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AN OVERVIEW ON GEOPOLYMER OR ALKALI-ACTIVATED BINDER ALTERNATIVE TO PORTLAND CEMENT AS ECO-FRIENDLY CONSTRUCTION MATERIAL

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Abstract

This review displayed, several extents of an alternative to Portland cement as Eco-friendly construction material to reduce CO2 emissions connected with the industry of the binder in concreting works and which are distributing as in general as follows: Replace the percentage of Portland cement with "low-carbon" supplementary cementitious materials (SCMs) in concrete. And development alternate low-carbon binders geopolymer or alkali-activated binder by Use alternative raw materials in the manufacture of concrete or mortar. The first path primarily reflects incremental improvements that can be completed relatively quickly and inexpensively as long as appropriate base materials can be identified. The second path is but also holds a potential pledge for really substantial reductions in CO2 if achieved on a large scale. If use SCM, as an alternative for cement. by use low-carbon binders geopolymer for the manufacture of concrete or mortar.

Keywords : Keyword1; Ground granulated blast-furnace slag (GBFS); palm oïl fuel ash(POFA); Geopolymer mortar(GM); Bagasse of ash (BA); supplementary cementitious materials (SCMs)

1.0 INTRODUCTION

Since many years of cement (PC) the conventional and spacious used in concrete manufacture. anyway, about 3 Gt Portland cement (PC) annual production is the controlling binder of the construction materials industry has been questioned extensively over the last decades due to the environmental influenced by-product of clinker [1-3]. The manufacture of one ton of cement release 0.55 ton of CO2 emission and demands an additional 0.39 ton of CO_2 emission in fuel emissions for grinding, accounting for a total of 0.94 ton of CO_2 [4-6]. The estimated for the universal the requested for Portland cement shows that it will have a twofold increase in the next 40 years, come to 6 GT/year [7]. through the production of cement and manufacture of concrete, the major problems such as CO_2 emissions beside together the utilize of power, gravels consuming in a significant quantity, destruction concrete waste and demands for fillers share the anticipated environmental impact that concrete manufacturing is not agreeable or acceptable to the needs of sustainable growth. A number of studies have focused on discovering an alternative that can be used as a cement surrogate. The way to use untouchable base materials and to be a break-solution in a green planet is surrogate cement materials. Can be substitutional solid waste materials with (PC) this material came from various sources specifically agriculture, industry, etc. generally, most of the pozzolanic materials come from natural processes or human industries wastes. From the previous information and researchers, agricultural and industrial wastes, which are solid waste that is disposed of in a landfill, and that the waste can be recycled and used at the lowest value, provides an opportunity to realize these potential benefits of recycling, reuse and regeneration programs. subsequently, studies investigated activity performance, and readily obtainable waste to be (PC) substitutional production new friendly and pozzolanic. should be required materials rich in silica, aluminium and calcium from its source. are smoothness and permeable medium that could be utilized as an adsorbtion for mineral ion, which is hurtful to the environment. that showed the ratio and grade of collection applied for material with Si, Al, CaO content diverse founded on that purpose. pozzolanic materials with silica, aluminium and calcium content had various feature, such as reduce sulfate attack of concrete, permeability and, compressive strength and reduce segregation, and durability, etc. This an overview main feature various of these issues in the specific context of inserting various pozzolanic materials come from natural processes or human industries wastes. Still, pozzolanic by-product can be utilized as the greening construction and friendly with the environment. The system of utilising pozzolanic material to building implementation has an effective report, which includes pozzolanic materials. So, landfilled waste become disposal of and landfilled are now consider worthy in enhancing the desired properties of concrete. can be utilized pozzolanic materials for producing greening construction and friendly with the environment.

2.0 Some wastes materials use as geopolymer concrete and alkali-activated binder or as replace with Portland cement

Universal output a huge quantity of various sorts of waste as by-producing from types of various sections same as agricultural, industrial, and junk from the village and civilized community, etc. The garbage stays in the circumference for long-term ago it is utilised. The squandering elimination squeeze arose due to the formating of musty waste. Another method to the disposal this squeeze wastes recycling into products beneficial. studies into innovatory usage of waste are regularly advanced. Waste, such as ground granulated blast slag, palm oil fuel ash, fly ash, rice husk ash, silica fume, had been effectively utilized in concrete for more than a decennium [8-11]. Effective utilised as part or full surrogate of OPC contribute to resolving landfill issues, reducing the price for constructing materials, gives a favourable resolution to the environmental case and dilemmas linked with junk administration, saving power, and assist environmental safeguard from defilement. rice husk ash, fly ash. There are agricultural wastes which are used as pozzolanic products and used as a partial replacement for cement. Basically, a combination of OPC, water, sand, and gravel is concrete. The maximum concrete mixed-use supplementary cement materials are either blended cement or extra individually in the blender. The usage of (SCMs) like palm oil fuel ash, a product from agriculture, represents an applicable solution to the part of (PC) exchange. It is split into normal and synthetic materials. The utilisation of (SCMs) without additive process causes a significant reduction in CO_2 emissions per ton in the weather. pozzolanic materials, given indicated as pozzolanic materials utilised in concrete and blended together OPC, leading to form cementitious particles, but by themselves do not have any cementitious combination. thereafter, the environmental interest will reduce the great necessary and requested of OPC per unit volume of concrete and the enormous deflation range of GHG emissions.

2.1. Wastes of Agricultural

Global warming is probably the most important global crisis. Solid waste products, such as agriculture, manufacturing, and urban and rural society, come from everywhere. For the general climate, farm waste is useful. As stated previously, the use of waste materials in structural materials would generate abundant interest. The best thermal stability of properties was demonstrated by the use of agricultural concrete waste in the study [12-14]. In the Energy and Environmental Design (LEED) ranking system, sustainable weather and power grade leadership points can be given as a result. In addition, the limitations of the rise-set back and the available boundary of the initial material.

2.1.1. Rice Husk Ash

(RHA) are casings naturally created from plant rice, petite through, growth, signifying agricultural raw material, and highly obtained from producing countries of rice.They are not merchant attention while extracted through the refinement process. The (RHA) milling manufacture is one of the essential scopes in certain states, such as Indonesia, China, India, and Malaysia. By the purpose of 2014, (RHA) production of about 742 million metric tons' harvester of rice paddy yearly in the world [15]. (RHA) A carbon- neuter green produced from the basic rice varied to cinder utilizing the combustion operation it is a good pozzolan. The colour of (RHA) extent from grey to black, relying on base materials, time, and calcination temperature. abundant ways we're thinking of throwing them by utilized a commercial method of RHA.Rice husk was burning at 600 C- 800 C at the lab [12]. is an excellent (RHA) material. The particle size of (RHA) about from 5 to 12 mm [16]. RHA should meet the requirements for pozzolan's chemical composition to be used in cement and concrete, as stated per ASTM C618 [17]. certain that the OPC and construction industries' sustainable development could be achieved by maximising the use of cementitious and pozzolanic by-products. According to ASTM C 595 [18].

2.1.2. Palm Oil Fuel Ash (POFA)

The ashes of palm oil are widely used these years, especially in East Asia. POFA produced in large quantities as agro-industry by-products with the significant possibility to serve as supplementary cementitious materials (SCM). The POFA from calcination residue from empty fruit bunches, palm kernel shells, and palm fibres in the mills to heat boiler for electricity generation. The world's countries producers of POFA are Indonesia, Malaysia, and Thailand [19]. However, these ashes' production was estimated at more than 3 million tons/year in Malaysia only. [21]. moreover, POFA is more concentrated in Asian countries, creating technological interest in other parts of the world to look for its potential as a new alternative pozzolanic raw material. It has been noticed that the amount of POFA continues to increase annually [22,21].

2.1.3. Bagasse of Ash (BA)

The manufacturing method for sugar cane is raw sugar and the processing of by-product products, as well as the extraction process of sug.The output from the co-generation and method burning-specific the sugar cane bagasse temperature named bagasse of ash.

Asia countries such as Malaysia, Indonesia, Thailand have annual outputting great quantities of (BA). In fact, they will end up the earth and be ruined and disposed of. It was stated that this waste is a positive pozzolanic material and can be used successfully with (PC) or geopolymer mortar and concrete as supplementary material. For instance, Cordeiro *et al*. [26] recorded a substantial decrease of 40 percent by weight of BA, with the highest adiabatic temperature increase of classic concrete. Amorphous silica, high surface area and low carbon content are present in bagasse ash formed with air calculations at 600 C and a heating rate of 10 C/min[27].Similarly, while using BA, mixing of concrete not only decreased global carbon dioxide, but also improved the benefit of waste[23-25].

2.2. Industrial Waste

The utilized of concreting are openly construction, around more than 10 billion ton of concrete output yearly [28]. one resolution comes of environmentally-friendly, which can minimize the environmental load and share into humankind and nature [29]. The connotation of utilizing waste for constructing implementations had a long and effective history, including silica fume, slag, and fly ash. These once fishy, landfilled waste materials now look valuable ware for boosting specific properties of concrete. In a situation where the cost of alternate raw material is lower than that of cement thus offering similar efficiency, economic interest from used alternate materials is best realized.

2.2.1. Fly Ash

Last few years, the annual worldwide (PC) production has ripened from 1.0 million tons to approximately 1.7 billion tons, which is enough to generate 1 m3 of concrete per person per year. [29]. Besides, case, such as CO2 emissions through OPC output, along with a considerable quantity of power, aggregate, water, and fillers utilized to produce porous concrete, make this critical construction. subsequently, focused the concrete technology on other alternates utilized as OPC replacement materials in concrete. Research into innovatory use of waste materials is constantly progressing. such as (GGBFS), (FA), (RHA), (SF), and (POFA) has successfully utilized in concrete for decennium [30,31]. Nowadays, many researchers had been used of (FA) widely in purposes as a replacement with cement in porous concrete [30]. The characteristics of Fly ash has comparable to pozzolanic materials in terms of SiO2 and Al2O3 content [32]. According to ASTM C 595.

2.2.2. Silica Fume

From Common pozzolans materials silica fume, it depends mainly (90%) of silicon oxide. silica fume is non-crystalline and pure form. The presents a small quantity of magnesium, iron, and alkali oxides in Silica Fume. production of Silica fume in arc electric furnaces as a by-product of the production of elemental silicon or alloys containing silicon. Silica fume is "very finer and non-crystalline silica. Silica fume recognized as admixture a pozzolanic for in enhancing effective the mechanical properties to a large extent. The use of silica fume (SF) for the production of concretes is widespread. Sakr, [33]. Some reports that at 15% silica fume content display raise strength by 23.52% at 7 days.

2.2.3. Slag

In the general description, slag is generated in a blast furnace synchronously together sulfuric. Additional to the iron raw to separate impurities. In the reducing process raw iron to iron, a molten slag forms as a non-metallic liquid (consisting primarily of silicates and aluminosilicates of calcium and other bases) that floats on top of the molten iron. Used in both mortar and concrete for many purposes as an alternative or combination mix ratio of (PC). GGBFS' chemical components consist primarily of the system of CaO-SiO_2-MgO-Al_2O_3 and other anhydrides (TiO_2, MnO, Na_2O, K_2O, Pb2O5). Also, it includes several other minor molecules (such as SO_3 and Fe_2O_3) capable of steering crystallization to one compound rather than the other by nucleation functions [34].

3.0 ALKALINE ACTIVATED BINDER OR GEOPOLYMER ALTERNATIVE BINDERS TO PORTLAND CEMENT

Alkaline activated binders had a ben long history beginning in the 1930s, where NaOH and KOH were initially used to test GGBFS to determine if the slag would be a supplement to (PC). Alkaline activated binders had a ben long history beginning in the 1930s, where NaOH and KOH were initially used to test GGBFS to determine if the slag would be a supplement to (PC). Reported the work by Feret (1939), who explored the possibility of replacing OPC partially with blast furnace slag. Still, he failed to explore such a binder's practical applications named alkali-activated slag (AAS). Li [35] narrated Purdon's work (1940), who attempted to improve the alkali-activated system be composed of GGBFS and discovered that the inserted alkali formed a new rapid-hardening binder.there are Other names in the literature, same as "Geocement," "alkali-bonded ceramic," and "inorganic polymer concrete,"[36]. Davidovits [37-39] first researcher in the 1980s studied the chemistry of such material in details and coined the term "geopolymer."Therefore, Palomo et al. [40] had been confirmed two models of alkaline activated binder systems. Alkaline activation of Si+Ca systems such as AAS that induces calcium-silicate-hydrate is the first model (C-S-H). The alkaline activation of Si+Al systems such as fly-ash or metakaolin is called the last model. As an alkaline activated binder (AAB) system, the Si+Ca system can best be represented. Due to its similarity to polymeric structures to natural zeolites, the second model, the Si+Al system, can be described as a geopolymer [36]. Table (1) shows the history of researchers in the alkaline activated binders and geopolymer.

Table 1. List of researchers' history of researchers in the alkaline activated binders and geopolymer.

No	Year	The indications	Authors
1	1939	Slags used for cement	Feret
2	1940	Alkali-slag combinations	Purdon
3	1959	development of alkaline cement	Glukhovsky
4	1965	First called "alkaline cement."	Glukhovsky
5	1979	"Geopolymer" term	Davidovits et al.,
6	1983	F-cement (slag-alkali-superplasticizer)	Forss et al.,
7	1984	Ancient building materials characterised	Langton et al.,
8	1985	Patent of "Pyrament" cement	Davidovits et al.,
9	I986	DSc thesis, R2O–RO–SiO2–H2O	Krivenko et al.,
10	1986	Slag cement-low level radioactive wastes forms	Malek et al.,
11	1987	Ancient and modern concretes compared	Davidovits
12	1989	Ancient concretes analogues.	Roy et al.,
13	1990	Activation of slag cement.	Wu *et al.*,
14	1991	Alkali-activated cement: an overview.	Roy *et al.*,
15	1992	CBC with metakaolin.	(Palomo *et al.*,
16	1993	Slag cement.	Roy and Malek
17	1994	Ancient, modern and future concrete.	Glukhovsky
18	1994	Alkaline cements.	Krivenko,
19	1995	Slag and alkali-activated microstructure	Wang *et al.*

3.1. Alkaline activators

Generality utilized alkaline activators are either KOH with K2SiO3 or NaOH with Na2SiO3 [40-43]. Katz (1998) studied alkali-activated slags and reported superfatted compressive strength when the activator's concentration increases. There are other researchers have been reporting the same behaviour utilized alkali-activated metakaolin [49-50]. Even so, Palomo *et al*. [40] stated that an activator with a 12 M concentration produces better results than an 18 M concentration for the alkaline-activation of fly ash. Some researchers used alkaline activators with free water glass and found less mechanical performance [44-45]. The alkaline activator plays a key role in the polymerization reaction, according to Palomo *et al.* [40], acting more rapidly when dissolved silica is available. This statement regarding the alkaline activator's role is also shared by Criado et al. [46].

3.2. Synthesis and Performance of Some Materials Used in Alkaline Activated Binder or Geopolymer

FOR developing AAB the researchers have carried out studies by using pozzolanic materials same as slag, fly ash, kaolin and POFA. The clarifies of these research result that the materials used provided AAB products with considerably higher compressive strength compared to OPC [47-49]. Recent studies have also shown that used possible to use 100% fly ash, POFA, MK, or slag as the binder in a mortar by activating them with alkaline activators [50,51]. Two models of alkali activation exist. The first one is the activation by low to moderate alkali of a substance which mainly contains silicate and calcium. This activation produces the calcium silicate hydrate gel (C-S-H). The Ca/Si ratio is lower, even though the calcium silicate hydrate gel (C-S-H) is close to the substance formed during Portland cement hydration. [52,53]. The second mechanism/model involves the activation of material containing primarily silicate and aluminates using a highly alkaline solution. This reaction forms an inorganic binder through a polymerisation process [54,55]. The term "geopolymer" is used to characterise this type of reaction from the previous one, and accordingly, the name geopolymer has been adopted for this type of binder [39]. Table (2) shows some materials used in alkaline activated binder or geopolymer

Table 2: The chemical compositions of the most commonly used source materials for geopolymer synthesis.

Source material	Researchers	year	Al_2O_3	MgO	SO_3	Na_2O	P_2O_5	Fe_2O_3	CaO
UPOFA	Zeyad *et al.*	(2016	5.72	4.58	0.33	0.07	4.69	4.41	8.19
(FA) class F	Rashad	(2015	23.3	1.85	0.	65	0.91	4.84	4.76
GGBFS	Deb *et al*	(2014	9.01	2.05	1.61	1.00	-	32.0	27.1
Red mud	He *et al*	(2013	14.0	-	-	20.2	23.2	30.9	2.5
Metakaolin	Paiva *et al*	(2012	23.2	-	-	<0.8	-	1.4	-
(FA) class C	Fauzi *et al*	(2016	9.01	2.05	1.61	1.00	-	32.01	27.01
Kaolin	Kakali *et al*	(2001	18.04	0.03	3.00	-	-	-	0.4

5.0 CONCLUSIONS

Eco-friendly construction with the development of the world's population. Researchers have raised concerns about the green economy concept, that is paramount to the environment and community. (PC), its prime principle binder utilized in concreting works is the energy-intensive manufacture output and responsible for massive emissions o carbon dioxide, no called a greenhouse gas The utilisation of agricultural and industrial waste can be break-over to make the industry more environmentally friendly and sustainable. subsequently, enhancing current knowledge and investigating other beneficial of wastes industrial and agricultural as (SCM) in the concreting work's mixture will be a valuable contribution. An applicable solution in sustainable construction produces greening in the environmental aspect. Although the growing demand for sustainable concrete in today's building and housing industry, as well as the foreseeable benefits of geopolymer technology, futurity research is indispensable to understand the relationships between geopolymer concrete structures and properties and to explain the most probable problems or problems involved in the manufacturing process.

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