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A Study on Mechanical Properties of High Strength Geo-polymer Concrete

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ABSTRACT

Finding means of utilizing waste products is very important in field of research at this moment. Efforts are urgently underway all over the world to develop environment friendly construction materials which help to reduce greenhouse gas emissions from Cement industries. In this connection, Geopolymer concretes (GPCs) are new class of building materials that have emerged as an alternative to Ordinary Portland Cement Concrete (OPCC) and possess the potential to revolutionize the building construction industry.Researchers have critically examined the various aspects of their viability as binder system. GPCs were produced from fly ash mixing with alkaline activators of sodium hydroxide and also sodium silicate solutions of some molar concentration. High range water reducing admixtures are used to develop sufficient workability. The objective of the present work is to study the effect of SCMs in fly ash based Geopolymer concrete at ambient room temperature curing. The present work deals with a development of Ground Granulated blast furnace slag (GGBS) based GPC. Trial mixes are carried out and results are compared. Workability properties of fresh state are measured and flexural strength properties are assessed at 7 and 28 days. The Reinforced GPC and OPC beams were designed considering a balanced section for the expected characteristic strength. Beams of length 1.15 m are laid to have a clear span of a one meter length beam and a cross section of 100*150 mm is chosen. Flexural behaviors of reinforced beams are assessed in UTM using 0.01 mm least count deflect meters. Load- Deflection characteristics are obtained and study has been carried out simultaneously.

Keywords : Waste utilization, Environmental sustainability, Construction materials, Greenhouse gas emissions, Geopolymer concrete (GPC), Ordinary Portland Cement Concrete (OPCC), Binder system, Fly ash, Alkaline activators, Sodium hydroxide, Sodium silicate, Water reducing admixtures, Workability, Flexural strength, Reinforced concrete

Introduction:

Concrete is generally utilized as construction material. Portland cement is the principle part utilized for making concrete. The concrete business is in charge of CO_2 discharge, in light of the fact that the creation of one tonne Portland bond frees around one tonne CO_2 into air which is not ecofriendly. Davidovits begat the term 'Geopolymer' to typify these binders. The Geopolymer innovation expresses that an option cover can substitute the Portland cement in concrete industry. Fly ash, silica fume, ground granulated blast furnace slag, rice husk ash and met kaolin can be utilized as an option fastener rather than concrete. Geopolymer cement is a high quality and lightweight inorganic polymer solid that can be utilized as a part of place of ordinary cement. It is made by blending diverse mixes of solidifying materials, for example, silica fume, rice husk ash, metakaolin, and Ground granulated blast furnace slag (GGBS) and Fly ash alongside fine aggregate, coarse aggregate and alkaline solution. Geopolymer concrete has picked up its fame as the interest for a green and maintainable building material. Around 75%-80% of the mass is made of coarse and fine aggregates. Nowadays the advancement of option materials to Portland cement concrete has turned out to be vital. The outline of Geopolymer cement gives an option answer for creation of ordinary cement. Normally, Geopolymers are blended from two-section blend, comprising of a basic arrangement (regularly solvent silicate) and strong alum inosilicate materials. High quality geopolymer cement is a solid blend which has high toughness and high quality when contrasted with ordinary cement. This concrete contains at least one cementitious materials, for example, fly ash, silica fume or ground granulated blast furnace slag as ordinarily a superplasticizer. The term high quality is to some degree self-important on the grounds that the fundamental fates of this solid is that its fixings and extents are particularly picked in order to have especially fitting properties for the normal utilization of structure, for example, high quality and low porousness. Geopolymer Concrete might likewise be utilized as a part of the Infrastructure works. Strengthened geopolymer cement ought to be used for composite materials in development of streets, extensions, building and other common frameworks. The interest for the material is required to increment in future attributable to ascent of framework needs in many creating and mechanical nations.

Materials:

Ground Granulated Blast furnace Slag (GGBS)

Ground Granulated Blast Furnace slag (GGBS) is the granular material shaped when liquid iron blast furnace slag (a by-result of iron and steel making) is quickly chilled (extinguished) by inundation in water. It is a granular item, very Cementitious in nature and, ground to concrete fineness, hydrates like Portland bond. Ground granulated impact heater slag (GGBS) is a by-item from the impact heaters while making iron. GGBS is one of the "greenest" of development materials and in addition the natural advantage of using a by-item, GGBS replaces something that is created by an exceptionally vitality serious process. By correlation with Portland cement, fabricate of GGBS requires not as much as a fifth the vitality and creates not as much as a fifteenth of the carbon dioxide discharges. GGBS which is locally accessible in gadivemula, close to Kurnool area from JSW cement production line**.**

Alkaline Liquids:

In readiness of Geopolymer Concrete (GPC), Sodium Hydroxide arrangement (NaOH) and Sodium Silicate arrangement (Na_2SiO_3) are utilized as basic activators. Sodium Hydroxide arrangement is set up by dissolving pellets in deionized water. Over the top warmth is developed amid blending of pellets in water and to stay away from this, arrangement is readied one day ahead of time. Sodium Silicate is known as fluid glass or water glass, and is accessible in fluid (gel) frame. The synthetic arrangement and physical properties of Sodium Silicate and Sodium Hydroxide.

Silica fume

Silica fume, otherwise called micro silica, (is an undefined (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder gathered as a by-result of the silicon and ferrosilicon composite creation and comprises of round particles with a normal molecule distance across of 150 nm. The principle field of utilization is as pozzolanic material for elite cement concrete. Silica fume is added to Portland cement to enhance its properties, specifically its compressive quality, bond quality, and abrasion resistance.

Reinforcing Steel

We never really observe it on the grounds that fortified steel is always covered. Concrete fortifying steel is utilized as a part of scaffolds, structures, high rises, homes, distribution centers, establishments and streets to expand the quality of the solid and at last help hold up the structures. While concrete alone is strong, strengthening steel essentially builds the strength of cement in a conservative and safe way
SuperplasticizersThese are later and more viable kind of water diminishing admixtures otherwise called high range water reducer. The primary advantages of super plasticizers can be condensed as takes after: Increased smoothness: Flowing Self-leveling Self-compacting solid Penetration and compaction round thick support

MixingofConcrete
Themixingof concreteis essential forthe production of uniformconcretethemixingshouldbemakesurethattheconcretebecomeshomogeneous,uniformandconsistency.Mixingofconcreteisdoneaccordingto I.S: 516-1959.Mixingoftheconcrete is done using a pan mixer. The ingredients cement,fine aggregates, coarseaggregates and water are introduced into the pan mixer. Initially dry cement and fineaggregates weremixed to which coarse aggregates were added and thoroughly mixed.

Cracking in Flexural members

In general, VRCC beams and GRPC beams crack at loads well below the service load and even prior to loading due to restrained shrinkage. Flexural cracks are not only inevitable but are necessary for the reinforcement to be used effectively. In a well-designed beam, flexural cracks are very fine and are invisible for casual observation. These cracks permit a little if any, for the corrosion of reinforcement.

Factors Affecting Crack Width

Bond between steel and concrete is the prime factor that effects crack width. Proper end anchorage in steel bars avoid in formation of hair line cracks. Beams with smooth round bar display a relatively small number of rather wide of in service, while beams with good slip resistance ensured by proper surface deformations on the bars show a large number of invisible cracks. The second factor of importance is the stress in the reinforcement. Experiments had shown that crack spacing and crack width are related to concrete cover and generally the increase in bottom cover increases the spacing of cracks and the crack width.

Permissible Crack Width and Control

Cracking of concrete should not adversely affect the appearance or durability of structure, the acceptable limits of cracking would vary with the type of structure and the environment. In members where cracking in the tensile zone is harmful either because they are exposed to the effects of the weather or continuously expose to moisture or in contact soil or ground water, an upper limit of 0.2 mm is suggested for the maximum width of cracks. For the aggressive environment particularly, the severe category, the surface width of cracks should not exceed

0.1 mm. It is always good to use a larger number or smaller diameter bars to provide the required area of steel than to use the minimum number of larger dia bars to control cracking. The bars should be well distributed in tensile zone of the concrete.

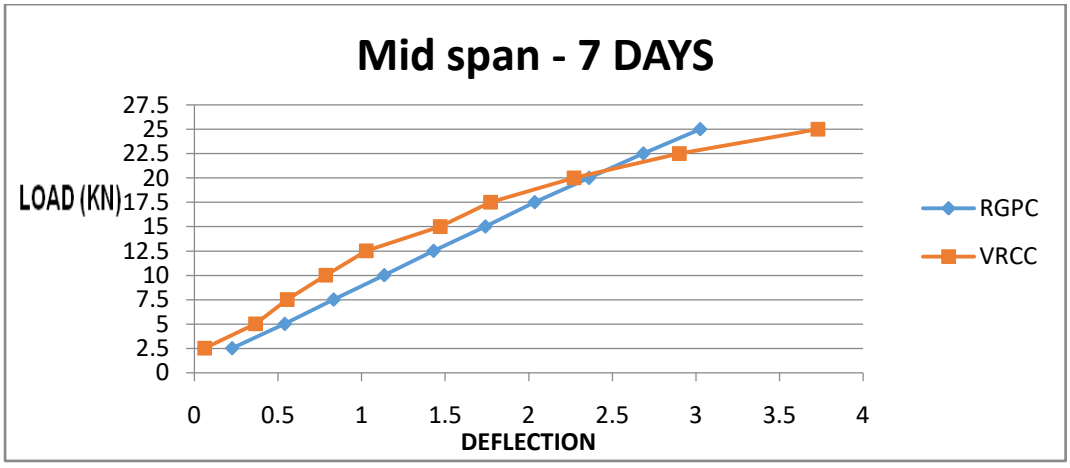
Deflections

Readings on dial gauges were recorded for deflections at 0.72 L, 0.28 L and mid span for RCC and RGPC respectively. Readings were recorded to a minimum of 0.01 mm with dial gauges with a least count of 0.01 mm.

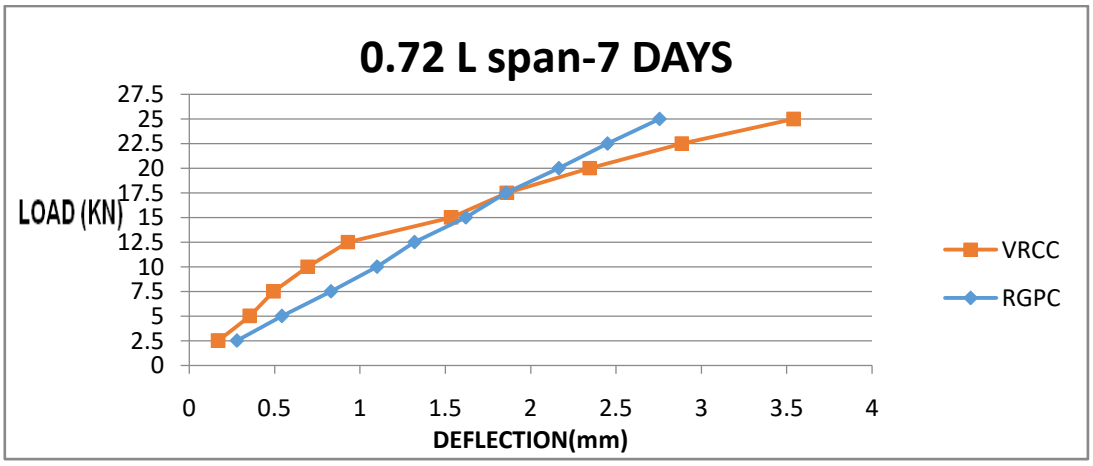
0.72L & 0.28 L span section

Dial gauges were fixed at 0.72L & 0.28 L span section points along the span and readings were recorded for a very increment load of 1.25 KN. The test results are presented in table 13 (a) & (b) at 7 days and table 14 at 28 days for RCC and RGPC respectively

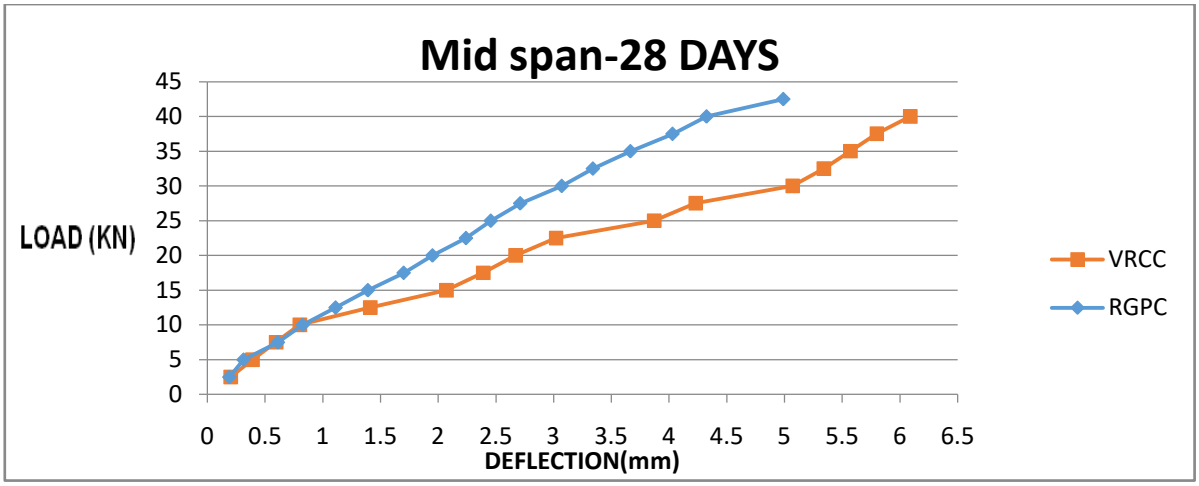
Results and Discussion



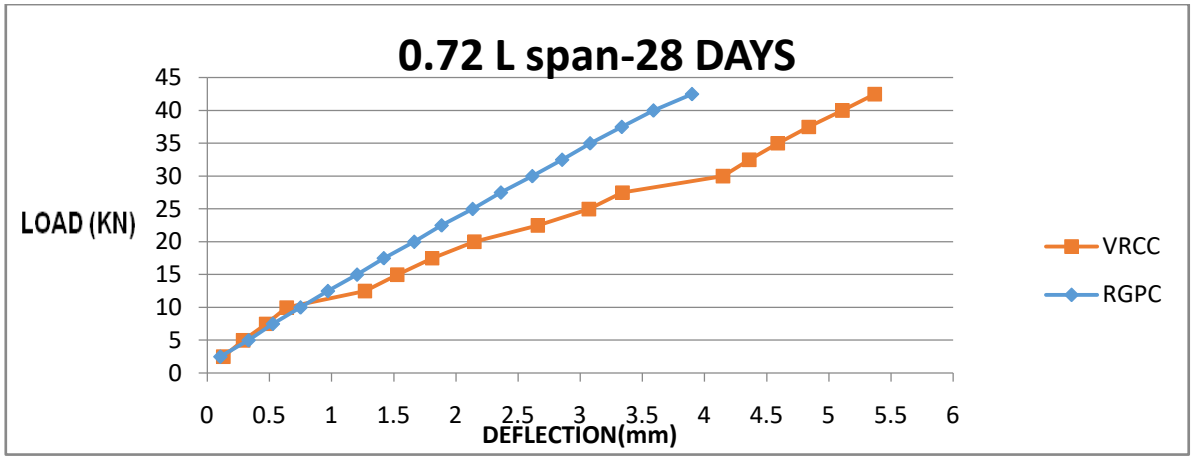
Load Deflection Curves At 7 Days @Mid Span



Load Deflection Curves @ 7 Days @ 0.72 L



Load Deflection Curves @ 28 Days @Mid Span



Load Deflection Curves @ 28 Days @ 0.28l

- Geopolymer concrete shows significant potential to be a material for the future; because it is environmentally friendly and possesses excellent mechanical properties.

- GPCs offer generally better protection to embedded steel from corrosion as compared to CC
- The ductility factor of GPCC beams could be marginally less than CC beams indicating higher stiffness of GPCC beams.
- Workability characteristics of GPC depend on mixing time of GPC that is workability of GPC is directly proportional to the mixing time.
- Compressive Strength and Split Tensile Strengths at 7 days and 28 days are higher in OPC, when compared with plain GPC and OPC concrete.
- It is observed that deflections are smaller in RGPC when compared with RCC beams from the load vs deflection graphs.
- Diagonal cracks in flexure and shear are observed to be smaller in magnitude in the RGPC beam, when compared to RCC beam.
- Beams are seen to fail at first by pulverizing of concrete in the pressure zone as the area is an over fortified.
- It is observed that the crack patterns for reinforced geopolymer beams are equally similar to those in CC beams.
- Useful suggestions on utilization of geopolymer solid innovation in down to earth applications, for example, precast concrete items and waste exemplification should be created in Indian context
- In light of lower interior vitality (very nearly 20% to 30 % less) and bring down CO_2 emission of elements of geopolymer based composites contrasted with those of routine Portland cements, the new composites can be thought to be more eco-accommodating and consequently their utility in useful applications should be produced and encouraged.

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