SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF CIVIL ENGINEERING

19CEE304 – CONCRETE TECHNOLOGY

III YEAR VI SEM

UNIT 2 – MIX DESIGN

TOPIC – IS MIX DESIGN

IS Method of Mix Design

- IS Recommended method of Concrete Mix Design (IS 10262-1982) was introduced in 1982.
- IS 456-2000 necessitated the revision of IS 10262-1982.
- New guidelines were then framed & given in IS 10262-2009
- After that after revision New guidelines were then framed & given in IS 10262-2019

Data Required

The following basic data are required to be specified for design a concrete mix:

- Grade of concrete
- Max. size of aggregate
- Minimum cement content
- Max. w/c ratio
- Workability in terms of slump
- Exposure conditions
- Max. temperature at the pouring point
- Early age strength (if required)
- Grading zone of fine aggregate
- Type of aggregate
- Maximum cement content
- Type of admixture used – Brand name
- Specific gravity of all materials used & dosage etc.,

Step – I :

Target Mean Strength

- The target average compressive strength (Fck) of concrete at 28 days is given by

$$\mathbf{F_{ck} = f_{ck} + t.s}$$

Where,

F_{ck}= target mean compressive strength at 28 days

f_{ck}= characteristics compressive strength at 28 days

s = Standard deviation

t = Tolerance factor

- Assumed Standard Deviation

Grade of Concrete	Assumed Std. Deviation (s) N/mm^2
M10 M15	3.5
M20 M25	4.0
M30 M35 M40 M45 M50 M55 M60	5.0

- Tolerance factor
  - Assumed to be 1.65 generally.
  - **$F_{ck} = f_{ck} + 1.65\ s$**

No. of samples	Tolerance Level				
	1 in 10	1 in 15	1 in 20	1 in 40	1 in 100
10	1.37	1.65	1.81	2.23	1.76
20	1.32	1.58	1.72	2.09	2.53
30	1.31	1.54	1.70	2.04	2.46
Infinite	1.28	1.50	1.64	1.96	2.33

Step-II

Selection of Water –Cement Ratio

- Selected based on experience.
- Selected from durability criteria table.
- Minimum of 0.4 is chosen.

Table 5 (IS 456-2000)

Durability Criteria as per IS 456- 2000

Exposure	Plain Concrete			Reinforced Concrete		
	Min. Cement	Max w/c	Min grade	Min. Cement	Max w/c	Min grade
Mild	**220 kg/m³**	**0.60**	**--**	**300 kg/m³**	**0.55**	**M 20**
Moderate	**240 kg/m³**	**0.60**	**M 15**	**300 kg/m³**	**0.50**	**M 25**
Severe	**250 kg/m³**	**0.50**	**M 20**	**320 kg/m³**	**0.45**	**M 30**
V. Severe	**260 kg/m³**	**0.45**	**M 20**	**340 kg/m³**	**0.45**	**M 35**
Extreme	**280 kg/m³**	**0.40**	**M 25**	**360 kg/m³**	**0.40**	**M 40**

Step – III :

Selection of water Content:

- Water content decreases when there is,
  - Increase in aggregate size
  - Reduction in W/C ratio
  - Reduction in slump
  - Use of rounded aggregate
  - Use of natural sand
  - Use of plasticizer
- Water content increases when there is,
  - Increased temperature
  - Increase in cement content
  - Increase in slump
  - Increase in W/C ratio
  - Use of Angular aggregate
  - Use of manufactured sand &
  - Large percentage of FA then CA

- The table value is for angular CA & 25-50mm slump.
- For sub-angular CA, reduce 10kg.
- For gravel with same crushed particle, reduce 20kg.
- For rounded gravel, reduce 25kg.
- Workability (slump):for every 25mm increased slump – increase water content by 3% of water.
- Use of
  - Plasticizer : reduce water content by 10%
  - Super plasticizer : reduce water content by 30%
  - PC based admixtures : reduce water content by 40%

Table 2 (IS 456-2000)

Nominal Maximum size of aggregate (mm)	Water Content per cubic metre of concrete (kg)
10	208
20	186
40	165

Step – IV:

Calculation of Cementitious material content:

- Cement material content = Water content / W- C Ratio
- Minimum cement content from durability requirement also checked.
- Greater value is adopted.

Durability Criteria as per IS 456- 2000

Exposure	Plain Concrete			Reinforced Concrete		
	Min. Cement	Max w/c	Min grade	Min. Cement	Max w/c	Min grade
Mild	220 kg/m^3	0.60	--	300 kg/m^3	0.55	M 20
Moderate	240 kg/m^3	0.60	M 15	300 kg/m^3	0.50	M 25
Severe	250 kg/m^3	0.50	M 20	320 kg/m^3	0.45	M 30
V. Severe	260 kg/m^3	0.45	M 20	340 kg/m^3	0.45	M 35
Extreme	280 kg/m^3	0.40	M 25	360 kg/m^3	0.40	M 40

Step – V :

Estimation of CA Proportion;

- Approximate aggregate volume for W/C ratio of 0.5 is given in the table.
- For every decrease in W/C ratio by 0.05, CA volume is increased by 1% to reduce sand content.
- For every increase in W/C ratio by 0.05, CA volume is reduced by 1% to increase sand content.
- For more workable mixes for pumping or tremie concreting, CA reduced by 10%.

Table 3 (IS 456-2000)

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	10	0.50	0.48	0.46	0.44
2	20	0.66	0.64	0.62	0.60
3	40	0.75	0.73	0.71	0.69

Step – VI :

Estimation of FA Proportion :

- Find out the absolute volume of all the so far known ingredients.
- Deduct the sum of all known absolute volume from unit volume.
- Result will be volume of CA + FA.
- We know the vol. of CA. Hence, FA volume can be calculated.

Step – VII :

Trial mixes :

- Weight of all ingredients in kg/m^3 can be found out.

Example - Design

A1)STIPULATIONS FOR PROPORTIONING

a) Grade designation	**:M40**
b) Type of cement	**:OPC 43 grade conforming to IS 8112**
c) Maximum nominal size of aggregate	**:20mm**
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/rn^3**
n) Chemical admixture type	**:Super plasticizer**

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:	
I) Coarse aggregate	**:2.74**
2) Fine aggregate	**:2.74**
e) Water absorption:	
I) 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:

I) 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**

Design

- Target Strength:

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

Where,

f'_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristic compressive strength at 28 days, and

s = *standard deviation.*

From Table I, standard deviation, $s = 5\ N/mm^2$

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

- Selection of W/C 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.

- Selection of water content:

From Table 2,

Maximum water content =186 kg (for 25 to 50 mm slump range)

For 20 mm aggregate,

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

$= 197$ kg

As superplasticizer is used, the water content can be reduced 20 % to 30 %.

Assume 29% to be reduced.

Therefore, Arrived water content $= 197 \times 0.71 =$ 140 kg

- 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,

Min. cement content for 'severe' exposure condition } = 320 kg/m^3

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

- Proportion of volume of CA and FA:

From Table 3,
Volume of CA 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 CA 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 CA 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.

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

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

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

- 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 = $\frac{\text{Mass of cement}}{\text{Sp. Gr. of cement}} \times \frac{1}{1000}$

$= \frac{350}{3.15} \times \frac{1}{1000}$

$= 0.111\ m^3$

c) Volume of water = $\frac{\text{Mass of water}}{\text{Sp. Gr. of water}} \times \frac{1}{1000}$

$= \frac{140}{1} \times \frac{1}{1000}$

$= 0.140\ m^3$

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

$= 1 - (0.111 + 0.140 + 0.006)$

$= \mathbf{0.743\ m^3}$

f) Mass of coarse aggregate $= e \times$ Volume of coarse aggregate $\times$ Specific gravity of coarse aggregate $\times$ 1 000

$= 0.743 \times 0.56 \times 2.74 \times 1\,000$

$= \mathbf{1\,140\ kg}$

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**

MIX PROPORTIONS

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

- To express in proportion,

Cement : FA : CA : Water

350 : 896 : 1140 : 140 (in kg/m^3)

1 : 2.56 : 3.26 : 0.4

For 1 bag of cement, multiply by 50,

50 : 128 : 163 : 20 (in kg)


thank you!