Evaluation of saturated conditioned concrete cubes by Initial surface absorption test

M.N. Balakrishna[1*], Fouad Mohammad[2], Robert Evans[2], and M.M. Rahman[2]

[1]School of Architecture, Design and the Built Environment, Research scholar, Nottingham Trent University, Nottingham, NG1 4FQ, UK
[2]School of Architecture, Design and the Built Environment, Faculty of Engineering, Nottingham Trent University, Nottingham, NG1 4FQ, UK

ABSTRACT: *The concrete deterioration is one of the most serious problem at all regions of the world. In fact, the construction materials suffer some degree of deterioration with time. The problems actually occur when deterioration occurs to an unsatisfactory degree. In such cases, the concrete is not durable enough for the environment in which it is place. The deterioration of reinforced concrete usually involves movement of aggressive gases or liquids from the surrounding environment into the concrete through the near surface concrete. In turn followed by physical or chemical actions in its internal structure. 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. Therefore, there exists a porosity gradient in the near surface concrete. The transport of the various aggressive substances into the concrete depends on the quality of the near surface concrete and on its permeation characteristics. Therefore, there is a need to quantify the permeation characteristics of the near surface concrete, which is of paramount importance. The present research work made an attempt to assess the water absorption of concrete by Initial surface absorption test (ISAT) in ordered to interpret different concrete mixtures design, which gives a test method for structural health assessment by a suitable correlation between Initial surface absorption value, and Time.*

Thus, the objectives of this present research are threefold. First, this research will examine the influence of conditioning such as saturated condition on the results of ISAT performed on concrete cubes with different mixtures proportion. In which slump, and w/c ratio value was vary with constant compressive strength as in the First case and compressive strength, and w/c ratio value varied with constant slump as in the Second case. Seventy-two concrete cubes (100 mm^3) with Grades of concrete ranges from 25 to 40 N/mm^2 were prepared and tested using ISAT. First, the non-destructive test parameters were relate to different mixtures proportion in ordered to characterize mixtures design. Second, this research will examine the influence of the ISAT value on time. Third, this research will also aim to develop non-destructive charts for different concrete mixtures proportion. Thus, the ISAT due to the developed chart gave a better value. This implied that the developed chart was more suitable for normal strength concrete in turn minimising inaccuracy in non-destructive tests. It has concluded from the results that, in saturated conditioned concrete cubes, the ISAT value was increase in all designed mixtures type at initial time as when compared to longer time duration. Furthermore, the 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. In addition, 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. Furthermore, the 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.

***Keywords:* Concrete, Mix proportion, Grade of concrete, Sample conditioning, Slump, Water-cement ratio, Moisture content, Initial surface absorption,**

INTRODUCTION

The concrete is an extremely versatile construction material, which seems to be considerable use in construction industry at worldwide [l]. In the majority of cases, it is entirely satisfactory and unfortunately, in a small proportion of concrete, problems occur, either because the concrete is not adequate for the particular conditions of use, or because it does not achieve its full potential [2]. Concrete deterioration is not a new problem [3], but it has become more prevalent in recent years [4]. An extensive use of concrete, changes in material properties, construction techniques, and design approaches have resulted in a large amount of concrete of uncertain durability [5]. The surface is seems to be as the weakest part of the concrete because it is here that aggressive agents attack [6]. The surface also has different properties from the bulk of the concrete, which makes it more vulnerable [2]. The surface is also important for aesthetic reasons. Nevertheless, it is still necessary to recognise that, concrete deterioration is not the result of an external attack such as faulty or unsuitable materials may be included during the mixing process, either deliberately, or by accident. Because of this, a great deal of

emphasis has been place on measuring permeability, because there is a widely held belief that because this affects the ingress and movement of fluids and ions, it must be relate to durability [7].

An effort has made in recent years to introduce non-destructive in-situ permeability test could be used for assessing durability. These have the advantage, as well as being non-destructive, that they assess the surface properties of the concrete [8]. A number of tests have been develop, which test either at the surface, or just below it. These tests do not give values of permeability, but rather times, rates of absorption, or rates of flow, none of which can be easily convert to a true permeability value, but which it is hope can be relate to durability [8]. Although some of these tests have been available for many years [9], little or no data is available to demonstrate their suitability for in-situ use. One major problem, which has led to a general reluctance to develop these tests further, is that moisture content affects the permeability of the concrete by the action of pore blocking as the degree of saturation increases [10]. As a result, data relating to these tests are either from specimens conditioned by oven drying in the laboratory, or from site concrete with no allowance made for the moisture in the concrete [8].

The measurement of the rate of ingress of water into hardened concrete is a key step in the determination of the potential durability of a structure [11]. Water is a necessary ingredient for the corrosion of embedded steel and freeze-thaw damage to concrete. Water ingress rates are also good predictors of the likelihood of the ingress of other detrimental fluids and ions into concrete. In-situ tests are intend to measure the permeation characteristics of concrete in structures have been develop and investigated [12]. The permeation measurements from them has been to provide durability indices, which correlate with the results from accelerated exposure testing [13]. 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 [12]. For this reason, meaningful in situ testing of concrete for permeation properties has not been possible. There are two possible approaches to overcoming this problem.

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 if laboratory trials is based on the effective water/cement ratio as defined in this paper [14]. 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. An important factor that influences permeation measurements is the moisture state of the concrete prior to testing. Moisture gradients known to exist in exposed concretes therefore; all laboratory tests are generally carried out after preconditioning to a reference moisture state. An extensive effort has been directed towards improving basic concrete properties and since the water penetration starts from the surface, this 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.

RESEARCH OBJECTIVES

The objectives of this research are threefold. First, this research will examine the influence of conditioning such as saturated condition on the results of ISAT performed on concrete cubes with different mixtures proportion. In which such as w/c ratio, slump, grade of concrete, fine aggregate, coarse aggregate, cement content, and water content under two different conditions such as slump, and w/c ratio value was varied with constant compressive strength as in the First case and compressive strength, and w/c ratio value varied with constant slump as in the Second case. Second, this research will examine the influence of the ISAT values on Time, w/c ratio, and grade of concrete. Third, this research will also aim to develop non-destructive charts for different concrete mixture proportions. Thus, the ISAT due to the developed chart gave a better value, suitable for normal strength concrete and in turn can be utilised in minimising inaccuracy in non-destructive tests.

EXPERIMENTAL PROGRAM

In the present research work, six different mixtures were prepared in total as per BRE, 1988 [15] code standards with a concrete cubes of size (100 mm^3). Three of the mixtures were concrete cubes (100 mm^3) with a compressive strength 40 N/mm^2, slump (0-10, 10-30, and 60-180 mm), and different w/c (0.45, 0.44, and 0.43). These mixtures were designate as M1, M2, and M3. Another Three of the mixtures were concrete cubes with a compressive strength (25 N/mm^2, 30 N/mm^2, and 40 N/mm^2), slump (10-30 mm), and different w/c (0.5 0.45, and 0.44). These mixtures were designate as M4, M5, and M6. The overall details of the mixture proportions were to be represent in Table.1-2. Twelve concrete cubes of size (100 mm^3) were casted for each mixture and overall Seventy-two concrete cubes were casted for six types of concrete mixture.

The coarse aggregate used was crush stone with maximum nominal size of 10 mm with grade of cement 42.5 N/mm^2 and fine aggregate used was 4.75 mm sieve size down 600 microns for this research work.

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

Mix No	Comp/mean target strength(N/mm^2)	Slump (mm)	w/c	C (Kg)	W (Kg)	FA (Kg)	CA(Kg) 10 mm	Mixture 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 No	Comp/mean target strength(N/mm^2)	Slump (mm)	w/c	C (Kg)	W (Kg)	FA (Kg)	CA(Kg) 10 mm	Mixture 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

INITIAL SURFACE ABSORPTION TEST

The concrete exposed to the natural environment inevitably contains gradients of moisture in the near-surface region that are relate to both the ambient climatic conditions in the immediate vicinity of the concrete surface and its internal microstructure. Moisture gradients in concrete exposed to natural wetting and drying cycles become complex and more difficult to predict. Saturated concrete, with a porous and permeable structure, can have a comparable air permeability or sorptivity to an unsaturated concrete with a less permeable and porous structure. Clearly, while interpreting the results of an in situ permeation test, the antecedent and current moisture state of the concrete cannot be ignored [16]. Thus, an Initial surface absorption test (ISAT) were conduct in the present research work as per BS 1881: Part 208:1996 [17] on all saturated conditioned 72 concrete cubes of size (100 mm^3) by using ISAT equipment as shown in Fig.1. After 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. Water was allow to penetrate the concrete surface from the reservoir into the cap. At the end of 10, 30, and 60 min, the reservoir flow was close and the water was allow to penetrate 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.

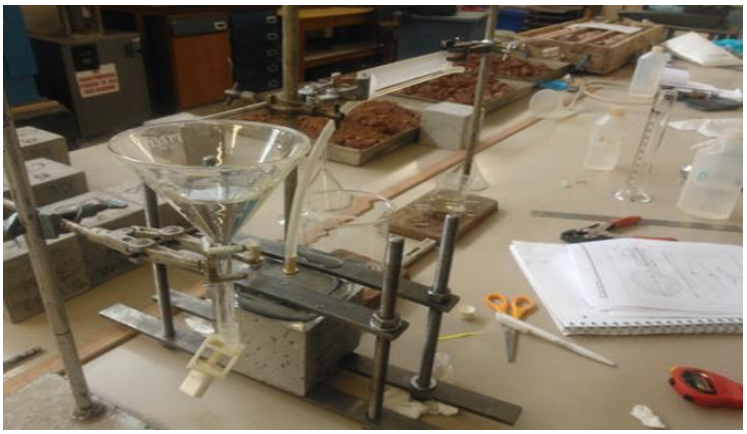

Fig.1 Schematic diagram of ISAT

Initially with the inlet tap opened, water flows to fill the cap and then through the outlet it climbs into the calibrated horizontal capillary tube. After 10 min, the tap is close and the rate of water suction by the concrete is monitor by following the retraction of the meniscus in the capillary tube. This provides the initial surface absorption at 10 minutes. The absorption values are determined in this manner at 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.3-4. 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.5.

Table.3 ISAT on SCC cubes for Mixtures type (M1-M3)

Mix ID	Comp/mean target strength(N/mm²)	Slump (mm)	Mix Proportion	Average values of ISAT, ml/m²/s, Mc = 2.5%		
				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	0.3	0.27	0.23
M3	40/47.84	60-180	1:1.18:2.63	0.33	0.26	0.22

Table.4 ISAT on SCC cubes for Mixtures type (M4-M6)

Mix ID	Comp/mean target strength(N/mm	Slump (mm)	Mix Proportion	Average values of ISAT, ml/m²/s, Mc = 2.5%		
				10	30	60 min
M4	25/32.84	10-30	1:1.55:4.44	0.29	0.24	0.2
M5	30/37.84	10-30	1:1.42:3.86	0.25	0.2	0.15
M6	40/47.84	10-30	1:1.29:3.87	0.21	0.2	0.14

Table.5 Variation of ISAT with compressive strength in SCC cubes

ISAT, ml/m²/s, aver on PSC cubes [Mc = 2.5%] in different mix types						
Mix ID/Time	M1	M2	M3	M4	M5	M6
Com Stg (N/mm²)	31.34	32.43	34.48	25.48	31.91	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 with different mixtures type (M1-M6) in saturated conditioned (Mc = 5%) concrete cubes were represented in Table.6-7. 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.8.

Table.6 ISAT on SCC cubes for Mixtures type (M1-M3)

Mix No	Comp/mean target strength(N/mm²)	Slump (mm)	Mix Proportion	Average values of ISAT, ml/m²/s, Mc = 5%		
				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	0.19	0.17

Table.7 ISAT on SCC cubes for Mixtures type (M4-M6)

Mix No	Comp/mean target strength(N/mm	Slump (mm)	Mix Proportion	Average values of ISAT, ml/m²/s, Mc = 5%		
				10	30	60 min
M4	25/32.84	10-30	1:1.55:4.44	0.23	0.21	0.19
M5	30/37.84	10-30	1:1.42:3.86	0.23	0.21	0.15
M6	40/47.84	10-30	1:1.29:3.87	0.17	0.13	0.11

Table.8 ISAT on SCC cubes for Mixtures type (M4-M6)

ISAT, ml/m²/s, aver on FSC cubes [Mc = 5%] in different mix types						
Mix ID/Time	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**
Com Stg (N/mm²)	31.34	32.43	34.48	25.48	31.91	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

DISCUSSION ABOUT RESULTS

Thus in the present research work, the effectiveness of 72 preconditioned concrete cubes of size (100) mm such as saturated condition was evaluated for in case of six designed mixtures type (M1-M6). In which first three mixtures type (M1-M3) was designed as constant compressive strength (40 N/mm²) with varied slump value (0-10, 10-30, and 60-180) mm and whereas second three mixtures type (M4-M6) was designed as constant slump value (10-30) mm with different compressive strength (25-30-40) N/mm². The ISAT value was increased (0.33-0.36 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 (0.21-0.22 ml/m²/s) for in case of same mixtures type. Whereas the ISAT value was more increased (0.21-0.29 ml/m²/s) in mixtures type (M4-M6) at initial time duration (10 min) as when compared to longer time duration (0.14-0.20 ml/m²/s) at 60 min. In fact, the rate of ISAT value was found to be slightly higher in concrete cubes for mixtures type (M1-M3) at initial time duration 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 moisture content (Mc = 2.5%) as observed from Fig.2.

Similarly, the 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 case of same mixtures type. Whereas the ISAT value was more increased (0.17-0.23 ml/m²/s) in mixtures type (M4-M6) at initial time duration (10 min) as when compared to longer time duration (0.11-0.19 ml/m²/s) at 60 min. In fact, the rate of ISAT value was found to be slightly higher/lower in concrete cubes for mixtures type (M1-M3) at initial time duration 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 moisture content (Mc = 5%) as observed from Fig.3.

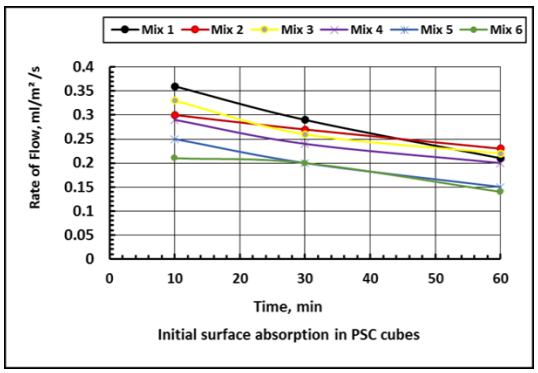

Fig.2 ISAT in PSC cubes

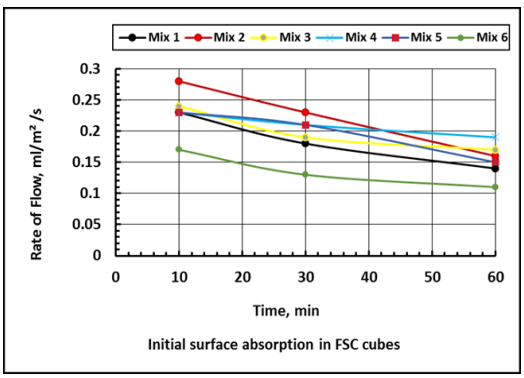

Fig.3 ISAT in FSC cubes

The ISAT value for in case of dry conditioned concrete cubes was reduce with constant higher compressive strength and varied slump at initial time duration (10 min) in all mixtures type (M1-M3). In addition, it is confirm from present results that, the ISAT values decreases for different time intervals (10-60) min. However, ISAT value was increases at longer time duration even though the compressive strength is higher in turn it may be due to different slump as well as w/c ratio. Whereas, ISAT values was increase in mixtures type (M4-M6) at initial stage (10 min) with different compressive strength and constant slump as compared to mixtures type (M1-M3). In fact, its observed from the results that, the ISAT values was clearly decreased for longer time duration at 30 min and 60 min with higher compressive strength. Furthermore, the ISAT values was vary in dry conditioned concrete 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 dry conditioned concrete cubes (Mc = 0%) results that (Fig.4), 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. Similarly, the ISAT was observe to increase at early time duration (10 min) as compared to longer time duration 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 compared to longer time duration at 30 min and 60 min which was varied about 17.95% as well as 31.75% respectively. Similarly, the variation of ISAT value with moisture content for in case of partially (Mc = 2.5%) and fully saturated (Mc = 5%) conditioned concrete cubes was represented in (Fig.5) for different designed mixtures type.

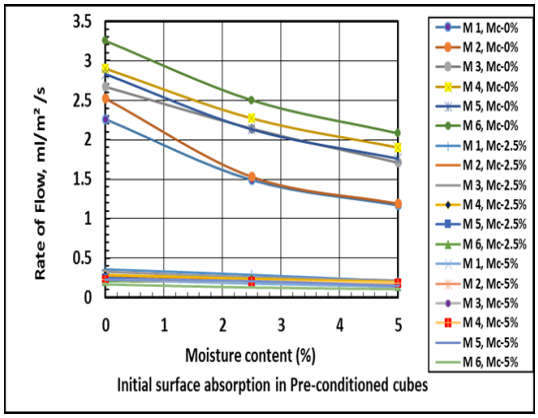

Fig.4 ISAT in PCC cubes

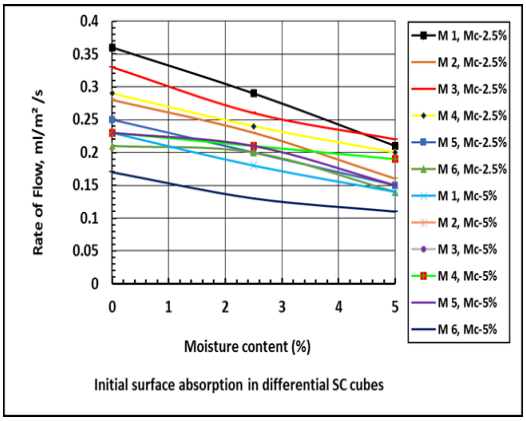

Fig.5 ISAT in SCC cubes

The 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 (M1-M3). In addition, it is confirm from present results that, the ISAT values decreases for different time intervals (10-60) min. However, ISAT value was slightly increases at longer time duration even though the compressive strength is higher in turn it may be due to different slump as well as w/c ratio. 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). In fact, it is observe from the results that, the ISAT values was clearly decrease for longer time duration at 30 min and 60 min with higher compressive strength. Furthermore, the ISAT values was found to be 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. Similarly, the ISAT was observe to increase at early time duration (10 min) as compared to longer time duration 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 duration at 30 min and 60 min which was varied about 14.00% as well as 34.78% respectively. As observed from results that (Fig.4), ISAT for in case of FSC cubes 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 16.89% as well as 33.10% respectively. Similarly, the ISAT was observe to increase at early time duration (10 min) as compared to longer time duration 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 duration at 30 min and 60 min which was varied about 13.64% as well as 29.15% respectively.

The variation of ISAT as observed from results that (Figs.6-7), in which, DCC concrete cubes was lesser at 30 min/60 min as when compared to initial time duration at 10 min. An ISAT values was varied in mixtures type (M1-M3) for constant higher compressive strength and varied slump at different time duration such as at 10 min as (2.26, 2.52, and 2.67) ml/m^2/s, at 30 min (1.49, 1.53, and 2.14) ml/m^2/s as well as at 60 min (1.17, 1.19, and 1.71) ml/m^2/s. In mixtures type (M4-M6), the ISAT was found to be more at 10 min time duration with their values as (2.9, 2.83, and 2.7) ml/m^2/s, (2.27, 2.13, and 2.5) ml/m^2/s, and (1.9, 1.76, and 2.08) ml/m^2/s respectively. Thus, it has confirmed that, the 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 increased in mixture type M2 and whereas in mixture type M3, its slightly higher compared to time duration at 10 min and 30 min with higher compressive strength (40 N/mm^2)and varied slump. The effectiveness of constant compressive strength on ISAT for mixtures type (M1-M3) in DCC concrete cubes at different time duration as shown in (Fig.6). This may be due to the fact that, if cement content was more, it creates cracks in concrete cubes in turn there exists a differential membrane between cement paste

and concrete matrix. Because of that, segregation was occur due that, cement content starts settled at top layer and concrete matrix settled at bottom with variations in ingredient such as aggregate volume fraction and w-c ratio.

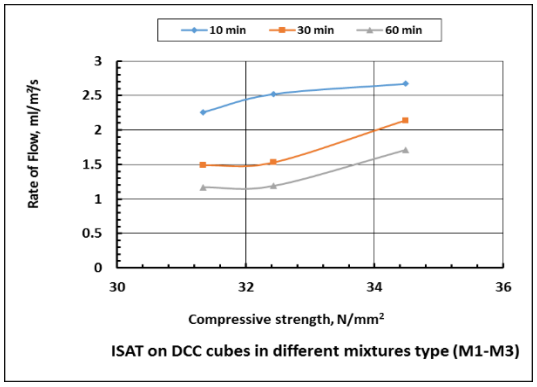

Fig.6 ISAT versus compressive strength

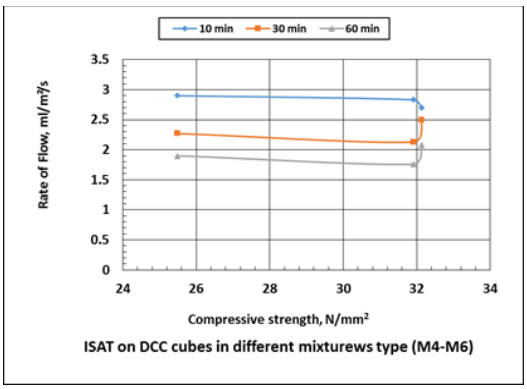

Fig.7 ISAT versus compressive strength

The effectiveness of different compressive strength (25-30-40 N/mm^2) on ISAT for mixtures type (M4-M6) in DCC concrete cubes at different time duration as shown in (Fig.7). Similarly, the ISAT in DCC concrete cubes was increase at 10 min and 30 min for lower compressive strength as when compare to longer time duration at 60 min. In which, the ISAT values was varied in mixtures type (M4-M6), for different compressive strength with constant slump at different time duration such as 10 min as (2.9, 2.83, and 2.7) ml/m^2/s, at 30 min (2.27, 2.13, and 2.5) ml/m^2/s as well as at 60 min (1.9, 1.76, and 2.08) ml/m^2/s. In mixtures type (M4-M6), the ISAT was found to be more at 10 min time duration with their values as (2.9, 2.27, and 1.9) ml/m^2/s, as when compared to time duration at 30 min (2.83, 2.13, and 1.76) ml/m^2/s, and at 60 min (2.7, 2.5, and 2.08) ml/m^2/s respectively. Thus its confirmed that, the ISAT was found to be 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. The effectiveness of different compressive strength (25-30-40 N/mm^2) on ISAT for mixtures type (M1-M6) in PSC and FSC concrete cubes at different time duration as shown in (Fig.8-11).

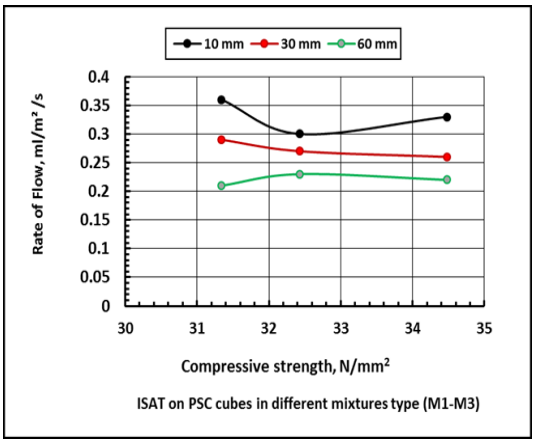

Fig.8 compressive strength versus ISAT in PSC cubes

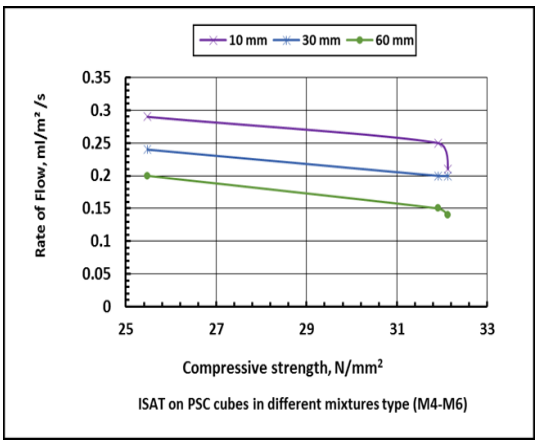

Fig.9 compressive strength versus ISAT in PSC cubes

The variation of ISAT value (Figs.8-9) in PSC concrete cubes was lesser at 30 min and 60 min as when compare to initial time duration at 10 min. In which the ISAT values was varied in mixtures type (M1-M3) for constant higher compressive strength with varied slump at different time duration such as at 10 min-30 min- 60 min. Whereas in mixtures type (M4-M6), the ISAT was found to be more at 10 min time duration. Thus, it has confirmed that, the 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 duration at 10 min and 30 min with higher compressive strength (40 N/mm^2) and varied slump. The effectiveness of constant compressive strength on ISAT for mixtures type (M1-M3) in PSC concrete cubes at different time duration as shown in Fig.8. The effectiveness of different compressive strength (25, 30, and 40 N/mm^2) on ISAT for mixtures type (M4-M6) in PSC concrete cubes at different time duration as

shown in (Fig.9). Similarly, the ISAT in PSC concrete cubes was found to be 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. Thus, it has confirmed that, the 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.

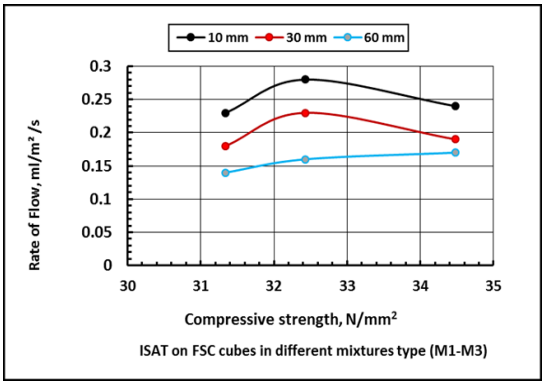

Fig.10 compressive strength versus ISAT in FSC cubes

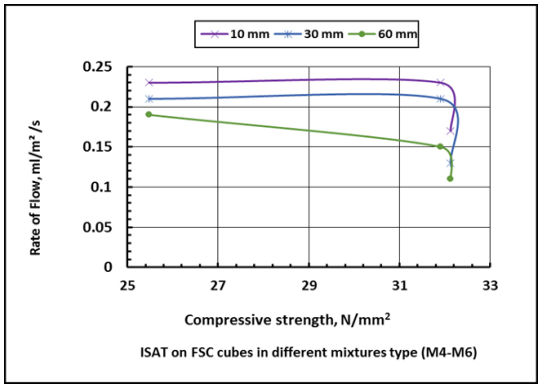

Fig.11 compressive strength versus ISAT in FSC cubes

The variation of ISAT value (Figs.10-11) in FSC concrete cubes was lesser at 30 min and 60 min as when compare to initial time duration at 10 min. In which the ISAT values was varied in mixtures type (M1-M3) for constant higher compressive strength with varied slump at different time duration such as at 10 min-30 min- 60 min. Whereas in mixtures type (M4-M6), the ISAT was found to be more at 10 min time duration. Thus, it has confirmed that, the 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 decreased in mixture type M2 and whereas in mixture type M3, its slightly higher compared to time duration at 10 min and 30 min with higher compressive strength (40 N/mm^2) and varied slump. The effectiveness of constant compressive strength on ISAT for mixtures type (M1-M3) in FSC concrete cubes at different time duration as shown in Fig.10. The effectiveness of different compressive strength (25, 30, and 40 N/mm^2) on ISAT for mixtures type (M4-M6) in FSC concrete cubes at different time duration as shown in (Fig.11). Similarly, the ISAT in FSC concrete cubes was found to be 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. Thus, it has confirmed that, the 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.

CONCLUSION

[1]. In DCC cubes, the ISAT value was increased in all designed mixtures type at initial time (10 min) as when compared to (30 min-60 min). Furthermore, the ISAT value was increase at 10 min in lower compressive strength and constant slump as well as the ISAT value goes on reduced with higher compressive strength and constant slump value.

[2]. The ISAT value was increased at initial time (10 min) with higher compressive strength and varied slump value as when compared to later time duration (30 min-60 min) with same higher compressive strength as well as varied slump value. Furthermore, the ISAT value was increase at 10 min 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 (30 min-60 min).

[3]. The 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 in turn it may be due to different slump as well as w/c ratio. Whereas, ISAT values was found to be decreased in mixtures type (M4-M6) at initial stage (10 min) with different compressive strength and constant slump as compared to mixtures type constant compressive strength and varied slump value.

[4]. In fact, its observed from the results that, the ISAT values was clearly decreased for longer time duration at 30 min and 60 min with higher compressive strength. Furthermore, the ISAT values was found to be 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.

[5]. Furthermore that, the ISAT values was decreased for in case of PSC cubes and FSC cubes as when compared to DCC cubes in all designed mixtures type. In addition to that, the ISAT values was observed to be increased in PSC cubes as when compared to FSC cubes which in turn indicates that, the moisture content has its effect on the variation of ISAT values.

REFERENCES

[1].Treadaway, K. W. J., 'Corrosion Problems in Middle Eastern Conditions-Causes and Remedies', Second European Seminar: The Failure and Repair of Corroded Reinforced Concrete Structures; London, 3rd October 1984.

[2]. Dewar, J. D., 'Testing Concrete for Durability', A One-Day Symposium: Developments in Testing Concrete for Durability; The Concrete Society, 26 September 1984, London.

[3]. Feld, J., 'Construction Failure', WILEY series of practical construction guides, 1968.

[4]. Madderom , F. W., 'How to Eliminate Concrete Scaling', Concrete International, V. 2, No.2, February 1980.

[5]. Somerville, G., 'The design Life of Concrete Structures', The Structural Engineer, V.64A, No.2, February 1986.

[6]. Browne, R. D., 'Practical Considerations in Producing Durable Concrete', Improvements of Concrete Durability, Thomas Telford Ltd. 1986. (Proceedings of the Conference: How to Make Todays Concrete Durable for Tomorrow; 8th May, 1985).

[7]. Lawrence, C. D., 'Laboratory Testing of Cores', One-day Conference: Permeability of Concrete and its Control; The -'Concrete Society, London, 12th December 1985.

[8]. The Concrete Society, 'Permeability of Site Concrete-A Review of Methods and Experience', Final Draft, November 1985.

[9]. Levitt, M., Discussion: 'Concrete Quality Conference London 1964', Proceedings of the Symposium, The Cement and Concrete Association, 1966.

[10]. Lawrence, C. D., 'Water Permeability of Concrete', The Concrete -. Society Materials Seminar: Serviceability of Concrete; 15-16 July 1985.

[11]. Dhir. R. K. et al, 'Near surface characteristics and durability of concrete: an initial appraisal', Mag. Concr. Res., 1986, 38, pp.54-56.

[12]. Dhir.R.K. et a/., 'Near surface characteristics of concrete: assessment and development of in situ test methods'. Mag. Concr. Res., 1987, 39, pp.183-195.

[13]. Dhir. R. K. et a/., 'Near surface characteristics of concrete: prediction of carbonation resistance'. Mag. Concr. Res., 1988, 41, pp.137-143.

[14]. Newman. K, 'The effect of water absorption by aggregates on the water/cement ratio of concrete', Magazine of Concrete Research, V.11, Issue 33, 01 November 1959, pp.135–142.
[15]. D C Teychenné, R E Franklin, and H C Erntroy, 'Design of normal concrete mixes, 2nd edition, BRE, 1988.

[16]. Parrott, L. J., 'Influence of environmental parameters upon permeability: a review', RILEM Technical Committee 116-PCD Report (1990).

[17]. British Standard Institution. BS 1881-208 Testing concrete. (1996). 'Recommendations for the determination of the initial surface absorption of concrete', BSI. London.