III 06-03-2023**	7	**IS 1717 : 2012**	Metallic materials - wire - simple torsion test **DSSSB Tech. Assist 23-10-2021**
2	**IS 7969 : 1975**	Safety code for handling and storage of building materials **DSSSB JE Teir-I Civil 28-06-2022 Shift II**	8	**IS 3764 : 1992**	Code of safety for excavation work **MPSC Mains 29-04-2023** **Maharashtra WRD JE 12-08-2022 Shift-II**
3	**IS 1646 : 1997**	Code of practice for fire safety of buildings **DSSSB JE Teir-I Civil 27-06-2022 Shift III**	9	**IS 3370 : 2021 (Part-I)**	Code of practice for concrete structures for storage of liquids (General requirements) **JSSC JE Civil 31-10-2022**
4	**IS 3362 : 1977**	Code of practice for natural ventilation of residential buildings. **UKPSC Draftsman 05-11-2023**	10	**IS 1642 : 1989**	Code of practice for fire safety of buildings (General): details of construction. **MPSC Mains 23-04-2023**
5	**IS 752 : 1968**	Handloom, Cotton Muslin, bleached. **OLICL JE 21-06-2023**	11	**NBC-2016**	National Building code of India **MPSC Mains Civil 23-04-2023** **Andman & Nicobar Plan Asst. 06-03-2023 Shift- III**
6	**IS 1492 : 1970**	Specification for Metric Surveying Chain. **TNPSC Road Inspector Civil 07-05-2023** **PCMC JE 28-05-2023**			

INDIAN STANDARD
PLAIN AND REINFORCED CONCRETE CODE OF PRACTICE
(Fourth Revision)

IS-456:2000
Reaffirmed:2005

IS-456 : 2000 Plain and reinforced concrete code of practice

■ LIST OF IMPORTANT CODES: –

IS Code No.	Title
IS 456:2000	Code of practice for plain and reinforced concrete **Rajasthan JE-2015**
IS 800:2007	Code of practice for general construction in steel
IS 875:1987	Code of practice for design loads (other than earthquake) for buildings and structures **WBPSC Civil 30-07-2023**
(Part-1)	Dead loads
(Part-2)	Imposed loads
(Part-3)	Wind loads **SSC JE 23-03-2019 (Even.)**
(Part-4)	Snow loads
(Part-5)	Special loads and load combinations
IS 1343:1980	Code of Practice for Prestressed concrete
IS 3370:1965	Code of Practice for the storage of liquids
IS 13920:2016	Code of Practice for ductile design and detailing of reinforced Concrete structure subjected to seismic forces
SP 6(1):1964	Handbook for structural engineers (Structural Steel Section)
SP 16:1980	Design aid for reinforced concrete to IS 456:1978
SP 23:1982	Handbook on concrete mixes
SP 24:1983	Explanatory handbook on Indian Standard Code of Practice for Plain and Reinforced Concrete (IS 456:1978)

Section-1
SOME IMPORTANT SYMBOLS

1.	A	Area
2.	b	Breadth of beam, or shorter dimension of a rectangular column
3.	b_{ef}	Effective width of slab
4.	b_f	Effective width of flange
5.	b_w	Breadth of web or rib
6.	D	Overall depth of beam or slab or diameter of column; dimension of a rectangular column in the direction under consideration
7.	D_f	Thickness of flange
8.	DL	Dead load
9.	d	Effective depth of beam or slab
10.	d'	Depth of compression reinforcement from the highly compressed face
11.	E_c	Modulus of elasticity of concrete
12.	EL	Earthquake load

13.	E_s	Modulus of elasticity of steel
14.	e	Eccentricity
15.	f_{ck}	Characteristic cube compressive strength of concrete
16.	f_{cr}	Modulus of rupture of concrete (flexural tensile strength)
17.	f_{ct}	Splitting tensile strength of concrete
18.	f_d	Design strength
19.	f_y	Characteristic strength of steel
20.	H_w	Unsupported height of wall
21.	H_{we}	Effective height of wall
22.	I_{ef}	Effective moment of inertia
23.	I_{gr}	Moment of inertia of the gross section excluding reinforcement
24.	I_r	Moment of inertia of cracked section
25.	K	Stiffness of member
26.	k	Constant or coefficient or factor
27.	L_d	Development length
28.	LL	Live load or imposed load
29.	L_w	Horizontal distance between centres of lateral restraint
30.	l	Length of a column or beam between adequate lateral restraints or the unsupported length of a column
31.	l_{ef}	Effective span of beam or slab or effective length of column
32.	l_{ex}	Effective length about x-x axis
33.	l_{ey}	Effective length about y-y axis
34.	l_a	Clear span, face-to-face of supports
35.	l'_a	l'_a for shorter of the two spans at right angles
36.	l_x	Length of shorter side of slab
37.	l_y	Length of longer side of slab
38.	l_o	Distance between points of zero moments in a beam
39.	l_1	Span in the direction in which moments are determined, centre to centre of supports
40.	l_2	Span transverse to l_1, centre to centre of supports
41.	l'_2	l_2 for the shorter of the continuous spans
42.	M	Bending moment
43.	m	Modular ratio
44.	n	Number of samples
45.	P	Axial load on a compression member
46.	q_o	Calculated maximum bearing pressure of soil
47.	r	Radius
48.	s	Spacing of stirrups or standard deviation
49.	T	Torsional moment
50.	t	Wall thickness
51.	V	Shear force
52.	W	Total load
53.	WL	Wind load
54.	w	Distributed load per unit area
55.	w_d	Distributed dead load per unit area
56.	w_i	Distributed imposed load per unit area
57.	x	Depth of neutral axis
58.	Z	Modulus of section
59.	z	Lever arm
60.	α, β	Angle or ratio
61.	γ_f	Partial safety factor for load
62.	γ_m	Partial safety factor for material

63.	δ_m	Percentage reduction in moment
64.	$\in_{cc}$	Creep strain of concrete
65.	σ_{cbc}	Permissible stress in concrete in bending compression
66.	σ_{cc}	Permissible stress in concrete in direct compression
67.	σ_{mc}	Permissible stress in metal in direct compression
68.	σ_{sc}	Permissible stress in steel in compression
69.	σ_{st}	Permissible stress in steel in tension
70.	σ_{sv}	Permissible tensile stress in shear reinforcement
71.	τ_{bd}	Design bond stress
72.	τ_c	Shear stress in concrete
73.	$\tau_{c, max}$	Maximum shear stress in concrete with shear reinforcement
74.	τ_v	Nominal shear stress
75.	ϕ	Diameter of bar

Section-2

Material, Workmanship, Inspection & Testing Materials

Clause No.

5.1 Cement–

■ **Types of recommended cement:**

(a) 33 grade ordinary Portland cement (OPC) conforming to IS 269
(b) 43 grade ordinary Portland cement (OPC) conforming to IS 8112
(c) 53 grade ordinary Portland cement (OPC) conforming to IS 12269
(d) Rapid hardening Portland cement conforming to IS 8041
(e) Portland slag cement conforming to IS 455
(f) Portland pozzolana cement (fly ash based) (PPC) conforming to IS 1489 (Part-I)
(g) Portland pozzolana cement (calcined clay based) conforming to IS 1489 (Part-II)
(h) Hydrophobic cement conforming to IS 8043
(j) Low heat portland cement conforming to IS 12600
(k) Sulphate resisting portland cement conforming to IS 12330

Note- According to amendment No. 5 July 2019 Clause No.5.1 (b) and (c) Delete.

5.2 Mineral Admixtures

(before Amendment No.5 July 2019)

5.2 Mineral Admixture - 'Mineral admixtures listed below may be used along with ordinary Portland cement. Uniform blending of the mineral admixtures with the cement should be ensured.'

(after Amendment No.5 July 2019)

5.2.1 Pozzolanas - Pozzolanic materials conforming to relevant Indian Standards may be used with the permission of the engineer-in-charge, provided uniform blending with cement is ensured.

(before Amendment No.5 July 2019)

5.2.1 Pozzolanas - Pozzolanic materials conforming to relevant Indian Standards may be used with the permission of the engineer-in-charge,

(*after Amendment No.5 July 2019*)

5.2.1.1. Fly ash (pulverized fuel ash) - Fly ash conforming to Grade 1 of IS 3812 may be used as part replacement of ordinary Portland cement provided uniform blending with cement is ensured.

(*before Amendment No.5 July 2019*)

5.2.1.1. Fly ash (pulverized fuel ash) - Fly ash conforming to Grade 1 of IS 3812 may be used as part replacement of ordinary Portland cement.

(*after Amendment No.5 July 2019*)

5.2.1.2 Silica fume - Silica fume conforming to a standard approved by the deciding authority may be used as part replacement of cement provided uniform blending with the cement is ensured.

(*before Amendment No.5 July 2019*)

5.2.1.2 Silica fume - Silica fume conforming to a standard approved by the deciding authority may be used as part replacement of cement.

(*after Amendment No.5 July 2019*)

5.2.1.4 Metakaoline - Metakaoline having fineness between 700 to 900 m^2/kg may be used as pozzolanic material in concrete.

(*before Amendment No.5 July 2019*)

5.2.1.4 Metakaoline - Metakaolin conforming to IS 16354 may be used as part replacement of ordinary Portland cement,'

(*after Amendment No.5 July 2019*)

5.2.2 Ground granulated Blast Furnace Slag– Ground granulated blast furnace slag obtained by grinding granulated blast furnace slag conforming to IS 12089 may be used as part replacement of ordinary Portland cements Provided uniform blending with cement is ensured.

(*before Amendment No.5 July 2019*)

5.2.2 Ground granulated Blast Furnace Slag– Ground granulated blast furnace slag conforming to IS 16714 may be used as part replacement of ordinary Portland cement.

(*after Amendment No.5 July 2019*)

5.2.3 Precautions

(*after Amendment No.5 July 2019*)

5.2.3.1 For concrete made with mineral admixtures, the setting time and rate of gain of strength may be different from those of concrete made with ordinary Portland cement alone

(*after Amendment No.5 July 2019*)

5.2.3.2. Concrete containing mineral admixtures may exhibit and increase in plastic shrinkage cracking because of its low bleeding characteristics. The problem may be avoided by ensuring that such concrete is protected against drying, both during and after finishing.

(*after Amendment No.5 July 2019*)

5.2.3.3 Some other properties of concrete such as modulus of elasticity, tensile strength, creep and shrinkage are not likely to be significantly different. For design purposes, it will be sufficiently accurate to adopt the same values as those used for concrete made with ordinary Portland cement alone.

(*after Amendment No.5 July 2019*)

5.2.3.4 Mixes that contain very fine mineral admixtures such as silica fume, can be sticky and difficult to finish.

***(after Amendment No.5 July 2019*)**

5.2.3.5 Concrete made using blended cements such as Portland Pozzolana cement and Portland slag cement shall also adhere to **5.2.3.1, 5.2.3.2** and **5.2.3.3.**

***(after Amendment No.5 July 2019*)**

5.3 Aggregates– Aggregates shall comply with the requirements of IS 383.As far as possible preference shall be give to natural aggregates.

***(before Amendment No.4 May 2013*)**

5.3 Aggregates -Aggregates shall comply with the requirements of IS 383.

(After Amendment NO.4 – May 2013)

5.3 Aggregates – Aggregates *derived from natural sources and from other than natural sources* shall comply with the requirements of IS 383. As far as possible preference shall be given to natural aggregates.

***(after Amendment No.5 July 2019*)**

I. Size of Structural Member– Aggregates should go to each corner of member and cover reinforcement completely.

II. Distance Between two Main Bars– Aggregates should be small enough so that it can pass through distance between two main bars. Due to this reason, it is kept 5 mm less than distance between two main bars.

III. Minimum Cover– If aggregates size is more than the minimum cover provided for member, then there is possibility of exposure of reinforcement to environment so it is kept 5 mm less to minimum nominal cover.

In general, 20 mm nominal size coarse aggregates is used for most of the work but in the case of massive concreting, like dam construction, 40 mm and even higher nominal size can used for extremely thin slabs, like shelf, 10 mm nominal size aggregate is used for better finish.

5.3.1 Aggregates (should not absorb more then 10% of their own mass of water**)** and free form excessive sulphate in the form of SO_3 size of coarse aggregates is governed by following:

5.3.4 Coarse and fine aggregate shall be batched separately. All- in- aggregate may be used only where specifically permitted by the engineer-in-charge

(before Amendment No.4 May 2013)

5.3.4 Coarse and fine aggregate shall be batched separately.

(After Amendment NO.4 – May 2013)

5.4 **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.

(before Amendment No.4 May 2013)

5.4 **Water–** Water, natural or treated, 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.

(After Amendment NO.4 – May 2013)

5.4.2 The pH value of water shall be not less than 6.

5.4.3 **Sea Water–** Mixing or curing of concrete with sea water is not recommended because of presence of harmful salt in sea water. Under unavoidable circumstances sea water may be used for mixing or curing in plain concrete with no embedded steel after having given due consideration to possible disadvantages and precautions including use of appropriate cement system.

(before Amendment No.4 May 2013)

5.4.3 **Sea Water –** Sea water shall not be used for mixing or curing of concrete because of presence of harmful salts.Under unavoidable circumstances sea water may be used for mixing or curing in plain concrete with no embedded steel after having given due consideration to possible disadvantage and precautions including use of appropriate cement system.

(After Amendment NO.4 – May 2013)

5.4.4 Water found satisfactory of mixing is also suitable for curing of concrete.

Effective modulus of elasticity using creep coefficient

$$E_{ce} = \frac{E_c}{1+\phi}$$

IES-2007
DFCCIL JE Civil-10-11-2018

5.4

Table-1
Permissible Limits for Solids

S.No.		Tasted as Per	Max. Permissible Limit
(i)	Organic	IS 3025 (Part-18)	200 mg/*l* **DDA JE Civil 1-4-2023(shift -II)** **DSSSB JE TIER I 28-6-2022(Shift -I)** **UPSSSC JE-2015** **DMRC JE-19-02-2020 (Shift-III)** **DMRC JE-26-02-2020 (Shift-II)**
(ii)	Inorganic	IS 3025 (Part-18)	3000 mg/*l*
(iii)	Sulphates (as SO_3)	IS 3025 (Part-24)	400 mg/*l* **UPPCL JE 21-02-2022(SHIFT-II)** **UPPCL JE-2020**
(iv)	Chlorides (as C*l*)	IS 3025 (Part-32)	2000 mg/*l*(For concrete not containing embedded steel) **DDA JE Civil 29-3-2023(Shift-III)** **DDA JE Civil 1-4-2023 (Shift-III)** **NHPC JE Civil 4-4-2022(shift-I&II)** 500 mg/*l* (for reinforced concrete work) **DDA JE Civil 29-3-2023(Shift-II)** **Jharkhand JSSC JE Civil 3-11-2022**
(v)	Suspended matter	IS 3025 (Part-17)	2000 mg/*l* **OLICL AE Civil 21-06-2023** **UPPCL JE 22-6-2022(Shift-II)**

5.5 Admixture–

5.5.2 Admixture should not impair durability of concrete nor combine with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.

5.5.5 Chloride content of admixtures shall be independently tested as it is harmful to concrete. Broadly, admixtures are divided intome two parts:

1. Mineral admixture

(i) Pozzolanas

(a) Fly ash

(b) Silica fume

(c) Rice husk ash

(d) Metakaoline

(ii) Ground Granulated Blast Furnace Slag (IS 12089)

2. Chemical admixture

(a) **Accelerating Admixture–** Calcium chloride, Fluosilicate, Triethanolamine

(b) **Retarding Admixture–** Sodium tartrate, Tartaric acid

(c) **Water Reducing or Plasticizer –** Calcium lignosulphonate

(d) **Air Entraining Admixture –** Aluminium powder, Neutralised vinsol resin.

5.5.7 The amount of admixture added to a mix shall be recorded in the production record. Redosing of admixtures is not normally permitted. In special circumstances, if necessary, additional dose of admixture may be added at a project site and mixed

adequately in mixer itself to regain the workability of concrete with the mutual agreement between the producer/supplier and the purchaser/ user of concrete. However the producer/ supplier shall assure the ultimate quality of concrete supplied by him and maintain record of quantity and time of addition.

Note- This clause is newly added according to amendment number 4- may 2013.

5.6 Reinforcement– The reinforcement shall be any of the following:

(a) Mild steel and medium tensile steel bars conforming to IS 432 (Part-I)

SSC JE-2014

(b) High strength deformed steel bars conforming to IS 1786

(c) Hard – drawn steel wire fabric conforming to IS 1566

(d) Structural steel conforming to grade A of IS 2062

5.6.3 Modulus of elasticity of steel shall be taken as 2×10^5 MPa

■ Three grades of steel is covered in this code

(1). Fe250

(2). Fe415

(3). Fe500

Recent development: Fe550 TMT (Thermo Mechanically Treated) bars is also available in market.

6.0 Concrete:

6.1 Grades–

6.1.1 The characteristic strength is defined as the strength of material below which not more than 5 percent of the test results are expected to fall. It is denoted by f_{ck}.

UPPCL JE-25-02-2020

SSC JE-2010

Chhattishgarh Prof. Exam Board-2016

6.2 Properties of Concrete–

6.2.1 There is normally a gain of strength beyond 28 days also but the design should be based on 28 days characteristic strength of concrete.

DDA JE-24-04-2018 (Shift-II)

Table-2
Grades of concrete

Group	Grade designation	Specified characteristic compressive strength of 150 mm cube at 28 days in N/mm^2
Ordinary concrete	M 10	10
	M 15	15 SSC JE-03-03-2017 (Even.)
	M 20	20 NBCC JE-2018 (Morn.)
Standard Concrete	M 25	25
	M 30	30
	M 35	35
	M 40	40
	M 45	45
	M 50	50
	M 55	55
High strength Concrete	M 60	60
	M 65	65
	M 70	70
	M 75	75
	M 80	80

NOTE-

(1) In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150 mm size cube at 28 days, expressed in N/mm^2

(2) For concrete of compressive strength greater than M 55, design parameters given in the standard may not be applicable and the value may be obtained from specialized literature and experimenal results.

(before Amendment No.4 May 2013)

Table-2
Grades of concrete

Group	Grade designation	Specified characteristic compressive strength of 150 mm cube at 28 days in N/mm^2
Ordinary concrete	M 10	10
	M 15	15 Andman&Nicobar APWD JE Civil 27-7-2019 SSC JE-03-03-2017 (Even.)
	M 20	20 KPSC AE Civil26-2-2023 NBCC JE-2018 (Morn.)
Standard Concrete	M 25	25 Andman & Nicobar Plan.Asst. 6-3-2023(Shift-I)
	M 30	30
	M 35	35
	M 40 KPSC AE Civil (26-2-2023)	40
	M 45	45
	M 50	50
	M 55	55
	M 60	60
High strength Concrete	M 65	65
	M 70	70
	M 75	75
	M 80	80
	M 85	85
	M 90	90
	M 100	100

NOTES

(1) In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150 mm size cube at 28 days, expressed in N/mm^2

(2) For concrete of compressive strength greater than M 60, design parameters given in the standard may not be applicable and the value may be obtained from specialized literature and experimental results.

In this amendment, Classification of Concrete has been changed. M60Gr. has been shifted to Standard concrete and from Grades M85 to M100 are added to High strength concretes. In note to M55 is replaced with M60.

(After Amendment NO.4 – May 2013)

6.2.2 Tensile strength of concrete is calculated using compressive strength by following formula.

Flexural strength,

$f_{cr} = 0.7\sqrt{f_{ck}}\ N/mm^2$

DDA JE Civil-29-3-2023 (Shift-II)
SSC JE 15-11-2022 (Shift-III)
BSPHCL JE Civil-29-01-2019 (Batch-I)
UPRVUNL JE-2019
SSC JE-02-03-2017 (Morn.)
SSC JE-2011, 2013
UPSSSC JE-2015
Haryana SSC JE-13-04-2018 (Shift-II)

6.2.3.1 The modulus of elasticity of concrete can be assumed as follows.

$E_c = 5000\sqrt{f_{ck}}\ N/mm^2$

NHPC Draftsman Civil 23-07-2023
WBPSC JE Civil 30-07-2023
SSC JE 23-3-2021 (Shift-I)
RPSC Lecturer Tech. Edu. Dept 15-3-2021 (Shift-I)
DFCCIL Civil JE-10-11-2018
SSC JE Civil-27-01-2018 (Even.)
SSC JE-23-09-2019 (Morn.)
BSPHCL-29-01-2019 (Batch-I)

Where,

$\mathbf{E_c}$ is short term static modulus of elasticity. Actual measured values may differ by ±20 percent from the values obtained from the above expression.

6.2.4 Shrinkage- The total shrinkage of concrete is most influenced by the total amount of water present in the concrete at the time of mixing and to a lesser extent, by the cement content.

6.2.4.1 The approximate value to total shrinkage strain for design may be taken as 0.0003.

Andman & Nicobar APWD JE Civil 27-7-2019

6.2.5.1 Creep of Concrete- Creep coefficient, which is used for the calculation of total creep depends upon age of concrete at the time of loading applied on it.

SSC JE-2016
SSC JE-01-03-2017 (Shift-I)

Creep coefficient (ϕ)- $= \dfrac{\text{Ultimate creep strain}}{\text{Elastic strain at the age of loading}}$

Age at loading	Creep coefficient (ϕ)
7 days	2.2 **Airport Authority of India JE-2015**
28 days	1.6 **JKSSB JE 29-10-2021** **LMRCL Asst. Manag. -15-05-2018**
1 year	1.1

Effective modulus of elasticity using creep coefficient

$E_{ce} = \dfrac{E_c}{1+\phi}$

IES-2007
DFCCIL JE Civil-10-11-2018

6.2.6 Thermal Expansion– The coefficient of thermal expansion depends on nature of cement, the aggregate, the cement content, the relative humidity and the size of sections. The value of coefficient of thermal expansion for concrete with different aggregates may be taken as below:

Types of Aggregate	Coefficient of Thermal Expansion for Concrete /°C
Quartzite	1.2 to 1.3 × 10^{-5}
Sand Stone	0.9 to 1.2 × 10^{-5}
Granite	0.7 to 0.95 × 10^{-5}
Basalt	0.8 to 0.95 × 10^{-5}
Lime Stone	0.6 to 0.9 × 10^{-5}

7.0 Workability of Concrete (IS 1199)–

7.1 Workability of concrete is defined as ease to work with concrete. There are five degree of workability as follows:

Degree of workability	Placing condition
Very low	In highway construction a layer of lean concrete with very low workability is used and it is compacted using roller.
Low (25-75) DDA JE Civil 29-3-2023 (Shift-III) SSC JE-2011	Mass concreting (like, dam construction) light reinforced section in slab, beam, colomn
Medium (50-100) DDA JE Civil 1-4-2023 (Shift-II) HPSSSB JE-31-04-2017 DFCCIL Civil JE-10-11-2018 SSC JE-25-01-2018 (Morn.)	Heavily reinforced section in slab, column, beams and when pumping of concrete is required
High (100-150)	Trench Fill
Very high	In-situ piling using tremie pipe

There are four tests for measurement of workability of concrete:

1. **Compacting Factor Test–** preferable for very low workability. Higher compacting factor means high workability.
2. **Slump Test–** preferable for low, medium and high. Its value varies from 25 (low) to 150 (high).
3. **Vee-bee test–** Higher value of means low workability.
4. **Flow test**

8.0 Durability of Concrete–

8.1 General– A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service. The materials and mix proportions specified and used should be such as to maintain its integrity and, if applicable, to protect embedded metal from corrosion.

NOTES to Table 5 Minimum Cement, Maximum water-Cement Ratio and Minimum Grade of Concrete for different exposures with normal weight aggregates of 20 mm nominal maximum size. – Cement content prescribed in this table is irrespective of the grades of cement and its is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (part I) and IS 455 respectively.

NOTES to Table 5 – Note 3 added – Only 2 note items mentioned.

(***before Amendment No.4 May 2013*****)**

8.1 General – A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service life. The materials and mix proportions specified and used should be such as to maintain its integrity and, if applicable, to protect embedded metal from corrosion.

NOTES to Table 5 Minimum Cement content, Maximum water-Cement Ratio and Minimum Grade of Concrete for different exposures with normal weight aggregates of 20 mm nominal maximum size. – Cement content prescribed in this table is irrespective of grades and types of cement and is inclusive of mineral admixtures mentioned in 5.2. The mineral admixtures such as fly ash or ground granulated blast furnace slag shall be taken into account in the concrete composition with respect to the cement content and water-cement ratio not exceeding the limit of fly ash and slag specified in IS 1489 (part I) and IS 455 respectively, beyond which these additions though permitted shall not be considered for these purposes.

NOTES to Table 5 – Note 3 added (3) The minimum cement content, maximum free water-cement ratio and minimum grade of concrete are individually related to exposure.

(After Amendment NO.4 – May 2013)

8.1.1 Durability of concrete is mainly influenced by following:

(a) The surrounding climate condition
(b) The cover to embedded steel
(c) The type and quality of constituent materials
(d) The cement content and water/cement ratio of the concrete
(e) Workmanship, to obtain full compaction and efficient curing
(f) The shape and size of the member

8.2 Requirement for Durability–

8.2.2 Exposure conditions– There are five environmental exposure condition:

Table 3

Environmental Exposure Conditions

(Clauses 8.2.2.1 and 35.3.2)

S.No.	Environment	Exposure condition
i.	Mild	Concrete surface protected against weather. Structure of coastal areas doesn't come in this category.
ii.	Moderate	Concrete surface sheltered from severe rain, saturated salt air in coastal areas, concrete continuously under normal water and in contact with non – aggressive soil.
iii.	Severe	Concrete surface exposed to severe rain, alternate wetting and drying, completely immersed in sea water, exposed to coastal environment. **DFCCIL Civil JE-10-11-2018** **DDA-24-04-2018 (Shift-I)**
iv.	Very severe	Concrete surface exposed to sea water spray, corrosive fumes, severe freezing condition and in contact with aggressive soil/ground water. **DDA JE-23-04-2018 (Shift-I)**
v.	Extreme	Surface of member in tidal zone or in direct contact with liquid/solid aggressive chemicals. **DDA JE-23-04-2018 (Shift-II)** **LMRC AE-2017 (Shift-I)**

8.2.5 Mix Constituents

8.2.5.2 Chlorides in concrete – It increases rate of corrosion to steel. Due to this reason Chloride content of admixture is tested separately.

8.2.5.3 Sulphates in concret – Sulphates are present in most cements and in some aggregates; excessive amounts of water-soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO_3, should not exceed 4 percent by mass of the cement in the mix.

(*before Amendment No.5 July 2019*)

8.2.5.3 Sulphates in concrete - Sulphates are present in most cements and in some aggregates; excessive amounts of water-soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO_3 *(where $SO_3 = 0.833\ SO_4$)*, should not exceed 4 percent by mass of the cement in the mix.

(*after Amendment No.5 July 2019*)

8.2.5.4 Alkali-aggregate reaction -

1. (b) Use of low alkali ordinary Portland cement having total alkali content not more than 0.6 percent [as Na_2O equivalent (expressed as $Na_2O + 0.658\ K_2O$].

Further advantage can be obtained by use of fly ash conforming to IS 3812 (Part 1) or ground granulated blast furnace slag conforming to IS 16714 as part replacement of ordinary Portland cement [having total alkali content as Na_2O equivalent (expressed as $Na_2O + 0.658\ K_2O$) not more than 0.6 percent], provided fly ash content is at least 25 percent or slag content is at least 50 percent.'

(*after Amendment No.5 July 2019*)

8.2.5.4 Alkali-aggregate reaction - Some aggregates containing particular type of silica may be susceptible to attack by alkalis (Na_2O and K_2O) originating from cement, producing an expansive reaction which can cause cracking and disruption of concrete.

(a) A high moisture level, within the concrete;

(b) A cement with high alkali content, or another source of alkali;
(c) Aggregate containing an alkali reactive constituent.

(***before Amendment No.5 July 2019*****)**

2. (b) Use of low alkali ordinary Portland cement having total alkali content not more than 0.6 percent (as Na_2O equivalent**)**.
Further advantage can be obtained by use of fly ash (Grade 1**)** conforming to IS 3812 or granulated blast furnace slag conforming to IS 12089 as part replacement of ordinary Portland cement (having total alkali content as Na_2O equivalent not more than 0.6 percent**)**, provided fly ash content is at least 20 percent or slag content is at least 50 percent.

(***before Amendment No.4 May 2013*****)**

2.(b) Use of low alkali ordinary Portland cement having total alkali content not more than 0.6 percent (as Na_2O equivalent**)**. Further advantage can be obtained by use of fly ash conforming to IS 3812 (Part I**)** or ground granulated blast furnace slag conforming to IS 12089 as part replacement of ordinary Portland cement (having total alkali content as Na_2O equivalent not more than 0.6 percent**)**, provided fly ash content is at least 25 percent or slag content is at least 50 percent.

(After Amendment NO.4 – May 2013)

8.2.6.2 Drainage – At sites where alkali concentrations are high or may become very high, the ground water should be lowered by drainage so that It will not come into direct contact with the concrete.
Additional protection may be obtained by the use of chemically resistant stone facing or a layer of plaster of Paris covered with suitable fabric, such as jute thoroughly impregnated with bituminous material.

(***before Amendment No.4 May 2013*****)**

8.2.6.2 Drainage – At site where alkali concentrations are high or may become very high, the ground water should be lowered by drainage so that it will not come into direct contact with the concrete.
Additional protection may be obtained by the use of suitable impermeable barriers.

(After Amendment NO.4 – May 2013)

Table-5

Minimum cement content, Maximum water-cement ratio and minimum grade of concrete for different exposures with normal weight aggregate of 20 mm nominal maximum size.

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum cement content kg/m^3	Maximum free water-cement ratio	Minimum grade of concrete	Minimum cement content kg/m^3	Maximum free water-cement ratio	Minimum grade of concrete
Mild	220	0.60	–	300 SSC JE-2011	0.55 DDA JE Civil 28-03-2023 (Shift-III) SSC JE 16-11-2022(Shift-I)	M20
Moderate	240	0.60 UPRVUNL JE-2019	M15 NHPC JE Civil 4-4-2022(Shift-II)	300 DDA JE Civil 28-03-2023 (Shift-III) SSC JE-2011	0.50 DSSSB JE 20-03-2021 (Shift-II) LMRC Asst. Manag.-15-05-2018	M25
Severe	250	0.50	M20 SSC JE 23-03-2021(Shift-I) DFCCIL Civil JE-10-11-2018	320 DDA JE Civil 28-03-2023 (Shift-II)	0.45	M30
Very Severe	260	0.45	M20	340	0.45	M35
Extreme	280	0.40	M25	360 ISRO TECH ASSISTENT Civil 4-6-2022	0.40 SSC JE 14-11-2022(Shift-I)	M40

Table 7
Limits of Chloride Content of Concrete
(Clause 8.2.5.2)

Sl. No.	Type or Use of Concrete	Maximum Total Acid Soluble Chloride Content Expressed as kh/m^3 of Concrete
(1)	(2)	(3)
i)	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete	0.4
ii)	Reinforced concrete or plain concrete containing embedded metal	0.6
iii)	Concrete not containing embedded metal or any material requiring protection from chloride	3.0

8.2.8 Concrete in sea water or exposed directly along the sea coast shall be at least M20 grade in the case of plain cement concrete and M30 in case of reinforced cement concrete.

SSC JE-2015
ESE-2005, 2012

9.0 **Concrete Mix Proportioning–** Concrete mix design is the calculation of proportion of constituent elements (Like cement, coarse aggregate, fine aggregate, water and sometime admixture also**)** to achieve desired degree of workability of fresh concrete and desired strength, durability, surface finish of hardened concrete.

9.1 **Mix Proportion–** The mix proportion shall be selected to ensure the workability of the fresh concrete and when concrete is hardened, its shall have the required strength, durability and surface finish.

9.1.1 **There are two type of concrete mix:**

1. Design mix concrete
2. Nominal mix concrete

Design mix concrete is always preferable to nominal mix for characteristic strength 20 N/mm^2 and above nominal mix is used for M20 and lesser strength concrete only.

DDA JE-23-04-2018 (Shift-II)

9.2 Design Mix Concrete

9.2.1 As the guarantor of quality of concrete used in the construction, the constructor shall carry out the mix design and the mix so designed (not the method of design**)** shall be approved by the employer within the limitations of parameters and other stipulations laid down by this standard.

(***before Amendment No.4 May 2013*****)**

9.2.1 As the guarantor of quality of concrete used in the construction, The constructor shall carry out the mix design and the mix so designed (not the method of design**)** shall be approved by the employer within the limitations of parameters and other stipulations laid down by this standard. If so desired, the employer shall be provided with supporting data including graphs showing strength versus water cement ratio for range of proportions, complete trial mix proportioning details to substantiate the choice of cement content, fine and coarse aggregate content, water, mineral admixtures, chemical admixtures etc.

(After Amendment NO.4 – May 2013)

9.2.2 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 2. The target mean strength of concrete mix should be equal to the characteristic strength plus 1.65 times the standard deviation.

(***before Amendment No.4 May 2013*****)**

9.2.2 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 2. The target mean strength of concrete mix should be equal to the characteristic strength plus 1.65 times the standard deviation.

(After Amendment NO.4 – May 2013)

9.3 **Nominal Mix Concrete–** Nominal mix concrete may be used for concrete of M 20 of lower.

Table -8
Assumed Standard Deviation
(Clause 9.2.4.2 and Table 11)

Grade of Concrete	Assumed Standard Deviation N/mm^2 DDA JE Civil 1-4-2023(Shift-II)
M10, M15	3.5
M20, M25	4.0
M30, M35, M40, M45, M50	5.0

NOTES-The above values correspond to the site control having proper storage of cement; weight batching of al materials; controlled addition of water; regular checking of all materials, aggregate gradings and moisture content; and periodical cheacking of workability and strength. Where there is deviation from the above the values given in the above table shall be increased by IN/mm^2.

(***before Amendment No.4 May 2013*****)**

Grade of Concrete	Nominal Mix proportion (cement: sand: coarse aggregate)
M20	1:1.5:3
M15	1:2:4
M10	1:3:6

Table -8
Assumed Standard Deviation
(Clause 9.2.4.2 and Table 11)

Grade of Concrete	Assumed Standard Deviation N/mm^2
M10, M15	3.5
M20, M25	4.0 UPPCL JE 21-02-2022(Shift-I)
M30, M35, M40, M45, M50, M55, M60	5.0

NOTES -

1. The above values correspond to the site control having proper storage of cement; weight batching of al materials; controlled addition of water; regular checking of All materials, aggregate gradings and moisture content; and periodical cheacking of workability and strength. Where there is deviation from the above the values given in the above table shall be increased by 1N/mm^2
2. for grade above M60, the standard deviation shall be established by actual trials based on assumed proportion, before finalizing the mix.
3. In this amendment, M55 and M60 has been added in the amended version to the Grade of Concrete. Also note 2 is added ***(After Amendment NO.4 – May 2013)***

Table-9
Proportions for Nominal Mix Concrete
(Clauses 9.3 and 9.3.1)

Grade of Concrete	Total Quantity of Dry Aggregates by Mass per 50 kg of Cement, to be Taken as the Sum of the Individual Masses of Fine and Coarse Aggregates, kg, Max	Proportion of Fine Aggregate to coarse Aggreate(by Mass)	Quantity of Water per 50 kg of Cement, Max
(1)	(2)	(3)	(4)
M5	800	Generally 1:2 but subject to an upper limit of 1:1½ and a lower limit of 1:2½ / 1:2	60
M7.5	625		45
M10	480		34
M15	330		32
M20	250		30

10.0 Production of Concrete– Production of concrete for construction is done in batching plant.

10.2 Batching - To avoid Confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass; admixture, if solid, by mass; liquid admixture may however be measured in volume or mass; water shall be weighted or measured by volume in a calibrated tank (see also IS 4925**)**. Ready-mixed concrete supplied by ready- mixed concrete plants or from on site or off site batching and mixing plants (see IS 4926**)**.

(***before Amendment No.4 May 2013*****)**

10.2 Batching – To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass; admixture, if solid, by mass; liquid admixture may however be measured in volume or mass; water shall be weighted or measured by volume in a calibrated tank (see also IS 4925**)**

For large and medium project sites, the concrete shall be sourced from Ready mixed concrete plants or from captive on site or off site automatic batching and mixing plants. The concrete produced and supplied by ready -mixed concrete plants shall be in accordance with IS 4926. In case of concrete from captive on site or off site automatic batching and maxing plants, similar quality control shall be followed.

(After Amendment NO.4 – May 2013)

10.2.1 Except where it can be shown to the satisfaction of the engineer-in-charge that supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock-piles. The material should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job being determined by the engineer-in charge to ensure that the specified grading is maintained.

(***before Amendment No.4 May 2013*****)**

10.2.1 The grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in right proportions, the different size being stocked in separate stock piles. The material should be stock-piled for several hours preferably a day before use. The grading of coarse and fine frequency for a given job being determined by the engineer-in charge to ensure that the specified grading is maintained.

(After Amendment NO.4 – May 2013)

10.2.2 The accuracy of the measuring equipment shall be within ± 2 percent of the quantity of cement being measured and within ±3 percent of the quantity of aggregate, admixtures and water being measured.

(***before Amendment No.4 May 2013*****)**

10.2.2 The accuracy of measuring equipment shall be within ± 2 percent of the quantity of cement and mineral admixtures being measured and within ±3 percent of the quantity of aggregate, chemical admixtures and water being measured. In a batching plant, the concrete production equipment shall be calibrated initially at the time of installation or reconditioning of the equipment and subsequently at the following intervals:

(a**)** Mechanical/ knife edge systems: At least once every two months

(b**)** Electrical /load cell system : At least once every three months

(After Amendment NO.4 – May 2013)

10.2.3 Proportion/Type and grading of aggregates shall be made by trial in such a way so as to obtain densest possible concrete. All ingredients of the concrete should be used by mass only.

(***before Amendment No.4 May 2013*****)**

10.2.3 All ingredients of concrete shall be used by mass except water and chemical admixtures which may be by volume.

(After Amendment NO.4 – May 2013)

10.2.5 It is important to maintain the water - cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the engineer- in charge according to weather conditions. The amount-of-the added water shall be adjusted to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregates, IS 2386 (part 3**)** may be referred to. To allow for the variation in mass of aggregate due to variation in their moisture content, suitable adjustments in the masses of aggregates shall also be made. 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 10.

(before Amendment No.4 May 2013**)**

10.2.5 It is important to maintain the water-cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the engineer-in-charge according to weather conditions. The amount- of the added water shall be adjust to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregates, IS 2386 (Part 3**)** may be referred to. Where batching plants are used, it is recommended to determine moisture content by moisture probes fitted to the batching plants. To allow for the variation in mass of aggregate due to variation in their moisture content suitable adjustments in the masses of aggregates shall also be made. 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 10.

After Amendment NO.4 – May 2013)

10.3 **Mixing –** Concrete shall be mixed in a mechanical mixer. The mixer should comply with IS 1791 and IS12119. The mixers shall be fitted with water measuring (metering**)** devices. The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete should be remixed.

(***before Amendment No.4 May 2013*****)**

10.3 **Mixing –** Concrete shall be mixed in Mechanical mixer (See also IS 1791 and IS 12119**)**. It shall be ensured that stationary or central mixers and truck mixers shall comply with the performance criteria of mixing efficiency as per IS 4634. Mixing efficiency test shall be performed at least once in a year. The mixers shall be fitted with water measuring (metering**)** devices. The mixers shall be continued until there is a uniform distribution of the materials and the mass is uniforms in colour and consistency. If there is segregation after unloading from the mixer, the concrete should be remixed.

(***After Amendment NO.4 – May 2013)***

10.3.1 For guidance, the mixing time shall be at least 2 min. For other types of more efficient mixers, manufacturers' recommendations shall be followed; for hydrophobic cement it may be decided by the engineer- in- charge.

(before Amendment No.4 May 2013**)**

10.3.1 As a guidance, the mixing time shall be at least 2 min for conventional free fall (drum) batch type concrete mixers. For other types of more efficient mixers, manufacturers' recommendations shall be followed.

(***After Amendment NO.4 – May 2013)***

10.3.3 Dosages of retarders, plasticisers and superplasticisers shall be restricted to 0.5, 1.0 and 2.0 percent respectively by weight of cementation's materials and unless a higher value is agreed upon between the manufacturer and the constructor based on performance test.

(***before Amendment No.4 May 2013*****)**

10.3.3 Dosages of retarders, plasticisers and superplasticisers shall be restricted to 0.5, 1.0 and 2.0 percent respectively by mass of cementitious materials; however, the dosages of polycarboxylate based admixtures shall not exceed 1.0 percent. A higher value of above admixtures may be used, if agreed upon between the manufacturer and the constructor based on performance test relating to workability, setting time and early age strength.

(***After Amendment NO.4 – May 2013)***

11.0 Formwork–

SSC JE-25-01-2018 (Even.)
SSC JE-03-03-2017 (Morn.)

Type Formwork	Minimum Period Before Striking Formwork
(a) Vertical formwork to columns, walls, beams	16–24 h RRB SSE Secundrabad-01-09-2015 (Shift-I)
(b) Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days
(c) Soffit formwork to beams (Props to be refixed immediately after removal of formwork)	7 days
(d) Props to slabs	
(i) Spanning up to 4.5 m	7 days UPPCL JE 02-01-2021(Shift-I) SSB HP-18-11-2018 RRB SSE Secundrabad-01-09-2015 (Shift-II)
(ii) Spanning over 4.5 m	14 days LMRC AE-2017 (Shift-I)
(e) Props to beams and arches	
(i) Spanning up to 6 m	14 days RRB SSE Online-01-09-2015 (Shift-II)
(ii) Spanning over 6 m	21 days

(Before Amendment No. 5 July 2019)

11.0 Formwork

Type of Formwork	Minimum Period Before Striking Formwork	
	For concrete made using OPC	**For concrete Made Using Cement Other than OPC or Using Mineral Admixtures Like Fly Ash and slag**
(i) Vertical formwork to columns, walls, beams	16–24h	16–24 h
(ii) Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days	7 days
(iii) Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days	10 days
(iv) Props to slabs:		
(1) Spanning up to 4.5 m	7 days	10 days
(2) spanning over 4.5 m	14 days	14 days
(v) Props to beams and arches:		
(1) Spanning up to 6 m	14 days	14 days
(2) Spanning over 6 m	21 days	21 days

Note- Utmost care shall be taken to provide props. The props shall be provided immediately after stripping each shuttering panel and not after stripping all the panels of the entire slab.

(after Amendment No.5 July 2019)

11.3.1 In case of use of cements other than OPC or in case of use of mineral admixtures like fly ash and slag, in lieu of the minimum period specified in

(before Amendment No.5 July 2019)

11.3.1 col 3, the stripping of formwork may be done in accordance with the provisions of **11.3.1** col 2, provided concrete cube testing is done to ensure that the following minimum strength is achieved:

(a) 3 days : 45 percent of specified strength — SSC JE Civil 11-10-2023,Shift I

(b) 7 days : 60 percent of specified strength

(c) 14 days : 85 percent of specified strength — PCMC JE Civil 28-05-2023

(after Amendment No.5 July 2019)

12.0 Assembly of Reinforcement–

12.3.2 Tolerance for cover at site should not deviat from the required nominal cover by 0 to + 10mm. (no negative variation is allowed**)**

13.0 Transporting, Placing, Compaction and Curing–

13.1 Transporting and handling–

After mixing, concrete shall be transported to the form work as rapidly as possible by methods which will prevent the segregation. Common way of transportation are given below.

(1**)** Head load

(2**)** Dumper

(3**)** Transit mixer if sites is far away from batching plant

(4**)** Concrete pump

13.2 Placing Generally the maximum permissible free fall of concrete may be taken as 1.5 m. If free fall is 2 m or 3m, then there may be possiibility of segregation.

SSC JE-24-01-2018 (Morn.)
SSC JE-23-01-2018 (Even.)

13.3 Compaction– Concrete should be thoroughly compacted and fully worked around the reinforcement and into corners of the formwork. Common way of compaction are given below:

(1**)** Manually by using steel rod

(2**)** Needle vibrator (Most commonly used**)**

(3**)** Surface vibrator (Used to compact slab concreting**)**

(4**)** Form work vibrator

Now a days self compacting concrete is being used which does not require any compaction.

13.3.1 Concrete shall be compacted using mechanical vibrators complying with **IS 2505, IS 2506, IS 2514** and **IS 4656**. Over vibration and under vibration of concrete are harmful and should be avoided. Vibration of very wet mixes should also be avoided.

***(before Amendment No.5 July 2019*)**

13.3.1 Concrete shall be compacted using mechanical vibrators complying with **IS 2505, IS 2506** and **IS 2514**.

***(after Amendment No.5 July 2019*)**

13.4 Construction joints and cold joints – Joints are a common source of weakness and, therefore, it is desirable to avoid them. If this is not possible, their number shall be minimized. Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be indicated by the designer. Construction joints shall comply with IS 11817.

***(before Amendment No.4 May 2013*)**

13.4 Construction joints and cold joints – joints are a common source of weakness and, therefore, if is desirable to avoid them. If this is not possible, their number shall be minimized. Concreting shall be carried out continuously up to construction joints, the position be indicated by the designer

(After Amendment NO.4 – May 2013)

13.5 Curing– Curing is the process of preventing the loss of moisture from the concrete whilst maintaining a satisfactory temperate regime. The prevention of moisture loss from the concrete is particularly important if the water-cement ratio is low. Broadly, curing is divided into two types:

(i) Moist Curing: Exposed surface of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas for at least 7 days from the date of placing concrete. Steam curing can also be done for high strength concrete. Railways sleepers are steam cured.

(ii) Membrane Curing: Curing compound may be used in line of moist curing. It is applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. It prevents evaporation of concrete water content.

14.0 Concreting Under Special Condition–

14.2 Under Water Concreting–

14.2.4 Concrete cast under water should not fall freely through the water otherwise, it may be segregated.

There are few techniques for underwater concreting:

(i**)** Tremie pipe method

(ii**)** Direct placement with pumps

(iii**)** Drop bottom bucket

(iv**)** Grouting

(v**)** Bags

15.0 Sampling and Strength of Designed Concrete Mix–

15.1 General– Samples from fresh concrete shall be taken as per IS:1199 and cubes shall be made, cured and tested at 28 days in accordance with IS:516.

15.1.1 Cubes casted using fresh concrete at the time of construction is tested for compressive strength after 28 days but in the case of speedy work progress it may be tested for 7 days strength also.

5.2 Frequency of Sampling–

15.2.2 Frequency–

Quantity of concrete in the work m^3	Number of test samples
1-5	1
6-15	2
16-30	3
31-50	4 SJVN Jr. Field Engg.22-06-2023
51 and above	4+one additional sample for each additional 50 m^3 UKPSC AE Peper-I 2022
Note: at least one sample shall be taken from each shift	

15.4 The test result of the sample shall be the average of the strength of three specimens the individual variation should not be more than ± 15 percent of the average.

DFCCIL EXECUTIVE 29-09-2021
UPSSSC JE-31-07-2016
Civil ESIC JE-2019

16.0 Acceptance Criteria–

16.1 Compressive Strength– The concrete shall be acceptable when both the following condition are met: IES-

(a) The mean strength determined from group of four consecutive test results satisfy the appropriate limits in column (2) of table 11.

(b) Any individual test result should satisfy the appropriate limits in column (3) of table 11.

Table 11

Characteristic Compressive Strength Compliance Requirement (Clases 16.1 and 16.3)

Specified Grade	Mean of the group of 4 Non-overlapping consecutive test result in N/mm^2	Individual test result in N/mm^2
(1)	(2)	(3)
M15	≥ f_{ck} + 0.825 × established standard deviation (rounded off to nearest 0.5 N/mm^2) or f_{ck} + 3 N/mm^2, whichever is greater	≥ f_{ck} – 3 N/mm^2
M20 or above	≥ f_{ck} + 0.825 × established standard deviation (rounded off to nearest 0.5 N/mm^2) or f_{ck} + 4 N/mm^2, whichever is greater	≥ f_{ck} – 4 N/mm^2 IES-2009

NOTE– In the absence of established value of standard deviation the values given in Table 8 may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

(before Amendment No.4 May 2013)

Table 11
Characteristic Compressive Strength Compliance Requirement
(Clases 16.1 and 16.3)

Specified Grade	Mean of the group of 4 Non-overlapping consecutive test result in N/mm^2	Individual test result in N/mm^2
M15 and Above	$\geq f_{ck} + 0.825 \times$ established standard deviation (rounded off to nearest 0.5 N/mm^2) or $f_{ck} + 3$ N/mm^2, whichever is greater	$\geq f_{ck} - 3$ N/mm^2

Note –: (1). In the absence of established value of standard deviation, the value given in Table 8 may be assumed, and attempt should be made to abstain results of 30 samples as early as possible to establish the value of standard deviation.

(2). For concrete of quantity up to 30 m^3 (where the member of samples to be taken is less than four as per the frequency of sampling given in 15.2.2) the mean of test results of all such samples shall be $f_{ck} + 4$N/mm^2 minimum.

(After Amendment NO.4 – May 2013

17.0 Inspection and Testing of Structures– In case of any doubt regarding the grade of concrete used in construction, testing is conducted again.

(1) Destructive test

a. Core test b. Load test

(2) Non-destructive test

IES-2006,09,10,11

a. Rebound hammer tests

b. Ultrasonic pulse velocity test

Section 3
General Design Consideration

18.0 Bases for Design–

18.1 The aim of design is to fulfill following five requirements:

(1) Safety
(2) Serviceability
(3) Durability
(4) Economy
(5) Aesthetic

19.0 Loads and Forces– Types of load which are taken into account while designing any structure are as follows:

(1) Dead load
(2) Imposed load
(3) Wind load, snow load
(4) Earthquake load
(5) Effect due to shrinkage, creep and temperature
(6) Foundation movement
(7) Soil and fluid pressure
(8) Vibration, impact, fatigue
(9) Erection load

19.2 Dead Loads– Dead load shall be calculated on the basis of unit weights which shall be stablished taking into consideration the materials specified for construction.

19.2.1 The unit weight of plain concrete and reinforced concrete may be taken as 24 kN/m^3 and 25 kN/m^3 respectively for calculation of dead load. [IS 875 (Part-I)]

DDA JE Civil 29-03-2023(Shift-I)
SSC JE-22-01-2018 (Even.)
NBCC JE-2018 (Shift-I)
Telangana AE-20-09-2015
SSC JE-23-09-2019 (Morn.)

19.9 **Design load-** Design load is the load to be taken for design of any structural member. In case of working stress method it is characteristic load while appropriate partial safety factor is multiplied for limit state design method.

21.0 Fire Resistance–

21.1 A structure is made fire resistance by using suitable construction material and providing appropriate cover to steel. Measurement of fire resistance capacity of any structure is in terms of hour for which structure can behave satisfactorily. Minimum width of beam that should be used for fire resistance building is 200 mm.

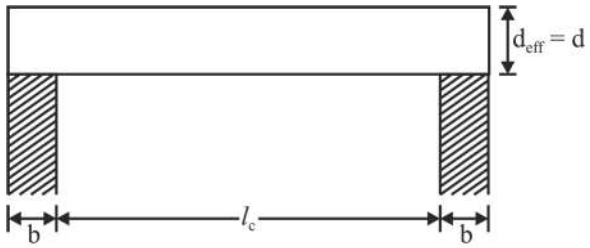
SSC JE-25-09-2019 (Morn.)

22.0 Analysis–

22.2 Effective Span–

(a) Simply Supported Beam and Slab– The effective span of a member shall be taken as clear span plus the effective depth of slab or beam or centre to centre distance of supports, whichever is less.

SSC JE-23-09-2019 (Even.)
SSC JE-22-01-2018 (Even.)
NBCC JE-2017



$l_{eff} = l_c + d$ or $l_c + b$ whichever is less

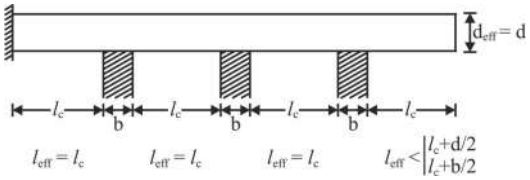
(b) Continuous Beam or Slab–

- If the width of support is less than $1/12^{th}$ of clear span, the effective span is same as mentioned in (a).
- If the width of support is more than $1/12^{th}$ of clear span or 600mm whichever is less then effective span is as follows:

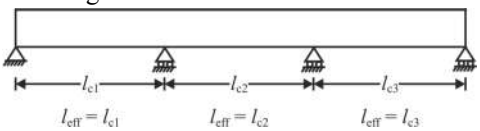
$b > \frac{\ell_c}{12}$ or 600, whichever is less

(i) For end span with one end fixed and the other continuous or for intermediate spans, the effective span shall be equal to the clear span between supports.

(ii) For end span with one end free and the other continuous, the effective span shall be equal to the clear span plus half the effective depth of the beam or slab or the clear span plus half the width of the discontinuous support, whichever is less.

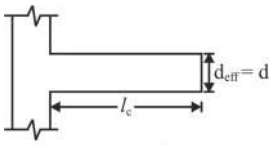


(iii) In the case of spans with roller or rocket bearings, the effective span shall always be the distance between the centers of bearing.



(c) Cantilever– The effective length of a cantilever shall be taken as its length to the face of the support plus half the effective depth.

UPRVUNL JE-2019
SSC JE-2013



(d) Frames: In the analysis of continuous frame, centre to centre distance is used.

22.3 Stiffness–

22.3.1 **(a) Gross Section–** The cross-section of the member ignoring reinforcement

(b) Transformed section: The concrete cross-section plus the area of reinforcement transformed using modular ratio.

(c) Cracked Section: The area of concrete in compression plus the area of reinforcement transformed on the basis of modular ratio.

22.4 Structural Frames–

IES-(1995, 2000, 2007)

22.4.1 Arrangement of imposed load–

Consideration may be limited to combination of:

(1) Design dead load on all spans with full design imposed load on two adjacent spans plus alternate spans for maximum hogging bending moment at the support B as shown below.

(2) Design dead load on all spans with full design imposed load on alternate spans for maximum sagging bending moment in between support A and B as shown below.

22.5 Moment and Shear Coefficient for Continuous Beams–

22.5.1 Unless more exact estimates are made, for beams of uniform cross-section which support substantially uniformly distributed loads over three or more span which do not differ by more than 15 percent of the longest, the bending moment and shear forces used in design may be obtained using the coefficients given in table 12 and table 13 respectively.

SSC JE-2012

Table 12
Bending Moment Coefficients
(Clause 22.5.1)

IES-2000

Type of load	Span moments		Support moments	
	Near middle of end span	At middle of interior span	At support next to the end support	At other interior supports
1	2	3	4	5
Dead load and imposed load (fixed)	$+\frac{1}{12}$ DDA JE Civil 28-03-2023(Shift-III) LMRCL (Asst. Manag.)-15-05-2018	$+\frac{1}{16}$	$-\frac{1}{10}$	$-\frac{1}{12}$
Imposed load (not fixed)	$+\frac{1}{10}$	$+\frac{1}{12}$	$-\frac{1}{9}$	$-\frac{1}{9}$
Note: For obtaining the bending moment, the coefficient shall be multiplied by the total design load and effective span.				

Table 13
Shear Force Coefficients
(Clause 22.5.1 and 22.5.2)

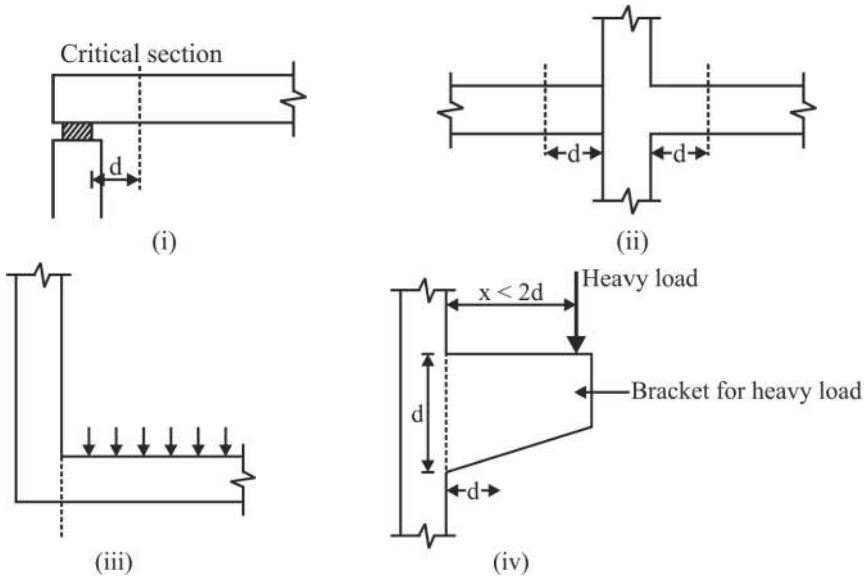
IES-2009

Type of load	At end support	At support next to the end support		At all other interior supports
		Outer side	Inner side	
1	2	3	4	5
Dead load and imposed load (fixed)	0.4	0.6	0.55	0.5
Imposed load (not fixed)	0.45	0.6	0.6	0.6
Note: For obtaining the shear force, the coefficient shall be multiplied by the total design load.				

22.6 Critical Sections for Moment and Shear–

22.6.1 **Critical Section for Moment–** For monolithic construction, the moments computed at the face of the support shall be used in the design of the members at those section.

22.6.2 **Critical Section for Shear–** The shears computed at the face of the support shall be used in the design of the member at that section except as in 22.6.2.1



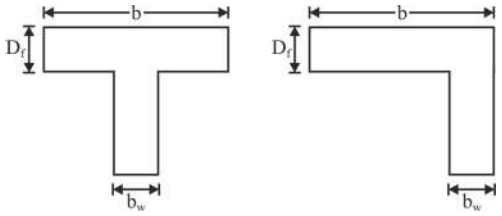
23.0 **Beams–**

- **Effective depth**- Effective depth of a beam is the distance between the centroid of area of tension reinforcement and the maximum compression fibre, in the case of two or three layers of tension reinforcement centroid of all tension reinforcement is considered.

23.1 A slab which is assumed to act as a compression flange of a T-beam or L-beam must be cast monolithically with the web or bonded firmly together.

23.1.2 Effective width of flange may be taken as the following but in no case greater than the width of the web plus half the sum of the clear distance to the adjacent beams on either side.

IES-2006



(a) For T-beam $b_f = \frac{l_o}{6} + b_w + 6D_f$

Raj. SSB JE-03-07-2016

(b) For L-beam $b_f = \frac{l_o}{12} + b_w + 3D_f$

(c) For isolated beams, the effective flange width shall be obtained as below but in no case greater than the actual width

T-beam, $b_f = \frac{l_o}{\frac{l_o}{b} + 4} + b_w$

TNPSC AE Civil 11-07-2022
MP Sub. Engg.-09-07-2017 (Shift-II)

L-beam, $b_f = \frac{0.5l_o}{\frac{l_o}{b} + 4} + b_w$

$\mathbf{b_f}$ = effective width of flange

$\boldsymbol{l_o}$ = distance between points of zero moments in the beam.

Note: For continuous beam and frames 'l_o' may be assumed as 0.7 times the effective span.

Haryana SSC-18-04-2018

23.2 (a) The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as cast level of the supports of floors should not normally exceed effective span/250.

IES-1996, 2006
Rajashthan PSC-2018
SSC JE-01-03-2017 (Even.)

(b) The deflection due to effects of temperature, creep and shrinkage after erection of partitions and the application of finishes should not normally exceed span/350 or 20 mm whichever is less.

Maharashtra WRD JE 09-08-2022(Shift-I)
IES-1995

23.2.1 The vertical deflection of beams is ensured within limit by providing following recommended values of effective span to effective depth ratios

Basic values of span to effective depth ratios for span upto 10 m:

Cantilever beam 7

SSC JE Civil 09-10-2023,Shift I
Gujarat SMC Civil Supervisior 05-03-2023
DSSSB Technical Asst23-10-2021
SSC JE-23-09-2019 (Even.)

Simply supported beam 20

Jharkhand JSSC JE Civil 4-11-2022
Haryana SSC-12-04-2018 (Even.)
MP Sub. Engg.-04-09-2018 (2:00 PM)
DDA JE-24-04-2018 (Shift-II)
DDA JE-23-04-2018 (Shift-II)
SSC JE-24-01-2018 (Morn.)

Continuous beam 26

Maharastra WRD JE 6-08-2022(Shift-I)
Haryana SSC-12-04-2018 (Even.)
Uttrakhand AE-2013

23.3 Slenderness Limits for Beams to Ensure Lateral Stability– IES-2005

A simply supported or continuous beam shall be so proportioned that the clear distance between the lateral restraints does not exceed 60 b or 250 b^2/d whichever is less, where d is the effective depth of the beam and b the breadth of the compression face midway between the lateral restraints.

UPRVUNL JE-2019
LMRC AE-2017 (Shift-I)
SSC JE-2005
Haryana SSC JE-11-04-2018 (Shift-II)

For a cantilever, the clear distance from the free end of the cantilever to the lateral restraint shall not exceed 25 b or 100 b^2/d whichever is less.

DDA JE Civil 1-4-2023(Shift-I)
DDA JE Civil 29-3-2023(Shift-II&III)
Jharkhand JSSC JE Civil 23-10-2022

24.0 Solid Slabs–

24.1

(1). For slabs spanning in two directions, the shorter of the two spans should be used for calculating the span to effective depth ratios.

Rajasthan PSC-2018

(2). For two way slabs of shorter span (up to 3.5 m) with mild steel reinforcement, the span to overall depth ratio given below may generally be assumed to satisfy vertical deflection limits for loading up to 3 kN/m^2.

Simply supported slab 35

WBPSC Sub AE Civil 05-06-2022
UPRVUNL JE-2019
SSC JE-23-01-2018 (Morn.)

Continuous slab 40

For high strength deformed bars of grade Fe415, the values given above should be multiplied by 0.8.

IES-1995

24.4.1 Restrained slab with Unequal Conditions at Adjacent Panels – In some cases, the support moments calculated from Table 26 for adjacent panel may be adopted to adjust them.

(a) Calculate the sum of moments at midspan and supports (neglecting sings.)

(*before Amendment No.4 May 2013*)

24.4.1 **Restrained slab with Unequal Conditions at Adjacent panels –** In some cases the support moments calculated from Table 26 for adjacent panels may differ significantly. The following procedure may be adopted to adjust them.

(a) Calculate the sum of the midspan moments and the average of the supports moments (neglecting signs**)** for each panel.

(After Amendment NO.4 – May 2013)

24.5 The loads on beams supporting solid slabs spanning in two directions at right angles and supporting uniformly distributed loads, may be assumed to be in accordance with Fig.7 below.

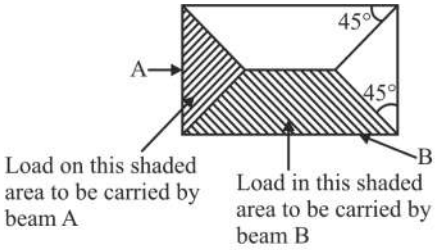


Fig. 7 : Load carried by supporting beams

25.0 Compression Members–

25.1 Definitions–

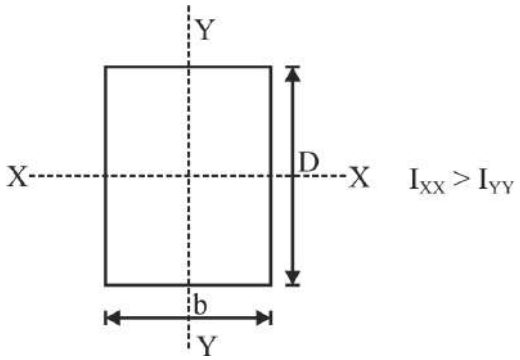
25.1.1 Column or strut is a compression members, the effective length of which exceeds three times the least lateral dimension. It is less than or equal to three then consider it as a pedestal.

Jharkhand JSSC JE Civil 23-10-2022

25.1.2 **Short and Slender Compression Members–** A compression member may be considered as hort when both the slenderness ratios $\frac{l_{ex}}{D}$ and $\frac{l_{ey}}{b}$ are less than 12.

IES-2011
UK Comb. AE-Paper-Ist-2012
Chhattishgarh Prof. Exam Board-2016
Haryana SSC-12-04-2016 (Even.)
SSC JE-2012

In general x-axis taken as major axis and y-axis is taken as minor axis.



25.1.3 **Unsupported Length–** The unsupported length *l* of a compression member shall be taken as the clear distance between end restraints.

25.3 Slenderness Limits for Columns–

25.3.1 The unsupported length between end restraints shall not exceed 60 times the least lateral dimension of a column.

PCMC JE Civil 27-05-2023
DDA JE Civil 29-03-2023(Shift-III)
Jharkhand JSSC JE Civil 04-11-2022
DSSSB AE 27-09-2021(Shift-II)

25.3.2 If in any given plane, one end of a column is unrestrained, its unsupported length, *l* shall not exceed $100b^2/D$.

DDA JE-23-04-2018 (12:30 to 2:30 PM)

25.4 Minimum Eccentricity–

All columns shall be designed for minimum eccentricity.

$$e_{min} = \frac{l_{unsupported}}{500} + \frac{\text{lateral dimension}}{30}$$ or 20 mm, which ever is more.

RRB JE CBT-II-28-08-2019 (Morn.)
Haryana SSC JE-10-04-2018 (Shift-I)
DDA JE-24-04-2018 (12:30 to 2:30 PM)
HP SSSB JE-31-04-2017

26.0 Requirements Governing Reinforce-ment and Detailing–

26.1 General– Reinforcing steel of same type and grade shall be used as main reinforcement in a structural member. However, simultaneous use of two different types of steel for main secondary reinforcement respectively is permissible.

26.1.1 Bars may be arranged singly, or in pairs in contact, or in group of three or four bars bundled in contact. Bundled bars shall be enclosed within stirrups or ties. Bundled bars shall be tied together to ensure the bars remaining together. Bars larger than 32mm diameter shall not be bundled, except in column.

26.2 Development of Stress in Reinforcement– The calculated tension or compression in any bar at any section shall be developed on each side of the section by providing development length or end anchorage or combination.

26.2.1 Development length of bars –

$$L_d = \frac{\sigma_{st}\phi}{4\tau_{bd}}$$

NHSRCL Jr. Manager Civil 13-07-2023,Shift II
UPRVUNL JE-2019
MP Sub. Engg.-04-09-2018 (2:00 PM)
UPSSSC JE-2015
SSC JE-2013
SSC JE-29-01-2018 (Even.)
DFCCIL-17-04-2016

Where,

ϕ = nominal diameter of bar

σ_{st} = stress in bar at the section considered at design load

τ_{bd} = design bond stress

Note (1) The development length includes anchorage values of hooks in tension reinforcement.

(2) For bars of sections other than circular, the development length should be sufficient to develop the stress in the bar by bond.

(before Amendment No.4 May 2013)

NOTES–(3) For plain cement concrete of M15 grade with nominal reinforcement, the design bond stress may be taken as 1.0 N/mm^2.

(After Amendment NO.4 – May 2013)

26.2.1.1 Design Bond Stress in Limit State Method for Plain Bars in Tension Shall be as Below–

Grade of concrete	M-20	M-25	M-30	M-35	M-40 and above
Design bond stress τ_{bd} N/mm^2	1.2 MPSC Mains Civil 23-04-2023 NHPC JE 4-4-2022(Shift-I) SSC JE-23-09-2019 (Even.)	1.4 Haryana SSC JE-11-04-2018 (Shift-II)	1.5 DDA JE Civil 29-03-2023(Shift-III)	1.7	1.9

Design bond stress for deformed bar shall be 60 percent higher than design bond stress of plain bar.

IES-1995
SSC JE-25-09-2019 (Morn.)
SSC JE-29-01-2018 (Morn.)
SJNVL JE-07-10-2018

Plain bar Deformed bar

For bar in compression, the values of bond stress for bar in tension shall be increased by additional 25 percent.

DDA JE Civil 29-03-2023(Shift-II)
Haryana SSC-13-04-2018
SSC JE-2014 (Even.)

26.2.1.1 Design bond stress in limit state method for plain bars in tension shall be as below: – For deformed bars conforming to IS 1786 these values shall be increased by 60 percent. For bars in compression, the values of bond stress for bars in tension shall be increased – by 25 percent.

(*before Amendment No.4 May 2013*)

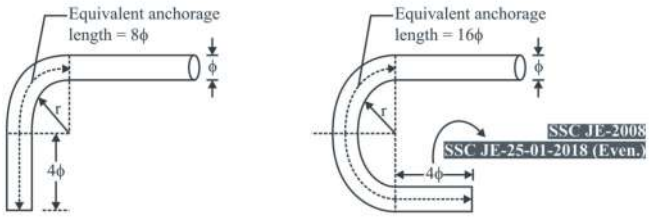
26.2.1.1 Design bond stress in limit state method for plain bars in tension shall be as below: – For deformed bars conforming to IS 1786 these values shall be increased by 60 percent. For bars in compression, the values of bond stress for bars in tension shall be increased -by 25 percent. For fusion bonded epoxy coated deformed bars, design bond stress values shall be taken as 80 percent of the vales given in the above table.

(After Amendment NO.4 – May 2013)

SSC JE Civil 10-10-2023 Sift- 1

26.2.2 Anchoring Reinforcing Bars– Anchoring is provided by bends and hooks at the end which is equivalent of resistance provided by straight bars.

WBPSC JE Civil 30-07-2023



SSC JE-2008
SSC JE-25-01-2018 (Even.)

(a) standard 90° bend

(b) standard U-type hook

SSC JE-22-01-2018 (Even.)

$r = 2\phi$ for plain bars

SSC JE-23-01-2018 (Morn.)

$r = 4\phi$ for HYSD bars

SSB HP-18-11-2018

Anchoring bars in tension

26.2.2.1 b) Bends and Hooks IS:2502–

(1) Bends– The anchorage value of bend shall be taken as four times the diameter of the bar for each 45° bend subject to a maximum of 16 times the diameter of bar.

Gujarat SMC Civil Supervisor 05-03-2023

(2) Hooks– The anchorage value of a standard U-type hook shall be equal to 16 times the diameter of the bar.

IES-2009
SSC JE CWC & MES-2011
UPPCL JE-2013
CRPF SI Overseer Civil-2017

Anchorage length of bend and hooks are not considered in the case of compression.

26.2.3 Curtailment of Tension Reinforce-ment in Flexural Members–

26.2.3.1 For curtailment, reinforcement shall extend beyond the point at which it is not longer required to resist flexure for a distance equal to the effective depth of the member or 12 times the bar diameter, whichever is greater except at simple support or end of cantilever. In addition 26.3.3.2 to 26.2.3.5 shall also satisfied.

IES-2006

Note: A point at which reinforcement is no longer required to resist flexure is where the resistance moment of the section, considering only the continuing bars, is equal to the design moment.

26.2.3.2 Flexural reinforcement shall not be terminated in a tension zone unless any one of the following conditions is satisfied.

IES-2009

(a) The shear at the cut off point does not exceed two thirds that permitted, including the shear strength of web reinforcement provided.

(b) Stirrup area in excess of that required for shear and torsion is provided along each terminated bar over a distance from the cut off point equal to three fourths the effective depth of the member. The excess stirrup area shall be not less than $0.4bs/f_y$, where b is the breadth of beam, s is the spacing and f_y is the characteristics strength of reinforcement in N/mm^2. The resulting spacing shall not exceed $d/8\ \beta_b$ where β_b is the ratio of the area of bars cut off to the total area of bars at the section, and d is the effective depth.

(c) For 36mm and smaller bars, the continuing bars provide double the area required for flexure at the cut off point and the shear does not exceed three fourth that permitted.

26.2.3.3 Positive Moment Reinforcement–

(a) At least one third the positive moment reinforcement in simple members and one fourth the positive moment reinforcement in continuous members shall extend along the same face of the member into the support, to a length equal to $L_d/3$.

(b) When a flexural member is part of the primary lateral load resisting system, the positive reinforcement required to be extended into the support as described in (a) shall be anchored to develop its design stress in tension at the face of the support.

(c) At simple supports and at points of inflection, positive moment tension reinforcement shall be limited to a diameter such that L_d computed for f_d by 26.2.1 does not exceed

$$\frac{M_1}{V} + L_0$$

Where,

M_1 = moment of resistance of the section,

f_d = 0.87 f_y in the case of limit state design and the permissible stress σ_{st} in the case of working stress design

v = shear force at the section due to design loads

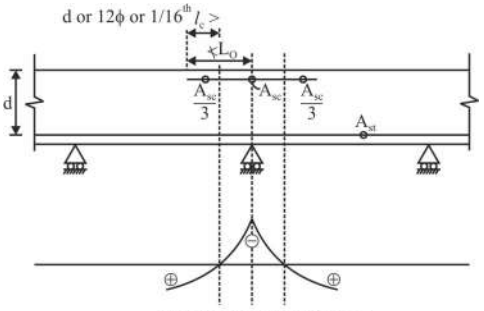
L_o = Anchorage length due to hook, maximum value of L_o is limited to the effective depth of the members or 12ϕ, whichever is greater.

ϕ = diameter of bar

According to code, for more safty of simply supported beam,

- The value of M_1/V in the above expression may be increased by 30 percent when the ends of the reinforcement are confined by a compressive reaction.

26.2.3.4 Negative Moment Reinforcement– At least one third of the total reinforcement provided for negative moment at the support shall extend beyond the point of inflection for a distance not less than the effective depth of the member of 12ϕ or one-sixteenth of the clear span whichever is greater.



Bending moment diagram

26.2.3.5 Curtailment of Bundled Bars– 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.

26.2.5 It is recommended that splices in flexural members should not be done at sections where the bending moment is more than 50 percent of the moment of resistance and not more than half the bars shall be splice at a section.

26.2.5.1 Lap Splices–

(a) Lap splices shall not be used for bars larger than 36 mm; for larger diameters, bars may be welded or mechanically spliced.

(*before Amendment No.3 August 2007*)

DDA JE Civil 1-4-2023(Shift-III)
DDA JE-24-04-2018 (Shift-II)
DDA JE-23-04-2018 (Shift-I)

26.2.5.1 (a) Lap splices shall not be used for bars larger than 32 mm. Bars larger than 32 mm. shall be welded (see 12.4) or mechanically spliced.

(*after Amendment No. 3 August 2007*)

UPPCL JE 26-06-2022 (Shift-II)

(c) Lap length including anchorage value of hooks for bars in flexural tension shall be L_d or 30ϕ whichever is greater and for direct tension shall be $2L_d$ or 30ϕ whichever is greater. The straight length of the lap shall not be less than 15ϕ or 200mm.

SSC JE-25-01-2018 (Even.)

(d) The lap length in compression shall be equal to the development length in compression, but not less than 24ϕ.

DDA JE Civil 28-03-2023(Shift-II&III)
DDA-24-04-2018 (Shift-I)
IES-2011
SSC JE-2009

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

Chhattishgarh Prof. Exam Board-2016

(f) When splicing of welded wire fabric is to be carried out, lap splices of wires shall be made so that overlap measured between the extreme cross wires shall be not less than the spacing of cross wires plus 100 mm.

(g) In case of bundled bars, lapped splices of bundled bars shall be made by splicing one bar at a time; such individual splices within a bundle shall be staggered.

(*before Amendment No.5 July 2019*)

26.2.5.1 Lap splices

(g) In case of bundled bars, lapped splices of bundled bars shall be made by splicing one bar at a time; such individual splices within a bundle shall be staggered. *Reinforcement couplers for mechanical splices of bars for concrete reinforcement, used, shall be in accordance with* ***IS 16172****.*

(after Amendment No.5 July 2019)

26.3 Spacing of Reinforcement–

26.3.3 Maximum distance between bars in tension–

(a) In Beams: The horizontal distance between parallel reinforcement bars near the tension face of the beam shall not be greater than the following–

f_y (N/mm^2)	Clear distance between bars (mm)
250	300
415	180
500	150

(b) In Slabs:

- The horizontal distance between parallel main bars shall not be more than three times the effective depth of solid slab or 300mm whichever is smaller.

(before Amendment No.3August 2007)

Gujarat SMC Civil Supervisior 05-03-2023
Karnataka PSC AE RWS 26-02-2023
SSC JE-23-01-2018 (Even.)
UKPSC AE-Paper-I-2017
SSC JE-02-03-2017 (Even.)
DMRC JE-2015
SSC JE-2007, 2012

(b) In Slabs:

- The horizontal distance between parallel main bars shall not be more than three times the effective depth of solid slab ***'for'*** **400 mm** Whichever is smaller.

(after Amendment No. 3 August 2007)

- The horizontal distance between parallel reinforcement bars provided against shrinkage and temperature shall not be more than five times the effective depth of a solid slab or 450mm whichever is smaller.

UKPSC AE-Paper-I-2007
SSC JE-02-03-2017 (Even.)

26.4 Nominal Cover to Reinforcment– Minimum values of nominal cover for different structural member depends upon exposure condition because cover is directly related to durability of the structure.

Exposure	Nominal cover (mm)
Mild	20 UPPCL JE 22-06-2022(Shift-I)
Moderate	30 SSC JE- Civil 11-10-2023 Shift- I DDA JE Civil 01-04-2023 (Shift-III) Haryana SSC-12-04-2018 SSC JE-03-03-2017 (Even.)
Severe	45 DDA JE-23-04-2018 (12:30 to 2:30) MP VYAPAM Sub. Engg.-09-07-2017

Very severe	50 **UPPCL JE 22-06-2022 (Shift-I&II)** **UPPCL JE 21-02-2022(Shift-I)** **DFCCIL Civil JE-10-11-2018** **Coal India-2016**
Extreme	75 **DDA JE Civil 1-4-2023(Shift-I)**

- For footings, minimum cover shall be 50mm.

Gujarat Engineering Service Civil 24-01-2023
LMRC AE-2017 (Shift-I)
SSC JE-23-09-2019 (Morn.)
DDA JE-24-04-2018 (Shift-II)

26.5 Requirements of reinforcement for structural members

26.5.1.1 Tension reinforcement–

IES-2009

Minimum tension reinforcement in beams,

$$A_{st} \geq \frac{0.85bd}{f_y}$$

WBPSC JE Civil 30-07-2023
Rajasthan JE-2015
MP VYAPAM Sub. Engg.-09-07-2017

Maximum tension reinforcement in beams,

$A_{st} \leq 0.04bD$

GETCO Vidyut Sahayak JE. Civil 05-01-2022
Gujarat SMC Civil Supervisior 05-03-2023
Gujarat Engg Service Civil 24-01-2023
DDA JE Civil 1-4-2023(Shift-I)
JSSC JE Civil Engg 3-07-2022
UPRVUNL JE-2019
SJVNL-07-10-2018
Haryana SSC-13-04-2018
MP Sub. Engg.04-09-2018 (2:00 PM)
UPSSSC JE-2015

26.5.1.2 Compression Reinforcement– There is no limit of minimum compression reinforcement in beam but maximum amount is limited to 0.04bD.

DDA JE Civil 29-3-2023(Shift-I)
Maharashtra WRD JE 12-08-2022(Shift-II)
IES-2009, 1997

26.5.1.3 Side Face Reinforcement– Where the depth of the web in a beam exceeds 750mm, side face reinforcement shall be provided along the two faces. The total area of such reinforcement shall be not less than 0.1 percent of the web area and shall be distributed equally on two faces at a spacing not exceeding 300mm or web thickness whichever is less.

OLICL JE Civil 21-06-2023
ACF 24-2-2021 Paper III
IES-1997, 1999
SSC JE- 2011

26.5.1.5 Maximum Spacing of Shear Reinforcement– The maximum spacing of shear reinforcement measured along the axis of the member shall not exceed 0.75d for vertical stirrups and d for inclined stirrups at 45°, where d is the effective depth of the section under consideration. In no case shall the spacing exceed 300mm.

ISRO TECH ASSISTENT Civil 4-06-2022
UPPCL JE 21-02-20222(Shift-I
HPSSC JE 11-04-2021
SSC JE-23-09-2019 (Morn.)
DFCCIL Civil JE-10-11-2018
Haryana SSC-02-04-2018 (Even.)
DDA JE-24-04-2018 (Shift-I)
Uttarakhand JE-2016

26.5.1.6 Minimum Shear Reinforcement– Minimum shear reinforcement in the form of stirrups shall be provided

$$\frac{A_{sv}}{bS_v} \geq \frac{0.4}{0.87f_y}$$

DDA JE Civil 1-4-2023(Shift-III)

Where,

A_{sv} = total cross sectional area of stirrup legs effective in shear.

S_v = stirrup spacing along the length of the member

b = breadth of the beam or breadth of the web of flanged beam

f_y = should not be more than 415 N/mm^2.

26.5.2 Slabs–

26.5.2.1 Minimum Reinforcement– A minimum reinforcing must be provided in slabs to take care of shrinkage and temperature effect. The mild steel reinforcement in either direction of slabs shall not be less than 0.15 percent of the total cross sectional area. However, this value can be reduced to 0.12 percent when high strength deformed bars is used.

MPSC Mains Civil 23-04-2023
Chhattishgarh Vyapam ITIR Building 22-06-2023
Panjab PSC JE 6-3-2022
SSC JE-29-01-2018 (Even.)
DFCCIL Civil JE-10-11-2018
ISRO JE-2015
ESE-2015

26.5.2.2 Maximum Diameter– The diameter of reinforcement bars shall not exceed one eight of the total thickness of the slab.

JSSC JE Civil Eng 3-7-2022
JSSB JE 23-03-2022
RIICO Asst Site Eng 12-02-2021 Paper-I
SSC JE-03-03-2017 (Even.)
Airport Authority of India JE-2015
SSC JE-02-03-2017 (Morn.)

26.5.3 Columns–

26.5.3.1 Longitudinal reinforcement–

(a) The cross sectional area of longitudinal reinforcement, shall be not less than 0.8 percent nor more than 6 percent of the gross cross sectional area of column.

SSC JE Civil 11-10-2023 (Shift- I)
DDA JE Civil 1-4-2023 (Shift-I)
DDA JE Civil 28-03-2023 (Shift-II)
RIICO Asst Site Eng 12-02-2021 Paper-I
UPRVUNL JE-2019
Airport Authority of India JE-2015
SSC JE-01-03-2017 (Even.)
SSC JE-2014, 2009, 2010
HP SSC JE- 2015

Note: The use of 6 percent reinforcement may involve practical difficulties in placing and compacting of concrete hence lower percentage is recommended. Where bars from the columns below have to be lapped with those in the column under consideration the percentage of steel shall usually not exceed 4 percent.

(b) In any column that has a larger cross sectional area than that required to suport the load, the minimum percentage of steel shall be based upon the area of concrete required to resist the direct stress and not upon the actual area.

(c) The minimum number of longitudinal bars provided in a column shall be four in rectangular columns and 6 in circular columns.

GETCO Vidyut Sahayak JE Civil 05-01-2022
Gujarat SMC Civil Supervisior 05-03-2023
Jharkhand JSSC Civil 4-11-2022
Maharashtra WRD JE 9-8-2022
RRB JE CBT-II-29-08-2019 (Even.)
NBCC JE-2017
SSC JE-03-03-2017 (Even.)

(d) The bars shall not be less than 12mm in diameter.

DDA JE Civil 1-4-2023 (Shift-I)
KPSC AE Civil 26-02-2023
SJNVL JE-01-10-2018
Raj. SSB JE-03-07-2016
HP SSSB JE-31-04-2017

(e) A reinforced concrete column having helical reinforcement shall have at least six bars of longitudinal reinforcement within the helical reinforcement. IES-2005

(f) In a helically reinforced column, the longitudinal bars shall be in contact with the helical reinforcement and equidistant around its inner circumference.

(g) Spacing of longitudinal bars measured along the periphery of the column shall not exceed 300 mm.

UKPSC AE-Paper-I-2007
SSC JE-2011
Uttarakhand AE-2013
DDA JE-24-04-2018 (Shift-I)

(h) In case of pedestals in which the longitudinal reinforcement is not taken into account in strength calculations, nominal longitudinal reinforcement not less than 0.15 percent of the cross sectional are shall be provided.

IES-2007

Note: Pedestal is a compression member, the effective length of which does not exceed three times the least lateral dimension.

SSC JE-2008
UPPCL JE-2013

26.5.3.2 Transverse Renforcement–

(c) Pitch and Diameter of Lateral Ties–

1. **Pitch–** The pitch of transverse reinforcement shall be not more than the least of the following distances:

DDA JE-24-04-2018 (Shift-I)
UKPSC AE-Paper-I-2007

   (i) The least lateral dimension of the compression members.
   (ii) Sixteen times the smallest diameter of the longitudinal reinforcement bar to be tied
   (iii) 300mm.

2. **Diameter:** The diameter of the polygonal links or lateral ties shall be not less than one forth of the diameter of the largest longitudinal bar and in no case less than 6 mm.

(d) Helical Reinforcement–

1. **Pitch:** Helical reinforcement shall be of regular formation with the turns of the helix spaced evenly and its ends shall be anchored properly by providing one and a half extra turns of the spiral bar. Where an increased load on the column on the strength of the helical reinforcement is allowed for, the pitch of helical turns shall be not more than 75mm, nor more than one sixth of the core diameter of the column, nor less than 25mm, nor less than three times the diameter of the steel bar forming the helix. In other cases, the requirements of 26.5.3.2 shall be complied with.
2. The diameter of the helical reinforcement shall be in accordance with 26.5.3.2. (c) (2)

27.0 Expansion Joints–

27.1 The structures adjacent to the joint should preferably be supported on separate columns or walls but not necessarily on separate foundation. Expansion joint should be completely clear, reinforcement should not extend across expansion joint.

Normally, structures exceeding 45m in length are designed with one or more expansion joints.

Section- 4

Special Design Requirements for Structural Members and Systems

29.0 Deep Beams–

29.1 **a)** A beam shall be termed as deep beam when the ratio of effective span to overall depth, *l*/D is less than

(1) 2.0 for a simply supported beam

SSC JE 23-03-2021(Evening)
DDA JE-23-04-2018 (Shift-I)

(2) 2.5 for a continuous beam.

DFCCIL EXECUTIVE 29-09-2021
DDA JE-24-04-2018 (12:30 to 2:30 PM)

29.2 Lever Arm–

The lever arm z for a deep beam shall be detemined as below:

a) For simply supported beams:

$z = 0.2\,(l + 2D)$ when $1 \le \frac{l}{D} \le 2$

or

$z = 0.6\,l$ when $\frac{l}{D} \le 1$

b) For continuous beams:

$z = 0.2\ (l + 1.5\ D)$ when $1 \le \frac{l}{D} \le 2.5$

or

$z = 0.5\ l$ when $\frac{l}{D} \le 1$

where l is the effective span taken as centre to centre distance between supports or 1.15 times the clear span, whichever is smaller, and D is the overall depth.

31 Flat Slab–

31.1 The term flat slab means a reinforced concrete slab supported directly by column. There is no role of beam in this case. Some times drops are provided at interface of column and slab.

NBCC JE-2017

31.2 Proportioning–

31.2.1 The minimum thickness of flat slab shall be 125mm. **UPSSSC JE-2015**

31.6 Shear in Flat Slab–

31.6.1 The critical section for shear shall be at a distance d/2 from the periphery of the column/ capital/drop panel, perpendicular to the plane of the slab where d is the effective depth of the section. The shape of critical section for shear is geometrically similar to the support immediately below the slab as shown in the figure below.

Rajasthan PSC-2018
ESE-1997

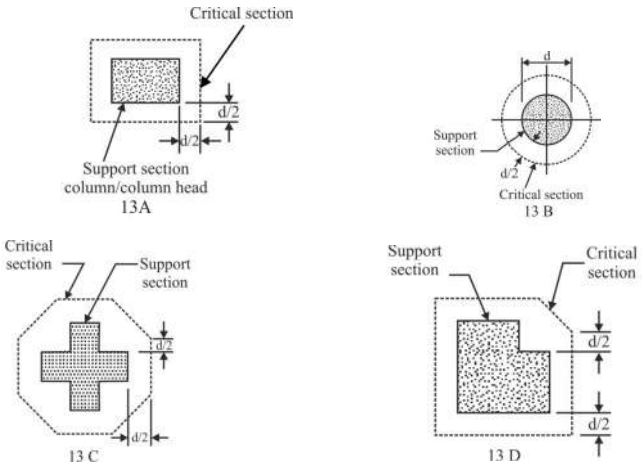


Fig. 13 : Critical sections in plan for shear in flat slab

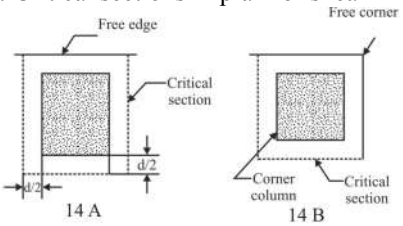


Fig. 14 : Effect of free edges on critical section for shear

31.6.3 Permissible Shear Stress–

31.6.3.1 When shear reinforcement is not provided, the calculated shear stress at the critical section shall not exceed $k_s\tau_c$

where, $k_s = (0.5 + \beta_c) \ge 1$

β_c = being the ratio of short side to long side of the column / capital

$\tau_c = 0.25\sqrt{f_{ck}}$ [in LSM]

KPSC AE Civil 26-2-2023

$\tau_c = 0.16\sqrt{f_{ck}}$ [in WSM]

SSC JE-2013

32.0 Walls– The minimum thickness of walls shall be 100mm.

32.2 Empirical Design Method for Walls Subjected to In plane Vertical Loads–

32.2.2 The design of a wall shall take account of the actual eccentricity of the vertical force subject to a minimum value of 0.05t. where t is thickness of wall.

32.2.3 The ratio of effective height to the thickness shall not exceed 30.

DDA JE-24-04-2018 (12:30 to 2:30 PM)
DDA JE-23-04-2018 (Shift-I)
Coal India-2016

32.5 Minimum requirements for reinforcement in walls– The reinforcement for walls shall be provided as below:

(a) The minimum ratio of vertical reinforcement to gross concrete area shall be:

(1) 0.0012 for deformed bars not larger than 16mm in diameter and with a characteristics strength of 415 N/mm^2 or greater.

(2) 0.0015 for other types of bars.

(3) 0.0012 for welded wire fabric not larger than 16mm in diameter.

(b) Vertical reinforcement shall be spaced not farther apart than three times the wall thickness nor 450mm.

(c) The minimum ratio of horizontal reinforcement to gross concrete area shall be:

(1) 0.0020 for deformed bars not larger than 16mm in diameter and with a characteristics strength of $415N/mm^2$ or greater.

(2) 0.0025 for other types of bars.

(3) 0.0020 for welded wire fabric not larger than 16mm in diameter.

(d) Horizontal reinforcement shall be spaced not father apart than three times the wall thickness nor 450mm.

DDA JE-24-04-2018 (Shift-I)
ESE-1998
Airport Authority of India JE-2015

32.5.1 For wall having thickness more than 200mm, the vertical and horizontal reinforcement shall be provided in two grids, one near each face of the wall.

34.0 Footings–

34.1.2 Thickness at the edge of footing- In reinforced and plain concrete footings the thickness at the edge shall be not less than 150mm for footings on soils, nor less than 300 mm above the tops of piles for footing on piles.

SSC JE Civil 10-10-2023 Shift- III
Lucknow Cantonment board AE Civil 18-12-2022
Jharkhand JSSC JE Civil 23-10-2022
Uttarakhand AE-2013
SSC JE-2012

34.2 Moments and Forces–

34.2.3.2 The greatest bending moment to be used in the design of an isolated concrete footing which supports a column, pedestal or wall, shall be calculated at section located as follows:

(a) At the face of the column, pedestal or wall for footings supporting monolithic constructed column, pedestal or walls.

SSC JE-2012

(b) Half way between the centre line and the edge of the wall, for footing under masonry walls.

Jharkhand SSC JE-2015

(c) Halfway between the face of the column or pedestal and the edge of the gusseted base, for footing under gussetted bases.

34.2.4 Shear and Bond–

34.2.4.1 There are two type of shear failure in footings, namely, one way shear and two way shear (punching shear)

(a) In case of one way shear, critical section is at a distance a from face of column of wall, where d is effective depth of footing.

(b) In case of two way shear critical section is at a distance d/2 from the face of column. Where d is effective depth of footings.

UPRVUNL JE-2014

34.4 Transfer of Load at the Base of Column

- The compressive stress in concrete at the base of a column or pedestal shall be considered as being transferred by bearing to the top of the supporting pedestal or footing. The bearing pressure on the loaded area shall not exceed the permissible bearing stress in direct compression multiplied by a value equal to $\sqrt{A_1/A_2}$ but not greater than 2:

UPRVUNL JE, 2019

Where,

A_1 = supporting area for bearing of footing, which in sloped or stepped footing may be taken as the area of the lower base of the largest frustum of a pyramid or cone contained wholly within the footing and having for its upper base, the area actually loaded and having side slope of one vertical to two horizontal and

A_2 = Loaded area at the column base.

For working stress method of design the permissible bearing stress on full area of concrete shall be taken as $0.25f_{ck}$; for limit state method of design the permissible bearing stress shall be $0.45f_{ck}$.

SSC JE 16-11-2022 (Shift-I)

Section-5
Structural Design
(Limit State Method)

35.0 Safety and serviceability requirement

35.1 The acceptable limit for the safety and serviceability requirements before failure occur is called Limit state.

35.3 Limit States of Seviceability–

35.3.2 Cracking – The surface width of the cracks should not, in general, exceed 0.3 mm in members where cracking is not harmful and does not have any serious adverse effects upon the preservation of reinforcing steel nor upon the durability of the structures. In members where cracking in the tensile zone is harmful either because they are exposed to moisture or in contact soil or ground water , an upper limit of 0.2 mm is suggested for the maximum width of cracks. For particularly aggressive environment, such as the 'severe' category in Table 3, the assessed surface width of cracks should not in general, exceed 0.1 mm.

GPSC AE 18-9-2022

(before Amendment No.4 May 2013)

35.3.2 Cracking – The surface width of the cracks should not, in general exceed 0.3 mm in members where cracking is not harmful and does not have any serious adverse effects upon the preservation of reinforcing steel nor upon the durability of the structure. In members where cracking in the tensile zone is harmful either because they are exposed to the effects of the weather or continuously exposed to moisture or in contact soil or ground water, an upper limit of 0.2 mm is suggested for the maximum width of cracks: For particularly aggressive environment, such as 'Very severe' and 'extreme' categories given in Table 3, the assessed surface width of cracks should not in general, exceed 0.1 mm.

GPSC AE 18-09-2022

(After Amendment NO.4 – May 2013)

Maximum allowable crack	Exposure condition
0.3mm	Mild
0.2mm	moderate
0.1mm	severe, and more aggressive environment

SSC JE

36.0 Characteristic and design values and partial safety factors

36.1 Characteristics strength of Material–Characteristics strength means that value of the strength of the material below which not more than 5 percent of the test results are expected to fall.

SSC JE, 2012

36.2 Characteristic Loads– Characteristic load means that value of load which has a 95 percent probability of not being exceeded during the life of the structure.

SSC JE-2005
UPSSSC JE-2015
Haryana SSC JE-13-04-2018

36.3 Design values–

36.3.1 Materials,

Design strength of material: $f_d = \frac{f}{\gamma_m}$

Loads

UPPCL JE 22-06-2022(Shift-II)

Design load: $F_d = F \cdot \gamma_f$

Where f, F = characteristic strength of material and characteristics load respectively.

γ_m, γ_f = partial safety factor for material and load respectively.

36.4 Partial safety factors–

36.4.1 Partial safety factors γ_f for loads (Table-18)

36.4.2 Partial safety factors γ_m for material strength

36.4.2.1 When assessing the strength of a structure or structural member for the limit state of collapse, the values of partial safety factor, γ_m should be taken as 1.5 for concrete and 1.15 for steel.

TNPSC AE Civil 11-07-2022
KPSC AE Civil 26-02-2023
UPSSSC JE 16-04-2022
DSSSB AE 26-09-2021(Shift-III)
Jharkhand JSSC Civil 04-11-2022
SSC JE-02-03-2017 /
SSC JE-2009
RJC Exam-21-08-2016
Coal India-2016
Haryana SSC JE-13-04-2018 (Shift-II)
DDA JE-23-04-2018 (Shift-I)
UPSSSC JE-31-07-2016
MP Sub. Engg.-2015
Uttarakhand AE-2013
Uttarakhand JE-2016

Table 18

Values of partial safety factor γ_f for loads

SSC JE-2012

Load combination	Limit state of collapse			Limit states of serviceability		
	DL	IL	WL	DL	IL	WL
1	2	3	4	5	6	7
DL + IL	1.5	1.5 DDA JE-23-04-2018 (Shift-II)	1.0	1.0	1.0	-
DL + WL	1.5 or 0.9	-	1.5	1.0	-	1.0
DL+IL+WL Guirat Engg. Services (Civil) 24-01-2023	1.2	1.2	1.2	1.0	0.8	0.8

37.0 Analysis–

37.1 Analysis of Structure– Method of analysis as in 22 shall be used. The material strength to be assumed shall be characteristic value in the determination of elastic properties of members irrespective of the limit state being considered.

37.1.1 In no case more than 30 percent moment redistribution is allowed.

37.1.2 Yield line theory or any other acceptable method may be used for analysis of slabs spanning in two directions at right angle.

38.0 Limit state of collapse: flexure

38.1 Assumptions– Design for the limit state of collapse in flexure shall be based on the assumption given below:

(a) Plane sections normal to the axis remain plane after bending.

(b) The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending.

SSC JE Civil 09-10-2023 (Shift- IV)
SSC JE 14-11-2022 (Shift-I)
UKPSC JE 08-05-2022 Paper-I
CGPSC AE 28-08-2022
SSC JE-23-09-2019 (Morn.)
Haryana SSC JE-2018 (Shift-II)

(c) The relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapezoid, parabola or any other shape which results in prediction of strength in substantial agreement with the results of test. An acceptable stress strain curve is given in fig. 21. For design purposes the compressive strength of concrete in the structure shall be assumed to be 0.67 times the characteristic strength. The partial safety factor $\gamma m = 1.5$ shall be applied in addition to this.

GAIL Jr. Associate 13-05-2023 Sift- IV
Haryana SSC JE-11-04-2018 (Shift-I)