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EXPERIMENTAL STUDIES ON GEOPOLYMER CONCRETE BY EQUIPROPORTIONAL REPLACEMENT OF FLY ASH & GGBS

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ABSTRACT: Manufacture of Portland cement produces large volumes of carbon dioxide and other gases. Releasing these gases causes atmospheric pollution and subsequent environmental degradation. Concrete is widely used and reliable material for construction. Some of challenges in industry are global warming and insufficiency of construction material. One of the methods for replacing concrete constituents is the use of geo-polymer which helps in using very less quantity of cement in concrete. Geopolymer results from the reaction of a source material that is rich in silica and alumina with alkaline liquid. It is essentially cement free concrete. This material is being studied extensively and shows promise as a greener substitute for ordinary Portland cement concrete in some applications. Research is shifting from the chemistry domain to engineering applications and commercial production of geopolymer concrete. It has been found that geopolymer concrete has good engineering properties with a reduced global warming potential resulting from the total replacement of ordinary Portland cement. This project represents study on the flexural behavior of fiber reinforced geopolymer concrete. In this study, geopolymer concrete is produced with fly ash, GGBS and sodium hydroxide and sodium silicate is used as a binder. Fly ash and GGBS are taken in equal proportion to enhance properties of concrete and the fiber used in this project is polypropylene fiber (Recron 3s). For this project, the mix design is carried out for 8M and 16M concentration of sodium hydroxide. Alkaline activator solution ratio of 2.0 is selected for this investigation. The specimen of size 500x100x100mm prisms were casted of M10, M20, M30 and M40 grade of concrete and the specimens of geo-polymer concrete are cured at ambient temperature for 7days and 28 days. The cured specimens were then tested for flexural strength and high strengths are achieved.

INTRODUCTION

Cement concrete is manmade material which prepared by mixing of cement, water, natural fine and coarse aggregate. The past century developed cement concrete as material for construction work. In 1902 August Perret, first designed building in Paris with structural components beams, slabs and columns. Construction variety of infrastructure and industrial sector by concrete makes it is an essential product. It is widely used manmade material in the globe. It is produced by natural materials, it is reliable material, gives architectural freedom. After water most widely consumed material is concrete as more than ton produced every year for each person in the world. But, the environmental hazard caused by production of concrete material has concerned to make an eco-friendly material for construction. It is been studied that embodied carbon dioxide (CO_2) ranges from 700-800 kg CO_2 for a tone of concrete. The embodied carbon dioxide varies depending upon methods and type of mix design.

The preparation of geopolymer concrete is same as conventional concrete, which uses alkaline activator solution (AAS) instead of water which acts as binder for the concrete.

The following are three basic form of geopolymer:

- Poly (sialate), which has [-Si-O-Al-O-] as the repeating unit.
- Poly (sialate-siloxo), which has [-Si-O-Al-O-Si-O-] as the repeating unit.
- Poly (sialate-disiloxo), which has [-Si-O-Al-O-Si-O-Si-O-] as the repeating unit.

Geopolymer concrete is new material to be developed for use in construction work which should be eco-friendly. The following are the properties of geopolymer concrete:

- Geopolymer concrete sets at room temperature
- It is non toxic
- It has long life
- It is impermeable

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- It is a bad thermal conductor and possess high resistance to inorganic solvents
- It gives more strength.

1.2 NECESSITY OF THE WORK

Construction is one of the fast growing fields worldwide. As per the present world statistics, every year around 260,00,00,000 tons of Cement is required. This quantity will be increased by 25% within a span of another 10 years. Since the Lime stone is the main source material for the ordinary Portland cement an acute shortage of limestone may come after 25 to 50 years. More over while producing one ton of cement, approximately one ton of carbon di oxide will be emitted to the atmosphere, which is a major threat for the environment. In addition to the above huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder.

OBJECTIVES OF THE WORK

In the present experimental investigation, main objective of study is the evaluation of strength characteristics of the fiber reinforced geopolymer concrete under flexural strength. The parameters like Fluid binder ratio and basic materials standards are kept constant throughout study and molarity of alkali solution are 8M and 16M .The study conducted on M10, M20, M30 and M40 grade of concrete. The fiber used in the study is Recron 3s. The strength results are obtained at different ages (7^{th} and 28^{th} days) compared and conclusions are drawn.

SCOPE OF THE WORK

The study builds on and contributes to the development of new environmentally friendly binders in concrete. Although there are numerous studies that assess the suitability of GGBS and fly ash based geopolymer to replace OPC as a binder in concrete, many of these studies have focused on the strength properties and durability of 'ambient cured' fiber reinforced geopolymer concrete.

LITERATURE REVIEW

2.1 GENERAL

The purpose of this chapter is to relate what is already known about geopolymer concrete by discussing the theoretical derivations and experimental findings of previous studies. As the present investigation deals with study on the flexural behavior of plain and fiber reinforced geopolymer concrete composites using fly ash as source material, an attempt has been made to review briefly the available literature on the following topics:

i) Investigations on geopolymer concrete

ii) Investigations on fiber reinforced concrete.

2.2 REVIEW OF LITERATURE

2.2.1 Review on Geopolymer Concrete

Davidovits (1993, 1994) has stressed that the name alkali created a lot of confusion in peoples mind, generating false granted ideas about the properties of Geopolymer Concrete. Also, alkalies were generally thought of as the cause of deleterious Alkali-Aggregate-Reaction (AAR) in Portland cement concrete. But Geopolymer did not generate any deleterious Alkali- Aggregate Expansion. Consequently, civil engineers had a misbelief that the pH value of Geopolymer cement was very high, between 12 and 14. But the actual pH value was in the range of 11.5 to 12.5, depending on the formulations. He concluded that high pH value would be deleterious for Geopolymer concrete and safe for Portland cement, in reducing corrosion.

SUMMARY

The review of literature on earlier works on geopolymer concrete reveals in most of the previous studies, strength of geopolymer concrete cured at elevated temperature was studied. An elevated temperature curing results in development of strength at early ages only. On the other hand, little information is available in the literature about the development of strength of geopolymer concrete when cured under ambient curing at room temperature. Hence there is a lot of scope to carry out investigations on geopolymer concrete under room temperature curing. Limited research works have been performed on the fiber reinforced geopolymer concrete. Despite the engineering characteristics of the geopolymer concrete, its performance under impact loading and flexural behavior of fiber added geopolymer composite reinforced concrete beams is not still well known.

METHODOLOGY

3.1 INTRODUCTION

In this study the basic concept is to reduce the emission of CO_2 to the environment. Cement industry is a major contributor in the emission of CO_2 as well as using up high levels of energy resources in the production of cement. By replacing cement with a material of pozzolanic characteristic, such as the ground granulated blast furnace slag (GGBS) and fly ash (industrial waste), the cement and concrete industry together can meet the growing demand in the construction industry as well as help in reducing the environmental pollution.

It also describes the experimental work. The geopolymer concrete is prepared and mixed in the same manner as it is done for a conventional cement concrete. The same sequence is followed except that cement is replaced by GGBS and water which is used to form the binder is replaced by alkaline liquid. The alkaline liquid is a mixture of sodium silicate solution and sodium hydroxide of desired molarity.

3.2 MIX DESIGN OF GEOPOLYMER CONCRETE

The primary difference between geopolymer concrete and Portland cement concrete is the binder. To form geopolymer paste alkaline activator solution used to react with silicon and aluminium oxides which are present in fly ash and GGBS. This alkaline activator solution helps to bind coarse aggregate and fine aggregate to form geopolymer mix. The fine and coarse aggregate occupy nearly 75% to 80% mass of geopolymer concrete. The fine aggregate was taken as 30% of total aggregate. The density of geopolymer concrete is taken 2400 kg/m3.The workability and strength of concrete are influenced by properties of materials that make geopolymer concrete. Fly ash and GGBS are taken in equi proportion. The ratio of sodium silicate to sodium hydroxide is 2.0 and is kept constant throughout this study. The ratio of alkaline activator to the fly ash and GGBS is varies according to the mix. The required data for a particular grade of concrete is obtained.

Concrete Mix Design for M40 Grade Concrete

Mix design as per code book **IS 10262: 2009**: Guidelines for concrete mix design proportioning

Reference code book- IS: 456-2000, **IS : 9103, IS : 383**

(A)Stipulations for proportioning:

a) Gradation Design - M 40

b) Type of binder - Fly ash and GGBS

c) Maximum nominal size of aggregate - 20mm

d) Binder content - 421 kg/m^3

e) Liquid to binder ratio - 0.38

f) Degree of supervision - Good

g) Type of aggregate - Crushed angular aggregate

h) Polypropylene fibre - 909 gms/m^3

i) Workability – 100mm (slump)

(B)Test data for materials

a) Binder used - Fly ash and GGBS

b) Specific gravity of binder material - 2.8

c) Specific gravity of

1. Coarse aggregate - 2.7
2. Fine aggregate - 2.65

d) Fine aggregate: Conforming to grading Zone I of Table 4 of IS 383

e) Alkaline liquids: specific gravity of

1. Sodium hydroxide(NaOH) = 1.16
2. Sodium silicate(Na2SiO3) = 1.57

(C) Target Strength for Mix Proportioning

f'ck = fck + 1.65 *s ;* where

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

fck = characteristic compressive strength at 28 days, and

s = standard deviation.

From Table 8, standard deviation, *s* =5 N/mm^2

Therefore, target strength (f'ck) = 40 + 1.65 x 5 = 48.25 N/mm^2

(D) Selection of water binder ratio

Based on experience we adopt liquid binder ratio = 0.38

Note: the water cement ratio / liquid binder ratio is replaced by alkaline liquid to fly ash and GGBS ratio.

(E) Proportion of volume of coarse and fine aggregate content

From Table 3 of IS: 10262-2009;

Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate confining to zone-II = 0.62

Volume of coarse aggregate content = 0.62 x 0.9 = 0.56

Volume of fine aggregate content = 1-0.56 = 0.44

(F) Mix calculations

The mix calculations per unit volume of concrete shall be as follows:-

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a) Volume of concrete = 1m^3

b) Volume of binder material = $\frac{\text{mass of binder}}{\text{specific gravity of binder}} \times \frac{1}{1000} = \frac{421}{2.8} \times \frac{1}{1000} = 0.15$

c) Volume of liquid = $\frac{\text{mass of liquid}}{\text{specific gravity of liquid}} = \frac{160}{1.4} \times \frac{1}{1000} = 0.115$

d) Volume of all in aggregate = [a- (b +c +d)]

= 1-(0.15+0.115+0.007) = 0.728m^3

e) Mass of coarse aggregate = *e* x Volume of coarse aggregate x Specific gravity of coarse aggregate x 1000 = 0.728x0.56x2.7x1000 = 1100kg

f) Mass of fine aggregate = *e* x Volume of fine aggregate x Specific gravity of fine aggregate x 1000

= 0.728x0.44x2.65x1000 = 849kg

(G) Mix proportions

Binder (GGBS + Fly ash)= 421 kg/m^3 (50%+50%)

Fine aggregate = 698.17 kg/m^3

Coarse aggregate = 1182.66 kg/m^3

Polypropylene fibre = 909 gms/m^3

Liquid binder ratio = 0.38

Alkaline liquid = 159.98 kg

Note: The same method for conventional concrete is used except that the cement is replaced by fly ash and GGBS in equiproportions and the water by alkaline liquid. Another deviation from this procedure is that the water- cement ratio is taken from the Fig.1 of IS: 10262–1982 in this work.

Nominal mix calculations

The proportions of materials for nominal mix concrete shall be in accordance with table 9 of IS 456: 2000

Table 3.1 Proportions for Nominal Mix Concrete

Grade of Concrete	Total quantity of dry aggregates by mass per 50 kg of cement, to be taken as the sum of the individual masses of fine and coarse aggregates, kg Max	Proportions of fine aggregate to coarse aggregate (by mass)	Quantity of water per 50kg of cement, Max (l)
M5	800	Generally 1:2 but subject to an upper limit 1:1½ and a lower limit of 1:2½	60
M7.5	625		45
M10	480		34
M15	300		32
M20	250		30

PREPARATION OF ALKALI SOLUTION

The preparation of solution is done by dissolving sodium hydroxide in water. The concentration of sodium hydroxide changes with molarity. The quantity of sodium hydroxide solution with a concentration of 8M and 16M is calculated. The mass of NaOH solids in solution varied depending on the concentration of the solution expressed in terms of molar, M. The NaOH solution with concentration of 8M consisted of 8 x 40 = 320gm of NaOH solids per liter of the solution, where 40 is the molecular weight of NaOH. Similarly, for 16M consisted of 640gm of NaOH solids per liter of the solution. The mass of NaOH solids in a solution varies depending on the concentration of the solution. The mass of NaOH solids per kg of the solution for other concentrations is measured and expressed as percentage. In Table 3.2 percentage of NaOH flakes percentage in various Molarity are given.

Table 3.2 Percentage of NaOH flakes in various Molarity

NaOH Solution	Percentage (%)
8M	26.23
10M	31.37
12M	36.09
14M	40.43
16M	44.44

EXPERIMENTAL INVESTIGATION

4.1 INTRODUCTION

This chapter deals with the experimental programme of particulars. The materials used, concrete mix details, casting procedure, curing and testing procedures and explained.

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4.2 MATERIALS

The properties and specifications of various materials used in the preparation of test specimens are as follows.

4.2.1 FLY ASH

Fly ash (FA) is a by-product of the combustion of pulverized coal in thermal power plants. It is a fine grained powdery and glassy particulate material that is collected from the exhaust gases by electrostatic precipitators or bag filters. When pulverized coal is burnt to generate heat, residue contains 80 per cent fly ash and 20 per cent bottom ash. The size of particles is largely dependent on the type of dust collection equipment. Diameter of fly ash particles ranges from less than 1 μm–150 μm. It is generally finer than Portland cement. Their surface area is typically 300 to 500 m^2/kg, although some fly ashes can have surface areas as low as 200 m^2/kg and as high as 700 m^2/kg. However, the effect of increase in specific surface area beyond 600 m^2/kg is reported to be insignificant. In Table 4.1 Chemical composition of fly ash is given.

Figure 4.1 Picture of fly ash

Table 4.1 Chemical composition of fly ash

Oxides	Fly ash	Requirements as per IS 3812-2003
SiO_2	63.24%	SiO2 > 35 Total > 70
Al_2O_3	17.35%	
Fe_2O_3	2.63%	
CaO	2.05%	-
Na_2O	0.24%	< 1.5%
K_2O	0.32%	
MgO	0.96%	< 5%
LOI	0.95%	< 12%

GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground-granulated blast-furnace slag (GGBS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS cement can be added to concrete in the concrete manufacturer's batching plant, along with Portland cement, aggregates and water. The normal ratios of aggregates and water to cementitious material in the mix remain unchanged. GGBS is used as a direct replacement for Portland cement, on a one-to-one basis by weight. Replacement levels for GGBS vary from 30% to up to 85%. Typically 40 to 50% is used in most instances.

Figure 4.2 Picture of GGBS

GGBS is provided by a local supplier Andhra cements Visakhapatnam. It was tested as per BS: 6699 with 70% GGBS and 30% OPC53 grade. The sand used in the tests, ambient conditions and methods of tests are as per IS 4031 & IS 4032.The product is conforming to BS: 6699: 1992 specification.

Table 4.2 Test results on GGBS

Particulars	Specifications	Requirements as per BS:6699:1992
Fineness (m^2/Kg)	335	275 min
Soundness-Le Chatlier Expansion (mm)	NIL	10 max
Initial setting time (min)	150	>of OPC
Insoluble residue (%mass)	0.6	1.5 max
Magnesia content(%mass)	9.12	14.0 max
Sulphide content (%mass)	0.6	2.0 max
Sulphite content (%mass)	0.26	2.2max
Loss on ignition (%mass)	NIL	3.0 max
Manganese content (%mass)	0.38	2.0 max
Chloride content	0.018	0.1 max
Moisture content	0.20	66.7 min
Compressive strength(N/mm^2) • 7 days • 28 days	26 46	12.0 min 32.5 min
Chemical moduli		
a. $CaO+MgO+SiO_2$	78.56	66.7
b. $(CaO+MgO) / SiO_2$	1.00	>1.0
c. CaO/SiO_2	0.98	>1.4

POLYPROPLENE FIBER (RECRON 3S)

Recron 3s fiber was used as a secondary reinforcement material. It arrests shrinkage cracks and increases resistance to water penetration,

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abrasion and impact. It makes concrete homogenous and also improves the compressive strength, ductility and flexural strength together with improving the ability to absorb more energy.

Use of uniformly dispersed Recron 3s fibers reduces segre- gation and bleeding, resulting in a more homogeneous mix. This leads to better strength and reduced permeability which improves the durability. The used Recron 3s Fiber's test results are given

Figure 4.4 Picture of Recron 3s fiber

EXPERIMENTAL SETUP

4.4.1 MIXTURE PROPORTIONING

As there are no code provisions for the mix design of geopolymer concrete Certain assumptions were made in formulating the mix proportions. .The density of geo-polymer concrete is assumed as 2400 Kg/m^3. The ratio of sodium silicate solution to sodium hydroxide solution is kept at 2.0 throughout the entire work. The total volume occupied by fine and coarse aggregate is adopt

ed as 77%. The mix details are given for 6 prisms as these number of prisms were cast for each mix.

The alkaline liquid to Fly ash and GGBS ratio is selected from the table 1 of Indian standard code IS: 10262-1982 which would be adapted as water-cement ratio for M10, M20, M30 and M40. The mixes M10 and M20 are designed as nominal mixes whereas the remaining mixes are designed using standard design mix.

The mix proportions are derived and shown in Table 4.8 which gives the deduced data for a volume of one cubic meter.

Table 4.7 Mix proportions of Fiber Reinforced Geopolymer concrete for 1m^3

Materials	**M10**	**M20**	**M30**	**M40**
Fly ash (kg)	110	150	195	210.5
GGBS (kg)	110	150	195	210.5
Fine aggregate (kg)	704	500	690.56	698.17
Coarse aggregate (kg)	1408	1000	1171.45	1182.66
NaOH (kg)	44	54.96	57.135	53.32
Na2SiO3 (kg)	88	109.97	114.32	106.61
Recron 3s fiber (gm)	909	909	909	909
Alkaline liquid to fly ash and GGBS ratio	0.6	0.55	0.44	0.38
Na_2SiO_3 to NaOH	2.0	2.0	2.0	2.0

The table gives the mix proportioning for both the molarities used in this work except that the concentration of sodium hydroxide solution varies.

4.4.2 PREPARATION OF FIBER REINFORCED GEOPOLYMER CONCRETE SPECIMENS

4.4.2.1 Preparation of Alkaline Activator Solution

A combination of sodium hydroxide solution and sodium silicate solution was used as alkaline activators for geopolymerisation. To prepare sodium hydroxide solution of 8 molarity (8 M), 320 g (8 x 40 i.e, molarity x molecular weight) of sodium hydroxide flakes were dissolved in distilled water and made up to one litre. The mass of NaOH solid mass in a solution will vary depending on the concentration of the solution expressed in terms of molarity, M. The mass of solid NaOH was measured as 255 g/kg in the 8 M NaOH solution and 444.6 g/kg in the 16 M NaOH solution .This shows that water was the major component in the sodium hydroxide solution and NaOH solids was only a fraction of the mass of NaOH solution.

After casting the specimens, they were kept in moulds for 24 hours and then they were demoulded, since the geopolymer concrete did not harden immediately at room temperature it takes

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some more time as it is compared to conventional concrete. Geopolymer concrete specimens took a minimum of one and half day for complete setting without leaving a nail impression on the hardened surface. All the specimens were kept under ambient conditions for curing at room temperature.

Figure 4.5 Casting of specimen

4.4.3 TESTING OF THE SPECIMENS

The testing of concrete plays an important role in controlling and confirming the quality of cement concrete works (Shetty, 2007). Systematic testing of raw materials and fresh concrete are inseparable parts of any control programme for concrete. The main task is that when different materials are used in the concrete, careful steps are to be taken at every stage of work for different tests. The tests also have a deterring effect on those responsible for construction work. Tests are made by casting prisms from the respective concrete. It is to be noted that the standard compression test specimens give a measure of the potential strength of the concrete, not of the strength of the concrete in structure. In this study total experimentation consists of Flexural strength test.

Flexural Strength Test

Flexural strength is a measurement that indicates the resistance of a material to deformation when placed under load. The beam specimens were 500 mm x 100 mm x 100 mm in cross-section. The geometry of the beam specimen is shown in Figure 4.6

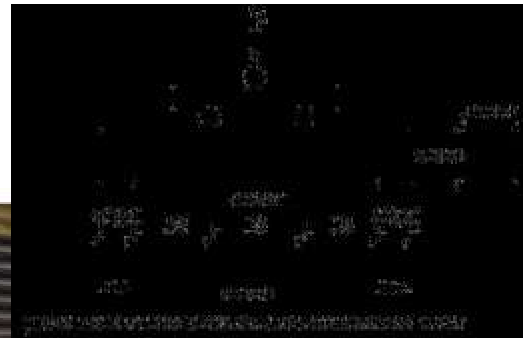

Figure 4.6 Two point loading setup in flexural test

The test specimen was mounted in a universal testing machine of 1000 KN capacity. The load was applied on two points from centre of the beam towards the support. The flexural strength of the specimen shall be expressed as the modulus of rupture fb .The photographic view of the experimental facility used to test the flexural strength is shown in Figure 4.6. Equation (4.3) and (4.4) represents the formula for calculating flexural strength

When a < 13.3, then

$$Fb = \frac{(3P \times a)}{(b \times d \times d)}$$

When a < 13.3, then

$$Fb = \frac{(P \times l)}{(b \times d \times d)}$$

where

Fb = Flexural Strength of Specimen in KN/mm2

a = Distance between crack point and nearest support point in mm.

b = Measured width of the beam in mm.

d = Measured depth of the beam in mm.

l = Length of the beam in mm.

P = Load applied in KN.

Figure 4.7 Experimental setup for Flexural strength Test

RESULTS AND DISCUSSIONS

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5.1 INTRODUCTION

In this chapter the results based on experimental work are presented and discussed. The Reinforced geopolymer concrete prisms made were tested in laboratory according to the procedures of the tests as explained in previous chapter. The tests are carried out on the concrete cubes on 7 days and 28 days of curing. The results obtained from experimental work include sieve analysis, specific gravity, unit weight of aggregate and flexural strength.

5.2 RESULTS

5.2.1 RESULTS OF MATERIALS

Tests conducted on fly ash

Specific gravity = **2.7**

Tests conducted on GGBS

Specific gravity = **2.9**

Tests conducted on Coarse aggregate

Specific gravity = **2.7**

Unit weight in loose condition = **1.55 g/cc**

Unit weight in dense condition = **1.70 g/cc**

Tests conducted on fine aggregate

Specific gravity = **2.65**

Unit weight in loose condition = **1.36 g/cc**

Unit weight in dense condition = **1.57 g/cc**

Sieve analysis of fine aggregate

The sieve analysis performed on fine aggregate showed that it belongs to zone II. A plot between the percent finer and sieve size is shown below in the Figure 5.1.

The sieve analysis of fine aggregate resulted out that it belongs to zone II.

Table 5.1 Results of sieve analysis

Sl.no	IS Siev size (mm)	% Passing
1	10	100
2	4.75	98.8
3	2.36	96.5
4	1.18	69.6
5	0.6	55.0
6	0.3	28.0
7	0.15	6

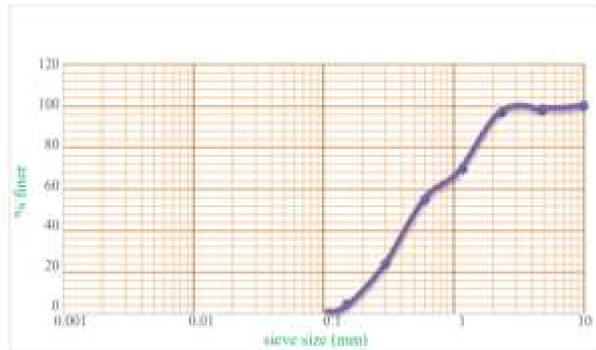

Figure 5.1 Logarithmic graph for sieve analysis of fine aggregate

5.2.2 RESULTS OF SPECIMENS

The standard sized prisms of dimensions 500mm x 100mm x100mm were tested. The test results are tabulated for 8 molar and 16 molar mixes separately. Simple graphs are plotted from this data and are presented.

16 molar

Table 5.2: 16 molar mixes 7th-day and 28th-day strength

Mix Type	Strength on 7th day (MPa)	Strength on 28th day (MPa)
M10	3.2	4.05
M20	5.2	6.5
M30	7.0	7.7
M40	8.25	8.4

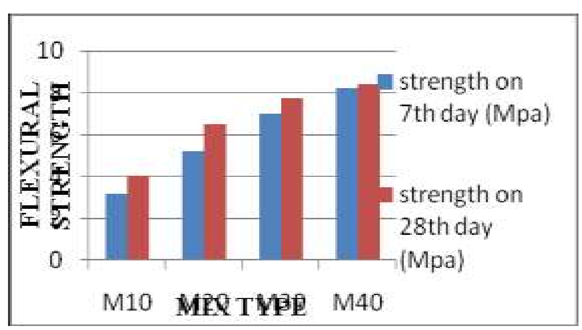

Figure 5.2 Variation of 7th day and 28th day flexural strength for 16 Molar

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8 Molar

Table 5.3: 8 molar mixes 7^{th}-day and 28^{th}-day strength

Mix Type	Strength on 7^{th} day (MPa)	Strength on 28^{th} day (MPa)
M10	2.8	3.8
M20	3.1	4.9
M30	4.9	5.2
M40	6.0	`6.8

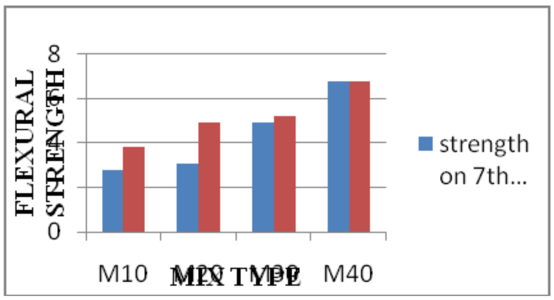

Figure 5.3 Variation of 7^{th} day and 28^{th} day flexural strength for 8 Molar

5.3 GRAPHICAL REPRESENTATIONS OF VARIATIONS

This section presents various graphical representation of variations in strength of concrete on different days of testing of the two different concretes and also compares these two concretes differing in concentration.

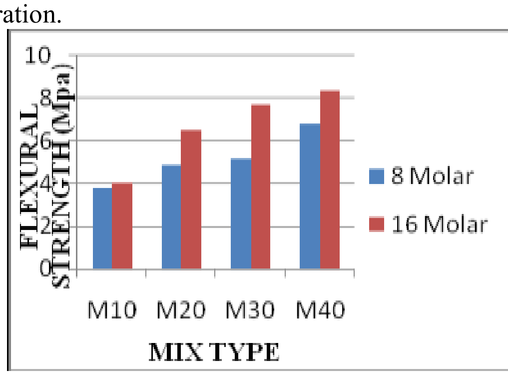

Figure 5.4 Variation of strengths between 8 molar and 16 molar on 7^{th} day testing

The above graph FIG 5.4 shows that the strength obtained for 16 molar specimens are greater than the strength obtained for 8 molar specimens on 7^{th} day testing.

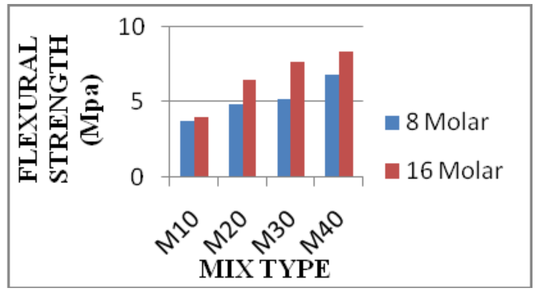

Figure 5.5 Variation of strengths between 8 molar and 16 molar on 28^{th} day testing

The above graph FIG 5.5 shows that the strength obtained for 16 molar specimens are greater than the strength obtained for 8 molar specimens on 28^{th} day testing.

A generalised variation of strength with alkaline liquid to binder ratio is plotted and shown for both the concretes of different concentrations in FIG 5.6 and 5.7.

Generalised curve for 28^{th} day strength for 16 molar

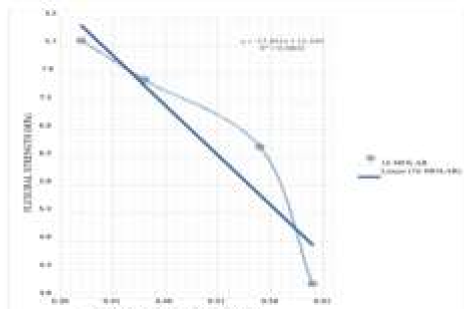

Figure 5.6 Generalised curve for 28^{th} day strength for 16 molar

Generalised curve for 28^{th} day strength for 8 molar

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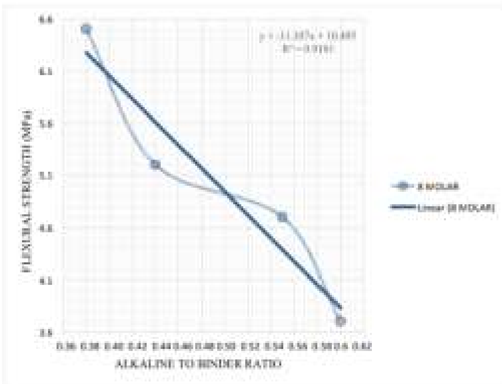

Figure 5.7 Generalised curve for 28th day strength for 8 molar

CONCLUSIONS

6.1 INTRODUCTION

This study discuss an experimental program carried out to investigate the effects of using by products and industrial waste in preparing concrete. M10, M20, M30 and M40 grades of concrete are adopted for the study. Where M10 and M20 are nominal mixes, M30 and M40 are design mixes of conventional concrete.

6.2 CONCLUSION

- The flexural strengths obtained on 7th day and 28th day testing of prism specimens of 16 molarity is greater than the 8 molarity in both nominal and design mixes.
- In 8 molarity the highest flexural strength is achieved for M40 and the strength is 6.5 MPa obtained on 28th day. The lowest flexural strength is achieved for M10 and the strength is 2.7 MPa obtained on 7th day.
- In 16 molarity the highest flexural strength is achieved for M40 and the strength is 8.4 MPa obtained on 28th day. The lowest flexural strength is achieved for M10 and the strength is 3.2 MPa obtained on 7th day.
- The generalized curve shows that the lowest ratios of Alkaline liquid to Fly ash and GGBS ratio gives the highest flexural strengths, for both 8 molarity and 16 molarity.
- Generalized curve obtained for 8 molarity is linear than generalized curve obtained for 16 molarity.
- It is observed that in 8 molarity flexural strengths increased for 28 days is 1.2 times greater than 7 days, in 16 molarity flexural strengths increased for 28 days is 1.125 times greater than 7 days.

REFERENCES

Experimental studies on Geopolymer concrete by equiproportional replacement of Fly Ash & GGBS.

Vennapusa Srinu (1), S.Narendra (2)

1 Dept., of Civil Engg., M-Tech Student (Structural Engineering), Qis institute of technology, ongole
2 Dept., of Civil Engg., Associate Professor (Structural Engineering), Qis institute of technology, ongole

TECHNICAL PAPERS

- Behzad Kalantari, Arun Prasad and Bujang B. K. Huat, (2011) "Use of cement, Polypropylene fibers and optimum moisture content values to strengthen peat" International Journal of Physical Sciences Vol. 7(8), pp. 1276 – 1285.
- P.Eswaramoorthi and G.E. Arunkumar (2014) " Fibers Study On Properties Of Geopolymer concrete With Polypropylene " Volume 3, Issue 2 (February 2014), PP.60-75
- Deotale.R.S, Sathawane S. H, Narde A.R, (2005)"Effect of Partial Replacement of Cement by Fly Ash, Rice Husk Ash with Using Steel Fiber in Concrete", Vol 3, pp 6.
- Siva Konda Reddy, B, Varaprasad, J and Naveen Kumar Reddy, K, (2009)," Strength and workability of low lime fly-ash based geopolymer concrete", Indian Journal of Science and Technology Vol.3, pp 12.
- Fareed, Ahmed, Memon, Muhd, Fadhil, Nuruddin, Samuel, Demieand, (2011) "Effect of Curing Conditions on

Strength of fly ash-based Self Compacting Geopolymer Concrete", International Journal of Civil and Environmental Engineering Vol 3, pp 3.

- Vijaya Rangan, B, Dody Sumajouw, Steenie Wallah, wantoro Hardjito Dj, (2006),"Reinforced low calcium fly ash-based geopolymer concrete beams and columns", Journal of Engineering Science and Technology Vol 4,pp16-17.

- Vijai.K, Kumuthaa.V and Vishnu ramb T.B, (2003) "Effect of inclusion of steel fibres on the properties of geopolymer concrete composites", International journal, Vol 7, pp 1-5.

- V. Supraja, and M. Kanta Rao "Experimental study on Geo-Polymer concrete incorporating GGBS" ISSN:2277-9477, Volume2

- Andi Arham Adam (2009)" Strength and Durability Properties of Alkali Activated Slag and Fly Ash-Based Geopolymer Concrete" thesis.

- Rohit Zende, and Mamatha. A (2015) "Study On Fly Ash and GGBS Based Geopolymer Concrete under Ambient Curing" JETIR (ISSN-2349-5162)