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LIST OF PUBLICATIONS

1. Ranjan, Alok, Kumar, Rajesh, and Mohan, Devendra (2018). “Experimental Investigation of Carbonation on Concrete under Variable Parameters.” International Journal of Civil Engineering and Technology, Volume 9, Issue 4.
2. Ranjan, Alok, Kumar, Rajesh, and Mohan, Devendra (2018). “Comparative Analysis of Phenolphthalein Indicator, XRDA and FTIR methods for Measurement of Carbonation Depth of Concrete.” International Journal of Civil Engineering and Technology , Volume 9, Issue 5.
3. Ranjan, Alok, Kumar, Rajesh, and Mohan, Devendra (2018). “Experimental Study of Carbonation Depths of Concrete by Conventional and Advanced method.” Journal of the Institution of Engineers.(under review)

APPENDIX

MIX DESIGN OF M25, M30 AND M35 GRADE CONCRETE

1. DESIGN STIPULATIONS

a) Grade designation	M25, M30, M35
b) Type of Cement	OPC Grade - 43 and PPC
b) Maximum nominal size of aggregate	20 mm
d) Workability (Slump mm)	100
e) Degree of Quality Control	Good
f) Type of Exposure	Moderate
g) Type of aggregate	Crushed angular

2. TEST DATA FOR MATERIALS

a)	**Type of Cement**		**OPC Grade -43 and PPC**
b)	**Specific gravity**		
1	OPC		3.15
2	PPC		2.92
3	Coarse aggregate	(CA20)	2.82
4	Coarse aggregate	(CA10)	2.73
5	Fine aggregate (Sand)		2.64
6	Fly ash		2.17
7	GGBS		2.85
8	Micro silica		2.22
9	Admixture		1.09

c)	**Water absorption**	
1	Coarse aggregate (CA20)	0.15 %
2	Coarse aggregate (CA10)	0.25 %
3	Fine aggregate (Sand)	1.77 %

3) Sieve Analysis

1) Coarse Aggregate

2) Fine Aggregate

4. TARGET MEAN STRENGTH OF CONCRETE

f'ck =fck +1.65 s or f'ck =fck + X whichever is higher

Where

f'ck = Target average compressive strength at 28 days ,

fck = characteristic compressive strength at 28 days and

S = standard deviation (Refer table 2- IS 1062-2009), X= Factor based on the grade of concrete (Refer Table 1- 10262-2019)

Table 8: IS 456 – 2000)

Assumed values of standard deviation (*Page No. 23)*

Grade of Concrete	**Target mean strength**
M25	= 25 + 1.65X4 = 31.6 N/mm^2
M30	= 30 + 1.65X5 = 38.25 N/mm2
M35	= 35 + 1.65X5 = 43.25 N/mm2

Assumed values of standard deviation (*Page No. 23, Table 8: IS 456 – 2000*), s = 5 for M30

and M35, s = 4 for M25

5. SELECTION OF WATER CEMENT RATIO

From the relation curve (Curve D, for cement of 28 days compressive strength) of free water cement ratio and compressive strength of concrete, free water-cement ratio required for the target mean strength is as below:

Grade of Concrete	W/C
M25	0.5
M30	0.45
M35	0.5

6. SELECTION OF WATER AND SAND CONTENT

From table 2 of IS 10262 - 2009 for Nominal Maximum Size Aggregate (NMSA) 20mm

Water content = 186 Kg/m3 for slump 50 mm

Estimated water content for 75-100 mm slump = 186(1+.06) = 197 Kg/m3.

(3% increase for every 25mm slump over and above 50 mm slump)

From table 3 of IS 10262 - 2009, for Zone II for w/c ratio 0.5 and for NMSA 20, p=0.38

Hence, p = 0.38, 0.37 & 0.36 respectively for W/C 0.5 0.45 & 0.4

[Volume of coarse aggregate is required to be increased to decrease the fine aggregate content. W/C lowered by 0.05. Volume of coarse aggregate is increased by 0.01.]

7. Super plasticizer:

As superplasticizer is used , water content can be reduced up to 20 percent

Based on trials with superplasticizer (Pce based), water content reduction by 14% has been

achieved.

Hence , the arrived value of water content = 197 X 0.86=169 liter

8. DETERMINATION OF CEMENT CONTENT

W/C	p	W (Kg/m^3)	C (Kg/m^3)
0.5	0.38	186x (1+0.06) = 197	197/0.5 = 394
0.45	0.37		197/0.45 = 438
0.4	0.36		197/0.4 = 493

Determination of mineral admixture as replacement of cement and fine aggregate

Replacement of 10%, 30%,50% and 70 % by weight of cement with mineral admixtures such as SF, FA and GGBS for OPC and PPC combinations

9. DETERMINATION OF COURSE AND FINE AGGREGATE

i) For design mix corresponding to W/C = 0.4; from the Table 3.11 and Fig. 3.1, it is concluded that 39 % of coarse aggregate 20 mm, 25 % of coarse aggregate 10 mm and 36 % of sand is used.

ii) For design mix corresponding to W/C = 0.45; from the Table 3.12 and Fig. 3.2, it is concluded that 38 % of coarse aggregate 20 mm, 25 % of coarse aggregate 10 mm and 37 % of sand is used.

iii) For design mix corresponding to W/C = 0.4; from the Table 3.13 and Fig. 3.3, it is concluded that 37 % of coarse aggregate 20 mm, 25 % of coarse aggregate 10 mm and 38 % of sand is used.

10. MIX CALCULATION

a) Volume of concrete	= 1 m^3
b) Volume of Cement	= (Mass of cement/Specific Gravity of cement)X (1/1000)
c) Volume of mineral admixture (Fly Ash,GGBS,Micro silica)	= (Mass of mineral admixture/Specific Gravity of mineral admixture)X (1/1000)
d) Volume of Water	= (Mass of Water/Specific Gravity of Water)X (1/1000)
e) Volume of Admxiture	= (Mass of Admixture/Specific Gravity of Admixture)X (1/1000)
f) Volume of all in aggregate f	= {a-(b+c+d+e)}
g) Mass of 20 mm coarse aggregate	= f X vol. of 20 mm C/A X sp. Gravity of 20 mm C/A X 1000
h) Mass of fine aggregate	= f X vol. of fine aggregate X sp. Gravity of Fine aggregate X 1000