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ARTICLE

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

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ABSTRACT

Wood and fly ash were observed to have significant qualities that could improve the strength of self compacting concrete. The material was applied to increase the compressive strength of concrete strength. This material could be the demanding material for partial replacement for cement. The study observed the behaviour of the material from experts that applied these material through experimental investigation, but the study monitored the behaviour of this material by applied modeling and simulation to determine other effect that could influence the behaviour of these materials in compressive strength. This was to determine the significant effect on the addictive applied as partial replacement for cement. Lots of experts have done works on fly ash through experiment concept, but the application of predictive concept has not been carried out. The adoption of this concept has expressed other parameters that contributed to the efficiency of wood and fly ash as partial replacement for cement on self compacting concrete. The study adopting modeling and simulation observed 10 and 20% by weight of cement as it is reflected on its performance in the simulation, from the simulation wood recorded 10% as it was observed from the growth rate of this self compacting concrete reflected from the trend. The simulation for model validation was compared with the works of the studies carried out [20]. And both values developed best fits correlation.

1. Introduction

The rate of concrete strength enhancement including high performance of it has expressed significantly in current time; it is now noted that it might be the demands in construction industries. The improvement of these studies has been assessed in the last three decades, furthermore, cementitious materials such as fly ash, silica fume and ground granulated blast furnace slag have been applied in high significant rates as cement replacement. These are due to the materials been observed that it can meaningfully improve the strength and stability characteristics of concrete. These can be as compared with ordinary Portland cement (OPC) alone, more so, this concept has also provided adequate required curing [12,13.14,15]. Nevertheless, studies have shown that there is desired for high strength concrete to improve in construction application for economic and dynamic growth. There is always the tendency

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of using silica fume known to be more useful as it is expressed by [2,314,15]. These class addictives were thoroughly observed to generated a very good particle packing. These are due to its strong pozzolanic property growing the resistance of concrete in most hostile environments [8,14,16,17]. Metakaolin (MK). Furthermore calcined kaolin has been investigated to be other types of pozzolan. It is produced by calcinations. It also has the ability to substitute silica fume as an alternative material. It has been observed that in India MK can generates higher quantities. They processed product of kaolin mineral. It is a wide spread proven reserves material available in the country [6, 7, 8, 9, 10]. Recently, studies have shown a lot of attention in MK as it has been observed to possess both pozzolanic and microfiller characteristics [17,18,19,20]. These concepts applied and it has generated successfully development on high strength self-compacting concrete. Further studies on the behaviour of parameters were carried using mathematical modeling techniques [13,14,15,16,19,20].

2. Theoretical Background

$$\frac{d_{cd}}{dx}+V\left(y\right)c_d=\Phi(y)c_d^n \quad (1.0)$$

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

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

Let

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

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

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

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

Integrating both sides we have

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

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

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

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

3. Materials and Method

Experimental Procedures

Compressive Strength Test Concrete cubes of size 150 mm × 150 mm × 150 mm were cast with and without copper slag. During casting, the cubes were mechanically vibrated using a table vibrator. After 24 hours, the specimens were demoulded and subjected to curing for 1-90 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 5.1.

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

Area of cross section of specimen (mm^2)

4. Results and Discussion

Table 1. Predictive and Experimental Values of Compressive Strength at Different Curing Age

Curing Age	Predictive Values of Compressive Strength [W/C-0.35]	Experimental Values of Compressive Strength [W/C-0.35]
7	36.76627272	36.799
8	36.78703329	36.816
9	36.80817351	36.833
10	36.82970032	36.85
11	36.8516208	36.867
12	36.87394215	36.884
13	36.89667169	36.901
14	36.91981688	36.918
15	36.94338534	36.935
16	36.9673848	36.952
17	36.99182315	36.969
18	37.0167084	36.986
19	37.04204873	37.003
20	37.06785247	37.02
21	37.09412809	37.037
22	37.12088421	37.054
23	37.14812963	37.071
24	37.17587329	37.088
25	37.2041243	37.105
26	37.23289195	37.122
27	37.26218567	37.139
28	37.2920151	37.156

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

Curing Age	Predictive Values of Compressive Strength	Experimental Values of Compressive Strength
7	36.79317316	36.773
8	36.81839149	36.792
9	36.84415705	36.811
10	36.87048171	36.83
11	36.89737761	36.849
12	36.92485714	36.868
13	36.95293297	36.887
14	36.98161804	36.906
15	37.01092556	36.925
16	37.04086904	36.944
17	37.0714623	36.963
18	37.10271941	36.982
19	37.13465479	37.001
20	37.16728317	37.02
21	37.20061956	37.039
22	37.23467935	37.058
23	37.26947823	37.077
24	37.30503222	37.096
25	37.34135773	37.115
26	37.37847149	37.134
27	37.41639061	37.153
28	37.45513256	37.172

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

Curing Age	Predictive Values of Compressive Strength	Experimental Values of Compressive Strength 1
7	31.01044419	31.5
28	39.22965511	39.5

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

Curing Age	Predictive Values of Compressive Strength	Experimental Values of Compressive Strength
7	33.62597125	33.773
14	36.98161804	36.906
21	38.07423097	38.039
28	39.22965511	39.172

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

Curing Age	Predictive Values of Compressive Strength	Experimental Values of Compressive Strength
7	28.27204882	28.5
14	31.24588015	30.94
21	32.75902279	33.18
28	35.107764	34.9

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

Curing Age	Predictive Values of Compressive Strength	Experimental Values of Compressive Strength
7	28.27204882	28.395
14	31.24588015	30.936
21	32.75902279	33.183
28	35.107764	35.136

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

Curing Age	Predictive Values of Compressive Strength	Experimental Values of Compressive Strength
7	28.27204882	29.384
8	32.29997055	32.406
9	32.33030621	32.428
10	32.36139766	32.45
11	32.39326375	32.472
12	32.42592376	32.494
13	32.45939747	32.516
14	32.49370517	32.538
15	32.52886763	32.56
16	32.56490614	32.582
17	32.60184254	32.604
18	32.63969919	32.626
19	32.67849901	32.648
20	32.71826552	32.67
21	32.75902279	32.692
22	32.8007955	32.714
23	32.84360897	32.736
24	32.8874891	32.758
25	32.9324625	32.78
26	32.97855638	32.802
27	33.02579866	32.824
28	34.39810117	32.846

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

Curing Age	Predictive Values of Compressive Strength [W/C-0.35]	Experimental Values of Compressive Strength [W/C-0.35]
7	29.81547163	29.781
8	29.84216636	29.814
9	29.86946969	29.847
10	29.89739547	29.88
11	29.9259579	29.913
12	29.95517151	29.946
13	29.98505112	29.979
14	30.01561193	30.012
15	30.04686946	30.045
16	30.0788396	30.078
17	30.1115386	30.111
18	30.14498307	30.144
19	30.17919	30.177
20	30.21417679	30.21
21	30.2499612	30.243
22	30.28656143	30.276
23	30.32399606	30.309
24	30.36228414	30.342
25	30.4014451	30.375
26	30.44149885	30.408
27	30.48246575	30.441
28	30.52436661	30.474

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

Curing Age	Predictive Values of Compressive Strength [W/C-0.35]	Experimental Values of Compressive Strength
7	35.50296438	35.477
8	35.52818271	35.508
9	35.55394827	35.539
10	35.58027293	35.57
11	35.60716883	35.601
12	35.63464836	35.632
13	35.66272419	35.663
14	35.69140925	35.694
15	35.72071678	35.725
16	35.75066026	35.756
17	35.78125351	35.787
18	35.81251063	35.818
19	35.84444601	35.849
20	35.87707439	35.88
21	35.91041078	35.911
22	35.94447057	35.942
23	35.97926944	35.973
24	36.01482344	36.004
25	36.05114895	36.035
26	36.08826271	36.066
27	36.12618183	36.097
28	36.16492378	36.128

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

Curing Age	Predictive Values of Compressive Strength [W/C-0.23]	Experimental Values of Compressive Strength [W/C-0.23]
7	31.14487105	30.327
14	32.00913265	32.694
21	35.91041078	35.911
28	37.1685143	36.128

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

Curing Age	Predictive Values of Compressive Strength [W/C-0.35]	Experimental Values of Compressive Strength [W/C-0.35]
7	31.11340204	30.821
14	31.93740969	32.788
21	35.80391931	34.951
28	37.01272223	37.31

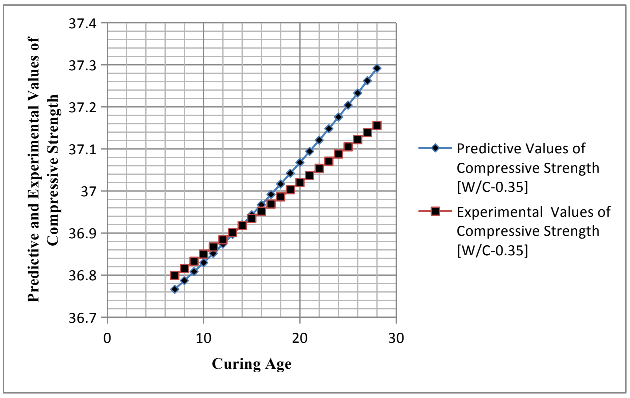

Figure 1. Predictive and Experimental Values of Compressive Strength at Different Curing Age

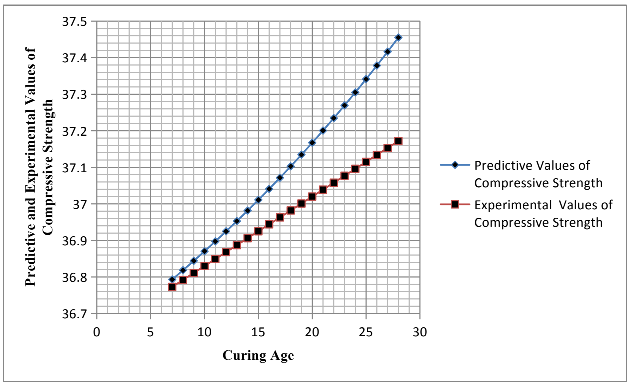

Figure 2. Predictive and Experimental Values of Compressive Strength at Different Curing Age

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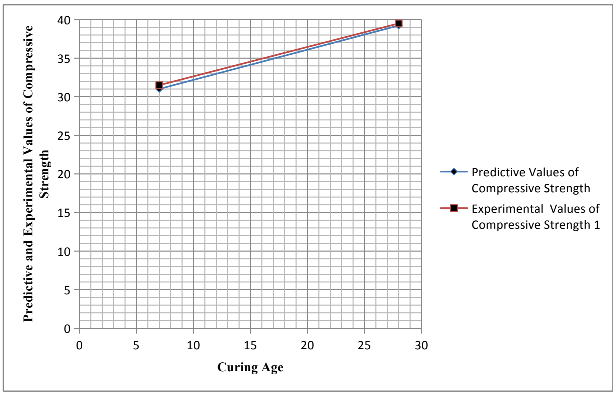

Figure 3. Predictive and Experimental Values of Compressive Strength at Different Curing Age

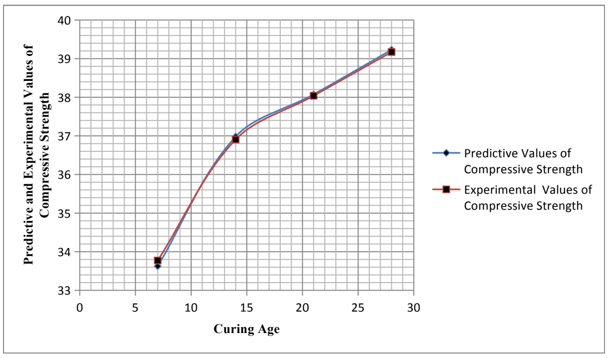

Figure 4. Predictive and Experimental Values of Compressive Strength at Different Curing Age

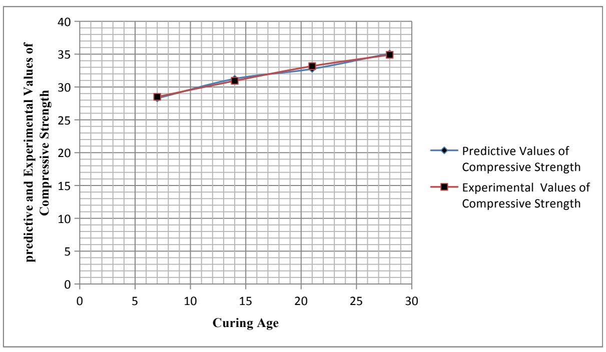

Figure 5. Predictive and Experimental Values of Compressive Strength at Different Curing Age

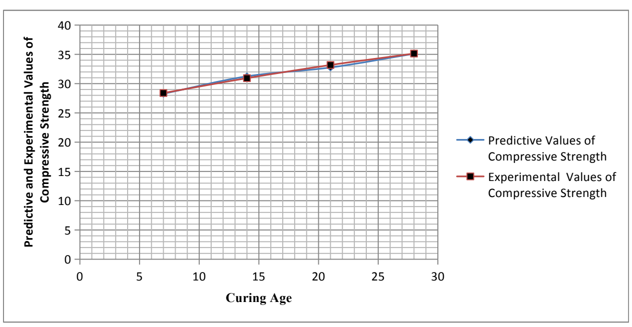

Figure 6. Predictive and Experimental Values of Compressive Strength at Different Curing Age

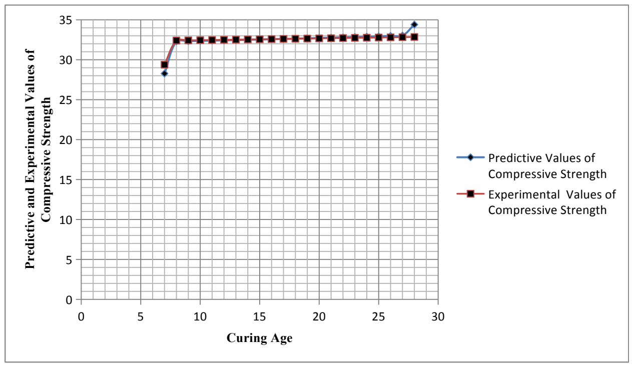

Figure 7. Predictive and Experimental Values of Compressive Strength at Different Curing Age

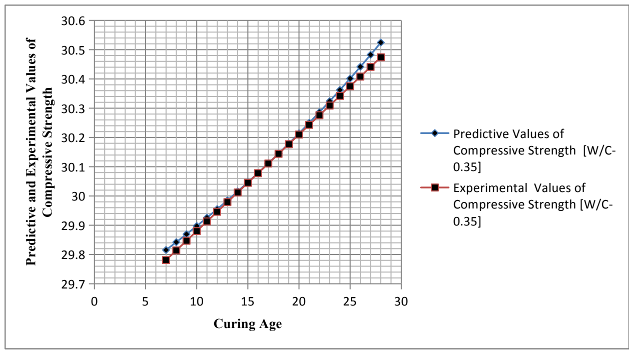

Figure 8. Predictive and Experimental Values of Compressive Strength at Different Curing Age

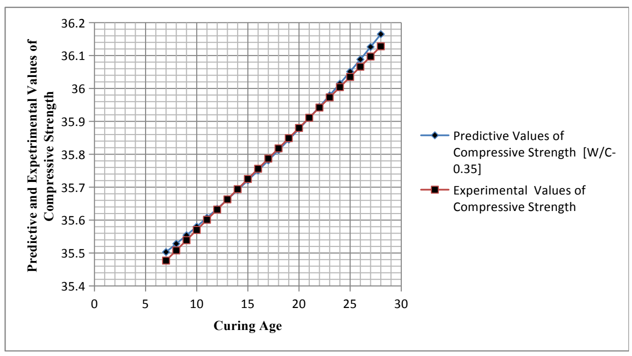

Figure 9. Predictive and Experimental Values of Compressive Strength at Different Curing Age

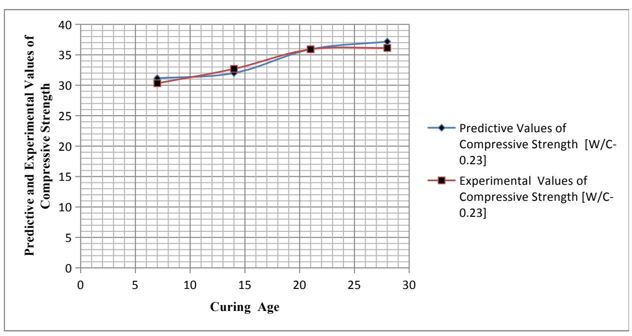

Figure 10. Predictive and Experimental Values of Compressive Strength at Different Curing Age

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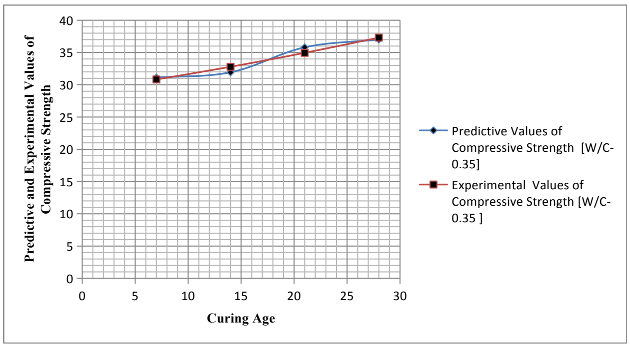

Figure 11. Predictive and Experimental Values of Compressive Strength at Different Curing Age

Figure one to Eleven experienced various rates of compressive growth rates. Some of the figures were monitored numerically while few figures were observed analytically. This value was based on different dimensions that the concrete strength was monitored for general performance as self compacting concrete. The water cement ratios were evaluated at different ratios. There behaviour in growth rate developed heterogeneous setting based on their different water cement ratios. There curing age was also heterogeneous. This was carried out to determine their various compressive strength reflecting on the mix design and concrete setting time. These are based on the variation of mixed proportions. The Performance of concrete is assessed from its mechanical properties that include shrinkage and creep, compressive strength, tensile strength, flexural strength, and modulus of elasticity. The reflections between mechanical and physical properties were monitored as it was observed from the growth rates on the trend. These include conductivity, corrosion resistance Density, ductility/malleability, Elasticity/stiffness, fracture toughness, hardness, and plasticity. The behaviour of the concrete expressed the reflection of the stated parameters, the study haven't monitored these qualities in concrete as it been evaluated holistically in quality control for self compaction, its partially replaced cement with wood and fly Ash, the derive model has definitely from the trend expressed the general effected in all aspect of the concrete growth rate. The figures show the validation as the experimental values of SachinPrabhu, et al 2018 that were compared with the predictive values, and both values developed best fits correlation.

5. Conclusions

Partial replacement of cement with wood and fly Ash was examined applying modeling and simulation techniques. The study was carried out for self compacting concrete. The application of such material contains less calcium oxide, thus having a significant quantity of silicon dioxide. These were applied as partial replacement for cement. The integration of this material was found to reduce the viscosity modifying agents. The application of these materials can be achieved through the reduction of water content in the mix. The application of modeling and simulation adopted were to monitor other influential parameters that could affect the growth rate of the system in terms of attaining the strength faster. The study adopting modeling and simulation observed 10 and 20% by weight of cement as it is reflected on its performance from the simulation. Similar observations were found also in superplasticiser. This was monitored to the rate of its improvement to the optimum at 15% and wood were recorded from the simulation at 10% the growth rate of self compacting concrete were reflected from the trend. The simulation values for model validation were compared with the works of SachinPrabhu, et al 2018. And both values developed best fits correlation.

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