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A REVIEW ON USE OF POZZOLANA AS NON OPC BINDER MATERIALS IN CONSTRUCTION

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***Abstract*—Natural, artificial, or waste materials can all be complementary materials. The cement industry has long utilized several pozzolanic ingredients that enhance cement characteristics. Concretes made with alkali-activated natural pozzolan (AANP) exhibit moderate to high mechanical strength, a high elasticity modulus, and significantly less shrinkage than concrete made with OPC. Pozzolan replacement percentages of 10%, 20%, 30%, and 40% are all considered partial. The findings showed that the FA=HL mix (FA=HL 14 90:10 by weight) with a NaOH concentration of 3.5% wt. by dry aggregate mass, a non-OPC binder, offered the most efficient mechanical qualities for a network of gel and needle-sharp cementitious products. The findings show that at 28 days, Non-cem mortar gains a compressive strength of 42.84 MPa (93.36 percent of OPC. Integrating both strength and resistivity results in a reliable and accurate assessment of pozzolanic reactivity. Strength can be increased to improve water transfer qualities. Durability was improved by increased resistance to sulphate and acid assaults as well as decreased chloride ion penetration. As improved sulphate, acid, and chloride ions penetration resistances were demonstrated, durability was also improved. The**

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findings and analyses may be used to guide decision-makers in choosing affordable and environmentally friendly binders for concrete production.

Keywords—Pozzolana, Fly ash, Rice husk, Silica fumes, Bamboo leaf ash, Compressive Strength, Acid resistance, Chloride penetration, Water absorption, Tensile strength.

I. INTRODUCTION

"To combat the grave threat of climatic change, global warming, and ozone layer depletion brought on by high greenhouse gas emissions and excessive energy use during the manufacturing process, strict environmental regulations are being implemented at cement manufacturing facilities, ready-mix plants, and pre-cast concrete plants. 1 m3 of concrete requires a significant amount of cement, a main building material, and generates 5% of the world's yearly CO2 emissions" [13]. Cement facilities emit 222 kg of carbon dioxide (CO2) per tonnes of cement produced, or 3.5% to 5% of the world's total anthropogenic CO2 emissions. According to additional reports, the cement industry is predicted to emit up to 1.5 billion tonnes of CO2 year, and it will continue to rise ".It is further reported that cement industries are estimated to discharge up to 1.5 billion tons per year of CO2 into the atmosphere and each year it will remain increasing at the rate of almost 6% from 1988 to 2015"[04]. "In cement industries, continuous attempts are being made (i) to reduce the cost of production of Portland cement, (ii) to reduce the consumption of the raw materials, (iii) to protect the environment and (iv) to enhance the quality of cement"[18]." Three common methods of construction practise are as follows: (1) partial replacement of OPC with one or more supplementary cementitious materials (SCMs) made of agro-industrial solid wastes like rice husk ash, fly ash, rice husk ash, silica fume, ground granulated blast furnace slag, metakaolin, and palm oil fuel ash; (2) development of an alternative binder known as geopolymer.In the concrete industry Portland cement have the ability to set and harden in the presence of water. Other methods, such as CO2 capture, the use of alternative fuel sources, or changing the way cement is made at cement plants, are also being used to reduce CO2 emissions by the concrete industry. However, switching to alternative SCMs in place of clinker is the most practical and cost-effective option that can be used with ready-mix concrete. Since the production of traditional cement contributes significantly to the depletion of natural resources, releases large amounts of CO2 into the atmosphere, and requires a lot of energy, there is a huge potential and bright future for the use of locally accessible agro-

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industrial waste that could provide more durable and cost-effective construction than traditional cement construction”[04]. “A mixture of 20–40% natural pozzolan and 60–80% Portland cement clinker, with a minor quantity of gypsum added, is used to make pozzolanic cement. The permeability of the paste would decrease as the natural pozzolan content of the cement increased, implying a high resistance to chemical attack and an improvement in durability” [12]. Pozzolan is the mineral additive that is most frequently used in the concrete industry. The definition of a "pozzolan" is "a siliceous or siliceous and aluminous material, which in itself possesses little or no cementing property, but will, in a finely divided form - and in the presence of moisture - chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties(Malhotra and Mehta, 1996)”. Examples of pozzolanic materials are volcanic ash, pumice, opaline shales, burnt clay and fly ash. Fly ash was very popular, with 20% of companies using it in concrete. Companies noted that FA is a great substitute for cement and it is cost effective. “The rice-husk ash (RHA) has no useful application, is usually dumped into water streams and causes pollution and contamination of springs. As a result, the use of rice-husk ash has aroused great interest in Uruguay. Rice-husk ash is a mineral admixture for concrete; the behavior of cementitious products varies with the source of RHA” [3,4]. “Investigating the impact of residual RHA from the rice paddy milling sector is the primary goal of this study [14]. Slag (12%) and silica fume (9%) were mentioned by several companies for usage in special projects, with the engineer's recommendations ranging from work to job”[02]. “By using FA for OPC in construction, GHG emissions can be decreased. FA is an excellent cementitious ingredient, however to create a new binder without OPC, it must be integrated with functional materials” [03]. “Wang and Chi, the fly ash/slag ratio and the amount of Na 2 O were identified as the key variables that influence the binding mechanism and overall performance. Using 2.5 M NaOH solution for AAB - 1 (42% slag, 28% POFA, and 30% RHA) and AAB - 2 (42% slag, 28% FA, and 30% RHA) at 28 days curing period, the author noted a significant compressive strength and mechanical properties of the pre-pared mortar specimens among the twelve different mix pro portions” [10]. “Using ternary cements has greater benefits than using binary cements or OPC. This paper's main goal is to discuss the optimization of compressive strength in ternary blended cement that contains silica fume and natural pozzolana” [15]. “The study showed that substituting bottom ash for 20–25% of OPC can produce mechanical and durability results that are comparable, but with greater environmental savings. Globally, concrete made using industrial SCMs was evaluated using the

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lifecycle assessment (LCA) technique for its effects on CO2 emissions, energy use, and other environmental factors" [06]. "Slag and FA that were activated with NaOH, KOH, and Ca(OH)2 alone or in combination with sodium/potassium silicate were used in a variety of experiments on alkali activated binders (AAB). Numerous studies have found that AABs containing slag exhibit better durability, effective strength, and mechanical properties" [15]. "Their main benefit is that they hydrate slowly, which results in a moderate rate of heat buildup. The study's goals are to determine the compressive and tensile strengths of mortar made using various amounts of natural pozzolan in place of cement as well as to experimentally assess the impact of doing so on the compressive strength of concrete.." [07].

II. MATERIALS USED

1. Fly Ash

"Turkey now has twelve coal-fired power plants running, and they generate about 15 million tonnes of fly ash yearly. Fly ashes that comply with ASTM C 618 for mineral admixtures in Portland cement concrete fall into one of two categories: Class F is produced when bituminous coal is burned, and it has a higher final strength than Class C, which is produced when sub-bituminous coal is burned and has a quicker rate of strength increase. the composition of various FA types chemically. Class C fly ash can be used in place of cement to replace between 20 and 35% of the mass of cementitious material. At least 25% of the Portland cement must be replaced with class C fly ash in order to decrease the effects of the alkali silica reaction.. When mixed with Portland cement, Class (F) fly ash can replace 20 to 30 percent of the mass of cementitious material"[02].

2. Silica Fume; -

"Silica fume is a by-product of the reduction of high purity quartz with coal, coke, and wood chips in an electric arc furnace to generate silicon metal or ferrosilicon alloys. The silica fume, which condenses from the gases leaving the furnaces, has a high concentration of amorphous silicon dioxide and is composed of tiny, spherical particles. For ferrosilicon alloys, the nominal silicon contents range from 61 to 98 percent. When the silicon content reaches 98 percent, the material is referred to as silicon metal rather than ferrosilicon. The concentration of silicon in the alloy will increase along with the amount of SiO2 in the silica fume"[02].

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3. **Bamboo leaf ash; -**

"To create bamboo leaf ash, bamboo leaves were sun-dried and then burned for two hours outside. The colour of the ash was grey [11]. A good pozzolanic substance is bamboo leaf ash, which interacts with calcium hydroxide to produce calcium silicate hydrate. With increasing time and temperature, bamboo leaf ash's pozzolanic activity increases" [18].

4. **Rice husk ash; -**

"A mineral additive for concrete is rice-husk ash; depending on the source of RHA, different cementitious products behave differently [14]. Non-crystalline, amorphous RHA is produced when rice husks are burned under controlled conditions between 500° and 800° C. (Mehta and Monteiro, 1993; Mehta and Folliard, 1995). RHA has a greyish or whitish hue. The RHA particles have a very high surface fineness and are found in cellular structures. They include 90–95 percent amorphous silica (Mehta and Folliard, 1995). As a result of its high silica content, RHA has exceptional pozzolanic activity. RHA's physical characteristics are significantly influenced by the burning environment" [01].

5. "In the beginning, residual RHA influenced concrete's compressive strength favourably, but as time went on, the behaviour of concretes containing RHA from controlled incineration became more significant"[05].

III. TEST PERFORMED

1. **Compressive strength test**

"Each combination was made into 3.94 x 3.94 x 3.94 in. (100 x 100 x 100 mm) cubes, and the compressive strength for these samples was evaluated in accordance with BS EN 12390- 3:2009, in order to ascertain the compressive strength of geopolymer concrete. In the part before, casting and curing details are discussed" [01]."In Fig. 2, which has a logarithmic x-axis, the compressive strength findings of concrete made with activated natural pozzolans and control Portland cement mixtures are shown. In every instance, the concretes got stronger with time. Early in life, the rate of strength increase is rapid, and it gradually slows down as people mature. It is generally known that OPC concrete's ability to generate strength is significantly impacted by curing." [01]. "According to ASTM C 109, the compressive strength of 50 mm cubic specimens

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was assessed. At 3, 7, and 28 days after curing, mortar samples were removed from the water tank, and compressive strength was assessed using a constant loading rate. Four samples from each batch were examined for each age, and the average results were given" [04]."The compressive strength falls as the percentage of bamboo leaf ash increases. BLA5, BLA10, and BLA10 all had compressive strengths that were 11%, 21%, and 41% lower than the control mix. Composite cements made of Portland cement and bamboo leaf ash were combined with sand in a 1:3 ratio and subsequently with water (I S: 4031 part 4, 1988). The mortars were set in 70.6 mm-3-diameter steel moulds" [18].

2. Tensile strength test; -

"The ATAF1 mixture gave 0.52 ksi (3.57 MPa) after 28 days, higher than the similar OPC control mixture at 0.39 ksi, whereas ATAF2 gave poorer tensile strength values at an early age—0.25 ksi (1.7 MPa) compared to 0.29 ksi (2.03 MPa) (2.67 MPa). The findings demonstrate that the activated Taftan geopolymer concrete mixtures have longer-lasting tensile strengths than OPC control mixtures, with 180-day tensile strengths of 0.54 and 0.44 ksi (3.69 and 3.0 MPa) compared to CM1 and CM2's tensile strengths of 0.41 and 0.29 ksi (2.81 and 1.99 MPa), respectively. After 180 days, the tensile strength for mixes of ACSH and ARSH is 0.28 and 0.19 ksi (1.96 and 1.3 MPa, respectively)"[01].

3. Specific gravity test; -

"One of the key factors in determining a material's relative density and weight is its specific gravity. Based on the results of the tests conducted on the raw materials utilised, the specific gravity of Non-cem was estimated (i.e., slag, POFA and RHA)" [05].

4. Chloride penetration test;

"According to Japanese Industrial Standard (JIS A6203), a chloride ion penetration test was conducted on prism specimens with dimensions of 40 mm*40 mm*160 mm. At the age of 28 days, specimens underwent a chloride ion penetration test. The two smooth surfaces and two ends of the dry mortar specimens were painted with epoxy resin before being submerged in sodium chloride (NaCl) solution. For the chloride ion penetration test, the specimens were then submerged in 2.5% NaCl solution at 20 C for 14 and 28 days. Chloride penetration of Non-cem mortar appears to be normal after the necessary immersion period (14 and

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28 days), the specimens were split, and the split cross-sections were sprayed with 0.1 N silver nitrate (AgNO3) solution”[05].

5. Water absorption test; -

“According to ASTM C642 (1997) standard, water absorption of the mortar prism specimens (40 mm 40 mm * 160 mm) was conducted. Prism specimens were dried until the weight remained consistent at the specified ages of 14, 28, and 90 days (Wd). After that, the samples were submerged in clean water for 30 minutes each for 1, 3, 6, 24, 48, and 72 hours. The samples were removed from the solution after the necessary immersion time, the surfaces were promptly cleaned with water, and then they were immediately weighed (Wa). As a result, the mortar specimen's water absorption was calculated as 100(Wa*Wd)/Wd in percentage. Finally, the average value of six specimens for the mortar's water absorption was used”[05].

6. Acid Resistance test;-

“By combining 5% sulphuric acid solution with distilled water, acid resistance is tested. Control mix, BLA5, BLA10, and BLA15 all had weight loss that was 0.6%, 3.0%, 0.5%, and 2.2%, respectively” [11].

IV. RESULT AND DISCUSSION

“At the same water content, the smaller C/S ratio offered a greater compressive strength than the larger ratio. The pozzolanic reaction with an extra aluminosilicate material resulted from the composites' adequate mechanical qualities, which were secured by the composites' ideal calcium content”. [3]

“After three and seven days, the compressive strengths dramatically increased.A logarithmic x-axis is used to display the compressive strength data for concrete made with activated natural pozzolans and control Portland cement mixtures. In every instance, the concretes got stronger with time. Early ages have rapid strength gains, which eventually decline as people age. It is generally known that OPC concrete's ability to generate strength is significantly impacted by curing”[01].” Of the F8L2 variations evaluated for compressive strength, the F8L2S1 had the highest rating”. [03] “In the case of bamboo leaf ash blended cement, the lower compressive strength values may be caused by decreased pozzolanic reactivity at the early stages of hydration”[18].“These findings show that this hybrid material's strength was significantly improved by the addition of 3.5% NaOH” [03].

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“After 180 days, the tensile strength is 0.28 and 0.19 ksi (1.96 and 1.3 MPa, respectively)” [1].

“At the same ages of the curing time, AAB mortar specimens' compressive strength can be seen to be slightly lower than that of OPC mortar specimens. Due to the porous microstructure of both AAB - 1 and AAB - 2, the compressive strength is less. RHA's microstructure may be seen to be very porous in the SEM image. Because AAB mortar has a porous microstructure, more water may pass through it” [10]. “The amount of water absorbed can be reduced by partially substituting volcanic ash (VA) powder for OPC” [06]. “AAS paste's apparent porosity, water absorption, and SiO2 content were better correlated, according to Qureshi and Ghosh . The use of FA as an AA in cement mortars led to an increase in water absorption.” [17].

“The AAB solution's resistance to organic acid increased as the CaO level rose”. [17]

“The resistance to chloride is seen to rise as the percentage of BLA increases, however 10% is the ideal percentage of BLA”.[11]

“RHA has a lower specific gravity than Portland cement” [14]. “Bamboo leaf ash's specific gravity was 12% lower than that of regular Portland cement. [11] OPC and FA had specific gravities of 3.15 and 2.10, respectively”[04]even after they have been defined in the abstract, define acronyms and abbreviations the first time they are used in the text. It's not necessary to define acronyms like IEEE, SI, MKS, CGS, sc, dc, and rms. If at all possible, avoid using abbreviations in the title or headings.

V. CONCLUSION

- “When 3.5% NaOH was added, the mixes' effective strength was increased in comparison to those without NaOH” [03].
- “While the addition of DPA to the mixture decreased the flow due to its non-uniform and irregular texture, FA increased spread due to the ball bearing effect produced by the smooth and spherical particles” [05].
- “The water absorption of Non-cem mortar was discovered to be slightly higher (e.g., 8.1% at 28 days) than that of OPC mortar (e.g., 6.2% at 28 days). By increasing its compressive strength, non-cem mortar can reduce the amount of water absorption” [05].

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- "The amount of chloride that penetrated Non-cem mortar was determined to be 11.3 mm, whereas the amount that penetrated OPC at 28 days was 10.1 mm. In comparison to OPC, the chloride penetration of Non-cem mortar appears to be reasonable. When compared to OPC mortar, Non-cem mortar showed excellent corrosion resistance" [05].
- "For OPC-based concrete, the maximum 28-day compressive strength was discovered"[06]
- "It has been noted that the compressive strength of concrete with 10% pozzolan replacement at 28 days is almost 65% that of concrete with pure cement"[07].
- "The water absorption of both AAB mortars was discovered to be marginally greater than that of the reference OPC mortar. At 270 days of curing, the water absorption of AAB-1 and AAB-2 rose 25% and 52%, respectively, over that of the OPC" [10].
- "As the percentage of bamboo leaf ash in concrete increases, its compressive strength drops". [11]
- "Early on, residual RHA had a beneficial impact on the compressive strength of concretes, but over time, the behaviour of concretes containing RHA from controlled incineration was more important" [14].

REFERENCES

[1] Dali Bondar, Engineering Properties of Alkali Activated Natural Pozzolan Concrete, ACI Materials Journal.

[2] Assist. Prof. Dr. Ibrahim A. S AL-Jumailya , Nahla Najib , Qays Kareem, An overview on the Influence of Pozzolanic Materials on Properties of Concrete, International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463 Vol. 4 Issue 3, March-2015, pp: (81-92), Impact Factor: 1.252.

[3] Walid Al-Kutti a , Muhammad Nasir a,b,⇑ , Megat Azmi Megat Johari b , A. B. M. Saiful Islam a , Abdullah A. Manda c , Nawaf I. Blaisi d, An overview and experimental study on hybrid binders containing date palm ash, fly ash, OPC and activator composites, Construction and Building Materials 159 (2018) 567–577.

[4] M.R. Karim a,b,⇑ , M.M. Hossain a,⇑ , M.F.M. Zain a,⇑ , M. Jamil a , F.C. Lai c, Durability properties of a non-cement binder made up of pozzolans with sodium hydroxide, Construction and Building Materials 138 (2017) 174–184.

[5] Tin Ni Ni Koa* , Dr. Nilar Ayeb, Experimental Research on Natural Pozzolan as Cement Replacement, American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) ISSN (Print) 2313-4410, ISSN (Online) 2313-4402 © Global Society of Scientific Research and Researchers.

[6] Md Maruf Hossain a , * , Md Rezaul Karim b , ** , Md Manjur A Elahi c , Muhammad Fauzi Mohd Zain d, Water absorption and sorptivity of alkali - activated ternary blended composite binder, Journal of Building Engineering 31 (2020) 101370.

[7] P. Asha, A. Salman, R. Arun Kumar, Experimental Study on Concrete with Bamboo Leaf Ash, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3 Issue-6, August 2014.

[8] İ. ALP1**, H. DEVECI1 , Y.H. SÜNGÜN2 , A. O.YILMAZ1 , A. KESİMAL1 AND E. YILMAZ1, POZZOLANIC CHARACTERISTICS OF A NATURAL RAW MATERIAL FOR USE IN BLENDED CEMENTS, Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 33, No. B4, pp 291-300 Printed in The Islamic Republic of Iran, 2009.

[9] *Opeyemi Joshua, Danladi S. Matawal et.al, DEVELOPMENT OF A FULLY POZZOLANIC BINDER FOR SUSTAINABLE CONSTRUCTION: WHOLE CEMENT REPLACEMENT IN CONCRETE APPLICATIONS, International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 2, February 2018, pp. 1–12, Article ID: IJCIET_09_02_001, ISSN Print: 0976-6308 and ISSN Online: 0976-6316.

[10] Gemma Rodrı´guez de Sensale, Strength development of concrete with rice-husk ash, Cement & Concrete Composites 28 (2006) 158–160.

[11] Mohamed Ghrici, Said Kenai, Mohamed Said-Mansour & El-Hadj Kadri, Some Engineering Properties of Concrete Containing Natural Pozzolana and Silica Fume, Journal of Asian Architecture and Building Engineering ISSN: 1346-7581 (Print)1347-2852 (Online) Journal homepage: https://www.tandfonline.com/loi/tabe20.

[12] M. Ghrici a , S. Kenai b,*, M. Said-Mansour c, Mechanical properties and durability of mortar and concrete containing natural pozzolana and limestone blended cements, Cement & Concrete Composites 29 (2007) 542–549.

[13] V.N. Dwivedi a , N.P. Singh b , S.S. Das a and N.B. Singh a*,A new pozzolanic material for cement industry: Bamboo leaf ash, International Journal of Physical Sciences Vol. 1 (3), pp. 106-111, November, 2006 Available online at http://www.academicjournals.org/IJPS ISSN 1992 - 1950 © 2006 Academic Journals.

[14] C. Shi, Studies on Several Factors Affecting Hydration and Properties of LimePozzolan Cements, J. Mater. Civ. Eng. 13 (6) (2001) 441–445.

[15] McGrath. P. 1996. Development of Test Methods for Predicting Chloride Penetration into High Performance Concrete. Ph.D. Thesis. Department of Civil Engineering, University of Toronto.

[16] Siddique R (2008) "Waste Material and By-Product in Concrete". Thapar Institute of Engineering & Technology (Deemed University), Patiala, India. ISBN 978-3-540-74294-4.

[17] Papadakis, V. G. & Tsimas, S. (2002). Supplementary materials in concrete. Part I: Efficiency and design. Cement and Concrete Research, Vol. 32, pp. 1035-1041.

[18] Jamrozy, Z. (1997). Use of silica fume for concrete. Cement Wapno Beton, Vol. 2, No. 4, pp. 140-143.

[19] Mehta, P.K. (1987). "Natural pozzolans: Supplementary cementing materials in concrete". CANMET Special Publication 86: 1–33.

[20] Islam, G. S., Rahman, M. H., & Kazi, N. (2017). Waste glass powder as partial replacement of cement for sustainable concrete practice. International Journal of Sustainable Built Environment. 6(1), 37-44.