A Comprehensive Review Of Geopolymer Concrete Incorporating Foundry Waste And M Sand"

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ABSTRACT:
Cement concrete is very important material used worldwide in infrastructure development. It can be said that, concrete is the second most consumed man-made substance in the world. Nearly, 5% of total global emission of CO_2 takes place due to production of concrete. Therefore, now it is necessary to find alternative products for cement because each tone of production releases equal amount of CO_2. Many researches have been done in order to replace cement with other materials. Geo-polymer can become one of the successful replacements with some drawbacks. Hence, more studies must be done in order to strengthen the research work executed in the area of Geopolymer concrete. The main byproduct of any thermal power station is Fly Ash which is rich in Silica and Alumina. Also, particles of fly ash are finer than cement which can be used in the production of geopolymer concrete. Ferrous and non-Ferrous metal casting industries produces waste material called as Foundry sand whose landfilling causes loss of energy and natural resources. So, the key purpose of this study is to analyse the differentproperties of fly ash contained geopolymer concrete made using foundry waste and M sand.

INTRODUCTION:

Majorly used binding material in concrete is cement throughout the world. Production of cement releases large amount of CO_2 which is hazardous to environment and health. The large-scale production of cement is posing environmental problems on one hand and unrestricted depletion of resources on the other hand. It is mandatory to find best alternative for cement. Many by products composites cementitious material like silica and alumina which can be a replacement for cement as binder. Geopolymer concrete is a fusion of waste materials like fly ash, granulated Blast Furnace Slag, Silica Fume, Rice husk, etc. with alkaline solution. Silica and alumina are the integrals of geopolymer concrete which polymerizes with alkaline activating solution and forms a molecular chain. Next to fly ash, foundry sand is the waste generated in ferrous and non- ferrous metal casting industries which also contains amount of silica and alumina. The studies shows that this material can be used as partial substitute for fine aggregate in concrete. Using these by-products materials in the construction is the best possible method to chuck out this waste.

Important factor that affects the strength of concrete is curing temperature in case of geopolymer concrete. The polymerization process will improve with longer curing time, contributes higher compressive strength.

As thermal industries produce huge amount of fly ash; ferrous and non-ferrous metal casting industries also produce by product which is also very harmful for environment. Traditional method of landfilling is used, to get rid of this foundry waste. But in today's time, it is very costlier and harmful. Therefore, it is a need of an hour to disclose safer and economical ways to dispose of such waste.

LITERATURE RIVEW:

The name geo-polymer was formed by French Professor Davidovits [1] in 1978 to represent a broad range of materials characterized by network of inorganic molecules (Geo-polymer Institute 2010). The geo-polymers depend on thermally activated nature materials like Meta kaolinite or industrial by-products like fly ash or slag to provide a source of silicon (Si) and aluminium (Al). These silicon and Aluminum is dissolved in an alkaline activating solution and subsequently polymerizes into molecular chains andbecome the binder. Geo-polymers are group of materials that are manufactured from alumina silicate mixture and an alkaline solution.

Palomo et al. [2] suggested that pozzolans such as blast furnace slag might be activated using alkaline liquids to form a binder and hence totally replace the use of OPC in concrete. In this scheme the main contents to be activated are silicon

and calcium in the blast furnace slag. The main binders produced is C-S-H gel, as the result of hydration process.
B. Vijaya Rangan [3] stated that stated that, “the polymerization process involves a substantially fast chemical reaction under alkaline conditions on silicon-aluminum minerals that results in a three-dimensional polymeric chain and ring structure….”
He also presented as presented as comprehensive study conducted on fly ash- based Geopolymer concrete. Tests are conducted to find out the effects of salient factors that influence the properties of the Geopolymer concrete in the fresh and hardened states. These results are to be utilized to propose a simple method for the design of Geopolymer concrete mix. The economic merits of the Geopolymer concrete are also mentioned presented information on fly ash-based Geopolymer concrete. Low calcium fly ash (ASTM Class F) is used as the source material, instead of the Portland cement to make concrete. It can be concluded that Low-calcium fly ash-based Geopolymer concrete has excellent compressive strength and is good for structural applications.M. I. Abdul Aleem [4] reports that Geopolymer concrete is a new construction material; it is produced by the chemical action of inorganic molecules. Fly Ash, which isa waste product of coal obtained from the thermal power plant is available in large amount worldwide. Silica and alumina content are very high in Fly ash which reacts with alkali solution and produce aluminosilicate gel. It acts as the binding material for the concrete ingredients. It is a very innovative and good construction material to the existingcement concrete. Geopolymer concrete is to be prepared by without usage of ordinary Portland cement. Authors briefly review the constituents of Geopolymer concrete and its strength parameters. Manvendra Verma et al. [5] The concrete cost was calculated by the number ofthe constituents present in the concrete mix design, and then, after calculating the rate of all individual constituent prices, the concrete mix design cost was found. The cost of the GPC at a bulk level reduced the cost of up to 40% of the OPC concrete. The cost of the OPC of 1 m3 is Rs. 3758, whereas the cost of the GPC of 1 m3 is Rs. 2230. The cost estimate only includes the materials and excludes the human resources. OPC concrete is 11% more expensive than GPC for better quality concrete. GPC costs 1.7% more than cement concrete for grades up to 30 MPa N.T. Sithole et al. [6] In a quest, to achieve the zero-waste goal this study proposes an approach that the metal casting industries can adopt to show their role played in support of the circular economy by repurposing their waste material. A feasibility study was carried out to develop concrete specimens from waste foundry sand, crushed stones, and alkali activated GGBFS. The Alkali activated GGBFS binding propertieswere also evaluated to demonstrate its potential to replace OPC in South Africa.Alkali activated GGBFS can be used as a binder and WFS can be used to replace natural sand in the production of green and clean concrete mortar. Ali Abdulhasan Khalaf et al. [7] The test results confirmed that the physical and mechanical properties notably improved when the FA percentage increased in the composition of the FA geopolymer-stabilized WFS. Dry density improved from 1.75 to g/cm3 ; longitudinal wave velocity increased from 897.3 to 2028.4 m/s, and unconfined compressive strength rose from 109 to 5261 kPa. To look towards potential applications and future directions, geopolymer-stabilized WFS emerges as an environmentally apprehensive solution for sustainable construction. It facilitates utilizing waste materials while minimizing the carbon footprint associated with traditional stabilizing agents.Sunit Kumar et al. [8] Nowadays, consideration of sustainable materials in the construction industry has become critical and WFS is one of such alternatives for use in concrete production. WFS as a waste in non-ferrous and ferrous metal industries generally have a mass production, so its use in concrete promises to resolve the issue of waste utilization and successful progress toward zero waste goal. Literature reported that partial replacement of sand by WFS in concrete founds to be significant, where often partial optimum replacement level concrete founds to be significant, where often partial optimum replacement level is achieved as 20–30% with desirable properties. Comparison of partial to full replacement of WFS in concrete showed that full replacement requires a drastic amount of water and especially workability and compressive resistance of the concrete founds to be declined with respect to the control mix, thus making full replacement unsuitable for structural concrete. In summary, the use of WFS in place of natural sand has advantages from a technological, economic, and environmental standpoint, which is imperative in the present time for sustainable construction.Sunit Kumar et al. [9] Nowadays, consideration of sustainable materials in the construction industry has become critical and WFS is one of such alternatives for use in concrete production. WFS as a waste in non-ferrous and ferrous metal industries generally have a mass production, so its use in concrete promises to resolve the issue of waste utilization and successful progress toward zero waste goal. Literature reported that partial replacement of sand by WFS in concrete founds to be significant, where often partial optimum replacement level concrete founds to be significant, where often partial optimum replacement level is achieved as 20–30% with desirable properties. 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NECESSITY OF GEOPOLYMER CONCRETE:

Construction field is growing very fast globally. Total consumption of cementwas estimated to cross 370 million tons in year 2022-23 in India. For the production of Ordinary Portland Cement, Limestone is the main ingredient which may cause shortageof it in upcoming years. As we discussed about the emission of CO2 during manufacture of cement, it is necessary to find alternative solution for cement. As we know that, natural resources available on earth is bounded so now we should hunt for some sustainable options in replacement for traditional concrete mix design. In addition to this, Fly ash is also the huge threat to environment. Fly ash is the by product of many industries which is dumped simply on ground. Therefore, proper use of fly ash can also help to heal environment.

Years on end, we are using sand as fine aggregate in standard concrete mix. But now we should understand the requirement of environment and compose new mix designs which can swap place fine aggregate with foundry waste which is subsidiary product of ferrous and non-ferrous metal casting industries.So, by using Geopolymer concrete as a replacement to ordinary concrete cansolve many of the major environmental issues such as pollution due to emission of carbondioxide. Mix design of geopolymer concrete using foundry waste will make it more environment friendly.

GEOPOLYMER CONCRETE DEVELOPMENT:

Materials possess silica and alumina comes in contact with alkaline solution, it undergoes geopolymerization process thorough which alumino silicate gel is formed. Geopolymer material is made up of this reaction. Geopolymer do not comprise any cement in it. Fly ash acts as binder instead of cement and alkaline solution as an activator. Combination of sodium hydroxide (NaOH) and sodium silicate (NaSiO3) is used for present time study as an alkaline solution. Binder is the most basic and important difference between conventional concrete and GPC because there are no traces of Portland cement in GPC as binder. In exchange for Portland cement, different industrial by products which consists of silica and alumina, such fly ash, silica fume, rice-husk and other resemblant materials are added to react with highly alkaline solution to get binder.Different types of natural as well as industrial by products which possess nebulous silica and alumina can be used as aluminosilicates in GPC. In emerging market, industrial or agro-waste material containing nebulous silica and alumina are usually used for generation pf energy.

$N(Si_2O_5Al_2O_5) + 2nSio_2 + 4nH_2O + NaoH \text{ or } KOH \rightarrow Na^+, K^+ + n\,(OH)_3\text{-Si-O-Al}^-\text{-O-Si-}(OH)_3$ (A)

(Si-Al materials) ↓

$(OH)_2$

(Geopolymer precursor)

| | |

$N(OH)_2\text{-Si-O-Al}^-\text{-O-Si-}(OH)_2 + NaoH \text{ or } KOH \rightarrow (Na^+, K^+)\text{-(-Si-O-Al}^-\text{-O-Si-O-)} + 4nH_2O$ (B)

| | |

0 0 0

$(OH)_2$

(Geopolymer backbone)

No water is involved for the development of geopolymer concrete rather water I drum out during curing process. This process is exactly opposite from the hydration reaction which takes place when Portland cement comes in contact with water. And primary products such as calcium silicate and calcium hydroxide are formed.

Calcium plays very important role that it can cause flash setting therefore it should be carefully oversee in the geopolymers made using fly ash.

FOUNDRY SAND:

In recent times, for sustainable and environment friendly construction development, employment of industrial waste in the construction has been largely increased. M. Heidemann [10] Waste foundry sand (WFS) is a by-product of metal foundry industries. It was initially utilized as a casting mold material, but it eventually degraded into finer particles due to the high temperature in the metal foundry process.

Dushyant R. Bhimani et al. [11] Foundry sand is typically sub angular to round in shape. After being used in the foundry process, a significant number of sand agglomerations form. When these are broken down, the shape of individual sand grains isapparent.

Table No. 1 physical properties of the foundry sand used by different researchersAishwary Pradeep Kawale [12]

Author	Siddique et.al	Singh andSiddique	N. Gurumoorthy	Ruofei Xiang
Specific Gravity	2.61	2.18	2.79	1.97
Density (kg/m3)	1638	-	1784	1538
Fineness modulus	1.78	1.89	2.23	1.32
Water Absorption(%)	1.3	0.42	5	3.20

Particle below 7µm (%)	18	8	1.08	54.90
Moisture content	-	0.11	-	-
Clay lumps	0.90	0.80	0.40	-

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