

Annexure I

Mix Design for M30 Grade of Geopolymer Concrete

1. Characteristic compressive strength of Geopolymer Concrete (f_{ck}) = 30 MPa.
2. Fly ash: Fineness in terms of specific surface: $235\text{m}^2/\text{kg}$
3. Alkaline activators (Na_2SiO_3 and NaOH)
 - (a) Concentration of Sodium hydroxide in terms of molarity: 8 M
 - (b) Concentration of Sodium silicate solution: 50.32 % solid content
4. Solution-to-fly ash ratio by mass: 0.5
5. Sodium silicate-to-sodium hydroxide ratio by mass: 1: 2.5
6. Fine aggregate

Natural river sand conforming to grading zone-III as per IS 383
Specific gravity = 2.52
7. Coarse aggregate

Type: Crushed/angular
Maximum size: 12.5 - 20 mm
Specific gravity = 2.75

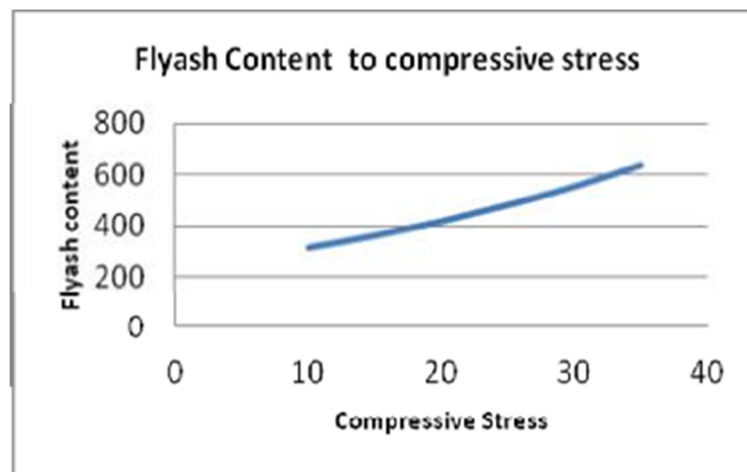
MIX DESIGN

1. Target mean strength

$$F_{ck} = 38.25 \text{ MPa}$$

2. Selection of quantity of fly ash

From Fig shown below, the quantity of fly ash required is 500 kg/m^3 for the target mean strength of 38.25 MPa at solution-to-fly ash ratio of 0.35 and for $265\text{m}^2/\text{kg}$ fineness of fly ash



3. Calculation of the quantity of alkaline activators

Calculate the quantity of alkaline activators considering:

Solution / Fly ash ratio by mass = 0.5

i.e: Mass of ($\text{Na}_2\text{SiO}_3 + \text{NaOH}$)/Fly ash = 0.5

Mass of ($\text{Na}_2\text{SiO}_3 + \text{NaOH}$)/500 = 0.5

Mass of ($\text{Na}_2\text{SiO}_3 + \text{NaOH}$) = 252 kg/m^3

Take the sodium silicate-to-sodium hydroxide ratio by mass of 1:2.5

Mass of sodium hydroxide solution (Na_2SiO_3) = 180 kg/m^3

Mass of sodium silicate solution (NaOH) = 72 kg/m^3

4. Calculation of total solid content in alkaline solution

Molarity Used = 8 M (8X 40 = 320 g of NaOH in 680g of water)

Solid content in the NaOH solution is 23.04 kg/m³ (320g in 1000g)

Water content in the NaOH solution is 48.96 kg/m³ (72 – 23.04)

Water content in the Na₂SiO₃ solution is 63.0 kg/m³ (0.35 X 180)

Solid content in the Na₂SiO₃ solution is 117.0 kg/m³

5. Selection of water content

For very high degree of workability and fineness of fly ash of 265 m²/kg, water content per cubic meter of geopolymer concrete is selected from the below Table

Degree of workability	Quantity of water required in kg/m ³			
	Fineness of fly ash in m ² /kg			
	<300	300–400	400–500	>500
Low	80	85	100	110
Medium	90	95	110	120
High	100	110	120	135
Very high	120	130	140	160

Water content per cubic meter of concrete from

Hence Water content = 120 kg/m³

6. Adjustment in water content

For sand conforming to grading-III, correction in water content is taken from following Table

Grading zone of fine aggregate as per IS 383	Correction in water content (%)
Zone-I	-1.5
Zone-II	–
Zone-III	+1.5
Zone-IV	+3

Adjustment in water content = +1.5

Total quantity of water required = 120 + 18 = 138 kg/m³

Water content in alkaline solutions = 111.96 kg/m³

7. Additional Water Content

= [Total quantity of water] – [Water present in alkaline solutions]

= 138 – 111.96 = 26.04 kg/m³

8. Aggregate content:

Assuming the sand content in total volume to be 38.5% and entrapped air as 2%

Using the below formulae the aggregate contents are found out

$VF = ((S_0/S_{s0}) + (S/S_s) + (F/S_f) + ((1/P) \times (F_a/S_{f_a}))) \times (1/1000)$

$VC = ((S_0/S_{s0}) + (S/S_s) + (F/S_f) + ((1/P) \times (C_a/S_{c_a}))) \times (1/1000)$

Where,

VF & VC = Absolute volume of fresh concrete, which is equal to gross volume minus the volume of entrapped air = 0.98

S = Sodium Silicate Solution (kg) per m^3 of concrete = 180

SO = Sodium Hydroxide Solution (kg) per m^3 of concrete = 72

F = Weight of Flyash (kg) per m^3 of concrete = 500

S_F = Specific gravity of Flyash = 2.3

P = Ratio of fine aggregate to total aggregate by absolute volume = 0.385

F_a & C_a = Total masses of fine aggregate and coarse aggregate (kg) per m^3 of concrete respectively = To find

S_{F_a} & S_{C_a} = Specific gravity of saturated surface dry fine aggregate and coarse

aggregate respectively = 3.47 & 3.88

S_s = Specific gravity of Sodium Silicate solution = 1.53

S_{SO} = Specific gravity of Sodium hydroxide solution = 1.47

Substituting in above equations,

We get,

$VF = 796.49 = 800 \text{ kg/m}^3$

$VC = 1422.65 = 1425 \text{ kg/m}^3$

MIX PROPORTION

Ingredients of geopolymer concrete	Fly ash	NaOH	Na_2SiO_3	Sand	Coarse aggregate	Total water (W/GPB)	Extra water
Quantity (kg/m^3)	500	72	180	800	1425	138	26.04
Proportion	1	0.5		1.6	2.85	0.276	0.05