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Study and Characterization of Crystal Growth in the Pores of Cement Mortar

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Abstract: ***Durability of concrete or cement mortar is one of the great concern among construction industry. The main reason for such durability problems is transport properties of cement mortar after the cement mortar set. Permeation, absorption and diffusion of water through the pores and pore connectivity cause a durability problem. In this study, these pores and pores connecting pathways are blocked by the process of pores crystallization. This is achieved by admixing certain well known crystals forming chemicals such as sodium acetates, potassium acetates and other salts of sulphates at various percentages and allowing the cement mortars to for crystal. This process of arresting transport of water into the mortar is partially new concept which has worked well and reduction in penetration of water is measured by sorption, Electrical resistance, Hollow cylinder method and Water absorption. The results are discussed in detail and optimum solution percentages are explained.***

Keywords: Durability, Crystal growth, Pores, Pore connectivity, Sorption, Penetration

1. Introduction

Concrete is the most used structural material, but due to its porous nature it results in deterioration of structures. Therefore, the penetration of undesired substances can cause progressive damage, although water is very important to concrete during the curing stage, it is considered to be an undesirable substance that could cause several damages to the concrete. Deterioration also occurs based on exposure conditions, which reduces the durability of the structure. Some of the systems are currently in practice to minimize the damages due to moisture penetration in the pore connectivity, where pore block effect is introduced; this barrier system is successful in preventing the water penetration. Along with pore blocking effect, waterproofing additives are also added to the concrete to increase the structural durability by blocking the pores by growth of crystals, this way the repair and maintenance cost are reduced and then the life of the concrete is increased. Selection of admixture for crystal growth in pores plays a major role in preventing the water penetration, by this study some of the moisture associated problems such as – Freeze and thaw damages, acid attack, chloride ion diffusion, sulphate attacks, etc. can be avoided.

In this research work several crystal growing chemicals and acetates are used for growth of crystals in the pores of concrete for blocking the pore connectivity and then denying the access to aggressive species. To evaluate the crystalline waterproofing products efficiency, the most commonly used tests are – water absorption, chloride penetration, electrical conductivity, etc. The purpose of this study is to analyze the use of crystalline waterproofing as admixture and comparing their performances with control. Also the study is conducted to know what kind of crystals those are and whether it is capable to seal the pore or crack.

2. Experimental Investigations

2.1 Materials

For entire casting, cement mortar of 1:3 with w/c ratio of 0.43 was taken, with the ten different admixtures of dosages 2%, 4%, 6%, 8%, 10%. Here, chemicals meant for crystal growing was only used as admixture, such as sodium silicate, sodium acetate, potassium acetate, calcium sulphate, ethyl acetate, methyl acetate, sodium bicarbonates, calcium carbide, magnesium acetate. Since these chemicals react with cement and water, whereas during hydration process and increases the density of C-S-H gel, this blocks the pores by insoluble crystals.

2.2 Methods

2.2.1 Mechanical properties study

Cylinder compressive strength test and split tensile test was conducted to determine the mechanical properties. The test was conducted in a compression testing machine of AIMIL brand of capacity 1000KN with the digital display of load at failure, for cylinder specimen of 60mm x 120mm.

2.2.2 Durability properties study

Based on durability studies, in this investigations the test such as Water absorption test, Sorptivity test, Electrical resistance test and Hollow core water absorption test were conducted, procedure is as follows,

(a) Electrical resistance test

This test was conducted for bar specimens with copper plates embedded at 20 mm c/c and dimension of bar 105 x 55 x 30 mm. Specimens were kept under partially immersed condition and, for every 2 hrs the electrical resistance was measured using multimeter, as shown in fig 2.1. The result with higher resistance works best in lower water absorption and was compared with control specimens.

Figure 2.1: Electrical resistance test for bar specimens

(b) Hollow core water absorption test

This test was conducted for hollow disc of 83mm x 50mm dimension, which contains an inset cylinder at its center (with dimension 40mm x 25mm) for determination of water absorbed in axial and radial directions as shown in fig 2.2, by filling the core portion with water for a period of time. Water was filled in the inner core and initially measured, with the decrease in the level of water; it was refilled again and examined for every 1hr upto 8hrs and again after 12hrs. Higher quantity of water refilled in core considered to be more porous when compared with the control.

Figure 2.2: Hollow core water absorption test

2.2.3 Accelerated electro chemical study

It includes Rapid Chloride Diffusivity test, in which the resistance to the penetration of chloride ions in cement mortar are determined as per ASTM C-1202-12, shown in fig 2.3.

3. Results and Discussions

3.1 Cylinder compressive strength test

For this test, specimens in triplicate were tested and average failure values were considered, from the test results it is found that the calcium carbide admixed mixes found to give very good compressive strength compared to control, and the poor values were obtained for ethyl acetate. The control specimen has a value of 28.12 N/mm^2 and calcium carbide with 8% addition has got a value of 44.64 N/mm^2 and the poorest value of 7.34 N/mm^2 is obtained for ethyl acetate. As the percentage of calcium carbide is increased from 2% to 8% the strength is also increased gradually. The increase in strength for calcium carbide can be attributed to the fact that, while adding water acetylene gas is released which is lighter than air. Once it is escaped into air, a tight mass is obtained and that gives the good strength and while tapping it gives metallic sound. When ethyl acetate is used there is a problem with combining capacity of ethyl acetate with organic cement particles and therefore reduces the strength.

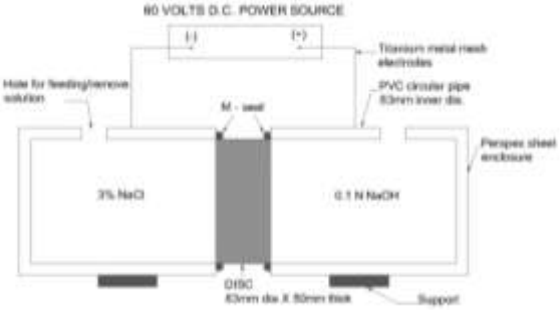

Figure 2.3: Schematic of rapid chloride ion penetration test

3.2 Split tensile test

Split tensile strength has been carried out with the help of cylindrical specimens of 60mm x 120mm, placed horizontally in a cube compressive testing machine. The specimens were locked with 3mm thick plywood at top and bottom of horizontal axis, the load at failure was noted and the corresponding split tensile strength was obtained. The spilt tensile strength results were nearly 0.12% of cylindrical compressive strength test and followed the trend exactly same as cylinder compressive strength and the reason for the strength is as coated in cylinder compressive strength test.

3.3 Sorptivity test (ASTM C 1585-13)

Sorptivity test was conducted on all specimens of size 50 mm x 80 mm. The circumferential surface was sealed with araldite, only top and bottom circular surfaces were uncoated. The specimens were fully dried and weight was measured, placed on 5 mm thick of water in a tray at regular interval of time. The weight was measured, the incremental weight at the time interval upto 60 minutes was noted, after 1-hour interval the weight gain was calculated and coefficient of water absorption K_a was calculated using the relation 3.1,

$$k = \left(\frac{Q}{A}\right)^2 * \frac{1}{t} \qquad \textbf{(3.1)}$$

Where, k = coefficient of water absorption
Q = quantity of water absorbed upto 1 hour (in ml)
A = cross sectional area of the specimen (mm^2)
t = duration of test (sec)

From this test, it is noted the methyl acetate admixed cement mortar showed lesser coefficient of water absorption (0.1 x 10^{-9}mm^2/s) and next to this sodium acetate admixed showed less water absorption coefficient (0.6 x 10^{-9}mm^2/s) and thirdly calcium carbide of 2%, sodium sulphate 4%and sodium acetate 6% showed a values of coefficient of water absorption as 0.7 x 10^{-9}mm^2/s. Although these are different from the strength, the absorption coefficient varies with crystal formation in the pores and voids, and therefore these results.

Table 3.1 Results for electrical resistivity test (KΩ)

Specimen	**0**	**2hrs**		**4 hrs**		**6 hrs**			**7 hrs**		
Cu plate	**2**	**2**	**3**	**2**	**3**	**2**	**3**	**4**	**2**	**3**	**4**
Control	**167.5**	**203.8**	**271.3**	**214.7**	**295.7**	**161.7**	**207.2**	**256.9**	**66.9**	**152.7**	**168.6**
$Ca_2.SO_4$ 2%	205.2	89.2	130.8	86.1	132.3	84.6	151.4	180.6	87.9	129.7	173.7
$Ca_2.SO_4$ 4%	283.3	225.4	269.5	215.6	256.4	210.39	260.1	273.4	196.6	236.7	274.8
$Ca_2.SO_4$ 6%	195.6	230.7	304.8	205.6	0.52	140.5	215.4	260.1	116.4	145.6	159.6
$Ca_2.SO_4$ 8%	294.8	240.86	330.5	150.8	251.8	190.6	250.7	320.5	145.6	184.5	272.5
$Ca.C_2$ 2%	101	75.8	84.3	68.3	77.5	57	51	67.4	57.5	61.3	87.3
$Ca.C_2$4%	57.3	50.5	84.7	62.7	87.6	60.3	86.7	89.7	29.6	58.6	70.8
$Ca.C_2$6%	60.2	55.4	69.2	58.2	78.9	55.1	66.5	70.8	58.1	65.3	67.8
$Ca.C_2$8%	33.96	55	51.5	40.2	51.7	34.9	45.9	57.8	26.2	43.7	58.8
$Na_{2.}Si.O_3$ 2%	65.1	72.5	135.4	109.2	69.8	125.4	117.1	119.1	158.7	43.7	88.9
$Na_{2.}Si.O_3$ 4%	**0.37X 10^3**	90.8	150.2	76.4	111	95	135.5	0.67	37.4	84.8	212.6
$Na_{2.}Si.O_3$ 6%	**0.77X 10^3**	**0.81X 10^3**	**1.36X 10^3**	**0.5X 10^3**	**0.85X 10^3**	**0.53 X 10^3**	**1.06 X 10^3**	**1.15 X10^3**	**0.53 X 10^3**	**0.88 X 10^3**	**0.93 X 10^3**
$Na_{2.}Si.O_3$ 8%	285.6	145.89	175.6	91.7	129.4	86.8	120.9	173.4	94.4	126.7	151.1
$CH_3COOC_2H_5$ 2%	242.3	47.9	89.9	27.1	65.6	24.2	44.8	98.8	23.3	41.47	39.7
$CH_3COOC_2H_5$ 4%	26.7	27.2	70.6	23.7	59.7	-	-	-	-	-	-
$CH_3COOC_2H_5$ 6%	**0.87 X 10^3**	110.27	215.4	63.5	225	32.8	280.9	**0.547 X 10^3**	22.85	144.8	257.6
$CH_3COOC_2H_5$ 8%	32.3	25.6	32.73	23.4	28	-	-	-	-	-	-
$Na.H.CO_3$ 2%	35.44	26.66	30.22	26.5	70	-	-	-	-	-	-
$Na.H.CO_3$ 4%	31.7	-	-	-	-	-	-	-	-	-	-
$Na.H.CO_3$ 6%	310.6	272	104.3	-	-	-	-	-	-	-	-
$Na.H.CO_3$ 8%	35.6	38.22	94.9	-	-	-	-	-	-	-	-
$Na_2.SO_4$ 2%	141.9	86.7	102.4	87.3	55.2	87.6	74.3	90.1	87.3	57.6	110.7
$Na_2.SO_4$ 4%	**0.46X 10^3**	**0.42 X 10^3**	150.0	128	**0.385 X 10^3**	167.3	**0.45 X 10^3**	140.2	99.1	75.8	90.9
$Na_2.SO_4$ 6%	110.7	117.7	135.4	121.7	142	181.6	144.3	136.8	85.5	95.8	101.4
$Na_2.SO_4$ 8%	102.6	86.7	86	81	75.3	70.5	74.6	61.7	26.2	36.5	59.1
$CH_{3.}COOCH_3$ 2%	154.5	135	147	145.2	155	158.7	157.3	202.8	146	122.8	200
$CH_{3.}COOCH_3$ 4%	174.3	130.4	175.7	128	182.3	140.1	184.5	163.7	69.2	99.2	97.8
$CH_{3.}COOCH_3$ 6%	48.3	25.13	80.6	25.15	76.2	26.7	35	347.8	30.13	93.7	280.3
$CH_{3.}COOCH_3$ 8%	195.3	150.1	210.3	127.4	197.6	163.2	167	232.6	128.9	144.6	210.1
CH_3COOK 2%	215	197.8	130.8	128.7	0.36	69.9	80.4	96.6	72.3	96.2	132.4
CH_3COOK 4%	162.3	140.5	0.62	95.4	133	33.8	62	79.3	73.7	97.2	109.2
CH_3COOK 6%	89.6	214	9.16	98.7	161.8	50.4	68.6	77.9	33.25	75.4	94.8
CH_3COOK 8%	80.3	94.7	66.6	39.4	69.8	35.6	69.7	70.9	30.63	69.1	39.62
CH_3COOK 10%	142.8	110.8	121.8	0.43	171	37.5	67	88.7	22.1	115.7	145.5
$CH_{3.}COONa$ 2%	240.3	172.8	150.7	120.7	181.5	62.5	86.4	102.1	37.3	74	91
$CH_{3.}COONa$ 4%	250.8	200.2	297.5	231.7	280.8	231.2	225.8	210.9	50.4	86.1	130.4
$CH_{3.}COONa$ 6%	**0.42X 10^3**	123.5	133.5	91.7	87.8	79.4	76.1	168.7	82	93.6	117.9
$CH_{3.}COONa$ 8%	0.86	220	220.3	290.7	235.7	87.5	98.6	217.3	87.2	95.5	125.7
$Mg(CH_3.COO)_2$ 2%	78.6	24.8	24.05	21.4	77.4	18.39	55.5	38.52	16.21	62.3	38.65
$Mg(CH_3.COO)_2$ 4%	**0.59X 10^3**	101.9	358.7	117.2	364.7	30.5	321.3	399	16.35	21.2	30.3
$Mg(CH_3.COO)_2$ 6%	**10.88X 10^3**	104.7	**8.10 X 10^3**	45.2	**19.5 X 10^3**	**11.5 X 10^3**	**9.15 X 10^3**	**1.33 X 10^3**	**20.9 X 10^3**	**35.4 X 10^3**	**0.94 X 10^3**
$Mg(CH_3.COO)_2$ 8%	42.65	11.6	22.05	**5.85 X 10^3**	12.65	112.8	85.5	30.8	**0.94 X 10^3**	**1.35 X 10^3**	20.23

Table 3.2 Determination of water absorbed in hollow core specimens

Specimen	Dry wt (g)	Quantity of water poured every one hour (in ml)									% of water absorbed
		initial	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs	7 hrs	24 hrs	
$Ca_2.SO_4$ 2%	524.34	26	3	1	1	-	-	-	-	3	30.77
$Ca_2.SO_4$ 4%	582.49	33	3	1	-	-	-	-	-	7	33.34
$Ca_2.SO_4$ 6%	553.48	36	3	1	1	-	1	-	-	4	27.78
$Ca_2.SO_4$ 8%	522.33	39	2	1	1	-	1	1	-	6	30.77
$Ca.C_2$ 2%	536.39	33	3	1	-	1	2	2	2	14	75.75
$Ca.C_2$4%	572.06	22	2	-	-	-	1	1	1	6	50
$Ca.C_2$6%	491.66	41	3	-	-	1	1	1	1	4	26.83
$Ca.C_2$8%	524.85	25	3	1	1	-	1	1	1	4	48
$Na_{2.}Si.O_3$ 2%	577.42	34	2	1	-	-	1	1	-	1	17.6
$Na_{2.}Si.O_3$ 4%	532.15	30	3	-	1	-	1	-	1	3	30
$Na_{2.}Si.O_3$ 6%	543.58	38	2	1	1	1	1	-	1	2	23.7

$Na_2.Si.O_3$ 8%	553.05	36	2	1	1	1	-	-	-	6	30.5
$CH_3COOC_2H_5$ 2%	509.75	41	24	5	6	4	6	5	5	36	86.75
$CH_3COOC_2H_5$ 4%	599.65	31	4	-	-	1	-	-	1	1	75.4
$CH_3COOC_2H_5$ 6%	546.55	41	15	5	3	2	4	2	2	13	78.9
$CH_3COOC_2H_5$ 8%	516.75	36	19	8	5	1	4	1	2	12	92.5
$Na.H.CO_3$ 2%	53.70	41	29	6	4	3	5	4	5	37	79.26
$Na.H.CO_3$ 4%	472.40	46	36	17	17	13	20	16	17	34	65.2
$Na.H.CO_3$ 6%	509.0	42	34	7	8	6	9	8	9	38	81.6
$Na.H.CO_3$ 8%	500.88	41	28	5	6	3	7	5	4	35	77.56
$Na_2.SO_4$ 2%	552.50	30	2	-	-	1	1	-	1	2	23.4
$Na_2.SO_4$ 4%	549.68	30	2	-	-	1	1	-	1	3	26.7
$Na_2.SO_4$ 6%	590.20	30	1	-	-	-	-	-	1	1	10
$Na_2.SO_4$ 8%	563.00	23	3	1	1	1	1	-	1	5	56.5
$CH_3.COOCH_3$ 2%	558.23	25	2	3	-	2	-	1	2	9	76.2
$CH_3.COOCH_3$ 4%	570.95	25	1	-	-	2	1	-	1	3	32
$CH_3.COOCH_3$ 6%	555.90	30	2	1	-	2	-	-	1	1	23.3
$CH_3.COOCH_3$ 8%	577.30	25	4	-	-	2	1	-	2	4	52
CH_3COOK 2%	541.61	33	2	-	-	1	1	-	-	2	18.1
CH_3COOK 4%	525.04	36	2	2	1	1	1	1	2	9	53
CH_3COOK 6%	517.40	36	4	2	2	1	1	1	-	10	58.3
CH_3COOK 8%	513.13	36	3	-	-	1	1	-	2	6	36.1
CH_3COOK 10%	564.13	30	5	1	1	-	-	-	2	6	50
$CH_3.COONa$ 2%	549.80	36	3	1	-	-	1	-	1	2	22.2
$CH_3.COONa$ 4%	561.50	32	2	-	-	1	-	-	1	2	18.75
$CH_3.COONa$ 6%	578.50	43	1	-	-	2	1	2	2	11	44.2
$CH_3.COONa$ 8%	556.97	28	2	-	1	1	-	-	2	5	39.3
$Mg(CH_3.COO)_2$ 2%	535.89	28	4	1	2	2	-	-	2	9	71.4
$Mg(CH_3.COO)_2$ 4%	576.03	32	3	1	1	1	-	2	-	10	56.24
$Mg(CH_3.COO)_2$ 6%	513.50	39	11	2	2	1	1	1	2	10	76.92
$Mg(CH_3.COO)_2$ 8%	513.25	39	5	1	1	-	1	-	2	12	56.41
Control	**556.18**	**40**	**4**	**1**	**1**	**1**	**1**	**-**	**1**	**7**	**40**

3.4 Water absorption test

Water absorption test has been carried out using cylindrical specimen of 50mm diameter and 80mm long. Initially, all the specimens were dried in electric oven at 105ºC for 48 hours to arrive at constant dry weight. The dry weight of each specimen was noted, and placed in a separate bucket and was immersed in water for a period of 48 hours. After that the specimens were retrieved from the bucket and wiped with cotton and saturated weight was measured for each specimen. The gain in weight was computed and corresponding water absorption was computed.

It is found that the control specimen has got water absorption of 8.4%. The mixes admixed with sodium sulphate has got reduced water absorption in the range of 4.77% to 5.38%. It is also observed as sodium sulphate percentage is increased, the percentage of water absorption is reduced and next to this the calcium carbide added mixes found to give reduced water absorption compared to control, and next to this sodium silicate added mixes found to give a reduced water absorption. In case of sodium sulphate the crystals formed in the pores and voids is the reason for reduction in water absorption. In case of calcium carbide admixed mortar, the tightness without voids and pores is the reason for reduced water absorption and in case of sodium silicate there is a thin film formation around the particles and in voids, pores etc., which blocks the entry of water and thus reduced water absorption.

3.5 Electrical resistance test

The electrical resistance with respect to time, when immersed in water to a depth of 5mm was noted for all specimens. This specimen was so designed with overall size of 100 mm x 50 mm x 25 mm and copper plates of size 25 mm x 20 mm were embedded at 20mm interval. It was placed vertical in water so as to absorb water in capillary direction. As the water is absorbed, the conductivity or the resistivity of the mortar medium changes. As the water is absorbed, the resistivity drastically drops down and the conductivity increases. Using high impedance multimeter, the resistance between the copper plates was measured and recorded. When the water absorption is poor, the multimeter recorded high resistance values in KΩ or MΩ, given in table 3.1.

3.6 Hollow core water absorption test

Hollow core circular specimen was specially designed with overall size of 83mm diameter and 50mm thick in which a 40mm diameter and 25mm depth hollow core was created centrally on one side of circular space. These specimens were cured for 28days and allowed for drying. Initially, the core space was filled with water and left for water absorption both radially as well as in vertical directions. When the quantity of water is reduced with time in the core space, it was filled again and the quantity of water filled with time was recorded. The total amount of water absorbed for 24 hours was recorded and the percentage of water absorption was calculated, shown in table 3.2. From this test results it can be concluded that sodium silicate admixed mortar showed lower percentage of water absorbed in radial and vertical direction, particularly when the percentage of admixture reduced. Next to this calcium sulphate admixed combinations and thirdly the sodium sulphate 6% admixed cement mortar showed lower percentage of water absorbed in the core space i.e., 10%, whereas control specimen value was 40%.

3.7 Rapid Chloride diffusivity test

Chloride ion diffusion test has been conducted as per ASTM C-1202-12. The apparatus used for diffusion test was fabricated with PVC pipes of 2 compartments of each capacity around 800-900 ml in each of this compartment. Titanium metal electrodes are placed and both compartments are linked with the mortar specimen of size 83mm x 50mm with water tight using M-seal. One compartment was filled with 3% NaCl solution and other compartment was filled with 0.1% NaOH solution. A 60V-5Amp electrical power supply source was engaged to supply 60V DC to the cells. Negative terminal was connected with NaCl solution and the positive terminal with NaOH solution, at every 30 minutes' time, the current was measured and recorded to a total duration of 6 hours. The individual circuit current thus recorded were used for calculating the charge passed in coulomb. The computed charge passed for the selected mixes are shown in table 3.3. The calcium carbide found to be the best mix and next to this sodium silicate and thirdly calcium sulphate followed by sodium sulphate. As the overall results calcium carbide admixed mix found to give good results.

Table 3.3: Results of Chloride Ion Permeability test

Specimens	Charge passed (Coulombs)	Chloride ion permeability
Calcium carbide 8%	256	Very low
Sodium silicate 6%	318	Very low
Calcium sulphate 2%	473	Very low
Sodium sulphate 2%	486	Very low
Sodium acetate 2%	493	Very low
Potassium acetate 4%	504	Very low
Ethyl acetate 4%	715	Very low
Control	2964	Moderate

4. Conclusions

This study presents a new technology for minimizing water related problems. It is based on crystallization by various dosages of chemicals solutions (i.e., 10 different chemicals with 41 different combinations of specimens, excluding the control). The conclusions drawn from the present study and the scope for further research are discussed in this chapter.

1) From the 10 combinations, the calcium carbide with cement mortar found to give the highest compressive strength. In this combination as the ratio of dosage is increased, the strength is also increasing. Next to this combination the calcium sulphate admixed mortars found to give higher compressive strength. In this case as the percentage of dosages increases, strength gradually reduced. Next to this the combination comprising sodium sulphate found to give good compressive strength values. As the percentage is increased the strength is also increasing.
2) The combinations comprising ethyl acetate, sodium acetate, magnesium acetate found to give lower values compared to the control compressive strength.
3) The split tensile strength of all the mixes is approximately 12% of the cylinder compressive strength. The trend of strength variations is similar to cylinder compressive strength.
4) From sorptivity test the coefficient of water absorption (k_a) has been calculated for all the combination of mixes, it is found that the combination made with sodium sulphate found to be best water resistant admixture, and next to this the combination made with methyl acetate. And finally the combination made with calcium carbide found to resist water sorption. Poor values have obtained for sodium bicarbonates.
5) In hollow core water absorption test to determination of water absorption in vertical and radial direction, it was analyzed the combinations comprising calcium carbide, sodium silicate, methyl acetate, calcium sulphate and sodium sulphate found to give good results, as these specimens has lower absorption. Poor values were obtained for ethyl acetate and sodium bicarbonates.
6) In immersed water absorption test (for 48 hrs), it was analyzed that the combinations comprising Sodium sulphate proves to be the lower water absorbed specimen, followed by methyl acetate, sodium silicate, calcium carbide, calcium sulphate and finally sodium acetate (when compared with conventional). Whereas, poor results were obtained for the combinations comprising sodium bicarbonate, ethyl acetate, magnesium acetate when compared to control specimens.
7) From the electrical resistivity test, sodium silicate admixed compositions showed the electrical resistance values in MΩ, particularly for 6% addition and next to this sodium sulphate with 4% addition showed high electrical resistance and thirdly 6% magnesium acetate showed high resistance values. Whereas, poor results were obtained for the combinations comprising sodium bicarbonate, ethyl acetate, magnesium acetate when compared to control.
8) In Chloride ion diffusion test, the computed charge passed for the selected mixes the calcium carbide found to be the best mix and next to this sodium silicate and thirdly calcium sulphate followed by sodium sulphate when compared with the control.

Therefore, it is proved that the cement mortar admixed with calcium carbide, sodium silicate, calcium sulphate and sodium sulphate performed well in strength aspects as well as in durability tests due to reduced pore connectivity by crystallization in pores and voids. Whereas mortar admixed with sodium bicarbonates, ethyl acetate gave poor results when compared with the control specimens.

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