Research Article
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Modeling and simulation to monitor the integration of palm fuel oil ash on compressive strength of concrete pavement influenced by variation of water cement ratios

Abstract

This model predicts the compressive strength of concrete pavement modified with palm oil fuel as partial replacement for cement. The study monitors the strength development of concrete pavement varying with different percentage of [POFA].The study express the output of the modifier from graphical representation, where optimum strength were observed at 5% at curing age between [7, and 28days].The study has observed that the modifier applied as partial replacement of cement experienced decrease in strength as the percentage of [POFA] dosage increase, these condition were observed from the graphical representation such that gradual decrease were experienced between [10-20%].The declined in strength development from variation of water cement ratio were experienced between [0.40-0.50], the influences from variation of these mixed proportion were also monitored, these conditions were reflected on the output results from the designed mix, the developed model were subjected to simulation, these values were compared with pone et al 2018, where the early strength from 2.5-5% 0f [POFA] were also in agreement with partial replacement of silica fume that also experienced early attained strength, between [2.5-5%] variations from concrete pavement porosity were observed from the heterogeneity of the strength at different water cement ratios, including variation of compaction and placement of the materials.

Keywords: modeling, palm oil fuel ash, compressive strength, water cement ratios

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Introduction

Nigeria and are known to major palm oil producers in the world, these two nations produces large quantity of waste namely, palm oil fuel ash and oil palm shell from the palm oil mill.[1,2] It has been observed that Over 6.89 million tons of oil palm shell[2,3] and 4 million tons of palm oil fuel ash[4] are produced yearly in Malaysia and light less in Nigeria. These by product are in waste dump site thus generating several pollution these nations.[5] According to experts,[6] the discarding of palm oil fuel ash developed lots of negative impact on the environment including health and well-being of the municipal. Nonstop in waste dumping at the landfill would pose further severe environmental complications in terms of pollution of ground water source as well as unsightly view. Have strong concrete objective to reduce quantity of disposed waste to the environment thus decrease quantity of natural resources from being harvested to applied in concrete production, experts has made tremendous effort to explore the potential of these palm oil industry by-products to be used in concrete industries. This headed to generation of several model concrete comprising palm oil fuel ash such as ordinary concrete,[7] aeratedconcrete,[8] high strength concrete[9] and high volume ash concrete[10] these are in large quantity produced. The application of oil palm shell as lightweight aggregate materials has been rated[11] this including the realization and it preservation of natural granite aggregate resources that has been applied in concrete industry, this also has opened a new area in lightweight aggregate concrete study. The abundantly accessible oil palm shell produced locally has steered toutilisation of this waste materials as lightweight aggregate in generation of oil palm shell, lightweight aggregate concrete(OPS LWAC) of varies in strength[12–14] for various usage. Accessibility of both wastes locally, has originated efforts to combine these materials in concrete generation integrating of palm oil fuel ash as partial cement replacement in oil palm shell lightweight aggregate concrete successfully enhances the compressive strength of concrete[15]

Theoretical background

Nomenclature

C = Compressive Strength

$A_{y(1-n)}$ = water cement Ratio

Φ^2 = Cementious Material/Addictive's

B_y = Specific Gravity

Y = Curing Age

$$\frac{dc}{dy} + A_{(y)}C_{(d)} = B_{(y)}C_d^{\,n}\,;n \ \geq 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Divided by (1) through by C_d^{-n} we have obtain

$$C_d^{\,-n}\frac{dc}{dy} + A_{(y)}C_d^{\,1-n} = B_{(y)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots... (2)$$

Let $\beta = C_d^{\,1-n}$

$$\frac{d\beta}{dy} = (1-n)c_d^{\,-n}\frac{dc}{dy}$$

Multiplying Equation (2a) through by (1- n)

$$(1-n)C_d^{\,1-n}\frac{dc}{dy} + (1-n)A_{(y)}C_d^{\,1-n} = (1-n)B_{(y)} \ldots\ldots\ldots\ldots (3)$$

$$\text{let } \frac{2}{2-\beta} = \varphi^2$$

$$\beta = \frac{1}{\varphi^2}\int (1-n)B(y)dy = \frac{1}{\varphi^2}(1-n)B(y)Y + K_1 \ldots\ldots\ldots\ldots (4)$$

$$\left[\beta = \frac{(1-n)}{\varphi^2}B(y)Y\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Materials and method

Experimental procedures

Compressive Strength Test Concrete cubes of size 150mm×150mm×150mm were cast with and without copper slag. During casting, the cubes were mechanically vibrated using a table vibrator. Seven day interval, the specimens were demoulded and subjected to curing for 7-28 days and seven day interval to 28 days in portable water. After curing, the specimens were tested for compressive strength using compression testing machine of 2000KN capacity. The maximum load at failure was taken. The average compressive strength of concrete and mortar specimens was calculated by using the following equation 3.1 (Tables 1-9).

Compressive strength (N/mm^2) = Ultimate compressive load (N)

Area of cross section of specimen (mm^2)

Table 1 Predictive values of compressive strength [7 Days] [w/c 0.50] of pofa

Percentage of Pofa	2.5	5	10	15	20
Compressive Strength [7 Days] [w/c 0.50]	35.18	40.74	38.03	30	27.65

Table 2 predictive values of compressive strength [28 Days [w/c0.50] of pofa

Percentage of pofa	2.5	5	10	15	20
Compressive Strength [28 Days [w/c0.50]	44.01	54.52	39.11	35.26	33.18

Table 3 Predictive and experimental values of compressive strength at 7days of pofa

Percentage of pofa	2.5	5	10	15	20
Predictive Values of Compressive Strength 7days [w/c 0.50]	35.18	40.74	38.03	30	27.65
Experimental Values of Compressive Strength 7days	35	44	36	29	27

Table 4 Predictive and experimental values of compressive strength at 28days [w/c 0.50] of pofa

Percentage of pofa	2.5	5	10	15	20
Predictive Values of Compressive Strength 28days [w/c 0.50]	44.01	54.52	39.11	35.26	33.18
Experimental Values of Compressive Strength	41	52	40	36	31

Table 5 Predictive and experimental values of compressive strength at [7 Days] of pofa

Percentage of pofa	2.5	5	10	15	20
Compressive Strength [7 Days]	35.18	40.74	38.03	30	27.65

Table 6 Predictive and experimental values of compressive strength at [7 Days] [w/c of 0.40] of pofa

Percentage of pofa	2.5	5	10	15	20
Predictive Compressive Strength [7 Days] [w/c of 0.40]	42.3650625	48.5765	45.96	35.8535	33.332
Experimental Compressive Strength	42.25	48.89	45.63	36	33.19

Table 7 Predictive and experimental values of compressive strength from 2.5 to 20 of pofa

Percentage of pofa	Predictive values of compressive strength [w/c 0.40]	Experimental values of compressive strength
2.5	37.78	35
5	40	44
10	37.33	36
15	28.002	29
20	26.5	26

Table 8 Predictive and experimental values of compressive strength at [28 Days] of pofa

Percentage of pofa [28 Days]	Predictive Values of Compressive Strength [w/c 0.40]	Experimental Values of Compressive Strength [w/c 0.40]
2.5	55.767125	53.33
5	60.0935	65.43
10	52.235	46.94
15	38.9865	42.31
20	40.298	39.83

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Table 9 Predictive Values of Compressive Strength at Different percentage of pofa and Curing Age

Pofa	2.5	5	10	15	20
Fcu7	42.3651	48.5765	45.96	35.8535	33.332
Fcu7	42.23	35.18	38.03	30	27.65
Fcu7	37.78	44.44	37.33	28.02	26.55
Fcu 28	44.01	54.52	39.11	35.26	33.18
Fcu28	55.7671	60.0935	52.235	38.9865	40.298

Results and discussion

(Figures 1-9) explain the behaviour of the [POFA] at different percentage; this has explain the rate at which the compressive strength on partial replacement of cement can developed an optimum strength. These express the rate of the strength development, it has achieved to an optimum compressive strength at different curing age with the mixed designed developed. Mechanical properties of these materials were also observed to reflect from the growth rate of the designed targeted strength, the figure from its graphical representation experienced other reflection from concrete characteristics such as the variation of voids in mixed compaction including placement of the material, these were observed to affect the strength development of the materials, the material; its self-express heterogeneity of void ratios and the porosity of the material at designed mix proportion of the concrete whereby [0.40-0.50] were applied. This mixed proportion predominantly determined the variation of concrete porosity, these includes the binders and its rates of compaction from its final placement, the hydration process on such condition developed it pressure thus generate an output that reflect the variation of strength development. The figures experienced gradual decrease in strength from 10-20%, this explained the rate of [POFA] dosage or percentage at different curing age, and it attained the optimum required strength. The study explained the entire figures that is monitored, this has explained the increase in [POFA] including output of water cement ratio that influence the decrease in designed targeted strength, these were variations between [0.40 and 0.50] mixed proportion from the simulation values were also monitored on their strength variations, these were observed in figure 10 were various water cement ratios at different curing age and its strength development were compared, these also generated different experienced from the results. The derived simulation values were subjected to validations and both parameters generated best fits correlation.

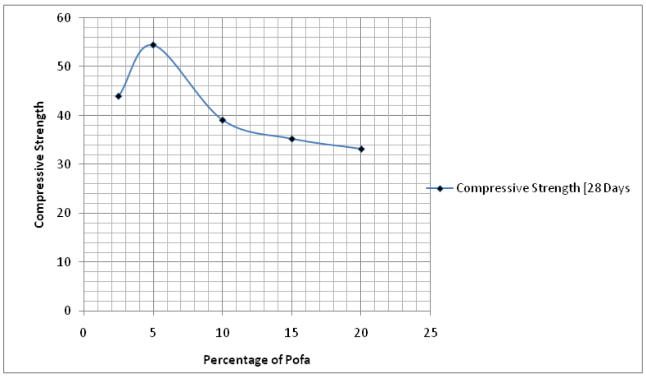

Figure 1 Predictive Values of Compressive Strength at 28days of pofa.

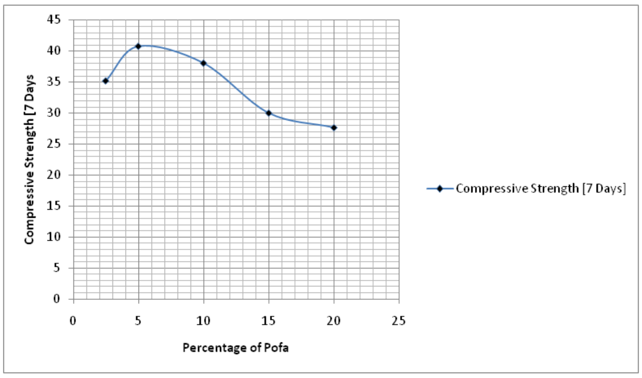

Figure 2 Predictive Values of Compressive Strength at 7days of pofa.

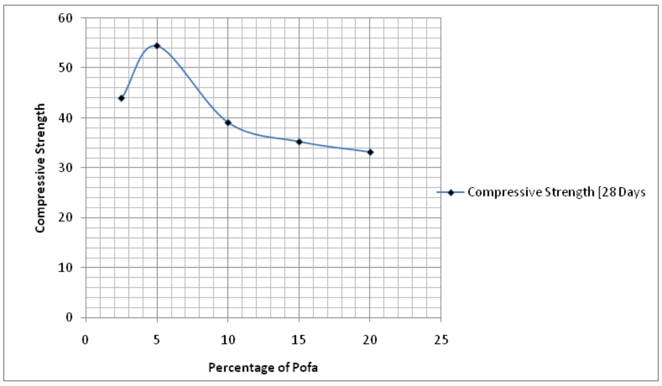

Figure 3 Predictive Values of Compressive Strength at 28days of pofa.

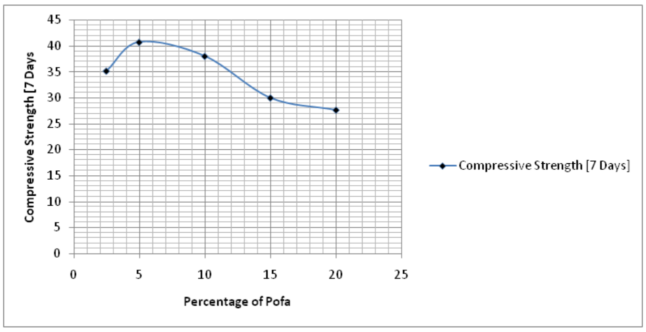

Figure 4 Predictive Values of Compressive Strength at 7days of pofa.

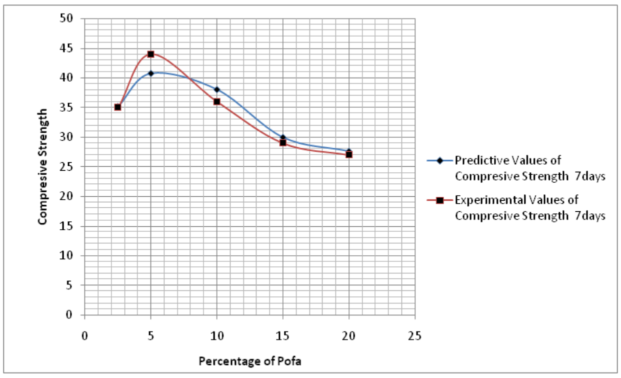

Figure 5 Predictive and Experimental Values of 7days and compressive strength at 7days of pofa.

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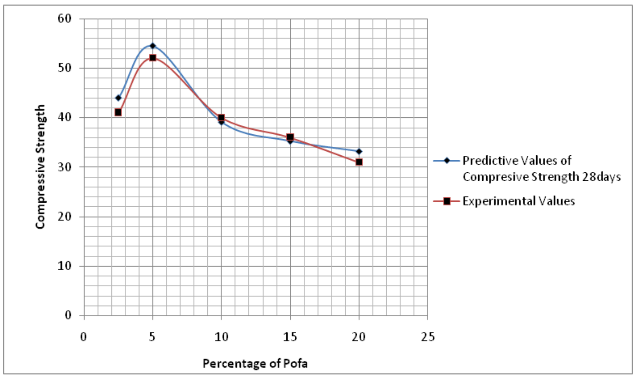

Figure 6 Predictive and experimental values of compressive strength at 28days of pofa.

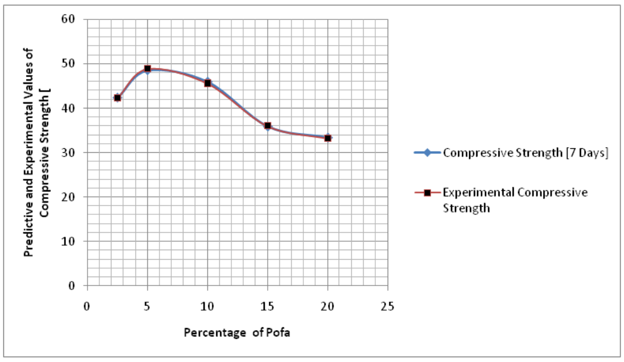

Figure 7 Predictive and experimental values of compressive strength at different percentage of pofa.

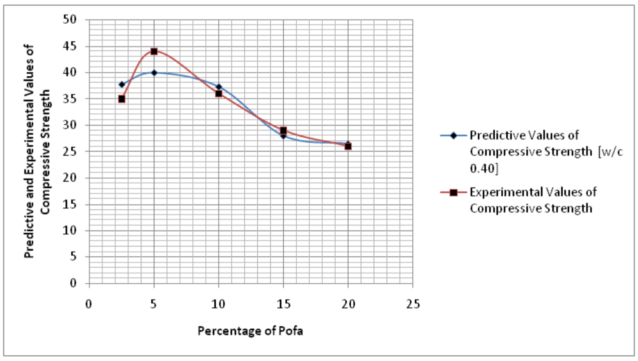

Figure 8 Predictive and experimental values of compressive strength [w/c 0.40] of pofa.

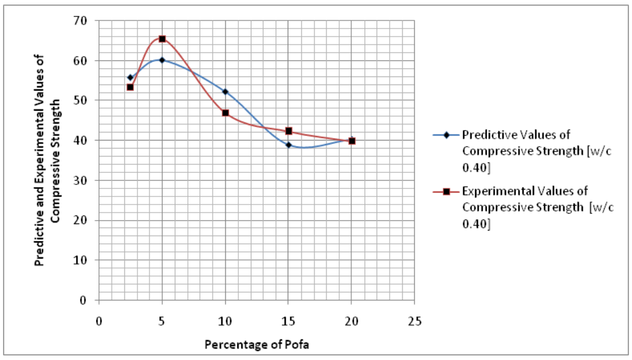

Figure 9 Predictive and experimental values [w/c 0.40] and compressive strength [w/c 0.40] of pofa.

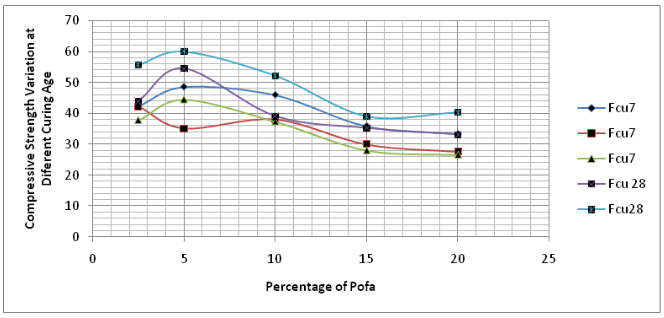

Figure 10 Predictive and experimental values of compressive strength at different percentage Fcu7 to Fcu28 of pofa.

Conclusion

The study has shown various outputs as a construction material, concrete pavement is active to resist compressive stresses, while at any positions wherever tensile strength or shear strength is of fundamental importance. The compressive strength is applied on approximation of the required property of concrete target to remain moist in order for it to be cured. Generally the internal relative humidity needs to be above 80% to 85% for hydration to take place. The film of water on the surface is a relatively large reservoir that can evaporate without affecting the moisture within the concrete's pores. The research expressed the behaviour of the material base on these factors such that the strength attained from partial replacement of cement developed maximum strength at 5%, then experienced gradual decrease as the percent of [POFA] increased at different curing age, these condition observed are reflected on the pressured from the mechanical properties, thus the concrete characteristics that determined the rate of compressive strength. The mixed designed applied between [0.40-0.50] shows these influenced that determined the rated of fluctuation in the developed concrete strength. The mixed proportion of these target strength shows results that determine the reflection of water cement ratios and curing age, the study developed the strength through derived model simulation values, the system considered the behaviour of the materials, based on the generated targeted strength, these were compared with experimental values from pone et al 2018, and both parameters developed best fits correlation.

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None.

Conflicts of interest

The authors declare no conflict of interest.

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