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Modeling Flexural Strength of Concrete Pavement Modified With Silica Influenced By Variation Water Cement Ratios

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ABSTRACT

This paper applied deterministic model to monitor the flexural strength of concrete pavement influenced by variations of water cement ratios, the study try to express the influences from water cement ratios on flexural strength of concrete pavement, flexural strength of concrete pavement were observed to experiences linear trend to the optimum values recorded at ninety days of curing age, the study observed from the results are from uniformity of aggregates that developed strong concrete bond, the decrease in void ratios and water absorption are reflected on the flexural strength that express the growth rate on concrete pavement, decrease in flexural strength are based on increase in water cement ratios as reflected on the generated predictive parameters, it is observed from the study that the variations of water cement ratios from [0.23-0.40] generated flexural strength that are still within the required specification for concrete pavement. The derived model were subjected to simulation that developed these parameters, the predictive values reflected different flexural strength base on variation of water cement ratios, validation of the predictive values from simulation are with experimental values, it developed best fits correlations, the study has detailed the significant role of water cement ratios on flexural strength of concrete pavement, the effect on flexural strength in terms of concrete bond through it type of crack has been observed from the study.

Keywords: *modeling flexural strength, pavement silica and water cement ratios*

INTRODUCTION

Cement and aggregates, which are the most indispensable constituents used in concrete production are also vitae materials needed for the construction industry. Recently, there have been successful applications of using local waste materials as a partial replacement for cement or aggregates in manufacturing concrete products in some parts of the world. Numerous researches on application of waste tyres as fine and coarse aggregates are available in the literature (Eldin and Senouci, 1993; Topcu, 1995; Toutanji, 1996; Khatib and Bayomy, 1999; Ling, 2011; Ohemeng and Yalley, 2013 Eric et al 2014 ode 2004; Ode and Eluozo 2016a), which demonstrated the feasibility of using gargantuan amounts of waste tyre in concrete products. Among the waste materials, plastic is one of the most common environmental issues in the contemporary world. Disposal of these plastics is considered to be a big challenge due to its non-biodegradable nature. Choi et al. (2005) investigated the effect of waste PET bottles aggregate on properties of concrete. The waste plastic could reduce the weight by 2 – 6% of normal weight concrete. Marzouk et al. (2007) studied the use of consumed plastic bottle as sand replacement and was noticed that the density lowered when the PET aggregate exceeded 50% by volume of sand. Suganthy et al. (2013) also mentioned a decreased in weight of concrete as the plastic content increased (Ode and Eluozo 2016b). It was noticed that there was linear relationship between decrease in weight and increase in plastic content. The test results showed lower compressive strength of the mix made with plastic than the reference mixture without plastic. Choi et al. (2005) also noticed a reduction in both compressive strength and splitting tensile strength (Eric et al 2014). Marzouk (2007) further reported a reduction of compressive strength in plastic concrete when the sand was replaced by plastic.

Al-Manasser and Dalal (1997) again studied the effect of plastic on concrete mix. It was noticed that the splitting tensile strength decreased as the plastic content increased. Batayneh et al. (2007) also reported that the splitting tensile strength and the flexural strength of concrete mix slumped as the plastic content went up. Several authors have also reported on the strengths of plastic concrete. It is observed that increase in plastic aggregate content reduces the strengths of plastic concrete. Batayneh et al. (2007) mentioned that the incorporation of ground plastic in concrete had effect on its compressive strength Ode and Eluozo 2016cOde and Eluozo 2016d.Naik et al. (1996) investigated the effect of post-consumer waste plastic in concrete as a soft filer(Ode and Eluozo 2016e,Ode and Eluozo 2016f).

THEORETICAL BACKGROUND

Nomenclature

α = water cement Ratios

β = Compressive Strength

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

Φ^2 = Cementious Materials/Additive's

B_y = Concrete slump

Y = Curing Age

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

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

$$C_d^{-n}\frac{d\beta}{dy} + A_{(y)}C_d^{1-n} = B_{(y)} \ldots \quad \ldots\ldots\ldots\ldots \quad (2)$$

Let $\alpha = C_d^{1-n}$

$$\frac{d\beta}{dy} = (1-n)C_d^{-n}\frac{d\beta}{dy}$$

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

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

Let $\frac{2}{2-\alpha} = \phi^2$

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

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

FLEXURAL AND TENSILE STRENGTH

Concrete has relatively high compressive strength in the range of 10 to 50 Nmm^2 and 60 to 120 Nmm^2 for high strength concrete. Tensile strength significantly low constitutes about 10% of the compressive strength (Neville & Brooks, 1996; Popovics, 1998).

Flexural test is done to find out the tensile strength of concrete. A typical set up recommended by British Standard is illustrated in Figure 3.2.

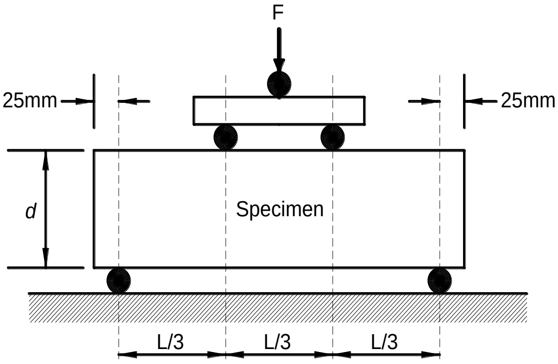

Fig3.2 Flexural Beam Test Set-ups

From Mechanics of Materials and analysis of Figure 3.2, maximum tensile stress is expected to occur at the bottom of the constant moment region within which pure bending occurs. The modulus of rapture can be calculated as:

$$f_{tb} = \frac{FL}{bd^2}$$

Where L=Span of specimen beam

F=maximum applied loads

b=breadth of beam

d=depth of beam

Other method used in determining the tensile strength of concrete is the indirect tension test (split cylinder test or Brazilian test, Figure 2.3) BS 1881: Part 117:1983 and ASTM C496-71. As recommended in these standards, the splitting test is done by applying compression loads at a loading rate 0.0112 to 0.0231 MPa/s along two axial lines that are diametrically opposite on a specimen 150 x 300 mm cylinder.

RESULTS AND DISCUSSION

Predictive from Derive model Simulation and Experimental Values of Flexure Strength are in Graphical Presentation and Tables.

Table 1: *Predictive and Experimental of Flexure Strength at Different Curing Age*

Curing Age	Predictive Values for Flexural Strength of Concrete Pavement (W/C of 0.23)	Experimental Values for Flexural Strength of Concrete Pavement (W/C of 0.23)
7	0.661884342	0.658
14	1.323768684	1.316
21	1.985653026	1.974
28	2.647537368	2.632
35	3.30942171	3.29
42	3.971306052	3.948
49	4.633190394	4.606
56	5.295074736	5.264
63	5.956959078	5.922
70	6.61884342	6.58
77	7.280727762	7.238
84	7.942612104	7.896
90	8.50994154	8.46

Table 2: *Predictive and Experimental of Flexure Strength at Different Curing Age*

Curing Age	Predictive Values for Flexural Strength of Concrete Pavement (W/C of 0.30)	Experimental Values for Flexural Strength of Concrete Pavement (W/C of 0.30)
7	0.601713035	0.602
14	1.20342607	1.204
21	1.805139105	1.806
28	2.40685214	2.408
35	3.008565175	3.01
42	3.61027821	3.612
49	4.211991245	4.214
56	4.81370428	4.816
63	5.415417315	5.418
70	6.01713035	6.02
77	6.618843385	6.622
84	7.22055642	7.224
90	7.73631045	7.74

Table 3: *Predictive and Experimental of Flexure Strength at Different Curing Age*

Curing Age	Predictive Values for Flexural Strength of Concrete Pavement (W/C of 0.35)	Experimental Values for Flexural Strength of Concrete Pavement (W/C of 0.35)
7	0.54733532	0.546
14	1.09467064	1.092
21	1.64200596	1.638
28	2.18934128	2.184
35	2.7366766	2.73
42	3.28401192	3.276
49	3.83134724	3.822
56	4.37868256	4.368
63	4.92601788	4.914
70	5.4733532	5.46
77	6.02068852	6.006
84	6.56802384	6.552
90	7.0371684	7.02

Table 4: *Predictive and Experimental of Flexure Strength at Different Curing Age*

Curing Age	Predictive Values for Flexural Strength of Concrete Pavement (W/C of 0.40	Experimental Values for Flexural Strength of Concrete Pavement (W/C of 0.40)
7	0.515754029	0.511
14	1.031508058	1.022
21	1.547262087	1.533
28	2.063016116	2.044
35	2.578770145	2.555
42	3.094524174	3.066
49	3.610278203	3.577
56	4.126032232	4.088
63	4.641786261	4.599
70	5.15754029	5.11
77	5.673294319	5.621
84	6.189048348	6.132
90	6.63112323	6.57

Table 5: *Predictive Values of Compressive Varying at Different Water Cement Ratios*

W/C	0.23	0.23	0.35	0.4
Fcu 7	0.661884342	0.601713035	0.54733532	0.54733532
Fcu 14	1.323768684	1.20342607	1.09467064	1.09467064
Fcu 21	1.985653026	1.805139105	1.64200596	1.64200596
Fcu 28	2.647537368	2.40685214	2.18934128	2.18934128
Fcu 35	3.30942171	3.008565175	2.7366766	2.7366766
Fcu 42	3.971306052	3.61027821	3.28401192	3.28401192
Fcu 49	4.633190394	4.211991245	3.83134724	3.83134724
Fcu 56	5.295074736	4.81370428	4.37868256	4.37868256
Fcu 63	5.956959078	5.415417315	4.92601788	4.92601788
Fcu 70	6.61884342	6.01713035	5.4733532	5.4733532
Fcu 77	7.280727762	6.618843385	6.02068852	6.02068852
Fcu 84	7.942612104	7.22055642	6.56802384	6.56802384
Fcu 90	8.50994154	7.73631045	7.0371684	7.0371684

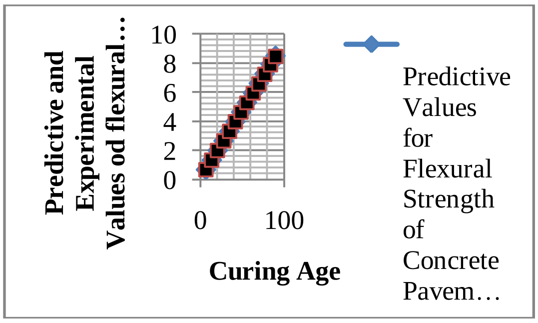

Fig 1: *Predictive and Experimental of Flexure Strength at Different Curing Age*

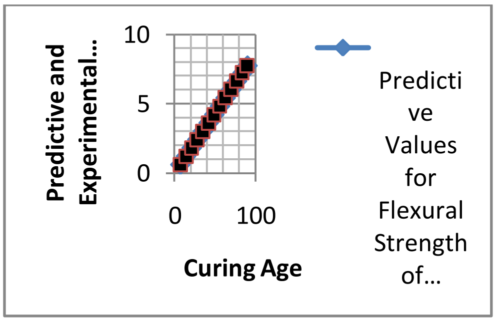

Fig 2: *Predictive and Experimental of Flexure Strength at Different Curing Age*

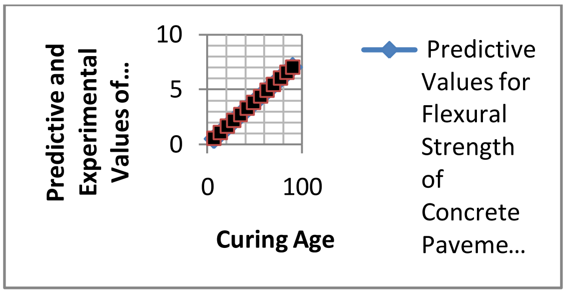

Fig 3: *Predictive and Experimental of Flexure Strength at Different Curing Age*

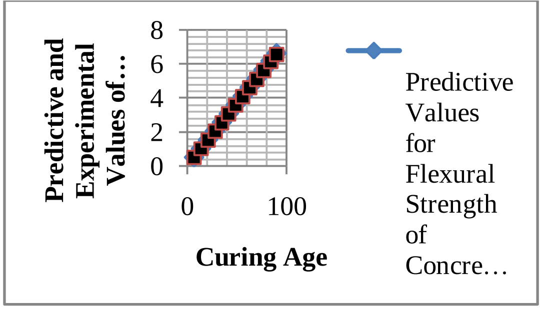

Fig 4. *Predictive and Experimental of Flexure Strength at Different Curing Age*

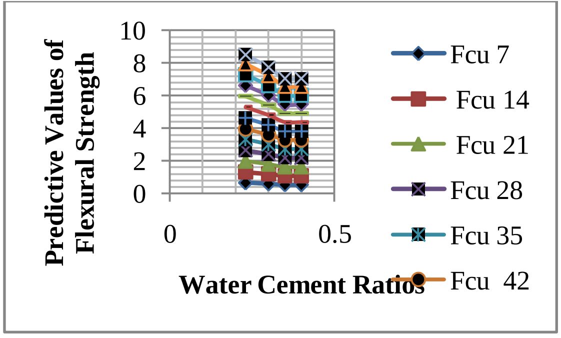

Fig 6. *Predictive Values of Compressive Varying at Different Water Cement Ratios*

figure 1-6 shows that the flexural strength of concrete experienced linear trend to optimum values recorded at ninety days of curing age, the study expression shows the effect on water cement ratios and curing age of the concrete pavement , the trend of flexural strength from this type of aggregates developed strong bond with partial replacement of cement, increase in trend on flexural strength are based on these factors, the aggregate sand filler matrix through the variations of mixed designed determined the variation of flexural strength, increase or decrease in the concrete characteristics such as variation of aggregate and mixed designed are reflected on the flexural strength of the concrete as its expressed on these figures.

The variation of concrete bond from the mixed proportion express different rate of flexural strength, increase in strength in all the figures also reflect uniformity in most aggregate that decrease water absorption permeability and void ratios of the concrete, this condition from flexural relationship with water cement ratios for concrete pavement implies that the mixed designed are still within the required strength that can developed rigid pavement from high strength development. Decrease in flexural strength base on increase in water cement ratios reflect the effect on the flexural strength while decrease in bond of the mechanical properties of the concrete also express similar condition, but the figures still develop flexural strength that determine concrete pavement within high concrete strength. The predictive values trend of flexural strength were compared with experimental values and both parameters developed best correlation.

CONCLUSION

The study shows the relation between flexural strength and water cement ratios, this study were carried to monitor the behavior of flexural strength under the influences of variation of water cement ratios, the trends experienced linear to the optimum flexural strength recorded at ninety days, the flexural strength were observed to reflect on the variation of water cement ratios, the study express variation of flexural strength at different water cement ratios and curing age, concrete characteristics such as aggregate of uniformity gradations are significant impact on concrete bond that determines the rate of flexural strength, such mechanical properties express the developed flexural strength generated from the study, the derived model generated simulation values of flexural strength that represent influenced of aggregate and dosage from partial replacement of cement. This determines increase and decrease of concrete bond. The study also reflects the variation of concrete voids ratios and permeability that affect the variation of flexural strength, predictive values were compared with experimental values and both parameters developed best fits correlations.

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