ISSN PRINT 2319 1775 Online 2320 7876

Research paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022

UTILISATION OF FLY ASH IN THE CONSTRUCTION INDUSTRY TO OVERCOME ENVIRONMENTAL HAZARDS: A REVIEW

Anil Kumar Jamgid

JIT University,Chudel

Dr.A.N.Swaminathen

ABSTRACT

Cement accounts for approximately 7% of global CO_2 emissions. Carbon dioxide, which causes global warming, threatens the environment. All efforts have been made to reduce CO_2 emissions, yet cement hasn't been substituted. Fly Ash (FA) based concrete reduces construction cement consumption. This study discusses using FA concrete in building to improve two environmental problems: thermal power stations' disposal of vast volumes of FA in big landfills and the cement industry's excessive carbon dioxide emissions. FA is a coal-burning byproduct. It's one of the most complicated human-made materials, and improper disposal wastes resources and harms the environment. The FA must be recycled urgently.

This review discusses FA's physical and chemical characteristics and worldwide risks. It discusses its current and prospective users in the construction industry. The merits and downsides of various uses, how FA is used globally, and future research prospects are discussed.

Keywords: FA, CS, Waste utilization, Microstructure, Curing.

1. Introduction

FA is typically greyish, abrasive, mainly alkaline, and refractory. Pozzolans, which are siliceous or siliceous and aluminous substances, combine with water and calcium to form cement. Hydroxides create cementitious products at temperatures and are also admixtures. FA from the combustion of pulverized coal is classified as a pozzolan. In addition to micronutrients P, K, Ca, and Mg and micronutrients Zn, Fe, Cu, B, and Mo, FA provides a variety of other critical plantgrowth components. The geotechnical qualities of FA make it appropriate for use in road and embankment construction, structural fill, etc. The pozzolanic qualities of the ash, notably its ability to bind lime, make it suitable for the production of cement, concrete, and concrete-additional products. The chemical composition of FA, which includes a significant proportion of silica (60–65%), alumina (25–30%), magnetite, and Fe_2O_3 (6–15%), enables its usage in the production of zeolite, alum, and precipitate silica. FA is suitable for adsorbent due to its bulk density, particle size, permeability, water-holding capacity, and surface area.

From the perspective of energy production, FA is a wasted item, while from the viewpoint of coal use, it is a resource that has not been fully exploited; thermal energy producers are therefore looking for ways to utilize FA. It could be used as a raw resource for the manufacturing of concrete by the cement industry. Coal FA discharged by power stations can also be exploited as a byproduct, and its usage in recycling materials for farming and engineering is now being explored. The transformation of FA into zeolite has likewise been extensively studied. Another possible application would be as a low-cost absorbent for water and gas purification. Several studies have been published on the use of FA for the adsorption of specific contaminants in aqueous solutions or flue gases. The outcomes are promising for removing heavy metals and organics from industrial effluent. This research will examine the various uses of FA, such as low-cost adsorbents for flue gas purification and wastewater treatment to remove harmful ions.

2. Literature Review

Reddy & Ravi Prasad, 2022 used FA and Bottom Ash, but EFCA is also used. This paper, in this study, looked at M20 concrete. At 6%, 13%, 22%, and 25%, cement, bottom ash, expanded FA clay aggregate, FA, and coarse aggregate are used. Split tensile strength and Compressive Strength (CS) of Concrete mixtures are also studied. Performance evaluation took seven d, 28 d, and 56 d. The flexural strength was checked at 7, 28, and 56 d. With 5% bottom ash, FA, and coarse EFCA aggregate, the performance got better. When tested for 56 d, beam-shaped pieces of concrete performed better in CS, Split TS, and FS. Not as good as 28 d. With no replacement and a steadily decreasing dry weight, the 28-day test gives the same strength as standard concrete (Reddy & Ravi Prasad, 2022).

ISSN PRINT 2319 1775 Online 2320 7876

Research paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022

Agnihotri & Ramana, 2022 investigated the GGBFS effect; 60:40 was the best mix of GGBS and FA for the PPC concrete mix. The chemical ratios of sodium alkaline activator silicate in concrete mix led to different results. This research helps us learn more about high-strength concrete mixtures and blast furnace slag as alternatives to cement. This study found that GGBS and FA concrete were strong, durable, and able to resist acid attacks. When added to a mixture, sodium silicate and hydroxide can change its strength and durability. By going from 8 to 16, the strength of sodium hydroxide went up to 25.97 MPa. The strength went from 19.62 MPa to 24.05 MPa when the curing temperature was raised from 60 °C to 90 °C by ten °C. After 4 hours, 24 hours, 72 hours, and 144 hours at 90 °C, the strength increased to 24.44 Mpa. So, when GGBS went from 40 to 60 %, strength went up by 50 %. When Sodium Sulfate and Sulfuric acid were put on GPC concrete, it lost weight and strength (Agnihotri & Ramana, 2022).

Amin et al., 2022 experimented on four mixes of high-strength concrete (HSC) made with Portland cement, and fifteen mixes of geopolymer concrete were made to compare. The mixtures were poured, left to harden, and then tested. For both HSC and HSGC mixtures, slump and air content were checked to see how fresh they were. At 3, 7, 28, and 91 d, the splitting tensile strength, flexural strength, and modulus of elasticity were measured. Studies were done on the water permeability coefficient, drying shrinkage at 3, 7, 14, 21, 28, 56, and 91 d, and temperatures from 100 to 700 degrees Celsius; also, as the granulated blast furnace slag increases, the permeability coefficient decreases. Geopolymer concrete shrank less when it was dry because minerals were added. SEM images showed that the geopolymer matrix has more scattered small-sized holes than other experimental mixes. New property results show that 500 kg/m^3 of geopolymer concrete made from slag had a slump of 225 mm. Compared to the control mix, the FA, MK, and GB reduce the amount of air by 12.5%, 16.5%, and 7.5%, respectively, as shown in HSC (Amin et al., 2022).

Anto et al., 2020 evaluated how ordinary concrete stacks up against concrete produced with Recron Fiber and FA. Concrete fractures can be reduced with a product called Recron Fiber, which is a short, discontinuous fiber. The %ages of Recron Fiber used in concrete ranged from 0 % to 1 %, with 0.25 %, 0.5 %, 0.75 %, and 1 % also being tested, along with 25 % FA. Nan Su's approach explored 30 N/mm2 mix designs. The project presents a report on the research findings on self-compacting concrete made from recon fiber and flies ash. The workability, compressive, splitting

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022**

tensile strength, and flexural strength of new concrete are all investigated in this study. This study compared the results of the 7-day and 28-day specimen tests to those of conventional concrete. The optimal %age of Recron Fiber for strength was 0.75 %, while FA was used in a cement substitute at 25 %. It is vulnerable to both acid and sulfate. During the experimental research, the F25R0.75 Self Compacting Concrete In comparison to conventional concrete, a reinforced beam's ultimate load-carrying capability is significantly more significant (Anto et al., 2020).

Bieliatynskyi et al., 2022 studied the effect of FA fiber was used for the first time in Ukraine to strengthen hot bitumen concrete mixtures used for road and airport pavement. The surface's topography, the asphalt binder's properties, and its ability to hold bitumen are all looked. Rheology is figured out. It has been found that powder stabilizers affect how the structure of crushed stone-mastic bitumen mixtures forms and the characteristics of crushed stone-mastic asphalt concrete. Fiber made from FA from thermal power plants is the best additive for reinforcing, the best additive for changing, and to be better than other additives. The research is good for the economy because it improves the strength and reliability of crushed stone-mastic asphalt concrete using fibers from FA from Chinese thermal power plants. It lowers the cost of SMAC because it doesn't need to be stabilized with expensive chemicals. The modified crushed stone-mastic bitumen concrete SMAC-10 & SMAC-15 can be utilized as road surfaces, busy streets, squares, bridges, and airfields. Fiber from FA from thermal power plants makes crushed stone-mastic bitumen concrete more robust and more resistant to shear, fracture, frost, and wear (Bieliatynskyi et al., 2022).

Chu et al., 2022 utilized the PVA and FA to affect the mechanical properties of concrete. People used PVA and FA, as well as curing patterns. The number of concrete samples went from 160 to 54, thanks to the Taguchi method. Thirty-six samples of concrete had between 10% and 20% FA and between 1% and 2% PVA. Then, all samples were dried in the open air, in normal water, and in a temperature bath. Samples with 1% PVA and 10% FA have the highest compressive, tensile, and elasticity properties. PVA and FA react with cement to fill holes and strengthen the connection. Water-cured samples were the strongest. When PVA and FA were mixed, the CS went up. The strength development at 25 °C and 50 °C was studied using two different curing methods. These

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022**

curing tests showed that concrete samples cured at 50 °C for eight had low compression and tensile strength, while concrete samples cured at 25 °C had higher strength (Chu et al., 2022).

Fantu et al., 2021 examined what happens to high-strength concrete when adding FA. There were tests in the lab. How easy fresh concrete is to work with depends on its slump height. The study found that the slump values go up when 10% of the cement is replaced with FA. More than 10% FA in fresh concrete makes it harder to work. FA lowers the strength and density of concrete. Up to 10 % FA can be used in place of cement to make concrete stronger. At 28 d, the strength of concrete with 5% and 10% FA got 1.6% and 2.97% stronger, respectively. This study shows that replacing 10% of the cement with FA makes high-strength concrete more robust and easier to work with. Ten % FA can be used instead of cement to make high-strength concrete (Fantu et al., 2021).

Hao et al., 2022 used alkali-activated foam concrete made from FA and slag with a density of 200-1,200 kg/m3. Based on the theory of bubble dynamics, mixed bubbles' mechanical behavior and stability were looked at, and a way to calculate them was given. The foaming agent was chosen to analyze the bubbles and how well they worked. Depending on the density, the CS was between 0.50 and 44.98 MPa, and the flexural strength was between 0.22 and 13.86 MPa. Even though they have the same density, foam concrete made with alkali is more robust than foam concrete made with Portland cement. Alkali-resistant glass fibers were used to make low-density foam concrete less brittle. The mechanical properties were improved by 0.5 % fiber volume fraction. How stable bubbles affect the quality of foam concrete. When bubbles are all the same size, they stick together less. In this work, the vertical stability index is suggested to stop concrete foam bubbles from breaking apart. In this study, the fluidity of AAFC is higher than the fluidity of OPC-based foam concrete. AAFC is more robust than foam concrete made with OPC. ARGF changes how low-density AAFC works. The best overall qualities of AAFC are at 0.5 % fiber (Hao et al., 2022).

Jayswal & Mungule, 2022 used high-strength concrete (HSC) breaks made with high calcium FA and Alccofine. For the HSC mixes, 20 % of the ordinary Portland cement (OPC) is made up of mineral additives, and 0.26 % of the OPC is made up of water. A chemical admixture of 2 % is used to make a flow of 150–200 mm. Compare the CS of FC-HSC and AL-HSC blended mixes at 7 and 28 d to that of a control specimen. The CS of AL-HSC and FC-HSC are about the same. No cracks were checked to see how strong the control specimen was. To study how blended HSC

ISSN PRINT 2319 1775 Online 2320 7876

Research paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022

mixes break, compare a load-CMOD response of FC-HSC or AL-HSC specimens at 28 d. At 28 d, the CS of AL-HSC and FC-HSC is the same, but they are both stronger than controls by 12% and 8%. Even though AL-HSC and FC-HSC have the same CS, they break differently. FC-HSC has 60% more fracture energy or, instead, 20% less critical intensity factor than FA-HSC, which shows that there are more meaningful ways for energy to be lost (Jayswal & Mungule, 2022).

Kumar et al., 2022 used FA to partially replace cement in concrete at varying %ages ranging from 0 to 24 % by weight of cement, whereas RM was utilized at varying %ages ranging from 0 to 24 % in the presence of 8 % FA. The mechanical strength of the concrete sample was measured and compared to a control. The usage of optimal FA improves strength, with the effect becoming much more apparent when RM use is also optimized. In the presence of FA, RM has the potential to be utilized as a strength modifier, which has the dual effect of lowering cement consumption and fostering more environmentally responsible building practices. Both FA and RM contribute to an increase in the mechanical strength of concrete. According to the study's findings, the optimum dose of FA was 16 %, while the optimum dosage of RM was 8 % when FA was present. Even while higher doses don't produce the best results, they're still an improvement over CS. According to the strength testing results, alkaline RM enhances the pozzolanic action of FA even when used in smaller doses (Kumar et al., 2022).

Liu et al., 2022 investigated the CS, shrinkage, creep, and CO2 emissions per unit volume of concrete made with FA or ground-granulated blast furnace slag (GGBS) in place of cement or FA. The FA was taken into account in the creep prediction model by the addition of KL. Using FA as a fine aggregate in concrete results in increased strength and decreased shrinkage and creep. The accuracy of the concrete creep strain prediction can be improved by including a FA component in the prediction algorithm. The CS of concrete was improved by using FA or GGBS. The CS of concrete made with FA instead of conventional concrete was increased by 45 %, and the strength of concrete made with GGBS instead of FA was increased by 112 %. According to the findings of these experiments, FA and GGBS can manufacture high-performance concrete (Liu et al., 2022).

Mani & Pradhan, 2020 studied the FA that affects the CS and development of the microstructure in chloride-rich geopolymer concrete (GPC). This study used 425 and 450 kg/m3 of FA to make geopolymer concrete. Before casting, sodium chloride was added to the alkaline solution to study

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022**

GPC in places with much chloride. The CS of cubes of different ages was tested. XRD and FESEM were used to look at the microstructure of GPC. As the amount of FA went up, the CS of GPC, which included the control GPC, went down. At both concentrations of FA, the CS of chloride-mixed GPC decreased as the amount of NaCl added went up (Mani & Pradhan, 2020).

Ogawa et al., 2020 examined the effects of using porous ceramic waste coarse aggregate (PCWA) as an internal curing agent on the compressive, shrinkage, and carbonated resistance of steam-cured concrete made with FA at 0, 20, and 40% by mass. PCWA has been used to replace 0%, 10%, and 20% of the volume of coarse aggregate. PCWA-made concrete with 40% FA is better at resisting compression and carbonation, but steam-cured concrete with 40% FA shrank more when dried. With a 40% FA replacement ratio, PCWA improved the CS of water FA concrete significantly. PCWA increased the CS of the concrete by 10–25%. There were both short-term and long-term effects. Because it is porous, replacing up to 20% of PCWA up to 364 d has no adverse effects. PCWA decreases the natural shrinkage of FA concrete cured with steam and increases the drying shrinkage. PCWA made the accelerated carbonation resistance of steam-cured concrete with 40% FA higher, and its effects were almost the same at 10% and 20% replacement ratios. When 10 and 20% PCWA was used instead of FA, the accelerated carbonation coefficient of 40% FA concrete dropped by 35%. % (Ogawa et al., 2020).

Rohith & Ravikumar, 2022 showed how strong concrete is when copper slag (CSg) is used to replace FA (FS) is used to replace some of the cement. CSg and FS are byproducts of industry. Concrete made from industrial waste is used in this experiment. According to Indian Standards for grade M40, seven different mixes were made with different amounts of CS, from 10% to 60%: 10% CSg with 90% FA, 20% CSg with 80% FA, 30% CSg with 70% FA, 40% CSg with 60% FA, 50% CSg with 50% FA, and 60% CSg with 40% FA. These mixes are held together with 30% FS and 70% cement. A standard mix with 0% CS and 0% FS is used to compare the properties of fresh and hardened concrete. All seven mixtures were poured into cubes, cylinders, and beams and left to harden between 7 and 28 d. Concrete that is both new and old is tested. The slump cone test shows how workable concrete is (Fresh concrete properties). Compression, split tensile, and flexure are three ways to test the quality of hardened concrete. The results of the tests show that the strength is much higher than with regular concrete. CSg made work more accessible. The best

ISSN PRINT 2319 1775 Online 2320 7876

Research paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022

mixture comprised 30% CS and 30% FS. Copper slag and FA can each replace 30 % of the FA and binding material (Rohith & Ravikumar, 2022).

Ruengsillapanun et al., 2021 studied the mechanical properties, shrinkage, and change in the heat of high-calcium FA concrete made with sodium silicate (Na2SiO3) and sodium hydroxide (NaOH). This study used ratios of Na2SiO3/NaOH of 0.3, 0.4, and 0.5 in this study might and 2, 4, 6, and 8 Molar NaOH. 7:1 ratio of liquid to the binder, 400 kg/m3 of FA. The CS of concrete increased as the amount of Na2SiO3/NaOH and NaOH in this study up. At 90 d, a mixture of 0.5 Molar Na2SiO3 and 2 Molar NaOH had the highest CS, 27.5 MPa. FA concrete made with alkali is just as flexible as regular concrete. Adding more NaOH to concrete made it shrink less, while adding more Na2SiO3/NaOH made it shrink more. At the same CS, alkali-activated FA concrete gives off half the heat that ordinary Portland cement concrete does. The temperature of alkali-activated FA concrete in this study is up when the amount of NaOH and the ratio of Na2SiO3 to NaOH is up. Adding more Na2SiO3/NaOH improved the early CS (NS05M2 specimens had 18.2 MPa at 7 d), while adding more NaOH improved the final CS. Alkali-activated FA concrete couldn't be made with 8 Molar NaOH because it needs much superplasticizer. When the amount of NaOH and the ratio of Na2SiO3 to NaOH go up, concrete heats up more; when there is more NaOH, the heat evolution of alkali-activated (Ruengsillapanun et al., 2021).

Sambangi & Eluru, 2022 determined the compressive, flexural, and split tensile strengths, as in this study as the RCPT, sorptivity of SCC with partially replaced electrically precipitated FA (EPFA) from 0 to 30 % at 5 % intervals in cement and polycarboxylate ether-based superplasticizer as an admixture are investigated. The performance of fresh concrete was evaluated utilizing the L-Box, the U-Box, the V-Funnel, and the slump flow. The findings in this study compared to a standard SCC mix. SEM and X-ray diffraction in this study were used to analyze the microstructure of concrete (XRD). The findings revealed that using 20 % EPFA as a partial alternative for SCC produces better results than regular concrete, which benefits both the economy and the environment (Sambangi & Eluru, 2022).

Soutsos et al., 2021 determined that the impact of an increase in curing temperature on the development of concrete strength was investigated using the C32/40 and C55/67 strength categories. The %age of FA in the bin ranged from 15 to 30 to 45 % of the total. Curing at high

ISSN PRINT 2319 1775 Online 2320 7876

Research paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022

temperatures increases early-age strength but is detrimental to long-term development. Concrete compositions containing FA loin in this study were cured at higher temperatures and had "apparent" activation energies than concretes containing Portland cement (PC). This study looked into how accurate estimates of maturity-based strength can be. Curing at high temperatures increases early-age strength but is detrimental to long-term development. Because of this, the "cross-over" effect occurred, and it was shown to be more evident in concretes made with Portland cement (PC) rather than FA (FA). Because of their loin, this study's "apparent" activation energies, concrete mixtures made with FA are less susceptible to damage from high temperatures during the curing process than concretes made with Portland cement (Soutsos et al., 2021).

Varun & Anila Kumar, 2021 investigated Pozzolana's behavior to improve concrete's durability. Polymers have long been a part of concrete. Some polymers that are good for the price are latexes and emulsions. In this study, FA and polymer are used together. The strength was tested after adding polymer in steps of 0.5 %, from 0.5 % to 5 %. As the amount of polymer increases, the strength peaks at 2 % and then goes down. Mix E compresses the best of all concrete mixtures. 30.23 % more strength than the concrete used as a standard. Mix E's tensile strength is 26.75 %, the highest of all the mixes. With more polymer, the strength increases, peaks at 2 %, and then goes down. (Varun & Anila Kumar, 2021).

Zou et al., 2020 determined that the CS of geopolymer concrete made with FA was measured with the help of supervised machine learning algorithms. R2, mean absolute error, mean square error, and root mean square error was used to judge how the model worked in this study. The performance of the model was confirmed by k-fold cross-validation. The bagging model had an R2 value of 0.97, higher than DT and AR. More minor errors (MAE, MSE, and RMSE) and a higher R2 showed this study that the model did a better job. A sensitivity study was also done to determine how much each parameter added to the prediction of the outcome. The BR model is better than DT and AR because it has a higher linear R2, and R2 was 0.97 for the BR model, 0.94 for the AR model, and 0.90 for the DT model. The results of both the DT and AR models in this study are also good. DT, AR, and BR all work well, as shown by statistics and k-fold cross-validation. The BR model did better in these tests than the DT and AR models. In that order, FA,

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022**

NaOH, and curing age helped predict results by 27.4%, 18.5%, and 16.6%, respectively. Other parts of the inputs this less critical (Zou et al., 2020).

CONCLUSION

FA concrete is an essential construction material for building in a way that is good for the environment and uses a lot of FA. Literature that has been talked about in this paper has provided an overview of the benefits of using FA in concrete to make it easier to work with and last longer. From the literature, FA concrete gains strength more slowly at younger ages is seen as a significant problem inside the Indian construction industry, which only cares about short-term strength gain. For designing FA concrete that will be strong enough at 28 d, there needs to be a detailed procedure for making the mix and confirming the results. Contractors must shift their attention to FA concrete, which is cheap and long-lasting, even if it needs more time to cure.

References:

Agnihotri, A., & Ramana, P. V. (2022). GGBS: Fly-Ash evaluation and mechanical properties within high-strength concrete. *Materials Today: Proceedings*, *50*, 2404–2410. https://doi.org/10.1016/j.matpr.2021.10.257

Amin, M., Elsakhawy, Y., Abu el-hassan, K., & Abdelsalam, B. A. (2022). Behavior evaluation of sustainable high strength geopolymer concrete based on FA, metakaolin, and slag. *Case Studies in Construction Materials*, *16*(November 2021), e00976. https://doi.org/10.1016/j.cscm.2022.e00976

Anto, J., Vigneshkannan, S., Devananth, R., & Manju, S. (2020). Experimental investigation on strength properties of Recron fibre with FA in concrete. *Materials Today: Proceedings*, *21*, 806–810. https://doi.org/10.1016/j.matpr.2019.06.765

Bieliatynskyi, A., Yang, S., Pershakov, V., Shao, M., & Ta, M. (2022). Study of crushed stone-mastic asphalt concrete using fiber from FA of thermal poin this studyr plants. *Case Studies in Construction Materials*, *16*(January), e00877. https://doi.org/10.1016/j.cscm.2022.e00877

BrabinWinsley, J. B., & Muthukannan, M. (2022). A study on strength parameters of concrete with expanded FA clay aggregate. *Materials Today: Proceedings*, *56*, 3484–3489. https://doi.org/10.1016/j.matpr.2021.11.128

Chu, H. H., Siddiq, B., Aslam, F., Javed, M. F., Wang, W., Joyklad, P., Khan, M. I., Qayyum, S., & Ali,

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022**

R. (2022). Coupled effect of poly vinyl alcohol and FA on mechanical characteristics of concrete. *Ain Shams Engineering Journal*, *13*(3), 101633. https://doi.org/10.1016/j.asej.2021.11.002

Fantu, T., Alemayehu, G., Kebede, G., Abebe, Y., Selvaraj, S. K., & Paramasivam, V. (2021). Experimental investigation of CS for FA on high strength concrete C-55 grade. *Materials Today: Proceedings*, *46*, 7507–7517. https://doi.org/10.1016/j.matpr.2021.01.213

Hao, Y., Yang, G., & Liang, K. (2022). Development of FA and slag based high-strength alkali-activated foam concrete. *Cement and Concrete Composites*, *128*(February), 104447. https://doi.org/10.1016/j.cemconcomp.2022.104447

Jayswal, S., & Mungule, M. (2022). A comparative assessment of strength and fracture performance of alccofine and FA blended high performance concrete. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2022.04.177

Kumar, K., Bansal, M., Garg, R., & Garg, R. (2022). Mechanical strength analysis of fly-ash based concrete in presence of red mud. *Materials Today: Proceedings*, *52*, 472–476. https://doi.org/10.1016/j.matpr.2021.09.233

Liu, Z., Takasu, K., Koyamada, H., & Suyama, H. (2022). A study on engineering properties and environmental impact of sustainable concrete with FA or GGBS. *Construction and Building Materials*, *316*(November 2021), 125776. https://doi.org/10.1016/j.conbuildmat.2021.125776

Mani, S., & Pradhan, B. (2020). Investigation on effect of FA content on strength and microstructure of geopolymer concrete in chloride-rich environment. *Materials Today: Proceedings*, *32*, 865–870. https://doi.org/10.1016/j.matpr.2020.04.216

Ogawa, Y., Bui, P. T., Kawai, K., & Sato, R. (2020). Effects of porous ceramic roof tile waste aggregate on strength development and carbonation resistance of steam-cured FA concrete. *Construction and Building Materials*, *236*, 117462. https://doi.org/10.1016/j.conbuildmat.2019.117462

Ramesh kumar, G., Bharani, S., Anupriya, R., Jeevitha, V., & Gnanajothi, G. (2022). Influence of electronic waste and FA in strength and durability properties of concrete. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2022.03.461

Reddy, P. V. R. K., & Ravi Prasad, D. (2022). A study on workability, strength and microstructure characteristics of graphene oxide and FA based concrete. *Materials Today: Proceedings*, *xxxx*, 2–8. https://doi.org/10.1016/j.matpr.2022.02.495

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved,** **UGC CARE Listed (Group -I) Journal Volume 11, Iss 8, Dec 2022**

Rohith, N., & Ravikumar, M. S. (2022). Strength characteristics of concrete made with copper slag and fly-ash. *Materials Today: Proceedings*, *60*, 738–745. https://doi.org/10.1016/j.matpr.2022.02.337

Ruengsillapanun, K., Udtaranakron, T., Pulngern, T., Tangchirapat, W., & Jaturapitakkul, C. (2021). Mechanical properties, shrinkage, and heat evolution of alkali activated FA concrete. *Construction and Building Materials*, *299*, 123954. https://doi.org/10.1016/j.conbuildmat.2021.123954

Saloni, Parveen, Lim, Y. Y., Pham, T. M., Jatin, & Kumar, J. (2021). Sustainable alkali activated concrete with FA and waste marble aggregates: Strength and Durability studies. *Construction and Building Materials*, *283*, 122795. https://doi.org/10.1016/j.conbuildmat.2021.122795

Sambangi, A., & Eluru, A. (2022). Behaviour of sustainable high strength self-compactinsg concrete with electrically precipitated FA(EPFA) – A thermal waste. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2022.03.452

Soutsos, M., Kanavaris, F., & Elsageer, M. (2021). Accuracy of maturity functions' strength estimates for FA concretes cured at elevated temperatures. *Construction and Building Materials*, *266*, 121043. https://doi.org/10.1016/j.conbuildmat.2020.121043

Varun, B. K., & Anila Kumar, C. P. (2021). Strength characteristics of polymer modified high volume FA concrete. *Materials Today: Proceedings*, *46*, 285–288. https://doi.org/10.1016/j.matpr.2020.08.038

Zou, X., Antino, T. D., Sneed, L. H., Zhu, H. H.-G. H. H. H., Leung, C. K. Y., Cao, Q., Li, C., Gao, D., Yang, L., Cheng, S., Zhang, Y., Li, T., Deng, M., Zhu, P., Wang, X. X., Wu, J., Liao, Z., Wang, L., Zhang, C., … A. Momayez H. Rajaie, and M. R. Ehsani, A. A. R. (2020). Shear bond strength in repaired concrete structures. *Construction and Building Materials*, *26*(1), 1–8. https://doi.org/10.1016/j.engstruct.2020.110746