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Experimental Study on Translucent Geopolymer Concrete

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ABSTRACT

The cement industry is the India's second highest payer of Central Excise and Major contributor to GDP. With infrastructure development growing and the housing sector booming, the demand for cement is also bound to increase. However, the cement industry is extremely energy intensive. Therefore, in order to tackle the current situation and increasing global carbon footprint every year our team has decided to replace cement in ordinary concrete with Fly ash to obtain a cleaner yet equally strong and durable concrete. Alternative but promising gainful utility of Fly Ash and Ground Granulated Blast Furnace Slag in construction industry that has emerged in recent years is in the form of Geopolymer cement concretes' (GPCCs), which by appropriate process technology utilize all classes and grades of FA and GGBS; therefore, there is a great potential for reducing carbon emissions to a great extent. Also, the product obtained will be much cheaper efficient and will gain strength faster. But, this process has already been developed tried and tested. Rapid growth in population has led to dense building constructions with cement and concrete with large internal lightening requirement. To achieve energy efficiency, new and innovative materials are required for sustainable construction practices. This remains as a challenging task for engineers and other building professionals to design and promote low energy requirement buildings in a cost effective and environmentally responsive way. Therefore, as a team we have decided to further help the environment by experimenting light transparency in Geo Polymer Concrete. Optical fibres in the range of 4 to 5% by volume is used for transparent concrete. Thickness of the optical fibres can be varied between 2 µm and 2 mm to suit the particular requirements of light transmission. The main advantage of translucent concrete is that it can transmit light. There, it can be used to make green buildings. Since it can transmit light from natural as well as artificial sources, the building can have fewer lights to meet its demand for lighting. Thus, saving huge energy cost. Transparent concrete uses sunlight as source of light instead of electrical energy and reduces power consumption. This concrete can also be used cold countries to transmit heat with sunlight. Thus, by introducing the Geo Polymer Translucent concrete we can expect a better and efficient concrete with the same durability as per the current standards.

INTRODUCTION

Rapid growth in population has led to dense building constructions with cement and concrete with large internal lightening requirement. To achieve energy efficiency, new and innovative materials are required for sustainable construction practices. This remains as a challenging task for engineers and other building professionals to design and promote low energy requirement buildings in a cost effective and environmentally responsive way.

Concrete is the primary materials used in civil engineering, mostly in structural industries. OPC (Ordinary Portland Cement) is mostly used as major binding material to produce concrete, but during preparing its emitted carbon dioxide and energy. The matter of environmental concern in view of global warming.

From environmental aspect, the world is concerning about the Global warming & increase in environmental pollutions, which is caused in engineering field mainly by cement production. While producing cement a huge amount of carbon dioxide is emitted to atmosphere. To overcome this phenomenon, either we can partially replace cement with fly ash, GGBS, Rice husk ash etc…or we can use the Geopolymer technology. Geopolymer concrete which can also be called zero cement concrete is an innovative construction material that has alkaline solution i.e. (sodium hydroxide & sodium silicate) and the fly ash as a binding material. Fly ash is a rich source of silica and alumina which react with alkaline solution and produces alumina silicate gel that acts instead of cement in concrete.

Geopolymer technology mainly aims in total replacement of Portland cement. Geopolymer concrete is gaining its popularity globally as a construction material. This technology was coined by Professor Joseph Davidovits. Geopolymers mainly uses alkaline activators such as silicates of potassium or sodium and hydroxides of potassium or sodium along with industrial by-products like ground granulated blast furnace slag (GGBS), fly ash etc. The alkaline activator liquid used in geopolymer concrete undergoes geopolymerization and then reacts with by-products of industries and produces binding property and binds the aggregates. In this study fresh property, hardened property, durability properties and microstructure studies of different mineral admixture based geopolymer concretes are discussed based on different curing conditions and molarity

In a quest to make concrete without the use of cement, the process of Geo - Polymerization of cementitious materials concrete was discovered. The benefits of reduced CO2 derived by usage of Geo-

Polymer instead of Cement are not obtained fully as the Geo-Polymerization to occur a higher temperature is required. This study is an attempt to obtain Geo-Polymer concrete in the ambient room temperature without creating any specialized curing conditions.

In the present work, light transmitting blocks of size 200mmx100mmx100mm were prepared by using plastic optical fibres. In this work, plastic optical fibres of 0.38mm diameter were used. Fibres are inserted in mortar bricks in order to investigate the light transmitting potential and also the strength parameter i.e., Compressive strength. The optimum fibre percentage is used for casting of prisms of size 50cmx10cmx10cm with mesh, fibres and combination of both mesh and fibres to observe the flexure crack pattern and study of the flexural strength and has been compared with that of conventional concrete.

OBJECTIVES

The main goal of the team is to help environment in combating pollution uprising. Therefore, we have taken a bold step forward in the lieu of environmental responsibility.

Objectives of our project are:

- Studying the impact of today's pollution on the future due to current construction standards.
- Performing a comprehensive research of materials which can be suited as best alternative towards omitting current high pollution standards.
- Conduct a detail study about different factors of concrete and its properties.
- Performing a detailed survey about material design mix for the concrete and detailed procedure for the same.
- Discuss the application of the product and shortcomings with remedies and perform a real-world analysis.

Conclude the research with appropriate results of product strength quality and durability.

METHODOLOGY

Preparation of alkaline solution

We used 8 molarity of sodium hydroxide solution for study. Preparation of alkaline solution is depend on it molecular weight of NaOH &Na2SiO3 are 40 and 282.4 respectively.to preparing 8 M of NaOH, Take 8×40=320 gram of NaOH pallets(9). These weighed pallets are dissolved in 1 liter distilled water. Then prepare sodium silicate solution and mixed both solution. These solutions should be prepared 24 hours before use for Geopolymer concrete in experiment. In this study used 8M constant solution but take different ratio of sodium silicate to sodium hydroxide i.e. (0.5, 1.5, and 2.5).

Mixing, Casting & Curing of Geopolymer Concrete

Geopolymer concrete manufactured same as conventional technique used for manufacturing OPC. In this process, first mixing of aggregates and fly ash up to 3 minutes it's called dry mixing of aggregate. After get good mixing of dry material add alkaline activator solution. It will be mixed for 5 minutes up to the homogeneous paste was obtained. (6)The addition of AA solution polymerization will take place emitting large amount of heat which mean the GPC must be used for 24 hours applicable.

In this method special formwork is to be made by drilling holes on any two opposite sides. Sides of formwork are then assembled on a base plate. The plate should be cleaned and oiled properly and then optical fibres are passed through the holes. Optical fibres are clamped on both the sides keeping the optical fibre in slight tension. Concrete mixture is then poured slowly into the formwork. During the process of casting concrete, the formwork is placed on vibrating machine in order to prevent air voids between optical fibre and concrete mixture, the concrete is now allowed to set for 24 hours and then formwork is removed and further curing process is carried out on the concrete block. Sides of the concrete block are polished for more aesthetical look.

MERITS

It is a newer product that is making traditional concrete look not so spectacular. Here are some of the top advantages of geopolymer concrete.

1. High Strength –

It has a high compressive strength that showed higher compressive strength than that of ordinary concrete. It also has rapid strength gain and cures very quickly, making it an excellent option for quick builds.

Geopolymer concrete has high tensile strength. It is less brittle than Portland concrete and can withstand more movement. It is not completely earthquake proof, but does withstand the earth moving better than traditional concrete.

2. Very Low Creep and Shrinkage –

Shrinkage can cause severe and even dangerous cracks in the concrete from the drying and heating of the concrete or even the evaporation of water from the concrete. Geopolymer concrete does not hydrate; it is not as permeable and will not experience significant shrinkage.

The creep of geopolymer concrete is very low. When speaking of creep in concrete terms it means the tendency of the concrete to become permanently deformed due to the constant forces being applied against it.

3. Resistant to Heat and Cold –

It has the ability to stay stable even at temperatures of more than 2200 degrees Fahrenheit. Excessive heat can reduce the stability of concrete causing it to spall or have layers break off. Geopolymer concrete does not experience spalling unless it reaches over 2200 degrees Fahrenheit.

As for cold temperatures, it is resistant to freezing. The pores are very small but water can still enter cured concrete. When temperatures dip to below freezing that water freezes and then expands this will cause cracks to form. Geopolymer concrete will not freeze.

4. Chemical Resistance –

It has a very strong chemical resistance. Acids, toxic waste and salt water will not have an effect on geopolymer concrete. Corrosion is not likely to occur with this concrete as it is with traditional Portland concrete.

This type of geopolymer concrete is starting to revolutionize concrete. It is being used more in highway construction projects and offshore applications. Construction is one of the world wide growing fields. As per the present world statics, every year million tons of cement are required. Ordinary Portland cement is commonly used in concrete. While producing one ton of cement, approximately one ton of carbon di oxide will be emitted to the atmosphere, which

cause major problems in environment. Also huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder. The Thermal Industry produces a waste called fly ash which is simply dumped on the earth, occupies large areas. The waste water from the Chemical Industries is discharged into the ground which contaminates ground water. By producing Geopolymer Concrete all the above mentioned issues shall be solved by rearranging them.

Waste Fly Ash from Thermal Industry + Waste water from Chemical Refineries = Geo polymer concrete.
Since Geopolymer concrete doesn't use any cement, the production of cement shall be reduced and hence the pollution of atmosphere by the emission of carbon di oxide shall also be minimized.

It has good light transmitting property and the ratio of optical fibre volume to concrete is proportion to transmission. It has very vital property for the aesthetic point of view. It can be used for the best architectural appearance of the building. Also used where the light cannot reach with appropriate intensity. Optical fibre also acts as reinforcement for the concrete.

Environmental benefit

De-carbonation of lime and calcination of cement clinker release CO2 as a reaction product in OPC concrete while the use of an alkaline hydroxide or silicate activating solution rather than water for cement hydration does reintroduce some CO2. Production of these activators needs temperature similar to de-carbonation of lime in OPC manufacture. The CO2 emission of geopolymer concrete can be quantified in terms of its compositions. Referring to the research was done by author, 110kg of activator is needed to be mixed with 400kg pozzolan to produce 1m3 of geopolymer concrete which has the CO2 emission equal to 27.5% of the same amount of OPC, when pozzolan used in natural state (It is estimated that the production of 1 tone of OPC results in the release of 1 tone of CO2). If the calcined form is used, the CO2 emission of AANP concrete would be the summation of CO2 emission due to producing the required activators and the amount related to calcination procedure. Since the temperature required for calcination these materials, is half of that needed to de-carbonate lime, the CO2 emission for calcinations of these materials can be considered 50% of equal OPC production. Therefore, in this case the CO2 emission

of geopolymer concrete increases to 77.5% of the amount emitted by the same weight of OPC. Hence the geopolymer concrete manufacture is liable to reduce CO2 emission from 22.5% to 72.5% compared to OPC production (Bondar, 2009).

DEMERITS

GPC needs higher temperature curing. Ambient temperature cured GPC has quite lower strength and durability. The properties of GPC are highly depending on the casting curing condition (it is very sensitive to the moisture, temperature, pressure etc.). Also, efflorescence is also a big problem for GPC.

Geopolymer cement is an innovative material and a real alternative to conventional Portland cement for use in transportation infrastructure, construction

and offshore applications.

Geopolymer cements cure more rapidly than Portland-based cements. They gain most of their strength within 24 hours. However, they set slowly enough that they can be mixed at a batch plant and delivered in a concrete mixer.

Being having many benefit Geopolymer Cement is less popular than Portland Cement because it's more expensive and many people are not aware about it unique features and benefits.

CONCLUSION

I. The compressive strength of light transmitting concrete is greater than that of conventional concrete up to some certain limit, beyond that limit the compressive strength goes on decreasing with increase in the volume of optical fiber.

II. The highest compressive strength occurs at optimum 4% of fibers with 18 strands at 4 positions.

III. The compressive strength of optimum light transmitting mortar brick is increased by 78.8% than that of nominal or conventional concrete.

IV. The flexural strength of optimum light transmitting concrete prism with fiber is increased by 2.485% than that of conventional concrete.

V. Also, the flexural strength of optimum light transmitting concrete prism with mesh alone is increased by 8.053% that that of conventional concrete prism.

VI. Finally, the flexural strength of optimum light transmitting concrete prism with a combination of mesh and fiber is increased by 53.03% than that of conventional concrete prism.

VII. It has good light transmitting property and the ratio of optical fiber volume is proportional to transmission. It is mainly recommended for aesthetic point of view and for architectural aspects.

Moreover, this light transmitting concrete can be utilized in the production of special types of home furniture. Also used where light cannot reach with appropriate intensity and also carries the same amount of light through a brick no matter how thick it is.

It is a Clear Example of Technology Transformed into Art Creating an Ecologically Solution that Reduces to Minimum Energy Consumption We have concluded that the compressive strength of M25 grade concrete compared with the both normal concrete as well as fibre concrete tends to be more or less same. Further we conducted the power transfer test on optic fibre to find the intensity loss. The test were done on three sources namely invisible spectrum (880nm), visible spectrum (650nm), and laser (770nm). By comparing it with normal fibre and plastic optic fibre, the intensity loss of fibre is less. In economic point of view the cost of the optic fibre is high. So we replaced with the optic fibre made by clear casting resin which is economically feasible. The Light Transmitting concrete do not loses strength parameter when compared to regular concrete. It has good light transmitting property and the ratio of optical fibre volume to concrete is proportion to transmission. Thus very vital property for the aesthetic point of view. It can be used for the best architectural appearance of the building. Also used where the light cannot reach with appropriate intensity. Optical fibre also acts as reinforcement for the concrete. All research papers and review papers show Geopolymer concrete is a best alternative construction material to replace the conventional concrete for reducing the carbon dioxide emission. To gain sufficient strength 60 to 90-degree Celsius curing temperature is good without water curing, but still can gain strength in room temperature. Increase of molarity of sodium hydroxide increases strength of concrete. Low calcium fly ash and increasing GGBS showed increase in strength of concrete.

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