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PERFORMANCE OF DRY WASTE OKRA POWDER CONCRETE PRODUCED WITH FLY-ASH AS PARTIAL REPLACEMENT OF CEMENT SUBJECT TO DIFFERENT CURING CONDITIONS

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Abstract

The research investigates the performance of Dry Waste Okra Powder (DWOP) concrete produced with Fly-Ash as partial replacement of cement subject to different curing conditions. The DWOP was mixed in concrete at various percentages of 0%, (control), 10%FA, 0.25, 0.5, 0.75 and 1% DWOP content, 10% by weight of cement was used for all concrete with admixture. Mold of size 100 x 100 x100mm was used with a mix ratio of 1:2.43:2.85 and 0.5 w/c ratio, cured for 7, 14, 28, 56 and 90days in H_2O, HCl and H_2SO_4 curing media. Result indicated that curing condition significantly affect strength, absorption capacity and resistance to abrasion properties of concrete. The density of concrete increase as the curing ages of concrete increases. 0% control concrete exhibited the highest 28days compressive strength while at later stages 0.75% DWOP content has the highest strength. In addition, concrete with DWOP content has reduced water absorption capacity and have high resistance to abrasion in all curing conditions. In conclusion, fly-ash is a good pozzolana and DWOP is a suitable admixture, therefore, it was recommended to be used to produce a strong, dense and durable concrete which can be used both in normal and chemically aggressive environments.

Keywords: Abrasion Resistance Test, Compressive Strength, Dry Waste Okra Powder, Fly-Ash, Water Absorption Test.

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1.0 INTRODUCTION

The rapid development of the construction industry recently requires the use of very high durable materials in building construction to accommodate the increasing need for shelter, devastating forces of construction and fast polluting environment which has brought about the high demand of some raw materials by the construction sector as well as shortage of building materials and the associated environmental damages (Brito & Saikia, 2012). Concrete industry is particularly important as it is not only responsible for consuming natural resources and energy but also for its capacity of absorbing other industries waste and by products (Almeida, 2007). Concrete made with conventional Portland cement suffers several performance problems such as brittleness, low tensile strength, as well as susceptibility to acid and sulphate attack (Hidayah, 2016). Cement is used as a major material in concrete. The use of cement is a huge contributor to greenhouse gases and the resultant effect associated with global warming. This is brought about by the manufacturing process in which limestone is used extensively. The limestone, however, is an important ingredient to the cement manufacturing process which contains the vital compound needed in the production of cement, that is calcium carbonate. If the same quality of cement, especially in terms of strength, can be obtained with little or no limestone used, then this would mitigate against the negative environmental impacts that the limestone has. The consumption of cement globally in the year 2010 was measured at 3,313 million metric tons, which shows that it is the most widely used material in the production of concrete (Vignesh et al, 2014). The exploration of its raw materials leads to natural resources exhaustion and deterioration of the environment. Production of cement emits CO_2 which pollutes the environment. This is worrisome as for every ton of cement produced a ton of CO_2 is emitted (Dahiru, 2010). The cost of cement is also on the rising trend (Waithaka, 2014) due to increased demand for the cement and the rising mining levies, a solution to this increase in prices would be a relief to the consumers of cement in the construction industry. According to Dadu (2011) the global current move is to reduce the amount of Portland cement contents used in the concrete mixtures with cheaper Supplementary Cementitious Material (SCM)/pozzolans to improve certain durability properties of concrete.

The American Society for Testing and Material (ASTM C125-06) defined pozzolan as a siliceous or siliceous-aluminous material, which in itself possesses little or no cementitious value but which will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. Shetty (2009) classified pozzolans as either natural or artificial pozzolan. Natural pozzolans include clay and shales, opaline cherts, diatomaceous earth, volcanic ash, volcanic tuffs and pumicites, Artificial pozzolans include fly ash, blast furnace slag, silica fume, rice husk ash, and metakaolin. Fly ash, being one of the classifications of artificial pozzolans and an area of study for this research is available, economical and accessible.

According to Joergensen (2014) using pozzolan to replace cement in concrete leads to reduced heat development during hardening and improve properties of the final concrete element. Strength property of concrete with fly ash already yield promising results but its durability property has not been being given due consideration. Fly ash is a fine powder which is an industrial waste which a product of burning of coal in electric generation power plants. Fly ash is a pozzolanic material that contains aluminous and siliceous materials that forms cement in the presence of lime and water. Fly ash can be classified as class F and class C according to (ASTM C618, 2005; Gourav & Reddy, 2014). According to Yazici and Sahan, (2012), fly ash is one of the potential materials in reducing the use of cement in construction as it possesses similar binding ability as of cement while containing little to no hazardous chemical substances, making it a more viable and environmentally friendly alternative material.

In addition, the use of recycled materials from different source as concrete ingredients has been gaining popularity due to increasingly stringent environmental considerations and the mineral often have complementary properties. The use of this material give room to more available resources required as mineral to improve the performance of concrete. It was found that using some of these waste materials result in certain positive means as Polymeric organic admixtures are widely used in concrete and mortar for several decades to modify properties of cement products which have yield good result and improved performance. The additions of polymeric admixtures have improved various mechanical and durability properties of concrete (Shen, *et al.,* 2015; Shen, *et al.,* 2016). However, majority of the synthetic polymers have harmful environmental effects, and the use of synthetic admixture also lead to high cost of a concrete construction (Amarita et al., 2016). Karandikar, *et al.,* (2014), investigated the effect of different types of natural bio polymeric extracts on the various fresh and hardened properties of cement mortar and concrete which were also compared with a commercially available chemical admixture. They observed better performances of natural bio polymeric materials as compared with the modern chemical admixtures.

Okra is a naturally occurring inexpensive source of biopolymer, which has several applications in the industries and is developed in pre-forest and forest regions with Nigeria being the second largest producer of okra in Africa with 105,597 tones and ranked third in the world (Souci, *et al.,* 1994). The enormous nutritional and other biological activities in the pods and seeds of okra is used daily in households in different forms as fresh fruits, grains, powder due to its organoleptic qualities (Kumar et al, 2010).

Furthermore, degradation of fresh okra is enhanced by its very high-water content which undergoes several heat treatments before its consumption and these could influence the bioavailability of micronutrients and causes the loss of minerals at too high temperature (AOAC, 2003; Nguessan, *et al.,* 2018). The strategy to reduce losses of okra was developed in the country which is sun-drying in order to preserve okra vegetable because of its availability. Drying is the most common method to keep okra from wasting. Dried okra is more accessible and available in markets and grocery stores. Drying of okra increases the storage time which extends its sale. The okra can therefore be exported and kept longer. In recent times dried waste okra is evaluated for used as a sustainable bio-admixture in the production of cement mortar and concrete.

Currently concrete structures are being built in highly polluted urban and industrial areas, aggressive marine environments, harmful sub soil, water in coastal areas and many other hostile conditions where materials of construction are found not to be durable (Shetty, 2009). Pozzolanic reactions is the reaction between silica, calcium hydroxide and water to produce calcium silicate hydrates(C-S-H). This C-S-H creates a high-density microstructure that increases strength, lowers permeability of concrete and improves chemical resistance (Osei & Jackson, 2012). According to Joergensen (2014) using pozzolan to substitute or replace cement in concrete to reduce heat development during the process of hardening and improves final concrete property. Concrete can be proportionally made strong but not durable. according to Nagesh (2012) lifelong service life of concrete is synonymous to durability, and that durability of concrete is the ability to perform in exposure condition satisfactorily over an intended period of time with little or no maintenance. Shetty (2009) stated that concrete researchers and designers paid too much attention on compressive strength in the past neglecting other properties of concrete like durability. However, it has now been recognized that concrete compressive strength alone is not sufficient to judge the quality of concrete, the degree of aggressiveness of the environment to which the concrete is subjected to, is equally important to look upon. Therefore, both strength and durability have to be considered thoroughly at both the research and design stage (Shetty, 2009). This research work therefore assesses performance of dry waste okra powder concrete produced with Fly-Ash as partial replacement of cement subject to different curing conditions.

Materials and Methods

All materials used for the laboratory experiment were procured from the immediate environment. The relevant standards were used in the process of conducting the experiments.

Materials

The materials for the laboratory experiment included, coarse aggregate fine aggregate, Cement, fly ash, dried waste okra powder ***(****Abelmoschus esculentus (L.)****)*** and water. coarse aggregate was obtained from a quarry site within Bauchi metropolis. The fine aggregate was obtained from Yelwa River-flow in Bauchi state. The Portland cement is the brand of Dangote of Grade 42.5 which was procured from vendors within Bauchi metropolis. The dried waste okra powder was obtained within Bayara in Bauchi local government area of Bauchi state from local farmers. The particle sizes of fine aggregate were those passing through sieve with aperture size of 2.36 mm but retained on sieves of 150μm. It was confirmed to be free from dust and free from deleterious substances. The coarse aggregates used in this study were granite with particle size range between 5 mm and 20 mm.

The dried waste okra powder (DWOP) was milled to fine powder, and stored in a cool place. Portable water which was fresh, colorless, odorless and free of organic matter was used in these experiments. For the purpose of this investigation, mix ratio of 1:2.43:2.85 by weight of cement, sand and gravel, and water cement ratio of 0.50 was used and concrete cured in water (H_2O), HCl, H_2SO_4. The cement in the mix was initially partially replaced with 10% fly ash, and dried waste okra powder was added 10% FA at 0.25%, 0.5%, 0.75% and 1%. The concrete with 0% pozzolanic replacement of cement and admixture served as the control, it is to note that all percentage addition of dry waste okra powder was produced with 10% fly-ash, while the control concrete was produced with cement and without any of fly ash and or dry waste okra powder.

Methods

Density Test

This was carried out prior to crushing of the concrete specimen. At the end of each curing period, the concrete specimens were weighed using an electric weighing machine balance. Density is calculated as mass of concrete specimen in (kg) divided by volume of concrete cube (m^3) and expressed in kg/m^3.

Compressive strength

Cubes of size 100 x 100 x 100mm were cast for each mix and left in room temperature for 24 hours before demolding and cured in water until testing at 7 days to 90 days. Compressive strength was determined in accordance with BS EN 12390-3 (2009), 100mm cubes have been used for the investigation and the nominal size of the coarse aggregate used in this study does not exceed 20mm.

Water absorption capacity test

This test was conducted at the curing ages of 28, 56 and 90 days on concrete containing percentage dosage of dry waste okra powder at 0%, 10%FA, 0.25%, 0.5%, 0.75%, 1%, in accordance with BS 1881-122:(1983). Specimens were tested for absorption capacity and on each day of testing, three cubes each were placed in the electric oven to dry the specimens at 105^0C for 24 hours. The specimens were removed from the oven and allowed to cool at room temperature before determining the initial weight which was recorded as (W1). The final weight was determined after the concrete specimen has been immersed in water for 24hrs. It was removed and dried with a piece of cloth; re-weighed and recorded as W2. The equation below was used to compute the absorption capacity for the specimens as:

$$\text{Water Absorption Capacity} = Fct = \frac{W2-W1}{W1}\; x\, 100$$

Where: W_1 = Weight of the concrete sample after oven dry

W_2 = Weight of the saturated surface dry concrete sample

Abrasion resistance test

Abrasion resistance is used to measure the resistance of concrete to surface wear by abrasion. It is aimed at determining the abrasion resistance of a material through sliding or scraping, thus causing a wearing down by friction. Gupta and Gupta (2012) explained that abrasion value should not be more than 30% for wearing surface and 50% for other surfaces. The initial weight of each concrete sample was determined before brushing and recorded as W1, after which a weight of 3.5kg was mounted and tightly fixed to the wire brush. It was then used to brush the surface of concrete specimen 60 times and the specimen was then re-weighed while the value was recorded as W2. The relation used to determine abrasion resistance of the concrete sample is given as:

$$\text{Abrasion Resistance} = AR = \frac{W1 - W2}{W1}\ x\ 100$$

Where W_1 = Initial weight of a concrete specimen

W_2 = Final weight of a concrete specimen

Result and Discussion

Density of Concrete

The results of the density test are shown in Figure 1, for OPC/FA-DWOP concrete samples cured in normal water (H_2O) and weighed at 7, 14, 28, 56 and 90 curing days. The density of concrete cube samples varies from 2450 kg/m^3 to 2560 kg/m^3 and it increase with increase curing periods. Concrete with 0.75% dried waste okra powder present higher density than all other percentage addition of admixture beyond 28days of curing. The density of concrete increase as the percentage admixture increases up-to 0.75%. Concrete samples with density higher than 2600kg/m² are called higher density concrete samples (Kazjonovs et al., 2010), Values obtained exceeded the 2400 kg/m^3 at 28days hydration period expected for a normal weight concrete. This indicates that concrete produced with fly ash and okra powder replacement shows dense concrete and possesses quality for greater durability of concrete.

Figure 2, present the result of OPC/FA-DWOP concrete samples cured in hydrochloric acid (HCl) medium and weighed at 7, 14, 28, 56 and 90 curing days. The density of concrete cube samples varies from 2430 kg/m^3 to 2550 kg/m^3 and it increase with increase curing periods. Concrete with 0.75% dried waste okra powder present higher density than all other percentage addition of admixture in acid medium beyond 28days. The density of concrete increase as the percentage admixture increases. Concrete samples with density higher than 2600kg/m² are called higher density concrete samples (Kazjonovs et al., 2010), Values obtained exceeded the 2400 kg/m^3 at 28days hydration period expected for a normal weight concrete. This indicates that concrete produced with fly ash and okra powder replacement shows dense concrete and possesses quality for greater durability of concrete.

The results of the density test are shown in Figure 3, for OPC/FA-OP concrete samples cured in sulphuric acid (H_2SO_4) medium and weighed at 7, 14, 28, 56 and 90 curing days. The density of concrete cube samples varies from 2420 kg/m^3 to 2545 kg/m^3 and it increase with increase curing periods. Concrete with 0.75% dried waste okra powder present higher density than all other percentage addition of admixture in H_2SO_4 curing medium beyond 28days curing medium. The density of concrete increase as the percentage admixture increases. Concrete samples with density higher than 2600kg/m² are called higher density concrete samples (Kazjonovs et al., 2010), Values obtained exceeded the 2400 kg/m^3 at 28days hydration period expected for a normal weight concrete. This indicates that concrete produced with fly ash and okra powder replacement shows dense concrete and possesses quality for greater durability of concrete.

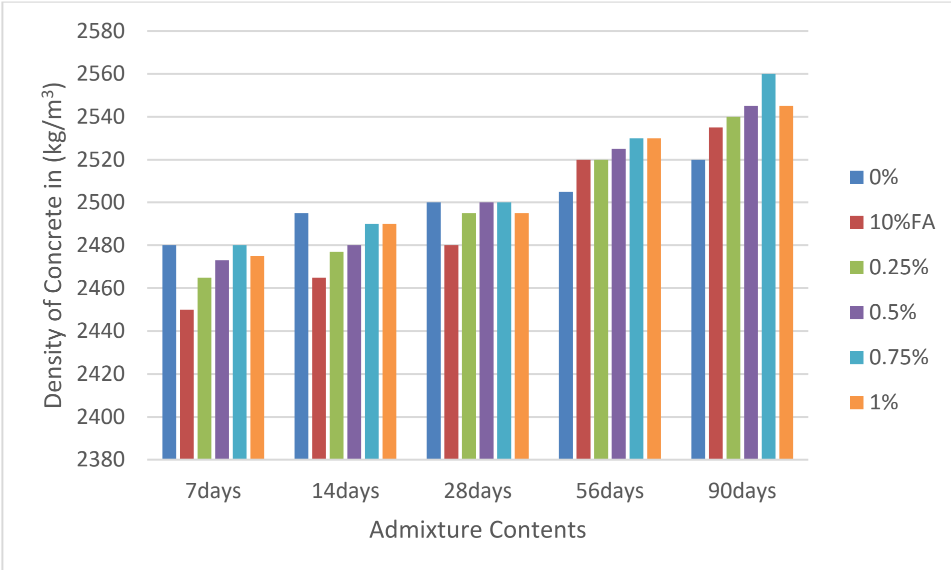

Figure 1: Density of FA-DWOP Concrete Cured in Water

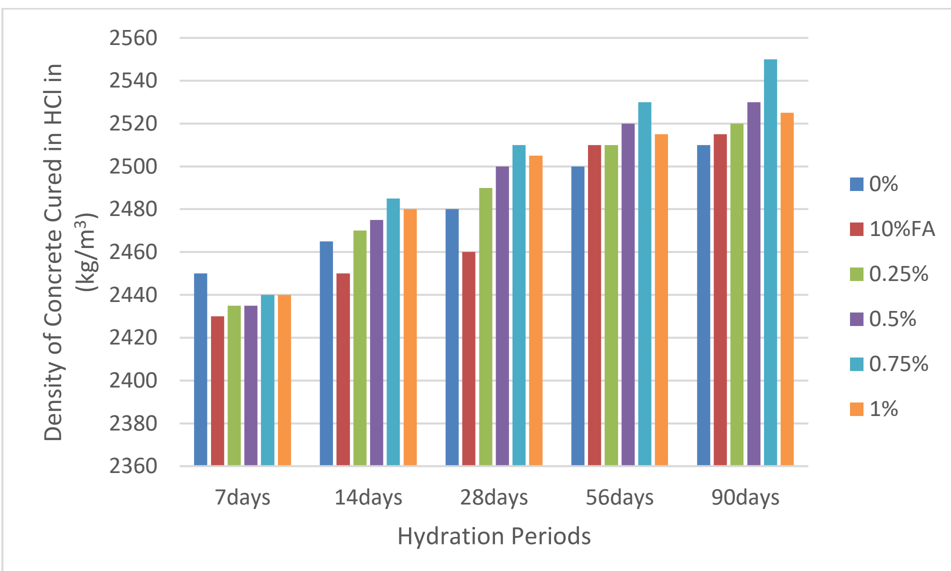

Figure 2: Density of FA-DWOP Concrete Cured in HCl

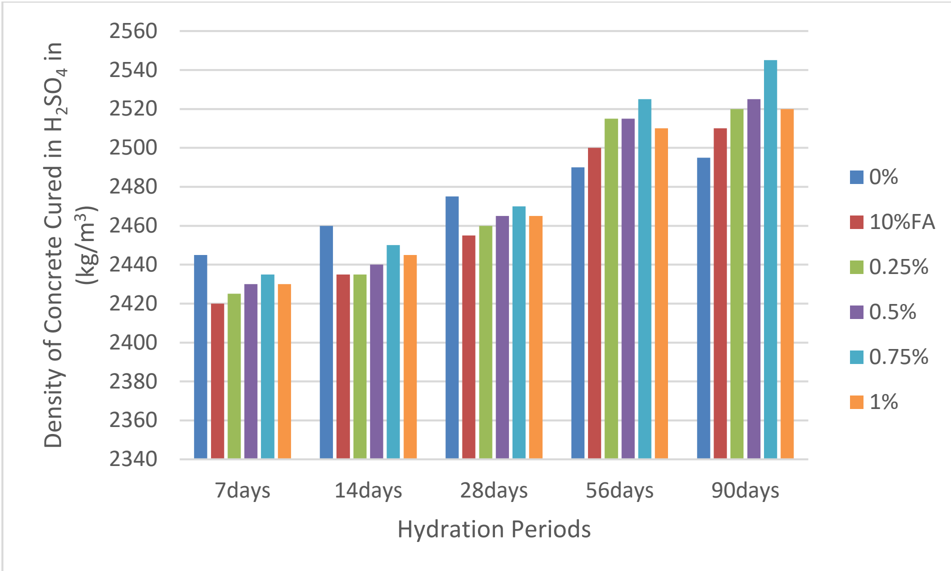

Figure 3: Density of FA-DWOP Concrete Cured in H_2SO_4

Figure 4 presents compressive strength of OPC/FA-DWOP concrete specimens cured in H_2O, and crushed at 7, 14, 28, 56 and 90days hydration periods. Concrete samples with 0% replacement has high strength index at early days of strength test at 7days to 28days but encountered loss in strength as compared to concrete with 10% fly-ash as cement replacement and other admixture addition percentage level. Concrete specimens with 0% admixture achieved 28.9 N/mm² while 10%FA achieved 28.4 N/mm² and 0.25%, 0.50%, 0.75%, and 1.0% FA-DWOP achieved 28.5 N/mm², 28.6 N/mm², and 28.9 N/mm², and 28.5 N/mm² at 28 days respectively.

Figure 5 presents compressive strength of OPC/FA-DWOP concrete specimens cured in HCL, and crushed at 7, 14, 28, 56 and 90days hydration periods. Concrete samples with 0% replacement has higher strength index up-to 28 days but encountered loss in strength as compared to other admixture percentage level at 56 days and 90days. Concrete specimens with 0% admixture achieved 27.9 N/mm² while 10%FA achieved 27.4 N/mm² and 0.25%, 0.50%, 0.75%, and 1% FA-DWOP achieved 27.5 N/mm², 27.5 N/mm², and 27.8 N/mm², and 27.6 N/mm² at 28 days respectively. This result represents 0.36% increase of 0% control concrete as compared to 0.75%FA-DWOP concrete. At 56 days curing age, concrete specimens with 0% control concrete achieved 28.2 N/mm² while 10%FA achieved 28.4 and 0.25%, 0.50%, 0.75%, and 1.0% FA-DWOP achieved 28.5 N/mm², 28.6 N/mm², 29.3 N/mm², and 28.5 N/mm². This shows 3.75% strength increase of 0.75%FA-DWOP concrete as compared to control concrete, also all replacement and addition level present high strength as compared to the control concrete. At 90 days curing age, concrete specimens with 0% control concrete achieved 28.5 N/mm² while 10%FA achieved 28.6 and 0.25%, 0.50%, 0.75%, and 1.0% FA-DWOP achieved 28.9 N/mm², 29.8 N/mm², 30.9 N/mm², and 29.4 N/mm² respectively. This shows 7.77% strength increase of 0.75%FA-DWOP concrete as compared to control concrete, also all replacement and addition level present high strength as compared to the control concrete, also admixture concrete present high strength as compared to fly-ash concrete and strength of concrete increase with increase in admixture content. The result is in line with the study of Agboola et al., (2020) who stated that pozzolanic material influences strength and durability properties of concrete at later stages. The increase in strength might be as a result of admixture and pozzolanic material present in the concrete mix. Presence of pozzolanic materials enhance the strength of concrete (Duggal, (2008); ACI E1-99 - E701 (2001)). Pozzolanic material can be used as a partial replacement of cement in concrete due to the high silica present in it and its ability to react with calcium in cement in the presence of water to form a compound with calcium hydrate silicate (CSH). The result shows 0.75% admixture has high strength beyond all other percentage admixture and the control concrete. The porosity is concrete and the ingress of chemical into the concrete product has high effect on the strength properties of concrete (Agboola, et al., 2021). Figure 6 presents compressive strength of OPC/FA-DWOP concrete specimens cured in H_2SO_4, and crushed at 7, 14, 28, 56 and 90days hydration periods. Concrete samples with 0% replacement has high strength at early strength test days of 7days to 28days but encountered loss in strength as compared to fly-ash concrete and other admixture percentage level. Concrete specimens with 0% control concrete achieved 26.8 N/mm² while 10%FA achieved 26.2 N/mm², and 0.25%, 0.50%, 0.75%, and 1.0% FA-DWOP achieved 26.5 N/mm², 26.6 N/mm², and 26.8 N/mm², and 26.3 N/mm² at 28 days respectively. 0.75%FA-DWOP concrete has same strength index with 0% control concrete. At 56 days curing age, 0% control concrete specimens achieved 27.5 N/mm² while 10%FA 27.6 N/mm² achieved 0.25%, 0.50%, 0.75%, and 1.0% FA-DWOP achieved 27.8 N/mm², 28.1 N/mm², 29.2 N/mm², and 28.2 N/mm². This shows 5.82% strength increase of 0.75%FA-DWOP concrete as compared to control concrete. At 90 days curing age, 0% control concrete specimens achieved 27.5 N/mm² while 10%FA 27.6 N/mm² achieved 0.25%, 0.50%, 0.75%, and 1.0% FA-DWOP achieved 27.8 N/mm², 28.1 N/mm², 29.2 N/mm², and 28.2 N/mm². This shows 5.82% strength increase of 0.75%FA-DWOP concrete as compared to control concrete. The result is in line with the study of Agboola et al., (2020) who stated that pozzolanic material influences strength and durability properties of concrete at later stages. The increase in strength might be as a result of admixture and pozzolanic material present in the concrete mix. Presence of pozzolanic materials enhance the strength of concrete (Duggal, (2008); ACI E1-99 - E701 (2001)). Pozzolanic material can be used as a partial replacement of cement in concrete due to the high silica present in it and its ability to react with calcium in cement in the presence of water to form a compound with calcium hydrate silicate (CSH). The result shows 0.75% admixture has high strength beyond all other percentage admixture and the control concrete. The porosity is concrete and the ingress of chemical into the concrete product has high effect on the strength properties of concrete (Agboola, et. al., 2021).

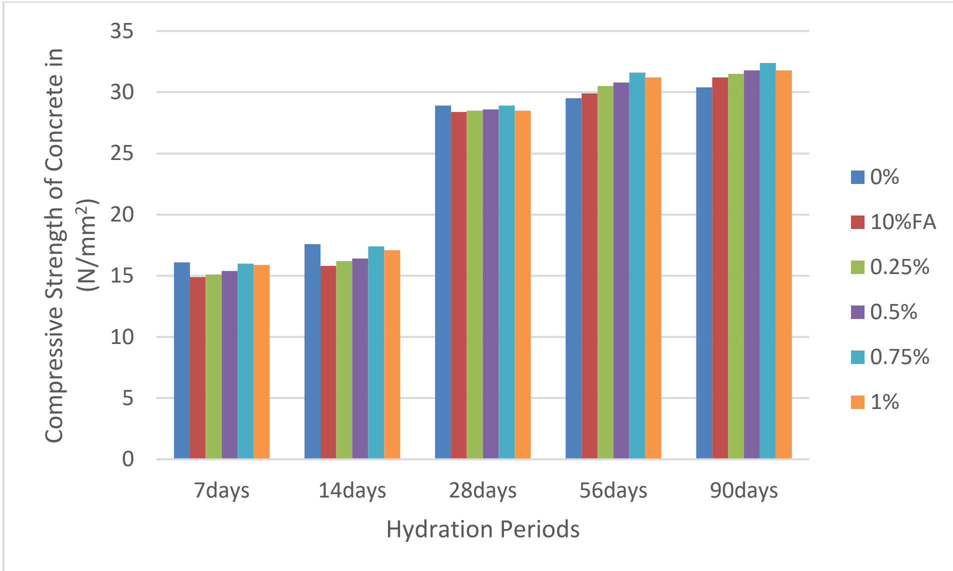

Figure 4: Compressive Strength of FA-DWOP Concrete Cured in Water

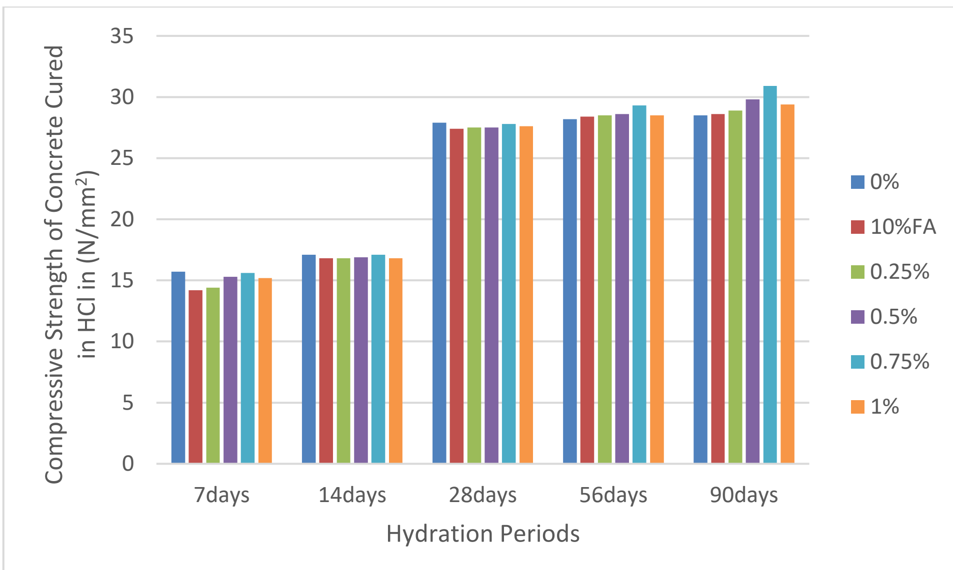

Figure 5: Compressive Strength of FA-DWOP Concrete Cured in HCl

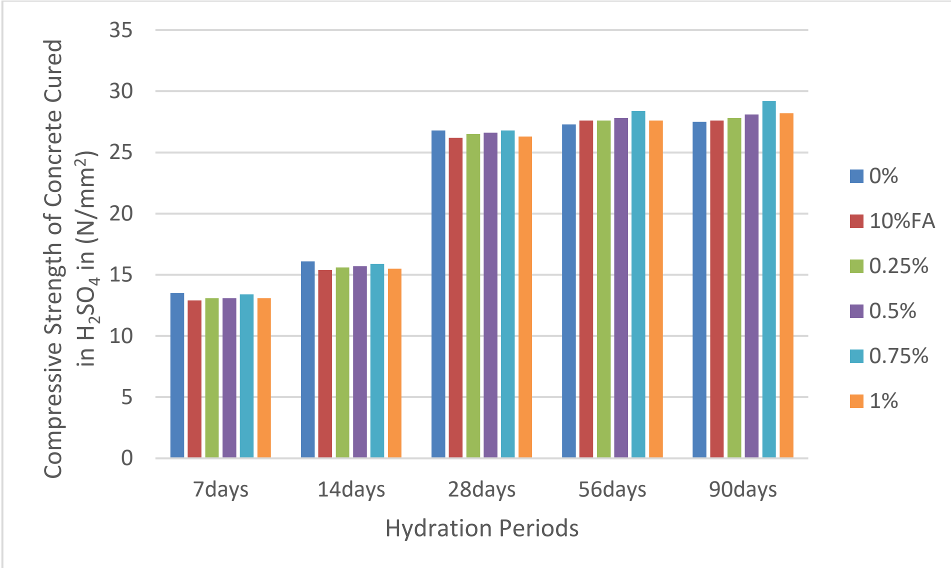

Figure 6: Compressive Strength of FA-DWOP Concrete Cured in H_2SO_4

Water Absorption Test of Concrete

Figure 7 shows the water absorption test of OPC/FA-DWOP concrete cured in water (H_2O) and tested at 28, 56- and 90-days hydration periods. For cubes cured in H_2O at 28 days 0% replacement absorbed more curing agent than all other percentage addition of admixture and pozzolana, 0% control concrete samples absorbed 2.11% while 10%FA absorbed 2.06% and 0.25%, 0.50%, 0.75%, and 1.0% percentage admixture absorbed 2.04%, 1.93%, 1.86%, and 1.73% respectively. Also, at 56 days curing age, 0% control concrete samples absorbed 1.91% while 10%FA absorbed 1.84% and 0.25%, 0.50%, 0.75%, and 1.0% admixture absorbed 1.82%, 1.75%, 1.64%, and 1.56% respectively. At 90 days curing age, 0% control concrete samples absorbed 1.85% while 10%FA absorbed 1.76% and 0.25%, 0.50%, 0.75%, and 1.0% admixture absorbed 1.71%, 1.66%, 1.58%, and 1.47% respectively. This means that the higher the percentages admixture in concrete samples the lesser the curing agent absorbed, the reduction in water absorbed can be attributed to the presence of filler material and admixture in the concrete specimen. The degree of absorption of the concrete tally with the work carried out by Agboola (2019) which show that the average absorption of the concrete test specimens with pozzolana shall not be greater than 5%.

Figure 8 shows the water absorption test of OPC/FA-DWOP concrete cured in hydrochloric acid and tested at 28, 56- and 90-days hydration periods. For cubes cured at 28 days curing age, 0% replacement absorbed more curing agent than all other percentage addition of admixture, concrete samples with 0% control concrete absorbed 2.25% while 10%FA absorbed 2.16% and 0.25%, 0.50%, 0.75%, and 1.0% percentage admixture absorbed 2.08%, 1.97%, 1.88%, and 1.81% respectively. Also, at 56 days curing age, 0% control concrete samples absorbed 1.98% while 10%FA absorbed 1.91% and 0.25%, 0.50%, 0.75%, and 1.0% admixture absorbed 1.85%, 1.81%, 1.71%, and 1.63% respectively. At 90 days curing age, 0% control concrete samples absorbed 1.91% while 10%FA absorbed 1.79% and 0.25%, 0.50%, 0.75%, and 1.0% admixture absorbed 1.74%, 1.71%, 1.61%, and 1.58% respectively. This means that the higher the percentages admixture present in concrete samples the lesser the curing agent absorbed in (HCl) curing medium, the reduction in water absorbed can be attributed to the presence of filler material that is fly ash and admixture dry waste okra powder in the concrete specimen. The degree of absorption of the concrete tally with the work carried out by Agboola (2019) which show that the average absorption of the concrete test specimens with pozzolana shall not be greater than 5%.

Figure 9 shows the water absorption test of OPC/FA-DWOP concrete cured in sulphuric acid and tested at 28, 56- and 90-days hydration periods, cured in (H_2SO_4) curing media. For cubes cured at 28 days curing age, 0% control concrete absorbed more curing agent than all other percentage replacement and addition of admixture, control concrete absorbed 2.38% while 10%FA absorbed 2.21% and 0.25%, 0.50%, 0.75%, and 1.0% percentage admixture absorbed 2.13%, 2.02%, 1.92%, and 1.88% respectively. At 56 days curing age, 0% control concrete samples absorbed 2.14% while 10%FA absorbed 1.94% and 0.25%, 0.50%, 0.75%, and 1.0% admixture absorbed 1.91%, 1.85%, 1.77%, and 1.71% respectively. At 90 days curing age, 0% control concrete samples absorbed 2.05% while 10%FA absorbed 1.88% and 0.25%, 0.50%, 0.75%, and 1.0% admixture absorbed 1.81%, 1.76%, 1.65%, and 1.62% respectively. This means that the higher the percentages admixture present in concrete samples the lesser the curing agent absorbed in suphuric acid curing medium, this reduction in water absorbed can be attributed to the presence of filler material that is fly ash and admixture dry waste okra powder in the concrete specimen. The degree of absorption of the concrete tally with the work carried out by Agboola (2019) which show that the average absorption of the concrete test specimens with pozzolana shall not be greater than 5%.

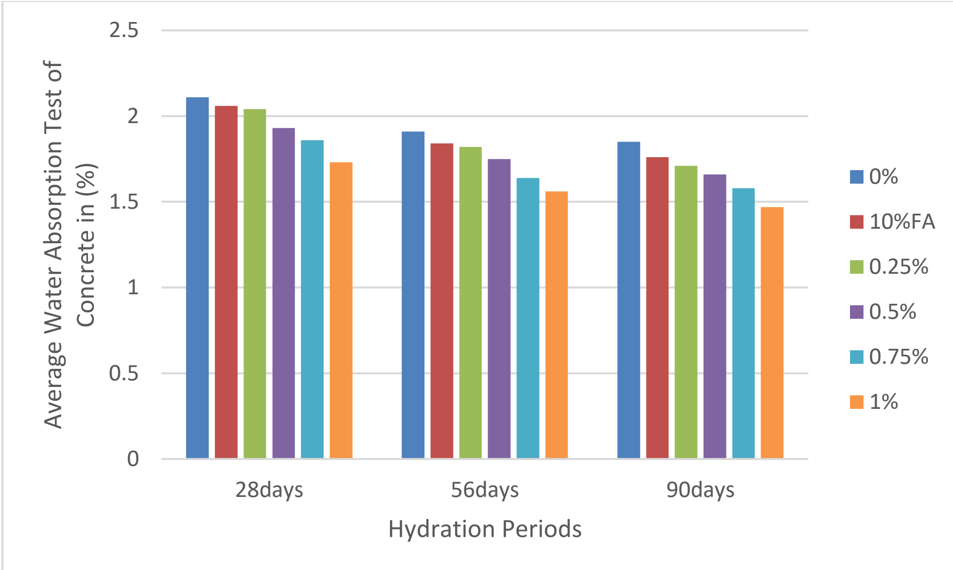

Figure 7: Water Absorption Test of FA-DWOP Concrete Cured in Water

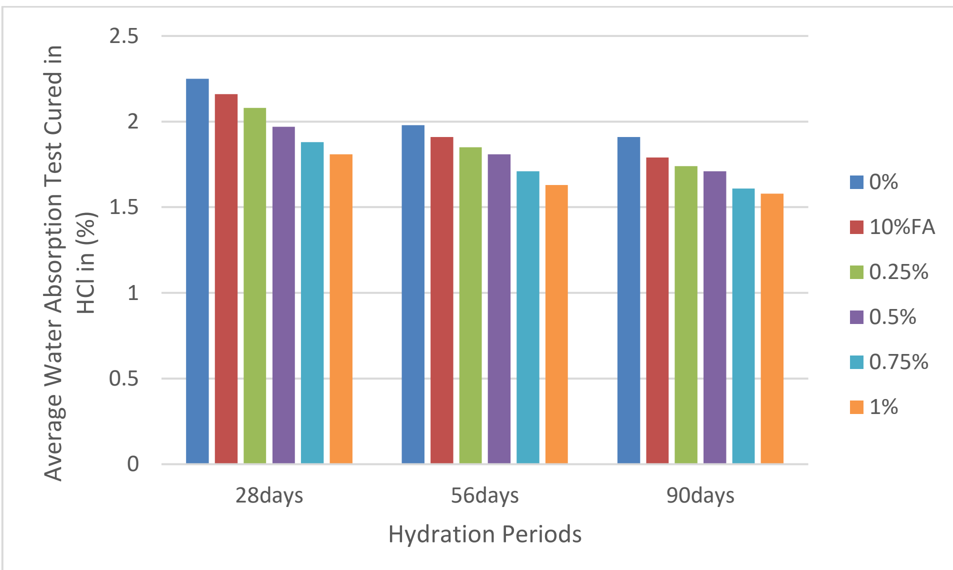

Figure 8: Water Absorption Test of FA-DWOP Concrete Cured in HCl

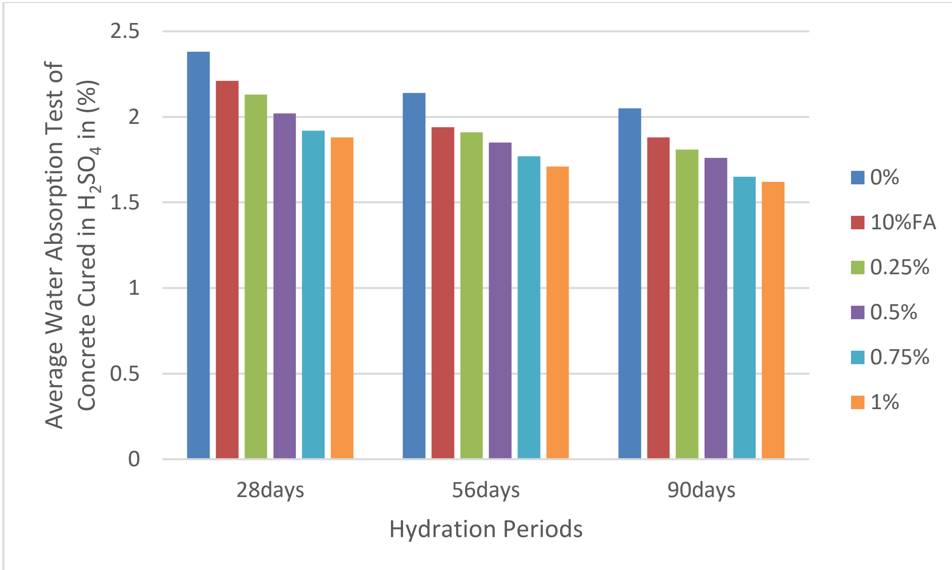

Figure 9: Water Absorption of FA-DWOP Concrete Cured in H_2SO_4

Abrasion Resistance of Concrete

Figure 10 shows the abrasion resistance of OPC/FA-DWOP specimens cured in H_2O and tested at 28, 56- and 90-days' hydration periods. Same weight loss of 0.09% was discovered for concrete samples at 0%, 10%FA and 0.25%, has a weight loss of 0.09%, while 0.5%, 0.75% and 1% has a weight loss of 0.08% respectively. At 56days it was discovered that 0%, 10%FA and 0.25% admixture have a weight loss of 0.08%, while 0.5%, 0.75% and 1% have less weight loss of 0.05% respectively. At 90days it was discovered that 0%, 10%FA and 0.25% admixture have a weight loss of 0.05%, while 0.5%, 0.75% and 1% have less weight loss of 0.04% respectively. Higher percentage admixture of 0.75% and 1% resists abrasion impact better than less percentage admixture, pozzolanic concrete and the control in water curing media generally.

Figure 11 shows the abrasion resistance of OPC/FA-DWOP specimens cured in HCl and tested at 28, 56- and 90-days' hydration periods. Same weight loss of 0.11% was discovered for concrete samples at 0% and 10%FA, 0.25% has a weight loss of 0.09%, while, 0.50%, 0.75% and 1% with 0.08% weight loss. At 56days it was discovered that 0% and 10%FA has a weight loss of 0.09%, 0.25% has a weight loss of 0.08%, while 0.5%, 0.75% and 1% has less weight loss of 0.05% respectively. At 90days it was discovered that 0% and 10%FA has a weight loss of 0.08%, 0.25% and 0.05% has a weight loss of 0.05%, while 0.75% and 1% has less weight loss of 0.04% respectively. Higher percentage admixture of 0.75% to 1% resists abrasion impact better than less percentage admixture and the control in hydrochloric acid curing media generally.

Figure 12 shows the abrasion resistance of OPC/FA-DWOP specimens cured in (H_2SO_4) and tested at 28, 56- and 90-days' hydration periods. Higher weight loss of 0.15% was discovered for concrete samples at 0%, 10%FA has a weight loss of 0.13%, while 0.25%, 0.50%, 0.75% and 1% has same weight loss of 0.11% respectively at 28 days curing age. At 56days it was discovered that 0% has a high weight loss of 0.13%, 10%FA has a weight loss of 0.11%, while 0.25% has a weight loss of 0.09%, 0.5%, 0.75% and 1% has same weight loss of 0.08% respectively. At 90days it was discovered that 0% has a high weight loss of 0.11%, 10%FA has a weight loss of 0.09%, 0.25% has a weight loss of 0.08%, 0.5%, 0.75% and 1% has same weight loss of 0.05% respectively. Higher percentage admixture of 0.5% to 1% resists abrasion impact better than less percentage admixture and the control in sulphuric acid curing media generally.

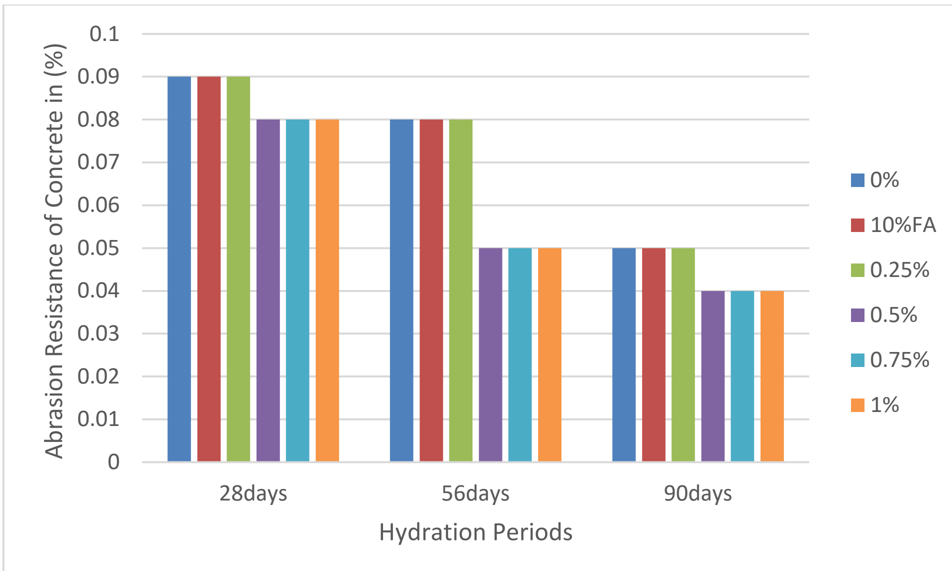

Figure 10: Abrasion Resistance of FA-DWOP Concrete Cured in Water

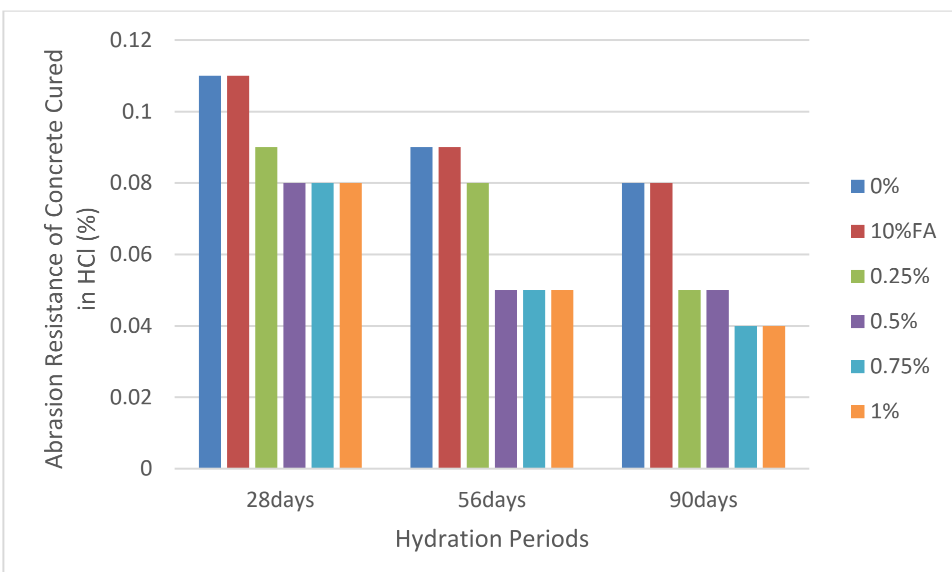

Figure 11: Abrasion Resistance of FA-DWOP Concrete Cured in HCl

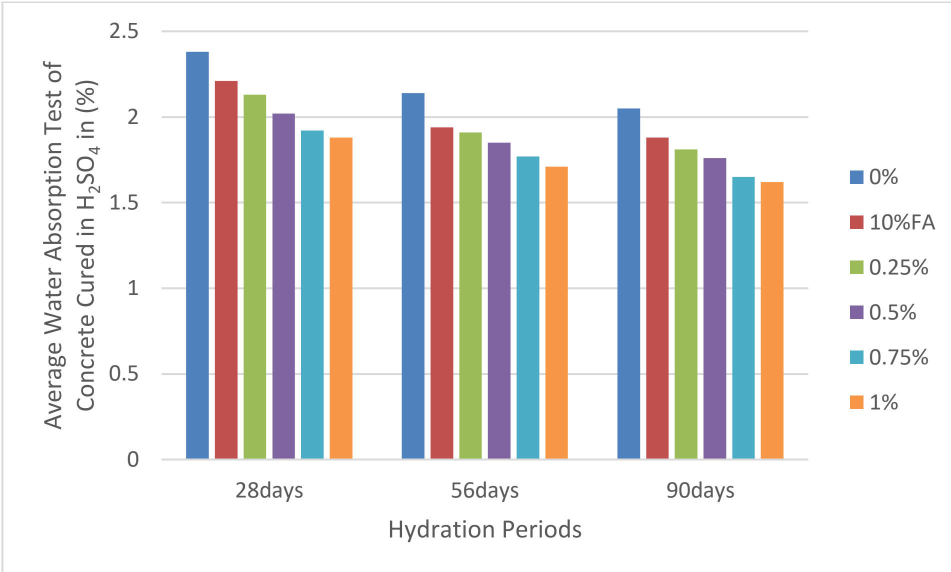

Figure 12: Abrasion Resistance of FA-DWOP Concrete Cured in H_2SO_4

CONCLUSION

Density of concrete is increased with an increase in DWOP content in the concrete mix. The maximum increase in density of concrete was observed at 0.75% DWOP content in concrete sample at 56 and 90 days in all curing medium. At 28days control concrete has the highest density although 0.5% and 0.75% shows promising result. Compressive strength of concrete increase with percentage increase in DWOP content in the concrete mix in all curing media of H_2O, HCL and H_2SO_4. The maximum compressive strength was observed at 0.75% DWOP content at later stages of 56 and 90 days in all samples, while at 28 days 0% control concrete has the maximum compressive strength in all curing media. Replacement of cement at 10% by fly-ash has reduced compressive strength range only marginally, and therefore it still has potential for applications in structural and mass concrete applications. Fly-ash replaces cement at 10% on the basis of the weight of cement in this experiment. The decrease in compressive strength is insignificant in term of economic value by cement replacement. This study also examines the role of fly-ash as a filler material in concrete to replace cement partially in concrete production. The decreased water absorption capacity of fly-ash blended concrete with increased DWOP content shows that concrete produced with fly-ash as cement replacement and dry waste okra powder as admixture will be more durable than normal concrete when subjected to chemical aggressive environment. Concrete samples with fly-ash as cement replacements and dry waste okra powder as admixture have higher strength both in chemical environments than control concrete samples at higher curing ages. Concrete samples made with pozzolanic material at 10% and admixture up-to 0.75% have high resistance to abrasion and less sorptivity in chemical environment.

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