EXPERIMENTAL INVESTIGATION OF MECHANICAL PROPERTIES OF CONCRETE USING NANO MATERIALS WITH M-SAND

GURU PRASAD N H. Student, RVS Technical campus, Coimbatore,
JUSTIN RAJ C. Assistant Professor, RVS Technical campus, Coimbatore,
KRISHNAN C. Assistant Professor, RVS Technical campus, Coimbatore,

1. INTRODUCTION

High Performance Concrete is an engineered concrete possessing the most desirable properties during fresh as well as hardened concrete stages. HPC is far superior to conventional cement concrete as the ingredients of HPC contribute most optimally and efficiently to the various properties and different conditions like chemical, mechanical and thermal stresses. The incorporation of pozzolonic materials like slag , fly ash etc., is achieving increased acceptance in concrete structures exposed to harsh environments. These pozzolanas react with OPC in two ways-by altering hydration process through alkali activated reaction kinetics of a pozzolanas called pozzolanic reaction and by micro filler effect. In pozzolanic reaction the pozzolanas react with calcium hydroxide, Ca(OH)2, (free lime) liberated during hydration of cement, which comprises up to 25 per cent of the hydration product, and the water to fill voids with more calcium-silicate-hydrate (non-evaporable water)that binds the aggregate particles together.

The pozzolanas may also react with other alkalis such as sodium and potassium hydroxides present in the cement paste. These reactions reduce permeability, decrease the amounts of otherwise harmful free lime and other alkalis in the paste, decrease free water content, thus increase the strength and improve the durability. In addition, economic and ecological benefits, such as energy-savings and resource-conservation, can be achieved using blended.

1.1 SAILENT FEATURES OF THE PROJECT

- Ease of placement
- Compaction without segregation
- Long-term mechanical properties
- Permeability
- Density
- Heat of hydration
- Toughness
- Volume stability
- Long life in severe environments

2. MATERIAL USED

- Cement
- Fine Aggregates
- Course aggregates
- Water
- Fly ash
- Super plasticizer
- Ground granulated blast furnace
- Glass fiber

3. MIX DESIGN

ISSN: 2582-3930

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. ACI Mix Design is adopted for Proportioning of Concrete Mix M75. By Weight Basis **(ACI 211.4R-93)**

Material Properties

Characteristic compressive strength = 75 MPa

Maximum size of aggregate used = 12.5 mm (passing through and retained on 10 mm sieve).

Specific gravity of cement = 3.15

Specific gravity of fine aggregate = 2.65

Specific gravity of coarse aggregate = 2.77

Dry rodded bulk density of FA = 1701.11 kg/m^3

Dry rodded bulk density of CA = 1692.73 kg/m^3

Slump assumed = 50-75 mm

3.4.2 Calculation Of Weight Of CA

From Table 4.3.3 of ACI 211.4R-93,

Fractional volume of oven dry rodded CA = 0.68 m^3

Weight of CA = 1692.73 x 0.68 = 1151.06 kg/m

3.4.3 Calculation Of Quantity Of Water

From Table 4.3.4 of ACI 211.4R-93,

For CA of 12.5 mm and slump of 50-75 mm

The mixing water = 148 ml

Void content of FA for this mixing water = 35 %

Void content of fine aggregate,

$$V = 1 - \left\{\frac{dry\ rodded\ of\ FA}{density\ of\ water * Gfa}\right\} * 100$$

V = 35.81 %

Adjustment in mixing water = (35.81 – 35) x 4.55 = 3.686 ml

Total water required = 148 + 3.686 = 151.686 ml.

3.4.4Calculation Of Weight Of Cement

Target mean strength f_{cr} = 75 + 9.65 = 84.65 MPa (12277.4 Psi)

Water / cement ratio = 0.26

Weight of cement (Kg) = 583.41 kg/m^3

3.4.5 Calculation Of FA

CEMENT = 583.41 / (3.15 x 1000) = 0.1852 m^3

WATER = 151.686 / (1 x 1000) = 0.152 m^3

CA = 1151.06 / (2.77 x 1000) = 0.416 m^3

Entrapped air = 2%

Total volume = 0.1852 + 0.152 + 0.416 + 0.02 = 0.773 m^3

Volume of FA = 1 – 0.773 = 0.227 m^3

Weight of FA = 0.227x2.65x1000 = 601.55 kg/m^3

Chemical Properties of GGBS

Table:1

Calcium Oxide(CaO)	40-52
Silicon Dioxide(SiO_2)	10-19
Iron Oxide(FeO)	10-40 (70-80% FeO_2,20-30%Fe_2O_3)
Manganese Oxide(MnO)	5-8
Magnesium Oxide(MgO)	5-10
Aluminium Oxide(Al_2O_3)	1-3
Phosphorous Pent Oxide(P_2O_5)	0.5-1
Sulphur(S)	<0.1
Metallic Fe	0.5-10

Product of hydration of OPC

<u>**REACTIONS**</u>

ISSN: 2582-3930

OPC(C_3S/C_2S) + H_2O ————> C-S-H + CH

Product of hydration of GGBS

GGBS(C_2AS/C_2MS) + H_2O ——> C-S-H + SiO_2

Reaction of pozzolanic material

SiO_2+ CH + H_2O —————>C-S-H

TABLE 2 Properties Of Fly ash

Chemical Properties	IS:3812-1981	Fly ash MTPP
SiO2+Al2O3+Fe2O3,min% by weight	70.00	90.50
SiO2, min% by weight	35.00	58.00
CaO max % by weight	5.00	3.60
SO3, max % by weight	2.75	1.80
Na2O, max % by weight	1.50	2.00
L.O.I, max 5 by weight	12.00	2.00
MgO, max %by weight	5.00	1.91

Mix Ratio

mix ratio for M75 concrete : **1 : 1.03 : 1.973**

Water Binder Ratio : **0.26**

Super Plasticizer : **4.75 l /m^3** of concrete

Mix Proportion Details

ACI MIX DESIGN METHOD: BY WEIGHT BASIS (ACI 211.4R-93)

Table 3 Mix Proportions

Mix	% GGBS	% Flyash	% Glass fibre	W/C ratio
MG1	5	0	0.3	0.26
MG2	7.5	0	0.3	0.26
MG3	10	0	0.3	0.26
MG4	12.5	0	0.3	0.26
MGF1	5	10	0.3	0.26
MGF2	.5	10	0.3	0.26
MGF3	10	10	0.3	0.26
MGF4	12.5	10	0.3	0.26
MC	0	0	0	0.26

4. EXPERIMENTAL WORK

A total of nine beams were cast. Out of those nine beams cast, one is conventionally reinforced concrete beam. Remaining eight beams were separated into two categories and were cast with concrete, one with the 5%, 7.5%, 10% & 12.5% GGBDS replacement and glass fibres and the other with above mentioned replacement of GGBS with glass fibres in addition to fly ash. All the beams were tested for flexure under a loading frame of capacity 1000kN. These beams were tested on a effective span of 1500mm with simply supported conditions under two point loading. Deflections were measured under the loading point and at the mid span using Linear Variable Differential Transducers (LVDTs).

4.1 DESIGN OF FLEXURE BEAMS

Flexure Beam Design

Grade of Concrete	M75
Grade of steel	Fe 415
Length of Beam	2.00m
Effective span Length	1.50m
Breath of beam	100mm
Depth of Beam	200mm
Loading Method	Two Point Load (Equal Distance (L/3))

 ISSN: 2582-3930

End Condition Simply Supported Beam

We have to design a Beam failures occurs in the mode of flexure

$$\frac{x_u}{d - x_u} = \frac{\varepsilon_{cu}}{\varepsilon_s}$$

$$\frac{x_u}{d} = \frac{\varepsilon_{cu}}{\varepsilon_{cu} + \varepsilon_s} \quad \varepsilon_{cu} = 0.0035$$ (IS 456-2000 38.1(b))

$$\varepsilon_s = 0.002 + \frac{0.87 f_y}{E_s}$$ (IS 456-2000 38.1(f))

$$\varepsilon_s = 0.002 + \frac{0.87x415}{2x10^5} = 0.00366$$

$$\frac{x_u}{d} = \frac{0.0035}{0.0035 + 0.00366} = 0.479 \approx 0.48$$

$$\frac{x_{u,max}}{d} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} bd} = 0.48$$ (IS 456-2000 Note 38.1)

Clear cover =20mm

Effective cover= (20+10/2) = 25mm

Effective depth= 200- 25 = 175mm

f_{ck} = 75 N/mm^2

b = 100 mm

$$M_{u,lim} = 0.36 \frac{x_{u,max}}{d}\left[1 - 0.42 \frac{x_{u,max}}{d}\right] bd^2 f_{ck}$$

(IS 456-2000 Annex G 1.1(c))

= 33.80 kNm

$$A_{st} = \frac{0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_u}{f_{ck} bd^2}}\right] bd$$

A_{st}=648.46 mm^2

Provide $A_{st} = 2x\frac{\pi x 10^2}{4} = 158 mm^2$

Moment carrying capacity of under reinforced section

$$M_u = 0.87 f_y A_{st} d\left[1 - \left(\frac{A_{st} f_y}{bd f_{ck}}\right)\right]$$

M_u = 9.46 kNm < $M_{u.lim}$

A_{st} = 158 mm^2

The section is failure mode of flexure.

Increase the shear resistance capacity of the beam.

$$M = \frac{Wl}{6}$$

$$w = \frac{6M}{l}$$

$$w = 6 \ x \frac{9.46}{1.5}$$

w = 37.84 kN

Jack load (2w) = 75.68 kN

Design of shear Resistance:

$$\% \text{ of steel} = \frac{100x158}{100x175} = 0.90\%$$

From Table 19,IS 456 -2000,

For f_{ck} = 75 N/mm^2 & P_t=0.90

Design shear strength of concrete τ_c = 0.55 N/mm^2

From Table 20,

Maximum shear stress $\tau_{c\,max}$ = 4 N/mm^2

$$\frac{v}{bd} = \frac{37.94x1000}{100x175} = 2.16 \text{ N/mm}^2$$

$\tau_v < \tau_{cmax}$

V_{us}= (τ_v - τ_c)x bd = (2.16-0.55) x 100x175 = 28.175 kN

IS 456 clause no : 40.4 (a)

$$S_v = \frac{0.87 f_y A_{sv} d}{V_{us}}$$

A_{sv}= total cross sectional area of stirrup legs

Using 8mm φ (2 legged stirrup)

$$A_{sv} = \frac{2\pi \ x \ 8^2}{4} = 101 mm^2$$

$$Sv = \frac{0.87 \times 415 \times 101 \times 175}{9.28 \times 1000} = 225 \text{ mm}$$

Provide maximum spacing of shear resistance

IS 456 – 26.5.1.5

1. Shall not exceed 0.75d for vertical stirrups (131.25mm)

2. Spacing should not exceed 300mm

We choose 6mm φ 2 legged vertical stirrups at a 125mm c/c distance

Beam with stand upto $V_u = V_c + V_s$

$$Vs = \frac{0.87 \times 415 \times 101 \times 175}{125} = 51.05 \text{ kN}$$

V_s = 51.05 kN

V_c = 0.75x100x175 = 13.13 kN

$V_u = V_c + V_s$ = 64.18 kN > 37.84 kN

The section is failure mode of flexure.

4.2 Beam Detailing

The reinforcement detailing for the beams to be tested for flexural behavior is shown below.

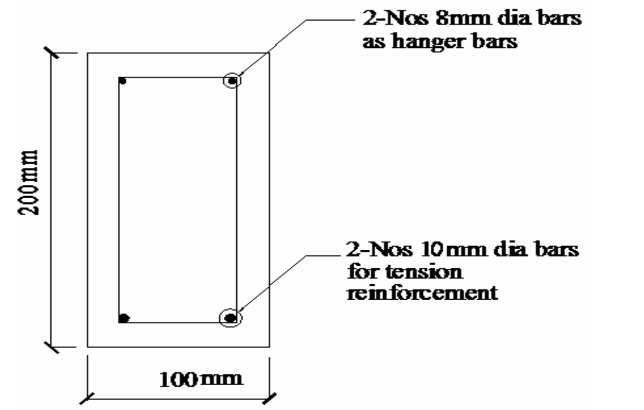


Fig.3.8 (a)Cross Section of Beam

Fig.3.8 (b) Longitudinal Section of Beam

5. CONCLUSION

- It is found that the incorporation of GGBS had increased the load carrying capacity of the beam. The production of additional hydrates to fill the voids accounts for dense concrete and hence the strength.
- It is found that the mix MGF3 has 2.85 % more ultimate load than conventional concrete.
- The addition of fly ash enhances the effect of GGBS and hence the mix MGF3 (10% GGBS+10% Fly Ash and 0.3% Glass Fiber) gives better load deflection characteristics compared to conventional concrete.
- Load deflection characteristics is comparable with ordinary High performance concrete.

6.RESULTS

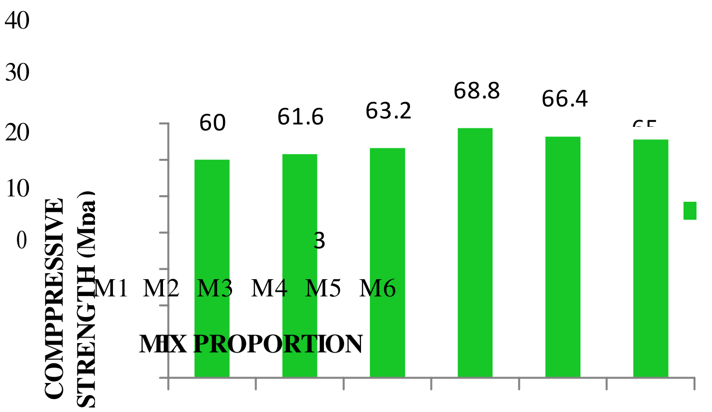
PROPORTION	FS % BY FA	FA BY % OF CEMENT	GGBS BY %OF CEMENT	7-DAYS STRENGTH (MPA)	14-DAYS STRENGTH (MPA)	28-DAYS STRENGTH (MPA)
M1	10	10	0	29.6	36	60
M2	20	20	0	29.6	40	61.6
M3	30	30	0	33.6	43.2	63.2
M4	10	0	10	36	40.8	68.8
M5	20	0	15	34.4	44	66.4
M6	30	0	20	32.8	42.4	65.6

Table No 4: Workability

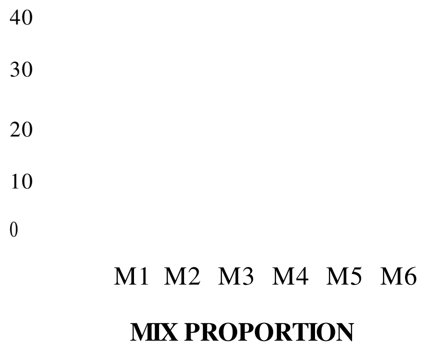
ISSN: 2582-3930

TEST RESULTS OF WORKABILITY			
	M1	M2	M3
Slump (mm)	57	58	60
Comp action factor	0.91	0.89	0.92

1) 7 DAYS COMPRESSIVE STRENGTH

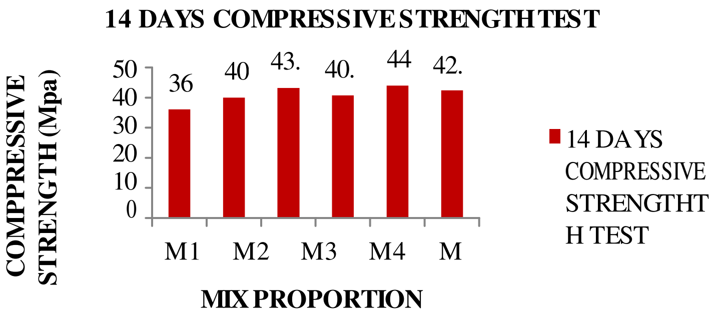


II.



The compressive strength of concrete is maximum achieved in the M4 mix proportion which is 36 MPa.

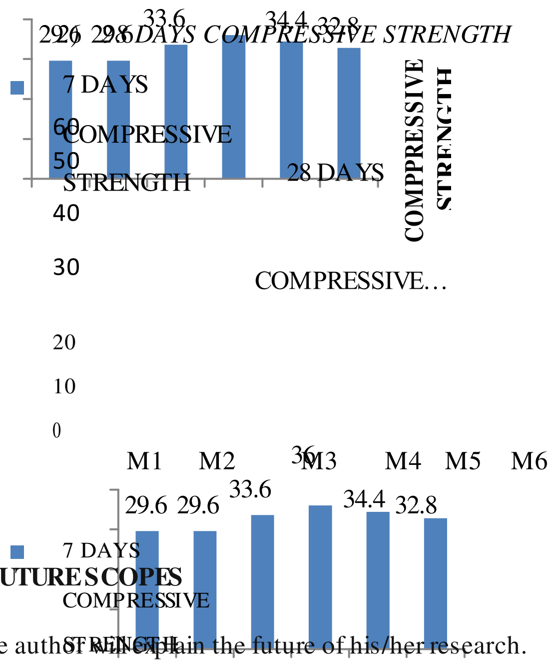
III. 14 DAYS AVERAGE COMPRESSIVE STRENGTH



The compressive strength of concrete is maximum achieved in the M5 mix proportion which is 44 MPa.

1) 28 DAYS COMPRESSIVE STRENGTH

The compressive strength of concrete is maximum achieved in the M5 mix proportion which is 68.8 MPa.



7. FUTURE SCOPES

Here author will explain the future of his/her research.

REFERENCES

1. (1) ACI 211.4R-93 'Guide for selecting proportions for High – Strength concrete with Portland Cement and flyash.'
2. Amer M. Ibrahim and Mohammed Sh. Mahmood (2009),' Finite Element Modeling of Reinforced Concrete Beams Strengthened with FRP Laminates', European Journal of Scientific Research, Vol.30 ,pp.526-541.
3. BIS 1989 IS-455 -1989 'Portland Slag Cement-Specification'.
4. BIS 1970 IS 383-1970 (reaffirmed 1997), "Specification for Coarse and Fine Aggregates from Natural Source for Concrete", New Delhi.

5. BIS 1987 IS 12269-1987 (reaffirmed 1999), "Specification for 53 grade Ordinary Portland Cement", New Delhi.
6. BIS IS 456-2000 (reaffirmed 2005) "Plain and Reinforced Concrete – Code of Practice", Fourth Revision, pp.14.
7. Gambhir.M.L, (2005) 'Concrete Technology',Tata McGraw Hill Pub.Co.Ltd.New Delhi.