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Experimental Study of Fibre Blended with Flyash in Geopolymer Concrete

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ABSTRACT: This project investigates the effect of basalt fibres on the durability and strength of binary mix geopolymer concrete. Geopolymer concrete will be prepared with fly ash as raw material, fly ash will comply with composite design IS 1489-Part-1 2005 as geopolymer concrete is one of the building materials emerging worldwide in recent research. Geopolymer concrete is more brittle. In order to improve the engineering performance of conventional concrete Geopolymer concrete, metal and non-metal basalt fibres will be incorporated into the material of the composite concrete. Consider basalt fibres with different volume percentages such as 0.25%, 0.3% and 0.35%. Various combinations of basalt fibres are tested to test durability parameters such as compressive strength, split tensile strength and durability. Similarly, long-term properties such as permeability, water absorption, sea erosion and sulfuric acid attack will be evaluated. According to data analysis, 0.3% basalt fibres have better strength and performance than binary hybrid geopolymer concrete. Basalt fibres improve many properties of geopolymer concrete. Basalt fibres control different levels of cracking, soft and smooth fibres effectively prevent micro-level cracking, while strong and thick fibres effectively control macro-level cracking.

I. LITERATURE REVIEW

Study on compression strength

Effect of high temperature on the behavior of hybrid glassfibres and basalt fibres added to Geo polymer cement mortars Zehra Funda Akbulut and Soner Guler investigated the workability, visual appearance, compressive strength, and flexural strength properties of single and hybrid glass (GL) , basalt fibres (BA) added fly ash(FA) based Geo-polymer cement (GPC) mortars after the high temperature effect. Micro and macro GL, BA fibres were added to the GPC mixtures in two different volumetric ratios 1% and 0.5%. 300°C and 800°C of high temperatures were applied to the GPC mortar samples. As a results of the study, it was observed that the GPC samples with GL and BA fibre adjectives had considerably high (upper 5) residual compressive strength and flexural strength after the high temperature effect. In addition, since GL fibres are less agglomerated but exhibit more homogeneous distribution in blends, they are slightly more effective in improving both workability and residual compressive strength and flexural strength of GPC motar samples compared to BA fibres.

Study on influence of hybrid basalt fibres length on Mechanical properties of self-compacted ambient cured Geopolymer concrete. This study was carried out by Bidur Kafle, Mohammad Heweidak and Riyadh Al-Ameri. Reinforcing geopolymer composites with small volume of fibres have been proven an efficient technique to enhance concrete's mechanical properties and durability. However, there is no research investigating the difference in length and volume content of basalt fibres between new and used self-compacting geopolymer concrete. Fly ash and slag in a ratio of 60:40 are the most widely used binder components in the production of SCGC composites. SCGC is prepared by mixing amounts of fly ash, slag and materials-based fly ash with a basic activator compound called anhydrous sodium metasilicate (Na₂SiO₃). A total of 10 composites were fabricated, including a composite of long and 30 mm long and short 12 mm basalt fibres. In the study, fresh and Mechanical properties of self-compacted geopolymer concrete, incorporated with 12 mm and 30 mm single and hybrid lengths of basalt fibres with weight content of 1%, 1.5% and 2% were investigated. The assessed parameter of fresh properties included flowability, viscosity measurement and passing ability and the mechanical parameters were compressive strength and indirect tensile strength. The increased basalt fibre length and weight directly indicates the new nature of SCGC. The maximum compressive strength for the HBF2 mixture, which combines long basalt fibres at a rate of 2% by weight, is 35.82 MPa. The compressive strength of HBF2 is 20.20% higher than the original SCGC. SCGC consists of 30 mm single length and mixed length basalt fibres showing compressive strength with basalt fibre weight increased up to 2%. The hybrid fibre modulus trends are in good agreement with the compressive and indirect tensile strength results.

Tanu H M, Shobha MS, MD Khalid and TV Reshma investigated that the manufacturing of ordinary Portland cement produces CO₂ which is responsible for global warming. Geo polymer concrete in the field of construction leads to economic sustainability and reduces adverse effects on environment. Geo polymer are inorganic polymers obtained from chemical reaction between an alumina silicate material and an alkaline activator solution without using cement. Alkali activators are homogeneous mixture consisting of NaOH and Na₂SO₃ or more chemicals in different proportions are highly corrosive and difficult to handle.

Pushpendra Kumar Sharma and Rashmi Pathwane critically reviewed effect of basalt fibre in geopolymer concrete. They referred nearly 33 journals based on Basalt fibre in geopolymer concrete. They came to a conclusion that Basalt fibre has good packing between both the surface. It had low thermal conductivity. They stated that fly ash Geo polymer concrete paste with basalt fibre has increased setting time, strength and also reduction of dry shrinkage have high ductility as compared to other fibres which increase the compressive strength of the concrete.

Technical Study: Effect of Composite Fibres on Behaviour of Geopolymer Concrete Beams Reinforced with Unmixed Basalt Fibre Reinforced Polymer Rods. In this study by Thong M Pham, Tung T Train and Hong Hao, the response of 13 thin geopolymer concrete beams reinforced with basalt fibre-reinforced polymer rods as longitudinal reinforcement without stirrups is investigated. To increase the capacity of the beam, composite fibre including a type of macroscopic steel fibres or macroscopic synthetic polypropylene fibres, a combination of SF and micro PVA fibres or PF and micro carbon fibres has been used. A total of 13 concrete blocks were poured and tested under static conditions until they broke. Experimental results show that the presence of SF leads to the greatest improvement in shear beam, post-cracking stiffness and fracture behaviour of beams.

Adding half a percent of SF to the GPC and OPC beams increased the shear strength by 14% and 56%, respectively. In contrast to SF, which increases the shear strength, the addition of PF in 0.5% fibre also increases the static strength by 33%. The combination of SF and PVF was found to be synergistic in increasing the shear strength of the beam. At the same time, the combination of PF and CF does not increase the shear strength of the beam, but greatly improves the ductility of the beam. Comparison of the estimation and experimental results shows that the model derived from the developed compressive field theory provides the best correlation.

Muthukann and Chithambar carried a study on Geopolymer concrete consisting of glass fibre, polypropylene fibres, GGBS and alumina silicate materials. The study on mechanical properties such as compression strength test were carried out. The specimen of size 100×100×100mm is casted at the aspect ratio of glass fibre and polypropylene fibres were taken as 60. The specimen was tested in the compression testing machine after 7 and 28 days of ambient curing. The variation on the behaviour shows that GPCB exhibits the maximum characteristic strength. The results also stated that glass-fibre imports more compression strength and polypropylene fibre increase the post-cracking behaviour and increases the yield stress of the specimens.

A Shalini, Umesh Raut and B Prabhu conducted a study of strength of Geo polymer concrete reinforced with basalt fibre. The materials used are GGBS, fly ash, alkaline activator solution and basalt fibre. The cubes of 100 mm were casted and ambient curing was done up to 28 days and testing is done in compression testing machine of 100 ton. The results stated that compressive strength increases as the amount of GGBS was increased, so the optimum percent is taken as lowest ratio that is 90% of fly ash and 10% of GGBS. The fibre was added from 0.1% to 0.5% to get optimum fibre content to give high strength concrete, from the test it was found that 0.2% of fibre gives high strength and also basalt fibre arrests the cracks in concrete and increases strength by 60 to 110%, beyond 0.2% the strength reduces.

Ajit Ramachandran and S Deepa Raj investigated the performance of hybrid fiber reinforced geopolymer concrete beams. The main difference is considered to be the volume fraction of 0.5% steel fibers with a ratio of 60. Compressive strength is measured on sphere, cylinder and other samples after 28 days curing as Indian Standard Specification. It was found that the addition of fiber to the geopolymer concrete mix reduces the workability and does not have a significant effect on the compressive strength. Only a slight increase in compressive strength was observed due to the volume ratio of the steel fibers.

R Sahana, N Ganesan and P V Indira aimed to obtain a compressive strength of M40 grade with satisfactory workability and durability of hybrid fibres reinforced binary blend geopolymer concrete. The materials used are GGBS,

flyash under alkaline activator basalt fibre and crimped Steel fibre. The casted cube size 150mm and includes steam curing for 24 hours. After 28 days compression test was conducted, results show compressive strength increases by 11%. The reason of improvement was addition of basalt fibre, which control micro-cracks. They also concluded that Geopolymer concrete specimen with combination of 0.5% of Steel fibre and 0.3% of basalt fibre exhibited better performed in terms of strength.

Study on improving compressive strength of flyash based Geopolymer concrete composite by basalt fibres addition. This study carried out by Weerada Rattanaprasit, Patthamaporn Timakul and Pavadee Aungkavattana. In the study, class C flyash used as an aluminosilicate source was activated by metal alkali and cured at low temperature. Basalt fibres were added to fly ash based geopolymers for 10-30% solid content to act as a reinforced material and its influence on the compressive strength of Geopolymer composite has been investigated. XRD study of synthesized Geopolymer showed an amorphous face of geo-polymeric gel in the 2θ region of 23.1 to 38.1 including calcium silicate hydrate phase and some crystalline phases of magnesioferrite, and unreacted quartz. The microstructure investigation illustrated flyash particles and basalt fibre were embedded in a dense aluminosilicate Matrix though there was some unreacted phase occurred. The compressive strength of flyash based Geopolymer Matrix without basalt fibres added samples aged 28 days was 35MPa which significantly increased 37% when the 10% weight Basalt fibres were added. The addition of basalt fibre from 15% to 30% weight had not shown a major improvement in compressive strength so in addition it was found that the compressive strength was strong relevant to Ca or Si ratio and the C-S-H phase in the Geopolymer matrix as high compressive strength was found in the samples with high Ca / Si ratio. It is suggested that basalt fibres are one of the potential candidates as reinforcements for geopolymer composite development.

V B Karikatti, Anil Ronad and S S Dyavanal studied on the mechanical properties of Geopolymer concrete reinforcement with basalt fibres. 150mm concrete specimen for compressive strength was calculated under 140kg/cm³ uniformly. The cube strength at 7 days and 28 days were calculated. The compressive strength of Geopolymer concrete is observed to be enhanced by 34.74% on the addition of basalt fibres.

II. STUDY ON TENSILE STRENGTH

Pushpendra Kumar Sharma and Rashmi Pathwane critically reviewed on the effects of Basalt fibre in geopolymer concrete. The results were found that the addition of basalt fibre boost the tensile strength. The dose of 0.5% of Basalt fibre, the strength is magnified when compared with standard concrete. The tensile strength was found to be increased significantly as compared to compressive strength.

Muthukannan and Chithambar Ganesh carried a study on geopolymer concrete consisting of glass fibre, GGBS, polypropylene fibres and aluminosilicate material. And conducted tests on mechanical properties like split tensile strength. Cylindrical specimens with 100mm diameter and 200mm length were casted and tested after 7 and 28 days of curing, it was found that glass fibre exhibits more tensile strength, because GGBS exhibits more split tensile strength. They also shows that tensile property can increased with appropriate combination of both high and low modulus fibre and Geopolymer concrete.

Umesh Rawat, and Shalini and B Prabhu conducted a study on Geopolymer concrete with basalt fibre which includes the tensile test. The tensile test was found to be the Geopolymer concrete shows increase in pattern of tensile strength but when fibres are added the strength increased up to 0.2% and then decreased to 6%.

S Deepa Raj and Ajit Ramachandran investigated the performance of hybrid fibres reinforced geopolymer concrete beams. They mainly used Steel fibre and polypropylene fibre with aspect ratio of 60 for steel fibre and 300 for polypropylene fibre. The test revealed that modulus of elasticity and split tensile strength of hybrid reinforced concrete are more than Steel fibre that uses waste carpet fibre in concrete can have high split tensile strength. They found that tensile strength of geopolymer concrete increases with increase in steel fibre in concrete.

P V Indira, N Ganesan and R Sahana worked on the experimental study of hybrid fibre to improve the durability and strength in Geopolymer concrete. The aspect ratio of crimped Basalt was 1384 and Steel was 66. The split tension result i.e., it was improved by 37%.

Anil ronald, S S Dyavanal and V B Karikatti studied on mechanical properties of Geopolymer concrete reinforced with basalt fibres. From the result, it was concluded that the addition of basalt fibre at an optimum content to Geopolymer concrete can increase the tensile strength. The cylindrical moulds were used with 150mm diameter and they are tested after 7days and 28days of different mixes. The % increase in tensile strength of Geopolymer concrete was found to be 47.5% with incorporation of basalt fibre.

Study on durability test

Durability of rice husk ash and basalt fibre based sustainable geopolymer concrete in rigid pavement. Gyanendra singh and Mahapara Abbass investigated that rice husk was employed as source material in Geopolymer concrete in the presence of an alkaline activator which was prepared by combining NaOH and sodium silicate. Fibre reinforced was done with basalt fibres. The sodium silicate to NaOH ratio and the alkaline activator to binder content ratio was kept at 0.4 and 2 respectively, the NaOH concentration was kept as 14M, super plasticizer was used to improve the fluidity of Geopolymer concrete, and the source material used was 500 kg/m³, in mix rice husk ash mix. The percentage of Basalt fibres employed were 1%, 5%, 10%, 15%, 20%, and 25% in combinations RHB1, RHB5, RHB10, RHB15, RHB20, and RHB25, and the results of Basalt fibresThe mix was compared to OPCM, a control mix prepared as 40% conventional Portland cement concrete with a water-cement ratio of 0.35. The results show that mixed water RHB10 has a low water absorption rate of 1.54%, a small weight of only 24.73% in the acid test, a chloride ion penetration depth of 2 mm, and a 12 mm water absorption rate after 28 weeks of sulfate attack. showed that he had swelling.The rice husk ash mixture was also stronger than the control OPCM mixture.

The effect of basalt fibers on the properties of self compacting natural hot curing geopolymer concrete. The study was conducted by Bidur Kafle, Riyadh A1-Ameri and Mohamed Heweidak. Reinforcing geopolymer composites with small amounts of fiber has proven to be a good technique for improving the durability and properties of concrete. The maximum tensile strength of HBF-2 is 4.13 MPa.The indirect tensile strength of HBF-2 is 61.96% higher than ordinary SCGC.The SCGC incorporated with hybridlength basalt fibres showed better indirect tensile strength performance than singlelength BF-reinforced SCGC for the same basalt fibres weight content. The hybrid fibre coefficient trend showed good consistency with compressive strength and indirect tensile strength results.

Dr Pushpendra Kumar Sharma and Rashmi patwane reviewed on BF geopolymer concrete. They found that BF reinforced concrete showed strong resistant to acid attack, chloride penetration and fire resistance. BFRCperformed better control than other concrete. They increased the durability.

N Ganesan, R Sahana andP V Indira mainly investigate on durability and strength of hybrid fibre reinforced binary blend geopolymer concrete. They considered Marine attract test, sulphuric attack test, water permeability test and water absorption testwhich comes under durability test. They concluded that the incorporation of hybrid fibres improves several durability parameters. The Geopolymer concrete specimen with the combination of 0.5% of steel fibre and 0.3% of basalt fibre exhibited better performance in terms of durability.

III. CONCLUSION

Basalt fiber has become an effective support in geopolymer materials. They develop new, hardened, micro and macro structural properties of concrete. They maintain high resistance to chemicals. Basalt fiber reinforced geopolymer concrete is superior to ordinary concrete. The combination of basalt fibers helps improve bone function and makes it harder for cracks to propagate.It was found that the dissolution time of the concrete increased with the basalt fiber percentage and also decreased the dry shrinkage of the geopolymer mortar. Basalt fibers increase resistance to sulfate and chloride attacks. They increase the durability of the mortar against thawing cycles.

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