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Analytical Study on Geopolymer Concrete Beam Made With Different Molarity

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ABSTRACT
Geopolymer concrete is proven to have an excellent engineering property with a reduced carbon footprint. It not only controls greenhouse gas emissions but also utilizes a large amount of industrial waste material such as fly ash, GGBS, silica fume, etc. If a structure is constructed with low cover thickness, concrete spalling, and corrosion of reinforcement occurred in the structure. Due to this reason, the life of the element is reduced, and also the structure gets collapsed. Hence, the geopolymer is recommended to improve the life of the element. This paper focus on an analytical investigation on reinforced geopolymer concrete incorporated with fly ash and GGBS. The development of reliable analytical models can reduce the number of required test specimens for the solution of a given problem, recognizing that tests are time-consuming and costly of the actual structure. The numerical (ABAQUS) results from the FEA are compared with the experimental results which showed good agreement between the results.
Keywords: *Behaviour of Strength, Crack Formation, Different Molarity, Geopolymer Concrete, Load-Carrying Capacity, Load-Displacement Characteristic & Crack Pattern.*

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I. INTRODUCTION

The geopolymer technology introduced by Dr. Joseph Davidovits in 1978 offers an attractive solution. The original concept of geopolymers to make fly ash-based geopolymer concrete was developed by Davidovits in 2001. The polymerization process in geopolymers involves a chemical reaction under highly alkaline conditions on Al-Si minerals, yielding polymeric Si-O-Al-O bonds as proposed by Davidovits. Geopolymers are a new class of materials that are being grown as replaced cement-based materials. In geopolymer is no cement used and it reduces 80% of carbon dioxide emission. To reduce the carbon dioxide emission from cement production is the development of geopolymer concrete in response to the need for a 'greener' concrete. Silica and alumina are the source material for manufactured in geopolymer concrete. It is possible to use an industrial by-product such as fly ash and ground granulated blast furnace slag (GGBS), to totally replace the use of ordinary Portland cement in concrete, and therefore to reduce the emission of carbon dioxide to the atmosphere.

II. LITERATURE REVIEW

2.1 Crack Formation

Swoo-Heon Lee et al(2020). investigated reinforced concrete beam and post-tensioned concrete beam by using external loads. Comparison between the analytical (Abaqus)software and experimental result. An experimental study carried out a flexural test, shear test, and two-point loading. Final results revealed that analytical results that of strength, deflection, and stress in the external rod are similar to those of experimental results. The tensile deformation of concrete cracks by the CDP (Concrete damaged Plasticity) model can be used to be well predicted when compared with an actual crack pattern.

Saranya et al(2019). conducted two-point loading on Steel fiber reinforced geopolymer concrete beams (SFGPC) and ordinary portland cement concrete beams (OPCC) on experimental and numerical (ANSYS) investigation. The result revealed that the addition of steel fibers to increase the ultimate load of the beam. The addition of steel fibers arrested crack propagation OPC concrete is observed in wider cracks compared with GPC. Numerous micro cracks are observed in SFGPC.

Deeparaj et al (2017). compared that study on Recycled aggregate geopolymer concrete (RAGPC) and geopolymer concrete beam on experimental investigation. To find the optimum percentage of recycled aggregate in GPC by replacing 20%, 30%, 40%, 50%, 60% of coarse aggregate by RA to produce recycled aggregate geopolymer concrete. Revealed that result the optimum percentage of RAGPC is 40% based on mechanical properties and workability. RAGPC beams and GPC beams were almost the same crack pattern and failure mode, but the GPC beam is less than that of RAGPC beamwidth of crack. GPC beam good agreement compared with RAGPC beam.

Jammi et al (2017). conducted that study on replacement of OPC (Ordinary Portland Cement) with GPC (Geopolymer Concrete). Analyzed the experimental and numerical study on ANSYS software. Finally, the result of the study OPC having higher deflection when compared with GPC. Both experimental and software the amount of failure crack observed in the same zone. At last, the GPC reduces the emission of greenhouse gases into the atmosphere.

Boudjamaa Roudane et al (2019). modeled different stages of construction of the reinforced concrete masonry wall and compared using Finite element analysis. Three main types were examined Base frame for one, two, and three stories, Brick walled. The comparison results between different cases showed that the application of plasterwork increases lateral stiffness and has significant effects on the dynamic response of the buildings.

Joseph Robert Yost et al (2013). conducted that experimental and numerical study on four-point monotonic bending for alkali-activated fly ash concrete (AAFAC) and ordinary Portland cement (OPCC). Nine steel-reinforced AAFAC beams are tested. Finally, the result of the study concrete strain at compression failure in under-reinforced AAFAC beams higher than under reinforced OPC beams. In flexural failure, OPCC is a less brittle material than AAFAC.

2.2 Load Carrying Capacity

Sureshkumar paul et al(2020). conducted a finite element analysis which is verified anti laboratory test of eight beams. The eight beams have the same cross-section and applied loaded under four-point bending. But the eight beams have the length of the carbon fiber reinforced plastic plate is different. The result of the study when the length of CFRB increases the load-carrying capacity increased.

Tung et al (2019). investigated the flexural behavior of geopolymer concrete beams reinforced with steel fibers. To compare the experimental results, the geopolymer concrete beam reinforced with steel fibers improved in the cracking resistance, ductility, and serviceability compared to the reference beam. Finally the result of the study to increase the volume fraction of steel fibers to increase the load-carrying capacity of the geopolymer concrete beam.

Kumaravel et al (2018). conducted flexural test carried out on M40 grade two control cement concrete beam and two geopolymer concrete beams. Final results are compared with experimental and numerical studies (ANSYS). Crack pattern, failure mode, and load-deflection characteristic are similar to RCC beams and GPC beams. Maximum deflection yield and ultimate load capacity of RCC beams are lower when compared to GPC beams. Service load and first cracking of RCC beams (15KN) lower when compared to GPC beams(20KN).

Tejaswini et al (2015). comparison between the experimental result and software (ABAQUS) result. Test carried out on the plain, under, over, and a balanced section of M30 grade concrete. The four-point bending test was conducted on the all type reinforced section. The software analyzed all types of reinforced section. The result that the ultimate load-carrying capacity is more plane concrete beam is 0.14 times under reinforced beam. Over reinforced concrete beam compared to under reinforced beam maximum element reach ultimate stress.

H. Toutanji et al (2005). studied eight RC beams that were tested under a four-point bending test, one control beam, and seven beams strengthened with carbon fiber sheets bonded with an inorganic epoxy. From the test results, it was found that the load-carrying capacity of the RC beams increased with the number of layers of the carbon fiber sheet. For three and four layers of FRP reinforcement, beams failed by the rupture of carbon fiber sheet; for five and six layers of FRP reinforcement, beams failed by FRP delamination. The ductility of those strengthened is greatly reduced compared to the control beam (unstrengthened beams).

2.3 Load Deflection Characteristic & Crack Pattern

Chithambar et al (2019). compared the flexural behavior of ordinary cement concrete and geopolymer concrete. This study was carried out by the comparison of numerical and experimental investigation of ordinary cement concrete and geopolymer concrete. The final results, this study exposed a lot of potential in the environs of geopolymer concrete. Geopolymer concrete exhibits lesser deflection than ordinary cement concrete.

Amir Mohammed amir et al (2016). conducted that experimental and numerical study on the structural behavior of Reinforced geopolymer concrete beam (RGPC). The experimental test on four-point bending carried out RGPC beam and the finite element model (ABAQUS) used analyzed the same type of RGPC beam. The result revealed that load-deflection curves similar to the FEM model and the experimental result. The deflection pattern of the finite element model compares well with the experimental model.

Ee Hui Chang et al (2016). discussed the bond behavior between geopolymer concrete and reinforcing bars in tensile splices in beams. Twelve full-scale beam specimens with lap- spliced reinforcing bars were cast and tested in the laboratory to study the bond performance of geopolymer concrete. Finally analyzed the behavior of beams, failure modes, and cracking patterns.

Madheswaran et al (2015). investigated the experimental study on the behavior of reinforced geopolymer concrete beams subjected to monotonic static loading. Finally, the experimental results compared with geopolymer concrete beam (GPC) and ordinary portland cement concrete beam (OPCC) subjected to monotonic static loading to compare the parameters are load-deflection character, ultimate load carrying capacity, and crack pattern.

Dattatreya et al(2011). reported a study on flexural behavior of Reinforced geopolymer concrete beams. Comparison between the RPCC and RGPC beams. Experimental test under two-point loading on eighteen beams. Three conventional RPCC beams and six RGPC beams. Concluded that results almost similar for crack pattern, failure mode, load-deflection characteristic of the RPCC beams and RGPC beams. The ultimate load capacity is more than for RGPC beams compared with RPCC beams.

Maranan et al (2015). the report also deals with the comparison between GFRP reinforced geopolymer concrete beam and steel-reinforced geopolymer concrete beam. The beams reinforced with GFRP bars failed by concrete crushing failure since they were designed as over-reinforced, while the under-reinforced beam with steel bars failed due to reinforcement yielding.

2.4 Behaviour of Strength

Aydin et al (2020). investigated the resistance of reinforced concrete panels due to explosive loading using nonlinear finite element analysis and predicted the Various errors are utilized to evaluated and compare the performance of the model. At last, the author founded that the key parameters are the panel thickness and compressive strength for the explosive strength of RCPS have the most impact on RCP failure.

Farid Abed et al (2019). has studied the Experimental and finite element investigation of the shear performance of BFRP-RC short beams. This paper reports on the experimental, analytical, and numerical results of deep concrete beams reinforced with basalt fiber-reinforced polymer (BFRP) bars without web reinforcement. However, increasing the longitudinal reinforcement ratio increased the shear capacity of the BFRP-beams significantly without affecting their midspan deflections.

Shirmardi et al(2019). Conducted numerical investigation of 20 concrete beams internally reinforced with GFRP bars without web reinforcement. Using ABAQUS software final result revealed that, more ductile for FRB reinforced beam compared with the steel reinforced beam. FRP reinforced beams have a more hardening trend than steel-reinforced beams 5% to 48% (24% average) and 2% to 11% (6% average) respectively.

Kowshika et al (2018). reported the study on the structural behavior of reinforced geopolymer concrete members and the effect of fiber inclusion. Experimental tests were conducted finally concluded that the study inclusion of fibers increases the flexural capacity and the shear crack formation to be delayed.

Karthik et al (2017). discussed analytical study on fiber-reinforced geopolymer concrete. This paper focuses on the Experimental and Analytical Investigation carried out on fiber-reinforced Geopolymer concrete with Fly ash and GGBS, glass fiber, and steel fiber. The experimental investigation of steel fiber reinforced concrete and glass fiber reinforced concrete was done by compression test and young's modulus was calculated.

Khoa Tan Nguyen et al (2016). investigated the behavior of the geopolymer beam is found using a flexural test with four-point bending, elastic theory, and a finite element model. The result of the study GPC tensile strength is greater than the portland cement concrete. Both GPC and PC concrete is the same as stress-strain relation.

Ali Ahmed (2014) explored the dynamic behavior of a beam under impact load using Abaqus software. Thirty different parameters were analyzed to find the best performing FE analysis model. High accuracy is confirmed upon extensive examination of the calculated structural responses of the FE model comparing with the published experimental results.

Prabir Kumar Sarkar et al (2011). conducted pul out test carried out on 24 Geopolymer concrete beam (GPC) and Ordinary portland cement concrete beam (ASTM A944 standard) end specimens. This paper compared the bond strength of GPC and OPC. Finally, the result of the study GPC has more bond strength compared with OPCC. Increase in concrete cover to increase the bond strength of concrete.

III. SUMMARY

ABAQUS can be used for analysis as it gives nearer results and similar failure patterns of the RC beams while testing. After through Literature survey on analyzing of Reinforced Geopolymer Concrete beam the following conclusion were drawn;

- Geopolymer concrete strength increase with increasing the molarity and alkaline solution.

- Increasing the length of CFRB increases the load-carrying capacity of the concrete beam.
- The analytical result strength, deflection, and stress are similar to those of experimental results.
- In fiber reinforced geopolymer concrete, the higher load carrying capacity is reached for higher fraction of steel fibers.
- GPC has more bond strength compared with OPCC.

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