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ARTICLE

Modeling and Simulation of Wood and Fly Ash Behaviour as Partial Replacement for Cement on Flexural Strength of Self Compacting Concrete

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ABSTRACT

Flexural strength was monitored and predicted on the application improving concrete strength with wood and fly as partial replacement for cement. The study observed the pressure from the constituent of these locally sourced material that has been observed from the study to influence the flexural strength through the effect from this locally sourced addictives. The study monitors concrete porosity on heterogeneity as it reflect on the flexural strength of self compacting concrete. Other condition considered was the compaction and placement of concrete. These effects were monitored at constant water cement ratio from design mix. The behaviour from this effects on the concrete observed the rate of flexural growth under the influences of these stated conditions. The simulation expressed the reactions of these effects through these parameters monitored to influence the system. Numerical simulations were also applied to the optimum curing age of twenty eight days, while analytical simulation was also applied. This concept is the conventional seven days interval that concrete curing were observed, these are improvement done on the study carried out by experts [16]. These locally sourced material were experimentally applied. The simulation predictive values are at the interval of seven days of curing, which was also simulated. The predictive values were compared with the experimental values of the researchers [16], and both values developed best fits correlations. The study is imperative because the system considered the parameters used on experimental and observed other influential variables that were not examined. These were not observed in the experimental procedure. Experts in concrete engineering will definitely find these concept a better option in monitoring flexural strength of self compacting concrete in general.

1. Introduction

There has been the exhibition of mechanical properties on High-Strength Concrete (HSC), two groups on these properties can be separated as short terms, known to be mechanical properties, and long-term mechanical properties. The stress strain from concrete on HSC are fundamentals that determine design model, it also includes the

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behaviour of the materials parameters, aggregates type are included through experimental values such as curing age at testing, the strain rate includes other level of interaction between the specimen and testing machine. The stress-strain model that is applied for NSC cannot be lengthy when it applied for HSC; it is observed from basis of loading curve that will definitely change it significantly [12,13,14,15]. Researchers through studies carried out have express the rising of steeper that observed sudden drop in strength after attaining a maximum value; this concept was developed from present numerical modeling on concrete stress-strain behaviour of HSC. [1,2,3] The study has recommended that HSC performs like a real composite material; it's also equivalents of stress-strain that can be drawn to the applied developed concept in rock mechanic [5,6,7]. [9] observed that it is observed to experienced less internal microcracking in HSC. This implies that it is more than that of NSC for the same axial strain imposed. It has been observed that HSC experience a smaller amount lateral strain, and consequently it has a level of efficiency internment on compressive strength. HSC is limited compared to that of NSC. Water cement ratios reduction [w/c] experienced increases the strength of concrete using locally 3/8 all-one aggregate [10]. Nevertheless, hydrated cement strength is low if it is associated with the strength of coarse aggregates. The Comparison carried out between it very important that strength and quality of coarse aggregates should increase, more so together with other factors. Typically, w/c ratios between 0.2- 0.4 are applied for HSC. Meanwhile it is observed that Low w/c ratio decreases its workability. [12,14,15,16] evaluates the influence of silica fume on strength development of HSC coring age between 7 to 28 days after mixing. Compressive strength measured on HSC is determined based on testing variables, which includes mold type, specimen size, end conditions and strain rate. 4×8 in. (102×204 mm), it also involves cylinder specimens that have been shown to generate (ACI, 2010). ACI-318 (ACI, 2011), it also defines the secant modulus of elasticity based on the ratio of stress and strain at 40% of the compressive strength. As strength of concrete experience increases, its modulus of elasticity also observed an increases, while Poisson's ratio is not affected by compressive strength, this could be through curing method age of concrete [5,6,8,10,12].

2. Theoretical Background

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

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

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

Let

$$\text{P}=c_d^{1-n}. \tag{1.2}$$

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

$$c_d^{-n}\frac{d_{c_d}}{dy}=\frac{1}{1-n}\frac{dp}{dy}. \tag{1.3}$$

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

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

tegrating both sides we have

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

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

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

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

3. Materials and Method

3.1 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 1.

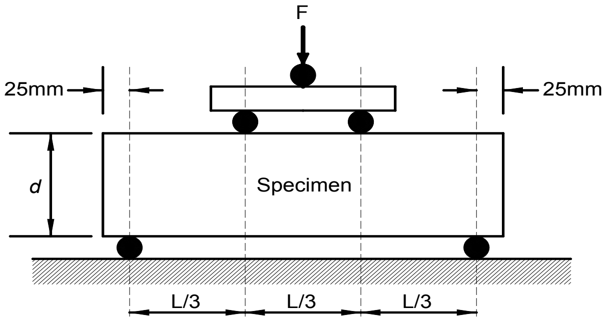

Figure 1. Flexural Beam Test Set-ups

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From mechanics of materials and analysis of Figure 1, 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:

$$f_{tb} = \frac{FL}{bd^2} \tag{3.1}$$

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) 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.

4. 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 Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength	Experimental Values of Flexural Strength
7	7.290147108	7.203
8	7.304122385	7.226
9	7.318276351	7.249
10	7.33261129	7.272
11	7.347129516	7.295
12	7.361833373	7.318
13	7.376725235	7.341
14	7.391807504	7.364
15	7.407082616	7.387
16	7.422553037	7.41
17	7.438221263	7.433
18	7.454089823	7.456
19	7.47016128	7.479
20	7.486438228	7.502
21	7.502923293	7.525
22	7.519619138	7.548
23	7.536528456	7.571
24	7.553653977	7.594
25	7.570998467	7.617
26	7.588564724	7.64
27	7.606355584	7.663
28	7.624373919	7.686

Table 2. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength[W/C-0.35]	Experimental Values of Flexural Strength [W/C-0.35
7	7.009346574	6.999
8	7.02154282	7.012
9	7.033876586	7.025
10	7.046349423	7.038
11	7.058962898	7.051
12	7.071718598	7.064
13	7.084618126	7.077
14	7.097663104	7.09
15	7.110855171	7.103
16	7.124195987	7.116
17	7.137687229	7.129
18	7.151330593	7.142
19	7.165127793	7.155
20	7.179080565	7.168
21	7.193190663	7.181
22	7.207459861	7.194
23	7.221889953	7.207
24	7.236482752	7.22
25	7.251240094	7.233
26	7.266163834	7.246
27	7.281255848	7.259
28	7.296518033	7.272

Table 3. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength	Experimental Values of Flexural Strength
7	7.025133782	7.525
14	7.992358786	7.952
21	8.091346222	8.281
28	8.392420249	8.432

Table 4. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength [W/C-0.35]	Experimental Values of Flexural Strength [W/C-0.35]
7	7.199053635	7.029
14	7.506583612	7.505
21	7.829833947	7.981
28	8.36704706	8.454

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Table 5. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength	Experimental Values of Flexural Strength
7	7.878527419	7.87441
8	7.891488403	7.88676
9	7.904603993	7.89929
10	7.917876033	7.912
11	7.93130639	7.92489
12	7.944896953	7.93796
13	7.958649631	7.95121
14	7.97256636	7.96464
15	7.986649095	7.97825
16	8.000899817	7.99204
17	8.015320531	8.00601
18	8.029913263	8.02016
19	8.044680066	8.03449
20	8.059623015	8.049
21	8.074744214	8.06369
22	8.090045786	8.07856
23	8.105529885	8.09361
24	8.121198687	8.10884
25	8.137054395	8.12425
26	8.15309924	8.13984
27	8.169335477	8.15561
28	8.18576539	8.17156

Table 6. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength [W/C-0.35]	Experimental Values of Flexural Strength [W/C-0.35
7	7.86456235	7.85794
8	7.875352825	7.86784
9	7.886251855	7.87786
10	7.897260532	7.888
11	7.908379959	7.89826
12	7.91961125	7.90864
13	7.930955532	7.91914
14	7.942413939	7.92976
15	7.953987622	7.9405
16	7.965677739	7.95136
17	7.977485461	7.96234
18	7.989411973	7.97344
19	8.001458468	7.98466
20	8.013626154	7.996
21	8.02591625	8.00746
22	8.038329989	8.01904
23	8.050868612	8.03074
24	8.063533378	8.04256
25	8.076325554	8.0545
26	8.089246423	8.06656
27	8.10229728	8.07874
28	8.115479431	8.09104

Table 7. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength	Experimental Values of Flexural Strength
7	7.075858436	7.044
14	7.424520654	7.382
21	8.176343921	8.068
28	8.393106863	8.334

Table 8. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength [W/C-0.35]	Experimental Values of Flexural Strength [W/C-0.35]
7	6.833394616	7.65794
14	7.391165982	7.72976
21	8.337609706	8.00746
28	8.217817623	8.19704

Table 9. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength	Experimental Values of Flexural Strength
7	6.888260628	6.881
8	6.904492123	6.895
9	6.920961562	6.909
10	6.937672434	6.923
11	6.954628276	6.937
12	6.971832682	6.951
13	6.989289294	6.965
14	7.007001809	6.979
15	7.02497398	6.993
16	7.043209612	7.007
17	7.061712568	7.021
18	7.080486766	7.035
19	7.099536182	7.049
20	7.118864852	7.063
21	7.138476869	7.077
22	7.158376387	7.091
23	7.178567619	7.105
24	7.199054843	7.119
25	7.219842398	7.133
26	7.240934686	7.147
27	7.262336175	7.161
28	7.284051397	7.175

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Table 10. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength [W/C-0.35]	Experimental Values of Flexural Strength [W/C-0.35]
7	6.870820879	6.866
8	6.884291658	6.878
9	6.897928946	6.89
10	6.911734801	6.902
11	6.925711307	6.914
12	6.939860574	6.926
13	6.954184736	6.938
14	6.968685956	6.95
15	6.983366423	6.962
16	6.998228351	6.974
17	7.013273984	6.986
18	7.028505593	6.998
19	7.043925476	7.01
20	7.059535961	7.022
21	7.075339404	7.034
22	7.091338189	7.046
23	7.107534731	7.058
24	7.123931476	7.07
25	7.140530896	7.082
26	7.157335499	7.094
27	7.174347819	7.106
28	7.191570424	7.118

Table 11. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength	Experimental Values of Flexural Strength
7	6.239583526	6.237
14	6.613762412	6.447
21	7.815783049	7.574
28	8.341567593	8.366

Table 12. Predictive and Experimental Values of Flexural Strength at Different Curing Age

Curing Age	Predictive Values of Flexural Strength [W/C-0.35]	Experimental Values of Flexural Strength [W/C-0.35]
7	6.219641662	6.223
14	6.568781151	6.318
21	7.761391953	7.449
28	8.328009693	8.315

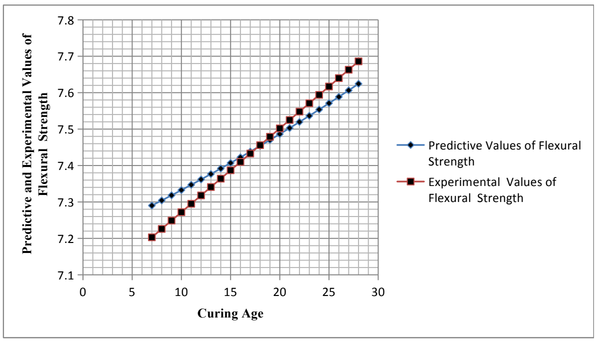

Figure 2. Predictive and Experimental Values of Flexural Strength at Different Curing Age

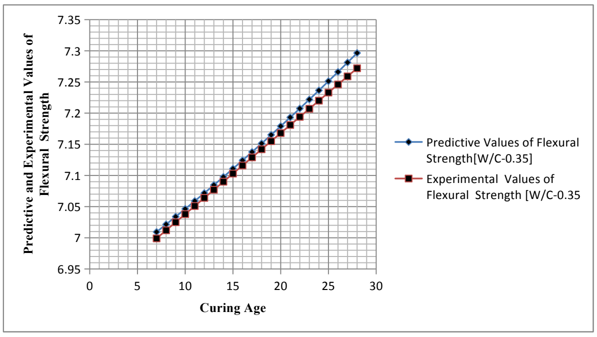

Figure 3. Predictive and Experimental Values of Flexural Strength at Different Curing Age

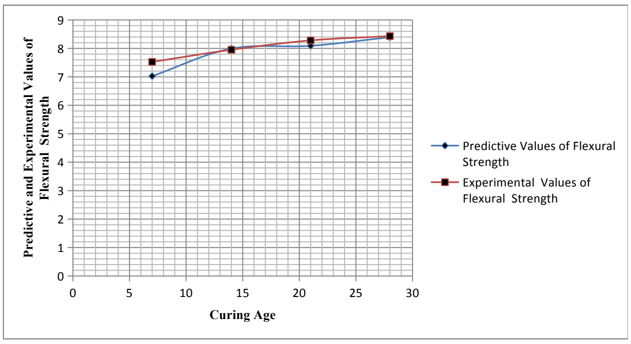

Figure 4. Predictive and Experimental Values of Flexural Strength at Different Curing Age

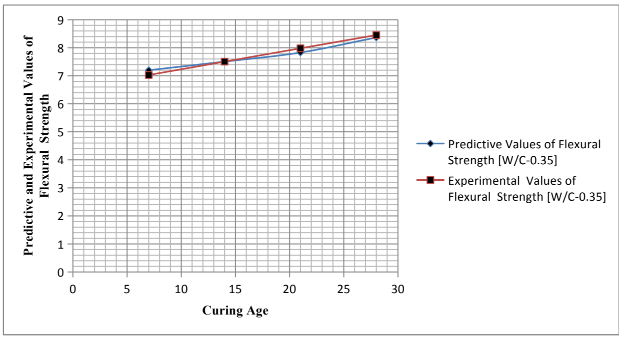

Figure 5. Predictive and Experimental Values of Flexural Strength at Different Curing Age

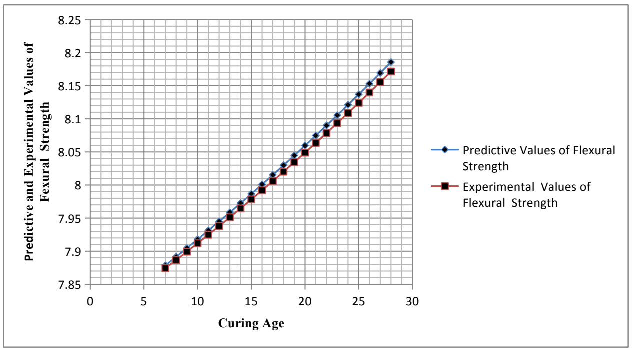

Figure 6. Predictive and Experimental Values of Flexural Strength at Different Curing Age

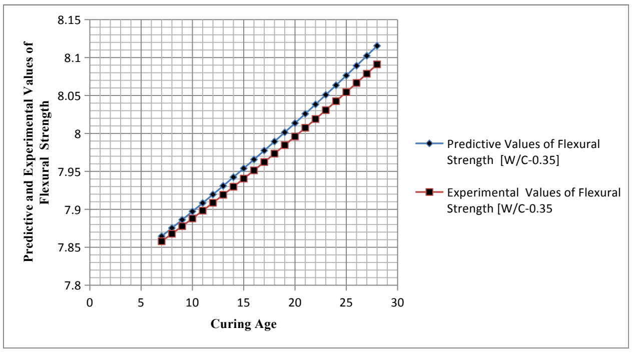

Figure 7. Predictive and Experimental Values of Flexural Strength at Different Curing Age

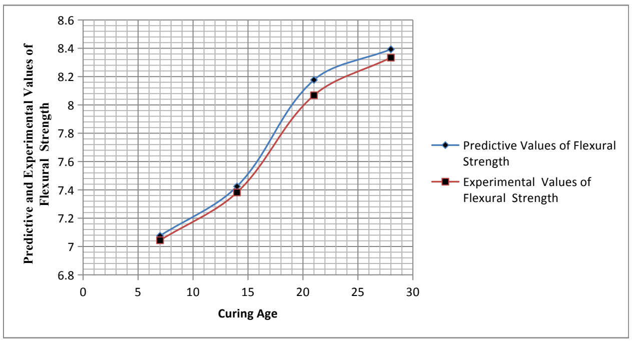

Figure 8. Predictive and Experimental Values of Flexural Strength at Different Curing Age

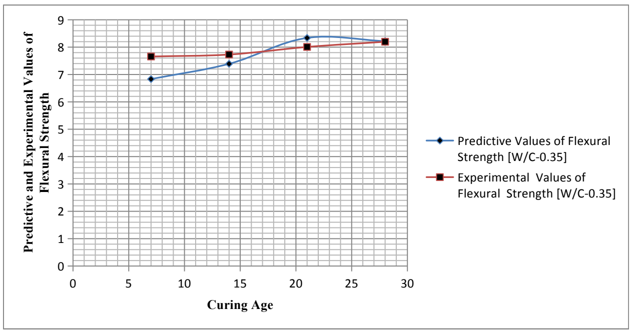

Figure 9. Predictive and Experimental Values of Flexural Strength at Different Curing Age

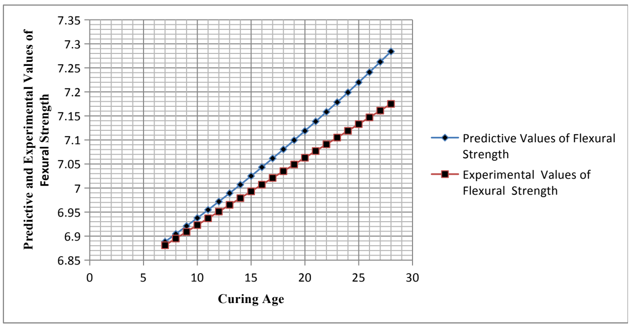

Figure 10. Predictive and Experimental Values of Flexural Strength at Different Curing Age

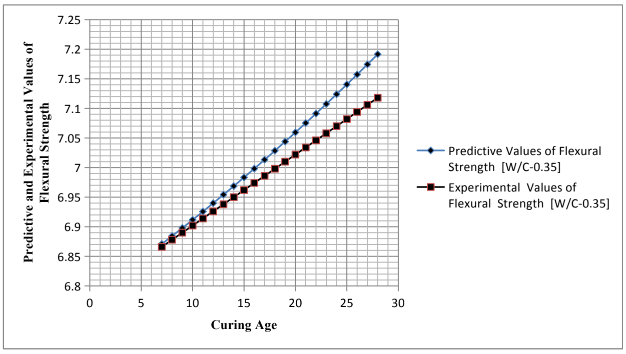

Figure 11. Predictive and Experimental Values of Flexural Strength at Different Curing Age

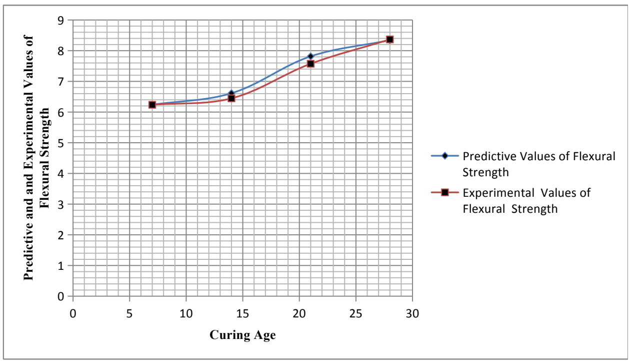

Figure 12. Predictive and Experimental Values of Flexural Strength at Different Curing Age

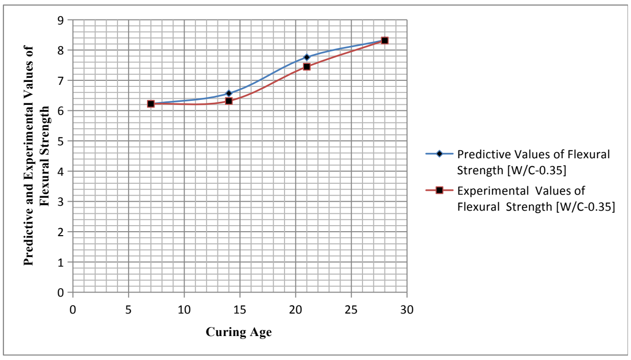

Figure 13. Predictive and Experimental Values of Flexural Strength at Different Curing Age

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Figure 2-13 explained the heterogeneous behaviour of flexural strength from concrete partially replace cement with wood and fly ash. The study observed linear growth rate from the numerical applied in some parts of the simulation, why some part of the figures expressed gradual increase, and at a certain level sight increase on the growth rate were experienced. These were in accordance with the conventional growth rate of concrete. The study monitored the effects from other parameters that were observed to reflect its reaction on the heterogeneous growth rate of the flexural strength. These parameters considered in the system simulation are porosities and compaction of concrete that generates the flexural strength. The study observed the variation rate of influence on the growth rate of the flexural strength based on these factors. Constant water cement ratios were applied on the simulation, and this were also monitored to see its heterogeneous reflection on flexural strength. The derived model were simulated, examined and observed the heterogeneous behaviour of flexural as it also reflects on its mechanical properties. The predictive were compare with the experimental values of SachinPrabhu et al 2018, and both parameters developed best fits correlation.

5. Conclusions

Flexural strength was developed from a mixed design that partially replaced cement with wood and fly ash on self compacting concrete. The study applied these locally sourced materials that developed a mixed design to generates flexural strength. The behaviour of the material on the target concrete strength generated the flexural strength under the influenced of the locally sourced addictives. The system was monitored considering the dosage of the addictive at different percentage in the mixed design. The self compacting concrete with partial replacement cement with wood and fly ash was thoroughly examined through these simulation. The reactions of these self compacting concrete were expressed experimentally by SachinPrabhu et al 2018. The predictive and the experimental values expressed best fits correlation. The study has expressed the effect from other parameters that improve the study done by SachinPrabhu et al 2018. Other improvement was carried out applying numerical simulation to monitor the growth rate of the flexural strength at every twenty four hour. The increase in flexural strength increase in the study were thoroughly evaluated.

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