Proceedings of Second Shri Chhatrapati Shivaji Maharaj QIP Conference on Engineering Innovations
Organized by Shri Chhatrapati Shivaji Maharaj College of Engineering, Ahmednagar
In Association with Novateur Publications JournalNX-ISSN No: 2581-4230
February, 22nd and 23rd, 2019

Geopolymeric Building Material By Using Synergistic Utilization Of Industrial Waste

Anjali Anil Solse, Kalyani Bhagwan Borkar[1]
Student, Department of Civil Engineering
SCSMCOE Nepti, Ahmednagar
Email Address: anjali.solse@gmail.com

Prof. Nikam P. G.[2]
Assistant Professor, Civil Engineering Department
SCSMCOE Nepti, Ahmednagar
Email Address:prasad.nikam999@gmail.com

Abstract: In present age the industrial waste are generated in huge amount. It mainly affects to environment, health etc. Due to rapid urbanization and industrialization the production of various types of solid wastes which pose serious problem to the environment have been generated. So the disposal and reuse of solid industrial wastes like phosphogypsum, flurogypsum, fly ash, slag and lime sludge, etc. become a big challenge to us .Recycling of such wastes and using them in construction materials is the solution not only to the pollution problem but also an economical option in construction [1]. It is estimated that about 300 million tones of inorganic waste from industrial and mining sectors are generated every year in India. We also see that while manufacturing cement, a huge quantity of CO2 is emitted by industries, it ultimately affect the environment and create a big problem of global warming [2]. Therefore it is necessary to take initiative to reduce the use of such cement [2]. And also the products that causes a major harm to the environment. Synergistic utilization of major industrial wastes generated in India, namely fly ash, blast furnace slag and red mud, has been explored to develop novel building components using geopolymerisation. These include: (a) high strength cements (b) self glazed wall tiles, and(c) pavement tiles. Fly ash was used as main source of silico-aluminate for geopolymerisation. Granulated blast furnace slag (GBFS) and red mud were used individually or in combination with fly ash to harden properties of the developed components. In view of utilization of industrial waste in construction material, the present paper reviews various waste materials at different levels in construction material [1]. The reviewed approach for development of new construction material using industrial waste is useful to provide a potential sustainable source.[1]

Keywords—Geopolymeric Concrete, Fly ash,Global Warming,Industrial Waste

I. INTRODUCTION

The concept of industrial ecology is based on integration of by-product and waste steams across industries leading to production of useful products with near zero flow of material to the environment. The Indian construction industry alone consumes approximately 400 million tons of concrete every year and the relative amount of mortar too. Therefore the demand of the concrete and the required raw materials are very high. This causes the hike in the costs of cement, fine and coarse aggregates. In coming years the shortage of these materials is also occurred. To avoid the problems like cost hike and cuts in supply of concrete and mortar, the alternate material or the partial replacements for the cement and aggregate should be developed by recycling of waste materials. This provides us the low cost, lightweight and eco-friendly construction material. Use of the waste materials also reduces the problem of land-filling, environmental and health concern.[1]

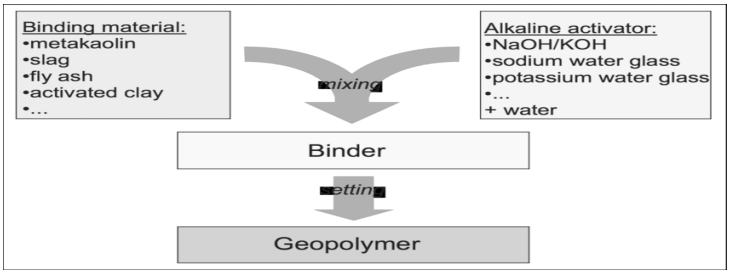

Fig.1

Geopolymerization is a developing field of research for utilizing solid waste and by-products. It provides a mature and cost-effective solution to many problems where hazardous residue has to be treated and stored under critical environmental conditions. Geopolymer involves the silicates and aluminates of by-products to undergo process of geopolymerization. It is environmentally friendly and need moderate energy to produce.geopolymer material have not only excellent resistant to chemical attack but also superior acid resistant. In the process of geopolymerisation,silicon (Si) and aluminum (Al) atoms react to form molecules that are chemically and structurally comparable to those binding natural rock and allows for novel products synthesis that exhibit the most ideal properties of rock-forming elements, i.e., hardness, chemical stability and durability. Fly ash, blast furnace slag and red mud are the three major industrial wastes in India. It is estimated that production of these wastes will double in future due to rapid expansion coal based power generation, and increase in the production of iron & steel and aluminum through primary processing. These waste materials contain SiO2 and Al2O3, along with Fe2O3, CaO, MgO, MnO, etc, and have great potential as manmade raw materials for geopolymers

This paper is based on recent wide variety of geopolymeric products using fly ash as the main raw material along with granulated blast furnace slag (GBFS) and red mud. The focus is on: (a) high strength cement, (b) self-glazed tiles, and (c) pavement tiles processing, structure and properties of the products.

Materials and Methods:

The main source material in the production of geopolymeric building material is:

1. Material that contain Silicon (Si) and Aluminium (Al) in amorphous form.
2. By-products materials such as fly ash, silicafume, slag, rice husk sash, red mud etc.
3. Waste from three industries like fly ash from thermal power plants, fly ash and granulated blast furnace slag from steel plant, has been used.

Fly as was used for the development of geopolymeric cement , combination of fly ash and blast furnace slag was used for self glazed tiles and all three wastes fly ash ,granulated blast furnace slag and red mud was used for pavement tiles.

A. Fly Ash Bricks:

Fly ash lime bricks are chemically bonded bricks manufactured by utilizing 80-82% of fly ash, 9-10% of lime, 9-10% of sand and 0.2% of Chemical accelerator [2]. These raw materials are mixed in a blender, during blending process Fly ash reacts with lime in presence of moisture to form a calcium silicate hydrate which is the binder material. After blending, the mixture is moulded into bricks and water cured for 10-12 days.

For manufacturing fly ash lime bricks no firing is needed, these bricks are suitable for use in masonry construction just like common burnt clay bricks[2]. The bricks are also suitable for the construction of building in coastal areas where normal red clay burnt bricks are found to be affected

B. Geopolymeric Concrete:

Geopolymer concrete is manufactured by using the low-calcium (ASTM Class F) fly ash obtained from coal-burning power stations, the silicon and aluminium oxides contents of which are about 80% by mass, with the Si-to-Al ratio of about 2. The content of the iron oxide usually ranged from 10 to 20% by mass, whereas the calcium oxide content was less than 5% by mass. The carbon content of the fly ash, as indicated by the loss on ignition by mass, was as low as less than 2%. The particle size of 80% of the fly ash particles was smaller than 50 micron. Coarse and fine aggregates used by the concrete industry are suitable to manufacture geopolymer concrete. The silicon and aluminium oxides in the low-calcium fly ash reacts with the alkaline liquid to form the geopolymer paste that binds the loose coarse aggregates, fine aggregates, and other un-reacted materials together to form the geopolymer concrete. One ton low calcium fly ash can be utilized to manufacture approximately three cubic meters of high quality fly ash based Geopolymer concrete[2].

Fig.2

C) Self glazed wall tile:

Conventionally ceramic tiles are produced by high temperature slag of aluminosilicate and silicate minerals such as clay, quartz, feldspar, etc. The strength and other properties of tiles are developed due to

Formation of ceramic bonds. The processing involved reaction between aluminosilicate mineral kaolinite and

NaOH at 100°C-150°C resulting into the formation of hydro-sodalities

$$Si_2O_5,Al_2(OH)_4 + NaOH \Rightarrow \square Na(\text{-Si-O-Al-O})_n \quad (1)$$

Kaolinite hydro-sodalite

In the alkali activation of fly ash and slag mixture, fly ash/slag ratio is the most relevant factor on the strength development. The additions of calcium content increase the degree of geopolymerisation at elevated temperature and results into higher strength beneficial effect of slag on fly ash geopolymerisation Was exploited in the development of self glazed wall tiles. The glazed surface and the body of tiles showed distinctly different Microstructure Critical control on particle size distribution, chemical composition, rheology of slurry and reaction environment is necessary for the formation of required phases in the glazed surface. The tiles developed conform to the European Nation (EN) specification for wall tiles. The natural colour of the tiles was light grey but different colour and designs were produced using colour pigments. Unlike the fired ceramic tiles, no crazing and other glaze defects were observed. Although the surface of the tile was impervious, the porosity of body was 13-17%, which is good for bonding with cement.[4]

4) Geopolymeric paver blocks:

Geopolymer Paver Blocks is an ecofriendly method of making concrete paver block using foundry sand in Geopolymer concrete. It is a by-product of ferrous and nonferrous metal casting industries. Applications of foundry sand in Geopolymer Paver block, which is technically, sound, environmentally safe for sustainable development. There is partially replacement of fine aggregate in Geopolymer paver block by used foundry sand for determining the change in the

compressive strength of paver blocks and cost of paver block. While casting a paver blocks Mix design for M 50 grade is used for the construction . IS 10262:2009 (Concrete Mix Proportioning Guideline) was used for design mix and different trials has been performed for deciding the molarity of alkaline solution. Cubes of size 15 × 15 × 15 cm can be casted and tested. In this concrete mix fly ash can be used instead of cement along with alkaline solution, coarse aggregate and fine aggregate.

This study aims at determining the suitability of using the waste foundry sand with replacement of fine aggregate in Geopolymer concrete blocks and make eco friendly Paver block.

Advantages and Disadvantages:

A) Advantages of Geopolemeric building material:

1) Geoplymeric material is low cost and environmental friendly.
2) There is proper utilization of industrial waste like fly ash, slag, mud etc.
3) The Geopolemeric building material have a excellent compressive strength and suitable for structural application.
4) Reduction in greenhouse gas which is emitted in the manufacturing process of OPC. It has also same elastic properties as that of Portland cement.
5) High-strength geopolymer concrete do not need any mineral or chemical admixtures to develop sufficient workability.
6) The Geopolemeric building material have a high durability, low permeability, fire proof also it has excellent properties within a acid and salt environment.

B) Disadvantages of Geopolemeric building material:

1) Geopolymeric material requires special handling needs and is extremely difficult to create. It requires the use of chemicals, such as sodium hydroxide, that can be harmful to humans.

2) Geopolymer concrete is sold only as a pre-cast or pre-mix material due to the dangers associated with creating it.

3) Uniformity is lacking.

II. CASE STUDY: CASE STUDY OF FLY ASH BRICK MANUFACTURING UNITS AT KOTA IN RAJASTHAN.[8]

Kota Super Thermal Power Station (KSPTS) of 1240 MW is located at Kota in Rajasthan, India. The quantity of fly ash generated by it is about 1.64 to 2.03 million tonnes per year. 1.79 million tonnes of fly ash is being utilized for making bricks, tiles, Portland pozzolana cement, construction of highways, and other purposes. Out of this total utilization, 0.6439 million tonnes (36.06 %) of fly ash was used for making bricks, blocks, and tiles.

Study of fly ash brick manufacturing units:

To study and understand various aspects of fly ash utilization for making bricks, a survey was conducted at two fly ash brick manufacturing units situated in Kota city of Rajasthan at Kunhari area near KSTPS. Fly ash bricks are made by using fly ash, 6 mm aggregate, stone dust, lime, and Plaster of Paris (POP) in various proportions. Fly ash is obtained from KSTPS, 6 mm aggregate and crusher dust are obtained from stone crusher plants at Kota, lime is brought from Borunda in Jodhpur (Rajasthan), and POP is brought from Nagaur (Rajasthan). The manufacturing process involves mixing the above-mentioned ingredients in requisite proportions.

Fig.3 *Manufacturing of Fly Ash Bricks*

The mixture is then carried to the fly ash brick-making machine. In the machine, it is pressed and molded into the standard brick size. The bricks are then sun dried with requisite amount of water curing.The industry not only utilise fly ash bt also provides bricks for building construction in Kota. This also has reduced the consumption of fired clay bricks. Fired clay bricks were not only causing air pollution but were also responsible for excavation of top soil. Hence in one way, the fly ash bricks can be called as green building construction materials.

Table No 1.

Description	***Unit1***	***Unit2***
Number of workers	**10**	**16**
Composition (%)	Fly ash (60%) 6mm aggregates(15%),crusher dust(10%) ,Lime (10%),POP(5%).	Fly ash (50%) crusher dust and6mm aggregates(30%) , Lime(15%),POP (5%)
Size of bricks	22.86cmX10.16cmX7.62 cm	22.86cmX10.16c mX7.62cm

III. CONCLUSION :

1. geopolymers have the potential of utilization of industrial wastes rich in silico-aluminates such as fly ash, GBFS, red mud, etc.
2. Novel building materials such as high strength geopolymerscementcanbe developed by additional processing such as mechanical activation, and self-glazed tile and pavement tiles can bedeveloped by synergistic use ofindustrial waste namely fly ash, GBFS and red mud.

3.The development of eco-friendly construction materials due to easy and simpleprocessing, low energy requirement and no CO2 emission. .The study in turn is useful for various resource persons involved in using industrial or agricultural waste material to develop sustainable construction material.[4]

Refereneces:

1) Utilisation of industrial waste in construction material-a review,Dhiraj Agrawal,Pawan Hinge,Depaetment of Civil Engineeering,YCCE,Nagpur-10,Maharashtra India,International Jornoul of Innovative Research in Science,Engineering and Technology ,ISSN:2319-8753(An ISO 3297:2007Certified Organisation),Vol.3,Issue1,January 2014.
2) Geopolymeric Building Material Using Industrial Waste Mr. S. C. Dighe1 & Mr. P. R. Gulave2, (Lecturer, Chemical Engineering Department, Pravara Polytechnic College Loni, Tal-Rahata, Dist-Ahmednagar), Imperial Journal of Interdisciplinary Research (IJIR) Vol-2, Issue-7, 2016 ISSN: 2454-1362.
3) Y. Sharma, B. K. Saxena, K. V. S. Rao, Case study of fly ash brick manufacturing units at Kota in Rajasthan, Department of Renewable Energy, Rajasthan Technical University, Kota, Rajasthan-324010, India.
4) Novel Geopolymeric Building Materials through Sinergistic utilisation of Industrial Waste.Sanjay Kumar,Rakesh Kumar,A.Bandopaadhyay,National Metallurgcal Laboratari Jamshedpur831007,India.