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PREDICTIVE MODEL TO MONITOR THE VARIATION OF CONCRETE DENSITY INFLUENCED BY VARIOUS GRADES FROM LOCALLY 3/8 GRAVEL AT DIFFERENT CURING TIME

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Abstract - The densities of concrete were monitored applying locally occurring 3/8 gravel, the material were used to generate various concrete performances in unwashed and washed at different water cement ratios, the study through calibrations developed model at different water cement ratios from washed and unwashed locally occurring 3/8 gravel concrete, the results express various effect from impurities on the density in unwashed than washed concrete, porosity relating to compaction of concrete formation made with this locally occurring 3/8 gravel were observed to have effect on its rate of density of concrete in some samples. While water cement ratios were found to affect the densities of some samples in various curing age, the densities of these concrete at different water cement ratios express various theoretical values that were compared with other measured values, both parameters generated best fits validating the developed theoretical values of densities at different water cement ratios and curing age, these measures can be apply to monitor higher concrete performances.

Keywords: predictive model, concrete density, and locally 3/8 gravel

1. Introduction

Every concrete formations requires curing in order that cement hydration can continue so as to permit for development of strength, these express its durability and other mechanical characteristics Akeem et al 2013. To achieve good concrete, specification on the placing of an appropriate mix must be followed by curing in appropriate environment, particularly during the early stages of hardening. According to Neville (1996), curing is the name given to measures applied for promoting hydration of cement, and its consistency in a controlled temperature and moisture movement from and into the concrete Eluozo and Ode 2015a, Eluozo and Ode 2015b, Eluozo and Ode 2015c). Price (1991) it also refers to curing as the procedure of protecting concrete for a specified stage of days after placement, it also supply moisture for hydration of the cement, these will definitely to supply proper temperature and to protect the concrete from damage by loading or Mechanical disturbance. Curing is designed bases to maintain the concrete moist by preventing loss of moisture throughout the period in which it is gaining strength. Curing can be attain by maintenance of the concrete element completely soaked or as much soaked as possible until the water-filled spaces are substantially declined by hydration products (Gowripalan *et al.*, 1992,adesanya et al 2002). This means that if the dampness of the ambient air is at smallest amount thus high, then it implies that there will be no need for active curing in other to ensure continuing hydration, because there will be slight movement of water within the concrete including ambient air. In most parts of the world like Nigeria, the relative dampness falls below 80 per cent at a certain period in a day, this implies that it may not permit voluntary curing but rather would demand active curing. But if the concrete is not cured and it is allowed to dry through air, it will gain only 50% of the strength of continuously cured concrete (Mamlouk and Zaniewski, 2006). But if concrete is not subjected to thorough curing, mostly at the early days, it will definitely not attained the required properties at preferred level due to a lower degree of hydration, and would suffer from irreparable loss (Ramezanianpour and Malhotra, 1995; Zain *et al*., 2000). Inappropriate curing would involve insufficient moisture and this has been observed to produce cracks, compromise strength, and decline long-term durability (Wojcik and Fitzgarrald, 2001 Ephraim and Ode 2004). It is an established fact that many other factors affect the development of strength of concrete and as a result its toughness other than curing or the curing method applied. These factors include quality and quantity of cement applied in a mix, grading of aggregates, maximum nominal size, shape and surface texture of aggregate (Arum and Alhassan, 2005) water/cement ratios, degree of compaction (Aluko, 2005) and the presence or otherwise of clayey particles and organic matter in the mix (Arum and Udoh, 2005). The scope of discussion in this study is methods of curing concrete (B.S 1990).

2. Materials and method

Standard laboratory experiment where performed to monitor concrete densities at different curing age, the deposition of concrete densities were determined at different water cement ratios, the experimental results are applied to be compared with the theoretical values to determined the validation of the model.

3. Results and Discussion

Results and discussion are presented in tables including graphical representation of water absorption at different water cement ratios.

Table: 1 Predictive and Measured Value for Density [0.45] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.45] KgM^3	Measured Density values for U-MIX [0.45]KgM^3
7	2195.35	2110
14	2218.47	2120
21	2107.38	2110
28	2022.16	2060
60	1220.76	1105
90	2261.34	2140

Table: 2 Predictive and Measured Values for Density [0.50] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.50] KgM^3	Measured Density values for U-MIX [0.50] KgM^3
7	2227.89	2222
14	2210.06	2240
21	2198.49	2180
28	2193.2	2220
60	2248.9	2245
90	2420.12	2410

Table: 3 Predictive and Measured Values for Density [0.55] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.55] KgM^3	Measured Density values for U-MIX [0.55] KgM^3
7	2222.41	2226
14	2235.47	2241
21	2246.18	2250
28	2254.54	2246
60	2262.8	2267
90	2225.9	2227

Table: 5 Predictive and Measured Values for Density [0.50] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.60] KgM^3	Measured Density values for U-MIX [0.60] KgM^3
7	2230.56	2220
14	2276.62	2260
21	2299.3	2296
28	2300.5	2310
60	2091.8	2080
90	1704.5	1660

Table: 6 Predictive and Measured Values for Density [0.55] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.65] KgM^3	Measured Density values for U-MIX [0.65] KgM^3
7	2250.09	2270
14	2268.742	2230
21	2274.94	2270.6
28	2268.7	2220
60	2081.66	2130
90	1670.09	1590

Table: 7 Predictive and Measured Values for Density [0.70] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.70] KgM^3	Measured Density values for U-MIX [0.70] KgM^3
7	2213.41	2215
14	2268.7	2240
21	2286.81	2260
28	2270.15	2320
60	1939.4	1800
90	1634.9	1190

Table: 7b Predictive and Measured Values for Density [0.75] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.75] KgM^3	Measured Density values for U-MIX [0.75] KgM^3
7	2228.9	2227
14	2234.43	2240
21	2237.57	2240
28	2241.3	2250
60	2270.33	2280
90	2257.3	2260

Table: 8 Predictive and Measured Values for Density [0.80] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.80] KgM^3	Measured Density values for U-MIX [0.80] KgM^3
7	2255.28	2245
14	2263.29	2240
21	2269.07	2270
28	2272.58	2270
60	2259.94	2260
90	2205.31	2207

Table: 9 Predictive and Measured Values for Density [0.85] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.85] KgM^3	Measured Density values for U-MIX [0.85] KgM^3
7	2221.08	2224
14	2232.67	2220
21	2242.84	2235
28	2251.51	2246
60	2331.66	2370
90	2264.16	2266

Table: 10 Predictive and Measured Values for Density [0.90] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.90] KgM^3	Measured Density values for U-MIX [0.90] KgM^3
7	2256.96	2260
14	2237.39	2239
21	2229.28	2226
28	2269.42	2250
60	2394.02	2360
90	2762.93	2620

Table: 11 Predictive and Measured Values for Density [0.95] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [0.95] KgM^3	Measured Density values for U- MIX [0.95] KgM^3
7	2241.98	2230
14	2224.53	2216
21	2208.64	2230
28	2194.33	2188
60	2148.86	2139
90	2135.99	2130

Table: 12 Predictive and Measured Values for Density [1.00] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [1.00] KgM^3	Measured Density values for U- MIX [1.00] KgM^3
7	2230.66	2260
14	2256.61	2260
21	2267.87	2260
28	2264.42	2270
60	2061.48	2050
90	1592.22	1760.4

Table: 13 Predictive and Measured Values for Density [0.1.05] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [1.05] KgM^3	Measured Density values for U-MIX [1.05] KgM^3
7	2109.09	2121
14	2210.08	2260
21	2234.48	2240
28	2259.75	2270
60	2116.2	2180
90	1726.8	2130

Table: 14 Predictive and Measured Values for Density [1.10] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for U -MIX [1.10] KgM^3	Measured Density values for U-MIX [1.10] KgM^3
7	2219.66	2230
14	2291.54	2285
21	2327.74	2310
28	2332.39	2430
60	2066.6	2030
90	1646.3	1830

Table: 15 Predictive and Measured Values for W-Density [0.35] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.35] KgM^3	Measured Density values for W-MIX [0.35] KgM^3
7	2128.16	2135
14	2029.44	2040
21	2044.2	2055
28	1635.31	1730
60	-75631	-7896
90	2604	2709

Table: 16 Predictive and Measured Values for Density W-[0.45] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.45] KgM^3	Measured Density values for W-MIX [0.45] KgM^3
7	2449.94	2440
14	2469.52	2470
21	2486.76	2490
28	2539.27	2520
60	2538.72	2520
90	2530.78	2530

Table: 17 Predictive and Measured Values for Density W-[0.45] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.50] KgM^3	Measured Density values for W-MIX [0.50] KgM^3
7	2486.59	2495
14	2501.17	2490
21	2483.79	2550
28	2454.79	2458
60	2444.2	2450
90	2243.8	2290

Table: 18 Predictive and Measured Values for Density W- [0.55] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.55] KgM^3	Measured Density values for W-MIX [0.55] KgM^3
7	2582.41	2592
14	2560.05	2551
21	2540.93	2514
28	2525.04	2572
60	2493.58	2487
90	2525.47	2535

Table: 19 Predictive and Measured Values for Density W- [0.60] of Concrete at Different Age of Days

Age [Days]	Predictive Density values for W -MIX [0.60 W/C] kg/m^3	Measured Density values for W-MIX [0.60] KgM^3
7	2453.44	2457
14	2461.78	2470
21	2470.03	2465
28	2478.18	2474
60	2514.18	2518
90	2546.07	2548

Table: 20 Predictive and Measured Values for Density W- [0.65] of Concrete at Different Age of Days

Age [Days]	Predictive Density values for W -MIX [0.65 W/C] KgM^3	Measured Density values for W-MIX [0.65] KgM^3
7	2444.11	2442
14	2448.74	2471
21	2461.49	2422
28	2429.58	2472
60	2418.46	2442
90	2341.69	2332

Table: 21 Predictive and Measured Values for Density W- [0.70] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.70] KgM^3	Measured Density values for W-MIX [0.70] KgM^3
7	2411.95	2417
14	2427.83	2440
21	2435.16	2427
28	2426.52	2430
60	2241.02	2250
90	1977.83	1890

Table: 22 Predictive and Measured Values for Density W- [0.75] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.75] KgM^3	Measured Density values for W-MIX [0.75] KgM^3
7	2508.82	2560
14	2459.69	2460
21	2437.53	2420
28	2438.19	2440
60	2617.2	2640
90	2590.6	2550

Table: 23 Predictive and Measured Values for Density W- [0.80] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.80] KgM^3	Measured Density values for W- MIX [0.80] KgM^3
7	2448.73	2420
14	2408.89	2418
21	2548.22	2530
28	2366.18	2264
60	2454.02	2440
90	2770.73	2690

Table: 24 Predictive and Measured Values for Density W- [0.85] of Concrete at Different Age of Days

W/C Density Age of Days	Predictive Density values for W -MIX [0.85] KgM^3	Measured Density values for W- MIX [0.85] KgM^3
7	2487.34	2475
14	2493.23	2450
21	2489.33	2470
28	2477.48	2460
60	2379.66	2330
90	2451.19	2440

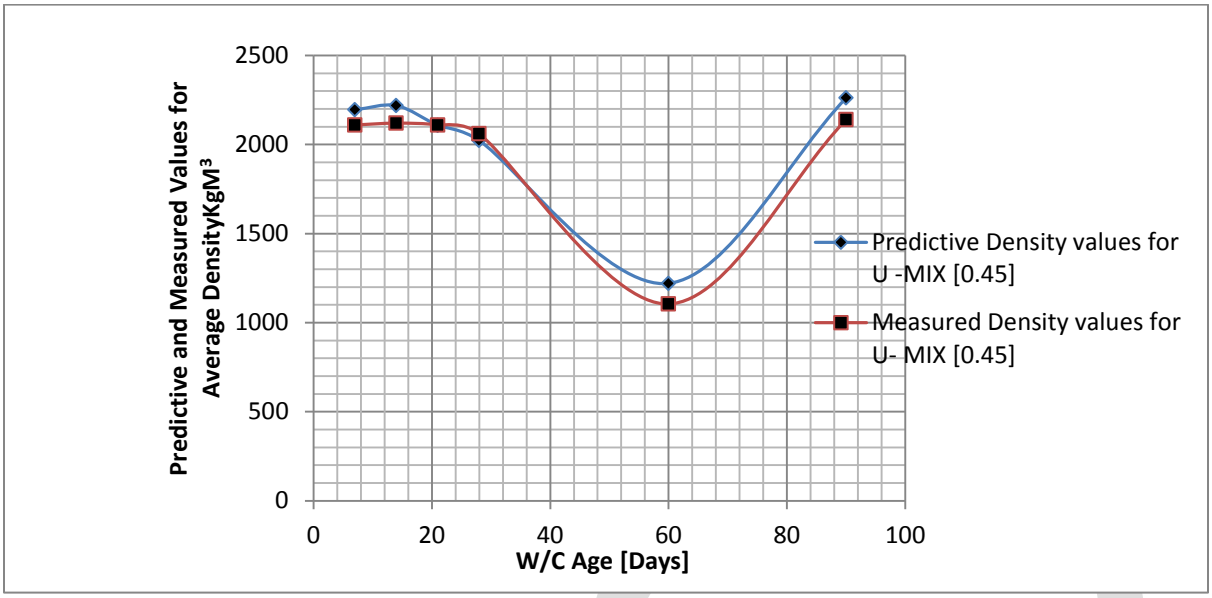

Figure: 1 Predictive and Measured Value for Density U- [0.45] of Concrete at Different Age of Days

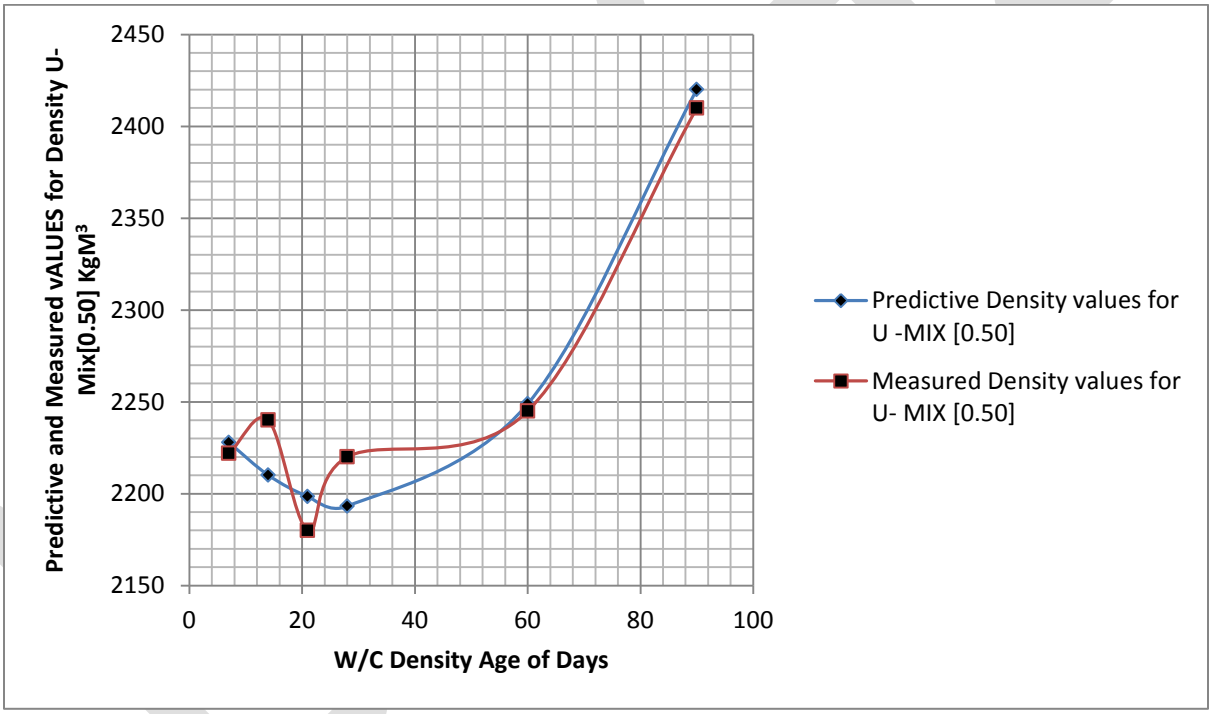

Figure: 2 Predictive and Measured Values for Density U- [0.50] of Concrete at Different Age of Days

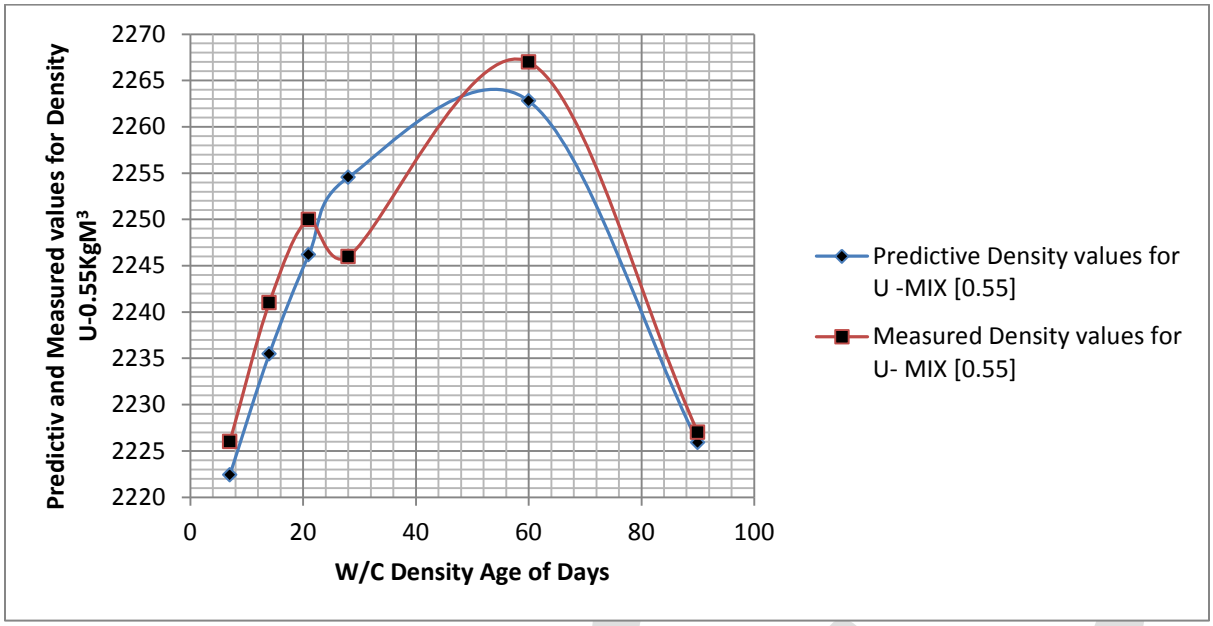

Figure: 3 Predictive and Measured Values for Density U- [0.55] of Concrete at Different Age of Days

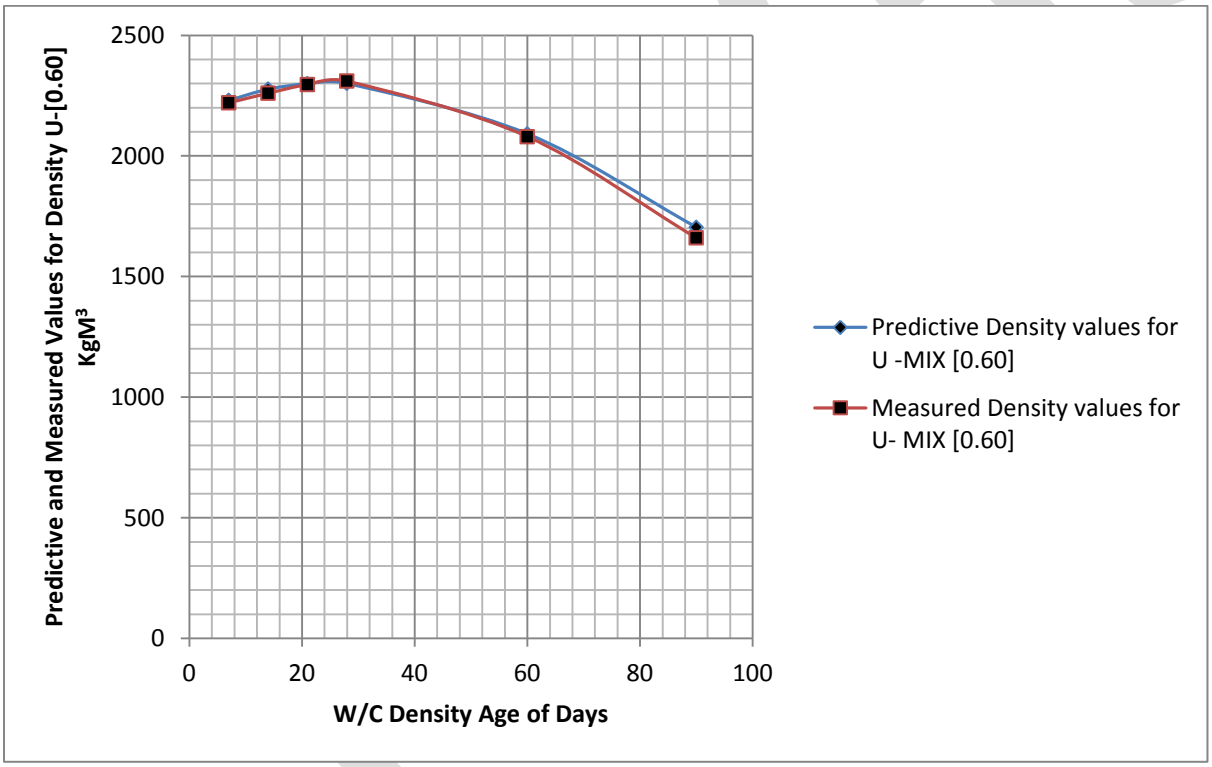

Figure: 4 Predictive and Measured Values for Density U- [0.60] of Concrete at Different Age of Days

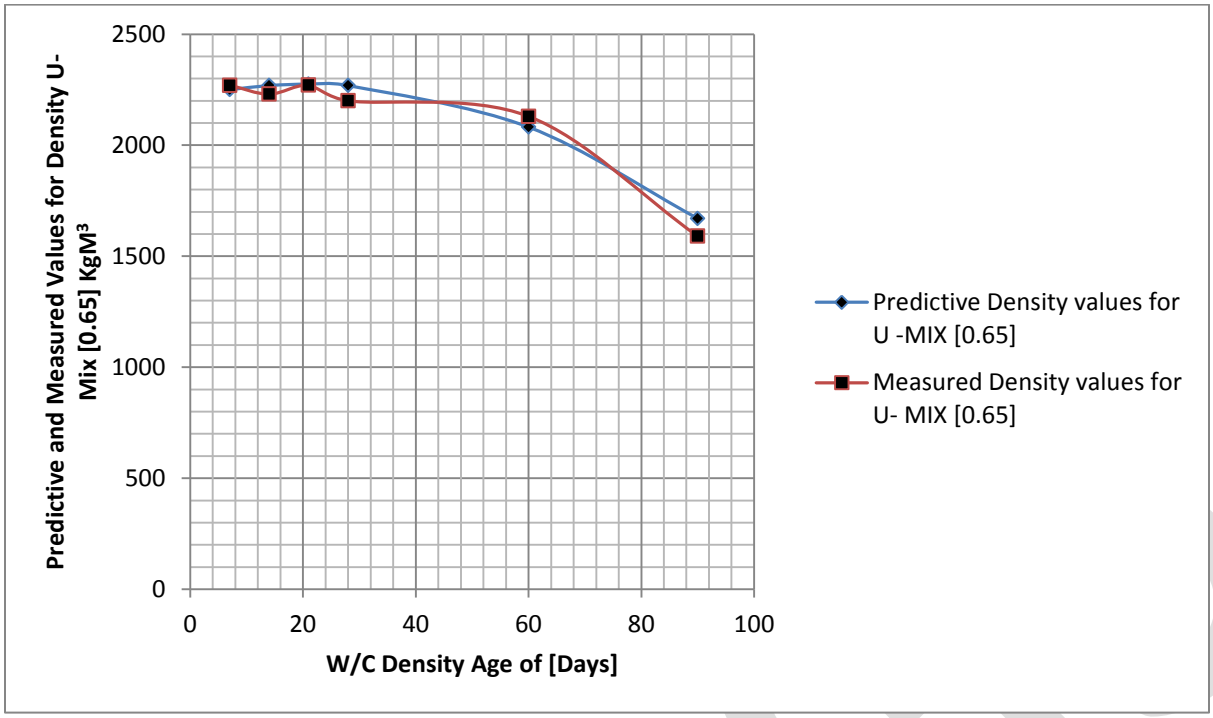

Figure: 5 Predictive and Measured Value for Density U- [0.65] of Concrete at Different Age of Days

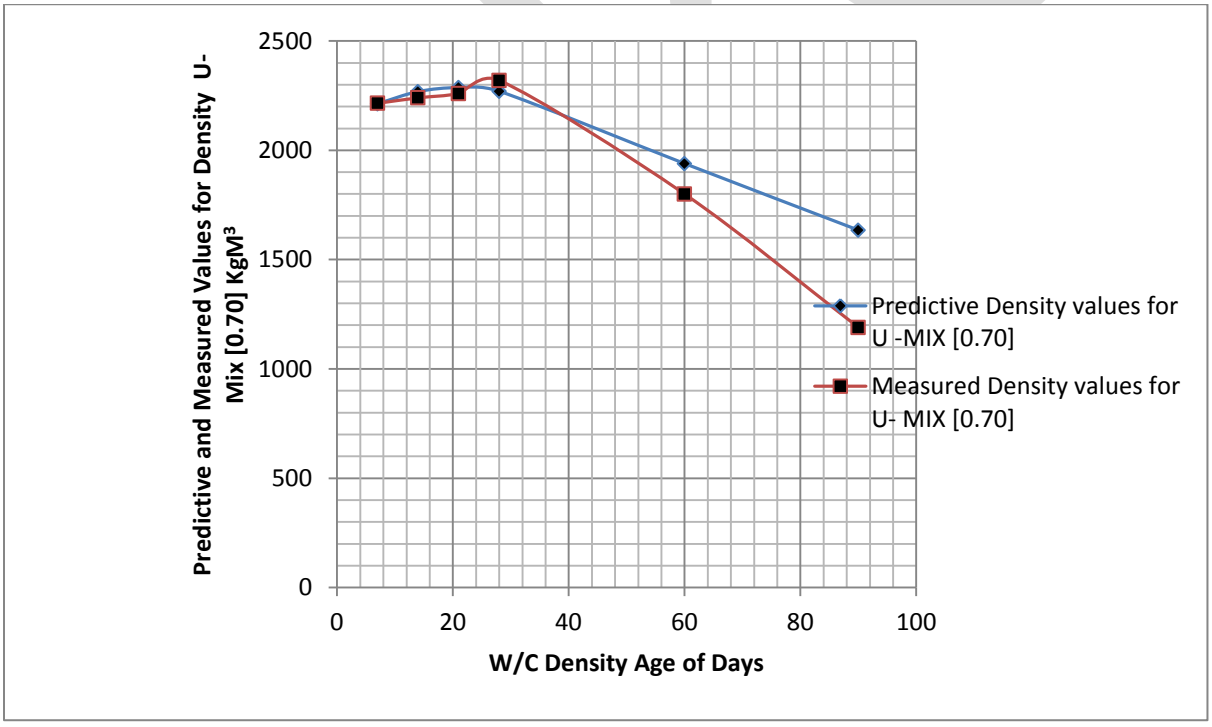

Figure: 7 Predictive and Measured Values for Density U- [0.70] of Concrete at Different Age of Days

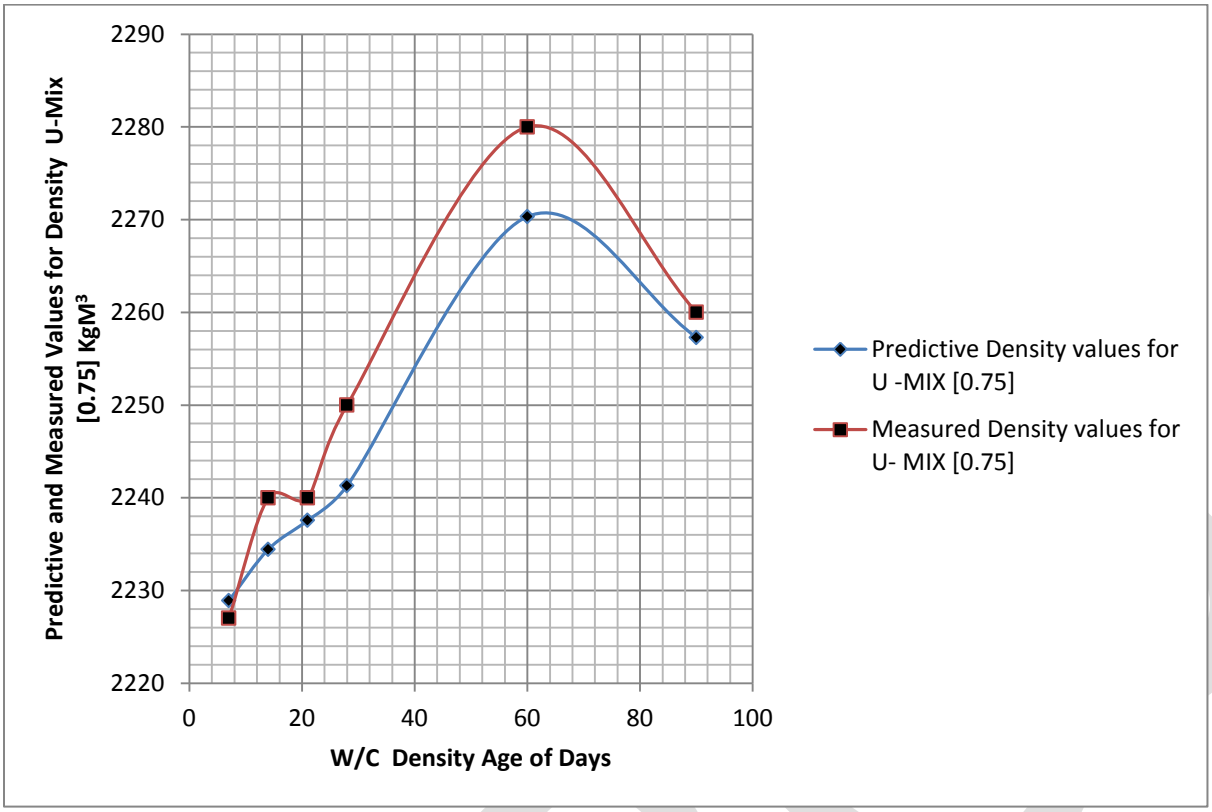

Figure: 8 Predictive and Measured Values for Density U- [0.75] of Concrete at Different Age of Days

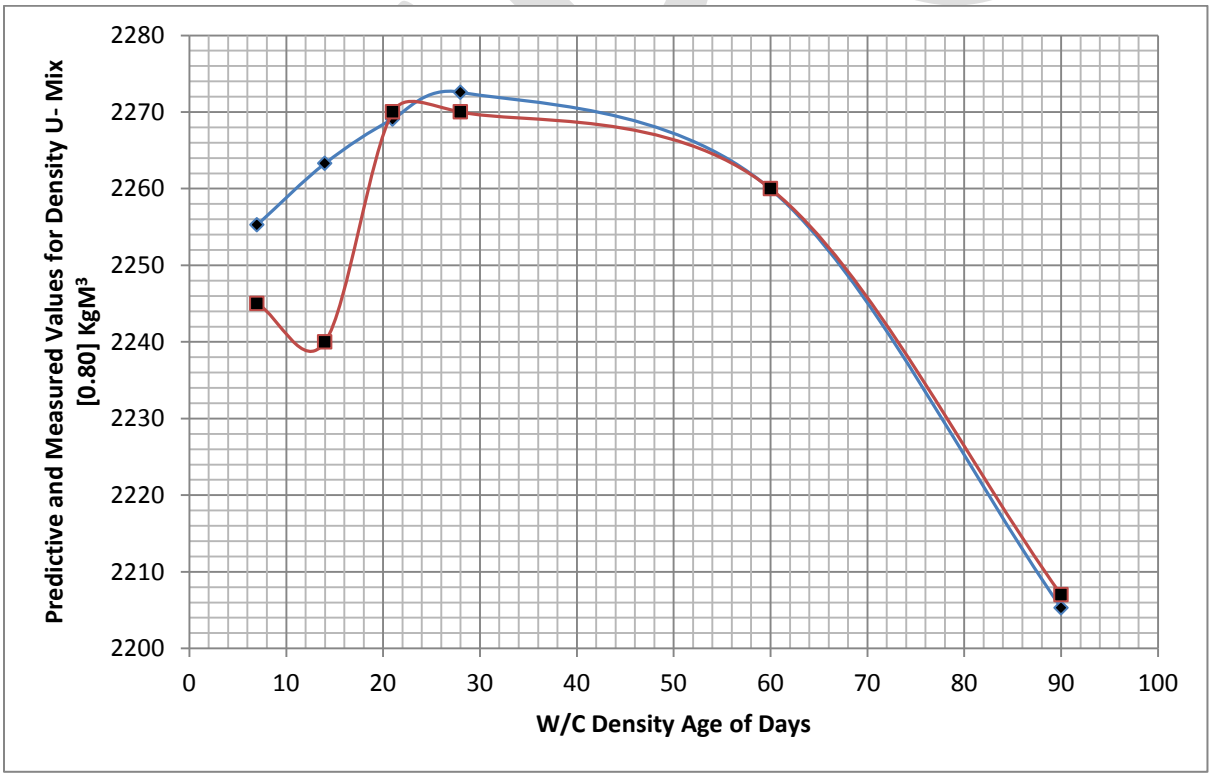

Figure: 9 Predictive and Measured Values for Density U- [0.80] of Concrete at Different Age of Days

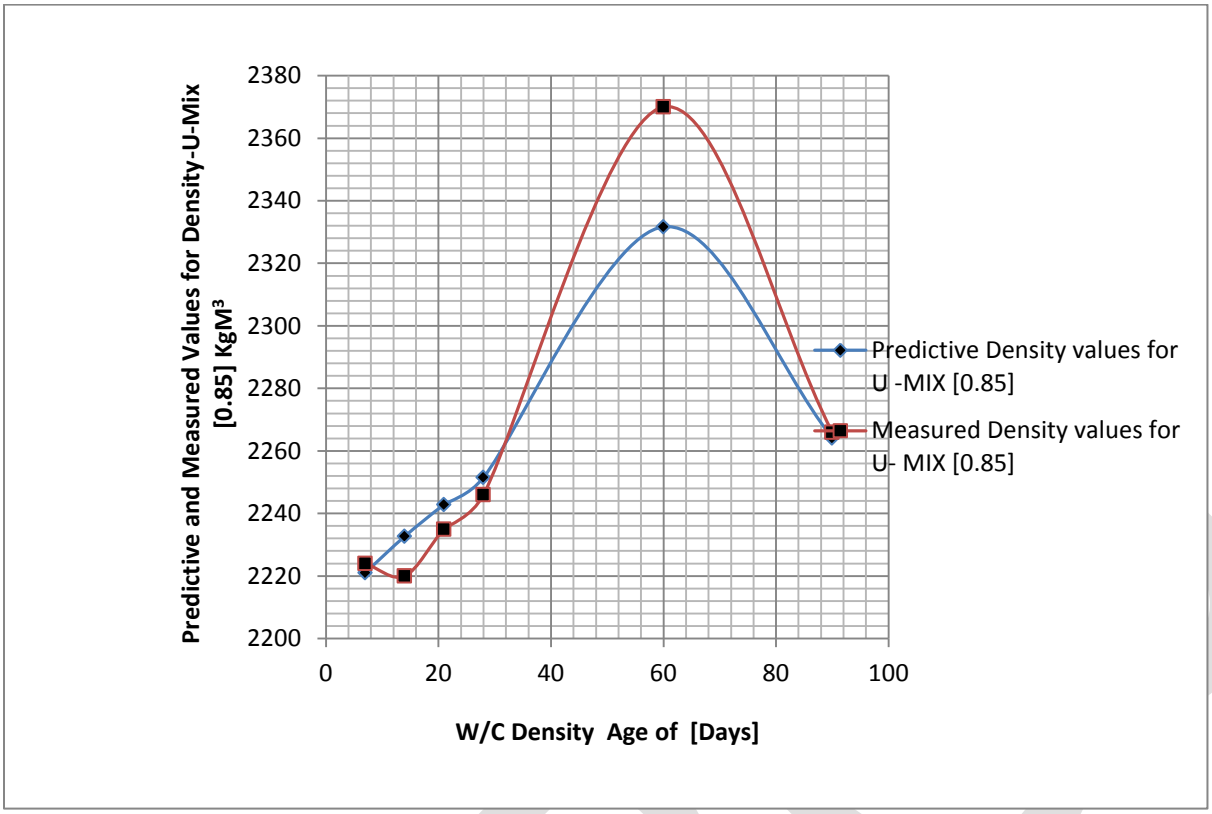

Figure: 10 Predictive and Measured Values for Density U- [0.85] of Concrete at Different Age of Days

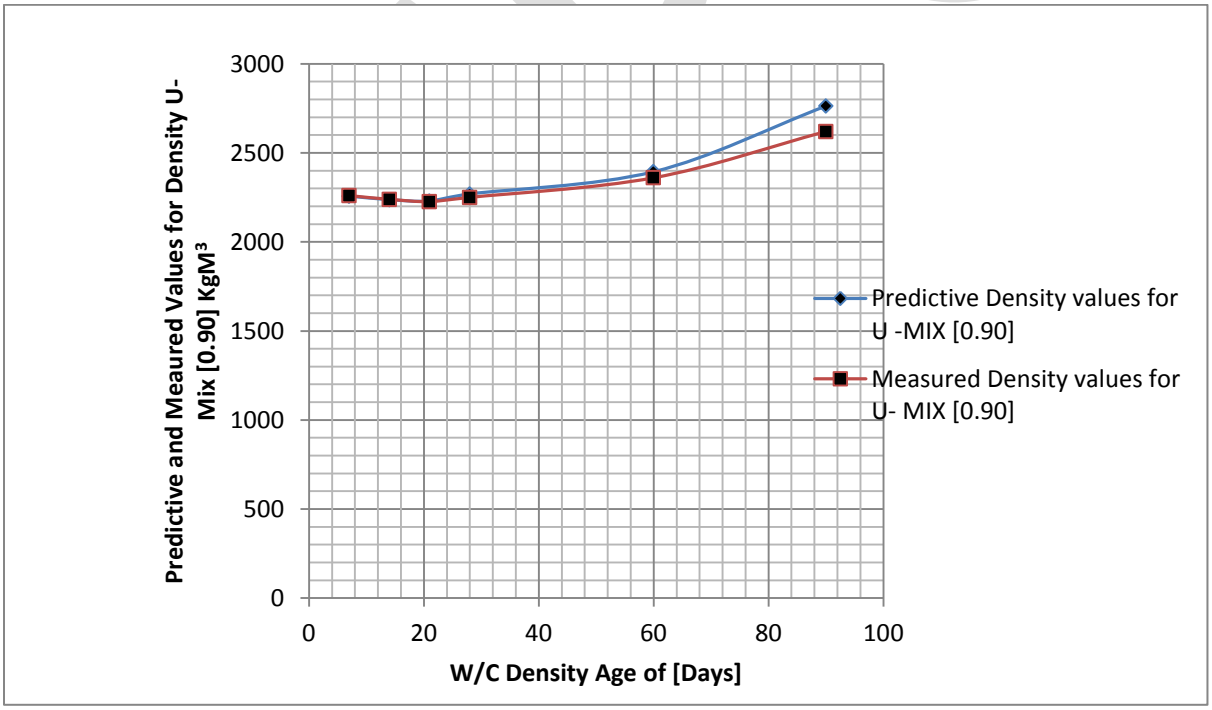

Figure:11 Predictive and Measured Values for Density U- [0.90] of Concrete at Different Age of Days

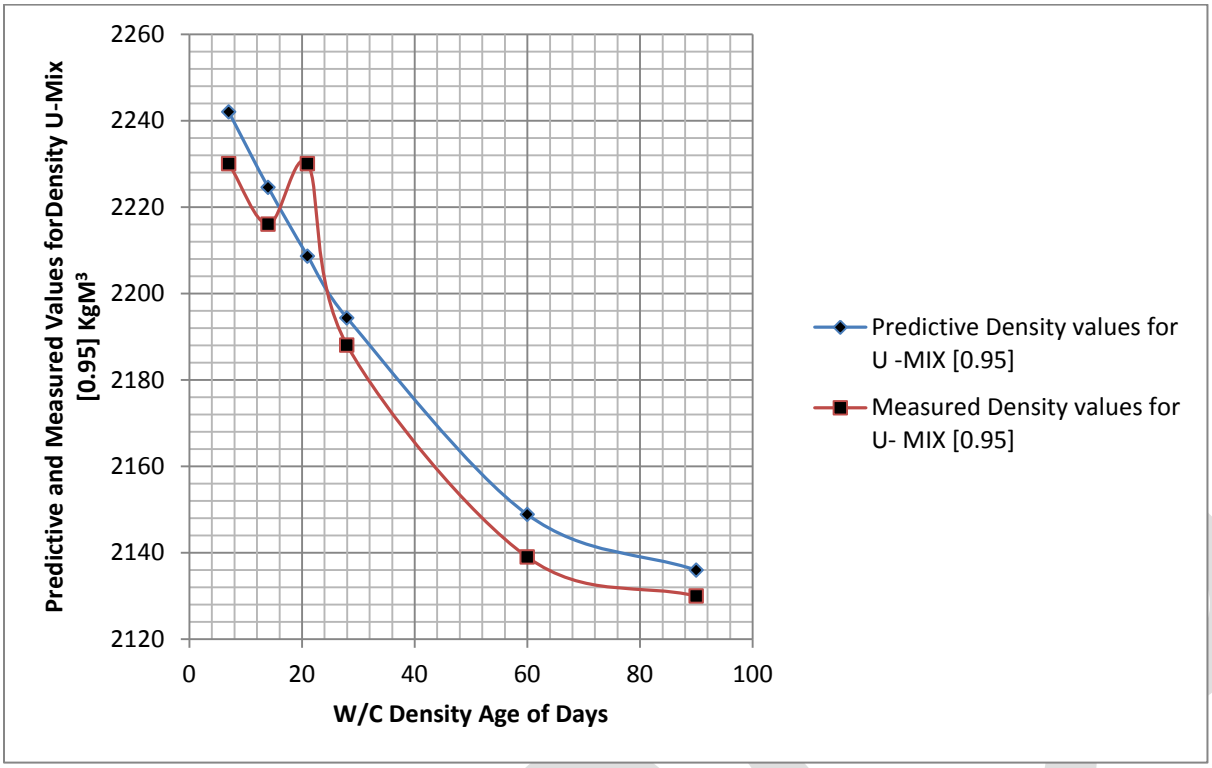

Figure: 12 Predictive and Measured Values for Density U- [0.95] of Concrete at Different Age of Days

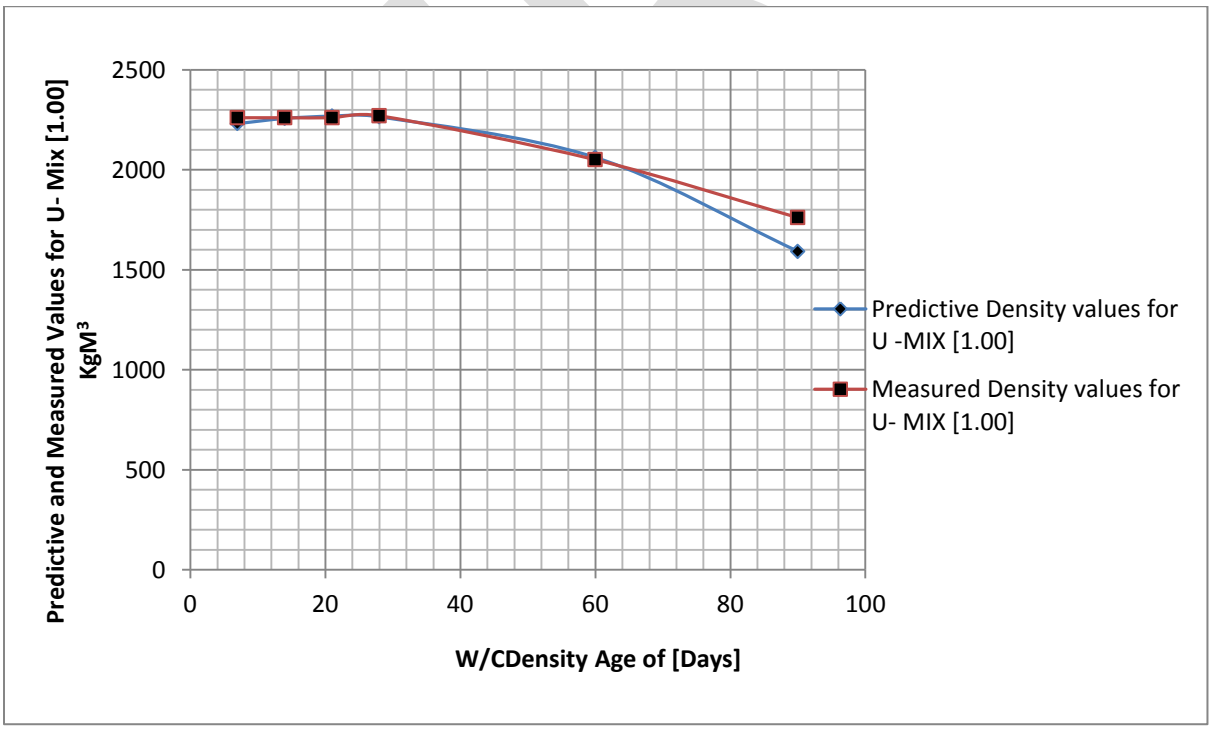

Figure: 13 Predictive and Measured Values for Density U- [1.00] of Concrete at Different Age of Days

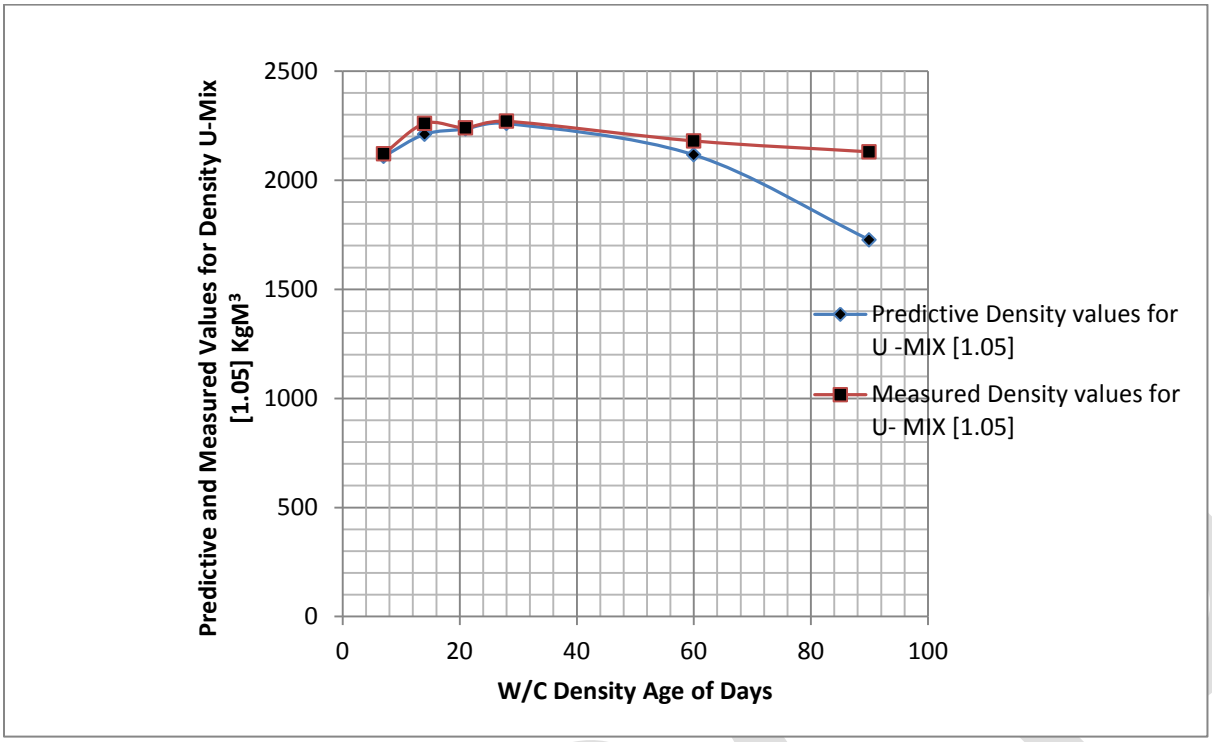

Figure: 14 Predictive and Measured Values for Density U- [1.05] of Concrete at Different Age of Days

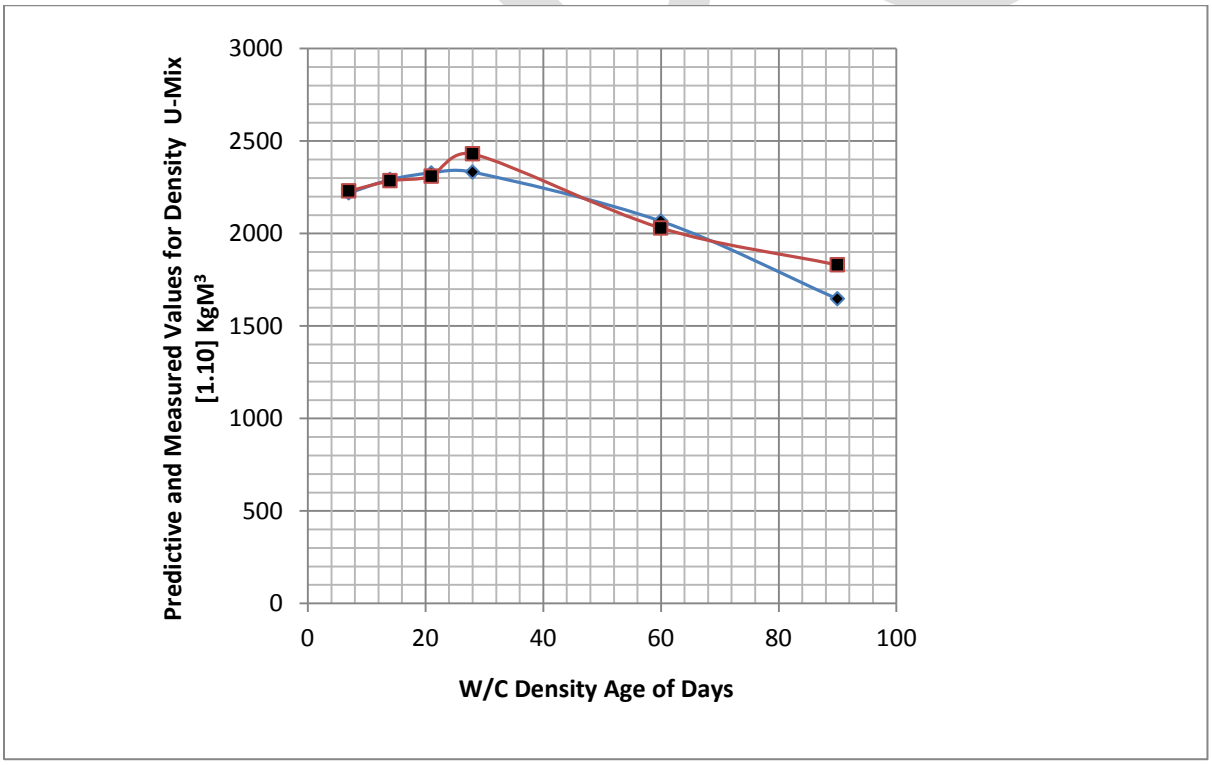

Figure: 15 Predictive and Measured Values for Density U- [1.10] of Concrete at Different Age of Days

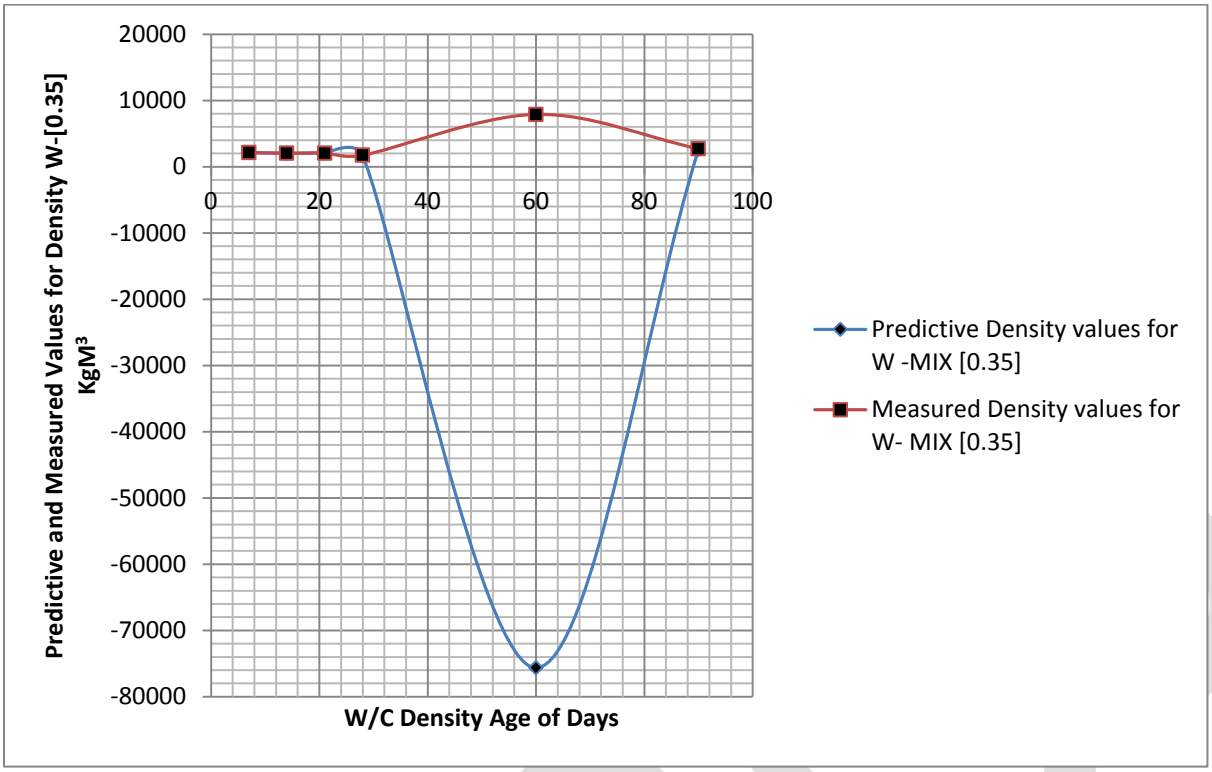

Figure: 16 Predictive and Measured Values for Density W- [0.35] of Concrete at Different Age of Days

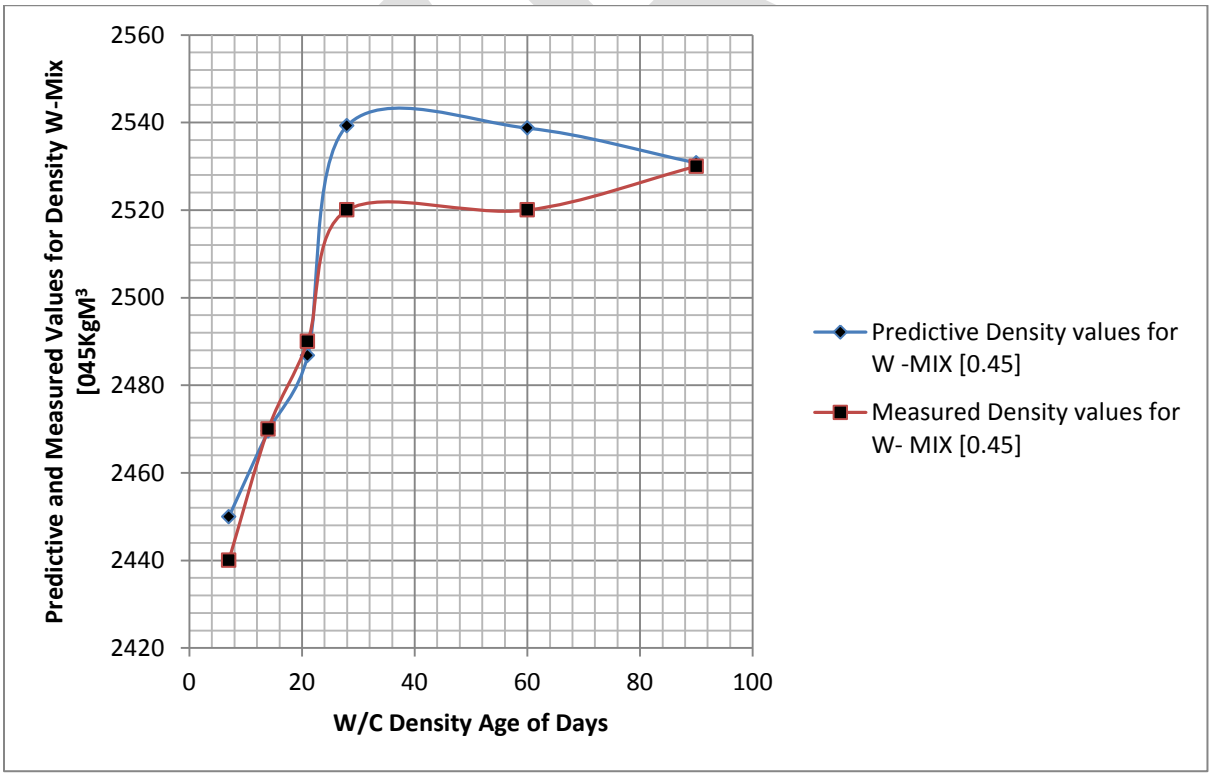

Figure: 17 Predictive and Measured Values for Density W- [0.45] of Concrete at Different Age of Days

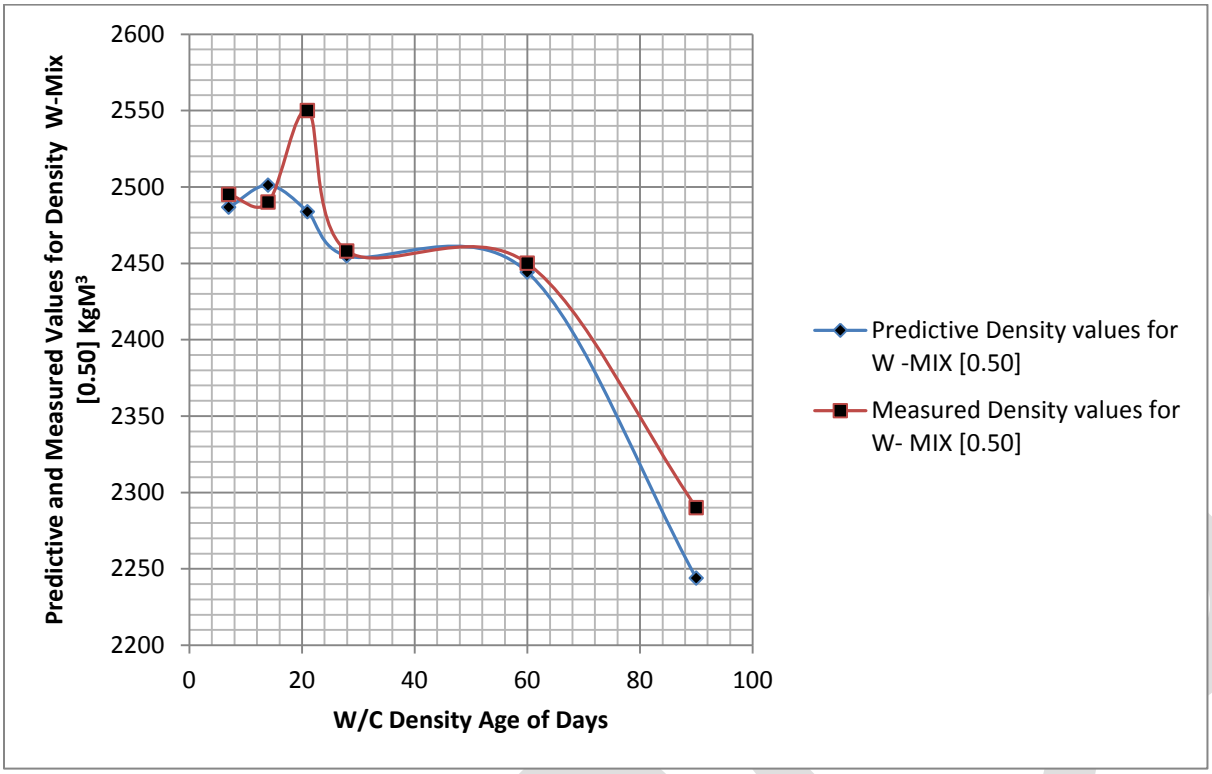

Figure: 18 Predictive and Measured Values for Density W- [0.50] of Concrete at Different Age of Days

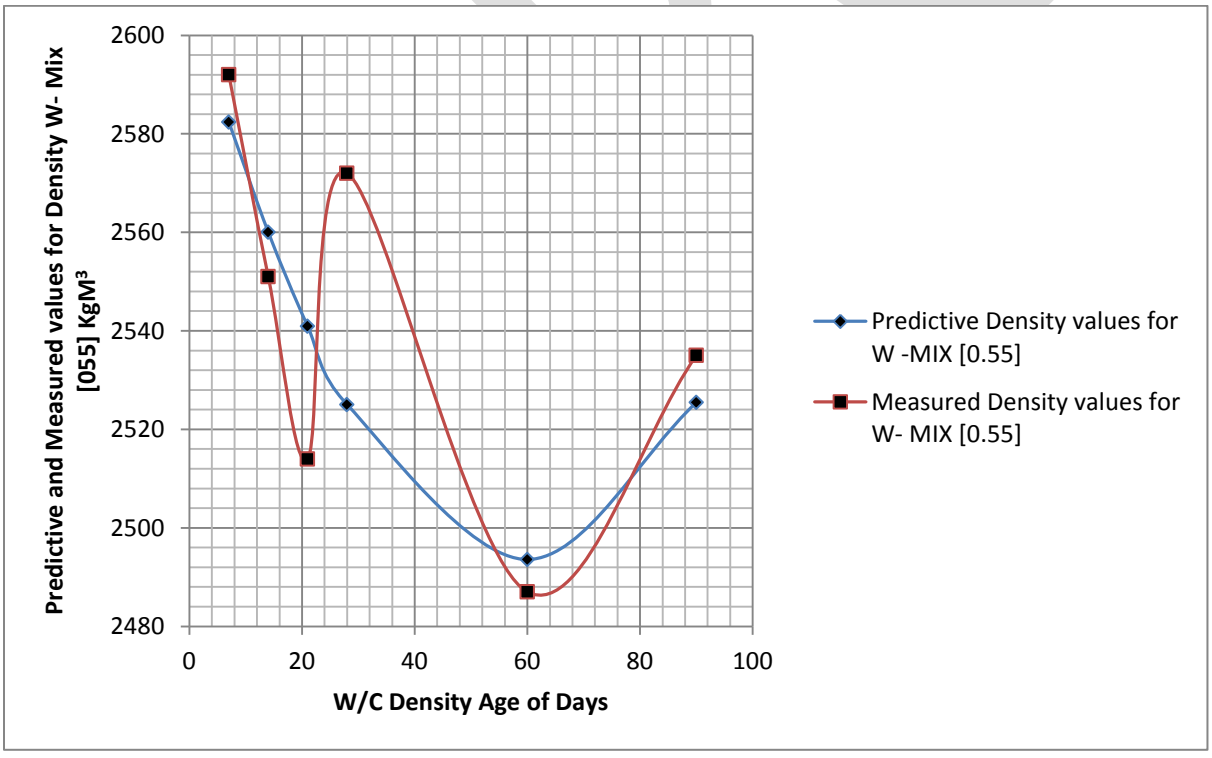

Figure: 19 Predictive and Measured Values for Density W- [0.55] of Concrete at Different Age of Days

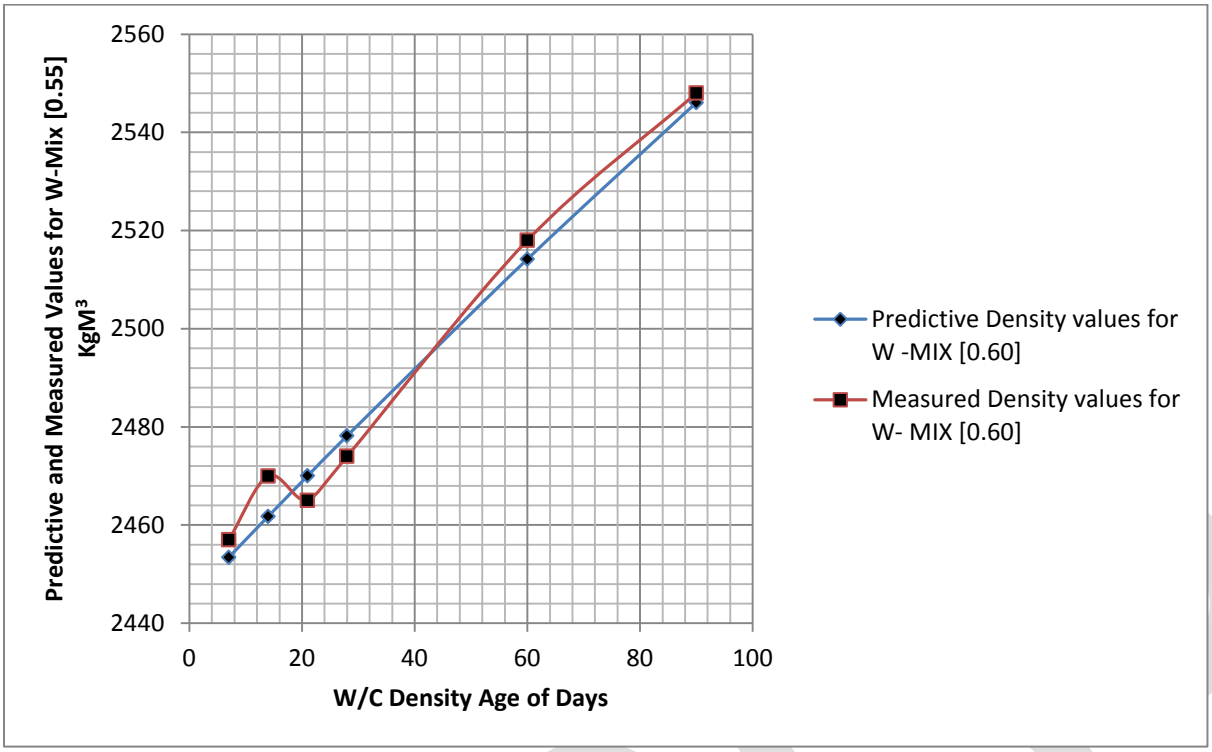

Figure: 20 Predictive and Measured Values for Density W- [0.60] of Concrete at Different Age of Days

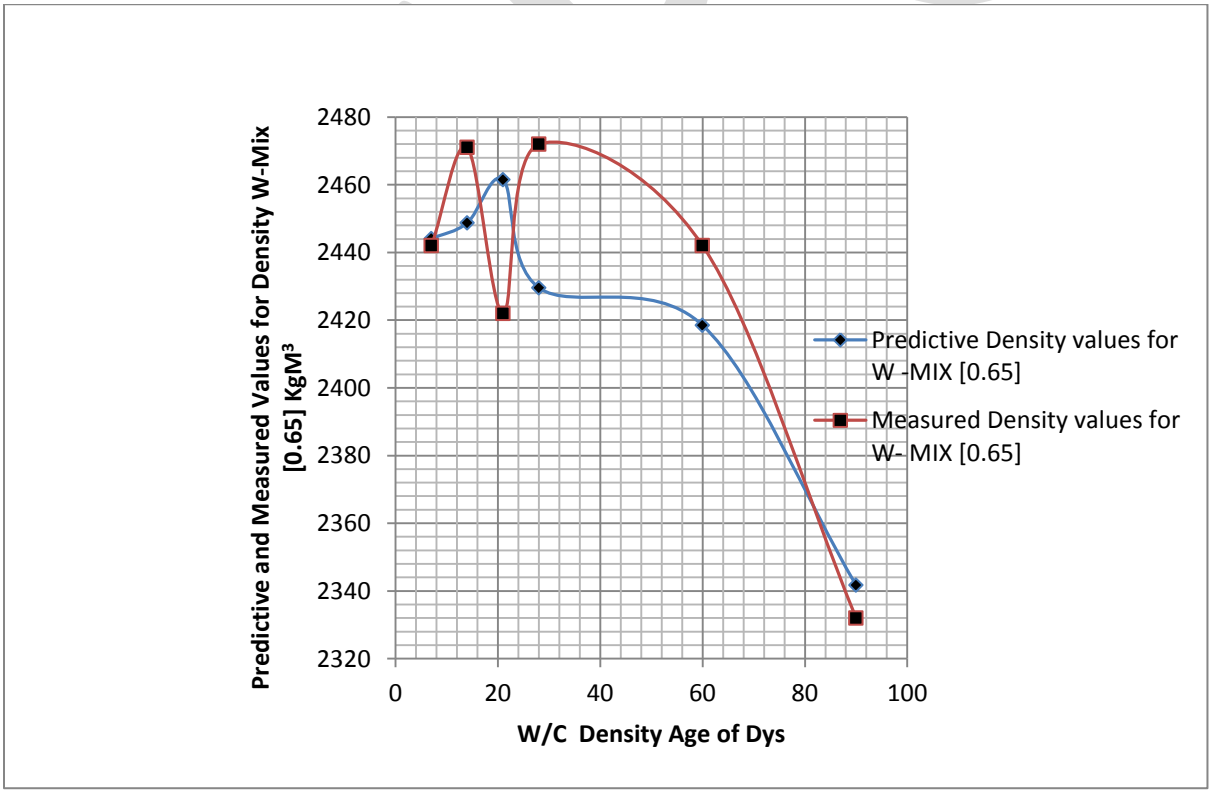

Figure: 21 Predictive and Measured Values for Density W- [0.65] of Concrete at Different Age of Days

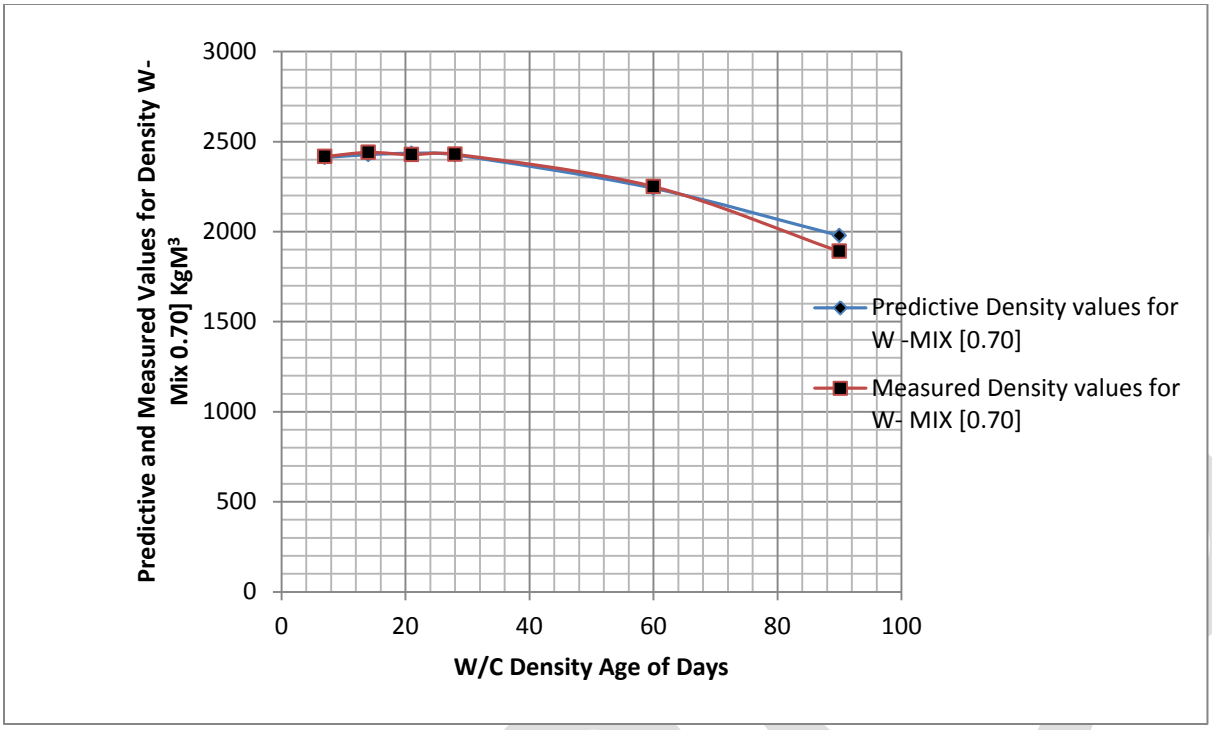

Figure: 22 Predictive and Measured Values for Density W- [0.70] of Concrete at Different Age of Days

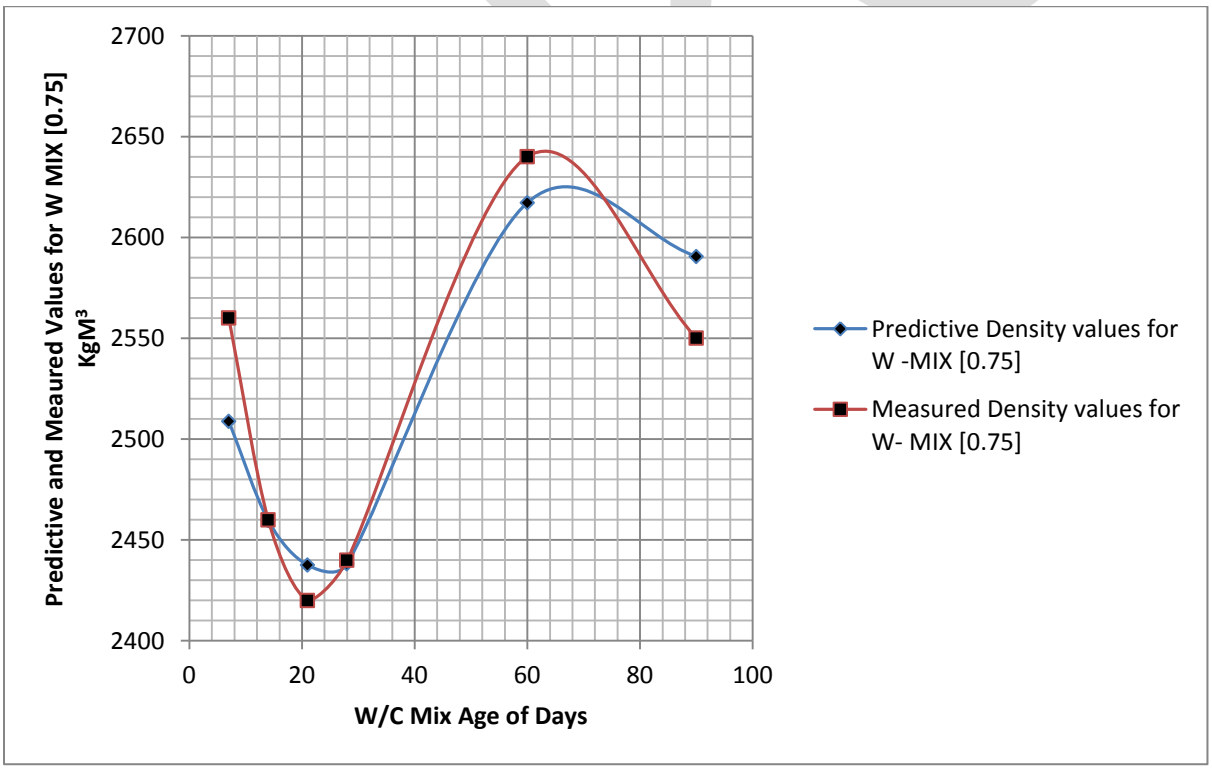

Figure: 23 Predictive and Measured Values for Density W- [0.75] of Concrete at Different Age of Days

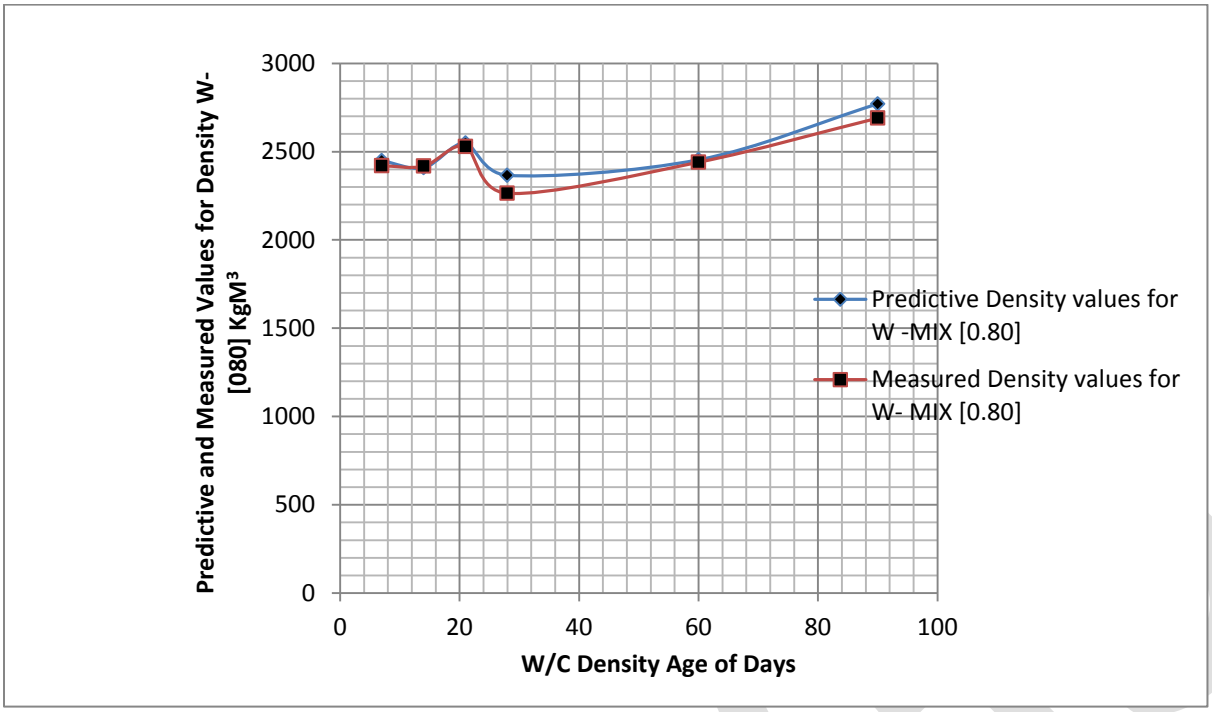

Figure: 24 Predictive and Measured Values for Density W- [0.80] of Concrete at Different Age of Days

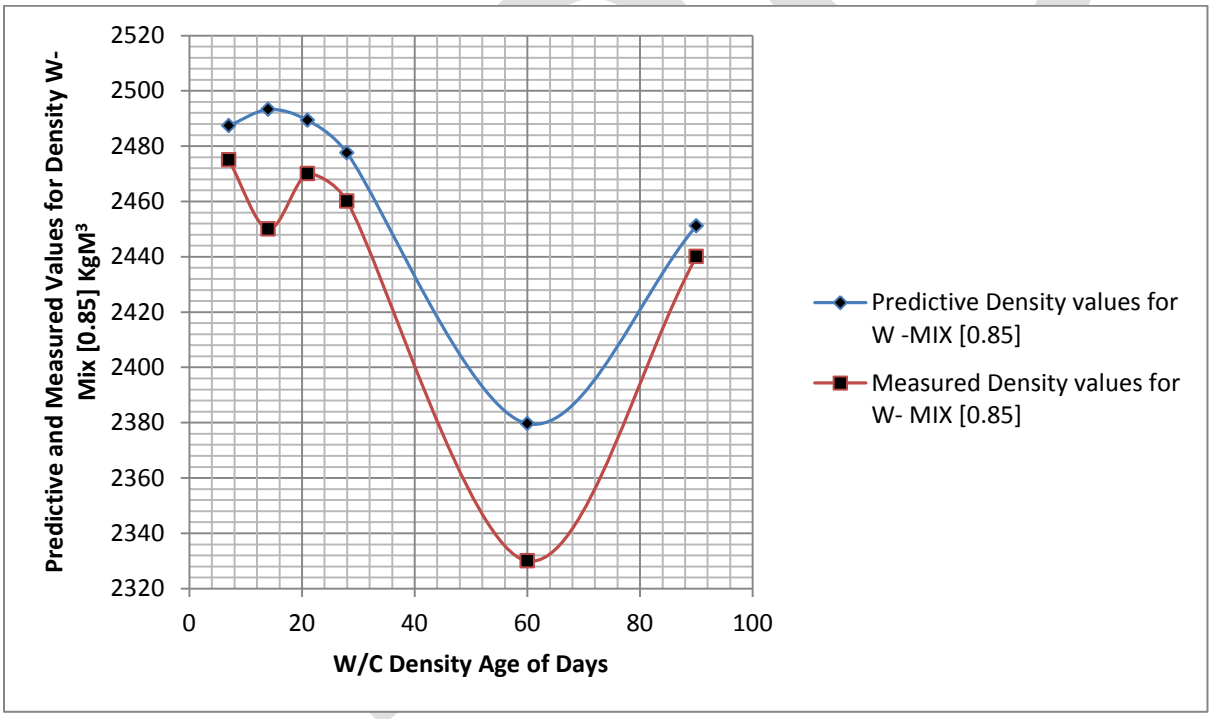

Figure: 25 Predictive and Measured Values for Density W- [0.85] of Concrete at Different Age of Days

The study expresses the variation rate of densities in different water cement ratios at various curing age, figure one express its density with rapid rate at seven curing days, sudden decrease were observed at sixty days thus gradual increase to the maximum density at ninety days. figure two express different conditions, vacillation were recorded between seven and twenty one curing days, while rapid increase were experiences to the maximum density recorded at ninety days, figure three express gradual increase to the optimum at twenty eight days and suddenly decrease down to the lowest at ninety days, similar condition were observed on the measure values but with slight fluctuation,. Figures four both predictive and measures values were observed developing best fits by expressing its maximum density within seven and fourteen days, but suddenly it developed slight decrease at

ninety days. figure five generated similar condition where the maximum density of both predictive and measured values express best fits trend line within seven and fourteen days, thus declining to where the lowest were recorded at ninety days. Figure six maintain established similarities on previous figures where optimum density was recorded within seven and fourteen days thus declining to the lowest at ninety curing days, figure seven developed different deposition of density, gradual increase were observed with fluctuation on the measured values to the optimum point at sixty days, sudden declined were experiences at ninety days. Figure eight express fluctuation from the measured, while the predicted developed gradual increase process to the maximum point at twenty eight days, in the same vein decline slightly at ninety days. Figure nine maintained similar condition both predictive and measured values with gradually increased to the maximum point at sixty days thus decrease rapidly at ninety days. Figure ten, the predictive and measured express gradual increase to the maximum point of ninety curing days. Figure eleven maintained gradual increase to the optimum values recorded at ninety curing days. While in figure twelve predictive and measured developed optimum density at fourteen days and suddenly decrease to the lowest at ninety days. Figure thirteen generated gradual increase where the maximum density was recorded at twenty eight days thus express slight decreases at ninety days. Figure fourteen developed exponential deposition of density declining down at ninety days, while the exponential continued on the trend of measured values. Figure fifteen developed similar trend, but with slight vacillation at twenty eight days thus decline at ninety days. Figure sixteen express linear increase of density and suddenly decline fluctuating with slight declined at ninety days, while it measured values express slight increase from the trend fits within seven and twenty eight days meeting at the point of ninety days. Figure seventeen predictive and measured values express rapid increase within seven and twenty eight days and suddenly maintained gradual increase at optimum point of ninety days. Figure eighteen developed fluctuation were the optimum values were recorded, between seven and twenty eight days and suddenly experienced rapid declined to the lowest at ninety days. Figure nineteen generated vacillation between the measured and predictive values were the lowest were recorded at twenty eight, thus rapid increases were observed to the optimum values at ninety days. Figure twenty predictive and measured expresses linear increase while the measured express slight vacillation between seven and fourteen thus develop linear increase to the optimum point at ninety days. Figure twenty one predictive and measured express oscillation were the optimum values recorded between seven and twenty eight days and finally express rapid declined to the lowest at ninety curing days, figure twenty two predictive and measured with best fits trend expresses maximum values at seven and gradually declined to the lowest at ninety days. Figure twenty three express gradual increase and suddenly deceases at twenty one, rapid increase were observe at sixty thus the maximum values were recorded with slight decline at ninety days. Figure twenty four, developed fluctuation expressing the lowest at sixty days, sudden increase were experienced at the maximum point of ninety days.

Conclusion

Concrete formations are determined by the type of materials and various mix designed, the density of concrete express the rate of compaction that will definitely developed variation in strength. These conditions establish some level of relationship in concrete formation, several densities of locally occurring 3/8 gravel express fluctuation due to variation of water cement ratio, the gravel were in two conditions washed and unwashed, most unwashed were observed to deposit some impurities that may reduce the compaction rate thus express variation of slight porosity at various mixed ratios, the locally sorted gravel predominantly generated impurities that developed variation on compactions thus fluctuation in density at different curing age. Such deposit variation of porosity affecting compaction on concrete density, these express the behaviour of concrete density fluctuating in locally occurring 3/8 gravel were thoroughly identified, the predictive model expressed the influences from porosity thus ingress of water on the strength variation in curing age of concrete from locally 3/8 occurring gravel, the measured values developed best fits predominantly express higher percentage of predictive values as a representation from the calibrated results.

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