COMPARISION BETWEEN STRENGTH BEHAVIOUR OF GEO-POLYMER CONCRETE WITH FULLY REPLACEMENT OF CEMENT USING WITH FLY ASH, METAKAOLIN, SILICA FUME

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ABSTRACT

Concrete is the most abundant used man made material in the world. One of the main ingredients of concrete mixture is Ordinary Portland Cement (OPC) which is the second most utilized material after water. The amount of the CO2 released during the manufacturing of OPC is nearly one ton for every ton of OPC produced and is responsible for approximately 7% of the world's carbon dioxide emissions. In order to create a more sustainable world, innovators are developing and using a greener building material, one of them is geopolymer Concrete. This paper discusses with fully replacement of cement using with Metakoline, silica fume, Fly Ash, as source material, to produce geopolymer concrete at room temperature. It has been generally accepted that heat treatment is required for producing geopolymer concrete which is considered a drawback affecting its applications. In this paper variation of source material for Fly ash, Silica fume and Metakaoline and at various molarities like 12M, 14M and 16M is done to achieve compressive strength, Split tensile strength and flexural strength for medium grade of concrete of M-35. ambient curing is done. It is found that geopolymer concrete with Metakoline , Fly ash, silica fume as increase its strength and shows good strength with increase in the molarity of the alkaline solutions.

Keywords: Geo-polymer Concrete , Fly Ash, Metakaolin, Silica fume , alkaline activators (combination of NAOH and NA2sio3) , ambient Curing, Compressive Strength, Flexural Strength, Split tensile Strength, N35 mix design

INTRODUCTION

BACKGROUND

An old, beloved and trusty structure, it's reliably served humanity virtually from the start of history. it's found in each culture and has passed down, through mankind's history, nearly unchanged. Concrete is that the essential material for construction. one amongst the foremost vital ingredient component is normal ordinary portland cement. India is that the second largest country for manufacturing cement. India consists of one hundred thirty massive cement plants and over three hundred little cement plants. The trade capability at the start of year 2009 concerning 198 million tones. The demand of cement is growing day by day. No construction work may be haunted with out cement. The cement trade is one amongst the first producers of carbon dioxide, a significant contribution of green house gases. the amount of carbonic acid gas made throughout manufacture of 1 tone of structural cement is one tone. The cement trade is liable for seven percent of the world's carbondioxide emissions. several concrete structures are detoriate once twenty years. To scale back this associate degree alternate material are thought-about for property world. one amongst them is geopolymer concrete. This paper deals with pozzolanic materials admire Flyash, Metakaolin and silica fume as source to supply geopolymer concrete at ambient curing. Geopolymer concrete is eco-friendly green product. it's been typically accepted that ambient curing is needed for manufacturing geopolymer concrete that is taken into account a downside moving its applications. Detoriation rate of GPC structures are under CC structures during this paper variation of supply material admire flyash, Metakaoline and silicon dioxide fume and at varied molarities like 14M, 16M and 18M is completed to realize compressive strength, split tensile and flexural strength for top grade of concrete of M-35.

IMPORTANCE OF PRESENT INVESTIGATION

There is associate degree increasing interest within the use of geopolymer concrete shows the new path of reusing waste materials and to scale back the adverse effects on the environment. Geopolymer concrete product are best-known to possess much better sturdiness and strength properties than OPC concrete. These properties are investigated extensively in laboratory to verify and ensure the superior sturdiness and strength properties. The investigation conjointly discusses the factors that prohibit the utilization of geopolymer concrete as another to opc concrete and conjointly source of geopolymer concrete. Laboratory tests are conducted on compressive strength, split tensile and flexural tests for specimens with different pozzolanic material primarily based geopolymer concrete and combination of various concentration of molarity. The results obtained are compared analytically and graphically.

OBJECTIVES

The main objective of victimisation this Metakaolin and ash is to scale back environmental pollutions like water pollution,air pollution and disposal issues on agricultural lands.

1.To overcome all the above effects we are victimisation the Metakaolin, Flyash and silica fume as a cement replacement material for the preparation of concrete, by this we are able to scale back the usage of natural resources and emission of greenhouse gas within the atmosphere

2.To understand properties of geopolymer concrete so as to use it as alternative for OPC.

• to determine the economical, technological and environmental benifts of geopolymer binders over OPC.

• To verify the advance of properties like compressive strength, split tensile strength, flexural strength etc by victimisation geopolymer binders rather than OPC.

• To draw conclusion on whether or not geopolymer technology can provide an appropriate alternative for Portland cement.

DISSERTATION OUTLINE

This thesis consists of chapters, that presents the results of this analysis and therefore the detailed information on experimental and analytical work administrated during this study.

The first chapter is an introduction, particularisation the background and about conventional concrete. It conjointly offers a breif description of the analysis motivations and present investigation/objectives.

Chapter 2 covers the literature review of the various source materials used for geopolymer concrete; pros and cons and its aptness are discussed. Notably, concerning strengthening and sturdiness of structure for various water to geopolymer ratios, alkalic activators are used.

Chapter 3 describes the careful study on geopolymer concrete in the aspect of pozzolanic materials used. In the way how ppolymerisation takes place and importance of alkaline activators.

Chapter 4 describes the careful experimental program undertaken to acheive the geopolymer. The development of mix proportion for pozzolanic material primarily based geopolymer concrete are carried out. varied material properties such as compressive strength, split tensile strength and flexuralstrength have been estimated.

Chapter 5 contains the details of the numerical studies undertaken on geopolymer concrete various test conducted on geopolymer concrete and provides the physical properties various pozzolanic materials in GPC.

Chapter 6 contains outline and concluding remarks, recommendations for future research.

INTRODUCTION

The awareness on geopolymer concrete came into being within the minds of engineers and scientists during the 1940s. GPC was basically originated and developed keeping the environmental risky in mind. this technique was notably a dire need for structures because conventional concrete effect on the environmental conditions terribly seriously. Further, it's continually fascinating to strengthen the structures instead of reconstruct in economical purpose of view. The term geopolymer was 1st coined and fancied by Davidovits that was obtained from Flyash as a results of geo-polymerization reaction. Extensive studies also demonistrated that heat-cured fly ash-based geopolymer concrete has a wonderful resistance to sulfate attack due the formation of stronger polymer chain due to polycondensation reaction.

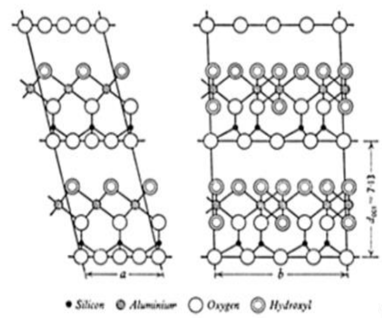

Figure3.1. Metakaolin structure

LITERATURE REVIEW

Joseph Davidovits found that Flyash reacted with alkaline answer and shaped a binding material.

Hardijito & Rangan discovered that higher concentration of hydroxide (molar) resulted higher compressive strength and better the quantitative relation of atomic number 11 silicate-to-sodium hydroxide liquid quantitative relation by mass, showed higher compressive strength of geopolymer concrete. They additionally found that the accumulated in set temperature within the vary of 30 to 90 °C accumulated the compressive strength of geopolymer concrete and longer set time additionally accumulated the compressive strength. They handled the geopolymer concrete up to120 minutes with none sign of setting and with none degradation within the compressive strength, resulted little or no drying shrinkage and low creep.

Suresh Thokchom etal rumored that the Geopolymer mortar specimens factory-made from ash with alkaline activators were structurally intact and didn't show any recognizable modification in color when eighteen weeks exposure in ten oil of vitriol answer and therefore the Geopolymer Concrete was high resistance against oil of vitriol.

D. Bondar etal indicated that the strength of geopolymer concrete faded because the quantitative relation of water to geopolymer solids by mass accumulated. Anuar etal disclosed that the concentration (in term of molarity) of NaOH influenced the strength characteristic of geopolymer concrete.

STUDY ON GEOPOLYMER CONCRETE

IMPORTANCE OF GEOPOLYMER CEMENT CONCRETES

Producing one tonne of cement requires about 2 tonnes of raw materials (shale and limestone) and releases 0.87 tonne (H" 1 tonne) of CO2, about 3 kg of Nitrogen Oxide (NOx), an air contaminant that contributes to ground level smog and 0.4 kg of PM10 (particulate matter of size 10 µm), an air borne particulate matter that is harmful to the respiratory tract when inhaled. The global release of CO2 from all sources is estimated at 23 billion tonnes a year and the Portland cement production accounts for about 7% of total CO2 emissions. The cement industry has been making significant progress in reducing CO2 emissions through improvements in process technology and enhancements in process efficiency, but further improvements are limited because CO2 production is inherent to the basic process of calcinations of limestone. Mining of limestone has impact on land-use patterns, local water regimes and ambient air quality and thus remains as one of the principal reasons for the high environmental impact of the industry. Dust emissions during cement manufacturing have long been accepted as one of the main issues facing the industry. The industry handles millions of tonnes of dry material. Even if 0.1 percent of this is lost to the atmosphere, it can cause havoc environmentally. Fugitive emissions are therefore a huge problem, compounded by the fact that there is neither an economic incentive nor regulatory pressure to prevent emissions.

The cement industry does not fit the contemporary picture of a sustainable industry because it uses raw materials and energy that are non-renewable; extracts its raw materials by mining and manufactures a product that cannot be recycled. Through waste management, by utilizing the waste by-products from thermal power plants, fertiliser units and steel factories, energy used in the production can be considerably reduced.This cuts energy bills, raw material costs as well as green house gas emissions. In the process, it can turn abundantly available wastes, such as fly ash and slag into valuable products, such as geopolymer concretes.

GEOPOLYMER CONCRETE

'Geopolymer cement concretes' (GPCC) are Inorganic polymer composites, which are prospective concretes with the potential to form a substantial element of an environmentally sustainable construction by replacing/supplementing the conventional concretes. GPCC have high strength, with good resistance to chloride penetration, acid attack, etc. These are commonly formed by alkali activation of industrial aluminosilicate waste materials such as FA and GGBS, and some other pozzolanic materials like silica fume rise husk ash, metakaolin etc, have a very small Greenhouse footprint when compared to traditional concretes.

ADVANTAGES OF GEOPOLYMER CONCRETE

1. The emissions of carbon dioxide is low.

2.It gives more economical structures.

3. It has better mechanical properties

4.It has excellent properties with in both acidic and salt environments.

PROPERTIES AND APPLICATION OF GEOPOLYMER CONCRETE

Application of geopolymer concrete technology is showing great promise to contribute positively to a sustainable concrete industry. Work conducted by Duxson et al (2007) indicated that, depending on the synthesis conditions (including nature of start materials), geopolymer concrete can be made to achieve the following properties.

- Good abrasion resistance.
- High compressive strength gain.
- Rapid controllable setting and hardening.
- Fire resistance (up to 1000ºC) and no emission of toxic fumes whenheated.
- High level of resistance to a range of different acids and salt solutions.
- Not subject to deleterious alkali-aggregate reactions.
- Low shrinkage and low thermal conductivity.
- Adhesion to fresh and old concrete substrate, steel, glass, ceramics.
- High surface definition that replicates mould patterns.
- Inherent protection of steel reinforcing due to high residual pH and low chloride diffusion rates.
- Precast concrete elements like railway sleepers, electric power poles and parking tiles etc.
- It is used in RCC structures satisfactorily.
- It is used in marine structures owing to resistant against chemical attack.

REVIEW ON POZZOLANIC PROPERTIES

The term pozzalona is used to designate a siliceous and aluminous material that itself possesses no cementatious worth however in presence of water, with chemicals react with calcium hydrate to create compounds possessing cementatious properties .The material that having the Pozzolanic property called Pozzolanic material. generally Pozzolanic materials are Industrial byproducts or Agricultural by merchandise (waste). Pozzolanic materials are those, that manufacture cementatious compounds on addition of lime. Non-Pozzolanic materials are those that don't manufacture comfortable cementatious compounds even on addition of lime. Here lime would acquire throughout association method of cement happen.

WORKING METHODOLOGY

COLLECTION OF RAW MATERIALS

FINE AGGREGATE: the sand used for our investigation is collected form Krishna river river sand which is conforming to Zone II as per Indian Specification 383-1970 codal provisions.

COARSE AGGREGATE: the coarse aggregate of max 65% of 20mm size and 35% of 12.5mm with an angular shape which is well graded.

FLYASH : flyash class f is collected from VTPS (Vijayawada Thermal Power Station)

METAKAOLIN: Metakaolin is obtained from the JEET JAICHANDLALL PVT LTD at Chennai on Tamil nadu state..

SILICA FUME: silica fume is obtained from SUPPLIERS AT VIJAYWADA

TESTS ON CONCRETE

FRESH CONCRETE

The test conducted on fresh concrete is workability of the concrete.

Workability:

Workability is defined as the ability of the fresh concrete to fill the mold under proper vibration without reducing the quality. Properties which influence workability are water content, aggregate, cement type, age of concrete and admixtures. Workability increases with increase in water content i.e. more water content results in bleeding and segregation of concrete mix which in turn results in the strength reduction. Chemical admixtures also increase the workability. Concrete mix from undeniable graded aggregate results in harsh mix having low slump which in turn results in low workability.

1. Slump cone
2. Compacting factor
3. Vee- bee test

In this project to determine the workability test is by flow test conducted.

Fig 5.1: flow Slump dimensions

Flow, percent=speard diameter-25/25X100

Result: The percentage of flow test is 80%

HARDENED CONCRETE

The tests performed on the cured concrete are compressive strength, flexural strength, split tensile strength.

PREPARATION OF SPECIMEN

Before placing the concrete in the mould, its interior surface and base plate were lightly oiled to prevent the unevenness of the specimen. The mixed concrete is placed in the oiled mold in layers, each layer of having 5cm thick. After placing each layer it is pampered 30 times using a slandered tampered rod. The strokes penetrated into the underlying layer and the bottom layer was ridded throughout its depth.

CURING OF TEST SPECIMEN

As soon as the concreting is completed, the mould is stored in a oven at 600c for 24 hours. Later the specimen is placed at room temperature untill taken for testing.

COMPRESSIVE STRENGTH

After 7 days and 28 days of curing the sample cubes are tested for compressive strength under compressive testing machine. The test samples are taken to testing. For one trail at least three specimens are to be tested.

The cube are placed under the compressive testing machine in a way that the load should be applied opposite faces of the other than the casted faces. The load is applied on the cube continuously at the rate of 140kg/cm2/min. the load is applied till the load break down and no more load can be taken i.e. the red needle returns back. The ultimate load is noted. The compressive strength is determined by dividing the ultimate strength by cube cross sectional area. Similarly the remaning two specimens are also tested. The average of the three specimens of one particular batch of mix gives the compressive strength. The variation of the strength of individual strength should not exceed more than 15%. If exceeded repeat the test.

FLEXURAL STRENGTH TEST

Concrete specimen beams are used to determine flexural strength of concrete and were tested by applying two point loading as per IS 516-1959.

Description of Testing Machine for Flexural Strength

The testing machine may be of any reliable type of sufficient capacity for the test. The bed of the testing machine shall be provided with two steel rollers, 38mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from centre to centre 40cm for 10cm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span i.e. spaced at 13.3cm centre to centre. The axis of the specimen shall be carefully aligned with the axis of the bearing surfaces of the specimen and the rollers. The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 7kg/sq.cm/min i.e., 180kg/min for the 10.0cm specimens. The arrangement for loading of flexural specimen is shown in fig 4.3 and universal testing specimen is shown in fig,

Fig- 5.4. Flexural testing machine with specimen

RESULTS AND DISCUSSIONS

Tests are conducted for geopolymer concrete made of replacement of Cement with Rice FlyAsh, Metakaolin, SilicaFume and the compressive strength, Split tensile strength and flexure strength are studied for different ages of curing. In this thesis work GEOPOLYMER BASED FLYASH, GEOPOLYMER BASED METAKAOLIN and GEOPOLYMER BASED SILICAFUME are used and comparison between the obtained strength values have observed. The results are tabulated and discussions have been made.

COMPRESSIVE STRENGTH RESULTS

Concrete cubes are casted for design mix at M35 replacement of Fly Ash, Metakaolin, SilicaFume. The compressive strength for M35 grade is tested for 3 to 56days age of curing and the obtained results are tabulated in the form of table and graph.

SPLIT TENSILE STRENGTH

Concrete cubes are casted for design mix at M35 replacement of Fly Ash, Metakaolin, SilicaFume. The Tensile strength for M35 grade is tested for 3 to 56days age of curing and the obtained results are tabulated in the form of table and graph.

CONCLUSION AND FUTURE SCOPE

SUMMARY

The need to study the role of supplementary Cementing materials like Fly Ash, Metakaolin, Silica Fume in concrete has been justified.

Concrete cubes were cast, cured and tested for Compressive Strength, Flexural Strength and Split Tensile Strength with full replacement of FlyAsh, Metakaolin and Silica Fume. The results have been presented in the form of tables and graphs in detail.

CONCLUSION

1.Geopolymer concrete is more environmental friendly and has the potential to replace ordinary cement concrete in many applications such as precast units.

2.Early strength is slightly greater in Geo Polymer Concrete than the conventional concrete

3.Early strength is attain with metakaolin when compared to flyash and silicafume.

4.Compressive strength increases with increase in concentration of NaOH from 12M to 16M. Increase in compressive strength was also observed with 24 hours curing time.

5.The test results show that the compressive strength increases with increase in air curing time from 3days to 56 days.

6.The compressive strength of GPC specimens with 16M is 1.15 times more than that of GPC with other molarities after 28 days and 56 days of ambient curing.

7.The split tensile strength of GPC specimens with 16M is 1.12 times more than that of GPC with other molarities after 28 days and 56 days of ambient curing.

8.The Flexural strength of GPC specimens with 16M is 1.058 times more than that of GPC with other molarities after 28 days and 56 days of ambient curing.

9.From the observations it is clear that when the molarity increased, the compressive strength is increasing. Compared to flyash based concrete and silicafume based cocrete the compressive strength of metakaolin based concrete are high, but the cost of metakaolin based concrete is more.

10.Geopolymer technology does not only contribute to the reduction of greenhouse gas emissions but also reduces disposal costs of industrial waste.

11.Geopolymer technology encourages recycling of waste and finally it will be an important step towards sustainable concrete industry.

12.As flyash and siliucafume is waste material, it reduces the cost of construction and reduces pollution in environment.

SCOPE FOR FURTHER STUDY

Although several studies were conducted on behavior of geopolymer concrete and by replacing Cement with flyash, metakaolin, silicafume concrete were studied earlier. Different physical and mechanical properties on geopolymer concrete were also studied to find the combination of pozzolanic materials. On geopolymer concrete several studies conducted with sulphate attack and alkaline attacks were studied later, the research pertaining to the effect of sea water on geopolymer concrete studies have to do. Following few avenues may be studied further to understand the behavior and to deliver guidelines useful for design of geopolymer concrete structures.

Effect of different combinations of water to binder ratio to improve the strength of geopolymer concretes further for best economical results.

Effect of different combinations of sodium silicate to sodium hydroxide ratio to improve the strength of geopolymer concretes further.

The study can be further investigated with 18M and other higher molarities.

Durability studies of geopolymer concrete exposed to elevated temperatures with different cooling conditions.

Water absorption studies of geopolymer concrete replaced by different pozzolanic admixtures to elevated temperatures with different cooling conditions.

REFFERENCES

1. Davidovits J (1995) Global warming impact on the cement and aggregate industries. World Res Rev 6(2):263–278

2. Hardjito D, Wallah SE, Sumjouw DMJ, Rangan BV (2004) On the development of fly ash based geopolymer concrete. ACI Mater J 101:467–472

3. Mullick AK (2005) Use of fly ash in structural concrete: part I—why? Indian Conc J 79:13–22

4. Kumar V, Mathur M, Sinha SS, Dhatrak S (2005) Fly Ash: an environmental savior. Fly Ash Utilisation Programme (FAUP), TIFAC, DST, Fly Ash India, New Delhi, IV, pp 1.1–1.4

5. Malhotra VM, Ramezanianpour AA (1994) Fly Ash in concrete. Canada Centre for Mineral and Energy Technology (CANMET), Canada

6. Malhotra VM (1999) Making concrete greener with fly ash. ACI Conc Int 21(5):61–66

7. Davidovits J (1991) Geopolymers: inorganic polymeric new materials. J Therm Anal 37:1633–1656

8. Davidovits J (1994) Geopolymers: man-made geosynthesis and the resulting development of very early high strength cement. J Mater Edu 16(2, 3):91–139

9. Davidovits J (1988) Geopolymer chemistry and properties. In: Proceedings of 1st European conference on soft mineralurgy. Geopolymere, vol 88, France, pp 25–48

10. Rangan BV (2008) Mix design and production of fly ash based geopolymer concrete. Indian Concr J 82:7–15

11. Anuradha R, Sreevidya V, Venkatasubramani R, Rangan BV (2012) Modified guidelines for geopolymer concrete mix design using Indian standard. Asian J Civ Eng (Build Hous) 13 (3):353–364

12. Patankar SV, Jamkar SS, Ghugal YM (2012) Effect of sodium hydroxide on flow and strength of fly ash based geopolymer mortar. J Struct Eng 39(1):7–12

13. Jamkar SS, Ghugal YM, Patankar SV (2013) Effect of fineness of fly ash on flow and compressive strength of geopolymer concrete. Indian Concr J 87(4):57–61

14. Patankar SV, Jamkar SS, Ghugal YM (2014) Selection of suitable quantity of water, degree and duration of heat curing for geopolymer concrete production. In: Proceedings of 3rd international conference on recent trends in

engineering and technology, ICRTET'2014.Supported by Elsevier

15. Patankar SV, Jamkar SS, Ghugal YM (2014) Effect of grading of fine aggregate on Flow and compressive strength of geopolymer concrete. In: UKEIRI concrete congress-innovations in concrete, pp 1163–1172

16. Patankar SV, Jamkar SS, Ghugal YM (2012) Effect of solution-to-fly ash ratio on flow and compressive strength of geopolymer concrete. In: Proceedings of 8th biennial conference on structural engineering convention (SEC–2012) at S.V.N.I.T., Surat, pp 161–166

17. Patankar SV, Jamkar SS, Ghugal YM (2013) Effect of water-to-geopolymer binder ratio on the production of fly ash based geopolymer concrete. Int J Adv Technol Civ Eng 2(1):79–83

18. Rangan, B. V., Hardjto, D. 2005. Development and properties of low calcium fly ash based geopolymer concrete. Research report GC-1, Faculty of Engineering, Curtins University of Technology, Perth, Australia.

19. Bakharev, T. 2005. Geopolymeric materials prepared using Class Fly ash and elevated temperature curing. Cement and Concrete Research. 35: 1224-1232.

20. Rangan, B.V., Wallah, S.E. 2006. Low-calcium fly ash based geopolymer concrete: long term properties. Research report GC-2, Faculty of Engineering, Curtin University of Technology, Perth, Australia.