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A STUDY ON SELF-COMPACTING GEOPOLYMER CONCRETE

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Abstract – **In this study aims to demonstrate the significance of Self-Compacting Geo-Polymer Concrete (SCGPC) in structures with congested reinforcement. To achieve good compatibility, ordinary geopolymer concrete must be compacted with a lot of vibration. It can be replaced with self-compacting Geo-Polymer Concrete (SCGPC), which do not require any type of compaction. Under its own weight, it fills every corner of the formwork. A less difference between deformability and stability is needed for the effective production of self-compacting geopolymer concrete. Researchers have developed some guidelines for proportioning self-compacting geopolymer concrete mixtures, which include i) lowering the aggregate-to-cementitious-material ratio. (ii) Raising the volume of the paste and w/c ratio as well as (iii) using different viscosity-enhancing admixtures in order to achieve high mobility in self-compacting geopolymer concrete, superplasticizers are typically needed. Segregation may be avoided by using a viscosity changing admixture or a large volume of powdered content. Fly ash, GGBFS, Silica Fume, Metakaolin, and slag, among other powdered materials, may be applied.**

Keywords – **SCGPC, Fly Ash, water-cement ratio, super-plasticizers, GGBFS**.

I. INTRODUCTION

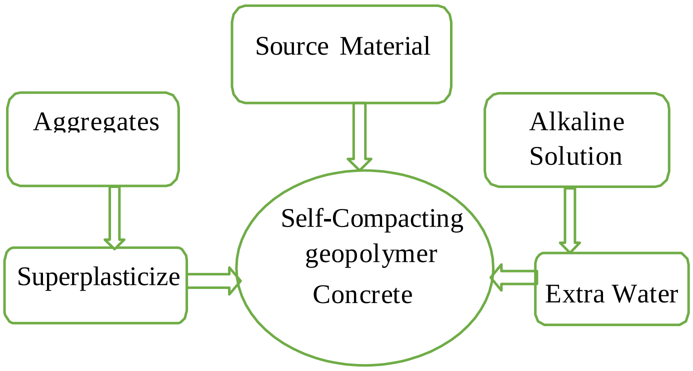
Concrete stands in second position next to water in terms of its consumption. Although Portland cement (PC) is an important component of concrete, it is not a green material. To make one tonne of PC, 1.6 tonnes of raw materials are required, as well as a significant amount of CO_2 and other greenhouse gases being released into the environment. One tonne of CO_2 is released into the environment to create one tonne of PC. CO_2 emissions will increase by around 50% by 2020 relative to current levels. Concrete is manufactured at a global rate of about 9 billion cubic metres per year. Worldwide the usage of concrete is 2[nd] to water. In addition to the above, cement production necessitates a considerable amount of energy. As a consequence, it is crucial.

Carbon dioxide was emitted during cement processing, polluting the entire environment. Thermal power plants generate a waste material called as Fly Ash, which is deposited on the ground and takes up alot of space. All of the problems described above can be solved by making Geopolymer Concrete. Since Geopolymer concrete does not contain any cement, cement production would be reduced. As opposed to (OPC) concrete, the use of geopolymer technology in the concrete manufacturing has an environmental advantage because it can minimize (CO_2) emissions to the atmosphere by up to 80%. Geopolymer concrete is an environmentally friendly concrete with a smaller carbon footprint than traditional concrete.

In 1978, a French professor named Davidovits became the first person to coin the term Geopolymer to describe a wide variety of materials characterized by networks of inorganic molecules (Geopolymer Institute2020). Geopolymers uses alkaline solution to activate the materials which are rich in silica and alumina for gaining the strength. A mixture of $Na(OH)_2$ and Na_2SiO_3, or KOH and $K_2Si_2O_5$, makes up the alkaline solution.

Ordinary Geopolymer concrete needs vibration for compaction to achieve good compatibility, but vibrating concrete promotes noise pollution. To mitigate the problems caused by compaction, it can be replaced with self-compacting concrete, which does not require any form of compacting. SCGPC is a novel idea that has been called "the most innovative breakthrough in concrete technology." Due to its excellent flowability, it can be laid down and fuse under its self-weight without any vibration. SCC is a fluid mixture which can be put in structures where congested reinforcement is present without inducing vibrations, and it also assists in the attainment of better surface finishes.

II. CONSTITUENTS OF GEOPOLYMER CONCRETE



ADVANTAGES OF SELF COMPACTING GEOPOLYMER CONCRETE

- Improved concrete quality, shorter construction time period, and easy to place in heavy reinforcements.
- Consolidation that is uniform and thorough
- Bond intensity has increased.
- Owing to the lack of vibration, noise levels are decreased.
- Overall costs are smaller, and workers are in a healthy working environment.

APPLICATIONS

- Self-compacting geopolymer concrete can be used in bridges in the form of decks which were pre-cast.
- Structural retrofits with geopolymer-fiber composites.
- In the case of offshore structures

III. MATERIAL AND STRENGTH PROPERTIES

The report's main goal is to describe an experimental method using 2 percent nano silica and alkali activated GGBFS based SCGPC slag by varying the percentages of molarity and binder for different mixes to evaluate its properties in mouldable and hardened states. The workability, toughness, and hardened properties of SCGPC are all altered by the NaOH solution and GGBFS material. The increased concentration increases the intensity and durability of the geopolymerisation reactions by reducing filling and passing capacity. Incorporation of 2% Nano Silica in the SCGPC improves toughness, workability, and mechanical efficiency. Compressive strength of SCGPC is influenced by NaOH solution and GGBS material. **Guneet Saini, Uthej vattipalli et al. (2020)**

The effect of Bacillus Lincheniformis on the fresh and hardened properties of SCC mixes is investigated in this paper. Cement is completely replaced by various percentages of GGBFS and fly ash. 10^5 cells/ml concentrations of Bacteria are added tothe concrete mixes. When compare with normal SCC, the GPSCC mixes achieve high strength at 60^0C heat curing can be achieved high strength geopolymer self-compacting concrete by use of alkali activated solutions. By increasing ground granulated percentage, the compressive and splitting tensile strength values of geopolymer self- compacting concrete have been improved. **Sushree Sangita Rautray, Biswajyoti N. Mohanty, Manas R. Das et al. (2020)**

Different failure modes, ranging from flexural to flexural-shear, were linked to the cracking pattern, which influenced the failure load. In addition, three models that are commonly used in conventional RC systems were deployed to calculate the spacing of the crack. It was found that flexural crack spacing of the FRP-reinforced beams is higher than that of a reinforced beam using steel bar. For an 8mm diameter bar, the spacing of the flexural crack of BFRP and CFRP was found to be increased by 23.63% and 9.27%, respectively, as compared to steel bar specimens. Zhang's model showed excellent relationship between the analytical and experimental crack spacing of 8mm steel bar when compared with JSCE and CEB FIP models. **Khuram Rashid, Xiaoda Li, Yan Xie, Jun Deng, Faji Zhang et al. (2020)**

The primary goal of this research was to determine the effectiveness of geopolymer in the structural system of a construction. Both SCGPC and regular SCC had their shear bond strength measured. To evaluate interface shear strength by two different types of push-off tests were conducted i) Conventional push-off tests and ii) push-off test with normal load acting over the shear interface. Finally, the results of the tests were compared to shear friction models used in the literature. By using same aggregate ratio, self-compacting geopolymer concrete showed better properties than normal self-compacting geopolymer. As a result, further trials with different shear reinforcement areas are required to test shear bond strength. **Mahima Ganeshan, Sreevidya Venkataraman et al. (2020)**

This project developed and tested the effects of steel fiber and nano silica. To check the effect, the SCGPC is made up of with and without nano-silica also with and without steel fiber were produced. 30 mm length hooked fiber were used and the ratio of 40mm. The ratio of 2.5 Na_2SiO_3 & NaOH solution is used for alkaline activator, while conducting fresh state experiments and hardened state experiments, oncompressive strength and fresh state properties, the effect of nano silicate was found to be supreme, and in terms of flexural performance and bonding strength, the steel fiber has created its impact. **Mehmet Eren Gulsan, Radhwan Alzeebaree, Ayad Ali Rasheed, Anil Nis, Ahmet Emin kurtoglu et al. (2019)**

The purpose of this research is to look at both types of mixes' mechanical and fresh properties. The slump flow test is used to examine the fresh properties of Heavy Weight Geopolymer Concrete and Heavy Weight Self Compacting Concrete. J-ring experiments, on the other hand, were only carried out on Heavy Weight Self Compacting concrete mixes to ensure that the flow criteria for self-compacting properties were met. Tensile and compressive tests were conducted on regular 100 x 200 mm cylinders. Prisms with dimensions of 45 x 10 x 10 cm were also tested for its flexural strength under four-point loading. For both mixes, the flexural load-displacement relationship was investigated. The control Self Compacting Concrete mix gained a maximum compressive strength of 53.54 MPa after 28 days, according to the results. However, 25 percent magnetite replacement samples reached a maximal compressive strength of 31.31 MPa in Heavy Weight Geopolymer Concrete mixes. The overall result shows that increasing magnetite aggregate proportions in Heavy Weight geopolymer concrete mixes reduces the strength of Heavy Weight Self Compacting Concrete. **AfsanehValizadeh, FarhadAslani, Zohaib Asif and Matt Roso et al. (2019**

Two series of SCGPC with a 0.50 alkaline-to-binder (a/b) ratio and 450 kg/m3 constant binder material. In each SCGPC series, FA was replaced with GGBFS at substitution levels of 0, 25, 50,75, and 100 percentages by weight. In the initial concrete series, steel fiber was not used and later in the second concrete series it was used by maintaining a uninterrupted level of 1% by volume. The results of the experiments showed that adding steel fiber had no effect on the fresh properties of the SCGPC mixtures, but adding GGBFS aggravated them. GGBFS, on the other hand, has greatly improved the mechanical properties of Self Compacting Geopolymer Concretes. **Saad Al-Rawi and Nildem Tayşi et al. (2018)**

The effect of temperature and ambient curing on mechanical properties is investigated in this report. SCGC is made with GGBFS and RHA. The impact of a percentage replacement of Rice Husk Ash is also discussed in the report. When RHA is replaced with GGBFS, the ambient curing time is reduced and its 10% more at temperature curing, the strength also higher at temperature curing when compare with ambient curing. The Rice Husk Ash Scanning Electron Microscope reveals that the high dense microstructure of temperature curing hence it is higher strength **Yamini J. Patel Niraj Shah et al. (2018).**

In this paper, natural sand is replaced with various replacement levels of spent garnet with a constant mass ratio of 0.4 L/B to achieve SCGPC. By conducting various test performance, the test results revealed that the spent garnet replacement is up to 25 percentage for Optimum performance, If the replacement of spent garnet is more than 25 percent, the strength of SCGPC is reduced. **Habeeb Lateef Muttashar, Mohd Azreen Mohd Ariffin, Mohammed Noori Hussein, Mohd Warid Hussin, Shafiq Bin Ishaq et al. (2017)**

In this study, the high viscosity of the alkaline solution in this sample, GPC had a lower slump than PCC in all situations. At both 20 and 40 °C, the compressive strength of GPC and PCC decreased as the amount of MPCM was increased. The mechanical properties of GPC are unaffected by whether the PCM is in a solid or liquid state. When concrete with integrated MPCM is subjected to temperature changes, these findings may conclude that GPC is a better one to adopt. Despite the negative effects of MPMs on GPC and PCC compressive strength, these materials have sufficient compressive strength for structural applications which should be in the range of 25 to 40 MPa. **Shima Pilehvar, Vinh Duy Cao, Anna M. Szczotok, Luca Valentini, Davide Salvioni, Matteo Magistri, Ramón Pamies, Anna-Lena Kjøniksen et al. (2017)**

In this spirit, SCGPC specimens are made with varying amounts of GGBFS and spent garnet (0 to 100%) while maintaining a uninterrupted Liquid/Binder mass ratio of 0.4. Toughness, workability, flexure, compression, and tension strength are among the tests used to evaluate the interpretation of the existing SCGPC samples. In terms of environmental friendliness, natural resource protection, and cost-effectiveness, it has been determined that spent garnet is a good substitute for sand substitution up to 25%. The irregular, high specific surface area, and porous nature of spent garnet were discovered to be important factors in the production of high-performing self- Compacting Geopolymer concretes. The as-prepared Self Compacting Geopolymer Concretes showed excellent resistance to rapid Co_2 penetration after 60 days in a Co_2 environment. **Habeeb Lateef Muttashar, Mohd Azreen Mohd Ariffin, Mohammed Noori Hussein, Mohd Warid Hussin, Shafiq Bin Ishaq et al. (2017)**

In this paper, the compressive strength and workability of SCGPC made with fly ash of low-calcium content were observed. By performing tests such as slump flow, V-funnel, L-box and J-ring, the filling and passing ability of SCGPC is evaluated. The compressive strength was also assessed, and the results of the tests are included here. The geo-polymerization process is enhanced by a longer curing time, which results in increased compressive power. The compressive strength of the specimens was highest after 96 hours of curing. Concrete specimens cured at 70°C achieved the maximal compressive strength as compared to specimens cured at 60°C, 80°C, and 90°C. **Fareed Ahmed M, Fadhil Nuruddin M, and Nasir Shafiq et al. (2011)**

IV. CONCLUSION AND ACKNOWLEDGEMENT

An eco-friendly material Self compacting geopolymer concrete is made up of different concentrations of Alkaline solutions. Different concentrations of NaOH solution (8 M, 10 M, 12 M, 14 M, and 16 M) will be investigated. The hardened properties of Geopolymer concrete were explained by a series of study experimental findings. As compared to traditional concrete, geopolymer concrete has more strength, according to the report. The aim of this project is to look into a variety of properties of Geopolymer concrete and SCGPC. Theaim of the SCGPC is that it can be used in buildings where congested reinforcement is present without inducing friction which resulted in reduction of noise levels because of the absence of vibration,and that it can help achieve a higher quality of surface finish and higher strength.

V. REFERENCE

[1] Guneet Saini, Uthej vattipalli (2020) **“**Assessing properties of alkali activated GGBS based self-compacting geopolymer concrete using nano-silica” https://doi.org/10.1016/j.cscm.2020.e00352.

[2] Sushree Sangita Rautray, Biswajyoti N. Mohanty, Manas R. Das (2020) "Performance of Self compacting geopolymer concrete using Bacillus Licheniformis” https://doi.org/10.1016/j.matpr.2020.02.587.

[3] Paul O. Awoyera, Mehmet S. Kirgiz, A. Viloriae, D. Ovallos-Gazabon (2020) “Estimating strength properties of geopolymer self-compacting concrete using machine learning techniques” https://doi.org/10.1016/j.jmrt.2020.06.008.

[4] Khuram Rashid, Xiaoda Li , Yan Xie , Jun Deng , Faji Zhang (2020) “Cracking behavior of geopolymer concrete beams reinforced with steel and fiber reinforced polymer bars under flexural load” https://doi.org/10.1016/j.compositesb.2020.107777.

[5] Mahima Ganeshan, Sreevidya Venkataraman (2020) “Interface shear strength evaluation of self compacting geopolymer concrete using push-off test” https://doi.org/10.1016/j.jksues.2020.08.005.

[6] Mehmet Eren Gulsan, Radhwan Alzeebaree, Ayad Ali Rasheed, Anil Nis, Ahmet Emin kurtoglu etal. (2019) “Development of fly ash/slag based self-compacting geopolymer concrete using nano-silica and steel fiber” https://doi.org/10.1016/j.conbuildmat.2019.03.228.

[7] Muhammad N.S.Hadi, Haiqiu Zhang, Shelley Parkinson (2019) “Optimum mix design of geopolymer pastes and concretes cured in ambient condition based on compressive strength, setting time and workability”

[8] Afsaneh Valizadeh, Farhad Aslani , Zohaib Asif and Matt Roso (2019) “Development of Heavyweight Self-Compacting Concrete and Ambient-Cured Heavyweight Geopolymer Concrete Using Magnetite Aggregates” (http://creativecommons.org/licenses/by/4.0/).

[9] Rajesh Suryanarayan, Dr. Hake S.L (2019) “Effect of NA_2SIO_3/NAOH Ratio for fly ash based self-compacting geopolymer concrete” Volume: 06 Issue: 12

[10] Saad Al-Rawi and Nildem Tayşi (2018) “Performance of self-compacting geopolymer concrete with and without GGBFS and steel fiber” Advances in Concrete Construction, DOI: https://doi.org/10.12989/acc.2018.6.4.323.

[11] Chameera Udawattha, Rangika Halwatura (2018) “Geopolymerized self-compacting mud concrete masonry units” https://doi.org/10.1016/j.cscm.2018.e00177.

[12] Habeeb Lateef Muttashar, Mohd Azreen Mohd Ariffin, Mohammed Noori Hussein, Mohd Warid Hussin, Shafiq Bin Ishaq (2017) “Self compacting geopolymer concrete with spend garnet as sand replacement” https://doi.org/10.1016/j.jobe.2017.10.007.

[13] Yamini J. Patel, Niraj Shah (2018) “Development of Self-compacting geopolymer concrete as a suitable construction material” https://doi.org/10.1016/j.serj.2018.08.004.

[14] Shima Pilehvar, Vinh Duy Cao, Anna M. Szczotok, Luca Valentini, Davide Salvioni, Matteo Magistri, Ramón Pamies, Anna-Lena Kjøniksen (2017) “Mechanical properties and microscale changes of geopolymer concrete and Portland cement concrete containing micro-encapsulated phase change materials” http://dx.doi.org/10.1016/j.cemconres.2017.07.012.

[15] Habeeb Lateef Muttashar, Mohd Azreen Mohd Ariffin, Mohammed Noori Hussein, Mohd Warid Hussin, Shafiq Bin Ishaq (2017) “Self-compacting geopolymer concrete with spend garnet as sand replacement” https://doi.org/10.1016/j.jobe.2017.10.007.

[16] Fareed Ahmed Memon, Muhd Fadhil Nuruddin, Sadaqatullah Khan, Nasir Shafiq, Tehmina Ayub (2013) “Effect of Sodium Hydroxide concentration on fresh

properties and Compressive Strength of self-compacting geopolymer concrete" Journal of Engineering Science and Technology Vol. 8, No. 1.

[17] Aziz Hasan Mahmood, Stephen J. Foster, Arnaud Castel (2020) "High-density geopolymer concrete for Port Kembla breakwater upgrade" https://doi.org/10.1016/j.conbuildmat.2020.120920.

[18] Henrique A. Santana, José S. Andrade Neto, Nilson S. Amorim Júnior, Daniel V. Ribeiro, Marcelo S. Cilla, Cleber M.R. Dias (2020) "Self-compacting geopolymer mixture: Dosing based on statistical mixture design and simultaneous optimization" https://doi.org/10.1016/j.conbuildmat.2020.118677.

[19] Ishwar K Naganur, Ramesh B M, Dr. Venkatesh Babu, Nagaraj V K, Veerendra Arikeri, Niranjan R Patil (2017) **"**A study on self-compacting geopolymer concrete with an alkaline activator ratio and different alkaline activator to cementitious binder ratios" International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 06.

[20] Guneet Saini, Uthej Vattipalli (2020) "Assessing properties of alkali activated GGBS based self-compacting geopolymer concrete using nano-silica" https://doi.org/10.1016/j.cscm.2020.e00352.