International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

PROLONGED TRANSITIONAL ZONE EFFECTIVENESS IN PRE-CONDITIONED SCC CUBES ON ISAT

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Abstract: *The near surface concrete is highly heterogeneous in nature, due to the relative movement of cement paste and aggregates during the compaction of fresh concrete and bleeding of mix water during the early stages of hydration of cement due to that there exists a porosity gradient in the near surface concrete. The transport of aggressive substances into the concrete depends on the quality of the near surface concrete and permeation characteristics. The present research work aim to assess the water absorption of concrete by initial surface absorption test (ISAT) to interpret different concrete mixtures design, which establish suitable correlation between initial surface absorption , and time. This research will investigate the influence of saturated condition on ISAT in concrete cubes with different mixtures proportion. For which slump, and w/c ratio value was vary with same compressive strength as in the first case and compressive strength, and w/c ratio value varied with same slump as in the second case. Seventy-two concrete cubes with different grades of concrete were prepared and tested using ISAT. In saturated conditioned concrete cubes, the ISAT value was increase in all designed mixtures type at initial time as against to longer time duration. ISAT value was increase at initial time in lower compressive strength and constant slump as well as the ISAT value goes on reduced with higher compressive strength and constant slump value. Its confirmed results that, the ISAT value was increase at initial time with higher compressive strength and varied slump value as when compare to later time duration with same higher compressive strength as well as varied slump value. ISAT value was increase at initial time in lower compressive strength and constant slump as well as the ISAT value goes on reduced with higher compressive strength, constant slump value, and at later time duration. ISAT could be more for in case of higher compressive strength in designed concrete mixtures type with increased water diffusion/sorptivity coefficient. ISAT was goes on decreased with decreased water diffusion coefficient. It is confirm from the results that, ISAT was increase in lower compressive strength with increased water diffusion/sorptivity coefficient and goes on decreased with decrease in water diffusion/sorptivity coefficient, increased concrete compressive strength and constant slump.*

Keywords: *Deterioration, sorptivity, water diffusion coefficient, time, pre-condition, saturated conditioned concrete, near surface character*

1.0 Introduction

The concrete is an extremely versatile construction material, which is use in construction industry at worldwide [Treadaway, 1984]. Now a day's concrete manufacturing sector may face technical problems because the concrete is not adequate for the particular conditions of use, and it does not achieve its full potential to concrete industry [Dewar, 1984]. Concrete deterioration is not a new problem [Feld, 1968], but it has become more prevalent in recent years [Madderom, 1980]. An extensive use of concrete, construction techniques, and design approaches has induced uncertainty about durability of concrete structure [Somerville, 1986]. Investigation about near surface characteristics is more important as its the weakest pothole for the concrete through which aggressive agents penetrate in to the concrete [Browne, 1986]. The surface also has different properties from the bulk of the concrete, which makes it more vulnerable [Dewar, 1984]. Concrete deterioration is not the result of an external attack (unsuitable materials) may be included during the mixing process. Because of this, an extensive emphasis has been place on measuring permeability, which affects the ingress and movement of fluids [Lawrence, 1985]. In recent years, non-destructive in-situ permeability test could be implementing for assessing durability and assess the near surface characteristics of the concrete [Concrete society, 1985]. Numerous tests had been developing which test either at the near surface/ just below it and its not give values of permeability, but rather rates of absorption, as well as none of which can be easily convert to a true permeability [Concrete society. 1985]. In fact, some of these tests have been available for many years [Levitt, 1966], little or no data is available to demonstrate their suitability for in-situ use. One major problem, which has led to develop these tests, is that, moisture content affects the permeability of the concrete by the action of pore blocking [Lawrence, 1985]. As a result, data relating to these tests are either from specimens conditioned by oven drying in the laboratory/ site concrete with no allowance made for the moisture in the concrete [Concrete society, 1985]. The measurement of the rate of ingress of water into hardened concrete is a main factor in the determination of the durability of a structure [Dhir, 1986]. Water ingress rates are also good predictors of the likelihood of the ingress of other detrimental fluids and ions into concrete. In-situ tests were aim to measure the permeation characteristics of concrete in structures have been develop and investigated [Dhir, 1987]. The permeation measurements from them have been to provide durability indices, which correlate with the results from accelerated exposure testing [Dhir, 1988]. However, the major difficulty in applying these tests in situ is that their measurements are substantially affect by the amount of water already present in the concrete, and it has been shown that any uncertainties about the original moisture content lead to poor reproducibility of the results [Dhir, 1987]. For this reason, meaningful in situ testing of concrete for permeation properties has not been possible. The first is to measure the moisture content and compensate for it in the results, and the second is to precondition the sample by removing the moisture. The effective water/cement ratio for workability is more difficult to define. It can be assume, provisionally, that initially dry aggregates will have achieved, at the time of the workability test, the same degree of saturation, as they would have in water. These effects of absorption only apply to high-strength mixes. Rich, uneconomical site mixes can be avoid [Newman, 1959].Thus, greater emphasis now being place on the durability of concrete and the need for on-site characterization of concrete for durability, there

is an increasing dependence on the measurement of the permeation properties of concrete. The present study in fact focused on the near surface absorption characterization of saturated concrete cubes for in case of different designed mixtures type by ISAT.

2.0 Research Objectives

The main aim of this research will interpret the influence of saturated condition (PSC and FSC) on the performance of ISAT in concrete cubes with different concrete mixtures design. For which slump, and w/c ratio value was vary with same grade of concrete as in the first case and compressive strength, and w/c ratio value varied with same slump as in the second case. It is also possible to correlate relationship between initial surface absorption-diffusion coefficient and near characteristics to sorptivity coefficient at different time intervals respectively.

3.0 Experimental program

In the pilot program, six mixtures types were prepared as per BRE, 1988 [Teychenné, 1988] standards with a concrete cubes of size (100 mm^3). Three of the mixtures (M1, M2, and M3) were concrete cubes with a same concrete compressive strength, differential slump, and w/c ratio. Another three set of the mixtures types (M4, M5, and M6) were with a differential compressive strength, same slump, and different w/c ratio. The overall details of the mixture proportions were to be representing in Table.1-2. In total seventy-two concrete cubes were casted for six types designed concrete mixture. The coarse aggregate used was crush stone (10 mm) with grade of cement 42.5 N/mm^2, and fine aggregate used was 4.75 mm sieve size down 600 microns.

Table: 1 (Variable: Slump & W/C value; Constant: Compressive strength)

Mix ID	Comp/mean target stg,N/mm^2	Slump (mm)	w/c	C (Kg)	W (Kg)	FA (Kg)	CA (Kg) 10 mm	Mix proportions
M1	40/47.84	0-10	0.45	3.60	1.62	5.86	18.60	1:1.63:5.16
M2	40/47.84	10-30	0.44	4.35	1.92	5.62	16.88	1:1.29:3.87
M3	40/47.84	60-180	0.43	5.43	2.34	6.42	14.30	1:1.18:2.63

Table: 2 (Variable: Compressive strength & W/C value; Constant: Slump)

Mix ID	Comp/mean target stg, N/mm^2	Slump (mm)	w/c	C (Kg)	W (Kg)	FA (Kg)	CA (Kg) 10mm	Mix proportions
M4	25/32.84	10-30	0.50	3.84	1.92	5.98	17.04	1:1.55:4.44
M5	30/37.84	10-30	0.45	4.27	1.92	6.09	16.50	1:1.42:3.86
M6	40/47.84	10-30	0.44	4.35	1.92	5.62	16.88	1:1.29:3.87

3.1 Initial surface absorption test

The concrete contains gradients of moisture in the near-surface region that are related to ambient climatic conditions approximately the concrete surface and its internal microstructure. Moisture gradients in concrete exposed to wetting/drying become complex with more difficult to predict. Interpreting the results of an in situ permeation test, the antecedent and current moisture state of the concrete could not ignore [Parrott, 1990]. ISAT were conduct in the present research work as per [BS 1881: Part 208:1996] on all saturated conditioned 72 concrete cubes of size (100 mm^3) by using ISAT equipment as shown in Fig.1. Concrete cubes were oven dried (3 days) at a constant temperature of 105±5 °C, and exposure to natural air for about 7 days until it reaches constant weight change. At the end of 10, 30, and 60 min, the reservoir flow was close and the water could allow penetrating the concrete surface from the capillary tube. The test gives the water flow ($ml/m^2/sec$) into the surface of the saturated conditioned concrete cube by calibration capillary tube.

Fig.1 Arrangement of ISAT

The absorption values are determined at 10, 30, and 60 min from the start of the test. The average values of ISAT with different mixtures type (M1-M6) in saturated conditioned (Mc =2.5%) concrete cubes were represented in Table.3. Similarly, the average values of ISAT at various compressive strength values with different mixtures type (M1-M6) in saturated conditioned concrete cubes was represent in Table.4.

Table.3 ISAT on PSC cubes for Mixtures type (M1-M6)

Mix ID	Comp/mean target stg, N/mm²	Slump (mm)	Mix proportion	ISAT,avr Mc = 2.5% ml/m²/s 10 min	30 min	60 min
M1	40/47.84	0-10	1:1.63:5.16	0.36	0.29	0.21
M2	40/47.84	10-30	1:1.29:.3.87	0.30	0.27	0.23
M3	40/47.84	60-180	1:1.18:2.63	0.33 2.1	0.26	0.22
M4	25/32.84	10-30	1:1.55:4.44	0.29 2.27	0.24	0.20
M5	30/37.84	10-30	1:1.42:3.86	0.25 2.13	0.20	0.15
M6	40/47.84	10-30	1:1.29:3.87	0.21 2.5	0.20	0.14

Table.4 Variation of ISAT with compressive strength in PSC cubes (Mc = 2.5%)

Mix ID/Time Com stg, N/mm²	M1 31.34	M2 32.43	M3 34.48	M4 25.48	M5 31.91	M6 32.13
10 min	0.36	0.30	0.33	0.29	0.25	0.21
30 min	0.29	0.27	0.26	0.24	0.20	0.20
60 min	0.21	0.23	0.22	0.20	0.15	0.14

The average values of ISAT for mixtures type (M1-M6) in saturated conditioned (Mc = 5%) concrete cubes were represented in Table.5. Similarly, the average values of ISAT at various compressive strength values with mixtures type (M1-M6) in saturated conditioned concrete cubes was as represent in Table.6.

Table.5 ISAT on FSC cubes for Mixtures type (M1-M6)

Mix ID	Comp/mean target stg, N/mm²	Slump (mm)	Mix proportion	ISAT,avr Mc = 5% ml/m²/s 10 min	30 min	60 min
M1	40/47.84	0-10	1:1.63:5.16	0.23	0.18	0.14
M2	40/47.84	10-30	1:1.29:.3.87	0.28	0.23	0.16
M3	40/47.84	60-180	1:1.18:2.63	0.24 2.1	0.19	0.17
M4	25/32.84	10-30	1:1.55:4.44	0.23 2.27	0.21	0.19
M5	30/37.84	10-30	1:1.42:3.86	0.23 2.13	0.21	0.15
M6	40/47.84	10-30	1:1.29:3.87	0.17 2.5	0.13	0.11

Table.6 ISAT with compressive strength in FSC cubes (Mc = 5%)

Mix ID/Time Com stg, N/mm²	M1 31.34	M2 32.43	M3 34.48	M4 25.48	M5 31.91	M6 32.13
10 min	0.23	0.28	0.24	0.23	0.23	0.17
30 min	0.18	0.23	0.19	0.21	0.21	0.13
60 min	0.14	0.16	0.17	0.19	0.15	0.11

4.0 Discussion about Results

In the present research work, the effectiveness of 72 preconditioned concrete cubes (100) mm in saturated condition was evaluate for in designed mixtures type (M1-M6). For which first three mixtures type (M1-M3) was design as same grade of concrete with varied slump value and second three mixtures type (M4-M6) was design as same slump value with different compressive strength. The ISAT value was increased (0.33-0.36 ml/m²/s) in mixtures type (M1-M3) at initial time (10 min) as when compared to longer time (60 min) which was (0.21-0.22 ml/m²/s) for in same mixtures type. ISAT value was increased (0.21-0.29 ml/m²/s) in mixtures type (M4-M6) at initial time (10 min) as against to longer time (0.14-0.20 ml/m²/s) at 60 min. Rate of ISAT was slightly higher in concrete cubes for mixtures type (M1-M3) at initial time for same grade of concrete and varied slump value as against to mixtures type (M4-M6) with different grade of concrete and constant slump value with (Mc = 2.5%) as observed from Fig.2. ISAT value was increased (0.23-0.24 ml/m²/s) in mixtures type (M1-M3) at initial time duration (10 min) as when compared to longer time duration (60 min) which was ranged between (0.14-0.17 ml/m²/s) for in same mixtures type. ISAT value was increased (0.17-0.23 ml/m²/s) in mixtures type (M4-M6) at initial time (10 min) as when compare to longer time duration (0.11-0.19 ml/m²/s) at 60 min. Rate of ISAT was slightly higher/lower

in concrete cubes for mixtures type (M1-M3) at initial time for constant grade of concrete and varied slump value as when compared to mixtures type (M4-M6) with different grade of concrete and constant slump value with (Mc = 5%) as observed from Fig.3.

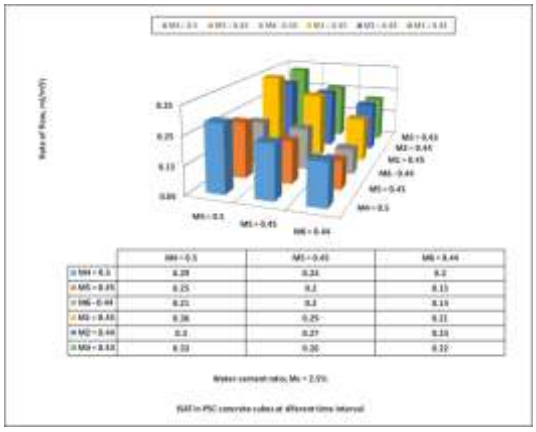

Fig.2 Variation of ISAT-w/c ratio in PSC cubes

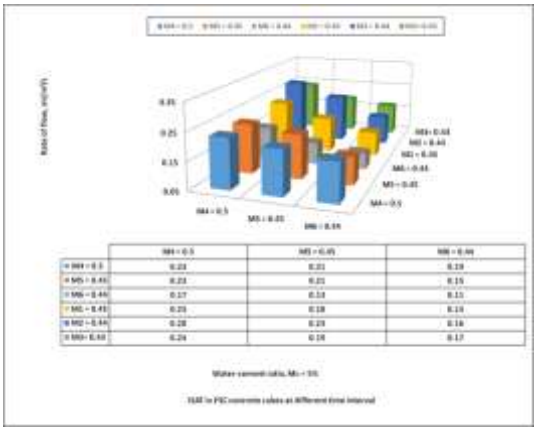

Fig.3 Variation of ISAT-w/c ratio in FSC cubes

As observed from DCC (Mc = 0%) results that, ISAT was increased in all mixtures type (M1-M6) at 10 min. Actually ISAT was increased at early stage (10 min) as compared to 30 min and 60 min which was varied about 24.51% as well as 38.70% respectively. ISAT was observe to increase at early time (10 min) as compared to longer time at 30 min and 60 min in which it has varied as 31.06% as well as 45.65% for in mixtures type (M1-M3). Whereas in case of mixtures type (M4-M6), the ISAT was slightly decreased at early stage (10 min) as when against to longer time at 30 min and 60 min which was varied about 17.95% as well as 31.75% respectively [Balakrishna, *et a*l, 2018]. The ISAT value for in PSC cubes (Mc = 2.5%) and FSC cubes (Mc = 5%) was slightly increased with same higher compressive strength and varied slump at initial time (10 min) in all mixtures type (M1-M3). ISAT values decreases for different time interval (10-60) min. However, ISAT value was slightly increases at longer time even though the compressive strength is higher. Whereas, ISAT values was decrease in mixtures type (M4-M6) at initial stage (10 min) with different compressive strength and constant slump as compared to mixtures type (M1-M3). ISAT values were clearly decrease for longer time at 30 min and 60 min with higher compressive strength. Furthermore, the ISAT values was varied in PSC cubes as well as FSC cubes even though the mixtures proportion was designed with constant slump and compressive strength as well as varied compressive strength and slump. As observed from results that (Fig.4), ISAT was increased in all mixtures type (M1-M6) at 10 min. Actually ISAT was increase at early stage (10 min) as compared to 30 min and 60 min, which was, varied about 15.44% as well as 33.78% respectively. ISAT was observe to increase at early time (10 min) as against to longer time at 30 min and 60 min in which it has varied as 16.88% as well as 32.77% for in mixtures type (M1-M3). Whereas in case of mixtures type (M4-M6), the ISAT was slightly decreased at early stage (10 min) as when compared to longer time at 30 min and 60 min which was varied about 14.00% as well as 34.78% respectively. As observed from results that (Fig.5), ISAT for in case of FSC cubes was increased in all mixtures type (M1-M6) at 10 min. ISAT was increased at early stage (10 min) as compared to 30 min and 60 min, which was, varied about 16.89% as well as 33.10% respectively. ISAT was observe to increase at early time (10 min) as compared to longer time at 30 min and 60 min in which it is varied as 20.14% as well as 37.05% for in mixtures type (M1-M3). Whereas in case of mixtures type (M4-M6), the ISAT was slightly decreased at early stage (10 min) as when compared to longer time at 30 min and 60 min which was varied about 13.64% as well as 29.15% respectively[Balakrishna, *et al*, 2017]. Similarly the variations of ISAT decreased value with moisture content for in case of partially (Mc = 2.5%) and fully saturated (Mc = 5%) conditioned concrete cubes was analysed as well as compared at different time intervals (10-30, 10-60, and 30-60 min) as represented in (Fig.4-5) for various designed mixtures type.

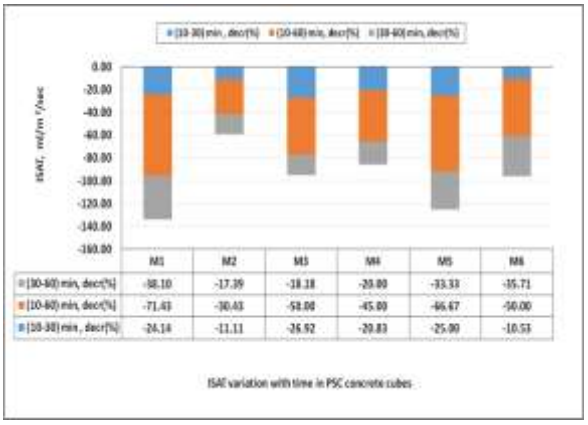

Fig.4 ISAT in PCC cubes

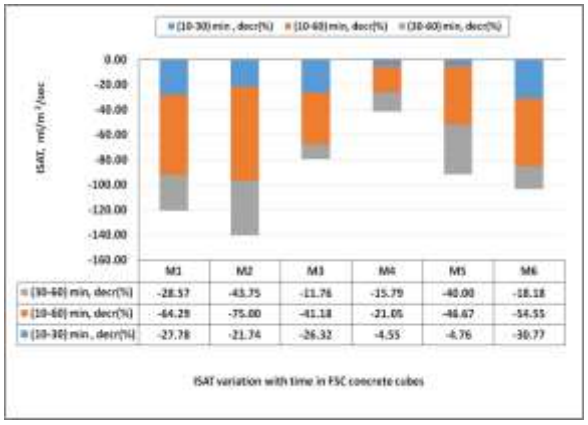

Fig.5 ISAT in FSC cubes

ISAT was increased for in case of partially (Mc = 2.5%) and fully saturated (Mc = 5%) conditioned concrete cubes was analysed as well as compared at different time intervals (10-30, 10-60, and 30-60 min) as represented in (Fig.6-7) for various designed mixtures type. The variation of ISAT value in PSC concrete cubes was lesser at 30 min and 60 min as when compare to initial time duration at 10 min. ISAT values was varied in mixtures type (M1-M3) for constant higher compressive strength with varied slump at different time (10 min-

30 min- 60 min). Whereas in mixtures type (M4-M6), the ISAT was more at 10 min time interval. ISAT was more in lower compressive strength as when compared to higher compressive strength value with constant slump. Similarly, the ISAT values in mixtures type (M1-M3) at time duration 60 min in which, the ISAT was slightly increased in mixture type M2 and whereas in mixture type M3, its slightly lower compared to time at 10 min and 30 min with higher compressive strength (40 N/mm^2) and varied slump. Similarly, the ISAT in PSC concrete cubes was increased at 10 min and 30 min for lower compressive strength as when compared to longer time duration at 60 min. Whereas in mixtures type (M4-M6), the ISAT was found to be more at 10 min time duration as when compared to time duration at 30 min-60 min respectively. ISAT was more in lower compressive strength as when compared to higher compressive strength value with constant slump. Similarly, the ISAT values in mixtures type (M4-M6) at time duration 60 min, in which the ISAT was slightly decreased in mixture type M6 and whereas in mixtures type M4 and M5, its slightly higher compared to time duration at 60 min with higher compressive strength and constant slump.

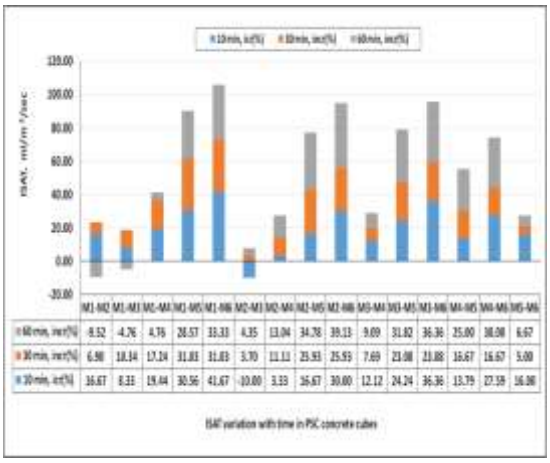

Fig.6 ISAT variation in designed PSC cubes

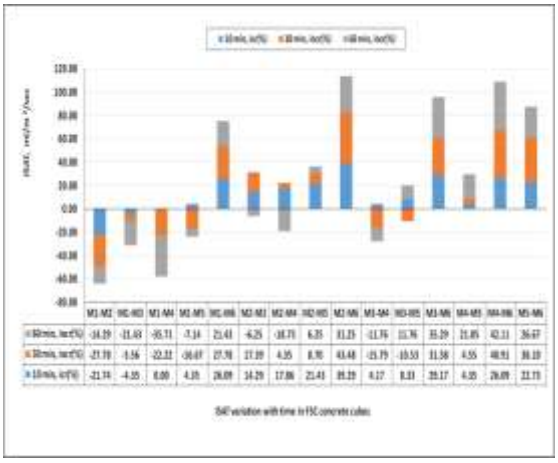

Fig.7 ISAT variation in designed FSC cubes

ISAT-water diffusion coefficient variation for in fully saturated (Mc = 5%) conditioned concrete cubes was analysed as well as compared at different time intervals (10, 30, and 60 min) as noted in (Fig.8) for various designed mixtures type. ISAT could be more for in case of higher/lower compressive strength in all designed concrete mixtures type (M1-M6) with increased water diffusion coefficient. ISAT was goes on decreased with decreased water diffusion coefficient. Its confirmed from the results that, ISAT was increased in lower compressive strength with increased water diffusion coefficient and goes on decreased with decrease in water diffusion coefficient, increased concrete compressive strength and constant slump for in case of concrete mixtures design (M4-M6) respectively. ISAT-sorptivity coefficient value with moisture content for in FSC concrete cubes was analysed at different time intervals (10, 30, and 60 min) as represented in (Fig.9) for various designed mixtures type. ISAT could be more for in case of higher compressive strength in all designed concrete mixtures type (M1-M6) with increased sorptivity coefficient. ISAT was goes on decreased with decreased water absorption capacity. Its confirmed from the results that, ISAT was increased in lower compressive strength with increased rate of water capacity and goes on decreased with decrease in water absorption capacity, increased concrete compressive strength and constant slump for in case of concrete mixtures design (M4-M6) respectively.

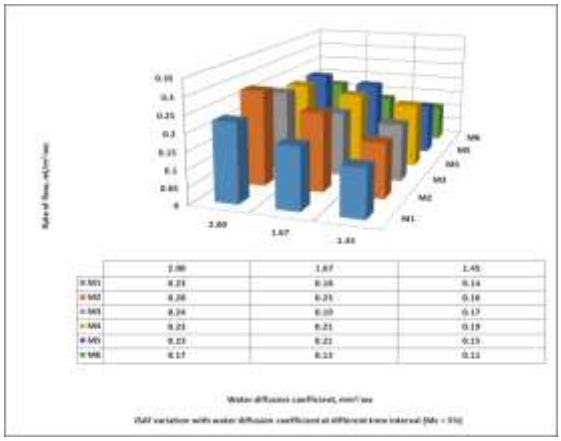

Fig.8 ISAT- water diffusion coefficient

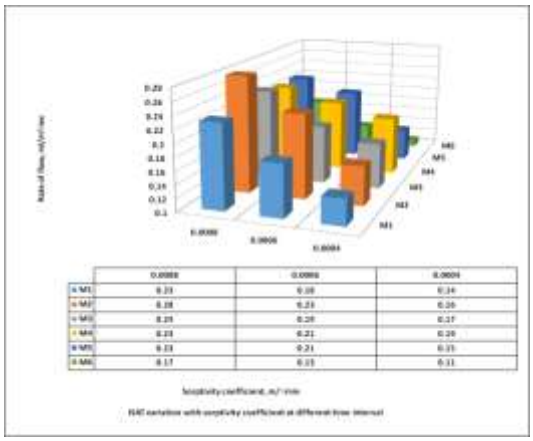

Fig.9 ISAT- sorptivity coefficient

5.0 Conclusions

- In DCC cubes, ISAT was increase in all designed mixtures type at initial time (10 min) as against to (30 min-60 min). ISAT value was increase at 10 min in lower compressive strength and constant slump as well as the ISAT value goes on mitigate with higher grade of concrete and same slump value.

- ISAT value for in case of PSC cubes (Mc = 2.5%) and FSC cubes (Mc = 5%) was slightly increased with constant higher compressive strength and varied slump at initial time duration (10 min) in all mixtures type. However, ISAT value was slightly increases at longer time duration even though the compressive strength is higher. ISAT values were decrease at initial stage (10 min) with different compressive strength and constant slump as compared to mixtures type (constant compressive strength and varied slump value). ISAT values were decrease for longer time duration at 30 min and 60 min with higher compressive strength. Furthermore, the ISAT values was varied in PSC cubes as well as FSC cubes even though the mixtures proportion was designed with constant slump and compressive strength as well as varied compressive strength and slump.

- ISAT values were decrease for in PSC cubes and FSC cubes as when compare to DCC cubes in all designed mixtures type and Its increased in PSC cubes as against to FSC cubes which in turn indicates that, the moisture content has its effect on the variation of ISAT values.

- ISAT could be more for in case of higher/lower compressive strength in designed concrete mixtures type with increased water diffusion coefficient. ISAT was goes on decreased with decreased water diffusion coefficient. It is confirm from the results that, ISAT was increase in lower compressive strength with increased water diffusion coefficient and goes on decreased with decrease in water diffusion coefficient, increased concrete compressive strength and constant slump.

- ISAT could be more for in case of higher compressive strength in designed concrete mixtures type with increased sorptivity coefficient and goes on decreased with decreased water absorption capacity. ISAT was increased in lower compressive strength with increased rate of water capacity and goes on decreased with decrease in water absorption capacity, increased concrete compressive strength and constant slump

6.0 References

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