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A Review of Mechanical Properties of Fly Ash Based Geo-Polymer Concrete Used As Paver Blocks

Awdhesh Kumar[1], Anuj Verma[2]

[1]M.Tech Scholar, Department of Civil Engineering, Rajshree Institute of Management and Technology, Bareilly (U.P.)

[2]Asst. Prof. & Head, Department of Civil Engineering, Rajshree Institute of Management and Technology, Bareilly (U.P.)

***Abstract*- The world is facing the challenges of climate changes due to the increase in CO2 emissions. Cement production is one of the biggest contributors to CO2 emissions due to combustion processes that require high temperatures. The new development in building construction showed that fly ash based Geopolymer concrete can be as structure materials to reduce or even eliminate ordinary Portland cement concrete. This paper presented the research results of fly ash based geopolymer concrete mechanical properties, like the compressive strength, flexural strength, and Elastic Modulus.Paver block is often used in alternative functions, such as those in street as well as other areas of building. So far, roof tiles and paving bricks are the only products to have been manufactured at the lab-scale. Future studies could focus on the investigation of other mechanical and durability properties of the optimum formulations, in order to find applications in the manufacturing of a variety of building materials.**

***Keywords*- Paver block, geopolymer, fire, strength, porosity, conventional concrete, weight, structural, polymerization, Fly ash.**

I. INTRODUCTION

Cement industry is one of the industries responsible for increasing CO2 emissions globally. It is estimated that the cement industry worldwide contributes 9% of CO2 emissions. It is required to take quick and appropriate steps to reduce CO2 emissions into the atmosphere in order to reduce global warming. Variety of steps have been taken to reduce the growth of cement consumption, namely by increasing the use of pozzolanic materials such as fly ash, slag, palm oil fuel ash as cementitious materials for replacing part of the PC. [1] Reducing the use of PCs will be more effective if we use geopolymer concrete as structural concrete. Geo-polymer concrete is made without using PC cement. Fly ash as the main ingredient of geopolymer concrete with alkaline solution will produce binder paste, which determines the concrete strength. For example, it is estimated that Electrical Steam Power Plant throughout Indonesia will produce around 2.75 million tons of fly ash per year. [2]

1. Fly Ash:

Fly ash is a byproduct from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. The fine powder does resemble Portland cement but it is chemically different. Fly ash chemically reacts with the byproduct calcium hydroxide released by the chemical reaction between cement and water to form additional cementitious products that improve many desirable properties of concrete [3-5].

Fig 1. Fly Ash.

Geopolymer concrete is a type of concrete that is made by reacting aluminate and silicate bearing materials with a caustic activator. Commonly, waste materials such as fly ash or slag from iron and metal production are used, which helps lead to a cleaner environment. This is because the waste material is actually encapsulated within the concrete and it also does not have to be disposed of as it is being used. [5-7]Geopolymer concrete is does not require heat to make it and it does not produce carbon dioxide. Standard Portland cement based concrete requires both heat and carbon dioxide. [8]

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2. Advantages of Geopolymer Concrete:

Geopolymer concrete has significant advantages over standard concretes. It is much more long lasting than standard concrete and requires little repair, thus saving huge amounts of money that would otherwise have to be spent on repairing and maintaining concrete based infrastructure. You might be interested to learn that geopolymer concrete is the modern equivalent of the ancient concretes such as those used by the Romans that have survived for thousands of years. Geopolymer concretes will safely last for hundreds of years while standard concretes will last for tens of years. [9]

Geopolymer concrete is more resistant to corrosion and fire, has high compressive and tensile strengths, and it gains its full strength quickly (cures fully faster). It also shrinks less than standard concrete. [10]

II. LITERATURE REVIEW

S.no	Author	Year	Conclusion
1	Thaarrini	2019	Preliminary investigations were carried out on the geopolymer mortar and the optimal replacement of the textile effluent was 50% with a molarity of 6 M with an alkaline liquid-binder ratio of 0.4 and 0.5. With optimal parameters, the geo polymer concrete blocks were manufactured and tested for their mechanical properties. The results show that the mercerization effluent of cotton can be used as a partial replacement of the alkaline activation solution of geopolymer concrete.
2	Dr. R.Kumutha, S.Aarthy and Dr.K.Vijai	2018	Develop the double layered geopolymer concrete paver blocks by the activation of fly ash and GGBS by adding polyester fibres in the top half thickness of paver blocks. Test results indicated that addition of polyester fibres in paver blocks has significant advantages with respect to flexural strength and abrasion resistance.[11]
3	AbhayTawalare, RupaliKejkar and Mahesh Kumar	2018	"Performance with geopolymer paver block using natural aggregate and recycled aggregate as fine aggregate and slag as coarse aggregate. The geopolymer paver block with recycled aggregates having mixed proportion as GPC4 shows all the test results within the limit as per IS15658, so it can be used in residential driveways, light vehicles / public pedestrian and light vehicle paths".
4	M. Muthu kumar, L. Mareeswaran, S. Subburaman, B. Jeyaprakash	2017	These are observed that the compressive strength results match well the compressive strength necessary.[12]
5	DarshanPokharkar, SanchitShirsath, Majidul Islam, Yogesh Wadge	2017	Test results show that incorporating the use of rubber pads with the inclusion of different per centages of waste steel aggregates in paver blocks gives up to 50% more impact power than ordinarypaverblocks.[13]
6	Vikas Kumar Patel and V. V. Singh	2017	Specific paper and study works based on fine aggregates (sand) replaced by various percentage of other industrial waste materials and cement replaced by different percentages of other slurry base material and found that resistance, resilience and cost reduction and usage of waste material improved.[14]
7	K. Ashok Kumar and Dr. P. Partheeban	2017	Following 20 days of atmospheric recovery, the compressive strength of the Geopolymer concrete paver block was 14.4 percent lower than the control concrete paver block of grade M35.[15]

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8	D.V. Karunarathne, K. Arulolipavan and K.M.L.A. Udamulla	2017	The compressive strength, slip/skid resistance and water absorption of GPC paving blocks were determined and were compared with SLS 1425 part 1 and 2. GPC paving blocks for all strength classes which is cured in 80ºC ambient temp erature is found to satisfy all SLS specifications while compressive strength of geo polymer concrete paving bocks cured in ambient temperature is found to be less than the design strength.[16]
9	C. Banupriya, Sharon John, R. Suresh, E. Divya and D. Vinitha	2016	Geopolymer brick provided strong compressive strength using 65 per cent FA & 35 per cent GGBS. "Small volume fly ash based geopolymer concrete (mix ratio of 65, 70, 75 and 80 percent FA) used for bricks and high volume ground granulated blast furnace slag based geopolymer concrete (mix ratio of 65, 70, 75 and 80 percent GGBS) used for paver blocks".[17]
10	Basil M.Mali and Renjan Abraham	2016	Test results show that low-calcium fly ash-based geopolymer concrete pavers have excellent compressive strength in a short time (3 days) without water healing and are ideal for practical applications.
11	Anjali Gargav and Dr.J.S.Chauhan	2016	The geopolymer has the advantages of quick strength gain, water healing removal, strong mechanical and toughness properties and is an environmentally friendly and sustainable alternative to concrete based on Ordinary Portland Cement (OPC).
12	S.Kavipriya&Dr.R. Ilangovan	2016	The test results show that cement concrete showed better performance when 0.5 per cent of the inclusion of polypropylene fibers (PP) was a comparatively better result when 1 per cent of PP fibers were added as geopolymer concrete records. The findings also show that GPC performs comparatively better than CC with and without inclusion of fiber.
13	Rismy Muhammed, Deepthy Varkey	2015	Test results show that it provides strong results for abrasion resistance and flexural strength at 28 days respectively with the addition of PPF by 0.2 per cent. Based on the test results, the PFRGPC was found to have comparatively greater power than the GPC & OPC pavers.[19]
14	Rounak Hussain	2015	From the test results it was observed that compressive power of the grades M30 and M35 was reached in early ages under ambient healing.
15	Kewal	2015	Tests for both the compressive strength of the concrete will be performed; the compressive strength test will be conducted for 7 and 28 days. Obviously, it takes some more experimental works to research the method from an environmental point of view.
16	Ritesh Mall, Sharda Shrama and R.D.Patel	2014	Concrete Paver Block seems to be a better choice in road construction compared to traditional roads made of bitumen and gravel in terms of cost point view and improved suitability. India is a developing country, so road-building and development play an important role here.

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17	Priyanka Ramkripal Singh and N.D. Shah	2014	Ferndandez-Jimenez reported that the secret to a fly ash-based geopolymer product with optimum binding properties was extracted from the use of a fly ash material with the following properties: less than five per cent of unburned material; less than 10 per cent of Fe2O3; low CaO content; 40–50 per cent relative silica; 80–90 per cent of particles with a diameter of less than 45 □m; and high CaO content; vitreous phase.
18	Aman Jatale1, Kartikey Tiwari, SahilKhandelwal	2013	Fly-ash effect on workability, setting time, density, air quality, compressive power, elasticity modulus is studied. Based on this analysis, compressive strength v/ s W/C curves were designed to allow direct design of concrete mixtures of grades M15, M20, M25 with difference percentage of fly-ash.
19	Aaron Darius Vaz, Donal Nixon D'Souza, Noothan Kaliveer, Satish K.T and Amar S.M	2012	The usage of geopolymer concrete in precast concrete paver blocks and contrasts the output with the same mix proportions of commercially available OPC paver blocks. The mix design was built with target strength of 47 MPa to produce paver blocks that are suitable for highways. The experiments were carried out and the findings were tabled.
20	Shankar H. Sanni	2012	The test results indicate that when compared to traditional concrete, the heat-curing fly ash-based geopolymer concrete has excellent resistance to acid and sulphate attack. Geopolymer development has thus a relatively higher strength, excellent volume stability and better durability.
21	F. D.B. Raijiwala and H.S. Patil	2011	Once the samples were combined at 25 degrees Celsius and healed at 30 degrees Celsius, the compressive strength was weak at an early stage, but slowly increased.
22	E. Lloyd, N. and Rangan	2009	Geopolymer concrete has excellent properties and is well-suited for the manufacture of precast concrete goods that are required after a disaster to rehabilitate and retrofit the structures. It also outlined the economic benefits and contributions of concrete geopolymer to sustainable development.
23	DjwantoroHardjito, Steenie E. Wallah, Dody M. J. Sumajouw, and B.Vijaya Rangan	2004	The research demonstrates the effects of various parameters on Geopolymer concrete properties. This also describes the use of concrete geopolymer and future research needs.

III. CONCLUSION

The mechanical properties of fly ash-based geopolymer paste were hardly influenced by several factors such as fly ash chemical composition and setting time of its fresh geopolymer paste.

Chemical composition of fly ash such as CaO content play important role in the setting time and compressive strength of geopolymer paste produced. High CaO content in the fly ash will deliver short setting time of geopolymer paste.

However, CaO content and compressive strength of geopolymer paste has direct proportional correlation. High CaO content of fly ash will deliver high compressive strength of geopolymer paste produced.

On the other hand, geopolymer paste which has fast setting time performed high compressive strength.

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