ISSN 2229-5518

MODEL PREDICTION TO MONITOR THE RATE OF WATER ABSORPTION OF CONCRETE PRESSURED BY VARIATION OF TIME AND WATER-CEMENT RATIOS

Ode .T. and Eluozo S.N.
1Department of civil Engineering, Faculty of Engineering Rivers State University of Sciences and Technology Nkpolu, Port Harcourt
Email:odethangod@gmail.com
2Subaka Nigeria Limited Port Harcourt Rivers State of Nigeria
Director and Principal Consultant Civil and Environmental Engineering, Research and Development
E-mail: solondu2015@yahoo.com
E-mail: Soloeluozo2013@hotmail.com

Abstract : Strength as a parameter to obtain in any concrete is determined from mix design approach that is why water cement ratio is important parameters. Concrete formation using locally occurring 3/8 gravel to generate higher concrete performances was carried out, but for these study focus on the rates of water absorption on concrete formation at different water cement ratios and curing age. The model predictions for water absorption were also studied. The behaviour of water absorption were expressed through graphical representation showing various absorption rates at different water cement ratios and curing age, these were generated through calibration that express various resolved model equations at different water cement ratios, the results observed fluctuations of water absorption predominant from washed and unwashed locally occurring 3/8 gravel at different water cement ratios. the rates of absorption are also determined from porosity as significant factors in various mix, it also include some inhibition of impurities especially on those unwashed on locally occurring 3/8 gravel that can reduces higher concrete strength, the study is imperative because the behaviour of water absorptive at different mix proportion for washed and unwashed has been developed, the rate of strength from these dimension can be monitored.

Keywords: model prediction, water absorption, curing age and water cement ratios

———————————— ◆ ————————————

Introduction

As an imperative construction material, concrete has been extensively applied in various ecological conditions; this includes marine environment and cold regions. For several past few decades, the sturdiness difficulty of reinforced concrete formation has been recognized thus in these present time become the subject of ongoing research (Wang, 2014). The most major issues of durability associated study is to examine the transport properties of concrete when it is exposed to aggressive environment (Shi, Xie, Fortune, & Gong, 2012). However, several predictive models normally consider concrete in a perfect state, uncracked condition and ignore the fact that concrete in real formation usually cracked (Hearn, 1999; Rodriguez & Hooton, 2003). Concrete structures especially (e.g., thin concrete cover). Cracking within concrete, possibly they usually induced by external loading, drying shrinkage, thermal deformation, or chemical attack, most times it does not only affects its mechanical behavior but also pressured the efficacy of concrete as a barrier against aggressive agents, because cracks significantly modify the tortuosity and continuity of the pore formation of concrete

(Mu, de Schutter, & Ma, 2013; Ye, Tian, Jin, Jin, & Fu, 2013). More so Water plays a very imperative function in the transport procedures of concrete, because it operates as the medium for aggressive instrument that move into concrete and finally reach the surface of steel bars. In general, there are two most important mechanisms that control the ingress and movement of water among concrete, these includes permeation and absorption (Gerard, Breysse, Ammouche, Houdusse, & Didry, 1996; Sabir, Wild, & O'Farrell, 1998). Permeability is frequently taken as indicators that represent the capability of concrete to water transport. Previous works concerning the effect of load level on water transport used permeability as the assessment parameter (Aldea, Ghandehari, Shah, & Karr, 2000; Aldea, Shah, & Karr, 1999a, 1999b; Hearn, 1999; Wang, Jansan, & Shah, 1997). However, in the realism of an open exposed environment, concrete structures are always subjected to the drying actions of wind and sun (Sahmaran & Li, 2009). When concrete is in the state of unsaturation, it has always been realized over many years that the capillary absorption of water will act as the dominant factor for the aggressive substances to ingress (Hall, 1989; Lunk, 1998; Martys & Ferraris, 1997).

2. Materials and method

Standard laboratory experiment where performed to monitor water absorption on concrete at different curing age, the quantity of water in concrete were determined at different water cement ratios, the experimental result 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 water Absorption of unwashed Mix at [0.55] at Different Curing Days

W/C Age of Days	TYPE U KgM^3MIX [0.55]
7	1.91
14	2.33
21	2.13
28	1.77
60	2.62
90	3.24

ISSN 2229-5518

Table: 2 Predictive and Measured Values for water Absorption Mix at [0.55] at different curing days

W/C Age of Days	Theoretical values for U MIX [0.55] KgM^3	Measured values for U MIX [0.55] KgM^3
7	2.034	1.87
14	1.999	2.23
21	2.174	2.19
28	2	1.88
60	2.369	2.45
90	1.619	2.94

Table: 3 water Absorption of unwashed Mix at [0.65] at Different Curing Days

W/C Age of Days	TYPE U MIX [0.65] KgM^3
7	0.91
14	0.81
21	1.23
28	0.92
60	2.55
90	1.76

Table: 4 Predictive and Measured Values for water Absorption Mix at [0.65] at different curing days

W/C Age of Days	Predictive values for U MIX [0.65] KgM^3	Measured values for U MIX [0.65] KgM^3
7	0.888	0.89
14	0.993	0.89
21	1.098	1.17
28	1	0.98
60	1.683	1.87
90	2	1.98

Table: 5 water Absorption of unwashed Mix at [0.75] at Different Curing Days

W/C Age of Days	TYPE U MIX [0.75] KgM^3
7	0.7
14	1.04
21	1.18
28	1.28
60	1.57
90	1.63

Table: 6 Predictive and Measured Values for water Absorption Mix at [0.75] at different curing days

W/C Age of Days	Predictive values for U MIX [0.75] KgM^3	Measured values for U MIX [0.75] KgM^3
7	0.799	0.8
14	1.002	1.04
21	1.205	1.19
28	1.408	1.38
60	2.336	1.97
90	3	2.63

Table: 7 water Absorption of washed Mix at [0.45] at Different Curing Days

W/C Age of Days	TYPE W- MIX [0.45] KgM^3
7	0.87
14	1.08
21	1.56
28	0.99
60	1.04
90	1.14

Table: 8 Predictive and Measured Values for water Absorption Mix at [0.45] at different curing days

W/C Age of Days	Predictive values for W - MIX [0.45] KgM^3	Measured values for W- MIX [0.45] KgM^3
7	1.055	0.97
14	1.088	1.077
21	1.116	1.26
28	1.136	1.09
60	1.16	1.14
90	1.07	1.05

Table: 9 water Absorption of washed Mix at [0.55] at Different Curing Days

W/C Age of Days	TYPE W- MIX [0.55] KgM^3
7	2.09
14	0.94
21	0.62
28	0.66
60	1.14
90	1.41

Table: 10 Predictive and Measured Values for water Absorption Mix at [0.55] at different curing days

W/C Age of Days	Predictive values for W - MIX [0.55] KgM^3	Measured values for W-MIX [0.55] KgM^3
7	1.995	2.09
14	1.17	0.94
21	0.712	0.82
28	0.514	0.62
60	1.882	1.55
90	3.98	2.71

Table: 10 water Absorption of washed Mix at [0.65] at Different Curing Days

W/C Age of Days	TYPE W- MIX [0.65] KgM^3
7	0.34
14	0.22
21	0.38
28	0.35
60	0.58
90	3.89

Table: 10 Predictive and Measured Values for water Absorption Mix at [0.55] at different curing days

W/C Age of Days	Predictive values for W -MIX [0.65] KgM^3	Measured values for W-MIX [0.65] KgM^3
7	0.58	0.54
14	0.3	0.28
21	0.121	0.28
28	0.037	0.15
60	0.901	0.78
90	3.571	3.66

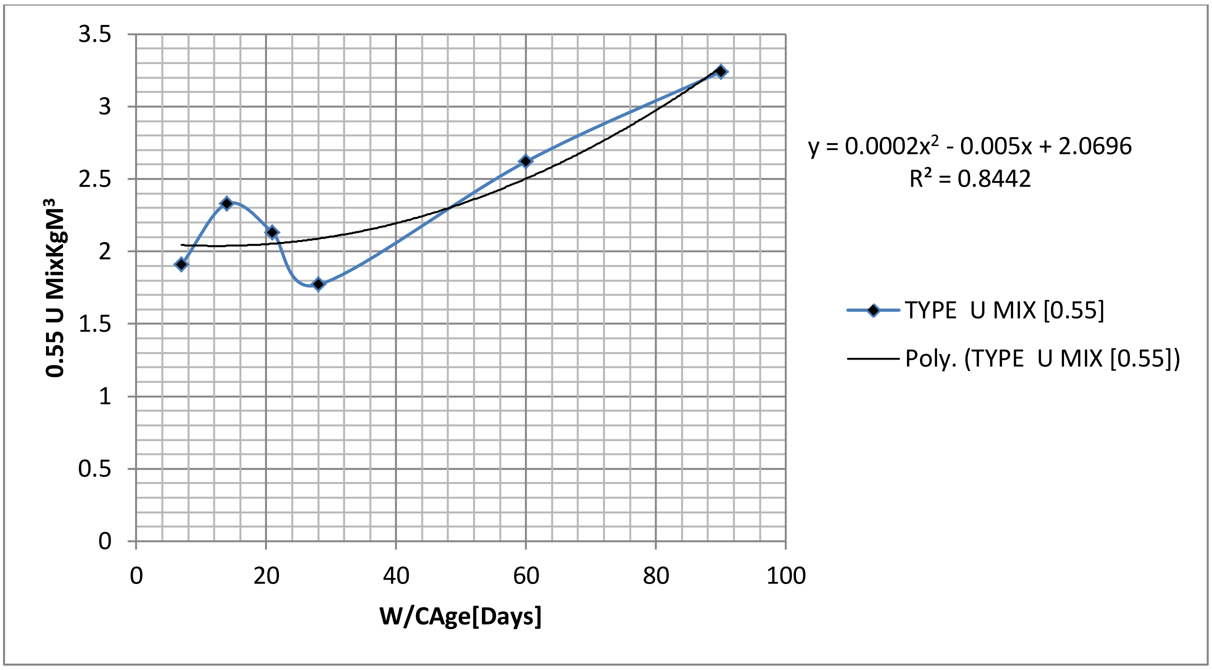

Figure: 1 water Absorption of unwashed Mix at [0.55] at Different Curing Days

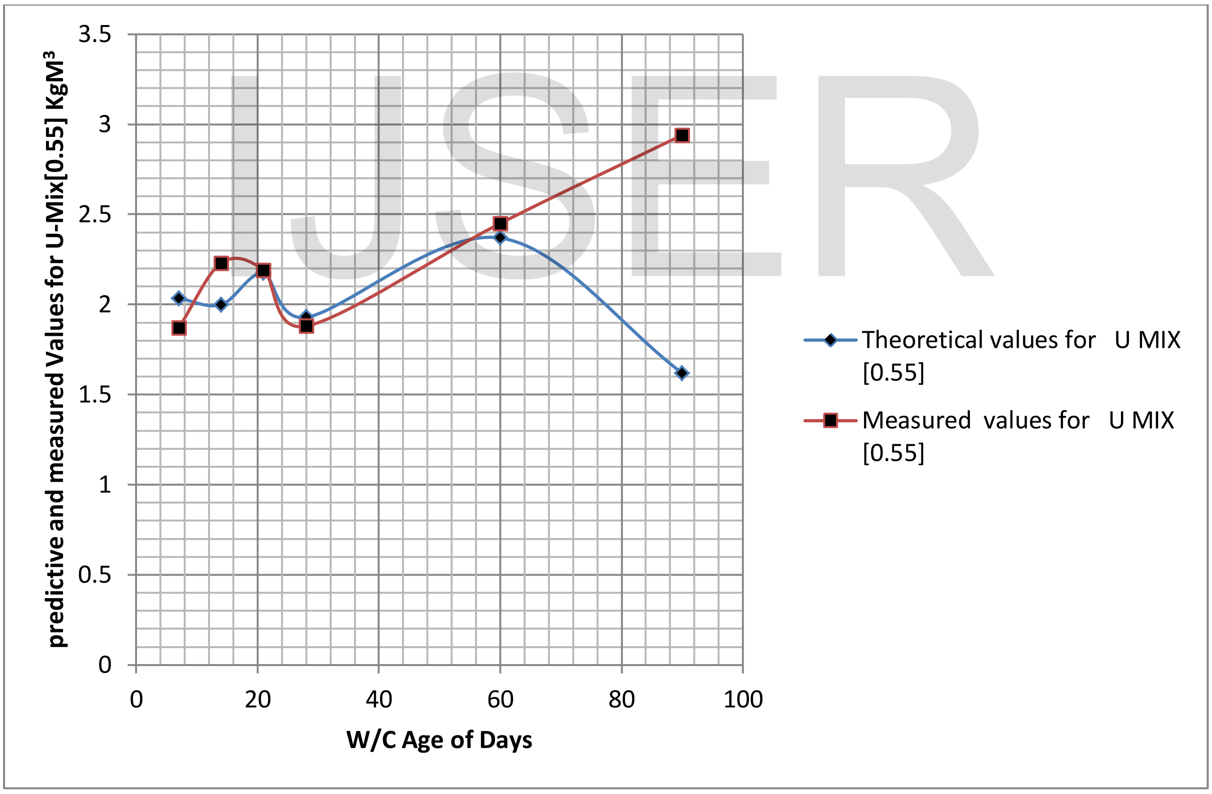

Figure: 2 Predictive and Measured Values for water Absorption Mix at U-[0.55] at different curing days

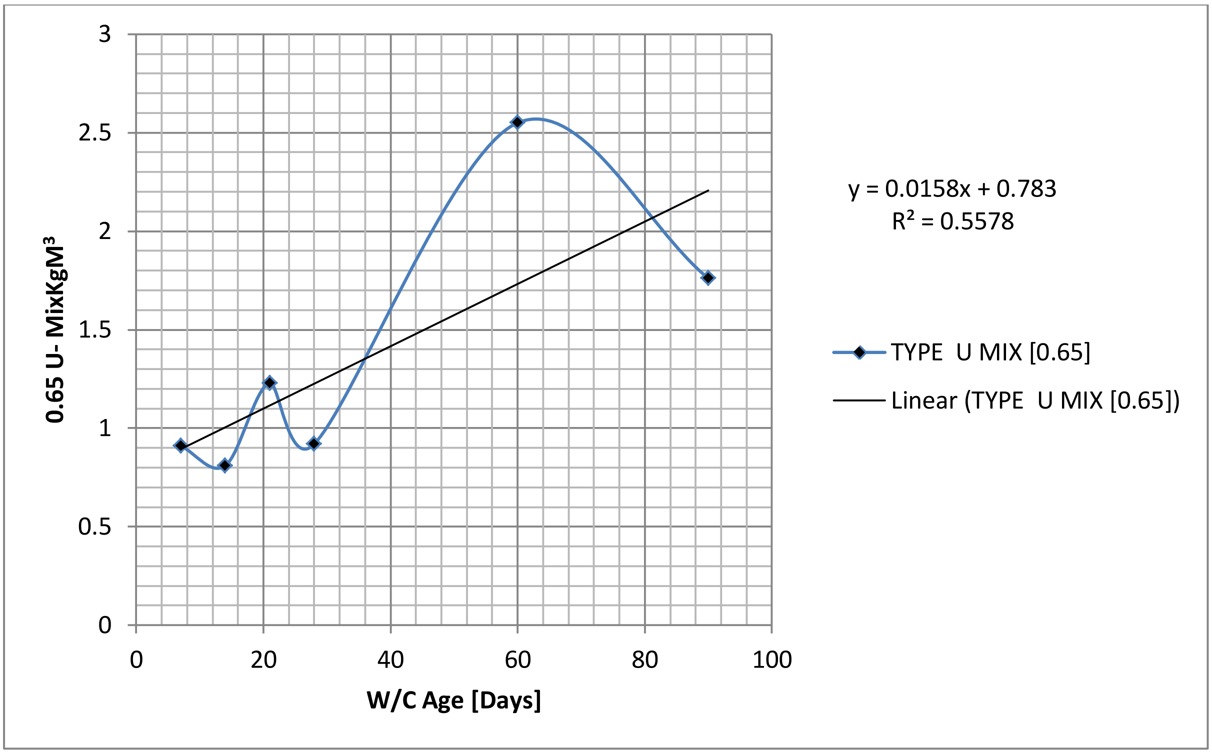

Figure: 3 water Absorption of unwashed Mix at U-[0.65] at Different Curing Days

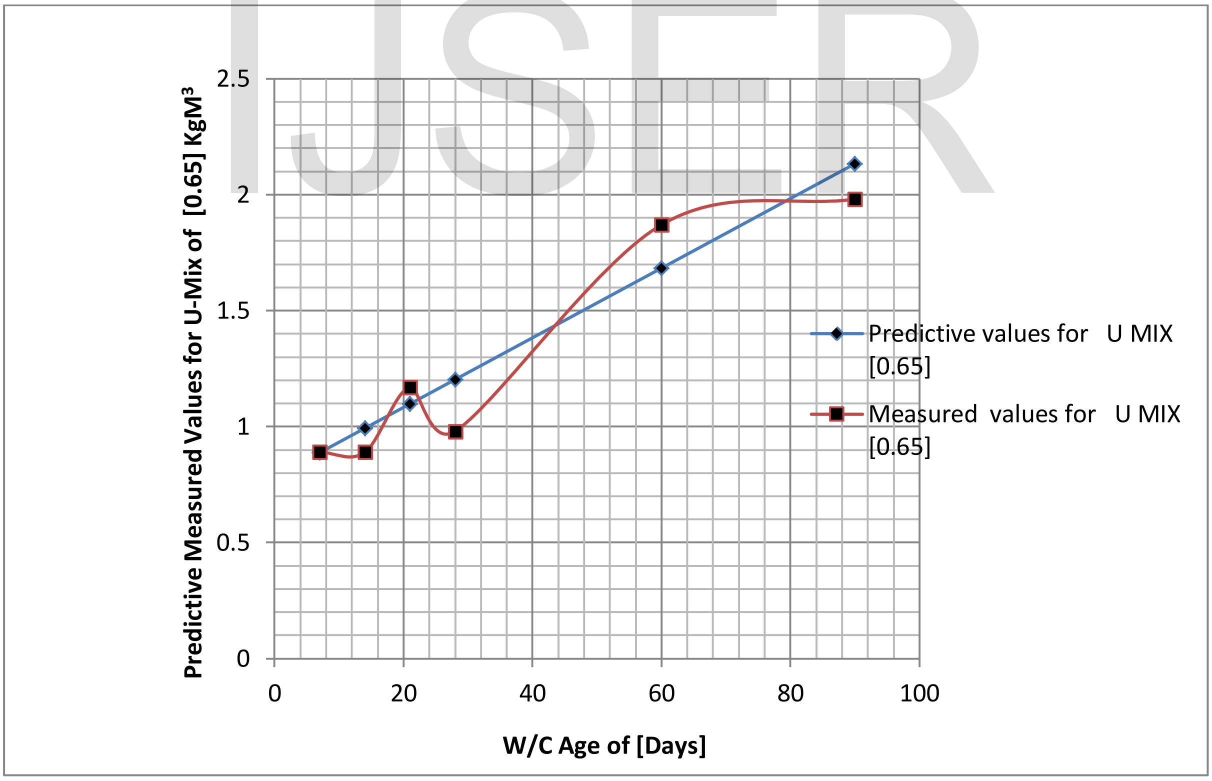

Figure: 4 Predictive and Measured Values for water Absorption Mix at U-[0.65] at different curing days

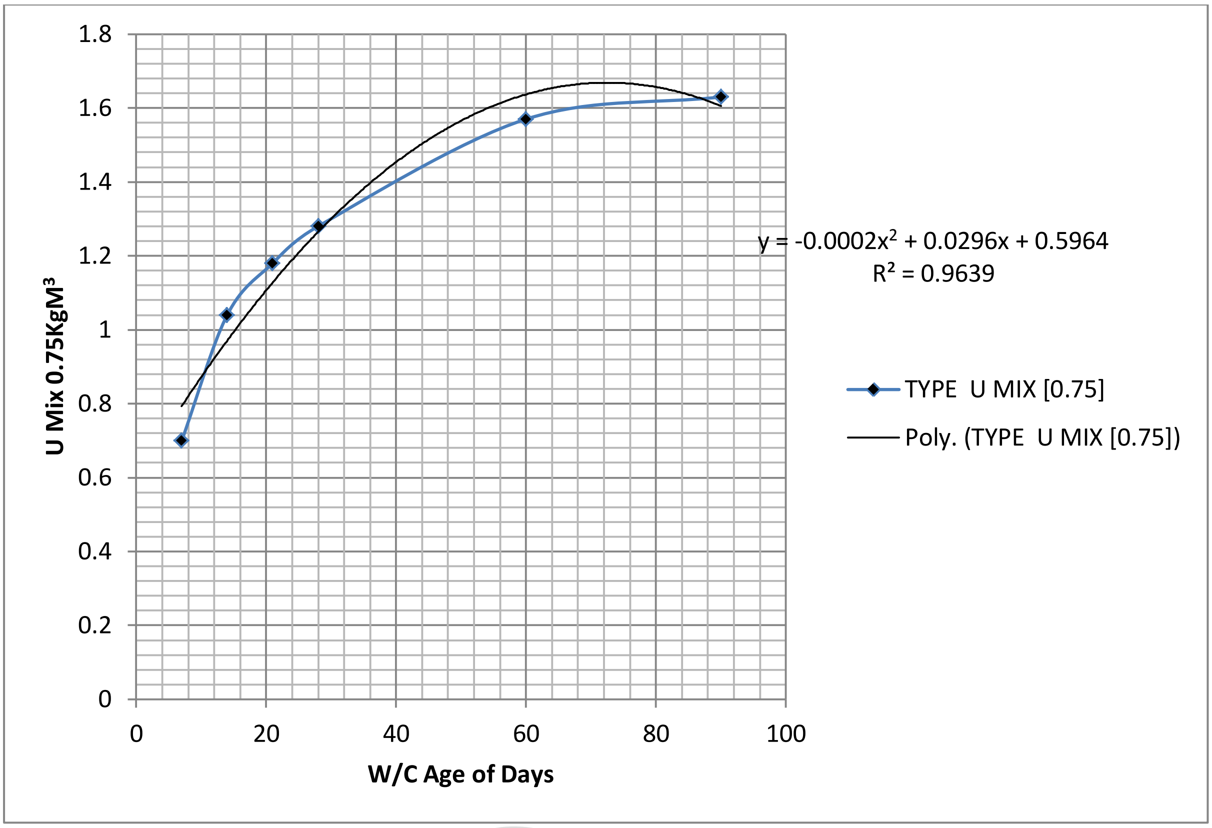

Figure: 5 water Absorption of unwashed Mix at U-[0.75] at Different Curing Days

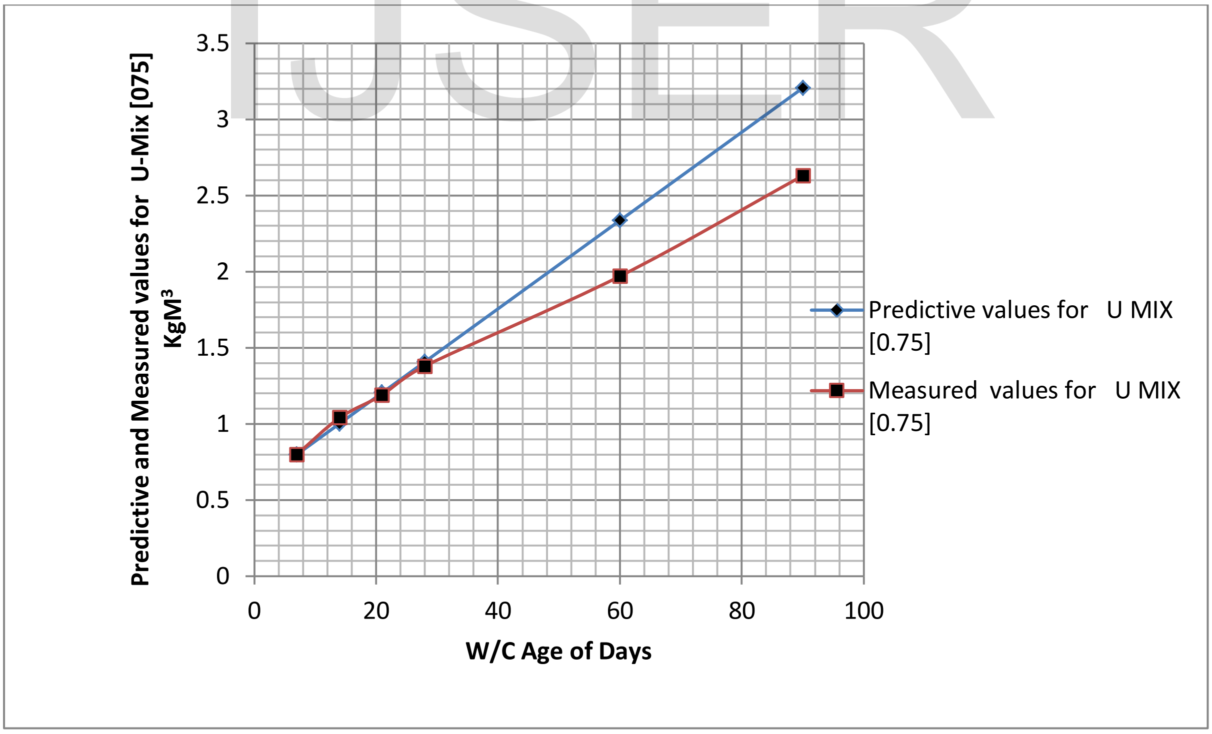

Figure: 6 Predictive and Measured Values for water Absorption Mix at U-[0.75] at different curing days

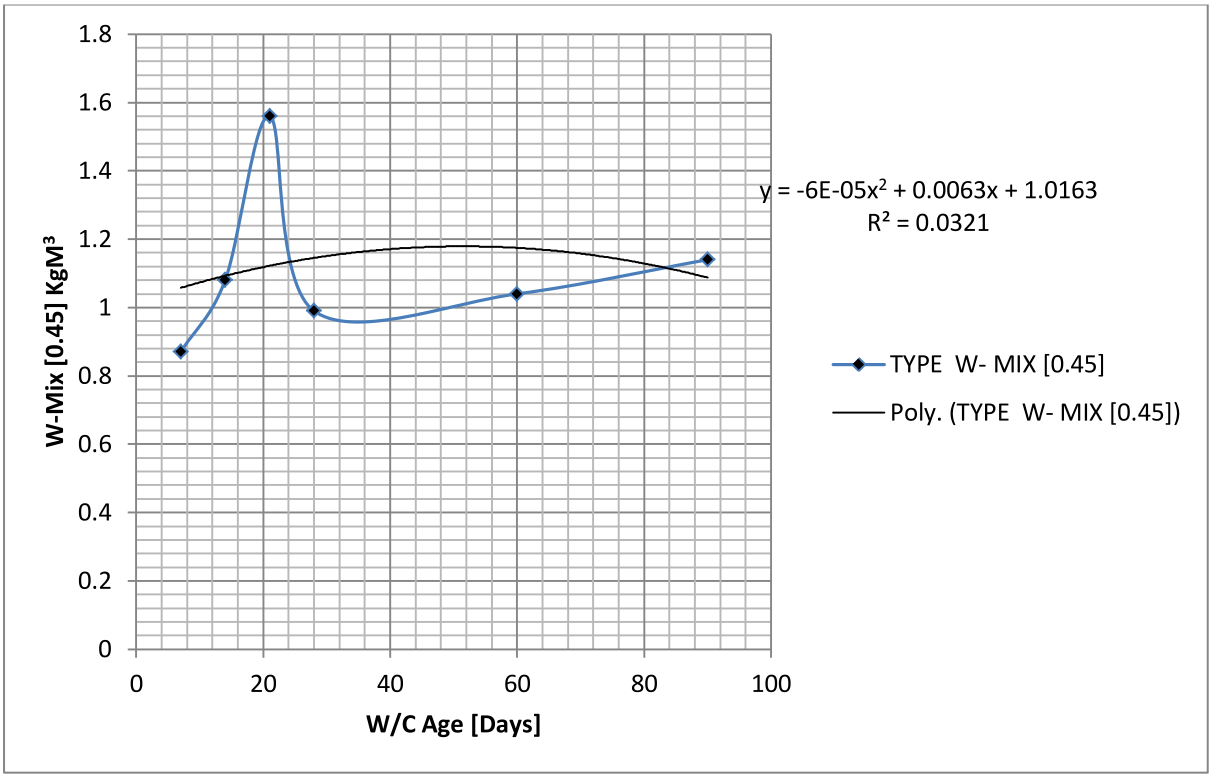

Figure: 7 water Absorption of washed Mix at W-[0.45] at Different Curing Days

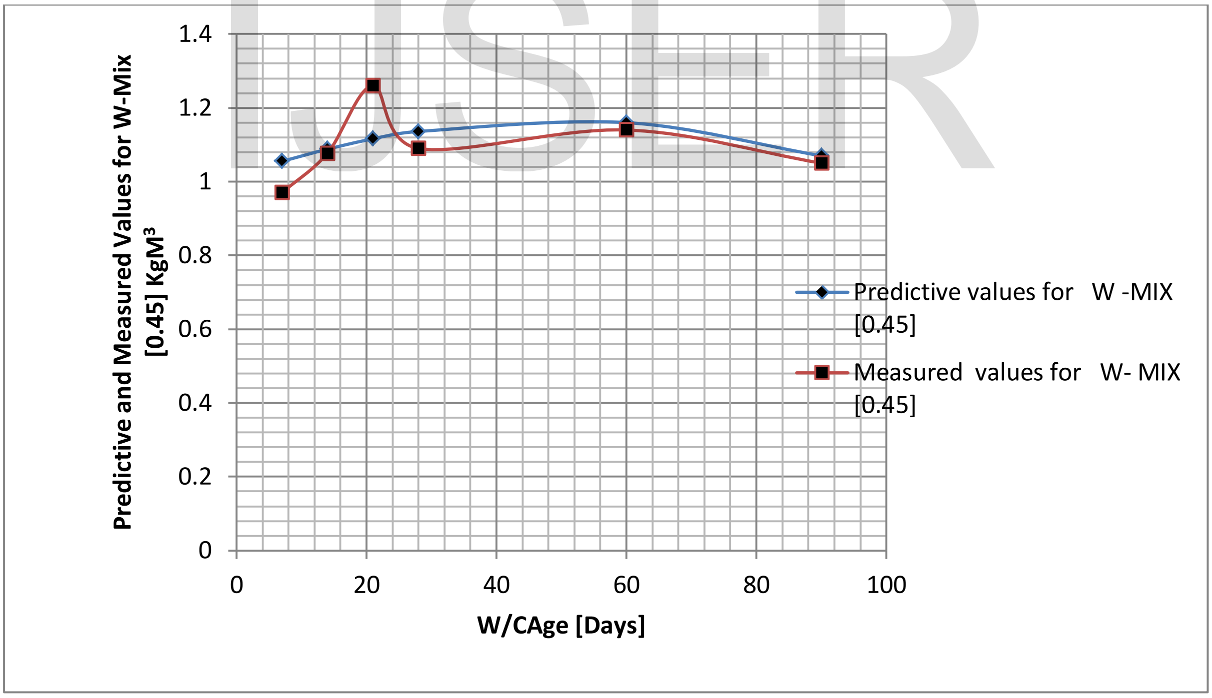

Figure: 8 Predictive and Measured Values for water Absorption Mix at W-[0.45] at different curing days

ISSN 2229-5518

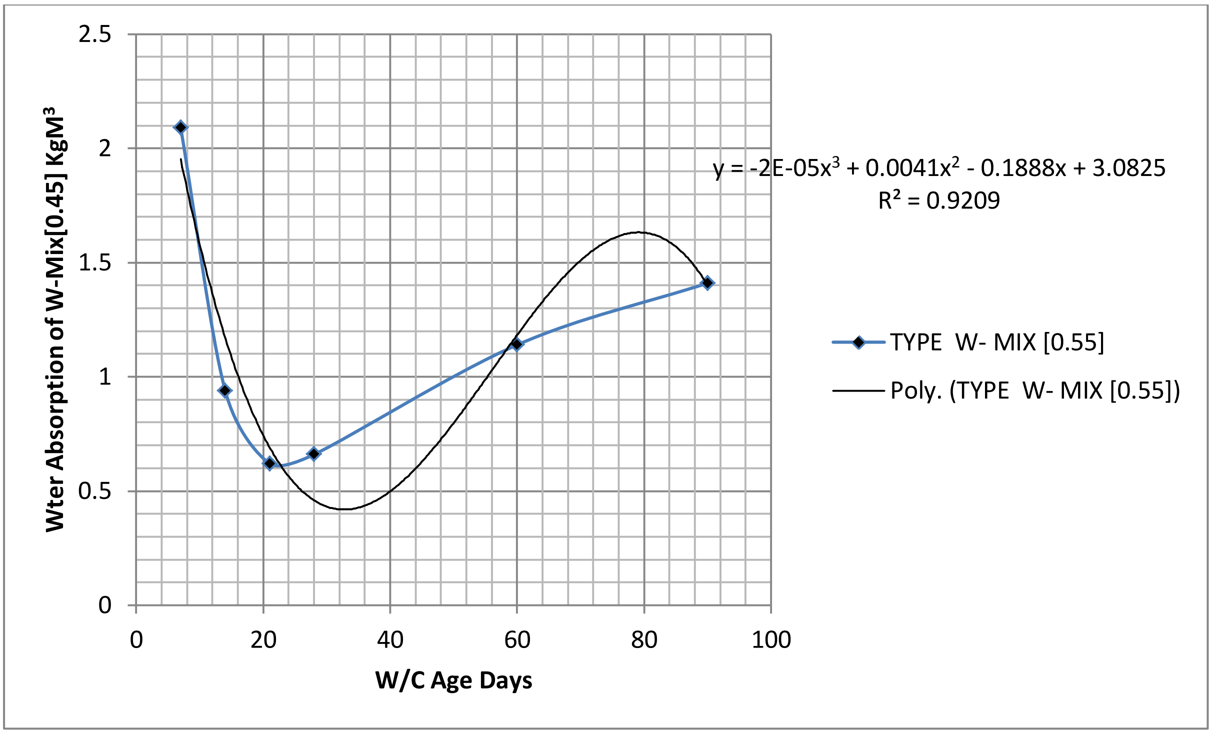

Figure: 9 water Absorption of washed Mix at W-[0.55] at Different Curing Days

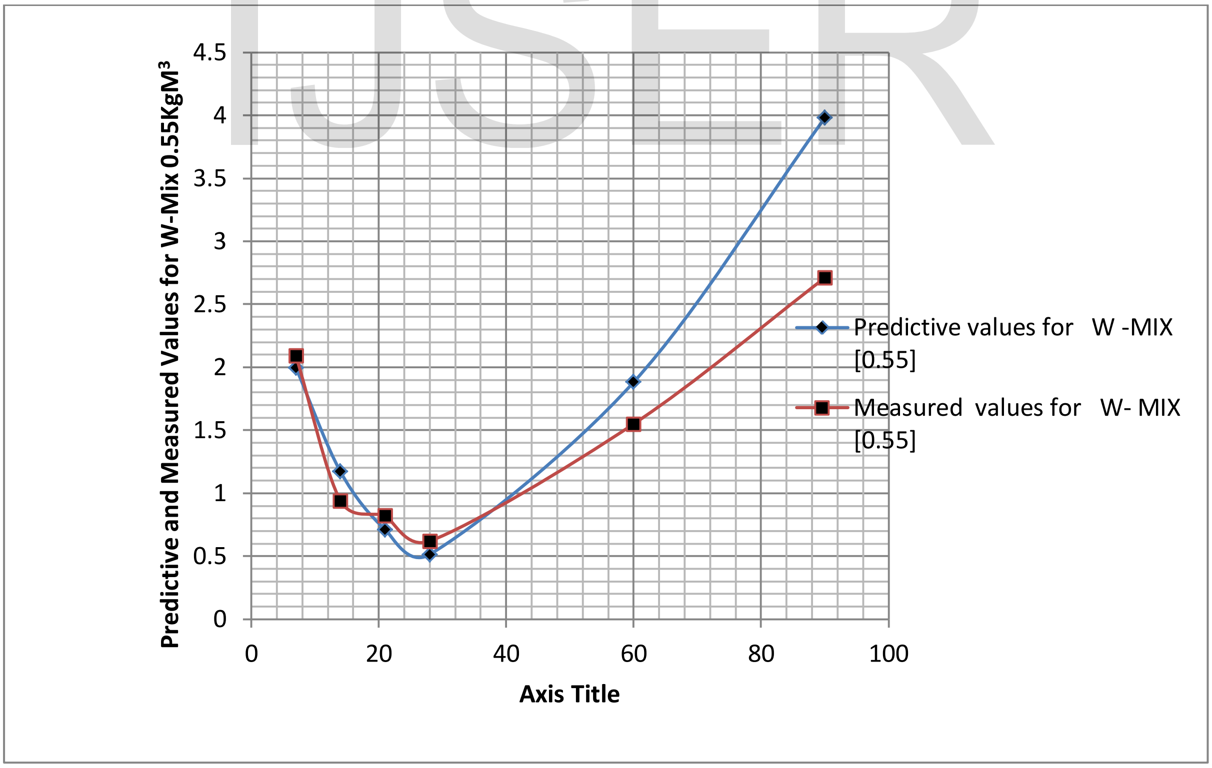

Figure: 10 Predictive and Measured Values for water Absorption Mix at W-[0.55]at different curing Days

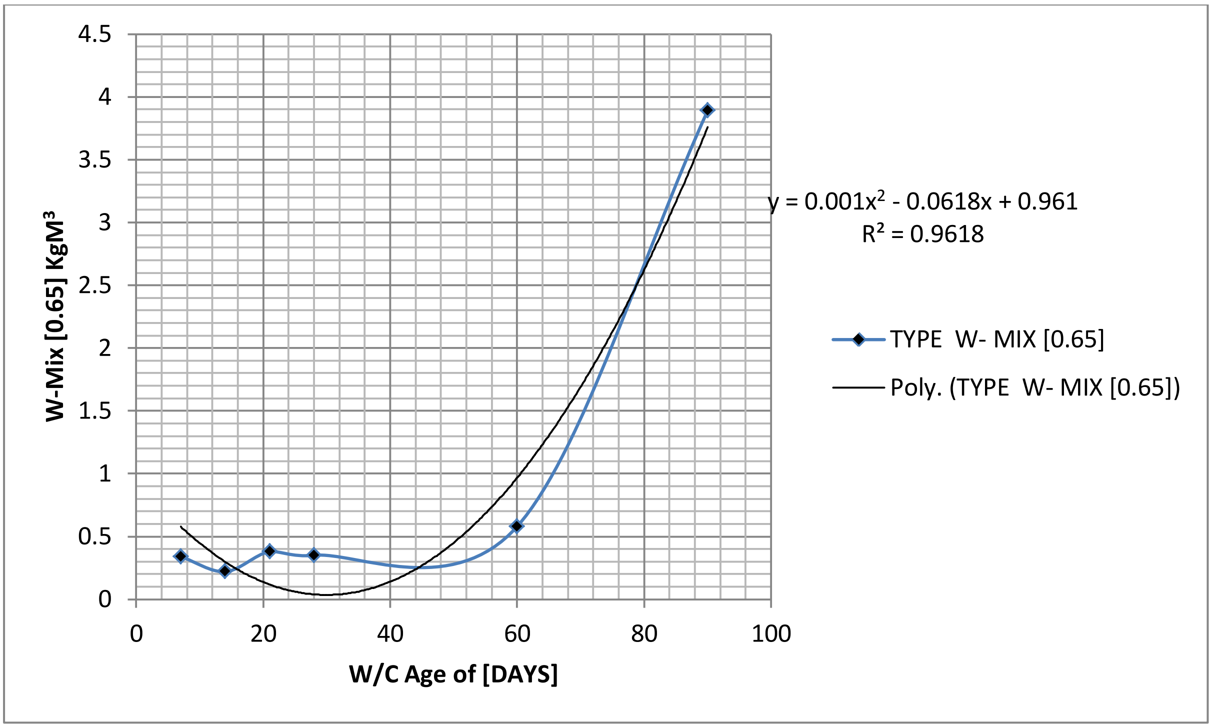

Figure: 11 water Absorption of washed Mix at W-[0.65] at Different Curing Days

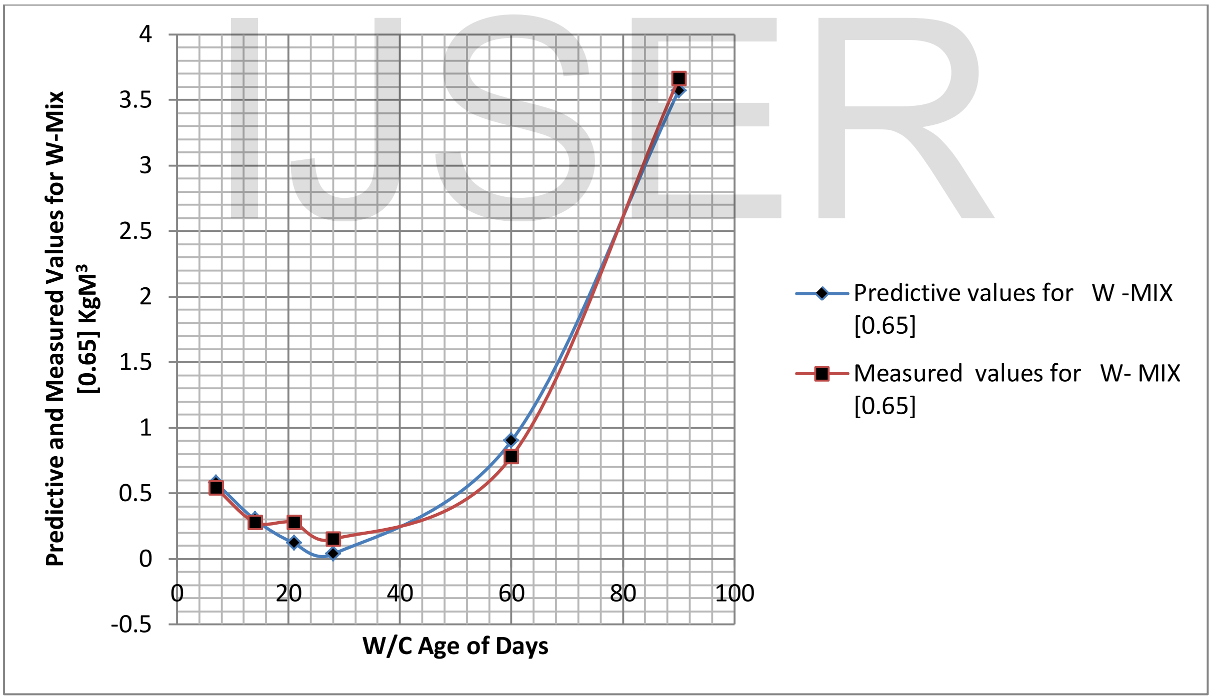

Figure: 12 Predictive and Measured Values for water Absorption Mix at W-[0.65] at different curing days

The behaviour of water absorption with respect to curing by attaining the required strength from locally 3/8 gravel has been thoroughly expressed. The behaviour of unwashed gravel generated locally has definitely developed some strength in concrete formation that should be evaluated,. Figure one express the fluctuation between seven and twenty one days due to some deposited impurities in the mix, sudden increase were observed due to inhibition of those impurities from the hydration reaction, rapid increase were experienced to the optimum values at ninety days. Figure two, comparing the predicted and measured values, both parameters express exponential phase to some extended within sixty and ninety day were the predicted express decrease in absorption were the measured express increase, these condition can be attributed to the compaction expressing porosity in the concrete formation, figure three express increase in water absorption on concrete base on the variation of water cement ratios, more so the absorption obtained it maximum strength at sixty days thus developing slight decrease in water absorption within ninety day, these are base on the mix ratio expressing decrease of strength at ninety days of age, figure four, calibrating the results properly the predicted and measured express variation of absorption to a point where rapid increase express it maximum absorption at ninety curing days. Figure five express gradual increase to the optimum values recorded at ninety curing days, while figure six developed linear increase to the optimum level, figure seven express gradual increase to the maximum point at twenty one curing day, sudden decrease was experienced, linear absorption were generated from twenty eight to ninety days. Similar condition were observed in figure eight, gradual increase were observed to the maximum point at sixty days, while the measured values express slight fluctuation within seven and twenty one days thus the maximum value were record, the trend finally express gradual increase with slight decrease at ninety curing days. Figure nine express rapid increase at seven days thus generate sudden decrease from twenty eight to sixty days and finally expressing slight decrease at ninety days. Figure ten, the predicted and measured values maintained the same condition in its rate of absorption, sudden decrease were observed at twenty eight day thus generating rapid increase to ninety days were it maximum absorption were recorded, figure eleven expressed slight fluctuation within seven and twenty one days thus sudden increase were experience to the maximum absorption recoded at ninety curing days, similar condition were found on figure twelve, the predicted and measures maintained the same expression were the optimum values were recorded at ninety days

Conclusion

It has been observed in years past that concrete is a porous material that interacts with the surrounding. The durability of mortar and concrete depends largely on the movement of environments, fluid like water and gas enters and moves around its, these relates to the rate of permeability known to be an indicator of concrete's ability to transport water more precisely through these mechanism, it control the uptake and transport of water and gaseous substances into cementitious material. These are base rate that describe the rate of water uptake ingression into concrete measured by the rate of Permeability, because it measured flow of water under pressure in a saturated porous medium of the concrete formation. Relating it to Sorptivity as materials, it is known as the ability to absorb and transmit water through it by capillary suction. Furthermore, Uptake of water by unsaturated, hardened concrete may be characterised by the sorptivity. This is a simple parameter to determine the rate of absorption which is a conceptual framework applied as a measure of concrete resistance to exposure in aggressive environments. These two concepts known as Sorptivity, or capillary suction, water absorption in concrete formation definitely describes the transport of liquids in porous and solids, these can be attributed to surface tension acting in capillaries which may be a function of viscosity, density and surface tension of the liquid. More so pore structure that includes (radius, tortuosity and continuity of capillaries) of the porous solid. It is calibrated as the rate of uptake of water. Transport mechanisms act at the level of the capillary pores and depend on the fluid and the solid , the behaviour of water absorption are determined by various water cement ratios from locally occurring 3/8 gravel locally sorted out in the study area. the absorption rate of water at different curing age are base on the rate of porosity deposition that will allow transport of water to any rates, the performance of these concrete with mix designed of different water cement ration influence the rate of water absorption, it is has been expressed base on these conditions in concrete structure. Finally the Predicted values and measured values maintained the best fits validating these models generated.

References

Aldea, C.-M., Ghandehari, M., Shah, S. P., & Karr, A. (2000). Estimation of water flow through cracked concrete under load. *ACI Materials Journal, 97*(5), 567–575.

Aldea, C.-M., Shah, S. P., & Karr, A. (1999a). Permeability of cracked concrete. *Materials and Structures, 32*(5), 370–376.

Aldea, C.-M., Shah, S. P., & Karr, A. (1999b). Effect of cracking on water and chloride permeability of concrete. *Journal of Materials in Civil Engineering, 11*(3), 181–187.

Gerard, B., Breysse, D., Ammouche, A., Houdusse, O., & Didry, O. (1996). Cracking and permeability of concrete under tension. *Materials and Structures, 29*(3), 141–151.

Hall, C. (1989). Water sorptivity of mortars and concretes: a review. Magazine of Concrete Research, 41(147), 51–61.

Hearn, N. (1999). Effect of shrinkage and load- Induced cracking on water permeability of concrete. *ACI Materials Journal, 96*(2), 234–241.

Lunk, P. (1998). Penetration of water and salt solutions into concrete by capillary suction. *Journal for Restoration of Buildings and Monuments, 4*(4), 399–422

Martys, N. S., & Ferraris, C. F. (1997). Capillary transport in mortars and concrete. *Cement and Concrete Research*, *27*(5), 747–760.

Mu, S., de Schutter, G., & Ma, B. G. (2013). Nonsteady state chloride diffusion in concrete with different crack densities. *Materials and Structures, 46*(1–2), 123–133.

Rodriguez, O. G., & Hooton, R. D. (2003). Influence of cracks on chloride ingress into concrete. *ACI Materials Journal, 100*(2), 120–126.

Sabir, B. B., Wild, S., & O'Farrell, M. (1998). A water sorptivity test for mortar and concrete. *Materials and Structures, 31*(8), 568–574.

Sahmaran, M., & Li, V. C. (2009). Influence of microcracking on water absorption and sorptivity of ECC. *Materials and Structures*, *42*(5), 593–603.

Ye, H. L., Tian, Y., Jin, N. G., Jin, X. Y., & Fu, C. Q. (2013). Influence of cracking on chloride diffusivity and moisture influential depth in concrete subjected to simulated environmental conditions. *Construction and Build Materials, 47*, 66–79.

Shi, X., Xie, N., Fortune, K., & Gong, J. (2012). Durability of steel reinforced concrete in chloride environments: an overview. Construction and Building Materials, 30, 125–138.

Wang, K., Jansan, D. C., & Shah, S. P. (1997). Permeability study of cracked concrete. Cement and Concrete Research, 27(3), 381–393.

Wang L.C Experimental Study on Water Absorption by Concrete Damaged by Uniaxial Loading 4th International Conference on the Durability of Concrete Structures 24–26 July 2014 Purdue University, West Lafayette, IN, USA