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An Experimental Investigation on Behaviour of Geopolymer Concrete with Ferro Cement

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Abstract

This project presents the experimental investigation of the resistance of geopolymer mortar slabs to impact loading. For this, specimens of size 200mmx210mmx100mm. The results obtained show that the addition of the above mesh reinforcement has increased the impact residual strength ratio of geopolymer ferrocement by 4-28 that of the reference plain ferrocement mortar slab. The combination of 1 layer of weld mesh and 4 layers of chicken mesh of geopolymer ferrocement specimens show the best performance in the test, i.e. energy absorbed, residual impact strength ratio (I-rs), It was concluded that the increase in Volume fraction of reinforcement V-r, increases the energy absorption and also residual impact strength ratio of geopolymer ferrocement than that of ferrocement specimens.

Keywords: Ferro cement, Geopolymer mortar slab, Residual impact strength ratio.

INTRODUCTION

GENERAL :

Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminum.

On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture cement products. When used as a partial replacement of OPC, in the presence of water and in ambient temperature, fly ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C-S-H) gel. The development and application of high volume fly ash concrete, which enabled the replacement of OPC up to 60% by mass is a significant development.

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In 1978, Davidovits proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash and rice husk ash. He termed these binders as geopolymer.

FLY ASH-BASED GEOPOLYMER MORTAR:

In this project, fly ash-based geopolymer is used as the binder, instead of Portland or other hydraulic cement paste, to produce cement mortar. The fly ash-based geopolymer paste binds the loose fine aggregates and other un-reacted materials together to form the geopolymer mortar, with or without the presence of admixtures. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods.

The silicon and the aluminium in the fly ash react with an alkaline liquid that is a combination of sodium silicate and sodium hydroxide solutions to form the geopolymer paste that binds the aggregates and other un-reacted materials.

CONSTITUENTS OF GEOPOLYMER

CLASS F FLYASH:

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 10% lime (CaO). possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate to a Class F Fly ash can leads to the formation of a geopolymer.

ALKALINE LIQUIDS :

The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate. Alkaline liquid plays an important rolein the polymerization process. Reactions occur at a high rate when the alkaline liquid contains soluble silicate, either sodium or potassium silicate, compared to the use of only alkaline hydroxides. Addition of sodium silicate solution to the sodium hydroxide solution as the alkaline liquid enhanced the reaction between the source material and the solution. Furthermore, after a study of the geopolymerisation of sixteen natural Al-Si minerals, they found that generally the NaOH solution caused a higher extent of dissolution of minerals than the KOH solution.

GEOPOLYMERS :

Alkaline liquid could be used to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in byproduct materials such as fly ash and rice husk ash to produce binders. Because the chemical reaction that takes place in this case is a polymerisation process, the term ‘Geopolymer’ is used to represent these binders.

Geopolymers are members of the family of inorganic polymers. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous instead of crystalline. The polymerisation process

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involves a substantially fast chemical reactionunder alkaline condition on Si-Al minerals, those results in a three dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds, as follows

COMPRESSIVE STRENGTH DEVELOPMENT IN GEOPOLYMER MORTAR USING FERRO CEMENT TECHNOLOGY

DEFINTION OF FERRO CEMENT:

Ferro cement is a thin walled reinforced concrete commonly constructed of hydraulic mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable materials.

REINFORCED CEMENT CONCRETE and FERROCEMENT :

Physical

- Thickness- Less than 25 mm
- Reinforcement- Distributed uniformly
- Matrix-Cement Mortar

Mechanical

- Homogenous and Isotropic- Two Way action
- Tensile Strength- High. Also high modulus of rupture.
- Specific Surface of Reinforcement-High
- Ductility-High increases with increase in layers
- Smaller crack widths-Multiple cracking
- Durability-GI wire and small cracks
- Fire Resistance- Ok.

PROPERTIES OF FERRO CEMENT TECHNOLOGY :

- Very High quality Control
- Prefabricated products readily available
- Easy production & Installation - of product & machinery - At site
- Manpower can be Easily trained at site
- Very useful in rural areas
- No extra time required. Fast production - 262 sqft of Roof ready in One shift
- 50-75% lighter than conventional techniques
- 41% more insulating than RCC
- Cost effective - 15%-50% cheaper than conventional techniques
- Environment friendly- 40% less cement & sand.

RESULTS AND DISCUSSIONS OF RESULTS

CALCULATIONS OF MORTAR CUBES :

Size of the cube = 7.07cm

Volume of the cube = $3.53*10^{4} m^3$

Density of geo polymer concrete = $2200 kg/m^3$

Weight required = density*volume = $3.53*10^{4} m^3 * 2200 kg/m^3$ = 0.777kg (take 800gms)

Take fly ash to sand ratio as 1:3

Fly ash =200gms

Ennore sand=600gms

Take ennore sand as a combination of grade1,

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grade 2, grade 3. Each 200gms

Take sodium silicate to sodium hydroxide in different ratio as 1.5, 2, 2.5, 3, 3.5. Make the alkaline solution 24hrs before the preparation of mortar cubes

One day oven curing is there to get strength (60°c) 7day compressive strength is to be find.

CALCULATIONS :

- **For Cement Mortar Prisms & Geopolymer Mortar Prisms**

Size of the mortar cube = 200*100*100 = 0.002 m3

Density of Geopolymer mortar = 2200 Kg/m3

Weight of the cube = 2200*0.002 = 4.4 Kg.

- **For 1:1 Ratio of Flyash & Fine aggregate**

Alkaline / Flyash = 0.38, Sodium silicate/ Sodium hydroxide = 2.5; Flyash = 2.2 Kg, Fine aggregate = 2.2 Kg;

Alkaline solution = 836 ml,

Sodium silicate = 598 ml,

Sodium hydroxide = 238 ml,

Wt. of NaOH = 76.16 gms (taking Molarity M=8).

- **For 1:1.5 Ratio of Flyash & Fine aggregate**

Alkaline / Flyash = 0.40, Sodium silicate/ Sodium hydroxide = 2.5;

Flyash = 1.76 Kg, Fine aggregate = 2.64 Kg;

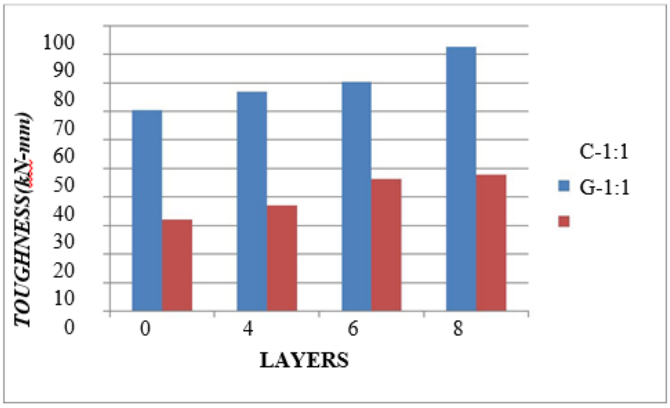
Alkaline solution = 704 ml,

Sodium silicate = 503 ml,

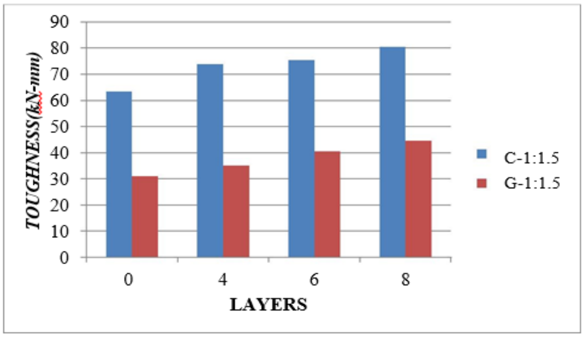
Sodium hydroxide = 201 ml,

Wt. of NaOH = 64.32 gms (taking Molarity M=8).

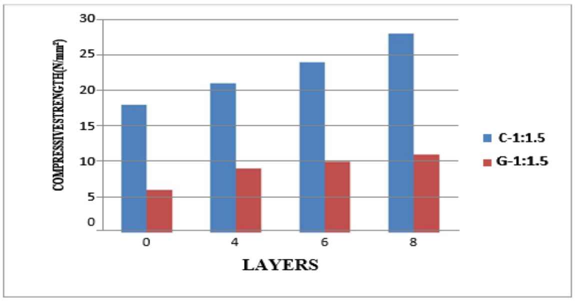
Na2SiO3/ NaOH	**COMPRESSIVE STRENGTH (N/mm2)**
1.5	12
2	13
2.5	15
3	11
3.5	10



Graphical representation of toughness with no.of layers for ratio 1:1

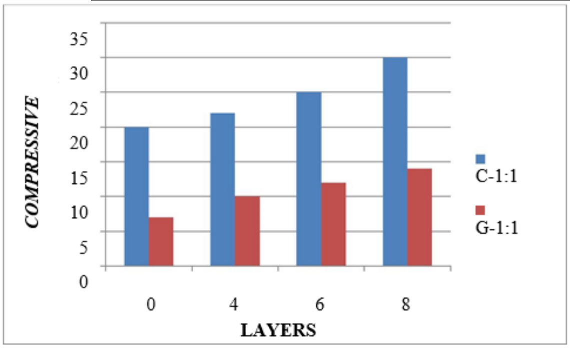


Graphical representation of toughness with no.of layers for ratio **1:1.5.**



Variation of Compressive strength values with no. of layers :-

LAYERS	C - 1:1	G - 1:1	C - 1:1.5	G – 1:1.5
0	20	7	18	6
4	22	10	21	9
6	25	12	24	10
8	30	14	28	11



Graphical representation of compressive strength values with different layers for ratio**1:1**.

Graphical representation of compressive strength values with different layers for ratio of **1:1.5.**

Comparision of Toughness values for Geopolymer mortar & Cement mortar with diff ratios :-

LAYERS	G – 1:1	G – 1:1.5	C – 1:1	C- 1:1.5
0	32.06	30.89	70.33	64.32
4	36.98	35.05	76.94	73.81
6	46.2	40.54	77.67	77.47
8	47.8	44.54	92.52	80.43

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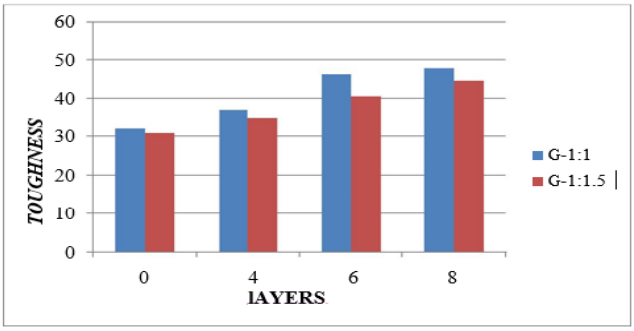

Graphical representation of Touchness values for Geopolymer mortar with diff ratios.

Comparision of Compressive strength values for Geopolymer mortar & Cement mortar with diff ratios :-

LAYERS	G – 1:1	G – 1:1.5	C – 1:1	C- 1:1.5
0	7	6	20	18
4	10	9	22	21
6	12	10	25	24
8	14	11	30	28

Stress - Strain and load-displacement values for C 1:1 (0layers):-

DISPLACEMENT (mm)	LOAD (KN)	STRAIN	STRESS (N/mm2)	INITIAL TANGENT LINE	AREA
0	0	0	0	0	0
0.001	10	0.000005	1	0.9588	0.005
0.005	20	0.000025	2	4.794	0.06
0.021	30	0.000105	3	20.1348	0.4
0.035	40	0.000175	4	33.558	0.49
0.061	50	0.000305	5	58.4868	1.17
0.076	55	0.00038	5.5	72.8688	0.7875
0.089	60	0.000445	6	85.3332	0.7475
0.123	70	0.000615	7	117.9324	2.21
0.145	75	0.000725	7.5	139.026	1.596
0.167	80	0.000835	8	160.1196	1.705
0.189	85	0.000945	8.5	181.2132	1.815
0.212	90	0.00106	9	203.2656	2.0125
0.245	95	0.001225	9.5	234.906	3.0525
0.267	100	0.001335	10	255.9996	2.145
0.298	110	0.00149	11	285.7224	3.255
0.312	120	0.00156	12	299.1456	1.61
0.334	130	0.00167	13	320.2392	2.75
0.378	140	0.00189	14	362.4264	5.94
0.412	150	0.00206	15	395.0256	4.93
0.456	170	0.00228	17	437.2128	7.04
0.5	180	0.0025	18	479.4	7.7

0.534	180	0.00267	18	511.9992	6.12
0.567	200	0.002835	20	543.6396	6.27
0.632	170	0.00316	17	605.9616	12.025
				Toughness	70.33 KN-mm

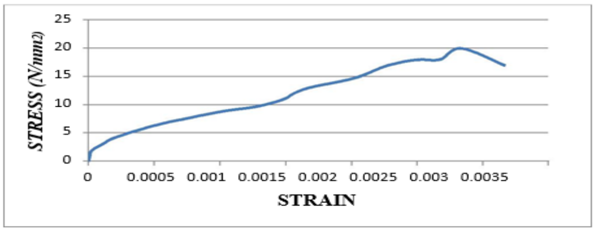

Fig 2.1 Graphical representation for stress-strain curve for **C 1:1** (**0**layers).

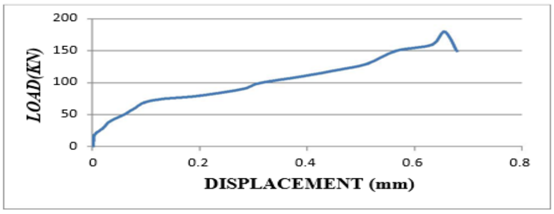

Fig 2.2 Graphical representation of load-displacement for **C 1:1**(**0** layers).

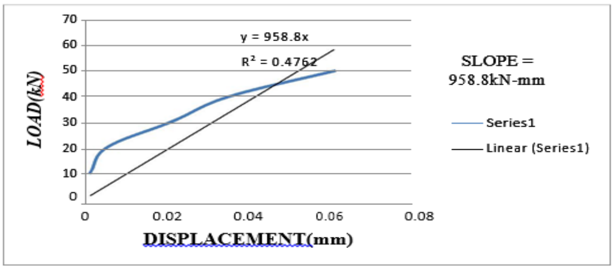

Fig 2.3 linear fit for **C 1:1**(**0** layers)

Table 2 **Stress - Strain and load-displacement values for C 1:1.5 (0layers):-**

DISPLACEMENT (mm)	LOAD (KN)	STRAIN	STRESS (N/mm2)	INITIAL TANGENT LINE	AREA
0	0	0	0	0	
0.001	10	0.000005	1	1.013	0.005
0.005	20	0.000025	2	5.065	0.06
0.021	30	0.000105	3	21.273	0.4
0.032	40	0.00016	4	32.416	0.385
0.058	50	0.00029	5	58.754	1.17
0.067	55	0.000335	5.5	67.871	0.4725
0.078	60	0.00039	6	79.014	0.6325
0.098	70	0.00049	7	99.274	1.3
0.134	75	0.00067	7.5	135.742	2.61
0.2	80	0.001	8	202.6	5.115
0.278	90	0.00139	9	281.614	6.63
0.312	100	0.00156	10	316.056	3.23
0.389	110	0.001945	11	394.057	8.085
0.456	120	0.00228	12	461.928	7.705
0.511	130	0.002555	13	517.643	6.875
0.565	150	0.002825	15	572.345	7.56
0.632	160	0.00316	16	640.216	10.385
0.656	180	0.00328	18	664.528	4.08
0.678	150	0.00339	15	686.814	3.63
				toughness	63.33kN-mm

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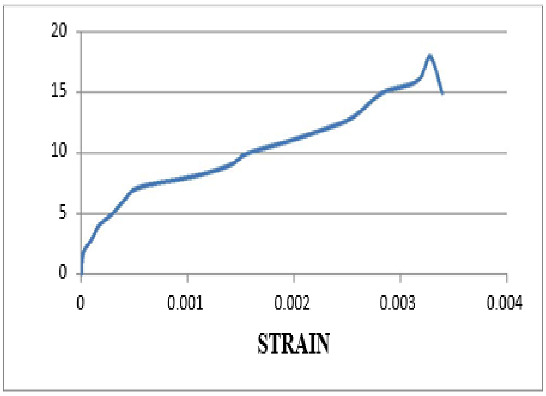

Fig 2.1 Graphical representation of stress-strain curve for **C 1:1.5(0** layers).

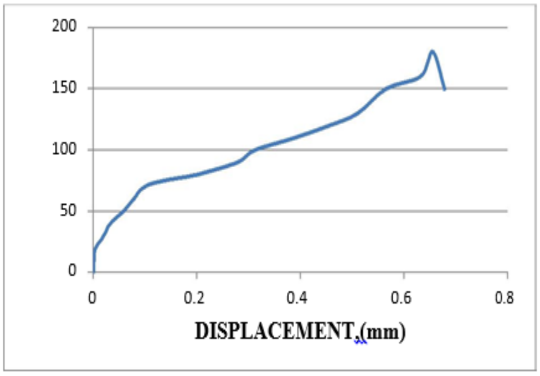

Fig 2.2 Graphical representation of load-displacement curve for **C 1:1.5(0**layers).

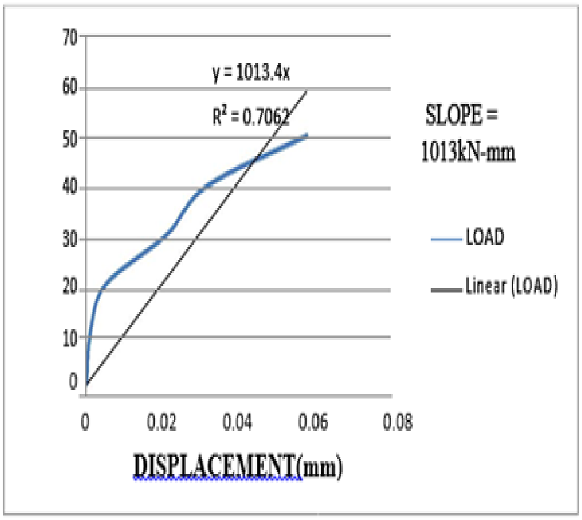

Fig 1.3 linear fit for **C 1:1.5(0** layers).

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Recommendations for further research:

- We used fly ash obtained from bituminous coal which contains 10% CaO, fly ash from sub bituminous coal shall also be determined.
- Rice husk ash and GGBS shall be tried instead of fly ash and properties shall be determined.
- Investigation should be made on Structural members like beams, columns, and slabs using geopolymer as binder.
- Using oven curing technology to improve initial strength of geo polymer members.

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