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सत्यमेव जयते

भारत सरकार - Government of India

रेल मंत्रालय - Ministry of Railways

कंक्रीट मिश्र अभिकल्प पर जाँचसूची

CHECKLIST FOR CONCRETE MIX DESIGN

केमटेक/2021/सि/कंक्रीट मिश्र अभिकल्प - जाँचसूची /1.0

CAMTECH/2021/C/CONCRETE MIX DESIGN - CHECKLIST/1.0

दिसम्बर - 2021

December – 2021

UPDATED VERSION INCORPORATING

CORRECTION SLIP – 01, JUNE 2022

अअमा सं RDS
रेल अग्रदूत Transforming Railways

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CHECKLIST FOR CONCRETE MIX DESIGN

Foreword

In civil engineering structures, concrete work plays an important role in construction of railway platforms, workshops, industrial floors, bridges, RCC Roads, etc. The concrete mix prepared with basic ingredients and designed in accordance with the provisions of Indian Standards should be cost effective while maintaining quality and strength of the concrete.

The booklet prepared by CAMTECH is informative and used as a checklist for validation /verification of test data as given in test reports of constituent materials of the concrete and that of design mix of concrete with reference to their codal provisions.

It is expected that this booklet will be quite helpful to field engineers of open line, who are engaged in maintenance and construction of Civil Engineering Structures in Indian Railways.

CAMTECH/Gwalior ***(Jitendra Singh)***
24th, December, 2021 ***Pr. Executive Director***

Preface

In structures, where concrete as a construction material is adopted, it becomes very important to ensure quality of concreting during execution so that long term safety and durability of these structures may be obtained.

Before concreting, the process involves the identification and acceptance of source of basic ingredients of concrete and acceptance of concrete mix design. For acceptance of basic ingredients of concrete and that of concrete mix design, test reports submitted by agency are verified in accordance with the provisions of relevant IS Codes.

It has been observed that field engineers of open line (IOWs & AENs) are busy in their routine inspections and maintenance works and they have constraint of time to refer codal/ manual provisions in detail. The document has been prepared to serve as checklist to validate/ verify the test data/ values as given in test reports of constituent materials of the concrete and that of design mix of concrete with reference to their codal provisions.

This booklet is not statutory & contents are only for the purpose of knowledge dissemination. Most of the data & information in some form or the other are based on codal provisions of relevant IS Codes. For more in-depth information/knowledge, the relevant detailed literature, BIS Codes, etc. available on the subject may be referred to.

I am grateful for the assistance given by Shri K.C. Shakya, SSE/Civil for his continuous study, hard work, sincere efforts & dedication to make this publication useful for the field engineers of open line.

We welcome valuable suggestions from our readers for further improvements of this booklet.

CAMTECH/Gwalior — ***(Deepak Mehra)***
23rd December, 2021 — ***Joint Director/Civil***

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संशोधन पर्चियों का प्रकाशन
ISSUE OF CORRECTION SLIPS

इस हस्तपुस्तिका के लिए भविष्य में प्रकाशित होने वाली संशोधन पर्चियों को निम्नानुसार संख्यांकित किया जाएगा :

The correction slips to be issued in future for this handbook will be numbered as follows:

केमटेक/2021/सि/कंक्रीट मिश्र अभिकल्प – जाँचसूची/1.0/सीएस# XX दिनांक_____

CAMTECH/2021/C/CONCRETE MIX DESIGN - CHECKLIST/1.0/CS # XX date_____

जहाँ XX संबन्धित संशोधन पर्ची की क्रम संख्या है (01 से प्रारम्भ होकर आगे की ओर)

Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

प्रकाशित संशोधन पर्चियाँ
CORRECTION SLIPS ISSUED

क्र.सं./ Sr. No.	**प्रकाशन दिनांक/ Date of issue**	**संशोधित पृष्ठ संख्या तथा मद संख्या/ Page no. and Item No. modified**	**टिप्पणी/ Remarks**
1	*June 2022*	*Annexure-2 Coarse Aggregate Page No. 12 & 13 , S. No. 3 'Tests for Mechanical Properties'*	*In accordance with IS :383:2016 (Reaffirmed 2021) – Third Revision*

1.0 PURPOSE OF DOCUMENT

In recent times, a number of bridges, RUB/LHS works are being executed by the open line where concreting is one of the major activity. For the long term safety and durability of these structures, quality control during execution becomes very important. As far as quality of concrete is concerned, the design mix of concrete is one of the important activities in quality control.

However, field engineers of open line (IOWs & AENs) are busy in their routine inspections and maintenance works and they have constraint of time to refer codal/manual provisions in detail.

In this context, the current document has been prepared to serve as checklist to validate/verify the test data/ values as given in test reports of constituent materials of the concrete and that of design mix of concrete with reference to their codal provisions.

The document so prepared is not meant to elaborate the procedure of concrete mix proportioning but limited to the aspect of verifying the values of design mix reports submitted by contractor with the values as prescribed by relevant IS codes.

2.0 SCOPE OF DOCUMENT

i. It is applicable for ordinary and standard strength concrete grades only. It does not cover high strength concrete grades, self compacting concrete.
ii. Provisions of only Ordinary Portland Cement and Portland Pozzolana Cement conforming to IS 269:2015 & IS 1489:2015 (Part 1&2) respectively have been considered for mix design. No other supplementary cementitious material (mineral admixtures) has been considered in design mix.
iii. Aggregates (Coarse & Fine both) only from natural sources have been considered. Provisions for manufactured aggregates have not been considered.
iv. It has been assumed that aggregates do not contain any alkali reactive constituents.

3.0 CONSTITUENTS OF CONCRETE

Concrete is a composite material composed of aggregates (fine and coarse) that is bonded together by cement and water. Thus in most basic form, the concrete is made up of following constituent –

i) Cement
ii) Coarse Aggregates
iii) Fine Aggregates
iv) Water

Some chemical admixtures in the form of powder or fluid are added into concrete while mixing to give certain desirable properties which are not obtainable with plain concrete mixes.

4.0 CONCRETE MIX DESIGN

Designing a concrete mix is the process of finding right proportions of all its constituents to achieve target strength in structures along with fulfilling durability and workability provisions,

thus making the concrete construction economical. Mix design of concrete will determine the proportioning of all above five constituents based on their properties, type of structure being built, exposure condition, method of placing, etc.

5.0 DATA REQUIRED FOR CONCRETE MIX DESIGN

- Type of Basic Constituents & their properties
  - Cement
    Type of Cement OPC/PPC
    Grade of Cement (28 days expected characteristic strength)
  - Fine Aggregates
  - Coarse Aggregates
    Maximum nominal size of aggregate
    Type of aggregates - angular/sub angular/gravel with some crushed particles/ rounded gravel
  - Water
  - Chemical Admixtures
- Workability Required at the time of placement
  - Workability tests shall be performed using Slump moulds as it is the quick measure of workability of concrete mixes.
- Durability Requirement based on Exposure condition
  - Minimum cement content, Maximum Water-Cement Ratio, Minimum grade of concrete
- Maximum Cement Content
- Grade Designation of Concrete
  - Minimum compressive strength requirement
- Degree of Site Control
- Transportation time
- Method of Placing

6.0 CONSTITUENT MATERIALS OF CONCRETE & THEIR CODAL REQUIREMENTS

1. **Cement:** Codal requirements for Ordinary Portland Cement and Portland Pozzolana cement conforming to IS 269:2015 & IS 1489:2015 (Part 1&2) respectively have been tabulated in **Annexure-1**.
2. **Coarse Aggregate:** Provisions of coarse aggregate from natural sources not containing any alkali reactive constituents conforming to IS 383 has been considered in the present document and their codal requirements have been tabulated in **Annexure-2**.
3. **Fine Aggregates:** Provisions of fine aggregate from natural sources not containing any alkali reactive constituents conforming to IS 383 has been considered in the present document and their codal requirements have been tabulated in **Annexure-3**.
4. **Chemical Admixtures:** Provisions of Chemical Admixtures conforming to IS 9103 has been considered in the present document and their codal requirements have been tabulated in Annexure-4.
5. **Water** *(Ref. – Cl. 5.4 of IS 456:2000)***:** 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.

Table – 1 Permissible Limit for Solids
(Ref. – Table 1 of IS 456:2000)

Sl No.		Tested as per	Permissible Limit, Max
i)	Organic	IS 3025 (Part 18)	200 mg/l
ii)	Inorganic	IS 3025 (Part 18)	3 000 mg/l
iii)	Sulphates (as SO_3)	IS 3025 (Part 24)	400 mg/l
iv)	Chlorides (as Cl)	IS 3025 (Part 32)	2 000 mg/l for concrete not containing embedded steel and 500 mg/l for reinforced concrete work
v)	Suspended matter	IS 3025 (Part 17)	2 000 mg/l

- Potable water is generally considered satisfactory for mixing concrete.

- Average 28 days compressive strength of at least three 150 mm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water.

- The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 min and shall not differ by ± 30 min from the initial setting time of control test block prepared with the same cement and distilled water.

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

7.0 WORKABILITY & DURABILITY REQUIREMENTS AS PER IS 456:2000

7.1 Workability of Concrete required at the time of placement

Suggested range of workability of concrete depending up on the placing conditions is given as follows:

Table – 2 Range of Workability of Concrete
(Ref. – Cl. 7.1 of IS 456:2000)

Placing Conditions	Degree of Workability	Slump (mm)
Blinding concrete; shallow sections; Pavements using pavers	Very low	In the 'very low' category of workability where strict control is necessary, for example pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (see IS 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns; Floors; Hand placed pavements; Canal lining; Strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls,	Medium	50-100

columns; Slipform work; Pumped concrete		
Trench fill	High	100-150
Tremie concrete	Very high	In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS 9103).

7.2 Durability Requirement based on Environmental Exposure condition

The general environment to which the concrete will be exposed during its working life is classified into five level of severity as described in Table –

Table – 3 Environmental Exposure Conditions

(Ref. – Table 3 of IS 456:2000)

SN	Environment	Exposure Conditions
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet. Concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non- aggressive soil/ground water. Concrete surfaces sheltered from saturated salt air in coastal area
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in sea water. Concrete exposed to coastal environment.
iv)	Very Severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete in contact with or buried under aggressive sub-soil ground water.
v)	Extreme	Surface of members in tidal zone. Members in direct contact with liquid/solid aggressive chemicals

7.2.1 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete to be adopted

Appropriate values for minimum cement content and the maximum free water-cement ratio are given in following Table for different exposure conditions.

Table -4 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 *(Ref. – Table 5 of IS 456:2000)*

SN	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
(i)	Mild	220	0.6	-	300	0.55	M20
(ii)	Moderate	240	0.6	M15	300	0.50	M25
(iii)	Severe	250	0.50	M20	320	0.45	M30
(iv)	Very severe	260	0.45	M20	340	0.45	M35
(v)	Extreme	280	0.40	M25	360	0.40	M40

Table – 5 Adjustments to Minimum Cement Contents for Aggregates Other Than 20 mm Nominal Maximum Size *(Ref. – Table 6 of IS 456:2000)*

SN	Nominal Maximum Aggregate Size, mm	Adjustments to Minimum Cement Contents in Table 5 of IS 456:2000, kg/m^3
(i)	10	+40
(ii)	20	0
(iii)	40	-30

8.0 MAXIMUM CEMENT CONTENT

Cement content in excess of 450 kg/m^3 should not be used. *(Ref. – Cl. 8.2.4.2 of IS 456:2000)*

9.0 GRADE DESIGNATION OF CONCRETE

Ordinary and Standard Concrete has been considered only for the preparation of the current document and as per IS 456:2000, the grades of concrete as given in Table 6 fall under these groups:

Table – 6 Grade of Concrete
(Ref. – Table 2 of IS 456:2000)

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
	M 20	20
Standard Concrete	M 25	25
	M 30	30
	M 35	35
	M 40	40
	M 45	45
	M 50	50
	M 55	55
	M 60	60

10.0 STANDARD DEVIATION BASED ON DEGREE OF SITE CONTROL

In order that not more than the specified proportions of test results are likely to fall below the characteristic strength, the concrete mix has to be proportioned for higher target mean compressive strength (f'ck).

The relations with characteristic strength of concrete ($f$ck) is given by the following formula –

$$f'ck = fck + X$$
or
$$f'ck = fck + 1.65\ S$$
(whichever is higher)

Table – 7 Value of X
(Ref. Table 1 of IS 10262:2019)

Sl No.	Grade of Concrete	Value of X
(1)	(2)	(3)
i)	M10, M15	5.0
ii)	M20, M25	5.5
iii)	M30, M35, M40, M45, M50, M55, M60	6.5

X = factor based on the grade of concrete, as per Table 7.
S = standard deviation, in N/mm^2

The Standard Deviation (S) for each grade of concrete shall be calculated separately based on test strength of samples. However, where sufficient test results for a particular grade of concrete are not available, the value of standard deviation as per Table 8 may be assumed for the proportioning of mix. The values of standard deviation in Table 8 correspond to good degree of site control having

a) proper storage of cement
b) weigh batching of all materials
c) controlled addition of water
d) regular checking of all materials
e) aggregate grading and moisture content
f) regular checking of workability and strength

Where there are deviations from the above, the site control shall be designated as fair and the values given in the above table shall be increased by 1 N/mm^2.

Table – 8 Assumed Standard Deviation
(Ref. – Table 2 of IS 10262:2019)

Sl No.	Grade of Concrete	Assumed Standard Deviation N/mm^2
(1)	(2)	(3)
i)	M10	3.5
	M15	
ii)	M20	4.0
	M25	
iii)	M30	5.0
	M35	
	M40	
	M45	
	M50	
	M55	
	M60	

11.0 TRANSPORTATION TIME

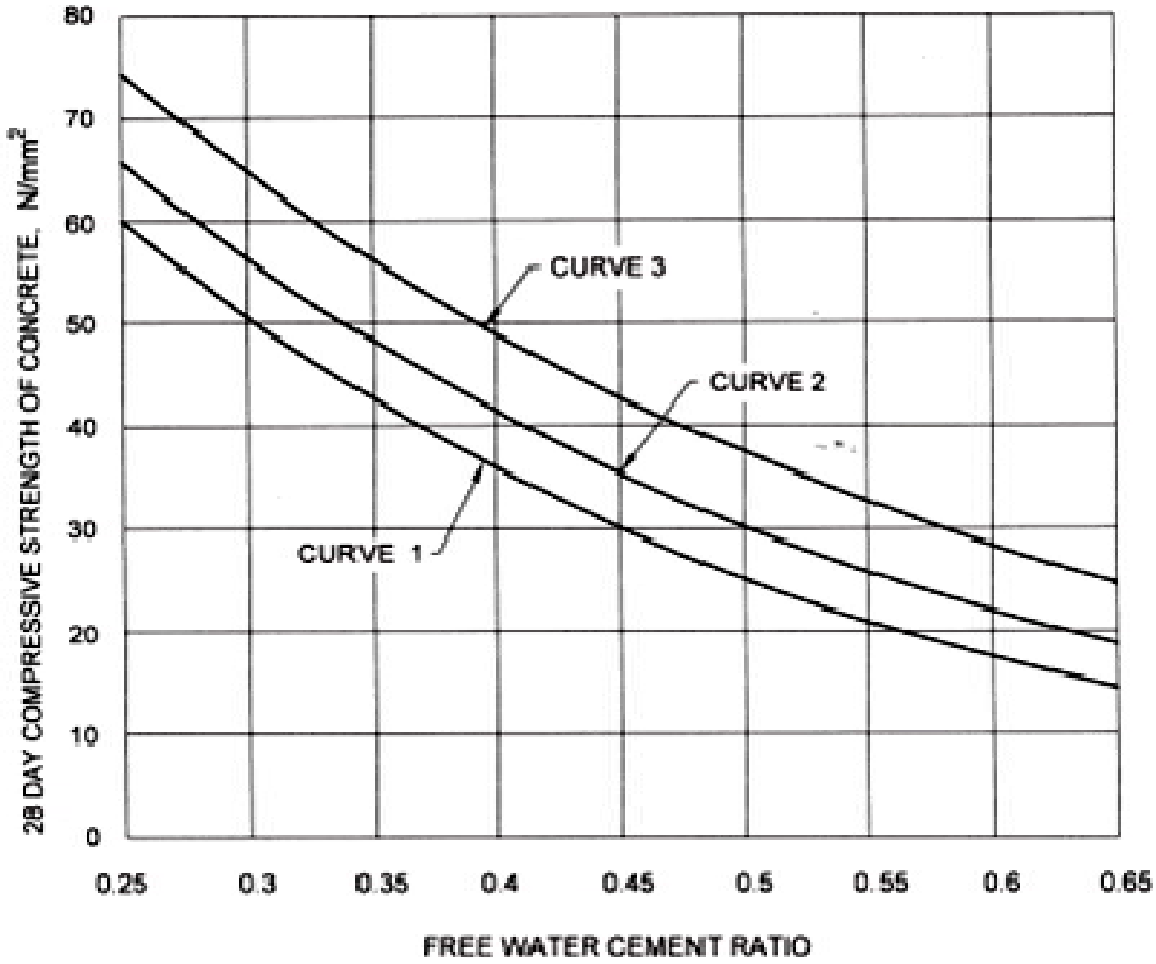
Transportation time may result in loss of workability and setting of concrete before placement. Suitable chemical admixtures may be added in the concrete based on the time taken before placement of concrete to prevent early setting and achieve desired workability.

12.0 SELECTION OF MIX PROPORTION

Step-1 Selection of Water-Cement Ratio

For trial mix, in absence of any data, the preliminary free water-cement ratio (by mass) (w/c) corresponding to compressive strength at 28 days may be selected from the relationship at Fig. 1 for the expected 28 days strength of cement.

The selected water-cement ratio shall be checked against the limiting water-cement ratio for the requirements of durability (*Refer Table 5 of IS 456:2000*) & lower of the two values adopted.



Curve 1: for expected 28 days compressive strength of 33 and < 43 N/mm^2.
Curve 2: for expected 28 days compressive strength of 43 and < 53 N/mm^2.
Curve 3: for expected 28 days compressive strength of 53 N/mm^2 and above.

NOTES
1. In the absence of data on actual 28 days compressive strength of cement, the curves 1, 2 and 3 may be used for OPC 33, OPC 43 and OPC 53, respectively.
2. 2 While using PPC/PSC, the appropriate curve as per the actual strength may be utilized. In the absence of the actual 28 days compressive strength data, curve 2 may be utilized.

FIG - 1 Relationship between Free Water Cement Ratio and 28 Days Compressive Strengths of Concrete for Cements of Various Expected 28 Days Compressive Strengths

Step-2 Estimation of Approximate Air Content

Approximate amount of entrapped air to be expected in normal (non-air entrapped) concrete is given in Table 9.

Table – 9 Approximate Air Content
(Ref. – Table 3of IS 10262:2019)

Sl No.	Nominal Maximum Size of Aggregate mm	Entrapped Air, as Percentage of Volume of Concrete
(1)	(2)	(3)
i)	10	1.5
ii)	20	1.0
iii)	40	0.8

Step-3 Selection of Water Content and Admixture content

The quantity of mixing water per unit volume of concrete for angular coarse aggregate and for 50 mm slump is to be taken from the table 10.

To produce same workability (from other than angular coarse aggregate), the water content can be reduced by approximately

- 10 kg for sub-angular aggregates
- 15 kg for gravel with some crushed particles
- 20 kg for rounded gravel

Table – 10 Water Content per Cubic meter of Concrete for Nominal Maximum Size of Aggregate
(Ref. – Table 4 of IS 10262: 2019)

Sl No.	Nominal Maximum Size of Aggregate mm	Water Content[1)] kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

[1)]Water content corresponding to saturated surface dry aggregate.

NOTES

1 These quantities of mixing water are for use in computing cement/cementitious materials content for trial batches.

2 On account of long distances over which concrete needs to be carried from batching plant/RMC plant, the concrete mix is generally designed for a higher slump initially than the slump required at the time of placing. The initial slump value shall depend on the distance of transport and loss of slump with time.

For the desired workability (other than 50 mm slump), the required water content may be increased or decreased by about 3 percent for each increase or decrease of 25 mm slump or may be established by trial. This illustrates the need for trial batch testing of the given materials as each aggregate source is different and can influence concrete properties.

Further, the water so calculated can be reduced by use of chemical admixture conforming to IS 9103. Water reducing admixture or super plasticizing admixtures usually decrease water content by 5 to 10 percent and 20 to 30 percent and above respectively at appropriate dosages.

Step-4 Calculations of Cement Content

Cement content per unit volume of concrete may be calculated from the free water-cement ratio (Step-1) and the quantity of water per unit volume of concrete (Step-3).

The cement content so calculated shall be checked against the minimum cement content for the requirement of durability. *(Refer Table 5 of IS 456:2000)*

The maximum cement content shall be 450 kg/m^3 as per *Cl. 8.2.4.2 of IS 456:2000.*

Step-5 Coarse Aggregate Proportion

Approximate values for this aggregate volume are given in Table below for a water-cement ratio of 0.5, which may be suitably adjusted for other ratios, the proportion of volume of coarse aggregates to that of total aggregates is increased at the rate of 0.01 for every decrease in water-cement ratio by 0.05 and decreased at the rate of 0.01 for every increase in water-cement ratio by 0.05.

Table – 11 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate for Water-Cement Ratio of 0.50

(Ref. – Table 5 of IS 10262:2019)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.54	0.52	0.50	0.48
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.73	0.72	0.71	0.69

NOTES

1 Volumes are based on aggregates in saturated surface dry condition.

2 These volumes are for crushed (angular) aggregate and suitable adjustments may be made for other shape of aggregate.

3 Suitable adjustments may also be made for fine aggregate from other than natural sources, normally, crushed sand or mixed sand may need lesser fine aggregate content. In that case, the coarse aggregate volume shall be suitably increased.

4 It is recommended that fine aggregate conforming to Grading Zone IV, as per IS 383 shall not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

Step-6 Estimation of Fine & Coarse Aggregate Content

With the completion of procedure given in Step-4, all the ingredients have been estimated except the coarse and fine aggregate content. These quantities are determined by finding out the absolute volume of cementitious materials, water and the chemical admixture; by dividing their mass by their respective specific gravity, multiplying by 1/1000 and subtracting the result of their summation from unit volume (excluding the volume of entrapped air).

The values so obtained are divided into coarse and fine aggregate fractions by volume in accordance with coarse aggregate proportion already determined in Step-5. The coarse and fine aggregate contents are then determined by multiplying their volume with their respective specific gravities and multiplying by 1000.

Step-7 Trial Mixes

The calculated mix proportions shall be checked by means of trial batches. Workability of the trial mix No. 1 shall be measured. The mix shall be carefully observed for freedom from segregation and bleeding and its finishing properties.

- If the measured workability of Trial Mix No. 1 is different from the stipulated value, the water and/or admixture content shall be adjusted suitably. With this adjustment, the mix proportion shall be recalculated keeping the free water-cement/water-cementitious materials ratio at the pre-selected value, which will comprise Trial Mix No. 2.
- In additional two more Trial Mixes No. 3 and 4 shall be made with the water content same as Trial mix No. 2 and varying the free water cement/ cementitious materials ratio by about ± 10 percent of the pre-selected value, while satisfying the workability requirements as well.
- Mix No. 2 to 4 normally provides sufficient information, including the relationship between compressive strength and water-cement ratio, from which the mix proportions can be finalized, such that the strength and durability requirements are also satisfied.
- Additional field trials are recommended particularly for workability requirements. The concrete for field trials shall be produced by methods of actual concrete production.

***

Annexure – 1

ORDINARY PORTLAND CEMENT (OPC) & PORTLAND POZZOLANA CEMENT (PPC)

SN	Material / Test		Codal Requirement							
			IS 269: 2015						IS 1489: 2015 (Part 1 & 2)	
			Method of Test, Ref to	OPC 33	OPC 43	OPC 43S	OPC 53	OPC 53S	FLY ASH BASED PPC	CALCINED CLAY BASED PPC
1	**PHYSICAL TESTS** *(Table 3 of IS 269:2015 and Table 2 of IS 1489: 2015 (Part 1 & 2))*									
A	**Fineness**, m^2/kg, *Min*		IS 4031 (Part 2)	225	225	370	225	370	300	300
B	**Soundness:**									
	a) By Le-Chatelier Method, mm, *Max*		IS 4031 (Part 3)	10	10	5	10	5	10	10
	b) By Autoclave Test Method, percent, *Max*			0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Note: In the event of cements failing to comply with any one or both the requirements of soundness as specified, further tests in respect of each failure shall be made as described in IS 4031 (Part 3), from another portion of the same sample after aeration. The aeration shall be done by spreading out the sample to a depth of 75mm at a relative humidity of 50 to 80 percent of a total period of 7 days. The expansion of cements so aerated shall be not more than 5mm and 0.6 percent when tested by Le-Chatelier method and autoclave test respectively. For OPC 43S and OPC 53S, the requirement of soundness of unaerated cement shall be maximum expansion of 5 mm whe tested by Le-Chatelier method.									
C	**Setting time:**									
	a) Initial, minutes, *Min*		IS 4031 (Part 5)	30	30	60	30	60	30	30
	b) Final, minutes, *Max*			600	600	600	600	600	600	600
	Note: If cement exhibits false set, the ratio of final penetration measured after 5 min of completion of mixing period to the initial penetration measured exactly after 20 second of completion of mixing period, expressed as percent, shall be not less than 50. In the event of cement exhibiting false set, the initial and final setting time of cement when tested by the method described in IS 4031 (Part 5) after breaking the false set, shall conform to the values given above.									
D	**Compressive Strength**, MPa (N/mm^2):									
	a) 72 ± 1 h, *Min*		IS 4031 (Part 6)	16	23	23	27	27	16	16
	b) 168 ± 2 h, *Min*			22	33	37.5	37	37.5	22	22
	c) 672 ± 4 h,	*Min*		33	43	43	53	53	33	33
		Max		48	58	-	-	-	-	-
E	**Transverse Strength** (optional)		IS 4031 (Part 8)	Mutually agreed to between the purchaser and the supplier at the time of placing the order						
2	**CHEMICAL TESTS** *(Table 2 of IS 269:2015 and Table 1 of IS 1489: 2015 (Part 1 & 2))*									
A	Ratio of percentage of lime to percentages of Silica, Alumina and Iron Oxide, when calculated by the formula: $\frac{Cao - 0.7\ SO_3}{2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3}$		IS 4032	0.66-1.02	0.66 - 1.02	0.80 - 1.02	0.80 - 1.02	0.80 - 1.02	-	-
B	Ratio of percentage of Alumina to that of Iron Oxide, *Min*			0.66	0.66	0.66	0.66	0.66	-	-
C	Insoluble residue, percent by mass,	*Max*	IS 4032	5.0	5.0	2.0	5.0	2.0	[x+ 4.0(100-x)/100][1]	[x+ 4.0(100-x)/100][2]
		Min		-	-	-	-	-	0.6x	0.6x
	[1]Where x is the declared percentage of fly ash in the given Portland pozzolana cement. [2]Where x is the declared percentage of pozzolana in the given Portland pozzolana cement.									

D	Magnesia, percent by mass, *Max*	IS 4032	6.0	6.0	5.0	6.0	5.0	6.0	6.0
E	Total Sulphur content calculated as Sulphuric Anhydride (SO_3), percent by mass, *Max*		3.5	3.5	3.5	3.5	3.5	3.5	3.5
F	Loss of ignition, percent by mass, *Max*		5.0	5.0	4.0	4.0	4.0	5.0	5.0
G	Chloride content, percent by mass, , *Max*		0.1	0.1	0.1	0.1	0.1	0.1	0.1
			0.05*	0.05*	0.05*	0.05*	0.05*	0.05*	0.05*
			* (for prestressed structures)						
H	Alkali content expressed as Sodium oxide (Na_2O+ 0.658 K_2O)		< 0.6%						
	Note: On large and important jobs where concrete is likely to be exposed to humid or wetting action, it is advisable that the aggregate to be tested for alkali aggregate reaction. In the case of reactive aggregates, the use of cement with alkali content below 0.6 percent expressed as sodium oxide (Na_2O+ 0.658 K_2O), is recommended.								
I	Tricalcium aluminate content (C_3A) [C_3A = 2.65 (Al_2O_3)-1.69 (Fe_2O_3)], percent by mass, *Max*	IS 4032	-	-	10.0	-	10.0	-	-
J	Tricalcium silicate (C_3S) [C_3S=4.07(Ca)-7.6(SiO_2)-6.72(Al_2O_3)-1.43(Fe_2O_3)-2.85(SO_3), percent by mass, *Min*		-	-	45.0	-	45.0	-	-

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Annexure – 2

COARSE AGGREGATE

SN	Material / Test	Code Ref./Limits Code	Permissible Limits/ variations:
1	**Gradation test**	IS 383:2016	As per table below

Coarse Aggregates – *(Ref. – Table 7 of IS 383:2016)*

(i) Graded coarse aggregates may be supplied in the nominal sizes given in table below.

A	SN	IS Sieve Designation	Percentage passing for single-sized Aggregate of Nominal size						Percentage passing for Graded Aggregate of Nominal size			
			63mm	40mm	20mm	16mm	12.5mm	10mm	40mm	20mm	16mm	12.5mm
	1	80mm	100	-	-	-	-	-	100	-	-	-
	2	63mm	85- 100	100	-	-	-	-	-	-	-	-
	3	40mm	0-30	85-100	100	-	-	-	90-100	100	-	-
	4	20mm	0-5	0-20	85-100	100	-	-	30-70	90-100	100	100
	5	16mm	-	-	-	85-100	100	-	-	-	90-100	-
	6	12.5mm	-	-	-	-	85-100	100	-	-	-	90-100
	7	10mm	0-5	0-5	0-20	0-30	0-45	85-100	10-35	25-55	30-70	40-85
	8	4.75mm	-	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
	9	2.36mm	-	-	-	-	-	0-5	-	-	-	-

(ii) Coarse aggregate for mass concrete works shall be in sizes specified in table below.

SN	Class and Size	IS Sieve Designation	Percentage Passing
1	Very large, 150 mm to 80 mm	160 mm	90-100
		80 mm	0-10
2	Large, 80 mm to 40 mm	80 mm	90-100
		40 mm	0-10
3	Medium, 40 mm to 20 mm	40 mm	90-100
		20 mm	0-10
4	Small, 20 mm to 4.75 mm	20 mm	90-100
		4.75 mm	0-10
		2.36 mm	0-0.2

2 Test for Deleterious Materials

Limits of Deleterious Materials – As per table below *(Ref. – Table 2 of IS :383:2016)*

	SN	Deleterious Substance	Test Procedure, Ref Code	Coarse Aggregate Percentage by Mass, Max	
				Uncrushed	Crushed
A	(i)	Coal & lignite	IS 2386 (Part 2)	1.0	1.0
	(ii)	Clay lumps	IS 2386 (Part 2)	1.0	1.0
	(iii)	Materials finer than 75 micron IS sieve	IS 2386 (Part 1)	1.0	1.0
	(iv)	Soft fragments	IS 2386 (Part 2)	3.0	-
	(v)	Total of percentage of all deleterious materials (including SN (i) to (iv) for uncrushed/crushed coarse aggregate	-	5.0	2.0
B	Combined Flakiness & Elongation index		IS 2386 (Part 1)	≯ 40% for uncrushed or crushed aggregate.	

3 Tests for Mechanical Properties *(Ref. – Cl. 5.4 of IS :383:2016)*

A	Aggregate Crushing Value/ Ten Percent Fines Value **OR**	IS 2386 (Part 4)	≯ 30% for aggregates to be used in concrete for wearing surfaces, (such as runways, roads, pavements, tunnel lining carrying water having flow velocity more than 6 m/s, spillways and stilling basins).
			In case the aggregate crushing value exceeds 30% for aggregates to be used in concrete other than for wearing surfaces, then the test for 'ten percent fines' should be conducted and the maximum load for the ten percent fines should be 50KN.

	Aggregate Impact Value	IS 2386 (Part 4)	≯ 30% for aggregates to be used in concrete for wearing surfaces, (such as runways, roads, pavements, tunnel lining carrying water having flow velocity more than 6 m/s, spillways and stilling basins).
			≯ 45% for aggregates to be used in concrete other than for wearing surfaces.
B	Aggregate Abrasion Value	IS 2386 (Part 4) using Los Angeles Machine	≯ 30% for aggregates to be used in concrete for wearing surfaces, (such as runways, roads, pavements, tunnel lining carrying water having flow velocity more than 6 m/s, spillways and stilling basins).
			≯ 50% for aggregates to be used in concrete other than for wearing surfaces.
C	Test for Soundness of Aggregates (For concrete liable to be exposed to the action of frost)	Sodium or magnesium sulphate accelerated soundness test as per IS 2386 (Part 5)	The limits to set by agreement between the purchaser and supplier. However, as a general guide, it may be taken that the average loss of mass after 5 cycles shall not exceed 12% when tested with sodium sulphate (Na_2SO_4), and 18% when tested with magnesium sulphate ($MgSO_4$).

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Annexure – 3

FINE AGGREGATES

SN	Material / Test	Code Ref./ Limits Code	Permissible Limits/ variations
1	**Gradation test**	Cl. 6.3 & Table 9 of IS :383:2016	As per table below

Fine Aggregates – The grading of fine aggregates, when determined in accordance with IS 2383 (Part 1) shall be within limits given table below.

SN	IS Sieve Designation	Percentage Passing			
		Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
1	10 mm	100	100	100	100
2	4.75 mm	90-100	90-100	90-100	95-100
3	2.36 mm	60-95	75-100	85-100	85-100
4	1.18 mm	30-70	55-90	75-100	90-100
5	600 µm	15-34	35-59	60-79	80-100
6	300 µm	5-20	8-30	12-40	15-50
7	150 µm	0-10	0-10	0-10	0-10

Note:
1. Where the grading falls outside the limits of any particular grading zone of sieves other than 600 µm IS Sieve by an amount not exceeding 5 percent for particular sieve size, (subject to cumulative amount of 10 percent), it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing 600 µm IS Sieve or to percentage passing any other sieve size on the coarse limit of Grading Zone I or finer limit of Grading Zone IV.
2. For crushed stone sands, the permissible limit on 150 µm IS Sieve is increased to 20 percent. This doesn't affect the 5 percent allowance permitted in Note 1 above.
3. It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

2 **Test for Deleterious Materials** *(Ref. - Table 2 of IS :383:2016)*

Limits of Deleterious Materials – Fine Aggregates

SN	Deleterious Substance	Test Procedure, Ref Code	Fine Aggregate Percentage by Mass, Max	
			Uncrushed	Crushed
1	Coal & lignite	IS 2386 (Part 2)	1.0	1.0
2	Clay lumps	IS 2386 (Part 2)	1.0	1.0
3	Materials finer than 75 micron IS sieve	IS 2386 (Part 1)	3.0	15.0 (for crushed sand) 12.0 (for mixed sand)
4	Soft fragments	IS 2386 (Part 2)	-	-
6	Total of percentage of all deleterious materials (except mica)	-	5.0	2.0

3 **Mechanical Tests** *(Ref. – Cl. 5.4 of IS :383:2016)*

A	Test for Soundness of Aggregates (For concrete liable to be exposed to the action of frost)	Sodium or magnesium sulphate accelerated soundness test as per IS 2386 (Part 5)	The limits to set by agreement between the purchaser and supplier. However, as a general guide, it may be taken that the average loss of mass after 5 cycles shall not exceed 10% when tested with sodium sulphate (Na_2SO_4), and 15% when tested with magnesium sulphate ($MgSO_4$)

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Annexure – 4

CHEMICAL ADMIXTURES

(Ref.- IS 9103.1999)

Concrete made with admixtures when compared with identical concrete made without the admixture in accordance with the provisions of IS 9103 shall conform to the requirements appropriate to the type of admixture given in the following table.

Physical Requirement

(Ref. – Table 1A of IS 9103.1999)

S. N.	Requirement	Test Procedure, Ref Code	Accelerating Admixture	Retarding Admixture	Water Reducing Admixture	Air-Entraining Admixture	Super plasticising	
							Normal	Retarding type
1	Water content, percent of control sample, mix.	*IS 2386 (Part3)*	-	-	95	-	80	80
2	Slump	*IS 1199*	-	-	-	-	Not more than 15mm below that of the control mix concrete	
3	Time of setting allowable deviation from control sample hours.	*IS 8142*						
	Initial - Max.		-3	+3	±1	-	±1.5	+4
	Min.		-1	+1	-	-	-	+1
	Final - Max.		-2	+3	±1	-	±1.5	+3
	Min.		-1	-	-	-	-	-
4	Compressive strength percent of control sample, Min	*IS 516*						
	1 day		-	-	-	-	140	-
	3 days		125	90	110	90	125	125
	7 days		100	90	110	90	125	125
	28 days		100	90	110	90	115	115
	6 months		90	90	100	90	100	100
	1 year		90	90	100	90	100	100
5	Flexural strength, percent of control sample, Min.	*IS 516*						
	3 days		110	90	100	90	110	110
	7 days		100	90	100	90	100	100
	28 days		90	90	100	90	100	100
6	Length change, percent increase over control sample, Max.	*IS 1199*						
	28 days		0.010	0.010	0.010	0.010	0.010	0.010
	6 months		0.010	0.010	0.010	0.010	0.010	0.010
	1 year		0.010	0.010	0.010	0.010	0.010	0.010
7	Bleeding, percent increase over control sample, Max.	*IS 2386 (Part 3) & Annex D of IS 9103*	5	5	5	5	5	5
8	Loss of workability	*Cl. 7.2.1.2 of IS 9103:1999*	-	-	-	-	At 45 min the slump shall be not less	At 2 h, the slump shall be not less than that of

							than that of control mix concrete at 15 min	control mix concrete at 15 min
9	Air content % Max. over control	-	-	-	-	-	1.5	1.5

Requirement for High Workability Test Mix

(Ref. – Table 1B of IS 9103.1999)

Sr. No.	Requirement	Test Procedure, Ref Code	Type of super plasticising admixtures	
			Normal	**Retarding type**
1.	Flow	*Cl. 7.2.1.1 of IS 9103:1999*	510-620 mm	510-620 mm
2.	Loss of workability on standing	*Cl. 7.2.1.2 of IS 9103:1999*	At 45 minute slump shall be not less than that of control mix concrete at 15 minute.	At 2 hours the slump shall be not less than that of control mix concrete at 15 minute.
3.	Minimum Compressive strength, Percent of control mix concrete 7 days 28 days 06 months 01 year	*IS 516*	 90 90 90 90	 90 90 90 90

Uniformity Test and Requirement of an Admixture

(Ref. – Table 2 of IS 9103.1999)

Any batch of admixture shall have the same physical state and composition, as that of admixtures tested for acceptance. To check the uniformity of composition, a representative sample of the batch shall be tested and shall satisfy the requirement given in table as under –

S. No.	Property	Test Procedure, Ref Code	Requirement reference
1.	Dry material content for liquid or solid admixtures	Annex E of *IS 9103:1999*	Within 3 percent of the value stated by the manufacturer
2.	Ash content		Within 1 percent of the value stated by the manufacturer
3.	Relative density		Within 0.02 percent of the value stated by the manufacturer
4.	Chloride ion content		Within 10 percent of the value or 0.2 percent whichever is greater as stated by the manufacturer
5.	Ph value		7-8

Note - Uniformity requirement for ash content is not applicable to accelerating admixtures, which may contain more than 1% chloride content.

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REFERENCES

S. No.	Description
1.	IS 10262 : 2019 Concrete Mix Proportioning - Guidelines (Second Revision)
2.	IS 456 : 2000 Plain And Reinforced Concrete - Code of Practice (Fourth Revision) (Re-affirmed 2021)
3.	IS 383 : 2016 (Reaffirmed 2021) Coarse and Fine Aggregate for Concrete – Specification (Third Revision)
4.	IS 269 : 2015 Ordinary Portland Cement – Specification (Sixth Revision)
5.	IS 1489: 2015 (Part 1- Fly Ash Based) Portland Pozzolana Cement – Specification (Fourth Revision)
6.	IS 1489: 2015 (Part 1- Calcined Clay Based) Portland Pozzolana Cement – Specification (Fourth Revision)
7.	IS 9103:1999 Concrete Admixtures – Specification (First Revision) (Re-affirmed 2004)

NOTES

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गुणवत्ता नीति

आर. डी. एस. ओ. लखनऊ में हम सतत सुधार और ग्राहक मूल्यांकन प्राप्त करने हेतु गुणवत्ता प्रबंध प्रणालियों की आवधिक समीक्षा के माध्यम से रेलों में यात्री और माल यातायात की बढ़ती आवश्यकताओं, माँग और अपेक्षाओं को पूरा करने के लिए गुणवत्ता प्रबंध प्रणाली की व्यवहारिक आवश्यकताओं और अनवरत सुधारों को पूरा करने के समर्पण गुणवत्ता उद्देश्यों को निर्धारित करके अनुसंधान, अभिकल्पों और मानकों में उत्कृष्टता के माध्यम से वैधानिक और नियामक अपेक्षाओं का अनुपालन करते हुए सुरक्षित, आधुनिक और किफ़ायती रेल प्रौद्योगिकी विकसित करने हेतु सेवाओं को बनाए रखने और अद्यतन पारदर्शी मानकों हेतु प्रतिबद्ध हैं। इसे संगठन के अंदर संसूचित एवं लागू किया गया है तथा सभी संबंधित पक्षकारों को भी उपलब्ध कराया गया है।

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