IS 10262 (2009): Guidelines for concrete mix design proportioning [CED 2: Cement and Concrete]

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भारतीय मानक

कंक्रीट मिश्र अनुपातन — मार्गदर्शी सिद्धांत

(पहला पुनरीक्षण)

Indian Standard

CONCRETE MIX PROPORTIONING — GUIDELINES

(*First Revision*)

ICS 91.100.30

BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

This standard was first published in 1982. In this first revision, the following major modifications have been made:

a) The title of the standard has been modified as 'Concrete mix proportioning — Guidelines' from the earlier title 'Recommended guidelines for concrete mix design'.
b) The applicability of the standard has been specified for ordinary and standard concrete grades only.
c) Various requirements have been modified in line with the requirements of IS 456 : 2000 'Plain and reinforced concrete — Code of practice (*fourth revision*)'.
d) The requirements for selection of water-cement ratio, water content and estimation of coarse aggregate content and fine aggregate content have been reviewed and accordingly modified. Similarly, other requirements such as trial mixes, illustrative examples, etc, have also been reviewed and modified.
e) A new illustrative example of concrete mix proportioning using fly ash as one of the ingredients has been added.
f) Considering that the air content in normal (non-air entrained) concrete is not of much significance in mix proportioning procedure and is also not a part of IS 456 : 2000, the consideration of air content has been deleted.

Concrete has become an indispensable construction material. According to the present state-of-the-art, concrete has bypassed the stage of mere four component system, that is, cement, water, coarse aggregate and fine aggregate. It can be a combination of far more number of ingredients for example, a judicious combination of ingredients from as many as ten materials. In the recent past, apart from the four ingredients mentioned above, fly ash, ground granulated blast furnace slag, silica fume, rice husk ash, metakaoline and superplasticizer are six more ingredients which are generally used in concrete produced in practice as the situation demands. Hence, it is all the more essential at this juncture to have general guidelines on proportioning concrete mixes. The need has been further augmented by the importance given to proportioned concrete mixes according to IS 456 : 2000.

The objective of proportioning concrete mixes is to arrive at the most economical and practical combinations of different ingredients to produce concrete that will satisfy the performance requirements under specified conditions of use. An integral part of concrete mix proportioning is the preparation of trial mixes and effect adjustments to such trials to strike a balance between the requirements of placement, that is, workability and strength, concomitantly satisfying durability requirements.

Concrete has to be of satisfactory quality both in its fresh and hardened states. This task is best accomplished by trial mixes arrived at by the use of certain established relationships among different parameters and by analysis of data already generated thereby providing a basis for judicious combination of all the ingredients involved. The basic principles which underline the proportioning of mixes are Abram's law for strength development and Lyse's rule for making mix with adequate workability for placement in a dense state so as to enable the strength development as contemplated. From practical view point, compressive strength is often taken as an index of acceptability. This does not necessarily satisfy the requirements of durability unless examined under specific context. Mix proportioning is generally carried out for a particular compressive strength requirements ensuring that fresh concrete of the mix proportioned to possess adequate workability for placement without segregation and bleeding while attaining a dense state. In addition, the method has scope to consider the combination of wider spectrum of cement and mineral admixtures proposed to be used to meet the requirements of durability for the type of exposure conditions anticipated in service.

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Indian Standard

CONCRETE MIX PROPORTIONING — GUIDELINES

(First Revision)

1 SCOPE

1.1 This standard provides the guidelines for proportioning concrete mixes as per the requirements using the concrete making materials including other supplementary materials identified for this purpose. The proportioning is carried out to achieve specified characteristics at specified age, workability of fresh concrete and durability requirements.

1.2 This standard is applicable for ordinary and standard concrete grades only.

1.3 All requirements of IS 456 in so far as they apply, shall be deemed to form part of this standard.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
383 : 1970	Specification for coarse and fine aggregates from natural sources for concrete (*second revision*)
456 : 2000	Code of practice for plain and reinforced concrete (*fourth revision*)
2386 (Part 3) : 1963	Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking
3812 (Part 1) : 2003	Specification for pulverized fuel ash: Part 1 For use as pozzolana in cement, cement mortar and concrete (*second revision*)
8112 : 1989	Specification for 43 grade ordinary Portland cement (*first revision*)
9103 : 1999	Specification for admixtures for concrete (*first revision*)

3 DATA FOR MIX PROPORTIONING

3.1 The following data are required for mix proportioning of a particular grade of concrete:

a) Grade designation;
b) Type of cement;
c) Maximum nominal size of aggregate;
d) Minimum cement content;
e) Maximum water-cement ratio;
f) Workability;
g) Exposure conditions as per Table 4 and Table 5 of IS 456;
h) Maximum temperature of concrete at the time of placing;
j) Method of transporting and placing;
k) Early age strength requirements, if required;
l) Type of aggregate;
m) Maximum cement content; and
n) Whether an admixture shall or shall not be used and the type of admixture and the condition of use.

3.2 Target Strength for Mix Proportioning

In order that not more than the specified proportion 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 margin over characteristic strength is given by the following relation:

$$f'_{ck} = f_{ck} + 1.65\, s$$

where

f'_{ck} = target mean compressive strength at 28 days in N/mm^2,

f_{ck} = characteristic compressive strength at 28 days in N/mm^2, and

s = standard deviation N/mm^2.

3.2.1 *Standard Deviation*

The standard deviation for each grade of concrete shall be calculated separately.

3.2.1.1 *Standard deviation based on test strength of sample*

a) *Number of test results of samples* — The total number of test strength of samples required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 samples (taken from site), as early as possible, when a mix is used for the first time.

b) *In case of significant changes in concrete* — When significant changes are made in the production of concrete batches (for example changes in the materials used, mix proportioning, equipment or technical control), the standard deviation value shall be separately calculated for such batches of concrete.

c) *Standard deviation to be brought up-to-date* — The calculation of the standard deviation shall be brought up-to-date after every change of mix proportioning.

3.2.1.2 *Assumed standard deviation*

Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in Table 1 may be assumed for the proportioning of mix in the first instance. As soon as the results of samples are available, actual calculated standard deviation shall be used and the mix proportioned properly. However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in Table 1, it shall be permissible to use that value.

Table 1 Assumed Standard Deviation

(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No.	Grade of Concrete	Assumed Standard Deviation N/mm^2
(1)	(2)	(3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

NOTE — The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. Where there is deviation from the above, values given in the above table shall be increased by 1 N/mm^2.

4 SELECTION OF MIX PROPORTIONS

4.1 Selection of Water-Cement Ratio (*see* Note)

Different cements, supplementary cementitious materials and aggregates of different maximum size, grading, surface texture, shape and other characteristics may produce concretes of different compressive strength for the same free water-cement ratio. Therefore, the relationship between strength and free water-cement ratio should preferably be established for the materials actually to be used. In the absence of such data, the preliminary free water-cement ratio (by mass) corresponding to the target strength at 28 days may be selected from the established relationship, if available. Otherwise, the water-cement ratio given in Table 5 of IS 456 for respective environment exposure conditions may be used as starting point.

NOTE — The supplementary cementitious materials, that is, mineral admixtures shall also be considered in water-cement ratio calculations in accordance with Table 5 of IS 456.

4.1.1 The free water-cement ratio selected according to **4.1** should be checked against the limiting water-cement ratio for the requirements of durability and the lower of the two values adopted.

4.2 Selection of Water Content

The water content of concrete is influenced by a number of factors, such as aggregate size, aggregate shape, aggregate texture, workability, water-cement ratio, cement and other supplementary cementitious material type and content, chemical admixture and environmental conditions. An increase in aggregates size, a reduction in water-cement ratio and slump, and use of rounded aggregate and water reducing admixtures will reduce the water demand. On the other hand increased temperature, cement content, slump, water-cement ratio, aggregate angularity and a decrease in the proportion of the coarse aggregate to fine aggregate will increase water demand.

The quantity of maximum mixing water per unit volume of concrete may be determined from Table 2. The water content in Table 2 is for angular coarse aggregate and for 25 to 50 mm slump range. The water estimate in Table 2 can be reduced by approximately 10 kg for sub-angular aggregates, 20 kg for gravel with some crushed particles and 25 kg for rounded gravel to produce same workability. For the desired workability (other than 25 to 50 mm slump range), the required water content may be established by trial or an increase by about 3 percent for every additional 25 mm slump or alternatively by use of chemical admixtures conforming to IS 9103. This illustrates the need for trial batch testing of local materials as each aggregate source is different and can influence concrete properties differently. Water reducing admixtures or superplasticizing admixtures usually decrease water content by 5 to 10 percent and

20 percent and above respectively at appropriate dosages.

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(*Clauses* 4.2, A-5 *and* B-5)

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

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

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

cement ratio and strength properties of concrete are consistent with the recommendations of IS 456 and meet project specification requirements as applicable.

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate
(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate[1] 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	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

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

4.3 Calculation of Cementitious Material Content

The cement and supplementary cementitious material content per unit volume of concrete may be calculated from the free water-cement ratio (*see* **4.1**) and the quantity of water per unit volume of concrete.

The cementitious material content so calculated shall be checked against the minimum content for the requirements of durability and greater of the two values adopted. The maximum cement content shall be in accordance with IS 456.

4.4 Estimation of Coarse Aggregate Proportion

Aggregates of essentially the same nominal maximum size, type and grading will produce concrete of satisfactory workability when a given volume of coarse aggregate per unit volume of total aggregate is used. Approximate values for this aggregate volume are given in Table 3 for a water-cement ratio of 0.5, which may be suitably adjusted for other water-cement ratios. It can be seen that for equal workability, the volume of coarse aggregate in a unit volume of concrete is dependent only on its nominal maximum size and grading zone of fine aggregate. Differences in the amount of mortar required for workability with different aggregates, due to differences in particle shape and grading, are compensated for automatically by differences in rodded void content.

4.4.1 For more workable concrete mixes which is sometimes required when placement is by pump or when the concrete is required to be worked around congested reinforcing steel, it may be desirable to reduce the estimated coarse aggregate content determined using Table 3 up to 10 percent. However, caution shall be exercised to assure that the resulting slump, water-cement ratio and strength properties of concrete are consistent with the recommendations of IS 456 and meet project specification requirements as applicable.

4.5 Combination of Different Coarse Aggregate Fractions

The coarse aggregate used shall conform to IS 383. Coarse aggregates of different sizes may be combined in suitable proportions so as to result in an overall grading conforming to Table 2 of IS 383 for particular nominal maximum size of aggregate.

4.6 Estimation of Fine Aggregate Proportion

With the completion of procedure given in **4.4**, 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 material, water and the chemical admixture; by dividing their mass by their respective specific gravity, multiplying by 1/1 000 and subtracting the result of their summation from unit volume. The values so obtained are divided into Coarse and Fine Aggregate fractions by volume in accordance with coarse aggregate proportion already determined in **4.4**. The coarse and fine aggregate contents are then determined by multiplying with their respective specific gravities and multiplying by 1 000.

5 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 ratio at the pre-selected value, which will comprise Trial Mix No. 2. In addition 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 ratio by ±10 percent of the preselected value.

Mix No. 2 to 4 normally provides sufficient information, including the relationship between compressive strength and water-cement ratio, from which the mix proportions for field trials may be arrived at. The concrete for field trials shall be produced by methods of actual concrete production.

6 ILLUSTRATIVE EXAMPLES

An illustrative example of concrete mix proportioning is given in Annex A. Another illustrative example of mix proportioning of concrete using fly ash is given in Annex B. These examples are merely illustrative to explain the procedure; and the actual mix proportioning shall be based on trial batches with the given materials.

ANNEX A

(*Clause* 6)

ILLUSTRATIVE EXAMPLE ON CONCRETE MIX PROPORTIONING

A-0 An example illustrating the mix proportioning for a concrete of M 40 grade is given in **A-1** to **A-11**.

A-1 STIPULATIONS FOR PROPORTIONING

a) Grade designation	:	M 40
b) Type of cement	:	OPC 43 grade conforming to IS 8112
c) Maximum nominal size of aggregate	:	20 mm
d) Minimum cement content	:	320 kg/m^3
e) Maximum water-cement ratio	:	0.45
f) Workability	:	100 mm (slump)
g) Exposure condition	:	Severe (for reinforced concrete)
h) Method of concrete placing	:	Pumping
j) Degree of supervision	:	Good
k) Type of aggregate	:	Crushed angular aggregate
m) Maximum cement content	:	450 kg/m^3
n) Chemical admixture type	:	Superplasticizer

A-2 TEST DATA FOR MATERIALS

a) Cement used	:	OPC 43 grade conforming to IS 8112
b) Specific gravity of cement	:	3.15
c) Chemical admixture	:	Superplasticizer conforming to IS 9103
d) Specific gravity of:		
1) Coarse aggregate	:	2.74
2) Fine aggregate	:	2.74
e) Water absorption:		
1) Coarse aggregate	:	0.5 percent
2) Fine aggregate	:	1.0 percent

f) Free (surface) moisture:
   1) Coarse aggregate : Nil (absorbed moisture also nil)
   2) Fine aggregate : Nil

g) Sieve analysis:
   1) Coarse aggregate :

IS Sieve Sizes mm	*Analysis of Coarse Aggregate Fraction*		*Percentage of Different Fractions*			*Remarks*
	I	II	I 60 percent	II 40 percent	Combined 100 percent	
20	100	100	60	40	100	Conforming to Table 2 of IS 383
10	0	71.20	0	28.5	28.5	
4.75		9.40		3.7	3.7	
2.36		0				

   2) Fine aggregate : Conforming to grading Zone I of Table 4 of IS 383

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

$$f'_{ck} = f_{ck} + 1.65\ s$$

where

f'_{ck} = target average compressive strength at 28 days,
f_{ck} = characteristic compressive strength at 28 days, and
s = standard deviation.

From Table 1, standard deviation, $s = 5$ N/mm^2.

Therefore, target strength = 40 + 1.65 × 5 = 48.25 N/mm^2.

A-4 SELECTION OF WATER-CEMENT RATIO

From Table 5 of IS 456, maximum water-cement ratio = 0.45.

Based on experience, adopt water-cement ratio as 0.40.

0.40 < 0.45, hence O.K.

A-5 SELECTION OF WATER CONTENT

From Table 2, maximum water content for 20 mm aggregate = 186 litre (for 25 to 50 mm slump range)

Estimated water content for 100 mm slump $= 186 + \frac{6}{100} \times 186$
= 197 litre

As superplasticizer is used, the water content can be reduced up 20 percent and above.

Based on trials with superplasticizer water content reduction of 29 percent has been achieved. Hence, the arrived water content = 197 × 0.71 = 140 litre

A-6 CALCULATION OF CEMENT CONTENT

Water-cement ratio = 0.40

Cement content $= \frac{140}{0.40} = 350$ kg/m^3

From Table 5 of IS 456, minimum cement content for 'severe' exposure condition = 320 kg/m^3

350 kg/m^3 > 320 kg/m^3, hence, O.K.

A-7 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 = 0.60.

In the present case water-cement ratio is 0.40. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of –/+ 0.01 for every ± 0.05 change in water-cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.40 = 0.62.

NOTE — In case the coarse aggregate is not angular one, then also volume of coarse aggregate may be required to be increased suitably, based on experience.

For pumpable concrete these values should be reduced by 10 percent.

Therefore, volume of coarse aggregate = 0.62 × 0.9 = 0.56.

Volume of fine aggregate content = 1 – 0.56 = 0.44.

A-8 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = **1 m³**

b) Volume of cement

$$= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1\,000}$$

$$= \frac{350}{3.15} \times \frac{1}{1\,000}$$

$$= \mathbf{0.111\ m^3}$$

c) Volume of water

$$= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1\,000}$$

$$= \frac{140}{1} \times \frac{1}{1\,000}$$

$$= \mathbf{0.140\ m^3}$$

d) Volume of chemical admixture (superplasticizer) (@ 2.0 percent by mass of cementitious material)

$$= \frac{\text{Mass of chemical admixture}}{\text{Specific gravity of admixture}} \times \frac{1}{1\,000}$$

$$= \frac{7}{1.145} \times \frac{1}{1\,000}$$

$$= \mathbf{0.006\ m^3}$$

e) Volume of all in aggregate

= [a – (b + c + d)]

= 1–(0.111 + 0.140 + 0.006)

= **0.743 m³**

f) Mass of coarse aggregate

= *e* × Volume of coarse aggregate × Specific gravity of coarse aggregate × 1 000

= 0.743 × 0.56 × 2.74 × 1 000

= **1 140 kg**

g) Mass of fine aggregate

= *e* × volume of fine aggregate × Specific gravity of fine aggregate × 1 000

= 0.743 × 0.44 × 2.74 × 1 000

= **896 kg**

A-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement	=	350 kg/m^3
Water	=	140 kg/m^3
Fine aggregate	=	896 kg/m^3
Coarse aggregate	=	1 140 kg/m^3
Chemical admixture	=	7 kg/m^3
Water-cement ratio	=	0.4

NOTE — Aggregates should be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregates are dry, the amount of mixing water should be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregates. The surface water and percent water absorption of aggregates shall be determined according to IS 2386.

A-10 The slump shall be measured and the water content and dosage of admixture shall be adjusted for achieving the required slump based on trial, if required. The mix proportions shall be reworked for the actual water content and checked for durability requirements.

A-11 Two more trials having variation of ±10 percent of water-cement ratio in **A-10** shall be carried out and a graph between three water-cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirement shall be met.

ANNEX B
(*Clause* 6)

ILLUSTRATIVE EXAMPLE OF MIX PROPORTIONING OF CONCRETE (USING FLY ASH AS PART REPLACEMENT OF OPC)

B-0 An example illustrating the mix proportioning for a concrete of M 40 grade using fly ash is given B-1 to B-11.

B-1 STIPULATIONS FOR PROPORTIONING

a) Grade designation	:	M 40
b) Type of cement	:	OPC 43 grade conforming to IS 8112
c) Type of mineral admixture	:	Fly ash conforming to IS 3812 (Part 1)
d) Maximum nominal size of aggregate	:	20 mm
e) Minimum cement content	:	320 kg/m^3
f) Maximum water-cement ratio	:	0.45
g) Workability	:	100 mm (slump)
h) Exposure condition	:	Severe (for reinforced concrete)
j) Method of concrete placing	:	Pumping
k) Degree of supervision	:	Good
m) Type of aggregate	:	Crushed angular aggregate
n) Maximum cement (OPC) content	:	450 kg/m^3
p) Chemical admixture type	:	Superplasticizer

B-2 TEST DATA FOR MATERIALS

a) Cement used : OPC 43 grade conforming to IS 8112
b) Specific gravity of cement : 3.15
c) Fly ash : Conforming to IS 3812 (Part 1)
d) Specific gravity of fly ash : 2.2
e) Chemical admixture : Superplasticizer conforming to IS 9103
f) Specific gravity of:
   1) Coarse aggregate : 2.74
   2) Fine aggregate : 2.74
g) Water absorption:
   1) Coarse aggregate : 0.5 percent
   2) Fine aggregate : 1.0 percent
h) Free (surface) moisture:
   1) Coarse aggregate : Nil (absorbed moisture also nil)
   2) Fine aggregate : Nil
j) Sieve analysis:
   1) Coarse aggregate :

IS Sieve Sizes mm	*Analysis of Coarse Aggregate Fraction*		*Percentage of Different Fractions*			*Remarks*
	I	II	I 60 percent	II 40 percent	Combined 100 percent	
20	100	100	60	40	100	Conforming to Table 2 of IS 383
10	0	71.20	0	28.5	28.5	
4.75		9.40		3.7	3.7	
2.36		0				

   2) Fine aggregate : Conforming to grading Zone I of Table 4 of IS 383

B-3 TARGET STRENGTH FOR MIX PROPORTIONING

$$f'_{ck} = f_{ck} + 1.65\,s$$

where

f'_{ck} = target average compressive strength at 28 days,
f_{ck} = characteristics compressive strength at 28 days, and
s = standard deviation.

From Table 1, Standard Deviation, $s = 5$ N/mm^2.

Therefore, target strength = 40 + 1.65 × 5 = 48.25 N/mm^2.

B-4 SELECTION OF WATER-CEMENT RATIO

From Table 5 of IS 456, maximum water-cement ratio (*see* Note under **4.1**) = 0.45.

Based on experience, adopt water-cement ratio as 0.40.

0.40 < 0.45, hence, O.K.

B-5 SELECTION OF WATER CONTENT

From Table 2, maximum water content
for 20 mm aggregate = 186 litre (for 25 to 50 mm slump range)

Estimated water content for 100 mm slump= $186 + \frac{6}{100} \times 186 = 197$ litre

As superplasticizer is used, the water content can be reduced up to 30 percent.

Based on trials with superplasticizer water content reduction of 29 percent has been achieved. Hence, the arrived water content = 197 × 0.71 = 140 litres.

B-6 CALCULATION OF CEMENT AND FLY ASH CONTENT

Water-cement ratio (*see* note under **4.1**) = 0.40

Cementitious material (cement + fly ash) content = $\frac{140}{0.40}$ = 350 kg/m^3

From Table 5 of IS 456, minimum cement content for 'severe' exposure conditions = 320 kg/m^3

350 kg/m^3 > 320 kg/m^3, hence, O.K.

Now, to proportion a mix containing fly ash the following steps are suggested:

a) Decide the percentage fly ash to be used based on project requirement and quality of materials

b) In certain situations increase in cementitious material content may be warranted. The decision on increase in cementitious material content and its percentage may be based on experience and trial (*see* Note).

NOTE — This illustrative example is with increase of 10 percent cementitious material content.

Cementitious material content = 350 × 1.10 = 385 kg/m^3

Water Content = 140 kg/m^3

So, water-cement ratio = $\frac{140}{385}$ = 0.364

Fly ash @ 30% of total cementitious material content = 385 × 30% = 115 kg/m^3

Cement (OPC) = 385 – 115 = 270 kg/m^3

Saving of cement while using fly ash = *350 – 270 = 80 kg/m^3, and*

Fly ash being utilized = *115 kg/m^3*

B-7 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 = 0.60.

In the present case water-cement ratio is 0.40. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of –/+ 0.01 for every ± 0.05 change in water-cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.40 = 0.62

NOTE — In case the coarse aggregate is not angular one, then also volume of coarse aggregate may be required to be increased suitably, based on experience.

For pumpable concrete these values should be reduced by 10 percent.

Therefore, volume of coarse aggregate = 0.62 × 0.9 = 0.56.

Volume of fine aggregate content = 1 – 0.56 = 0.44.

B-8 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = **1 m^3**

b) Volume of cement = $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1\,000}$

$$= \frac{270}{3.15} \times \frac{1}{1\ 000}$$

$$= \mathbf{0.086\ m^3}$$

c) Volume of fly ash

$$= \frac{\text{Mass of fly ash}}{\text{Specific gravity of fly ash}} \times \frac{1}{1\ 000}$$

$$= \frac{115}{1} \times \frac{1}{1\ 000}$$

$$= \mathbf{0.052\ m^3}$$

d) Volume of water

$$= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1\ 000}$$

$$= \frac{140}{1} \times \frac{1}{1\ 000}$$

$$= \mathbf{0.140\ m^3}$$

e) Volume of chemical admixture (superplasticizer) @ 2.0% by mass of cementitious material)

$$= \frac{\text{Mass of admixture}}{\text{Specific gravity of admixture}} \times \frac{1}{1\ 000}$$

$$= \frac{7}{1.145} \times \frac{1}{1\ 000}$$

$$= \mathbf{0.007\ m^3}$$

f) Volume of all in aggregate

$= [a - (b + c + d + e)]$

$= 1-(0.086 + 0.052 + 0.140 + 0.007)$

$= \mathbf{0.715\ m^3}$

g) Mass of coarse aggregate

= *f* × volume of coarse aggregate × Specific gravity of coarse aggregate × 1 000

$= 0.715 \times 0.56 \times 2.74 \times 1\ 000$

= **1 097 kg**

h) Mass of fine aggregate

= *f* × volume of fine aggregate × Specific gravity of fine aggregate × 1 000

$= 0.715 \times 0.44 \times 2.74 \times 1\ 000$

= **862 kg**

B-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement	=	270 kg/m³
Fly Ash	=	115 kg/m³
Water	=	140 kg/m³
Fine aggregate	=	862 kg/m³
Coarse aggregate	=	1 097 kg/m³
Chemical admixture	=	7.7 kg/m³
Water-cement ratio (*see* Note under **4.1**)	=	0.364

NOTE — Aggregates should be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregates are dry, the amount of mixing water should be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregates. The surface water and percent water absorption of aggregates shall be determined according to IS 2386 (Part 3).

B-10 The slump shall be measured and the water content and dosage of admixture shall be adjusted for achieving the required slump based on trial, if required. The mix proportions shall be reworked for the actual water content and checked for durability requirements.

B-11 Two more trials having variation of ±10 percent of water-cement ratio in **B-10** shall be carried out and a graph between three water-cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirement shall be met.

ANNEX C

(Foreword)

COMMITTEE COMPOSITION

Cement and Concrete Sectional Committee, CED 2

Organization	*Representative(s)*
Delhi Tourism and Transportation Development Corporation Ltd, New Delhi	Shri Jose Kurian (*Chairman*)
ACC Ltd, Mumbai	Shri Naveen Chadha Shri P. Srinivasan (*Alternate*)
Atomic Energy Regulatory Board, Mumbai	Dr Prabir C. Basu Shri L. R. Bishnoi (*Alternate*)
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Cement Manufacturers' Association, Noida	Shri E. N. Murthy Dr S. P. Ghosh (*Alternate*)
Central Board of Irrigation and Power, New Delhi	Member Secretary Director (Civil) (*Alternate*)
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Central Public Works Department, New Delhi	Chief Engineer (Design) Superintending Engineer (S&S) (*Alternate*)
Central Road Research Institute (CSIR), New Delhi	Dr Ram Kumar Shri Satander Kumar (*Alternate*)
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Public Works Department, Government of Tamil Nadu Chennai	SUPERINTENDING ENGINEER (DESIGN) EXECUTIVE ENGINEER (*Alternate*)
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BIS Directorate General	SHRI A. K. SAINI, Scientist 'F' & Head (Civ Engg) [Representing Director General (*Ex-officio*)]

Member Secretaries

SHRI SANJAY PANT
Scientist 'E' & Director (Civ Engg), BIS

SHRI S. ARUN KUMAR
Scientist 'B' & Director (Civ Engg), BIS

Concrete Subcommittee, CED 2 : 2

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In personal capacity (*36, Old Sneh Nagar, Wardha Road, Nagpur*)	SHRI LALIT KUMAR JAIN

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(*Continued from second cover*)

Proportioning of concrete mixes can be regarded as procedure set to proportion the most economical concrete mix for specified durability and grade for required site conditions.

As a guarantor of quality of concrete in the construction, the constructor should carry out mix proportioning and the engineer-in-charge should approve the mix so proportioned. The method given in this standard is to be regarded as the guidelines only to arrive at an acceptable product, which satisfies the requirements of placement required with development of strength with age and ensures the requirements of durability.

This standard does not debar the adoption of any other methods of concrete mix proportioning.

In this revision, assistance has also been derived from ACI 211.1 (Reapproved 1997) 'Standard practice for selecting proportions for normal, heavyweight, and mass concrete', American Concrete Institute.

The composition of the Committee responsible for formulation of this standard is given in Annex C.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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