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Modeling Tensile Strength of Concrete with Partial Replacement of Fine and Coarse Aggregates with Steel and Copper Slags

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ABSTRACT

This paper predicts the effect on steel slag and copper slag on the tensile strength of concrete, the study definitely express rate of the tensile growth based on the dosage of these material that partially replaced cement in different curing age, the application of modeling and simulation monitors the concrete properties that reflected it influence on the growth rate of the tensile strength, the ratio of water to the weight of cement at partial condition in the concrete mix are one of the factor for gaining strength development to generate the required tensile of the material. More so it is noted in the study that tensile ratio decrease with increase in porosity, these were monitored on the simulation by varying the concrete porosity, rapid growth rate from seven to fourteen days of curing were based on the workability of the concrete that generate the tensile within seven and fourteen, while at twenty eight days the tensile strength maintained gradual increase to the optimum values, that is why the behaviour of the concrete in this dimensions was monitored, the output from the concrete mixed design were monitored considering several factors, such as quality of raw materials, water/cement ratio, coarse/fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete, these factors were considered in the simulation of the tensile strength, but were not considered in experimental processed of the concrete grade, the study through simulation developed models that can consider various behaviour of concrete parameters to determined the minimum and maximum effect on tensile strength or any other properties of concrete.

Keywords: *Modeling, tensile Strength, coarse Aggregate, Fine Aggregate, Steel Slag and Copper Slag,*

INTRODUCTION

Waste production that has been investigate to replace cement that can increase compressive strength has been examined, these addictive has been developed tremendous increase in concrete mechanical properties, the mixed designed determine the grade of concrete that will be generated, the construction industries has swing action to monitor the variation growth rate of concrete, this concept has converted some waste product from waste to wealth thus economic values in the environment, this research has improved strength development at different grades, the application of these material as partial replacement for cement has definitely reduced the quantity of cement, the growth rate of hydration of cement, the consequences on the relative moisture in the pores of the hardening cement paste experience reduction and the paste shrinks. The Correlations from Experimental values were observed between relative humidity that decrease and autogenous shrinkage (Jensen & Hansen 1996), Though autogenous shrinkage observed increases for several months (Baroghel-Bouny & Kheirbek 2000 Ode 2004, Ode and Eluozo 2015; Ode and Eluozo 2016a; Ode and Eluozo 2016b), the leading part of the deformations include stresses which take place mostly the first hours after setting, when the strain capacity is lowest (Kasai & Okamura 1968 Golterman 1994 Tazawa et al. 2000 Ode and Eluozo 2016c Ode and Eluozo 2016d) more so the elastic modulus have experienced some reached substantial values. The degree and growth in time of autogenous shrinkage is basically iaffected by the w/c ratio. Baroghel-Bouny and Kheirbek (2000) observed that increase in shrinkage on cement pastes with a decrease of the w/c ratio.

Comparable results were experiences on concrete (Persson 1998, Tazawa et al. 2000 Ode and Eluozo 2016e). A little author have examined the influenced of different curing temperatures on autogenous shrinkage of concrete (Tazawa et al.

1995, Bjøntegaard 1999, Hedlund&Jonasson 2000, Lura et al. 2001 Ode and Eluozo 2016f).

Theoretical Background

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

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

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

Let

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

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

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

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

$$\int d\left[e^{V(y)(1-n)y}p\right] = \Phi\,(y)(1-n)\int e^{V(y)(1-n)y}dy$$

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

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 Method

Apparatus Required Tensile Strength

- Weights and weighing device.
- Tools, containers and pans for carrying materials & mixing.
- A circular cross-sectional rod (φl6mm & 600mm length).
- Testing machine.
- Three cylinders (φ150mm), & (300mm in height).
- A jig for aligning concrete cylinder and bearing strips

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 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 Centre 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 Value of Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Tensile Strength [100%, CA]	Experimental Values of Tensile Strength Variation [100%, CA]
7	2.178360835	2.16
14	3.138982721	3.11
28	3.221799349	3.42

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

Curing Age	Predictive Values of Tensile Strength 90 % CA + 10% steel slag	Experimental Values of Tensile Strength Variation [90 % CA + 10% steel slag]
7	2.418700365	2.43
14	3.664298541	3.69
28	4.16440511	4.18

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

Curing Age	Predictive Values of Tensile Strength 80% CA + 20 % steel slag	Experimental Values of Tensile Strength Variation 80% CA + 20 % steel slag
7	2.525344425	2.55
14	3.992475468	3.9
28	4.223916167	4.32

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

Curing Age	Predictive Values of Tensile Strength slag 70% CA + 30% steel slag	Experimental Values of Tensile Strength Variation 70% CA + 30% steel slag
7	2.537007223	2.5
14	3.169335577	3.2
28	3.605436483	3.64

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

Curing Age	Predictive Values of Tensile Strength 60% CA + 40 % steel slag	Experimental Values of Tensile Strength Variation 60% CA + 40 % steel slag
7	2.420207345	2.44
14	2.869934515	2.84
28	3.067167762	3.07

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

Curing Age	Predictive Values of Tensile Strength [100%, CA]	Experimental Values of Tensile Strength Variation [100%, CA]
7	**2.178360835**	**2.16**
14	**3.138982721**	**3.11**
28	**3.221799349**	**3.42**

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

Curing Age	Predictive Values of Tensile Strength 90 % CA + 10% steel slag	Experimental Values of Tensile Strength Variation [90 % CA + 10% steel slag]
7	2.402295769	2.41
14	3.296416029	3.25
28	3.642715736	3.67

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

Curing Age	Predictive Values of Tensile Strength 80% FA+ 20 % copper slag	Experimental Values of Tensile Strength Variation 80% FA+ 20 % copper slag
7	2.614034263	2.64
14	3.723602051	3.72
28	4.124464316	4.1

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

Curing Age	Predictive Values of Tensile Strength 70% FA+ 30% copper slag	Experimental Values of Tensile Strength Variation 70% FA+ 30% copper slag
7	2.816006922	2.8
14	3.953687129	3.98
28	4.410571254	4.42

Table10. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

Curing Age	Predictive Values of Tensile Strength 60% FA + 40 % copper slag	Experimental Values of Tensile Strength Variation 60% FA + 40 % copper slag
7	2.423758592	2.43
14	3.104553343	3.12
28	3.51306969	3.51

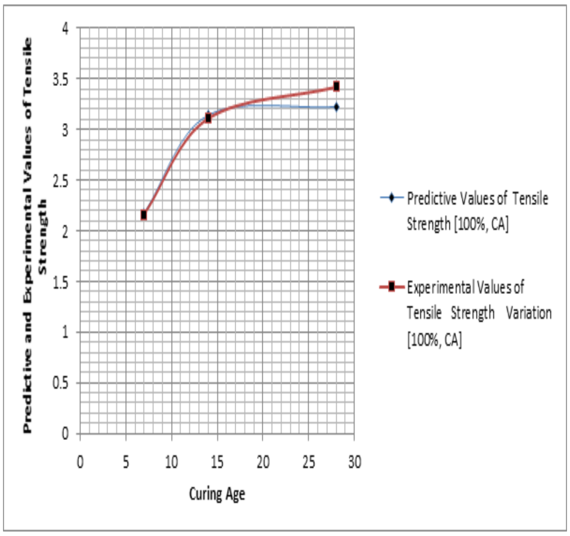

Figure1. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

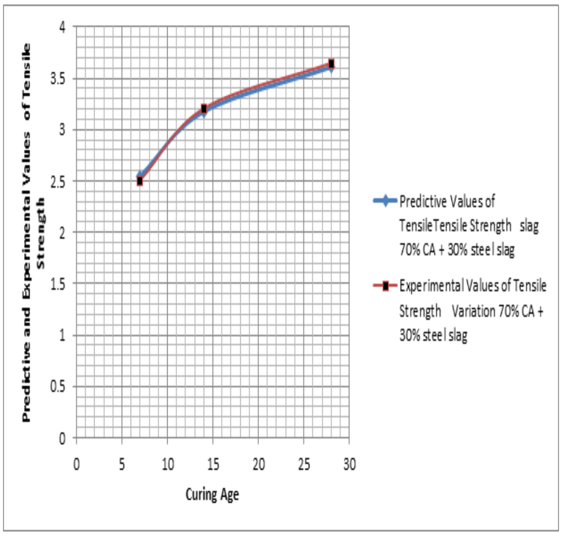

Figure4. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

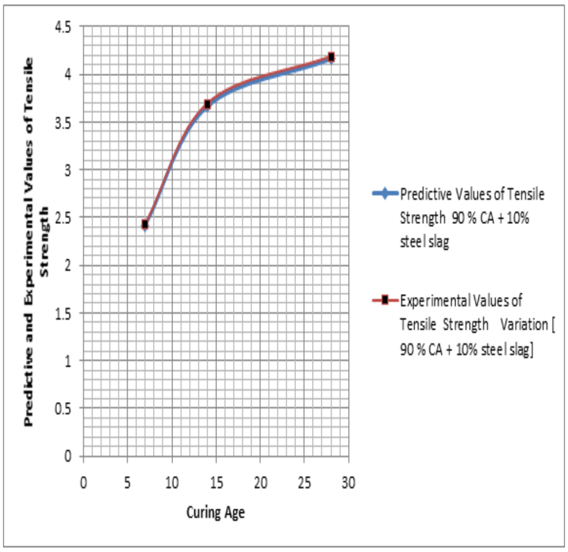

Figure2. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

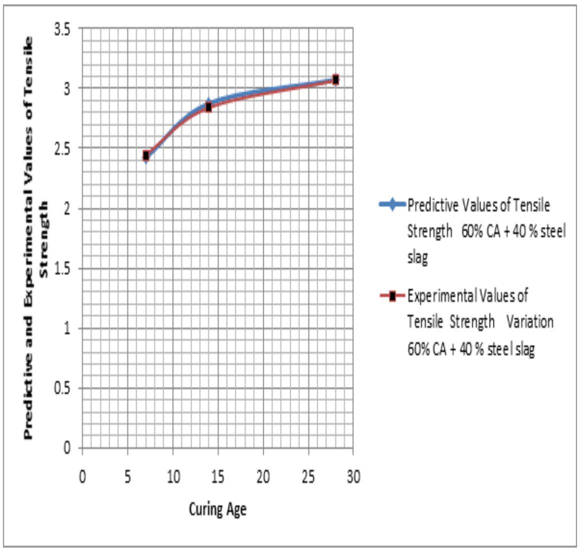

Figure5. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

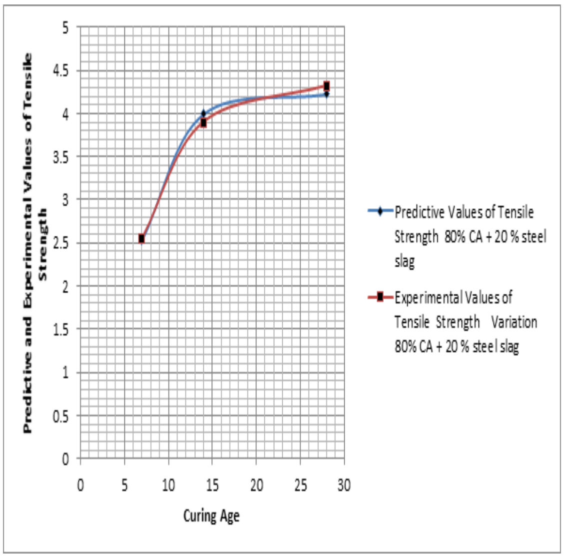

Figure3. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

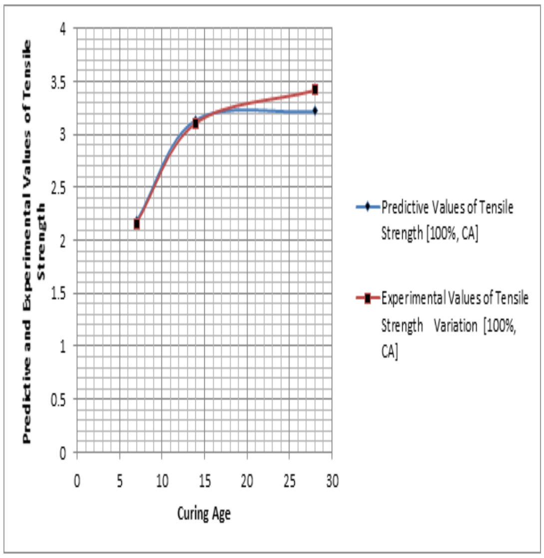

Figure6. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

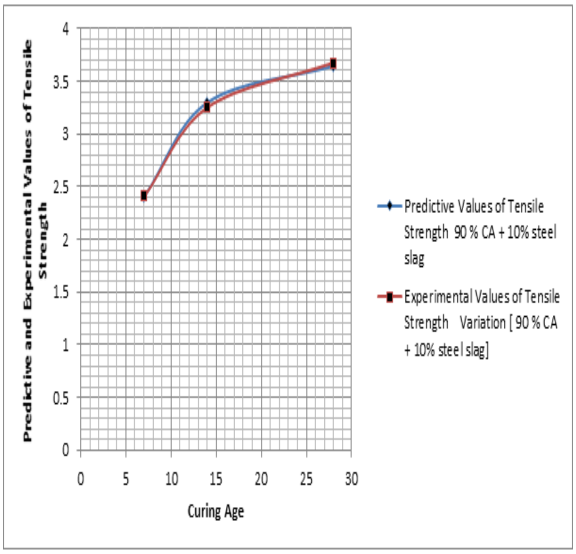

Figure7. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

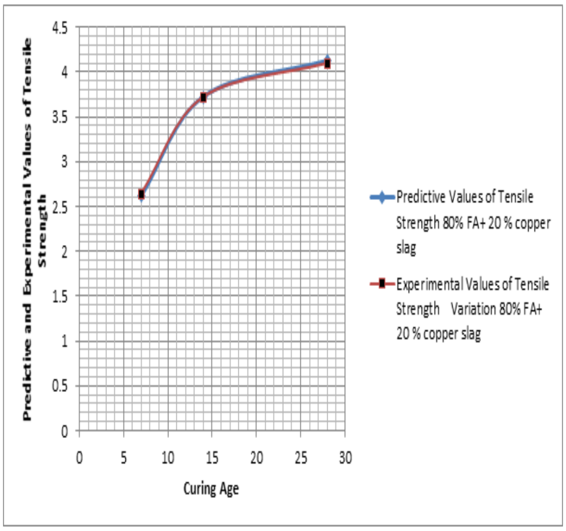

Figure8. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

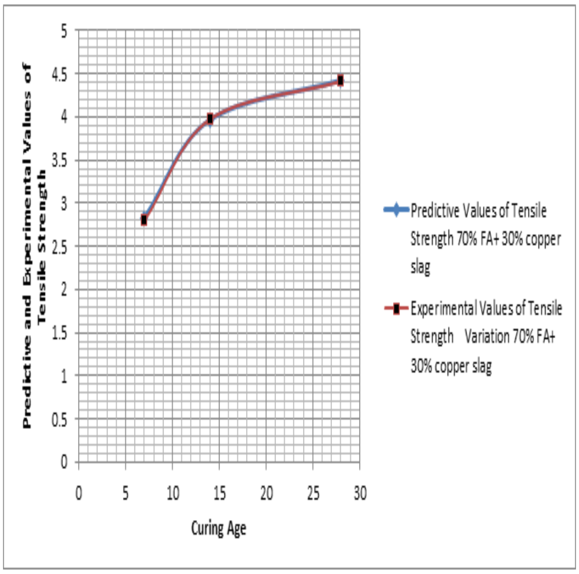

Figure9. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

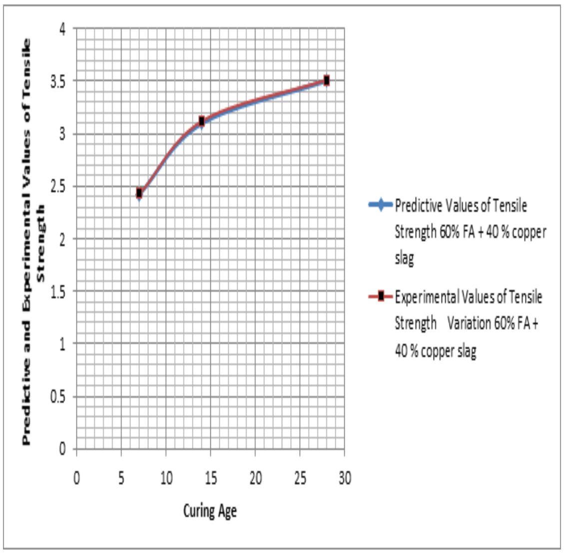

Figure10. *Predictive and Experimental Value of Tensile Strength at Different Curing Age*

Figure from 1-10 explained the trend of the tensile reflecting the model concrete that generated the tensile materials, since Tensile strength is an significant property of concrete due it ability on concrete structures, it is observed that it is to highly vulnerable to tensile cracking, because various type affects its applied loading itself. More so, tensile strength of concrete developed lower strength compared to its compressive strength. Tensile strength of concrete experienced an increased by increasing its compressive strength, because tensile strength is proportional to square root of compressive strength. Concrete formation is a material that is an addition of steel or glass fibers to the concrete mix. These materials will definitely have the most beneficial effect on tensile strength. The application of steel slag and copper slag from these materials also increase the tensile when the compressive strength experience an increase from the materials, the figures were influenced from the addictives to increase the required strength for the study, furthermore, since compressive/tensile strength ratio decreases with increase porosity. The compressive, flexural and splitting tensile strength of cement mortar has been measured and interpreted in terms of its porosity. The ratio decreases with increase porosity values of cement mortar. The reduction in water/cement ratio leads to an increase in strength of concrete. Therefore, for a given workability an increase in the cement content results in an increase in strength of concrete. The behaviour of the concrete formation reflects the rate of the tensile in terms of porosity fluctuation that is observed in tensile strength, this implies that the porosity deposited in concrete structure must be very low to increase the compressive /tensile of the concrete grade, therefore the behaviour of tensile in the trend also maintained the reflection of this model concrete grade. The application of derived model generated predictive values that were subjected to validation on the experimental study by Jayanth et al 2017 and both parameters developed best fits correlation.

CONCLUSION

The study has express the reflection of concrete properties on tensile strength, the behaviour on steel slag and copper slag were expressed on the mixed proportion through the mixed design, the tensile experienced rapid growth rate from seven to fourteen days of curing and observed slight increase on the twenty eight days of curing, the behaviour of the material observed are based on the concrete grades and the dosage of the addictives. Since the Tensile strength of concrete experience increased by increasing its compressive strength, it implies that every concrete property must exhibit effect on the concrete model, because tensile strength is proportional to square root of compressive strength. This implies that addition of steel or glass fibers to the concrete mix will have the most beneficial effect on tensile strength. Similar condition were observed in addition of steel slag and copper slag, the improvement of strength development reflected on the tensile at different dosage of the concrete grades, The tensile strength of a metal is essentially based on its ability to withstand tensile loads without failure. Ductility, on the other hand, measures a material's ability to deform under tensile stresses. This is an important factor in metal forming processes since brittle metals are more likely to rupture. The behaviour of variation of concrete porosities and voids were examined in the study. The decrease in water/cement ratio will definitely leads to an increase in strength of concrete. Therefore, for a given workability of an increase in the cement content results in an increase in strength of concrete. The behaviour of the concrete in this dimensions were monitored, the output from the concrete mixed design were affected by several factors, such as quality of raw materials, water/cement ratio, coarse/fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete, these factor were considered in the simulation of the tensile strength, but were not considered in experimental processed of the concrete grade, the study through modeling and simulation developed models that can consider various behaviour of concrete parameters to determine the minimum and maximum effect on tensile strength or any other properties of concrete.

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