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Mathematical Model to Predict Split Tensile Strength Durability from Partial Replacement of Silica Fumes and Iron Slag

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ABSTRACT

The identification of coppers slag for partial replacement of concrete with iron slag and silica fume has been conceptualized to reduce industrial waste, this is one ways of reducing environmental pollution challenges facing developing nations, the study find it imperative to apply iron slag and silica fumes to partially replace concrete, this concept were adopted experimentally to monitor the improvement rate of the concrete partially replaced cement with iron slag and silica fume. The applications of iron slag were observed to be more economical if it is applied in construction, thus reduce its rates of waste generation in the environment. The study monitor the partial replacement of cement with iron slag and silica fume applying modeling and simulation, the concept were adopted to thoroughly developed model that can be applied to predict the growth rate of tensile strength, such application were applied varying the parameters in various curing age, the level of growth rates varying different parameters were observed, the influence from void ratios, porosities of concrete were monitored, this were observed in different variations that influence the growth rate of tensile in different curing age, the study is imperative because the developed tensile strength from cement partially replaced with silica fumes and iron slag expressed the level of its economic usefulness in construction industry. The predictive and experimental values developed best fits correlation, this shows that the derived model can be applied to determine other mechanical properties of concrete partially replaced with iron slag and silica fumes.

Keywords: *mathematical model, split tensile strength silica fumes and ion slag*

1INTRODUCTION

Essential constituents applied in concrete generation known to be Cement and aggregates, they are mainly essential materials needed in construction industry. In this latest time, there have been successful applications of local waste materials as a partial replacement for cement or aggregates in developing of concrete products in most parts of the world. numerous researches has used waste tyres as fine and coarse aggregates, availability of these materials has yield results in development of concrete high strength in most recent 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), more so there is some demonstration on the feasibility of applying gargantuan amounts of waste tyre in concrete products. Among the waste materials, plastic is one of the most familiar environmental issues in the contemporary world. Plastics disposal has been considered to be a big challenge due to its non-biodegradable nature. Choi et al. (2005) examine the effect of waste PET bottles including aggregate on properties of concrete. This type of waste plastic could reduce the weight by 2 – 6% of normal weight concrete. Marzouk et al. (2007) studied the application of consumed plastic bottle as sand replacement and observed that the density lowered when the PET aggregate exceeded 50% by volume of sand. Suganthy et al. (2013) also mentioned a reduction in weight of concrete as there an increased on the plastic content (Ode and Eluozo 2016b). It was observed that there was linear relationship between decrease in weight and increase in plastic content. Such study provided commended test results as it showed lower compressive strength of the mix made with plastic compared to the reference mixture without plastic. Choi et al. (2005) there is another also reduction by other experts that carried out both compressive strength and splitting tensile strength (Eric et al 2014). Marzouk (2007) further reported on decrease of compressive strength on plastic concrete when the sand was replaced by plastic has been expressed. 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

$$\frac{dc_d}{dx} + V(y)c_d = \Phi(y)c_d^n \qquad (1.0)$$

Dividing equation (1.0) all through by c_d^n we have

$$c_d^{-n}\frac{dc_d}{dx} + v(x)c_d^{1-n} = \Phi(y) \qquad (1.1)$$

Let

$$P = c_d^{1-n} \qquad (1.2)$$

$$\frac{dp}{dy} = (1-n)c_d^{-n}\frac{dc_d}{dy}$$

$$c_d^{-n}\frac{dc_d}{dy} = \frac{1}{1-n}\frac{dp}{dy} \qquad (1.3)$$

Substituting equation (1.2) and (1.3) into equation (1.1) we have that

$$\frac{1}{1-n}\frac{dp}{dx} + V(y)p = \Phi(y) \qquad (1.4)$$

Integrating both sides we have $\int d\left[e^{V(y)(1-n)y}p\right] =$
$\Phi\ y(1-n)eVy1-nydy$

$$p = \frac{\Phi(y)}{Vu(y)} + Ae^{-Vu(y)(1-n)y} \qquad (1.5)$$

Substituting equation (1.2) into equation (1.13) we have

$$c_d^{1-n} = \frac{\Phi(y)}{Vu(y)} + Ae^{-Vu(y)(1-n)y} \qquad (1.6)$$

Materials and Method

4. Testing machine.5.

Three cylinders (φ150mm & 300mm in height).

6-A jig for aligning concrete cylinder and bearing strips

- 1 Prepare three cylindrical concrete specimens following same steps as test No.32.
- After moulding and curing the specimens for seven days in water, they can be tested.
- Two bearings strips of nominal (1/8 in i.e. 3.175mm) thick plywood, free of imperfections, approximately (25mm) wide, and of length equal to or slightly longer than that of the specimen should be provided for each specimen.
- The bearing strips are placed between the specimen and both upper and lower bearing blocks of the testing machine or between the specimen and the supplemental bars or plates.
- Draw diametric lines an each end of the specimen using a suitable device that will ensure that they are in the same axial plane. Centre one of the plywood strips along the center of the lower bearing block.
- Place the specimen on the plywood strip and align so that the lines marked on the ends of the specimen are vertical and centered over the plywood strip.
- Place a second plywood strip lengthwise on the cylinder, centered on the lines marked on the ends of the cylinder.
- . Apply the load continuously and without shock, at a constant rate within, the range of 689 to 1380 kPa/min splitting tensile, stress until failure of the specimen.

- Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and appearance of fracture.

Observations and Calculations

Calculate the splitting tensile strength of the specimen as follows:

T = 2P/Ld

Where: T: splitting tensile strength, N/mm²P: maximum applied load indicated by testing machine, NL: Length of the specimen, mmd: diameter of the specimen, mm

Results And Discussion

Table1. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.45	Experimental Values of Split Tensile Strength Variation of [W/C of 0.45
7	1.493881233	1.31
14	2.284310235	2.59
28	5.435724892	5.48

Table2. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Compressive Strength Variation of [W/C of 0.40	Experimental Values of Compressive Strength Variation of [W/C of 0.40
7	1.66813519	1.634
14	2.205259203	2.061
28	5.276005986	4.679

Table3. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.40	Experimental Values of Split Tensile Strength Variation of [W/C of 0.40
7	1.502754036	1.493
14	2.323589058	2.291
28	5.476806424	5.357

Table4. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.40	Experimental Values of Split Tensile Strength Variation of [W/C of 0.40
7	1.52704706	1.39
14	2.613438747	2.77
28	5.568151981	5.62

Table5. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.40	Experimental Values of Split Tensile Strength Variation of [W/C of 0.40
7	1.535231551	1.512
14	2.659932976	2.576
28	5.610863384	5.292

Table6. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.45	Experimental Values of Split Tensile Strength Variation of [W/C of 0.45
7	1.52704706	1.42
14	2.721484583	2.81
28	5.707297504	5.69

Table7. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.45	Experimental Values of Split Tensile Strength Variation of [W/C of 0.45
7	1.535231551	1.496

14	2.767978812	2.616
28	5.750008907	5.15

Table8. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.40	Experimental Values of Split Tensile Strength Variation of [W/C of 0.40
7	1.292500268	1.42
14	2.690375296	2.81
28	4.78002856	4.81

Table9. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Split Tensile Strength Variation of [W/C of 0.40	Experimental Values of Split Tensile Strength Variation of [W/C of 0.40
7	1.298935768	1.322
14	2.720678326	2.82
28	4.814866854	5.228

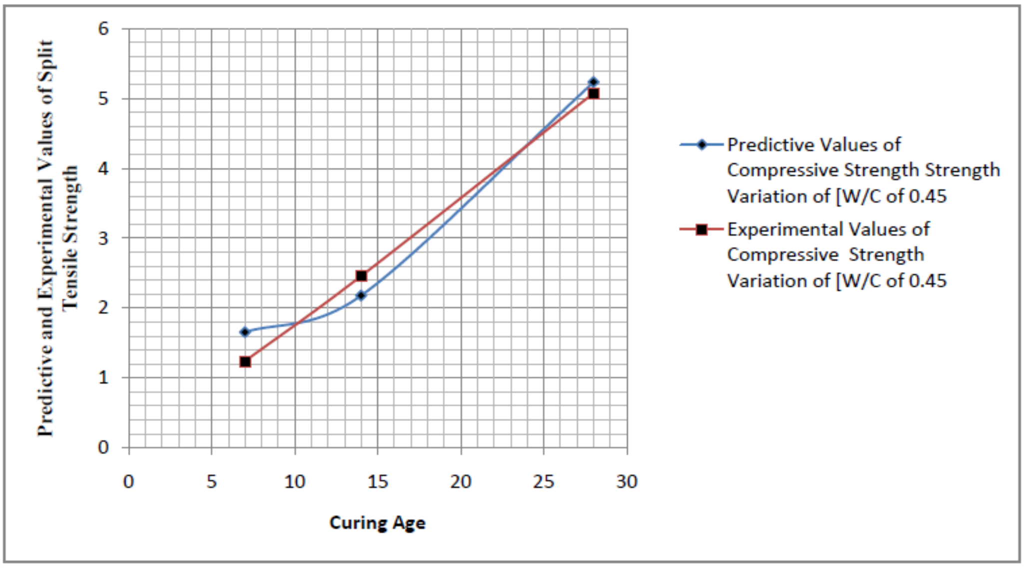

Figure1. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

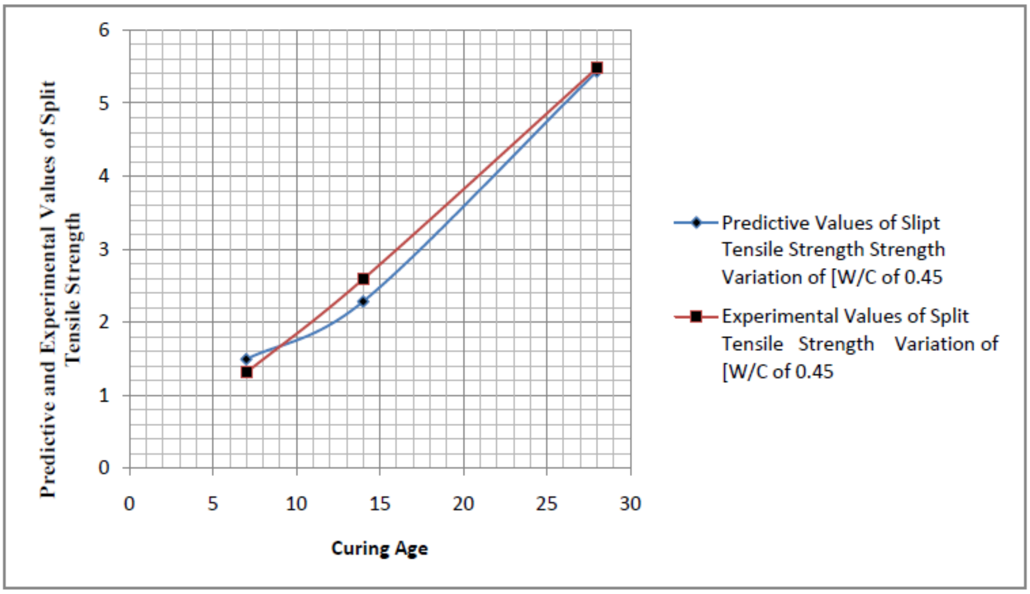

Figure2. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

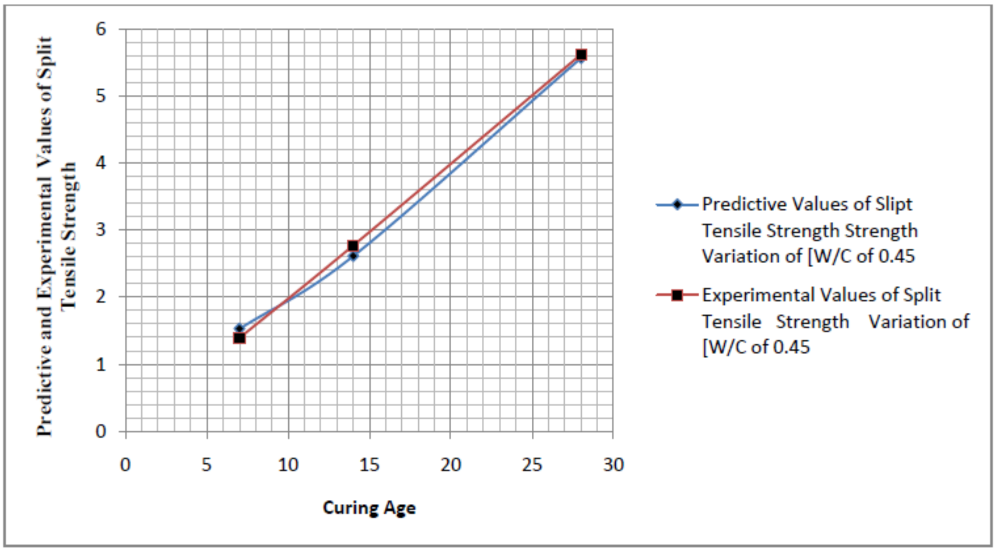

Figure3. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

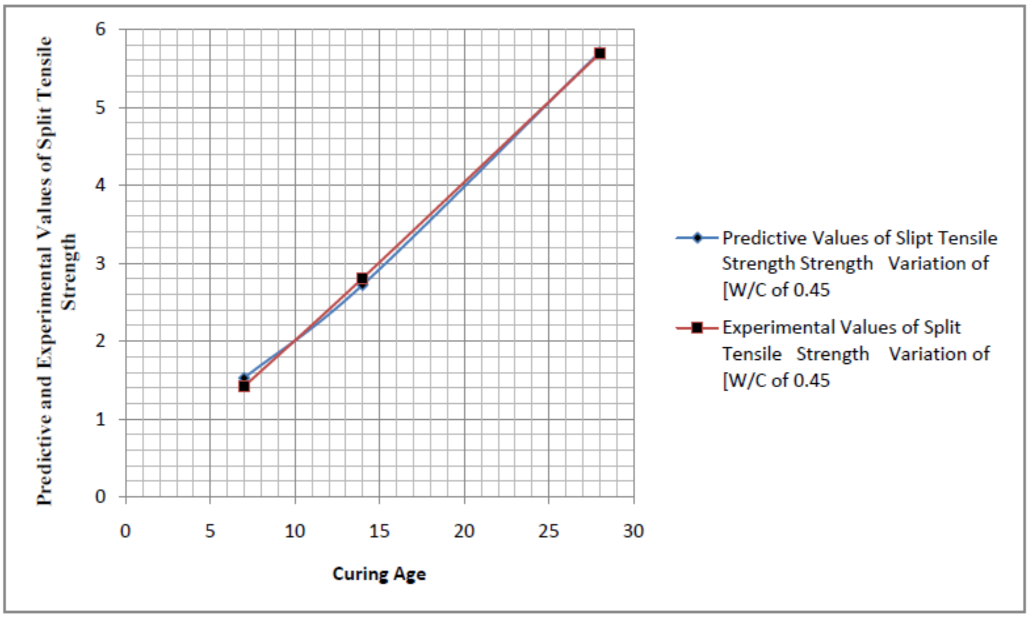

Figure4. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

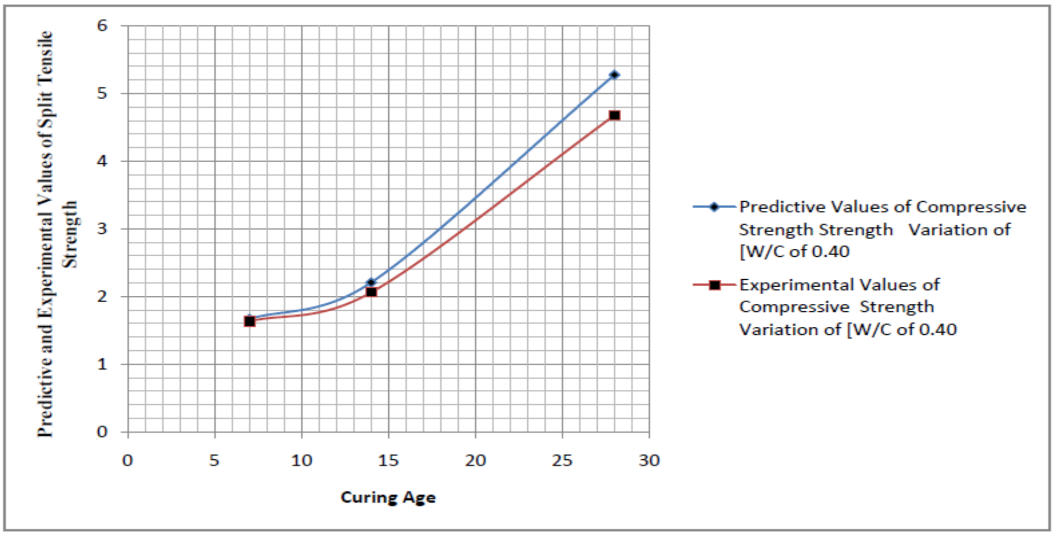

Figure5. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

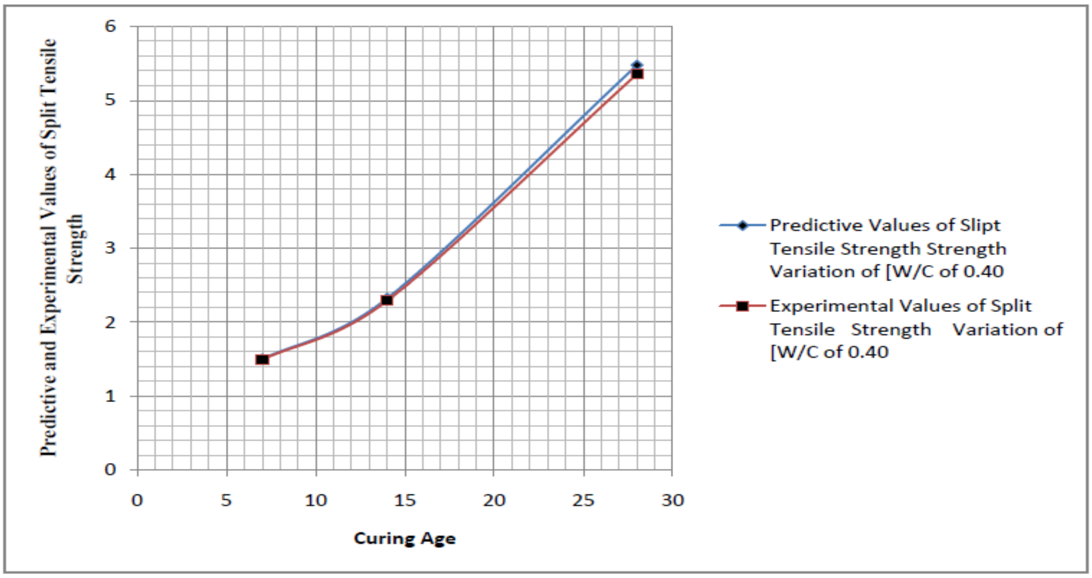

Figure6. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

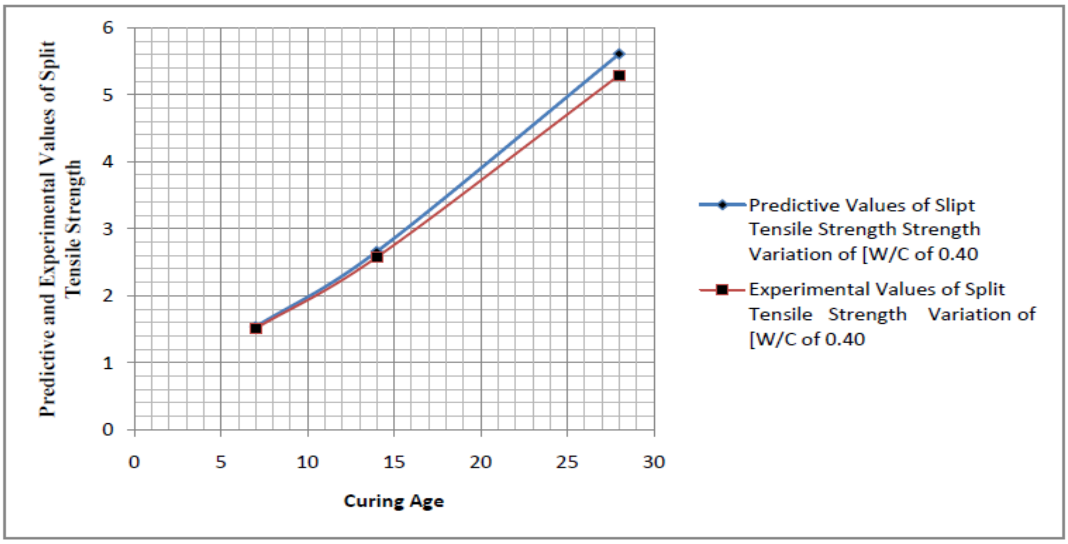

Figure7. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

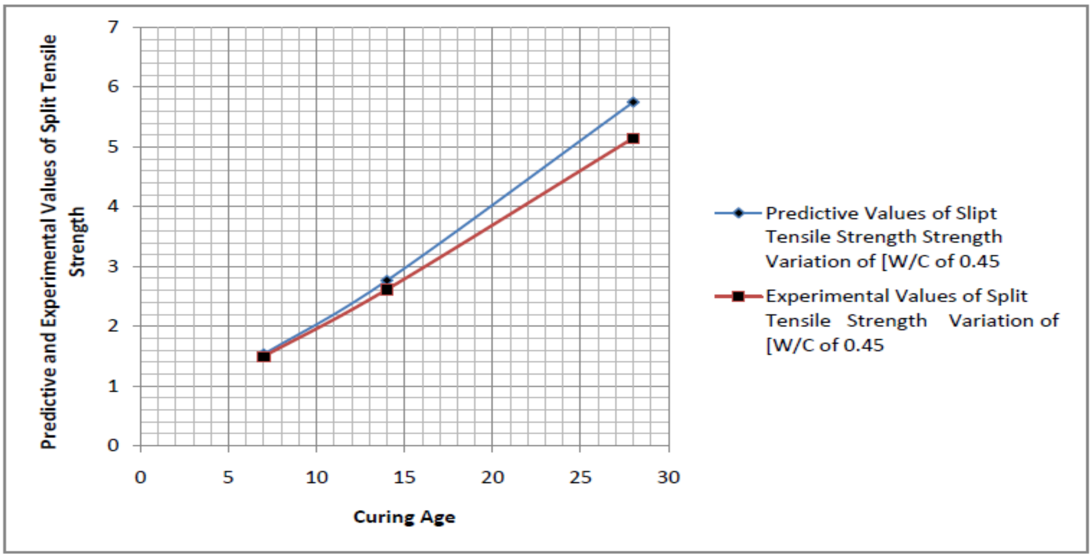

Figure8. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

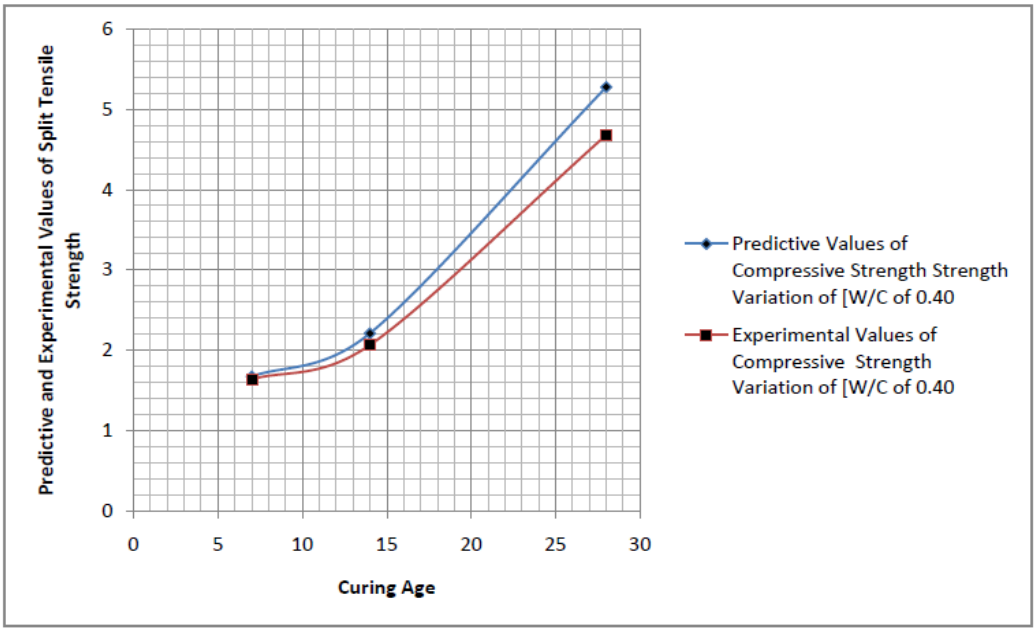

Figure9. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

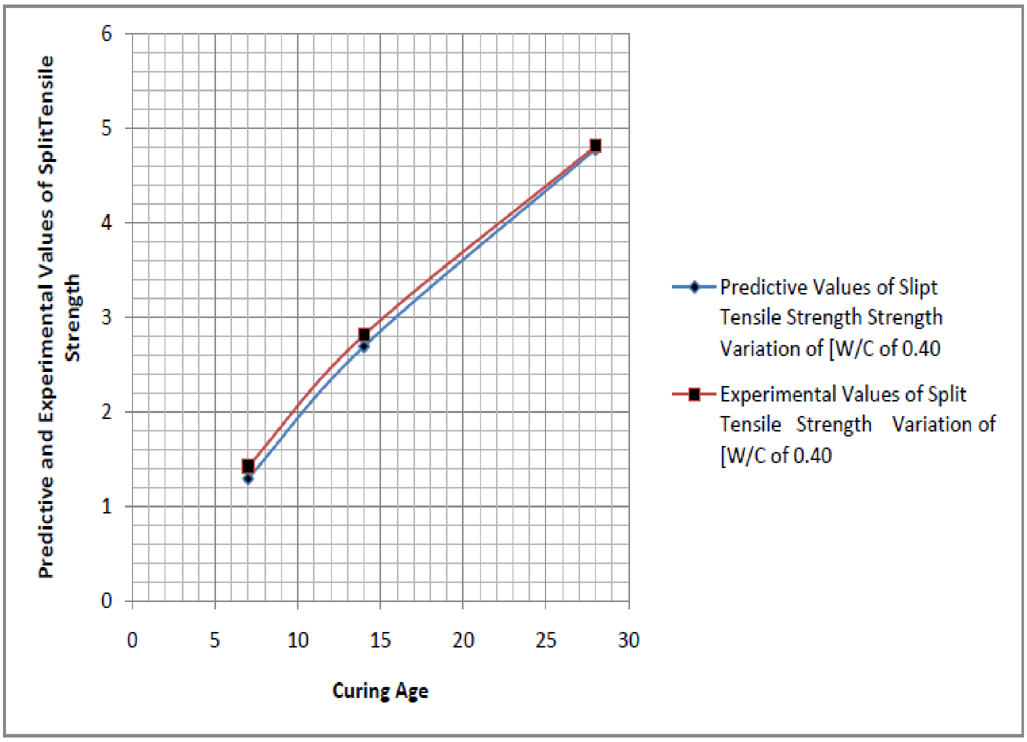

Figure10. *Predictive and Experimental Values of Split Tensile Strength at Different Curing Age*

Figure 1-10 experienced various growth rate at different mixed in the study, the growth rate experience similarities in its level tensile strength through the basic and significant properties, it is observed that in concrete structures, it has greatly influence the extent and size of cracks, because it is very weak in tension due to its brittle in nature. Concrete structure experience high rate of vulnerability to tensile cracking, it also observed that it is due to applications of all types of load itself, although it is very low compared to its compressive strength, figure 5 and 7 obtained the highest tensile just as it agrees with the experimental application by Parthi et al 2018, where the predictive at the optimum level is **5.568151981 against 5.62, 5.707297504 against 5, 69** experimental values, the derived model validated are in agreement with Parthi et al 2018 it is observed that the split tensile strength experienced gradual increase within m Mix 1 to Mix 3 for 0.7%. While that of Mix 4 has a lesser strength of 0.25% when compared to conventional concrete for 28 days curing. The study of Parthi et al 2018 experimentally developed the tensile strength with partial replacing of concrete with silica fumes and iron slag, the result has expressed the behaviour of the material in tensile condition, this implies that the derived model simulation values thoroughly expressed the behaviour of other properties of concrete that was not considered in the system, this application was able to monitor other internal parameters that are influential to concrete mixed for its mechanical properties in the designed mixed. The study has expressed these parameters effect that was not monitored in the experimental process. The application of the system detailed the significant of the derived solution as it predicts the influences of the other parameters, these are stress- strain and concrete void including porosity. The figures express best fits correlation with all the experimental values from (Parthi et al 2018).

Conclusion

The study has detailed the behaviour of the system in terms of the progressive rate of the tensile in different curing age, the application of silica fume and iron slag as partial replacement for cement has express the significant of the material from it tensile state, the experimental values that validated the predictive parameters has shows its level of development at different dosage of the substance partially replacing cement., the growth rate of tensile from the predictive values shows the influence from other concrete properties such as the T flow slump, porosities and void ratios of the concrete, the variation of these parameters were not monitored in the experimental process of the designed model concrete, but the system applying modeling and simulation has provided the platform to express detailed variables that its variations of the parameters inside the system will definitely affect the increase and decrease of the tensile strength. further studies from this dimensions is imperative because the application of modeling techniques has been developed to monitor the performance of this materials in all its mechanical properties, the behaviour of the material were express in the predictive model just like that of the experimental values carried out by Parthi et al 2018, the developed model also observed that The Mix 4 has a lesser strength of 0.25% compared to conventional concrete for 28 days curing Parthi et al 2018,.

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