VARIATION OF CUMULATIVE WATER ABSORPTION IN CONCRETE CUBES

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Abstract: *The presence of water in the concrete controls many fresh and hardened properties of concrete. Thus the mitigating the amount of water present in concrete and cement paste is important for an extension service life of concrete structures. It's necessary to limit its ability to transport fluids such as water in order to achieve durable concrete. An extensive knowledge about water movement is needed to develop realistic testing methods, which in turn determines the ability of concrete to withstand water penetration. In order to build durable oriented and practicable concrete structures, it is needed to be able to accurately predict the water absorption, and cumulative water absorption within the concrete structures. Therefore, there is a need to quantify the effectiveness of cumulative absorption as against water absorption in the concrete cubes which is a predominant factor in the concrete industries. An attempt was made to interpret the cumulative water absorption to differentiate the designed concrete mixtures types. It's possible to calibrate the influence of concrete ingredients on the performance of cumulative water absorption as per specified conditions in which slump, and w/c ratio value is 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. For that seventy-two concrete cubes with different grades of concrete (25-40 N/mm²) were prepared and evaluate the effectiveness of cumulative water absorption in the designed different mixtures type.*

It's clear from the results that, the cumulative absorption is related with rate water absorption by the exponential type of equation, it's observed from the results that, the cumulative water is decreased with decrease in water absorption and its goes on increases with increase in rate of water absorption in all designed concrete mixtures type. It's possible to compare to cumulative water absorption for in case of fine-coarse aggregate ratio at different time intervals. The cumulative water absorption is more for in case of lesser finer-coarse aggregate ratio (aggregate volume fraction) as confirmed from the experimental result and its goes on decreases with increases in the aggregate volume fraction at specified time interval. The cumulative water absorption is higher for lesser cement content as well as goes on increases with increased with time duration. It's possible to interpret cumulative water absorption as against cement content at different time intervals. The rate of cumulative water absorption is higher in magnitude for increased w/c ratio and it goes on reduces with decrease in w/c ratio at different time intervals. It's also observed that, the cumulative water absorption is increases with increase in time duration. For higher w/c ratio, the higher the water absorption and it goes on increases (water absorption) with increase in time duration. But it goes on reduces with decrease in w/c ratio. An average variation of cumulative water absorption is slightly more for increased compressive strength with varied slump. But in lower compressive strength and constant slump, the cumulative water absorption is slightly higher and its decreases with increase in compressive strength with constant slump value. The sorptivity coefficient is reduces with increase in cumulative water absorption. It's also observed that sorptivity coefficient is lesser for increased compressive strength and varied slump value. Whereas the sorptivity coefficient is found to be more for in case of lower compressive strength with constant slump value and its goes on decreases with more increased cumulative water absorption. But the sorptivity coefficient is reduced with higher compressive strength with constant slump value as well as with lesser water cumulative absorption.

Keywords: *Concrete mix design, water-cement ratio, cumulative absorption, sorptivity*

1.0 Introduction

Concrete structure durability is predominately depends on the fluid movement through the structure of concrete matrix and permeability is considered as an indicator of a concrete's ability to transport water. Permeability is a measure of the flow of water under pressure in a saturated porous medium. Matrix structure of concrete which relates to the transport of water is the pore system of the cement paste in the vicinity of the aggregate-paste interface. Even though higher porosity at the interfacial zone, water movement in concrete is predominantly controlled by the bulk of the hardened OPC paste, which is the only continuous phase in concrete [Larby, 1993].The researcher [Neithalath, 2006] adopted a combination of the exponential equation for sorption and a solution of Fick's second law for diffusion to predict water transport for in case of concrete as well as mortar. An investigation was carried out to interpret the effectiveness of the water absorption and sorptivity properties of mechanically loaded engineered cementitious composites [Mustafa Şahmaran, *et al*, 2009]. It's confirmed that, the micro cracks induced by mechanical loading increase the sorptivity value of ECC without water repellent admixture. However, the use of water soluble silicone based water repellent admixture in the production of ECC could easily inhibit the sorptivity even for the mechanically loaded ECC specimens. Risk of water transport by capillary suction in ECC, cracked or un-cracked, is found to be low compared as when compared to normal concrete. An extensive study is carried out by investigator [Tahir Gönen, and Salih Yazicioğlu., 2007] to interpret the influence of compaction pores on the sorptivity and the carbonation of concrete. The change in the compaction pores may significantly affect the carbonation rate and the sorptivity coefficient and sorptivity is a measure of the capillary forces exerted by the pore structure [Ganesan, *et a*l, 2008].

Sorptivity test is conducted by researchers [Wojciech Kubissa, *et al*, 2013] at 28 days and longer periods of time (2-24 months) on the concrete samples. An initial value of sorptivity can be regarded as quite an exact approximation of further measured values. The concrete sorption was measured by researchers [Esam Elawady, *et al*, 2014] to determine its sorptivity coefficient as per ASTM C 1585. Concrete sorptivity is decreased by 42.7% when cement content was increased for specimens cured in water for 28 days at 20^0C. Also, utilization of 10% SF as a partial replacement of cement resulted in sorptivity is decrease by 64.5% and 68.3% with cement content 350kg/m^3-450kg/m^3 respectively, for specimens cured in water for 28 days at 20^0C. Even though specimens stored in air, its experienced 11.6% loss in compressive strength, the sorptivity increased by 80.4% while permeability increased by nearly 345.3%. Specimens with lower sorptivity possessed lower permeability, and higher compressive strength. The study is carried out by investigators [Pandi, *et al*, 2015] on sorptivity and water absorption properties of Cashew nut shell Ash concrete. An excess of water in concrete structures evaporates, in turn it leaves voids inside the concrete element creating capillaries which are directly related to the concrete porosity and permeability.. Hence there is a need for type of test, which should measure the rate of absorption of water by capillary suction sorptivity of unsaturated concrete. The measurements of the permeability of concrete were used as an indicator of durability. The more quickly a fluid moves through the material, higher permeability, the lower anticipated durability. It's concluded that permeability [Mehta, 1991] is the key to all durability problems.. Such tests should measure the rate of absorption of water by capillary suction; "sorptivity" of unsaturated concrete [Pitroda, *et al*, 2013]. It's clear that, minimizing sorptivity is an important factor in order to reduce the ingress of aggressive agents into concrete structure [Sinha, et al, 2012]. The curing condition is found to be a major issue which affects the variation of the sorptivity test results and consequently the reproducibility of the test as confirmed by researchers [Khatri, *et al*, 1977]. Curing is more important for concrete with mineral admixtures than for normal concrete, as the pozzolanic reaction between amorphous silica and calcium hydroxide needs water to continue. Also, water curing has more effect on the sorptivity than on the strength of concrete as concluded by [Tasdemir, 2003]

2.0 Research Objectives

The water transport in a porous network like concrete is a complex criterion and this is due to different transport mechanisms as well as pores that may typically appear in the porous system. Therefore in the present study there is a need to study water transport mechanisms with different designed mixtures type in order to assess the effectiveness of cumulative absorption with water absorption in concrete cubes. Thus the objective of the present research is to examine the influence of concrete ingredients on the results of concrete cumulative water absorption with different concrete mix design. For which slump, and w/c ratio is varied with same compressive strength as in the first case and compressive strength, and w/c ratio value is varied with constant slump as in the second case. Seventy-two concrete cubes with grades of concrete (25-40 N/mm^2) were prepared to evaluate the rate of water absorption characteristics in concrete cubes.

3.0 Experimental program

In the present research work, six different mixtures type were prepared in total as per [BRE, 1988] code standards with concrete cubes of size (100 mm^3). Three of the mixtures type was concrete cubes with a constant compressive strength, different w/c and slump. These mixtures were indicated as (M1, M2, and M3). Another three of the mixtures type were with a different compressive strength, constant slump, and different w/c. These mixtures were designated as M4, M5, and M6. The overall details of the mixture proportions were to be represented in Table.1-2. Overall seventy-two concrete cubes were casted for six types of concrete mixture. The coarse aggregate (crushed stone) with maximum nominal size of 10 mm, grade of cement 42.5 N/mm^2 and fine aggregate (4.75 mm sieve size down 600 microns) were used was for the present research work.

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 Water absorption

The concrete cubes (100 mm^3) were immersed in water for about 28 days curing, oven dried at 50 ±2ºC for 3 days until the mass became constant and again weighed. This weight was noted as the dry weight (W1) of the concrete cube. Specimens were kept in contact with water from one surface with water level not more than 5 mm above the base of specimen. Ingress of water from the peripheral surface is prevented by sealing it with non-absorbent coating as per [ASTM C 1585] with their arrangement as shown in Fig.1.Then the weight is noted as the wet weight (W2) of the concrete cube.

Fig.1 Concrete cubes immersed in water

$$\text{Water absorption (\%)} = \left[\frac{\text{W2} - \text{W1}}{\text{W1}}\right] X100$$

The water absorption test is carried out on 72 concrete cubes with size (100 mm^3) in all six mixtures type (M1-M6) as per ASTM C1585 is used to determine the rate of absorption of water in concrete. Its influenced sample preparation, AND volume of paste in the samples. In fact lack of consideration of the material composition may lead to a misunderstanding of the actual absorption behaviour. The water absorption is increased (49.76%) at time interval 5 min as when compared to initial time 0 min in designed mixtures type (M1-M6). The water absorption (87.98%) is predominantly increased at longer time duration (28 day). The water absorption (48.91-50.57%) at 0 min as well as (87.82-88.13%) at 28 days is little bit varied as against different mixtures type (M1-M3) and (M4-M6). Similarly, the water absorption is more increased in mixture type (M4) for lower compressive strength with constant slump value. Also the water absorption is goes on decreased with increased compressive strength in case of mixture type (M5), but increased with compressive strength in mixture type (M6) at an initial stage as well as at longer time duration at 28 day. The variation of average water absorption is slightly increased with constant higher compressive strength and varied slump. It's higher with lower compressive strength and constant slump value and its goes on decreases with increased compressive strength.

3.2 Cumulative absorption

The cumulative absorption coefficient is found to be decreased at initial time duration (0.00097-0.00107) m for in case of mixtures type (M1-M3) as when compared to (0.00134-0.00097) m mixtures type (M4-M6). The cumulative absorption coefficient is increases (0.00899-0.0087) m at longer time duration for in case of mixtures type (M1-M3) with same grade of concrete, and cumulative absorption coefficient is varied (0.01323-0.00877) m in mixtures type (M4-M6) with different grade of concrete at constant slump value. In turn the rate of absorption is more at longer time duration and this rate of absorption decreases with increased grade of concrete. In fact the cumulative absorption coefficient is increases with increased rate of absorption (sorptivity coefficient) and lower grade of concrete. Absorption of water is regarded as the dominant factor for the ingress of aggressive substances. Mechanism responsible for water transport during the absorption process is hydrostatic pressure due to the capillary suction. Microstructures of concrete (porosity and pore distribution, and micro cracks) play a crucial role in the velocity of water ingress. Variation of average cumulative absorption, minimum, maximum and standard deviation for different designed mixtures type in concrete cubes is represented as in Table.3.

$$\text{Cumulative absorption (i)} = \text{S}.\sqrt{\text{t}}$$

- i = cumulative absorption at time (t), m/s
- S = sorptivity in mm,
- t = elapsed time in min,

Table: 3 Cumulative absorption in concrete cubes for different mixtures type

Mix ID	Average	Min,value	Max,value	STD
M1	0.0058	0.0031	0.0093	0.0010
M2	0.0069	0.0038	0.0115	0.0013
M3	0.0054	0.0030	0.0088	0.0011
M4	0.0084	0.0047	0.0137	0.0013
M5	0.0060	0.0033	0.0097	0.0012
M6	0.0057	0.0030	0.0091	0.0010

The cumulative water absorption is interpreted for about 28 days in concrete cubes for designed six mixtures type (M1-M6). The cumulative absorption is found to be increased at an initial time interval (10 min) as against (5 min) which is varied as 11.53%. Similarly, the cumulative absorption is found to be increased at final time duration (28 day) as when compared to 5 min which is varied as 77%. The cumulative absorption curve reaches first phase of equilibrium level at time duration 65.72 min. Thus the cumulative absorption of the mixtures type was decreases with the decrease in water-cementitious material ratio for in case of designed mixtures type (M1-M6) and as result of that, lesser water availability in the mixture which leads to the formation of dense concrete.

3.3 Sorptivity

It's a measure of the capacity of the medium to absorb/desorbs liquid by capillarity and widely used in characterizing soils as well as porous construction materials (brick, stone, and concrete) respectively.

$$\text{Sorptivity coefficient (S)} = \frac{\mathrm{i}}{\sqrt{\mathrm{t}}}$$

- $\boldsymbol{S}$ = sorptivity in mm;
- $\boldsymbol{i}$ = cumulative absorption at time (t), m/s;
- $\sqrt{\boldsymbol{t}}$ = square root of elapsed time in min.

Sorptivity coefficient (rate of water absorption) is increased at initial time duration (0.0009-0.0011 m/min$^{0.5}$) as when compared to longer time duration (4.2E-05-5.4E-05 m/min$^{0.5}$). The sorptivity coefficient is increases at initial time duration, this may be due to unsaturated pore structure, and in turn the rate of absorption is more at that time. As time increases, the rate of absorption goes on decreases with increased time duration in turn indicates that, pore structure may be reached fully saturated condition. Sorptivity test is a very simple technique that measures the capillary suction of concrete when it comes in contact with water and performed in as per ASTM C 1585. This test is used to determine the rate of absorption of water by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when only one surface of the specimen is exposed to water ingress of unsaturated concrete by capillary suction. The cubes (100 mm^3) were immersed in water for about 28 days curing and specimens were placed in a desiccators oven at temperature (50 ±2ºC) for 3 days. After that, specimens were put in contact with water from one surface with water level not more than 5 mm above the base of specimen and flow from the peripheral surface is prevented by sealing it with non-absorbent coating. The variation of sorptivity coefficient is directly proportional to the cumulative water absorption and in-directly proportional to the square of time with their variation of average, minimum, maximum, and standard deviation in concrete cubes is depicted in concrete cubes as shown in Table.4.

Table: 4 Sorptivity coefficients in concrete cubes for different mixtures type

Mix ID	Average	Min,value	Max,value	STD
M1	0.00029	0.00027	0.00092	0.00004
M2	0.00035	0.00033	0.00113	0.00005
M3	0.00027	0.00026	0.00089	0.00004
M4	0.00043	0.00041	0.00148	0.00007
M5	0.00030	0.00027	0.00092	0.00005
M6	0.00029	0.00027	0.00091	0.00004

The quantity of water absorbed in specified time interval is measured by weighting the specimen up to 0.1 mg and surface water on the specimen is wiped off with a dampened tissue with each weighting operation is completed within 30 seconds. Sorptivity (S) is a material property which characterizes the tendency of a porous material to absorb and transmit water by capillarity. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed time (t).

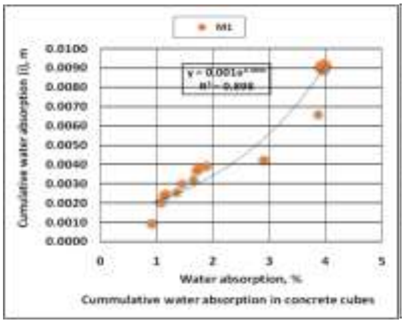
$$i = S\sqrt{t}$$
$$\mathrm{S} = \frac{\mathrm{i}}{\sqrt{\mathrm{t}}}$$

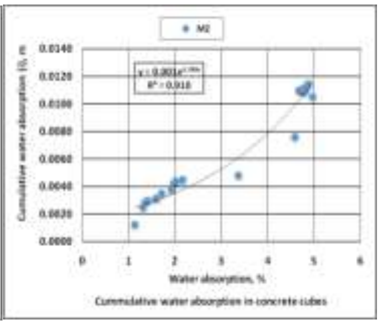
- S= sorptivity in mm,
- t= elapsed time in mint. I= Δ w/Ad
- Δ w= change in weight = W2-W1
- W1 = Oven dry weight of cube in grams
- W2 = Weight of cube after specified time minute capillary suction of water in grams
- A= surface area of the specimen through which water penetrated
- d= density of water

As observed from the results that, the sorptivity coefficient is increased at initial time duration with decreased cumulative water absorption in all mixtures type as against to longer time interval. The sorptivity coefficient at initial time duration is found to be in the range (0.0009-0.0014 m/min$^{0.5}$) and (4.5E-05-5.5E-05 m/min$^{0.5}$) at final time duration. Cumulative absorption varied at an initial stage between (0.002-0.003 m) at an early time duration and (0.008-0.013 m) at longer time duration. Finally, the sorptivity coefficient is decreases with decreased rate of cumulative absorption at longer time duration in turn it indicates that, the pore structure reaches fully saturated condition in all mixtures type. The sorptivity coefficient is decreased as when compared to initial time duration (5-10) min. In fact there is decrease in sorptivity coefficient (21.89%) at (10 min) as when compared to initial time interval (5 min) for in mixtures type (M1-M6). Similarly, Sorptivity coefficient is goes on decreases gradually at certain point, it reaches parabolic pattern, and afterwards it reaches equilibrium (28 days) in turn sorptivity coefficient is found to be decreased (95.18%). Whereas at 1 day, the increase in sorptivity coefficient is found to be 82.07% for in mixtures type (M1-M6). The sorptivity coefficient for in mixtures type (M1-M3) at time interval (10 min) is increased (21.32%) as when compared to time duration (5 min). Similarly, at 10 min, there is an increase in sorptivity coefficient (22.46%) as when compared to time interval (5 min) for in mixtures type (M4-M6). The rate of absorption is always more at an initial time duration because of differential gradient is exists between higher to lower concentration gradient section, where there is a variation in the rate of absorption up to certain time duration after that, it reaches parabolic pattern which is very smooth flow of rate of absorption. Once it reaches that, pore structure, cement paste, and concrete matrix reaches fully saturated condition in turn finally the sorptivity coefficient reaches equilibrium state. The sorptivity coefficient is higher/lower for mixtures type (M1-M6) at an initial time duration. But it goes on gradually decreased and reached equilibrium state as when pore structure is reached fully saturated condition. Logically at an initial time duration, the sorptivity coefficient is more but the cumulative absorption is lesser. Because the cumulative or net absorption is not achieved once for all, this may in turn depends on cement paste matrix, concrete matrix, aggregate volume fraction, w-c ratio, compressive strength, and slump. At an inetermedaite time duration, the sorptivity coefficient is gradually decreased with an increased cumulative absorption for in mixtures type (M1-M6). But once equilibrium reached, the sorptivity coefficient is still goes on reduced slightly in turn net cumulative absorption is found to be increased up to cetain time duration, after that both sorptivity coefficient and cumulative absorption is reversed in nature in turn both tries to decreases which indicates that pore structure is reached fully saturated state and finally there is no more increased rate of absorption for in case of longer time duration. It is possible to explain the water transport satisfactorily at early age in dry samples. Mortar/concrete surface is exposed to wetting by water and the cumulative water absorption is proportional at an initial absorption period, to the square root of elapsed wetting time as confirmed by investigator [Hall, 1989]. Initial rate of ingress observed to be decreases as the water has accessed all the major capillary pores. Water uptake-square root of time (decrease in gradient) indicates that sorptivity is now occurs through finer pores [Martys, and Ferraris, 1997]. Coarse pore structure, experiences little capillary suction and may show significant deviation from linearity after prolonged wetting. In dry/partially dry mortars/concretes, the predominant mechanism in the water absorption is the capillary suction with time lapses, and the material begins to be saturated, the predominant mechanism is the diffusion [Martys, and Ferraris, 1997]. Sorption does not take place in saturated materials/totally dry materials and its due to substantial absorption of water by the gel. The sorptivity will depend on the initial water content and its uniformity throughout the specimen under test. Increase in the mass of the specimen caused by the filling of the open surface pores on the inflow face with sides of the specimen [Neville, 1995].

4.0 Discussion about Results

The deterioration of concrete is caused by the movement of aggressive gases/ liquids into the concrete which leads to damage to the concrete structures. Concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Permeability relates to the size of the pores, their distribution and most importantly their continuity. It is not necessarily directly related to absorption. The lower the sorptivity value, the higher the resistance of concrete towards water absorption. It's depends on the pore distribution and micro structural properties of concrete [Abdul Razak, *et al*, 2004]. Cumulative water absorption of the concrete mixtures decreases with decrease in w/cm ratio for concrete due to lesser water in the mix. Concrete with lower w/cm ratio has lower water absorption for mixtures. The sorptivity values are least due to lower amount of water in the mix which results in lower porosity. The higher the porosity of the specimens causes the reduction of pervious concrete density. A denser concrete generally provides higher strength and fewer amount of voids and porosity. Smaller the voids in concrete, it becomes less permeable to water and soluble elements. Water is provided externally by curing/internally by using water saturated porous aggregates. By proper curing, reduces the rate of moisture loss and provides a continuous source of moisture required for the hydration that reduces the porosity [Alamri, 1988]. The hydration of cement in concrete is very important which ensures the development of maximum compressive strength with service life of concrete structures. The curing of concrete is used for promoting the hydration process of cement, controls temperature and moisture movement into the concrete. Hydration of cement ceases before it is complete, which results in strength reductions and durability indexes. As noted by researcher [Powers, 1947] that, the cement hydration ceases below 80% relative humidity and moisture loss to the environment in concrete also plays an important role in cement hydration. Thin concrete members were tends to lose moisture faster than thick members and a surface of concrete that is not properly cured also suffers from inadequate hydration as pointed by researcher [Carrier, 1983]. Study carried out by researchers [Carrier and Cady, 1970] that, on moisture loss from the concrete in a moderately severe field exposure condition confirmed that, the drying in concrete at a depth of 25 mm was not sufficient to stop hydration of cement at 28 days. Concrete layer that is not properly cured could deteriorate faster than inner layers. Curing process is enables the control of temperature and moisture movement from- into concrete for a definite period of time [Neville and Brooks, 2008]. Cement hydration takes place in water filled capillaries, it is important to keep concrete saturated as possible, until the water filled pores in the fresh cement paste are filled to the desired extent [Taylor, 2000]. Cement hydration can be combination of chemical and physical processes that take place after contact of the anhydrous solid with water [Stark, 2011]. The site concrete is the exceptional, which is hardly cured sufficiently for longer time duration and water cured specimens had better compact microstructure than uncured specimens. Lower w/c ratio mixes had a more compact microstructure than higher w/c ratio mixes. Furthermore, higher the w/c ratio mixes are known to have more and bigger micro pores resulting from water which is not used in hydration [Friedemann, 2006]. Thus there is need to investigate the effectiveness of cumulative absorption on water absorption in the concrete cubes in order to characterize different designed mixtures type in the present research work. It's possible to establish a relation between the cumulative water absorption and water absorption at different time intervals in the concrete cubes by exponential type of equation. The variation of cumulative water absorption with water absorption is as shown in Figs.2-7. It's observed from the results that, the cumulative water is decreased with decrease in water absorption and its goes on increases with increase in water absorption in all designed concrete mixes (M1-M6). Cumulative water absorption is increased with water absorption in the designed concrete mix (M2), but it's slightly lesser as when as against to lower concrete compressive strength and constant slump (M4-M6). It's also possible to interpret the variation as well as compare difference in cumulative water absorption and water absorption (%, increase) as shown in Figs.8-9 for in case of different designed concrete mixes (M1-M6) at various time interval such as (6, 12, 18, 24, and 28) days respectively. The comparison (% increase) of cumulative water absorption and water absorption is assessed in different concrete mixtures type (M1-M6) at different time duration (6-12, 6-18, 6-24, and 6-28) days as shown in Figs.10-11 respectively.





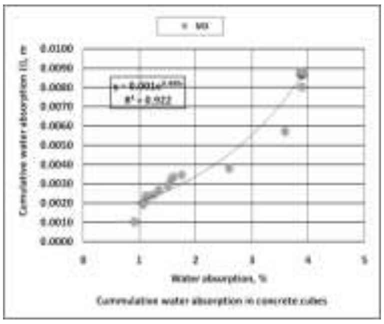
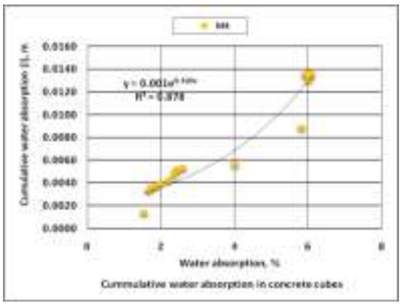
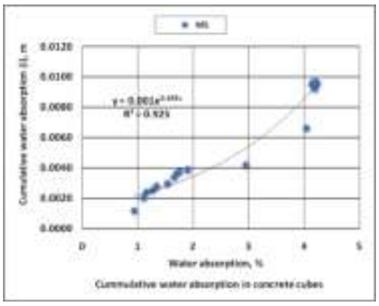


Fig.2 Cumulative-water absorption in M1 Fig.3 Cumulative-water absorption in M1 Fig.4 Cumulative-water absorption in M1





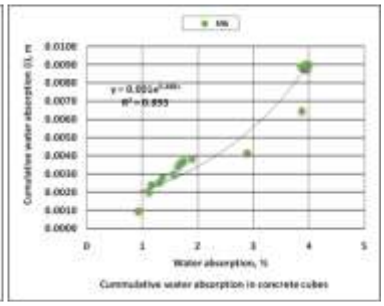
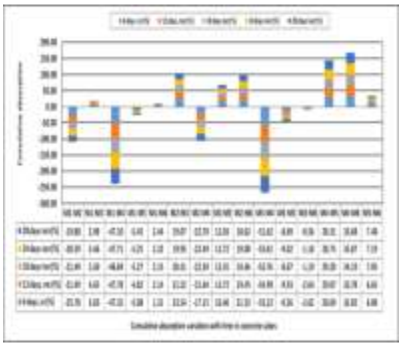
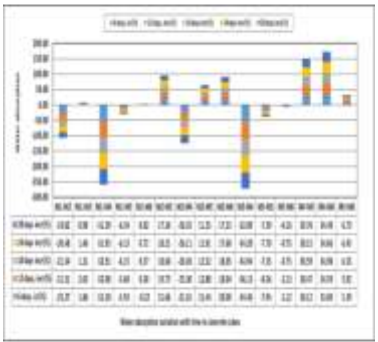


Fig.5 Cumulative-water absorption in M1 Fig.6 Cumulative-water absorption in M1 Fig.7 Cumulative-water absorption in M1

It's possible to compare to cumulative water absorption for in case of fine-coarse aggregate ratio (0.31, 0.33, and 0.45) at time intervals (0-5-10-15-20-30 min). The cumulative water absorption is more for in case of lesser finer-coarse aggregate ratio (aggregate volume fraction) as confirmed from the experimental result (Fig.12) and its goes on decreases with increases in the aggregate volume fraction at specified time interval.





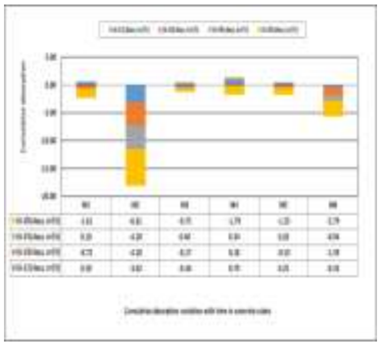
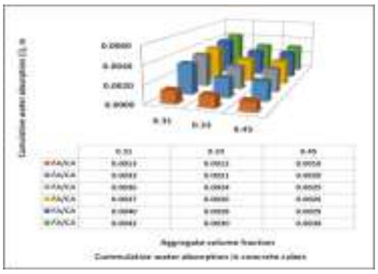


Fig.8 Cumulative-water absorption in M1 Fig.9 Cumulative-water absorption in M1 Fig.10 Comparasion cumulative absorption



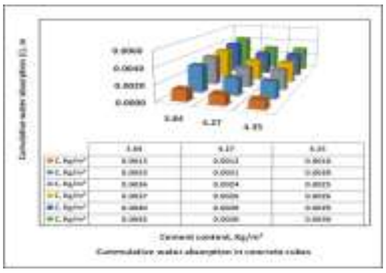


Fig.11 Comparasion of water absorption Fig.12 Cumulative-water absorption in M1 Fig.13 Cumulative-water absorption in M1

The cumulative water absorption is higher for lesser cement content as well as goes on increases with increased with time duration. It's possible to interpret cumulative water absorption as against cement content (3.84, 4.27, and 4.35 kg/m^3) at time intervals as representing in the (Fig.13). The cumulative water absorption is higher for higher w/c ratio and it goes on decreases with decrease in w/c ratio at time intervals. It's also observed that, the cumulative water absorption is increases with increase in time duration (Fig.14). For higher w/c ratio, the higher the water absorption and it goes on increases (water absorption) with increase in time duration. But it goes on decreases with decrease in w/c ratio (Fig.15).

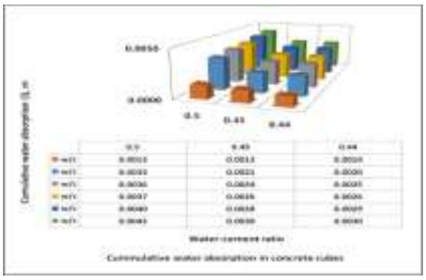


Fig.14 Cumulative-water absorption in M1

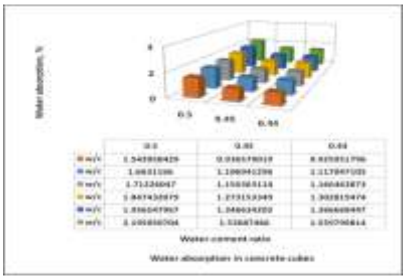


Fig.15 Cumulative-water absorption in M1

An average variation of cumulative water absorption is slightly more for in higher compressive strength and varied slump. In lower compressive strength and constant slump, the cumulative water absorption is slightly higher and its goes on decreases with increase in compressive strength and constant slump value. The sorptivity coefficient is goes on decreases with increase in cumulative water absorption. Sorptivity coefficient is lesser for in higher compressive strength and varied slump value. Whereas sorptivity coefficient is more for in lower compressive strength and constant slump value and its goes on decreases with more increased cumulative water absorption. But the sorptivity coefficient is reduced with increased compressive strength and same slump value as well as with lesser water cumulative absorption [Balakrishna, *et al*, 2018].

5.0 Conclusions

- It's clear from the results that, the cumulative water absorption is related with water absorption by an exponential type of equation, it's observed from the results that, the cumulative water is decreased with decrease in water absorption and its goes on increases with increase in water absorption in designed concrete mixtures type.
- It's possible to compare to cumulative water absorption for in case of fine-coarse aggregate ratio at different time intervals. The cumulative water absorption is more for in case of lesser finer-coarse aggregate ratio (aggregate volume fraction) as confirmed from the experimental result and its goes on decreases with increases in the aggregate volume fraction at specified time interval.
- The cumulative water absorption is higher for lesser cement content as well as goes on increases with increased with time duration. It's possible to interpret cumulative water absorption as against cement content at different time intervals.
- The cumulative water absorption is higher for higher magnitude of w/c ratio and it goes on decreases with decrease (w/c ratio) at different time intervals. Cumulative water absorption is increases with increased time interval. For higher w/c ratio, the higher the water absorption and it goes on increases (water absorption) with increase in time duration. But it goes on decreases with decreased w/c ratio
- An average variation of cumulative water absorption is slightly more for higher compressive strength and varied slump. In the lower compressive strength and constant slump, the cumulative water absorption is slightly higher and its goes on decreases with increase in compressive strength and same slump. The sorptivity coefficient is goes on decreases with increase in cumulative water absorption.
- Sorptivity coefficient is found to be lesser for in case of increased compressive strength and different slump. Whereas its more for in lower compressive strength and constant slump value and its goes on decreases with more increased cumulative water absorption. But the sorptivity coefficient is reduced with higher compressive strength and same slump as well as with lesser water cumulative absorption.

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