PREDICTIVE MODEL ON COMPRESSIVE STRENGTH OF CONCRETE MADE WITH LOCALLY 3/8 GRAVEL FROM DIFFERENT WATER CEMENT RATIOS AND CURING TIME

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Abstract: Compressive strength of concrete were generated through thorough empirical applications, the study focus on application of locally occurring 3/8 material characterized in unwashed and washed conditions, the concept were to determine the rate of higher concrete strength, various water cement ratios were used to generate these results for compressive strength at different curing age. These results were calibrated to generated resolved mathematical equations, predictive values were generated, these values were compared with measured values, both parameters developed favourable fits validated the developed model, graphical representation has express the rate of compressive strength as it is characterized, some values attained it maximum strength between twenty eight and ninety days, while some generate very low strength base on the variations of compressive rate thus porosity developing bleeding of concrete, the derived model from its predictive values express its compressive behaviour base on this influences, experts will definitely apply these empirical solutions in design of higher concrete strength.

Keywords: predictive model, compressive strength, concrete and water cement ratios

1. Introduction

Mechanical properties of High-Strength Concrete (HSC) can be divided in two groups as short- term mechanical properties and long-term mechanical properties. Stress-strain behaviour of HSC depends on material parameters such as aggregate type and experimental parameters that include age at testing, strain rate and interaction between specimen and testing machine. The stress-strain model used for NSC cannot be extended for use in HSC as the nature of loading curve changes significantly (Eluozo and Ode 2015a, Eluozo and Ode 2015b, Eluozo and Ode 2015c). Steeper rise and sudden drop in strength after maximum value presents difficulty in numerical modelling of stress-strain behaviour of HSC. Aĩtcin (1998) suggests that HSC behaves like a real composite material and parallels can be drawn to the stress-strain behaviour used in rock mechanic (Zhaoyu and Moses 2012). Carrasquillo et al. (1981) reported that there is less internal microcracking in HSC than NSC for the same axial strain imposed,. This also implies that HSC experience less lateral strain, and consequently effectiveness of confinement on compressive strength of HSC is often limited compared to NSC. Decreasing w/c ratio increases the strength of concrete (Ephraim and Ode, 2006). However, this trend follows only where strength of hydrated cement is low compared to the strength of coarse aggregates. When these two strengths become comparable, decreasing w/c ratio doesn't increase the strength significantly, and to further increase the strength of HSC, strength and quality of coarse aggregates need to be increased, in addition to other factors. Typically, w/c ratios between 0.2- 0.4 are used for HSC. Low w/c ratio decreases the workability. Super plasticizers are added to increase the workability in HSC. Shape, texture and maximum size of coarse aggregate affect the compressive strength of HSC. Smooth river gravel produces weaker concrete. Smallest size of coarse aggregate produces highest strength concrete owing to its high specific surface area. . Iravani (1996) investigated the effect of curing conditions on strength gain of HSC at later stages and concluded that drying followed by moist-curing increased the 147-day compressive strength of HSC relative to continuously moist-cured concrete tested under moist conditions (Shah and Ahmad, 1994). Addition of silica fume decreases the requirement of low w/c to achieve high compressive strength. Iravani (1996) noted that effect of silica fume on strength development of HSC is most prominent during 7 to 28 days after mixing. Measured compressive strength of HSC depends on testing variables, namely, mold type, specimen size, end conditions and strain rate. 4×8 in. (102×204 mm) cylinder specimens have been shown to produce (ACI, 2010). ACI-318 (ACI, 2011) defines the secant modulus of elasticity as the ratio of stress and strain at 40% of the compressive strength. As strength of concrete increases, its modulus of elasticity increases as well. Poisson's ratio is not affected by compressive strength, curing method and age of concrete (Logan et al., 2009 (Wight and MacGregor (2009; Whittaker 2012, Ahmad and Shah 1982)

2. Materials and Method

ELE England made concrete compressive machine was used. It consists of a measuring gauge with two indicator or pointer (black and red). The indicator must be set to zero mark before testing. Load is applied to test specimen through two steel loading platforms, with a fixed upper platform and an upward moving lower platform. The lower platform has marking which help in centralizing a test specimen to receive the concentric load. At failure, the black pointer drops back to zero and red pointer remains in position to give the reading of the failure load, after the reading has been taken, a knob is adjusted to release the lower platform to former position. The generated results were subjected to calibration, these results produced mathematical equations, the expressed equation were resolved to generated predictive values characterized to washed and unwashed, the result will be presented to be compared with measured values

3. Results and Discussion

Results and discussion are presented in tables including graphical representation of predictive and measured values for compressive strength of concrete. at various curing age

Table: 1Predictive and measured values of compressive strength u-mix 0.45 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.45	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	5.855	6.1
14	7.799	7.73
21	9.33	7.75
28	10.51	9.82
60	12.34	13.33
90	11.38	10.56

Table: 2 Predictive and measured values of compressive strength u-mix 0.50w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.50	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	3.935	4.03
14	6.05	5.74
21	4.539	4.78
28	8.678	9.26
60	8.868	9.33
90	5.958	6.11

Table: 3Predictive and measured values of compressive strength u-mix 0.55 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.55	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	7.05	6.82
14	10.84	10.22
21	10.57	9.04
28	7.48	8.85
60	10.15	9.93
90	13.3	12.56

Table: 4 Predictive and measured values of compressive strength u-mix 0.60 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.60	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	12.43	11.5
14	11.95	11.26
21	11.51	13.01
28	11.06	11.22
60	9.01	8.97
90	7.09	8.89

Table:5 Predictive and measured values of compressive strength u-mix 0.65 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.65	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	7.423	8.89
14	10.71	10.89
21	12.04	11.81
28	9.765	9.45
60	16.645	17.71
90	11.905	10.77

Table: 6Predictive and measured values of compressive strength u-mix 0.45 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.70	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	9.977	10.11
14	12.182	11.56
21	14.093	13.56
28	15.71	14.63
60	19.358	18.33
90	17.198	17.22

Table: 7Predictive and measured values of compressive strength u-mix 0.45 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.75	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	7.02	6.98
14	8.94	9.11
21	10.23	11.45
28	10.99	9.96
60	9.93	10.11
90	7.31	8.11

Table: 8Predictive and measured values of compressive strength u-mix 0.80 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.80	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	6.8	5.89
14	8.12	8.35
21	9.78	9.79
28	10.48	10.81
60	14.37	14.11
90	16.18	15.78

Table: 9 Predictive and measured values of compressive strength u-mix 0.85 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.85	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	6.4	6.33
14	8.48	8.69
21	10.24	9.96
28	11.35	10.52
60	12.23	11.67
90	15.78	15.12

Table: 10 Predictive and measured values of compressive strength u-mix 0.90 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.90	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	7.29	7.11
14	9.59	10.11
21	10.98	9.89
28	11.65	12.15
60	10.75	10.44
90	15.52	14.12

Table: 11Predictive and measured values of compressive strength u-mix 0.95 w/c at different curing age

Water Cement Ratio Curing Age Mix U-0.95	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	4.26	4.33
14	5.04	4.98
21	5.82	5.66
28	6.61	6.44
60	10.19	10.46
90	11.55	11.34

Table: 12 Predictive and measured values of compressive strength u-mix 1,.00 w/c at different curing age

Water Cement Ratio Curing Age Mix U-1.00	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	3.85	4.11
14	5.96	5.44
21	5.796	5.88
28	6.43	6.11
60	8.41	7.78
90	12.76	11.89

Table: 13Predictive and measured values of compressive strength u-mix 0.45 w/c at different curing age

Water Cement Ratio Curing Age Mix U-1.05	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	2.94	2.86
14	4.06	4.11
21	4.96	4.57
28	5.37	5.22
60	5.24	4.56
90	8.66	8.44

Table: 14 Predictive and measured values of compressive strength u-mix 0.45 w/c at different curing age

Water Cement Ratio Curing Age Mix U-1.10	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	3.78	3.11
14	5.09	5.33
21	5.59	5.48
28	6.38	6.3
60	8.71	8.47
90	9.04	8.98

Table: 15 Predictive and measured values of compressive strength W--mix 0.45 w/c at different curing ge

Water Cement Ratio Curing Age Mix W- 0.35	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	2.86	2.82
14	4.69	3.56
21	5.89	4.15
28	6.1	6.97
60	7.43	7.98
90	9.37	9.4

Table: 16Predictive and measured values of compressive strength W-mix 0.45 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.45	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	20.85	19.94
14	20.28	19.29
21	20.28	23.56
28	19.73	20.11
60	21.43	20.85
90	26.74	29.67

Table: 17 Predictive and measured values of compressive strength W-mix 0.50 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.50	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	17.29	16.99
14	18.94	17.98
21	20.49	21.02
28	21.93	21.81
60	27.31	27.67
90	30.49	29.67

Table: 18 Predictive and measured values of compressive strength W-mix 0.55 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.55	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	15.49	14.55
14	16.01	16.84
21	16.53	15.96
28	17.05	18.67
60	19.42	18.78
90	21.64	21.89

Table: 19 Predictive and measured values of compressive strength W-mix 0.60 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.60	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	13.34	12.89
14	16.44	16.08
21	18.53	17.98
28	19.8	20.59
60	20.41	19.54
90	24.47	23.89

Table: 20 Predictive and measured values of compressive strength W-mix 0.65 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.65	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	11.86	11.14
14	12.98	13.23
21	14.1	13.86
28	15.22	16.15
60	20.34	19.89
90	25.14	24.78

Table: 21Predictive and measured values of compressive strength W-mix 0.70 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.70	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	12.4	11.37
14	12.14	12.39
21	11.94	11.48
28	11.94	11.72
60	12.93	12.52
90	15.72	15.89

Table: 22Predictive and measured values of compressive strength W-mix 0.75 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.75	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	11.23	10.78
14	11.68	12.12
21	12.15	12.67
28	12.69	12.56
60	14.86	15.05
90	16.85	17.01

Table: 23Predictive and measured values of compressive strength W-mix 0.80 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.80	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	12.45	12.28
14	11.44	11.46
21	10.87	11.12
28	10.63	9.93
60	11.61	11.33
90	10.44	10.33

Table: 24 Predictive and measured values of compressive strength W-mix 0.85 w/c at different curing age

Water Cement Ratio Curing Age Mix W-0.85	Predictive Values for Compressive Strength N/mm^2	Measured Values for Compressive Strength N/mm^2
7	11.36	11.45
14	13.66	13.28
21	15.02	15.78
28	15.59	16.03
60	12.87	12.87
90	12.64	13.33

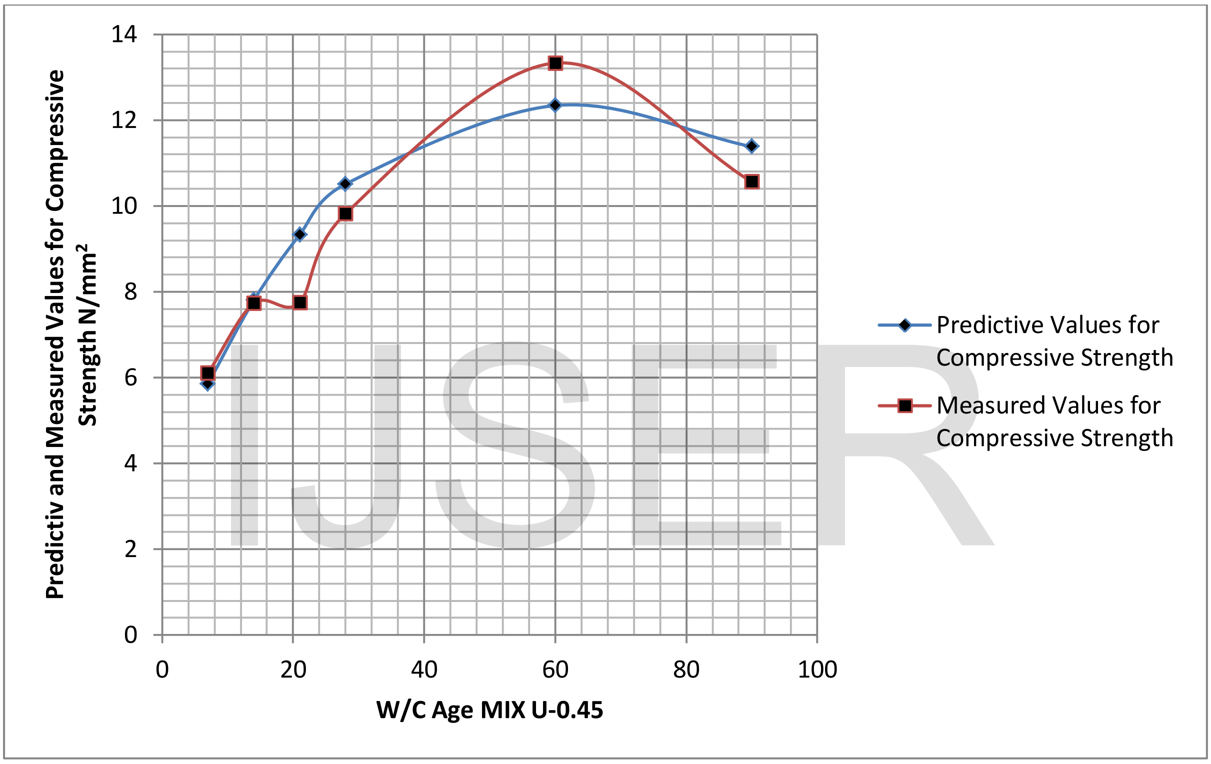

Figure: 1Predictive and measured values of compressive strength u-mix 0.45 w/c at different curing age

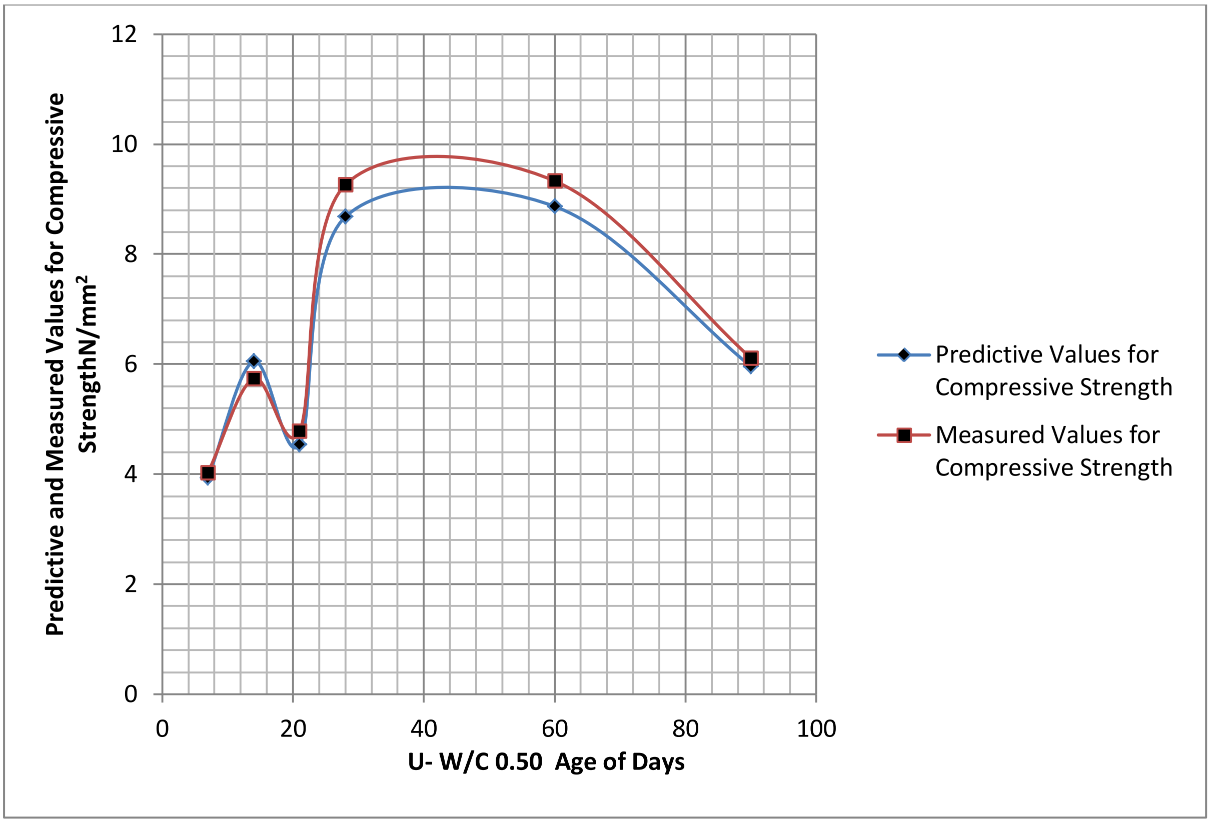

Figure: 2Predictive and measured values of compressive strength u-mix 0.50 w/c at different curing age

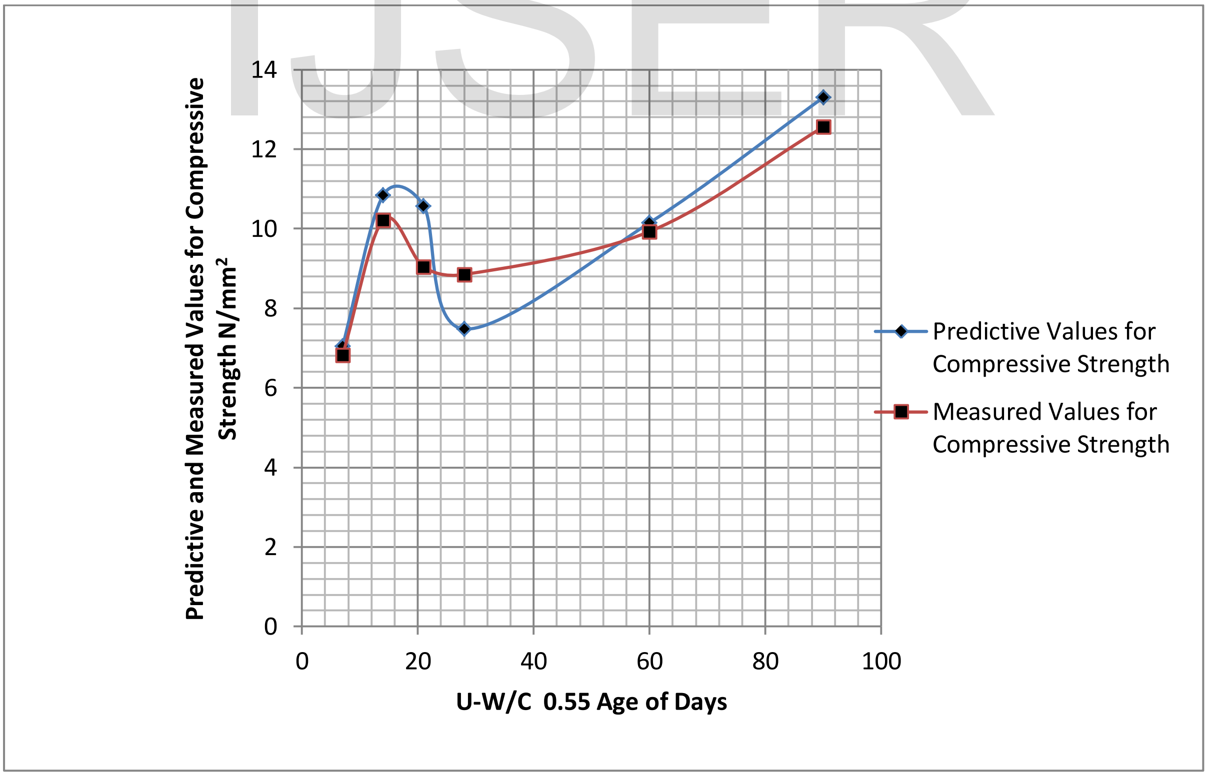

Figure: 3Predictive and measured values of compressive strength u-mix 0.55 w/c at different curing age

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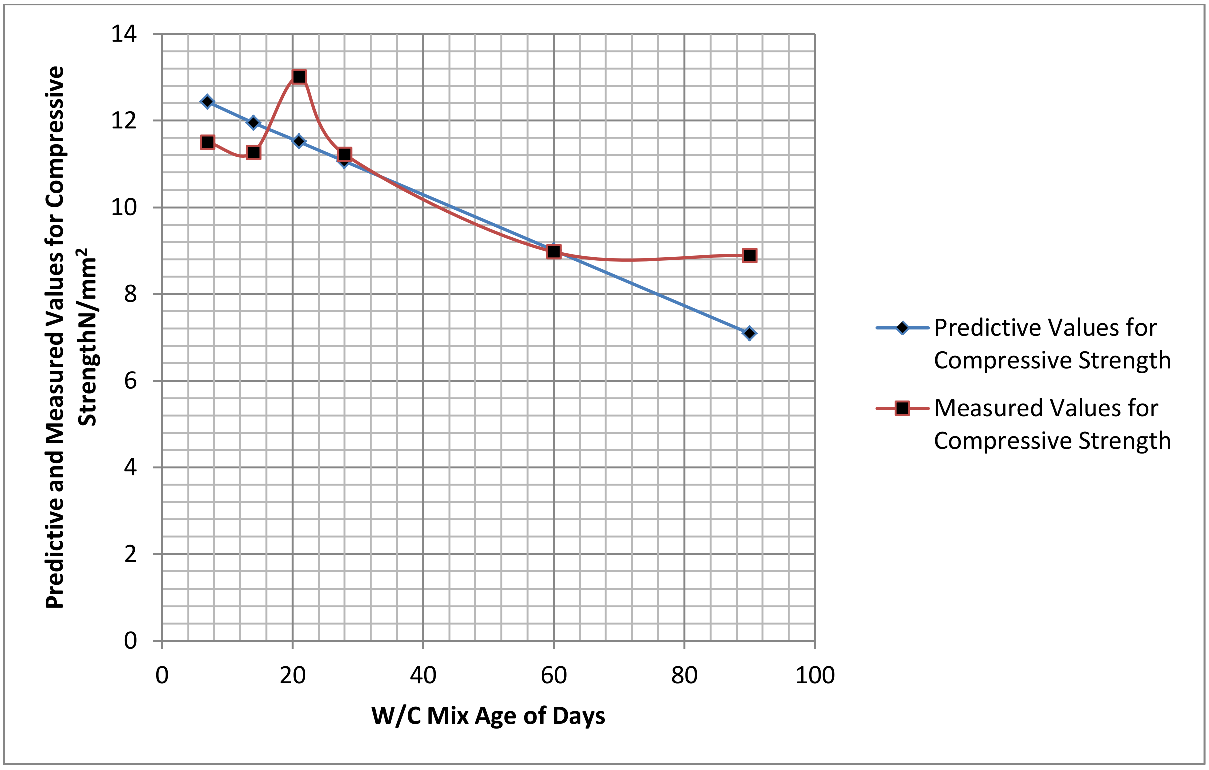

Figure: 4Predictive and measured values of compressive strength u-mix 0.60 w/c at different curing age

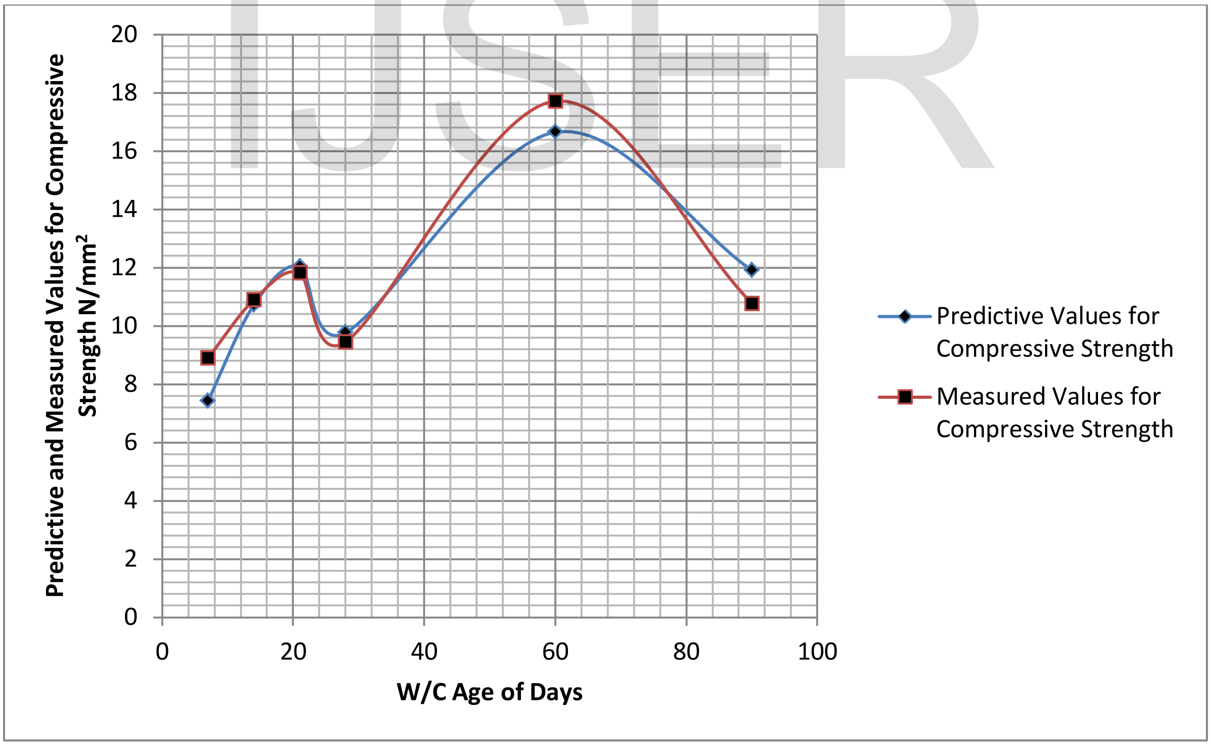

Figure: 5 Predictive and measured values of compressive strength u-mix 0.65 w/c at different curing age

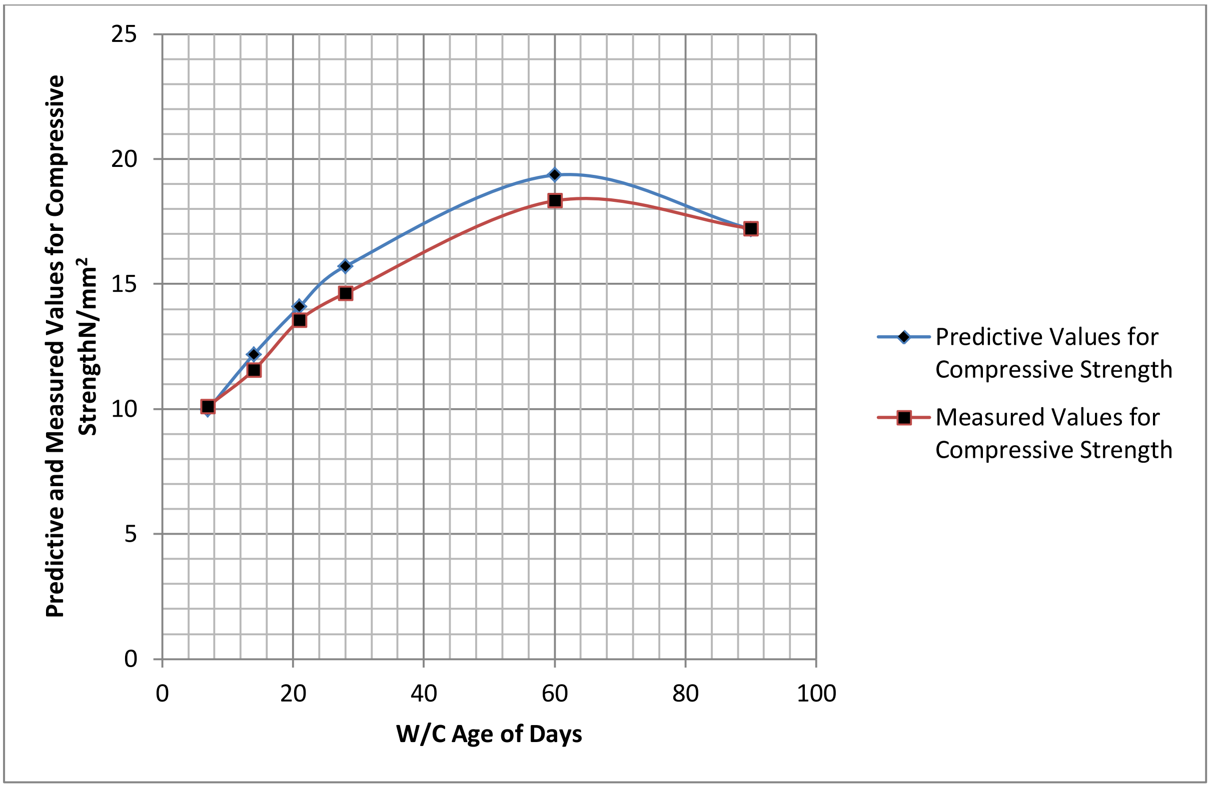

Figure: 6 Predictive and measured values of compressive strength u-mix 0.70 w/c at different curing age

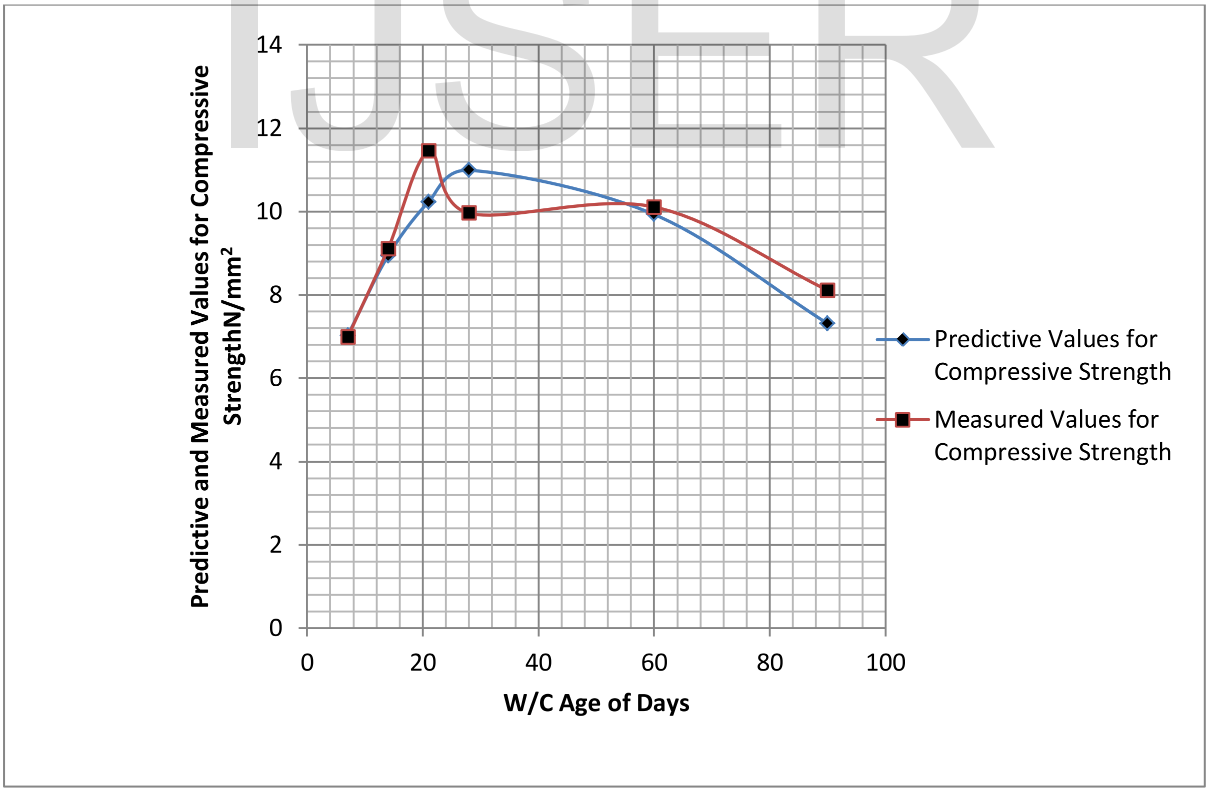

Figure: 7 Predictive and measured values of compressive strength u-mix 0.75 w/c at different curing age

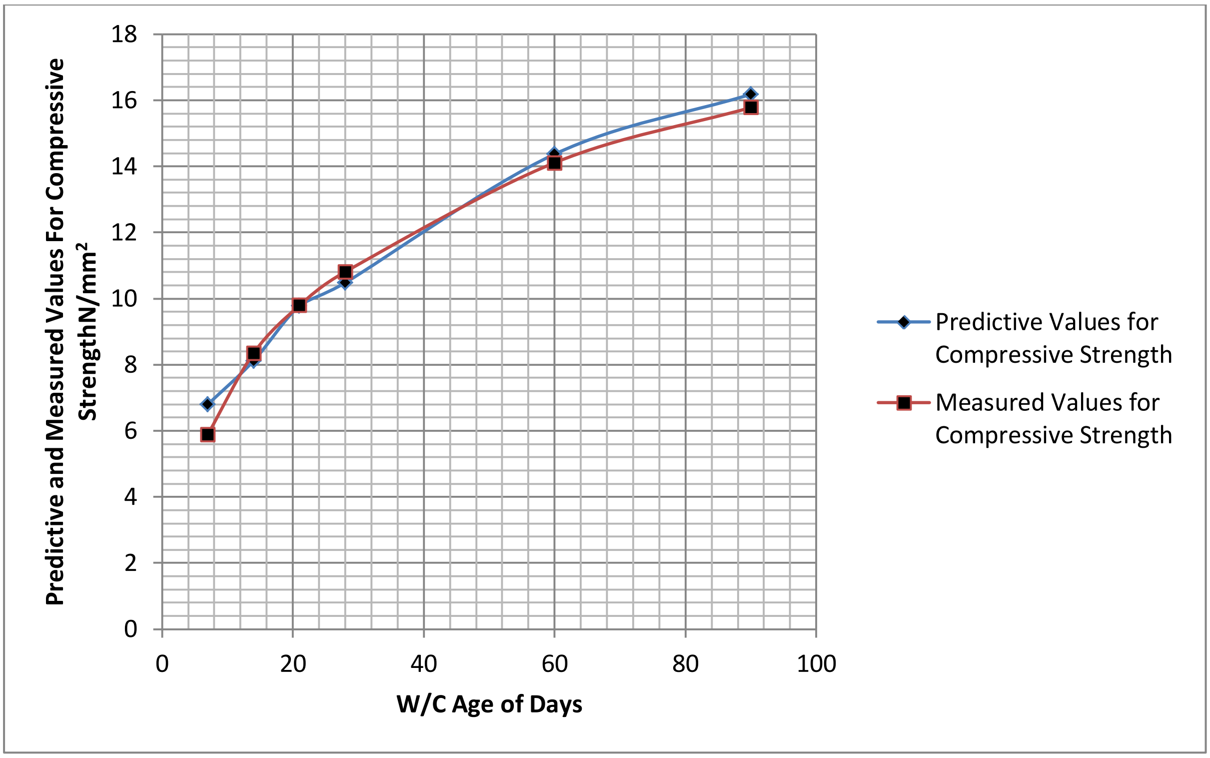

Figure: 8 Predictive and measured values of compressive strength u-mix 0.80 w/c at different curing age

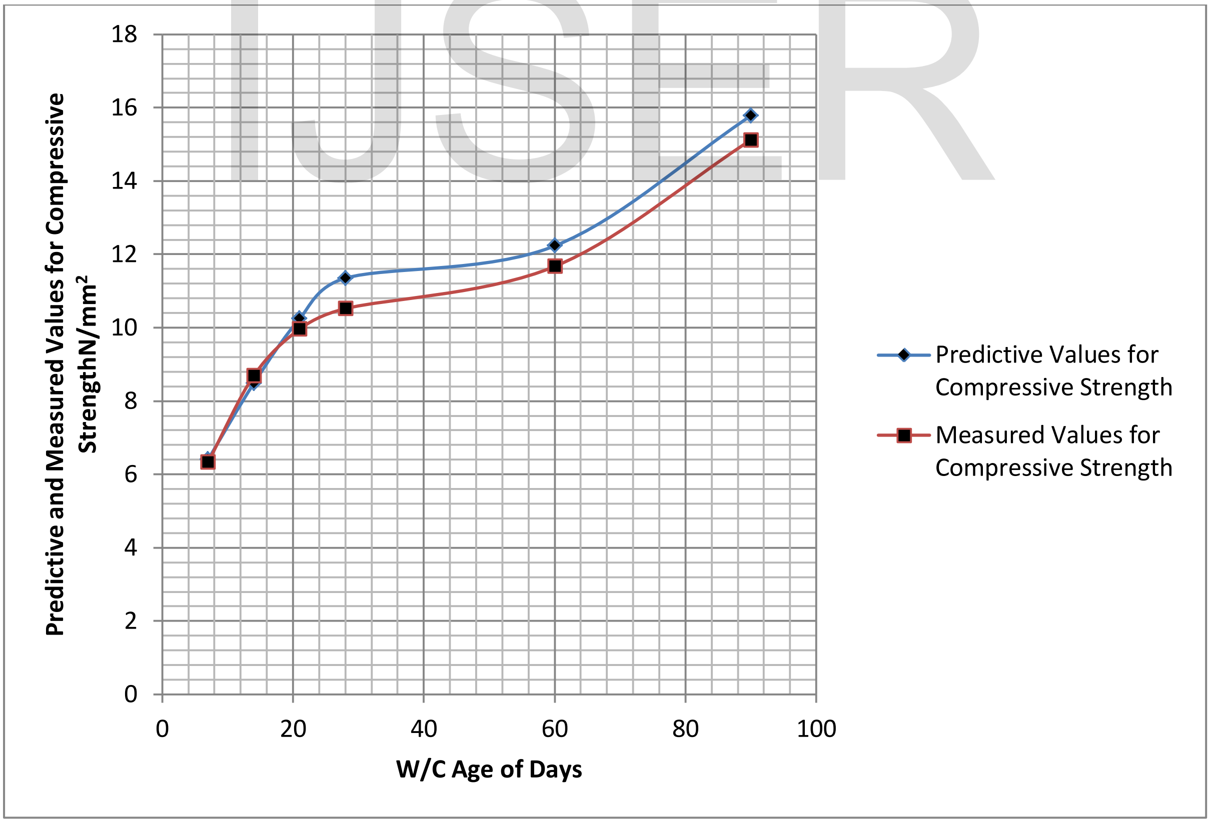

Figure: 9 Predictive and measured values of compressive strength u-mix 0.85 w/c at different curing age

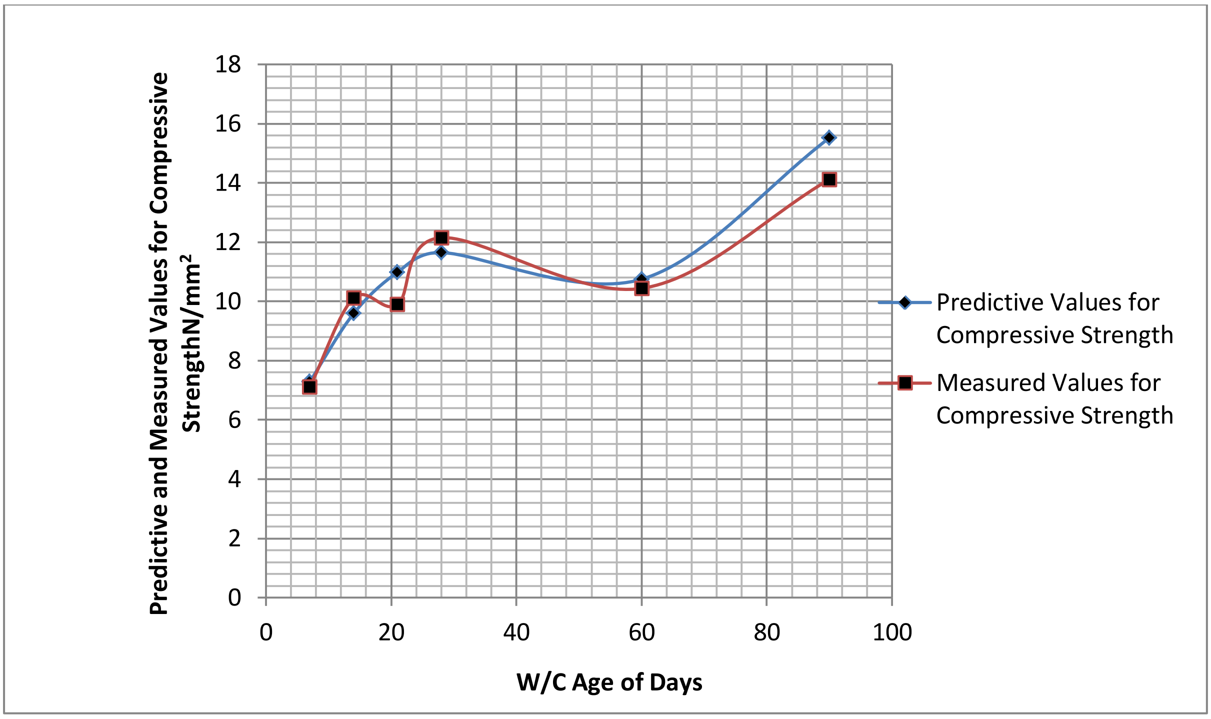

Figure: 10 Predictive and measured values of compressive strength u-mix 0.90 w/c at different curing age

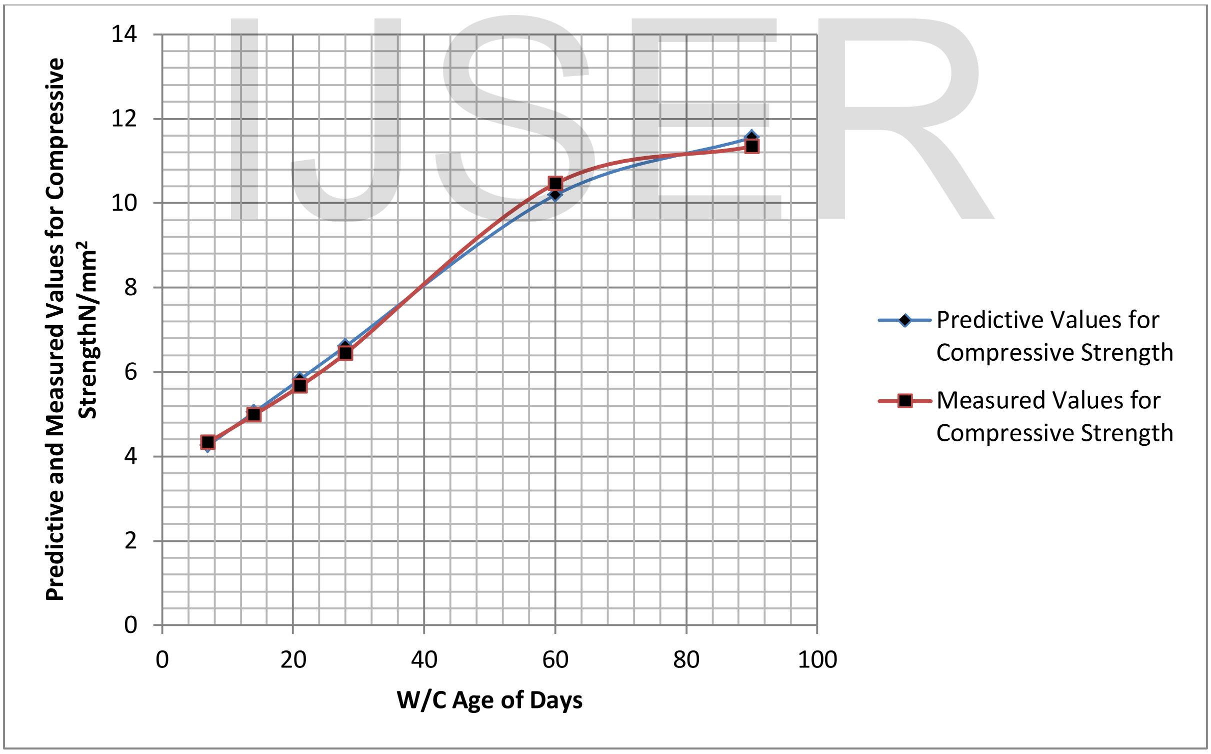

Figure: 11 Predictive and measured values of compressive strength u-mix 0.95 w/c at different curing age

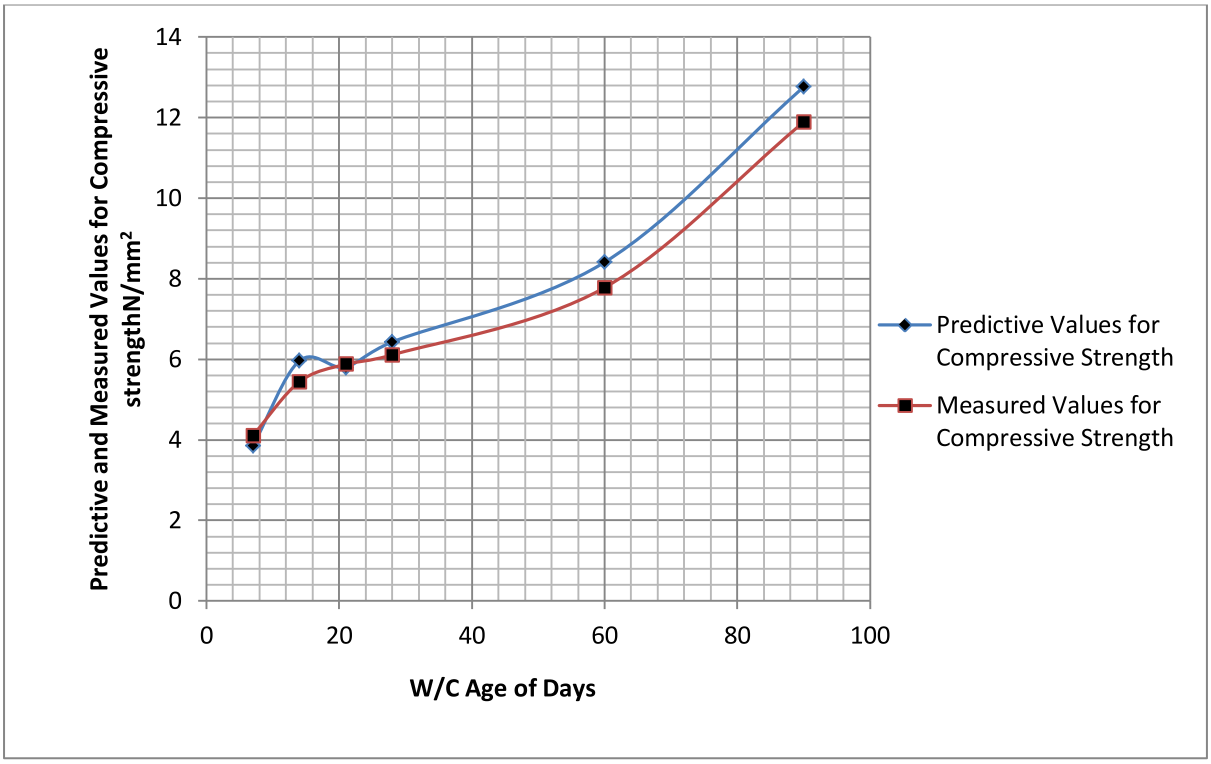

Figure: 12 Predictive and measured values of compressive strength u-mix 0.85 w/c at different curing age

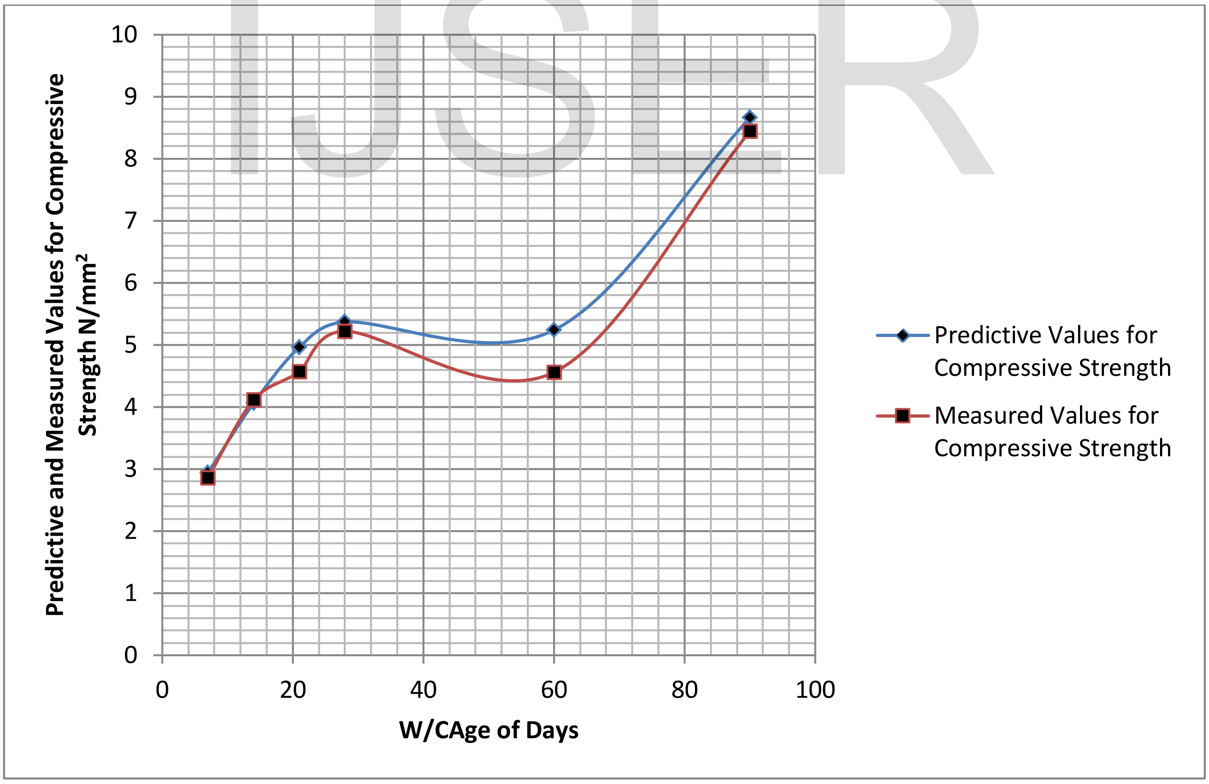

Figure: 13 Predictive and measured values of compressive strength u-mix 1.05 w/c at different curing age

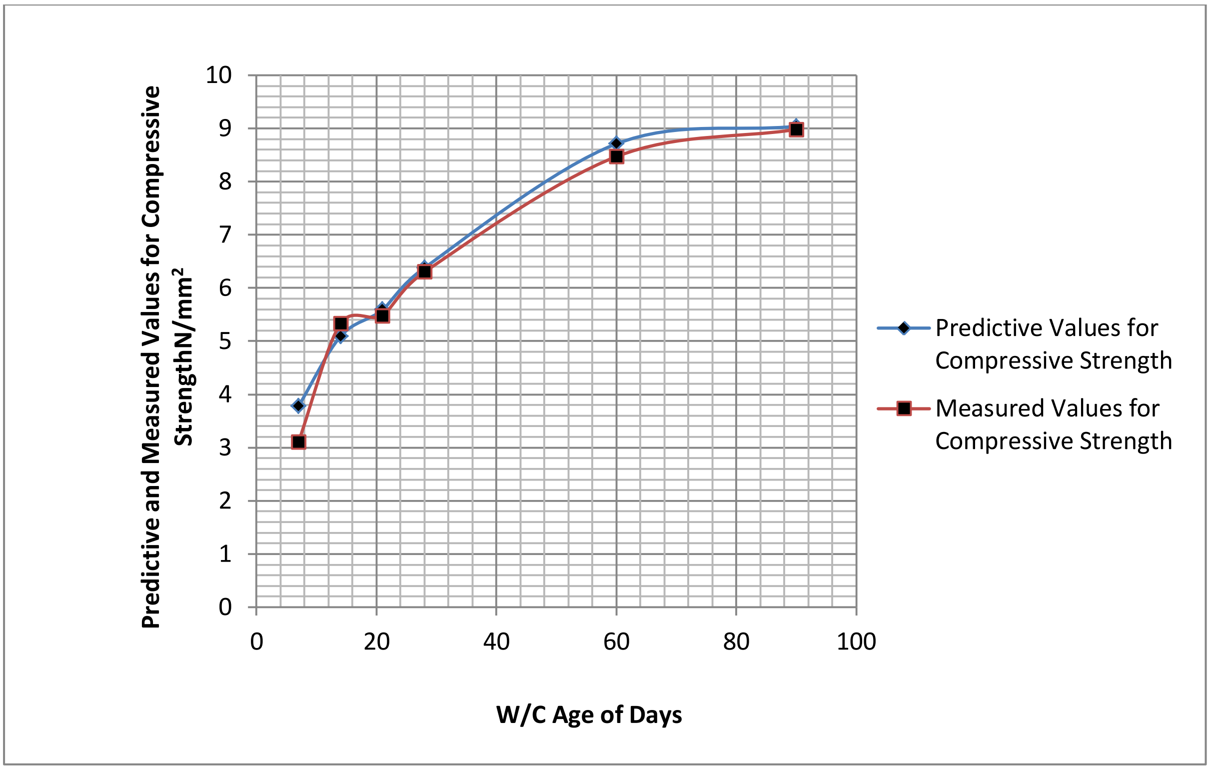

Figure: 14 Predictive and measured values of compressive strength u-mix 1.10 w/c at different curing age

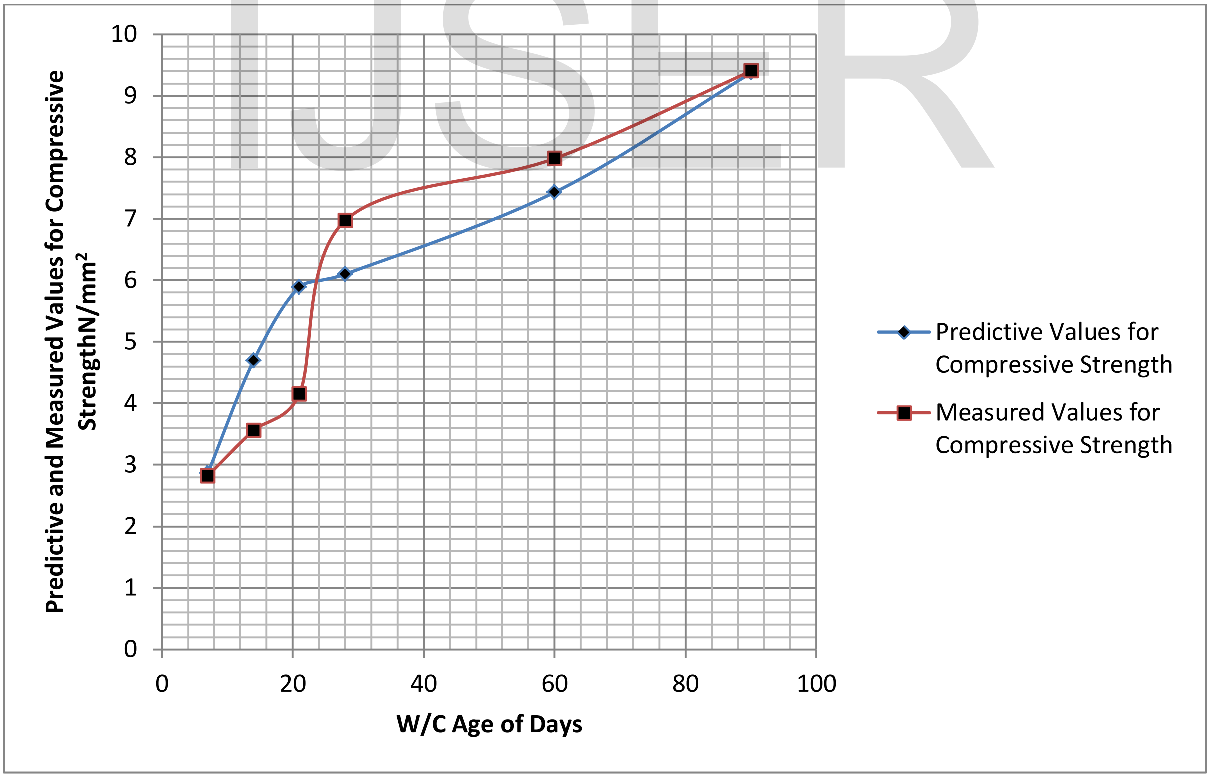

Figure: 15 Predictive and measured values of compressive strength w-mix 0.35 w/c at different curing age

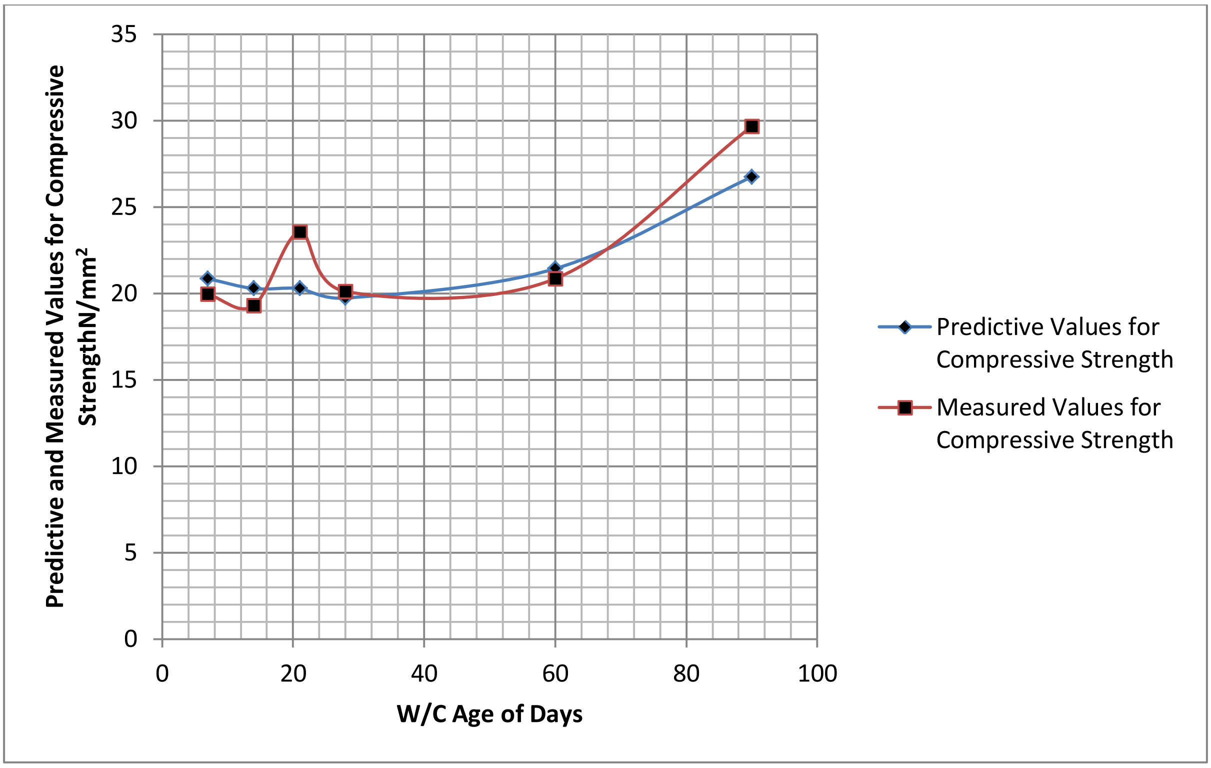

Figure: 16 Predictive and measured values of compressive strength w-mix 0.45 w/c at different curing age

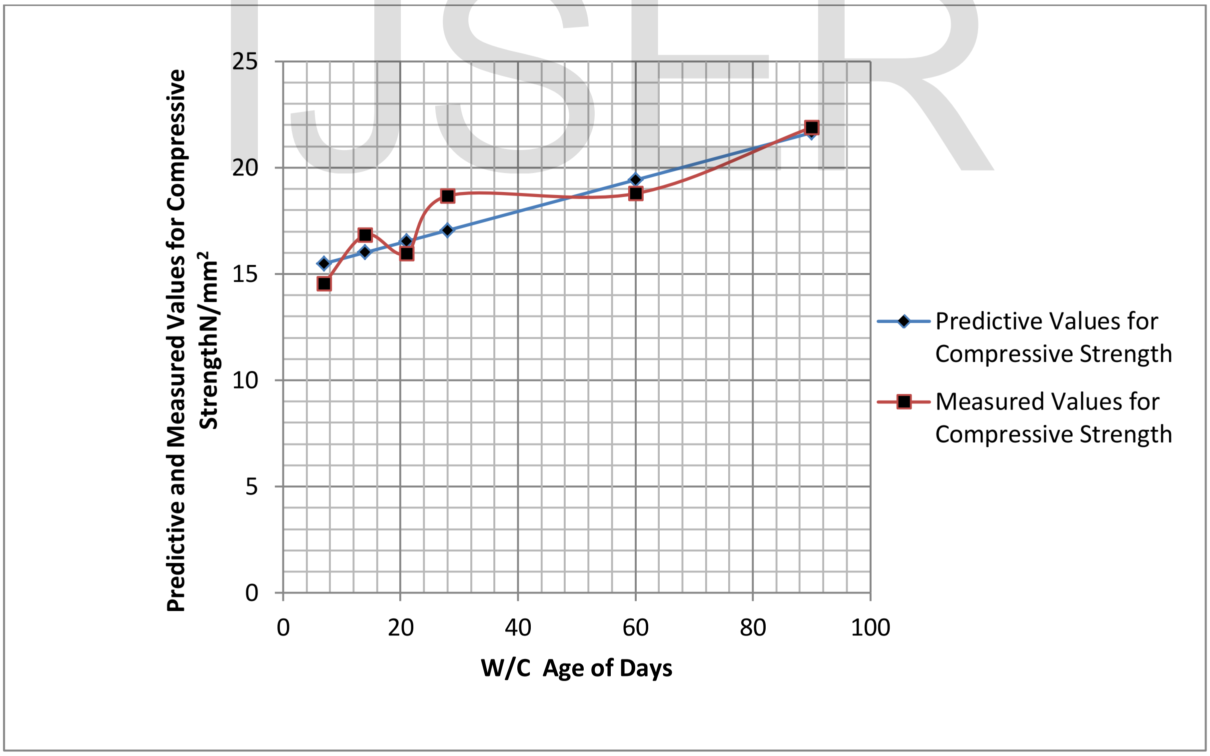

Figure: 17 Predictive and measured values of compressive strength w-mix 0.50w/c at different curing age

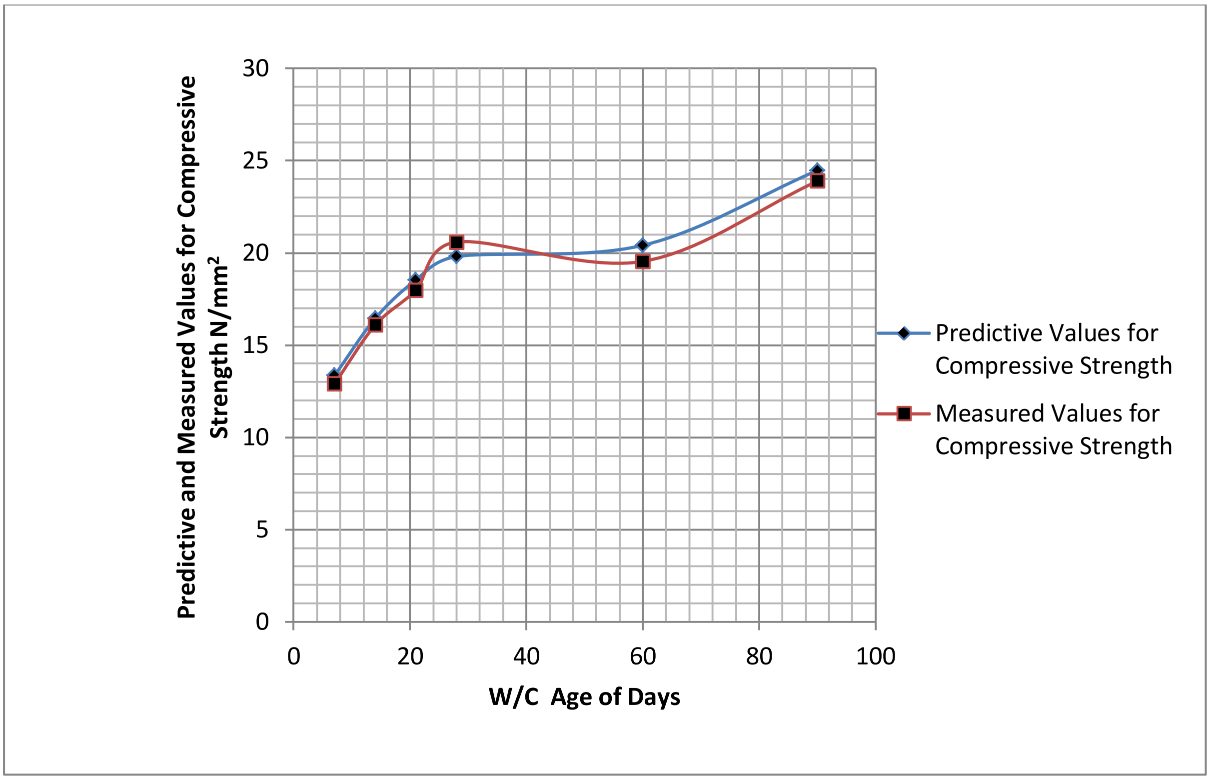

Figure: 18 Predictive and measured values of compressive strength w-mix 0.55 w/c at different curing age

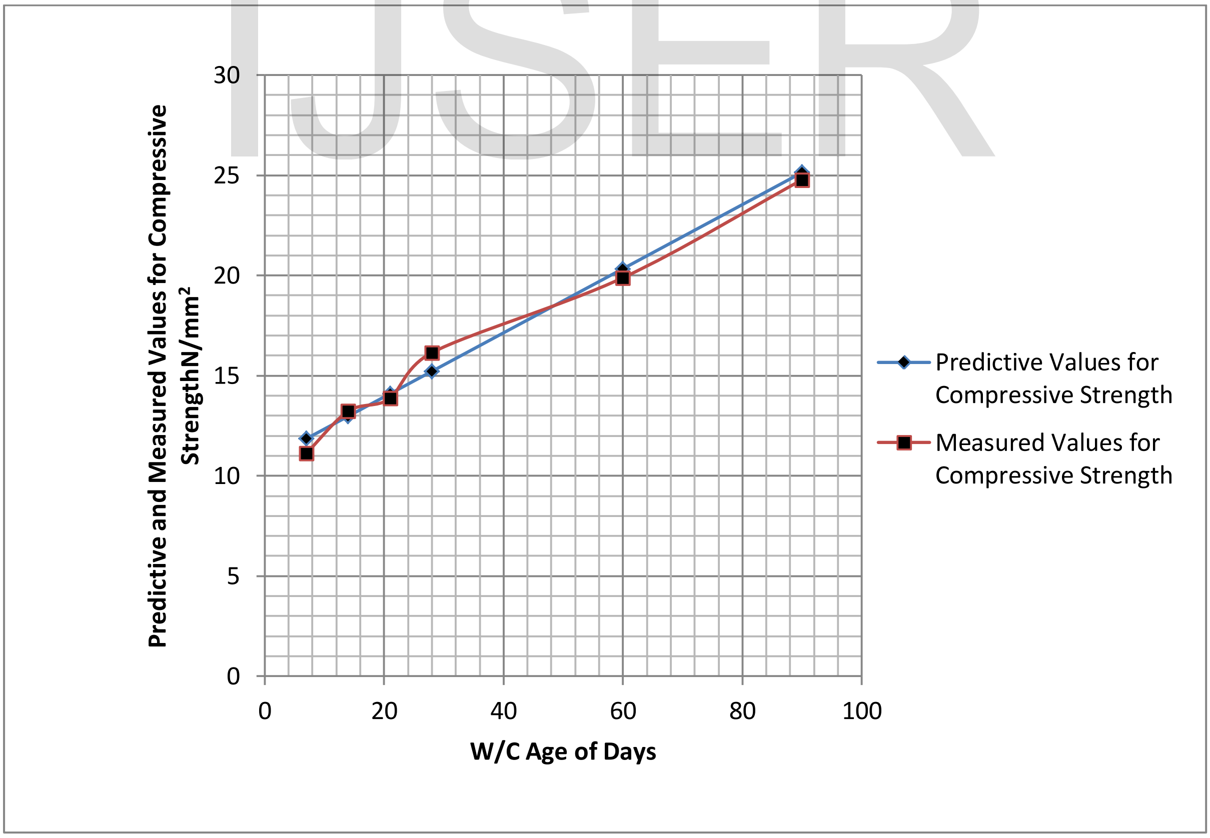

Figure: 19 Predictive and measured values of compressive strength w-mix 0.60w/c at different curing age

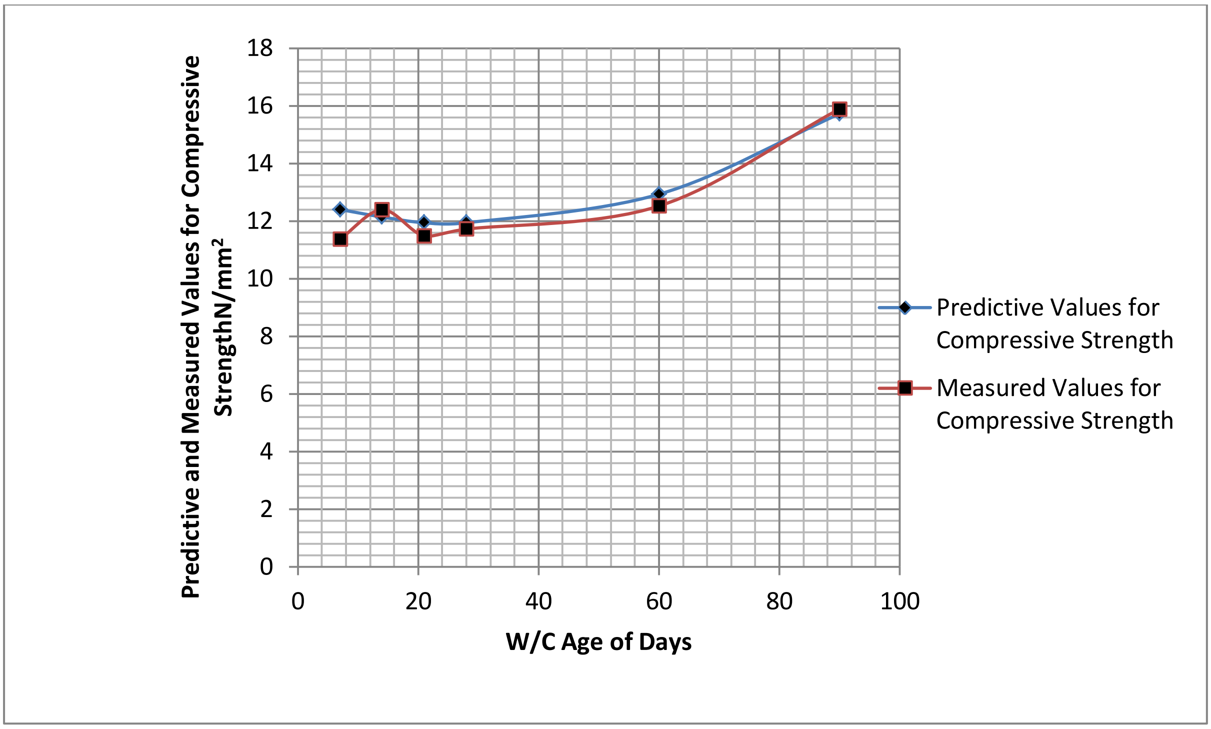

Figure: 20 Predictive and measured values of compressive strength w-mix 0.65 w/c at different curing age

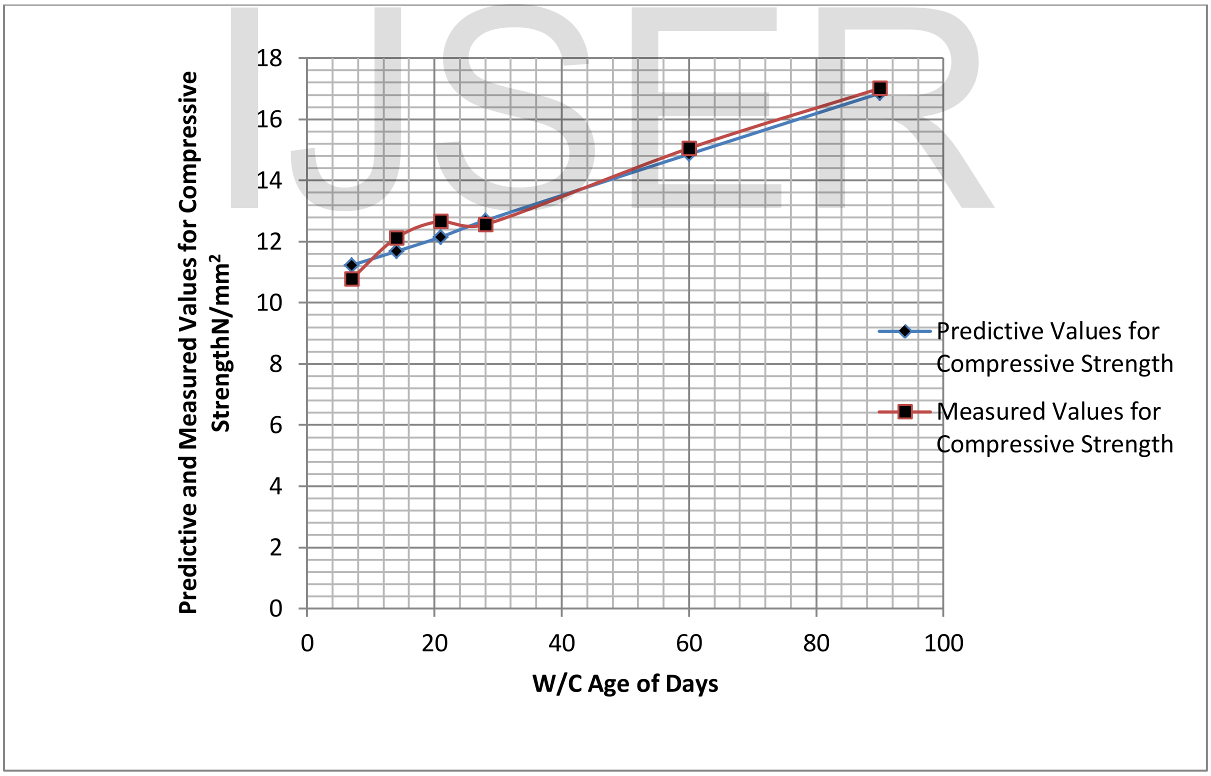

Figure: 21 Predictive and measured values of compressive strength w-mix 0.70 w/c at different curing age

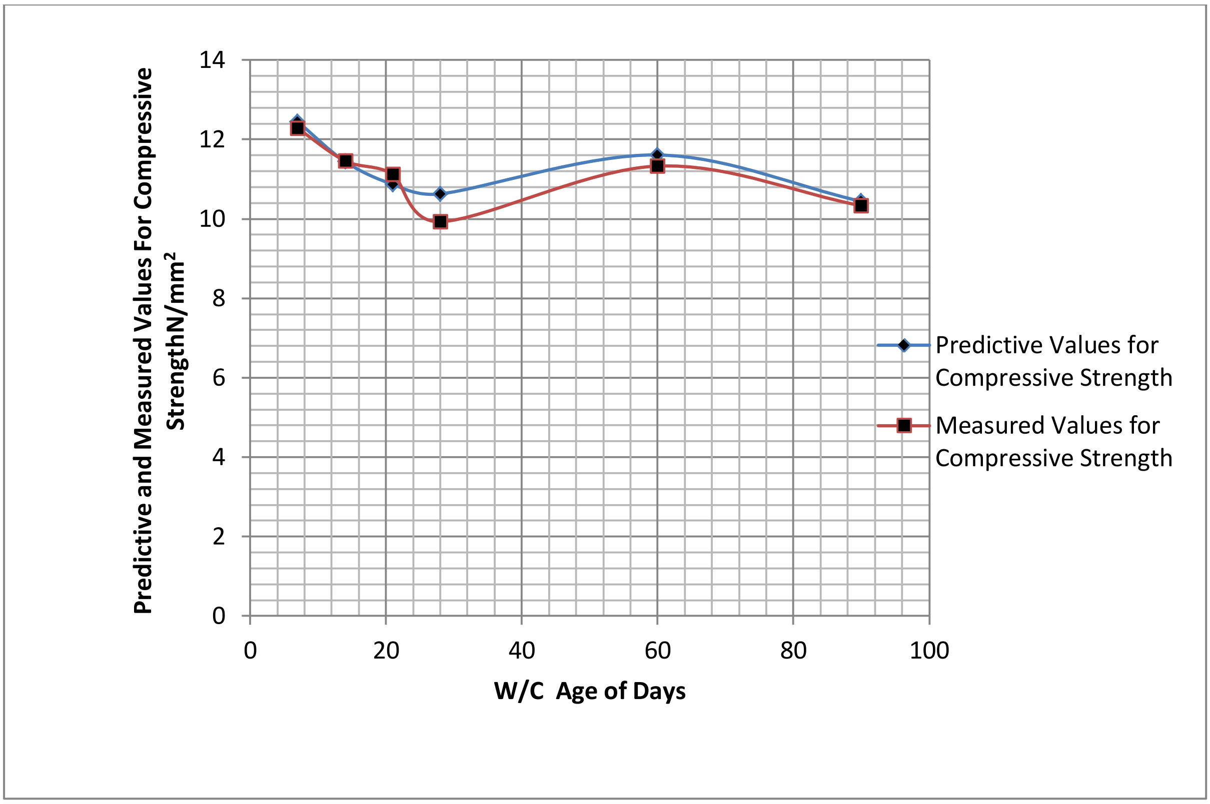

Figure: 22 Predictive and measured values of compressive strength w-mix 0.75 w/c at different curing age

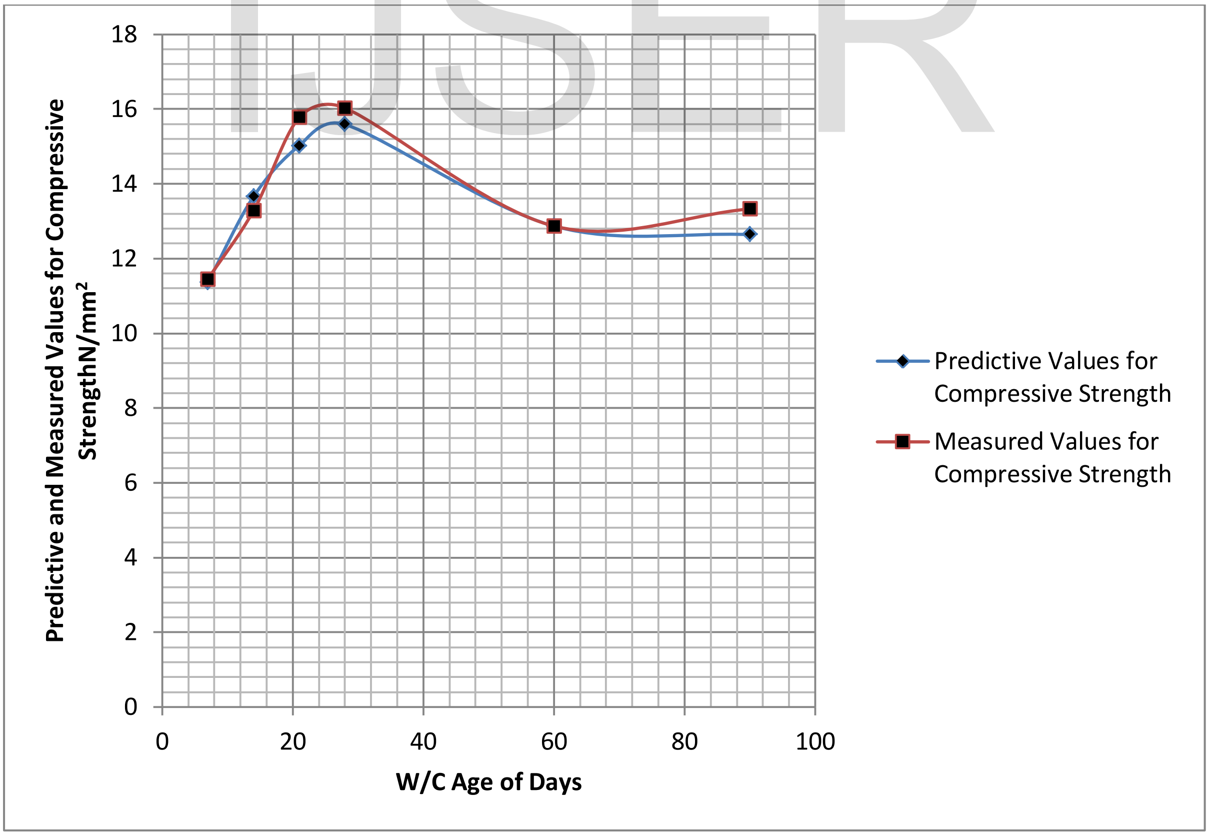

Figure: 23 Predictive and measured values of compressive strength w-mix 0.89 w/c at different curing age

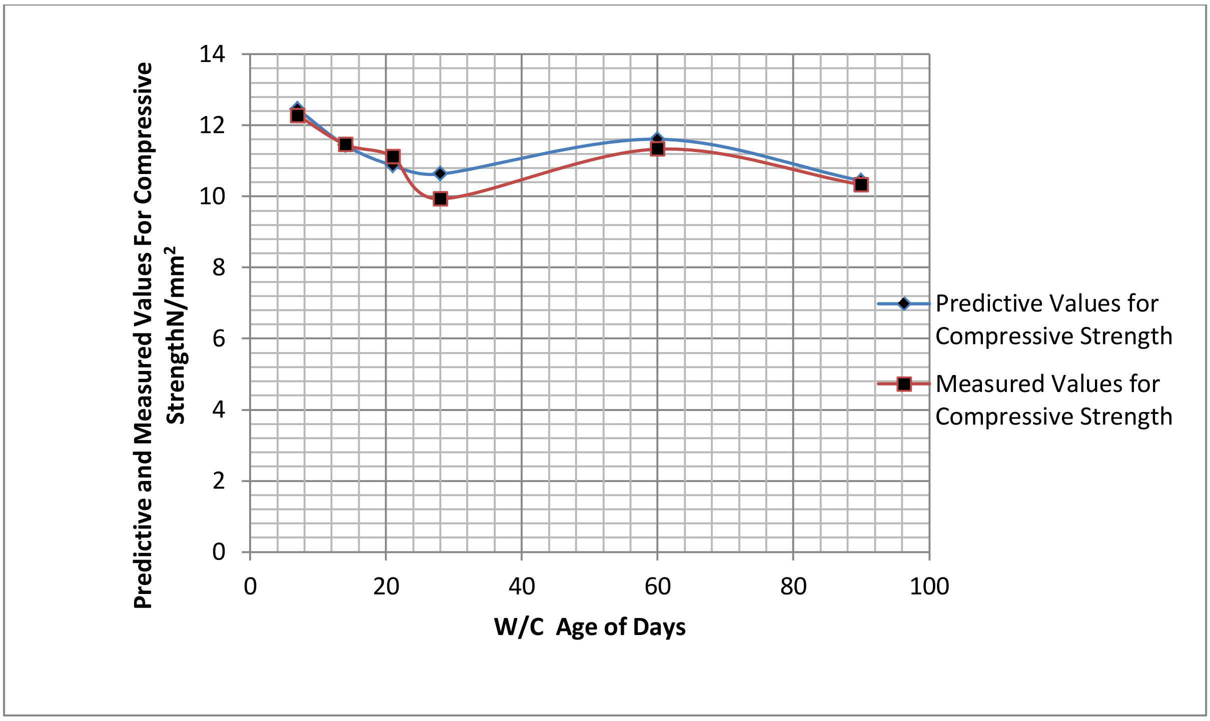

Figure: 24 Predictive and measured values of compressive strength w-mix 0.85w/c at different curing age

The derived predictive model for compressive rate of concreted generated from unwashed and washed locally 3/8 gravel at various mix ratio and curing time, these has been expressed through graphical representation showing various ways that compressive strength are obtained in various curing age. Figure one the predictive and measured values express the compressive strength in gradual in fluctuation within seven and twenty eight days, thus express the optimum values at sixty days, sudden increase were observed at the lowest rate at ninety curing days.. Figure two express fluctuation with gradual increase to the maximum compressive strength sixty days, thus declined down ninety curing days. Figure three express oscillations similar to previous figures, the maximum values at ninety days. Figure four express slight increases within seven and twenty to the optimum values at ninety days for measured values, while predictive express linear to the lowest at ninety days. figure five predictive and measured express slight vacillation and gradually increase to the maximum values at sixty days, sudden decrease were observe to the lowest at ninety days, figure six s observed gradual increase to the optimum values at sixty with slight decrease at ninety days figure seven predictive and measured values observed gradual increase with slight fluctuation where maximum values at twenty eight for measured while predictive recorded at sixty days. Figure eight experienced gradual increase to the maximum values at ninety days. Figure nine predictive and measured values maintained similar condition as gradual increase were also observed with slight vacillation increase to the optimum values recoded at ninety curing age.

Figure ten experienced fluctuation between seven and twenty sixty days to the optimum values were recorded at ninety days. Figure eleven developed linear from seven to ninety days.. Figure twelve predictive and measured values rapidly increase with slight fluctuation to the optimum values recorded at ninety days. Figure thirteen express fluctuations between seven and twenty eight days with rapid increase from sixty to ninety days. Figure fourteen maintained vacillation between seven and twenty eight days thus observed gradual increase to the maximum values recorded at ninety. Figure fifteen observed gradual increase with fluctuation to maximum values at ninety days, Figure sixteen predictive and measured values observed fluctuations between seven and twenty eight days and suddenly increase to the optimum values recorded at ninety days. Figure seventeen express vacillation for measured and linear for predictive to the point where the maximum values were recorded at ninety days. Figure eighteen predictive and measured maintained similar conditions fluctuation like the previous figure were observed down to the maximum values recorded at ninety curing days. Figure ninety days developed linear increase to the optimum values at ninety days. Figure twenty generated slight fluctuation , the optimum values recoded at twenty eight days thus experienced rapid declined between sixty and ninety day. Figure twenty one predictive and measured values maintained linear increase to the maximum values at ninety days. Figure twenty two, gradually increase between seven and twenty eight thus developed sudden decrease at sixty days with slight increase at ninety days. Figure twenty three express gradual increase to the optimum recorded at twenty eight days, thus developed slight increase at ninety days. Figure twenty four generated fluctuation between seven twenty eight were the highest values were recorded thus finally developed slight decrease at ninety days. Figure twenty five developed slight fluctuations from seven and twenty eight days, thus experienced sudden decrease from sixty to ninety curing days.

4. Conclusion

The compressive strength of local occurring 3/8 gravel were subjected to empirical modelling techniques to generated theoretical values through derived empirical equations. These developed theoretical values were calibrated to generated developed empirical equation at various water cement ratio from locally occurring sorted 3/8 gravel, it was characterized to unwashed and washed samples, developing mix designed applied using different water cement ratios express various results, these produced the generated empirical equations for compressive strength of concrete, the study were able to examine compressive strength at various curing age. The generated predictive values express variations of compressive strength at different curing time, washed and unwashed local occurring 3/8 gravel subjected to characterization express the rate of compressive strength of these material through graphical representations. Compressive strength in most concrete formations attained strength between twenty eight and nicety days, the influences are from variation in compaction including water cement ratios, it will definitely generate bleeding and segregations developing degradation in compressive values, the predictive values express favourable fits with the measured values, these has validated the developed model for concrete applying locally occuring 3/8 gravel and water cement ratios, the derived model will be applied to monitor concrete performances using locally occurring 3/8 gravel.

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