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COMPREHENSIVE STUDY ON BEHAVIOUR OF GEOPOLYMER CONCRETE WITH FERRO CEMENT

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ABSTRACT

This paper presents the experimental investigations of the resistance of geopolymer mortar slabs to impact loading. For this, specimens of size 230mmx230mmx25mm with 4 layers of chicken mesh 2 layers of rectangular weld mesh and combination of single layer of weld mesh and four layers of chicken mesh were cast and subjected to impact loading by drop weight test. 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.

I. INTRODUCTION

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 utilise 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.

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II. CHEMICAL COMPONENTS OF FLYASH OBTAINED FROM VARIOUS TYPES OF COAL

Components	Bituminous coal (%)	Sub-Bituminous coal (%)	Lignite coal (%)
SiO_2	20-60	40-60	15-45
Al_2O_3	5-35	20-30	20-25
Fe_2O_3	10-40	4-10	4-15
CaO	1-12	5-30	15-40
Loss of Ignition	0-15	0-3	0-5

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III. MATERIALS

3.1.1Fly ash

Fly Ash: The Fly ash was used as a partial replacement for cement. The fly ash used in the experiments was from Ramagundam thermal power station (NTPC). The specific gravity was 2.17. The fly ash had a silica content of 63.99%, silica+ alumina +iron oxide content of 92.7%, Calcium oxide of 1.71% , Magnesium oxide of 1.0%, Sulphuric anhydride of 0.73% , water and soluble salts of 0.04%, ph value of 10 and a loss on ignition of 2.12

3.1.1 Alkaline Liquid

In the present study we have used a combination of sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) solutions. The sodium hydroxide solids were either a technical grade in flakes form (3 mm), 98% purity, and obtained from National scientific company, Vijayawada, or a commercial grade in pellets form with 97% purity, obtained from National Scientific center, Vijayawada.

Figure 4.1: Sodium Silicate and Sodium Hydroxide Solution

3.1.2 Galvanized iron mesh:

Galvanized Iron Wire mesh: The galvanized iron wire mesh of square grid fabric is used in the Ferro cement. The properties of the wire mesh are

3.1.2 Galvanized iron mesh Properties

Diameter of wire mesh (mm)	Grid spacing of mesh wire (mm)		Yield strength of mesh wire (Mpa)	Ultimate strength (Mpa)
	Longitudinal	Transverse		
0.46	2.80	2.80	270	450

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IV. RESULTS AND DISCUSSIONS

RESULTS:

1.Calculations of Mortar cubes:

Size of the cube=7.07cm

Volume of the cube=3.53*10^{-4} m³

Density of geo polymer concrete=2200kg/m³

Weight required= density*volume

=3.53*10^{-4} m³*2200kg/m³ =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, 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 (60ºc) 7day compressive strength is to be find

V. .CALCULATIONS:

FOR CEMENT MORTAR PRISMS & GEO POLYMER MORTAR PRISMS

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

Density of geo polymer mortar=2200kg/m³

Weight of cube=2200*0.002=4.4 kg

5.1 Mortar cubes compressive strength values

Table 5.1

S.No	Liquid Content required	Na_2SiO_3 /NaOH	Na_2SiO_3 (ml)	NaOH	M (molarity)	Wt of NaOH (gm)	FLYASH	FA	Compressive strength (MPa)
1	98	1.5	58.8	39.2	8	12.544	200	600	12
2	98.96	2	65.98	32.98	8	10.55	200	600	13
3	97	2.5	69.3	27.7	8	8.86	200	600	15
4	96	3	72	24	8	7.68	200	600	11
5	95	3.5	73.88	21.1	8	6.75	200	600	10

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5.2 Table showing comparison of cement mortar prism and geo polymer mortar prisms for different layers for different ratios

FLY ASH/SAND OR CEMENT/SAND	LAYERS	CEMENT MORTAR PRISM		GEO POLYMER MORTAR PRISM	
		COMPRESSIVE STRENGTH (N/mm²)	TOUGHNESS (kN-mm)	COMPRESSIVE STRENGTH (N/mm²)	TOUGHNESS (kN-mm)
1:1	0	20	70.33	7	32.06
	4	22	76.94	10	36.98
	6	25	80.43	12	46.2
	8	30	92.52	14	47.8
1:1.5	0	18	63.32	6	30.89
	4	21	73.81	9	35.05
	6	24	77.47	10	40.54
	8	28	80.43	11	44.54

Table 5.3 Variation of toughness values for different layers.

LAYERS	C-1:1	G-1:1	C-1:1.5	G-1:1.5
0	70.33	32.06	63.32	30.89
4	76.94	36.98	73.81	35.05
6	80.43	46.2	75.42	40.54
8	92.52	47.3	80.43	44.54

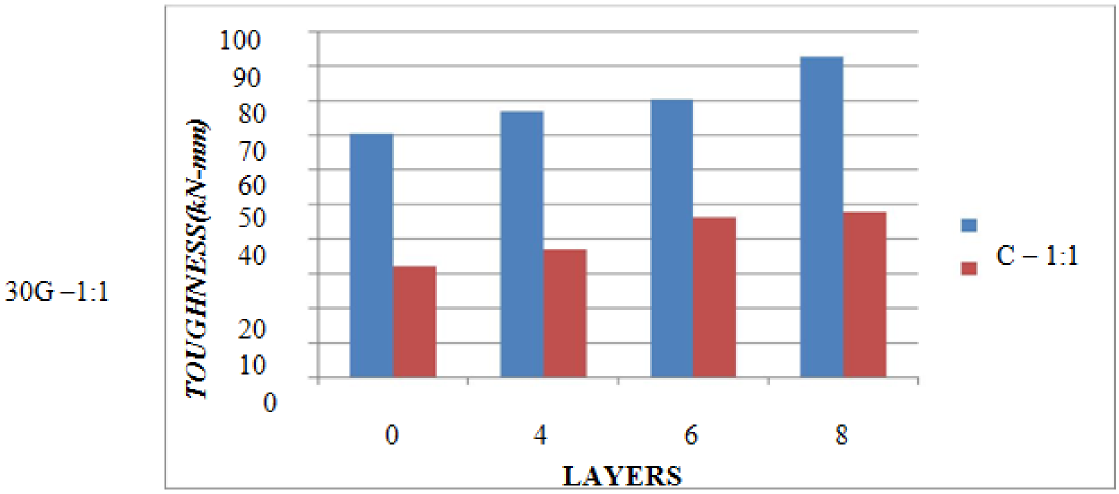

Fig 5.3.1 Graphical representation of toughness with no. of layers for ratio **1:1**

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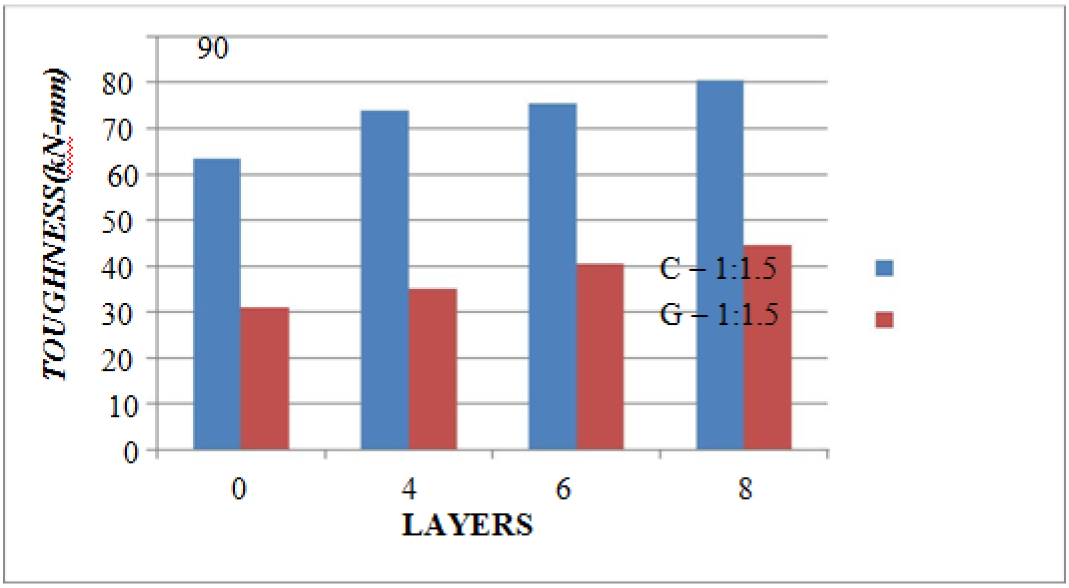

Fig 5.3.2 Graphical representation of toughness with no. of layers for ratio **1:1.5**.

Table 5.4 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

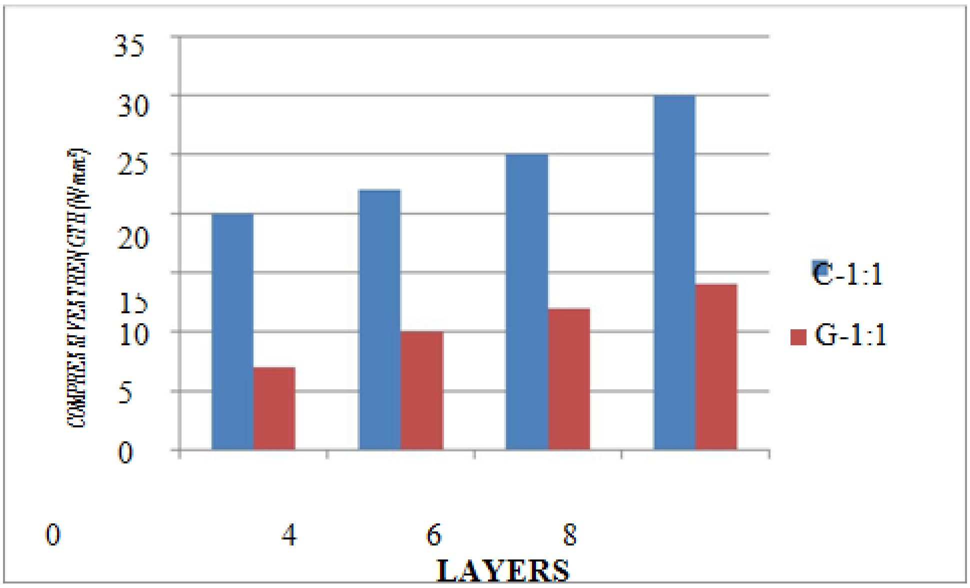

Fig 5.5.1 Graphical representation of toughness values for geopolymer mortar with different ratios.

Observations noticed:

- Geo polymer mortar develops sufficient strength even in ambient temperature conditions without any conventional curing, an encouraging outcome of the study

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- Industrial by products like fly ash can be advantageously used in producing ambient cured geo polymer composites
- Molarity of alkaline activator, fluid binder ratio and binder to aggregate ratio are some of the parameters influencing the development of strength of ambient cured geo polymer mortar
- Geo polymer mortar can emerge as an eco-friendly and sustainable construction material and can be used for the manufacture of compressed blocks/pavers
- It is observed that geo polymer mortar in ambient curing conditions can obtain good strength in 28 days.
- Compressive strength increases around 40% to 50% from 7 days to 28 days.
- Higher concentration (in terms of molarity) of sodium hydroxide solution results in higher compressive strength of fly ash-based geo polymer mortar.
- Workability of geo polymer mortar decreases with the increase in concentration of sodium hydroxide.
- Water content proved to be crucial parameter to retain mortar as workable but geo polymer mortar without water was too dry.
- 18% to 30% economy is achieved in geo polymer mortar when compared to cement mortar.

VI. CONCLUSIONS

- Compressive strength of geo polymer mortar is nearly half of cement mortar.
- Polymerization of geo polymer mortar can be achieved even in ambient temperature.
- From economy and from strength point of view take ratio of alkaline solution (Na_2SiO_3 /NaOH) as 2.5.
- Number of layers of wire mesh plays a crucial role in developing the compressive strength to the cement and geo polymer mortar.. With the increase in the number of layers compressive strength is increasing in cement mortar & geo polymer mortar.
- In case of geo polymer mortar increase in ratio of geo polymer to sand doesn't increase in compressive strength of geo polymer mortar due to decrease in the quantity of geo polymer.
- Toughness also increases with increase in number of layers of wire mesh and toughness of geo polymer mortar is nearly half of cement mortar.
- The cracking pattern is almost same for cement mortar and geo polymer mortar. The mesh wires resist the formation & propagation of cracks.

Table 1 Stress-strain and load-displacement values for C 1:1.5(0layers).

DISPLACEMENT (mm)	LOAD (kN)	STRAIN	STRESS (N/mm^2)	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

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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

DISPLACEMENT (mm)	LOAD (kN)	STRAIN	STRESS (N/mm^2)	Initial tangent line	AREA
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	1.595
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

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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	70.33kN-mm

Table 2 Stress-strain and load-displacement values for C 1:1(0layers).

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