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Concrete Mix Design

बिनोद प्रसाद सापकोटा
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Introduction

-Process, Calculation in lab to find the amount of ingredients of Concrete
-process of finding the combination of constituents that would give concrete of properties complying with certain specifications, economically.

Ingredients/ constituents
- Cement
- Water
- Fine Aggregate (Sand)
- Coarse Aggregate
- Admixture

Mix Design Procedure

- **Step 1**
  - **Sampling**
    - **The method of sampling shall be in according to with IS: 2430-1986**
    - **Collection of Sand and Aggregate from Site**
    - **Test of Ingredients (as per spec)**
    - **If not in the limit specified in Code –reject Sample or modify Sample**

Mix Design Procedure Step 1 Continue

- **Test on Ingredients**
  - **Cement**

Characteristics	Requirement			Remarks
	OC	HSC		Same in New Spec
Fineness , m2/Kg :(By Blaine's Air permeability Method	225			
Minimum Setting Time (Initial, Minutes)	45			
Maximum Setting Time(Final, Minutes)	600			
Soundness(by Le chatelier's method) mm, Maximum	10			
Minimum Average Compressive Strength of Three Mortar Cubes				
3 days	16	23	27	
7 days	22	33	37	
28 days	33	43	53	

Mix Design Procedure Step 1 Continue

- **Test on Ingredients**
  - **Fine Aggregate**

FINE AGGREGATES As per IS Code 383				
IS sieve Designation	Percentage passing for(by weight)			
	Grading zone I	Grading zone II	Grading zone III	Grading zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 mm	15-34	35-59	60-79	80-100
300 mm	5-20	8-30	12-40	15-50
150 mm	0-10	0-10	0-10	0-15
Fineness Modulus	2.71-4	2.11-3.37	1.71-2.72	1.35-2.25

Job mix Fineness Modulus ±0.3 for ordinary Concrete, ±0.2 high quality Concrete(in case of change in source)

Mix Design Procedure Step 1 Continue

- **Test on Ingredients**
  - **Coarse Aggregate**

Characteristics	**Requirement**		**Remarks**
Class A, B, C, D, E	OC	HSC	
Flakiness Index	<25	<15	
Water Absorption	<2 %		
Los Angeles Abrasion (LAA)	<45%	<35%	
Aggregate Crushing Value (ACV)	<30%		
Alkali Aggregate Reactivity			
Physical Test			
Chemical Test			

Mix Design Procedure Step 1 Continue

- **Test on Ingredients**
  - **Coarse Aggregate**

The coarse aggregate shall be used conform to IS: 383 -1970. Table No. 2

Is sieve designation	Percentage passing for **graded aggregate** of Nominal Size			
	40 mm	20 mm	16 mm	12.5 mm
40 mm	95-100	100	-	
20 mm	30-70	95-100	100	100
16 mm	-	-	90-100	-
12.5 mm	-	-	-	90-100
10 mm	10-35	25-55	30-70	40-85
4.75 mm	0-5	0-10	0-10	0-10
2.36 mm	-	-	-	

Mix Design Procedure Step 1 Continue

- **Test on Ingredients**
  - **Coarse Aggregate**

The coarse aggregate shall be used conform to IS: 383 -1970. Table No. 2

Is sieve designation	Percentage passing for **graded aggregate** of Nominal Size			
	40 mm	20 mm	16 mm	12.5 mm
40 mm	95-100	100	-	
20 mm	30-70	95-100	100	100
16 mm	-	-	90-100	-
12.5 mm	-	-	-	90-100
10 mm	10-35	25-55	30-70	40-85
4.75 mm	0-5	0-10	0-10	0-10
2.36 mm	-	-	-	

Mix Design Procedure Step 1 Continue

- **Test on Ingredients**
  - **Coarse Aggregate**

Is sieve designation		*Percentage passing for **single sized** aggregate of Nominal Size*				
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm
80 mm	100	-	-	-	-	-
63 mm	85-100	100	-	-	-	
40 mm	0-30	85-100	100	-	-	-
20 mm	0-5	0-20	85-100	100	-	-
16 mm	-	-	-	85-100	100	-
12.5 mm	-	-	-	-	85-100	100
10 mm	0-5	0-5	0-20	0-30	0-45	85-100
4.75 mm	-	-	0-5	0-5	0-10	0-20
2.36 mm	-	-	-	-		0-5

Job Mix ??

Mix Design Procedure

- **Step 2**
  - **Calculation of Target strength**

$$F_{tg} = Fck + Standard\ Error\ or\ Risk\ Factor * Standard\ Deviation$$

Step 2 Continue..

Assumed Standard Deviation as per IS 10262-2009		
S.N	Grade of concrete	Assumed standard deviation N/mm^2
i	M 10	
ii	M 15	3.5
iii	M 20	4
iv	M 25	
v	M 30	
vi	M 35	
vii	M 40	5
Viii	M 45	
IX	M 50	
X	M 55	

Risk Factor as per IS: 10262-2009	
Accepted proportion of flow results	Risk Factor
1 in 5	0.84
1 in 10	1.28
1 in 15	1.5
1 in 20	1.65
1 in 40	1.86
1 in 100	2.33

For Example
For M40
Ftg= 40+(1.65*5)
Ftg=48.25 N/mm^2

Mix Design Procedure

- **Step 3**
  - **Selection of W/C Ratio and Cement Content**
    - **Choose exposure condition, Max. W/C ratio and Minimum Cement Content**

Minimum cement content, maximum water-cement ratio and minimum grade of concrete for different exposures				
Table no.5 IS 456:2000				
Maximum nominal aggregates size 20 mm				
		Minimum cement content (kg/CUM)	Maximum free cement ratio	Minimum grade of concrete
Plane concrete	Mild	220	0.6	-
	moderate	240	0.6	M-15
	Sever	250	0.5	M-20
	Very sever	260	0.45	M-20
	extreme	280	0.45	M-25
Reinforced concrete	Mild	300	0.55	M-20
	moderate	300	0.5	M-25
	Sever	320	0.45	**M-30**
	Very sever	340	0.45	**M-35**
	extreme	360	0.4	**M-40**

S.N.	Nominal maximum size of aggregate (mm)	Adjustment to minimum cement content in table no 5 (kg/m^3)
1	10	+40
2	**20**	**0**
3	40	-30

Mix Design Procedure

- **Step 4**
  - **Selection of Water Content**
    - **Choose Nominal Size of Aggregate (Generally 20 mm)- 186 lit (Max.)**

S.N.	Nominal Maximum size of aggregates	Maximum water content KG
	2	
1		3
I	10	208
Ii	20	186
Iii	40	165

    - **Ideal Condition- Angular Agg, 25-50 mm Slump Value, SSD Agg**
    - **Make Adjustment as per IS Code (456-2000)**
      - **Factors**
        - **Slump Value –increase 3% for each 25 mm slump value**
        - **Aggregate –sub-agnular, rounded + crushed particles, Rounded- Reduce %wc**
        - **Admixture- reduces up to 20%**
    - **Get final Value of Water Content**

Mix Design Procedure

- **Step 5**
  - **Selection of Cement Content**
    - **Choose W/C Ratio less than Max W/C as above Step 3**
    - **For Example**
      - **W/C= .35 (Say), Adjusted Water Content say 180 , Than cement content= ?? (KG)**

Mix Design Procedure

- **Step 6**
  - **Quantity of Admixtures**
    - **Find Quantity – Product/Company Specification**
    - **Plasticizers- Flow gel +micro silica, Mark flow30 + Micro silica, Normet (Tamsen 53I) + microsilica**
      - **For Example**
        - **Micro silica= 5% of By weight of Cement**
        - **Mark flow 30= 0.6% By Weight of Cement**

Mix Design Procedure

- **Step 7**
  - **Calculation of Volume of Coarse and Fine aggregate**

IS 10262:2009 Table 3 volume of coarse Aggregates per unit volume of total Aggregates for Different Zones of fine aggregates (clauses 4.4, A-7 and B-7)

S.N.	Nominal maximum size of Aggregates(mm)	Volume of coarse aggregates per unit volume of total aggregates for different zones of fine aggregates			
		Zone IV	Zone III	Zone II	Zone I
1	10	0.5	0.48	0.46	0.44
2	20	0.66	0.64	0.62	0.6
3	40	0.75	0.73	0.71	0.69

Volumes are based on aggregates in saturated surface dry condition.

Adjustment should made in table no 3,it is only for w-c ratio 0.50 and if the water cement ratio change every -/+0.05 the coarse aggregate change by +/- 0.01

Eg.. w/c=.35, difference =0.15 for W/C=0.5, Than, (0.01*3)=.03 will be added on volume specified in table 3 i.E .62 (sand Zone ii) will be 0 .65

Mix Design Procedure

- **Step 7 Continue…**
  - From IS Table 3 10262-2000
  - Find Volume of Coarse Aggregate

For Example
For 20 mm nominal size of Coarse Aggregate and zone 2 of fine aggregate with w/c=0.5, is .62 Cum (Coarse Aggregate)
. Adjustment
- Every ± 0.05 w/c change = ±0.01 (Inversely)

After Adjustment find the volume of fine Aggregate i.e 1- Vol.of Coarse Agg

Mix Design Procedure

- **Step 8.**
  - **Calculation of Mass of Coarse Aggregate**

$$V=\left[\, w+\frac{c}{sc}+\frac{1}{1-p}*\frac{Ca}{SCa}\right]*\frac{1}{1000}$$

Where, v= absolute volume of fresh concrete=1 cum
W = mass of water (kg/m³)
C=mass of cement (kg/m³)
S_c= specific gravity of cement=3.15
P= ratio of fine aggregate and total aggregate by absolute volume
c_a=total mass of coarse aggregate (kg) per m³ =???
sc_a = specific gravity of saturated surface dry coarse aggregates

For admixture what???

Mix Design Procedure

- **Step 8.. Continue**
  - **Calculation of Volume of fine Aggregate**

$$V=\left[\ W+\frac{c}{sc}+\frac{1}{p}*\frac{fa}{Sfa}\right]*\frac{1}{1000}$$

Where, v= absolute volume of fresh concrete=1 cum
W = mass of water (kg/m³)
C=mass of cement (kg/m³)
S_c= specific gravity of cement=3.15
fa=total mass of fine aggregate (kg) per m³ =???
s_{fa} = specific gravity of saturated surface dry fine aggregates

Mix Design Procedure

- **Step 9 Aggregate moisture correction**
  - **Saturated surface dry condition up to this step**
  - **In site, Aggregate are in dry Condition so**
    - **the amount of mixing water should be increased by amount equal to the moisture likely to be absorbed by the aggregates**
    - **Necessary adjustments are also required to be made in mass of aggregates**
    - **Lab input Data**
      - **Water absorption and water content(Free Surface Moisture) of Fine and Course Aggregate**

Mix Design Procedure

- **Step 9 Aggregate moisture correction**

  - **Increase in weight of course Aggregate is equal to water content percentage of Course aggregate**
  - **Increase in weight of fine Aggregate is equal to water content percentage of fine aggregate**

  - **Batch Weight of Water**

Final Water Content=

$W_{BW} = W - (Ca \times \frac{MC_{CA} - A_{CA}}{100\%}) - (Fa * \frac{MC_{FA} - A_{FA}}{100\%})$

Ca=weight of coarse aggregate provided by initial design
Mc_{CA} =moisture content by coarse aggregate
A_{cA} = Water Absorption of Coarse Aggregate
Fa =weight of fine aggregate provided by initial design
A_{fA} = Water Absorption of fine Aggregate
Mc_{FA} = moisture content of fine aggregate
W=Initial design weight of water

Mix Design Procedure

- **Step 9 Continue..**

Now we get Final Values

Hence the Ratio						
	Water	Cement	Fine Agg	Course Agg	Remarks	
KG	148.52	450.656	650.67	1229.83	Per Cum	
Ratio	0.329	1	1.443	2.729		
Round off	0.32	1	1.4	2.7		

Batching ??- for this case use .4x.4X.4 cube box- One bag cement- 35 kg sand 2 times, 76.5 kg aggregate 2 times.. Batching by weight is best way to quality control, Concrete batching plant is preferable

Mix Design Procedure

- **Step 10 Trail Mixes**

Case	Procedure	Parameter	Remarks
Trail 1	As per initial design step 1-9	Find Slump Value	Change in Slump Value go to Trail 2
			Not Change in Slump Value go to Trail 3
Trail 2	Change in Water Content and admixture	W/C keep Constant	Better to change water content only and repeat step 4 to 9
Trail 3	Add 10% on W/C ratio	Keep Water Contain Constant	Repeat Step 5 to 9
Trail 4	reduce 10% on W/C ratio	keep Water Contain Constant	Repeat Step 5 to 10

Mix Design Procedure

Lab Test Equipment

- **Slump apparatus set**
- **Mixer small capacity up to .5 cum**
- **Weight Balance (capacity up to 20 kg) accuracy up to 1 gram)**
- **Beaker capacity up to 1 litre**
- **Cube Mould (min 30 nos) 15 cm**
- **Compressive strength Test machine capacity up to 2000 KN**
- **Tray, shovel, gloves, gallon**

Note : Test equipment on Cement, sand and Aggregate are not included.

Mix Design Procedure

Excel Sheet Exercise