Review on Geopolymer Concrete With Partial Replacement of Coarse Aggregate By Using Steel Slag

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Abstract- *This review aims to study further sustainability to the cement - less geopolymer concrete by replacing its natural gravel coarse aggregate by an industrial by-product, scrap steel slag. The compressive strength was evaluated by measuring the maximum acceptable load using compression testing equipment. Compressive strength depends on several factors, such as time and temperature of curing and the mixing proportion. The compressive strength of geopolymer concrete with steel slag substitution was higher compared to geopolymer concrete with gravel aggregate.This investigation work encourages the use of steel slag as coarse aggregate in concrete with its easy availability and low cost, if not free.*

Keywords- GPC, Fly ash, GCBS, Alkaline liquids, Steel slag

I. INTRODUCTION

Geopolymer concrete is concrete formed from geopolymer material as the matrix material and mineral aggregate as reinforcement and filler. Geopolymer concrete was invented by Joseph Davidovits, a French scientist in the late 1970s. Geopolymer has the potential to replace Portland cement, especially in its application as a base for the manufacture of concrete. On the surface of geopolymer concrete, a polycondensation polymerization reaction forms aluminosilicate (Davidovits, 1994). All industries produce waste, which is the remainder of product processing, and this waste, if The amount of solid steel waste (steel slag) generated by the steel smelting industry (in this paper represented by PT. Krakatau Steel, Banten) is up to 150 tons per day, and so waste reduction is needed to lower the impact to the environment. In this paper we report on the mechanical properties of concrete, represented by compressive strength, and the corrosion rate of the steel reinforcement in a geopolymer mix, using various types of filler materials, such as aggregates.not managed properly, will cause adverse effects to the environment. As the need for steel globally increases, waste produced from the steel processing industry will also increase. Hazardous waste from steel processing is produced in the form of physically dense coarse aggregate called steel slag.

II. LITERATURE SURVEY

a) Henki Wibowo Ashadi, Boy Ahmad Aprilando, SotyaAstutiningsih(2015), An alkaline activator solution was prepared by mixing sodium silicate, sodium hydroxide, and water. Sodium hydroxide was diluted with water and then mixed into the sodium silicate. The concrete was cured in an oven at 60°C in order to accelerate the hardening reaction of the concrete. The applied scan rate was 0.5 mV/sec. The density of carbon steel is 7.86 g/cm3. The equivalent weight of carbon steel is 27.925 g/mol. Testing was applied after day 1 of curing for 6 days at 60°C by using two cylinders for each test. The optimum strength of geopolymer concrete occurred on day 3 at an oven temperature of 60°C. The highest strength of the geopolymer concrete was 21.89 MPa with slag aggregate and was 15.89 MPa with gravel aggregate. Steel slag can increase the compressive strength of geopolymer concrete because steel slag reduces alkali silica attacks. The corrosion rate was equal to 0.07238 mm/year on day 3 and decreased on day 7 to 0.06240 mm/year, which was still above the corrosion rate on the first day. Acid rain conditions were higher on the first and the third day, with the rate equal to 0.05390 mm/year; however, the rate decreased to 0.05619 mm/year on day 7, which was still notably higher than that of the first day. The reinforcing steel in steel slag aggregate had a corrosion value on day 1 of 0.04394 mm/year, which increased to 0.05226 mm/year before dropping to 0.03974 mm/year on day 7.The corrosion rate of reinforcing steel in geopolymer concrete with steel slag substitution was found to be greater (0.07487 mm/year) compared to that of normal geopolymer concrete without steel slag (0.07238 mm/year) in seawater medium, whereas in an acid rain environment, steel slag substitution increased corrosion resistance.
b) Ahmet EminKurtoğlu, RadhwanAlzeebaree, Omar Aljumaili, AnılNiş, Mehmet ErenGülşan, Ghassan Humur and Abdulkadir Çevik(2018), Class F fly ash used and crush limestone was used as coarse aggregate with a maximum grain size of 10 mm, crushed limestone (≤4 mm) and natural sand used as fine aggregate. Sodium

silicate to sodium hydroxide ratio becomes in the range of 1.5 to 2.5 for economic reasons. Activator liquids/slag or fly ash ratio was selected as 0.45. SGPC specimens demonstrated superior compressive strength performance (~100 MPa) than control OPC specimens (~55 MPa) and FAGPC specimens (~50 MPa). The reduction in compressive strengths for SGPC specimens were 4%, 9% and 17% exposed to sea water, magnesium sulfate and sulfuric acid, respectively. The decline in compressive strength for OPC and FAGPC specimens were 8%, 17%, 35% and 7%, 16% and 32% exposed to sea water, magnesium sulfate and sulfuric acid environments, respectively.

c) *Deepth C, B Rajeevan* (2018),specific gravity and the fineness modulus of fine aggregate were 2.6 and 3.6 respectively. The uniformity coefficient was 3.33. Crushed natural stone of maximum size 20 mm, with a specific gravity and water absorption of 2.7 and 0.1%. Standard consistency of flyash was 28%. compressive strength was calculated at the end of 3, 7 and 28days curing. The compressive strength of the concrete was found to increase up to 25.6%. The optimum percentage of steel slag in geopolymer concrete was found to be 30%. Further the compressive strength was found to be reduced. The tensile strength of the concrete was found to increaseup to 52.3%. Further the compressive strength was found to be reduced. The maximum flexural strength were observed for specimen D30 and it's about 41.8%.

d) *Suganya N., Thirugnanasambandam S. T.(2020*), water absorption of geopolymer concrete is less than 5 %. The alkaline to fly ash ratio of 0.3 reduced porosity of concrete. Though aggregate to binder ratio of 3.5 gave higher strength, it has to be increased to 4.7 to achieve low porosity. Fly Ash to GGBS ratio = 70:30 , Activator solution to binder ratio = 0.45 , Molarity of NaOH = 8M ,Sodium hydroxide to Sodium silicate ratio = 2.5. The compressive strength of cement concrete was found 27.67 MPa and geopolymer concrete was 29.11 Mpa. 150 mm concrete cubes of cement concrete and geopolymer concrete after their curing period were immersed in 1% H_2SO4. The specimens were left in acid for 30 days. The compressive strength of geopolymer concrete with scrap steel slag coarse aggregate is 5 % higher than conventional concrete. Saturated water absorption for steel slag concrete is 0.3 % higher than cement concrete. But still less than 5 % limit, so it may not affect is performance.The reduction in compressive strength after 30 days of exposure in acid and sulphate are only 0.8 % and 0.5 % respectively.

e) Deepth C, B Rajeevan, The specific gravity and the fineness modulus of fine aggregate were 2.6 and 3.6 respectively. The uniformity coefficient was 3.33.Crushed natural stone of maximum size 20 mm, with a specific gravity and water absorption of 2.7 and 0.1% respectively.Standard consistency of flyash was 28%. The initial setting time of the flyash obtained was 3 hrs.Steel slag specific gravity and water absorption were 3.1and 1.9 % respectively.Five concrete mixes with different proportions of steel slag ranging from 0% to 40% were considered for the tests.The compressive strength of the concrete was found to increase up to 25.6%. Further the compressive strength was found to be reduced. The optimum percentage of steel slag in geopolymer concrete was found to be 30%.The tensile strength of the concrete was found to increase up to 52.3%. Further the compressive strength was found to be reduced. The optimum percentage of steel slag in geopolymer concrete was found to be 30%.The maximum flexural strength were observed for specimen D30 and it is about 41.8% more than the control specimen. The improvement in strength was due to the bonding of angular steel slag aggregate with geopolymer matrix.

f) O. M. Omar, A. M. Heniegal, G. D. Abd Elhameed, H. A. Mohamadien, the compressive strength of mixes containing 450 kg/m3 cement content is higher than the strength of mix prepared with 350 kg/m3 at 28 days.19% strength gain was obtained when the fly ash content increased from 350 kg/m3 to 450 kg/m3 at 28 days, for mix containing molarity of sodium hydroxide solution.The use of molarity M16 recorded that the compressive strength about 12%, and 2% higher than strength of mix prepared with molarity M10, and M14, respectively. At 28 days, with fly ash content 350 kg/m3 and crashed stone as coarse aggregates. On the other hand, the using of molarity M16, with fly ash content 450 kg/m3 , and crashed stone or local steel slag as coarse aggregates, the rate of compressive strength increase in the range about 9% and 1% for M10 and M14, respectively. The obtained results are in agreement with the published literatures.Average of density of geopolymer concrete approximately 2200 and 2263 kg/m3 in fly ash content 350 and 450 kg/m3 with crashed stone, respectively. In addition, cement concrete is approximately 2296 and 2323 kg/m3 in cement content 350 kg/m3 and 450 kg/m3 with crashed stone, respectively.The flexural strength of the geopolymer concrete increases compared to OPC concrete at the same age.

g) J Sanghamitra et al 2020, mechanical properties of GPC is examined with curing temperature 700C with a replacement of steel slag as coarse aggregate as 0%, 10%, 20%, 30% and 40%. Here the strength of GPC is increasing up to 30% replacement of steel slag as coarse aggregate. Specific gravity of fly ash,sand, steel slag is

2.85, 2.38,3.25.Development of high-volume fly ash-based GPC can show extremely good mechanical properties with higher compressive strength and longer durability. Also, Steel slag substitution as an aggregate can increase the strength of GPC up to 46% than natural coarse aggregate. From the above result it is noted that the strength is increasing upto 30% replacement of steel slag as coarse aggregate and then it decreases.

h) M.I.Abdulaleem,P.D. Arumairaj, He gives the higher concentration of sodium hydroxide resulted higher compressive strength and higher the ratio of sodium silicate to sodium hydroxide liquid ratio by mass, showed higher compressive strength of geopolymer concrete. As well as long curing time also increased the compressive strength.

i) Supriyakulkarni, the study of M25 grade of concrete mix and two different techniques of curing such as submerged curing and steam curing. The cubes were tested for 3, 7, 28 days for their compressive strength. He conclude that under water submerged curing, conventional concrete has better compressive strength when compared to geopolymer concrete. However under steam curing process the strength of geopolymer concrete is 10% higher than concentional concrete. Hence for geopolymer concrete steam curing is a better alternative than water submerged curing.

j) K.N okoye, J. Durgaprasad, N.B. Singh,

III. CONCLUSIONS

From the study, the following conclusions are described as follows:

1. Geopolymer concrete(GPC)is emits low carbon dioxide.
2. Long Curing time period also increased compressive strength of concrete.
3. under steam curing process the strength of geopolymer concrete is 10% higher than concentional concrete. Therefore geopolymer concrete steam curing is a better alternative than water submerged curing.
4. The ratio of sodium silicate to sodium hydroxide solution increases as well as compressive strength also increased.
5. Geopolymer concrete is slightly higer flexural value compared than OPC.
6. Super plasticizer its helps as increasing workability value.
7. 30% replacement of steel slag is gives more compressive strength compared than other mixes.

REFERENCES

[1] Supriya Kulkarni (2018), “Study on Geopolymer Concrete” in International research journals of engineering technology.

[2] M.I.Abdulaleem,P.D. Arumairaj (2012),Geopolymer concrete in IRJET.

[3] Lodeiro G, Palomo A, Jiménez F (2007). Alkali-aggregate reaction in activated fly ash system. Cement Concrete Res., 37: 175-183.

[4] S. E. Wallah and B. V. Rangan 2006: low-calcium fly ash-based geopolymer concrete: long-term properties, Research Report GC 2, Faculty of Engineering.

[5] Daniel L.Y. Kong, Jay G. Sanjayan 2008: Damage behavior of geopolymer composites exposed to elevated temperatures, Department of Civil Engineering, Monash University, Clayton, Victoria 3800.

[6] Davidovits J. Geopolymer cement to minimise carbon-dioxide greenhouse warming. Ceram Trans 1993;37:165–82.

[7] Hardjito D, Wallah SE, Sumajouw DMJ, Rangan BV. Brief review of development of geopolymer concrete. In: Proceedings George Hoff symposium on high performance concrete and concrete for marine environment, Las Vegas, USA; 2004. p. 63–72.

[8] Deepth C1 , B Rajeevan, Strength Behaviour of Geopolymer Concrete by Partial Replacement of Coarse Aggregate with Steel Slag.

[9] O. M. Omar, A. M. Heniegal, G. D. Abd Elhameed, H. A. Mohamadien, Effect of Local Steel Slag as a Coarse Aggregate on Properties of Fly Ash Based-Geopolymer Concrete

[10] S. Marathe, Mithanthaya, N. Bhavani, A Review on Strength and Durability Studies on Geopolymer Concrete, Vol. 5, Special Issue 9, May 2016.

[11] J Sanghamitra et al 2020, Experimental Investigation on Geo-Polymer Concrete by Using Steel Slag at Higher Temperature

[12] Rangan B.V., “On the Development of Fly Ash Based Geopolymer Concrete”, ACI Materials Journal, 2004

[13] N. P. Rajamane, M.C. Nataraja and N. Lakshmanan 2011: An introduction to geopolymer concrete, Indian Concrete Journal

[14] Rajamane N.P., M.C. Nataraja, N. Lakshmanan, and J.K. Dattatreya, (2010c), “Flexural Behaviour of Reinforced Geopolymer Concrete Beams”, Proceed of the 7th Structural Engineering Convention SEC 2010, Annamalai University, Annamalainagar, 8-10 December, pp 617-625