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Utilization of Waste Foundry Sand in Geopolymer Concrete

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ABSTRACT- As we know construction is very important in our life. In the world of construction, one material is used above all others: concrete. The cement is the base material of the concrete. In the production of OPC not only consumes significant amount of natural resources and energy but also releases substantial quantity of carbon dioxide to the atmosphere. Therefore, it is essential to find alternatives to make the concrete environment friendly. The geopolymer concrete is manufactured without using portland cement. This type of concrete has environmental benefit as it has very low greenhouse gas emission compared to that resulted from the production of portland cement. In addition, GPC also utilizes the abundantly available materials such as fly ash, rice husk, GGBS, WPS ashes and foundry sand that are waste by products & not easily disposed. In this way we makes eco friendly environment.

The objective of present work is to utilize the waste material such as foundry sand, fly ash in geopolymer concrete and study the variation in the properties of geopolymer concrete on addition of foundry sand. Using fly ash based geopolymer concrete will result in increasing compressive strength, tensile strength and flexural strength of concrete. Foundry sand and fly ash is waste material by using foundry sand and fly ash for producing geopolymer concrete the waste can be used effectively and results in low cost concrete.

Keywords: Geopolymer concrete, foundry sand, strength parameters, alkaline activators, environment.

1. INTRODUCTION

Concrete is a composite material composed of coarse aggregate, sand, cement. Usage of Concrete around the world is second only to water. Ordinary Portland cement is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel and consumes significant amount of natural resources. In addition, the extent of energy required to produce OPC. The global cement industry contributes around 1.35 billion tonnes of the green house gas emissions annually about 7% of the total man-made greenhouse gas emissions to the earth's atmosphere [Hardjito et.al. 2004]. Therefore, to preserve the global environment from the impact of cement production, OPC replaced with geopolymer concrete. Davidovits [1988] proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminum (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders. Because the chemical reaction that takes place in this case is a polymerization process, he coined the term geopolymer to represent these binders. The geopolymer concrete is produced by totally replacing the Ordinary Portland Cement (OPC). It is also called cement less concrete. There are two main constituents of geopolymers, the source materials and the alkaline liquids. The source materials for geopolymers based on alumina-silicate should be rich in silicon (Si) and aluminum (Al). These could be by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc could be used as source materials. The choice of the source materials for making geopolymers depends on many factors such as availability, type of application, cost and specific demand of the end users. The alkaline liquids are usually sodium or potassium based. The most common alkaline liquid used in geopolymerization is a combination of sodium hydroxide (NaOH) and sodium silicate or potassium hydroxide (KOH) and potassium silicate.

1.1 Fly Ash Based Geopolymer Concrete

In geopolymer concrete, the silica and the alumina present in the source materials are first induced by alkaline activators to form a gel. This geopolymer gel binds the loose aggregates and other unreacted materials in the mixture to form the geopolymer concrete. In this experimental work, fly ash is used as the source material to make geopolymer paste as the binder, instead of cement paste, to produce concrete. Foundry sand is used in concrete to improve its strength and other durability factors. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods. As in the Portland cement concrete, the aggregates occupy the largest volume, i.e. about 75-80 % by mass, in fly ash-based geopolymer concrete. Durability aspects of geopolymer products include good sustainability to weathering effects; however, they are not resistant towards high temperature beyond 400ºC. Several experimental studies showed that geopolymer concrete specimens immersed in sulphuric acid and caloric acid were found to be resistant to acid attack. While the Portland based cement showed deleterious reaction and resulted in surface deterioration followed by weight loss [Davidovits, 1994].

1.2 Process of Making Geopolymer Concrete

The materials used in GPC are alkaline solution like combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate, fly ash, foundry sand and coarse aggregate. The fly ash and the aggregates are first mixed together in dry state. The liquid component of the mixture is then added to the dry materials and the mixing continued usually for another 3to5 minutes. The setting mechanism depends on polymerization and the curing temperature is between 60º -90ºC.

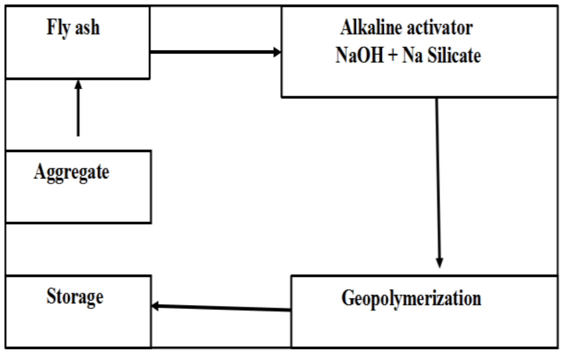

Fig -1: Process of making geopolymer concrete

1.3 Curing

The previous studies on geopolymer concrete revealed that geopolymer concrete did not attain any strength at room temperature or by water curing. The geopolymer concrete will harden at steam curing or hot air curing and the minimum curing period shall be 24hours. After casting the specimens, they were kept in rest period in room temperature for 2 days. The term 'Rest Period' was coined to indicate the time taken from the completion of casting of test specimen to the start of curing at an elevated temperature. The geopolymer concrete was demoulded and then placed in an auto clave for steam curing for 24 hours at a temperature of 60˚C.The cubes were then allowed to cool in room temperature for 24 hours.

2. LITERATURE REVIEW

Djwantoro Hardjito et.al. (2004) [1] made efforts to develop environmentally friendly construction materials. To reduce greenhouse gas emissions, fly ash based geopolymer concrete was developed. The author concluded that higher concentration (in terms of molar) of sodium hydroxide solution results in a higher compressive strength. Higher the ratio of sodium silicate-to-sodium hydroxide liquid ratio by mass, higher is the compressive strength. Longer curing time, in the range of 6 to 96 h (4 days), produces larger compressive strength of geopolymer concrete. The fresh geopolymer concrete is easily handled up to 120 min without any sign of setting and without any degradation in the compressive strength. The resistance of geopolymer concrete against sodium sulphate is excellent.

Djwantoro Hardjito et.al. (2004) [4] were investigated the effects of several factors on the properties of fly ash based geopolymer concrete, especially the compressive strength. The test variables included were the age of concrete, curing time, curing temperature, quantity of superplasticizer, the rest period prior to curing, and the water content of the mix. The development of geopolymer concrete is an important step towards the production of environmentally friendly concrete. The author concluded that the compressive strength of geopolymer concrete does not vary with age, and curing the concrete specimens at higher temperature and longer curing period will result in higher compressive strength. The water content in the concrete mix plays an important role.

N A Lloyd and B V Rangan et.al. (2010) [5] made efforts to develop fly ash based geopolymer concrete. The results of the tests conducted on large-scale reinforced geopolymer concrete member's show that geopolymer concrete is well-suited to manufacture precast concrete products that can be used in infrastructure developments and geopolymer concrete has excellent properties. The economic benefits and contributions of geopolymer concrete to sustainable development have also outlined.

Raijiwala D.B. et.al. (2010) [6] studied the different properties of geopolymer Concrete (using thermal power plant fly ash, potassium hydroxide and sodium hydroxide solutions). The actual compressive strength of the concrete depends on various parameters such as the ratio of the activator solution to fly ash, morality of the alkaline solution, ratio of the activator chemicals, curing temperature etc. In this paper author concluded that the properties of geopolymer Concrete (compressive strength, tensile strength, flexural strength) are better than other concrete except durability. The compressive strength of OPC increases over controlled concrete by 1.5 times (M-25 achieves M- 45).Split Tensile Strength of OPC increases over controlled concrete by 1.45 times. Flexural Strength of OPC increases over controlled concrete by 1.6 times. In Pull Out test, OPC increases over controlled concrete by 1.5 times. In Durability test, there is decrease in weight loss by 10 times (At 56 days % loss in weight has reduced from 5.66% to 0.60%).

Mohd Mustafa Al Bakri et.al. (2011) [7] develop environmental friendly concrete by replacing OPC with fly ash. The author concluded that fly ash-based geopolymer is better than normal concrete in many aspects such as compressive strength, exposure to aggressive environment, workability and exposure to high temperature.

Dali Bondar [8] has been studied the geopolymer concretes, its specifications, benefits, applications, carbon footprint and cost. Curing time and temperature have an effective role on compressive strength of geopolymer concrete. Two curing conditions can be considered which are fog and sealed conditions. It is shown that sealed condition shows around 15% more compressive strength than samples are cured at steam condition. The author concluded that the geopolymer concrete develop moderate to high mechanical strength with a high modulus of elasticity and a shrinkage much lower than with OPC and is liable to reduce CO_2 emission from 22.5% to 72.5% compared to OPC production.

Shankar H. Sanni et.al. (2012) [9] investigated performance of geopolymer concrete subjected to severe environmental conditions. Increase awareness regarding the ill-effects of the over exploitation of natural resources, eco-friendly technologies are to be developed for effective management of these resources. The author concluded that the heat cured fly ash based geopolymer concrete has an excellent resistance to acid and sulphate attack when compare to conventional concrete and we can say the production of geopolymers have a relative high strength, excellent volume stability and better durability.

M.A.Bhosale et.al. (2012) [10] made effort to studied the factors that influence the early age compressive strength such as molarities of sodium hydroxide (NaOH) have been studied. Sodium hydroxide and sodium silicate solution were used as an alkaline activator. The result showed that the geopolymer paste with NaOH concentration, compressive strength increase with molarities increases. The compressive strength is more for oven drying as compare to specimen left in ambient temperature.

Kolli. Ramujee et.al. (2013) [11] attempt is made to develop the mix design for geopolymer concrete in low, medium and higher grades and relative comparison has been made with equivalent mix proportions of grades of OPC Concretes in both heat cured and ambient cured conditions. The result showed that the compressive strength of GPC can be achieved by decreasing water binder ratio. The compressive strength attained at 28 days for all grades of geopolymer concrete under ambient curing is almost equal to compressive strength achieved by geopolymer concrete at 7 days. Because of the slow reactivity of flyash at ambient temperature, considerable heat must be applied to increase the geopolymerization process. .

Shankar H.Sanniet.al. (2013) [12] experimentally investigated the variation of alkaline solution on mechanical properties of geopolymer concrete. The curing period improves the polymerization process resulting in higher compressive strength. The author concluded that the ratio of alkaline solution increases, the workability of mix goes on increasing. The strength of geopolymer concrete can be improved by decreasing the water/binding and aggregate/binding ratios. The optimum dosage for alkaline solution, which is used a geopolymer binder can be considered as 2.5, because for this ratio, the GPC specimens of any grade produced maximum strength results with compression and tension.

3. CONCLUSION

Geopolymer concrete holds great promise as an eco-friendly. Based on the review of literature on geopolymer concrete it can be concluded that the research has been conducted to develop environment friendly concrete, to reduce greenhouse gas emissions and effects of parameters like activator to fly ash ratio, curing temperature and type of curing on properties of geopolymer concrete. However, there is scope for future research to overcome the current limitations associated with more wider application of material.

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BIOGRAPHIES

Rekha Devi receives her B.Tech degree in Civil Engineering from Rayat Bahra Institute of engineering and nano technology, hoshiarpur in 2012. At present she is in final year of her M. Tech program in Construction and technology management from National Institute of technical teacher training and research Chandigarh.

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