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Corrosion Resistance of Concrete by Adding Calcium Stearate

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***Abstract*: At the time of concrete hardening water used in concrete get evaporated. Due to this process so many capillaries are formed in hardened concrete. The gases and liquids penetrate into the concrete through capillaries. Entering of fluids and gases to the concrete can be reduced by some methods. In this study calcium stearate ($Ca_{36}H_{70}CaO_4$) is used for improving corrosion resistance of concrete and also for improving micro structure of concrete.0%, 1%, 3% and 5% of calcium stearate is used. Calcium stearate is added to concrete by partially replacing cement. The test model consists of 60 specimens. Cube 150 mm x 150 mm x 150 mm and slab with 500 mm length, 500 mm width and 60 mm height. The specimens are tested for compressive strength test, water absorption test and accelerated corrosion test respectively.**

***Keywords*: Calcium stearate, compressive strength, water absorption, accelerated corrosion, weight loss and slump test.**

1. Introduction

Corrosion is serious problem for reinforcement in concrete. Chloride ions and Sulphate ions infiltrate in to the concrete and cause reinforcement corrosion. Rust is the main form of corrosion. Steel reinforcements are in a passive condition which is protected by concrete. This protective layer gets damaged when chloride and Sulphate ions enters into the concrete. This cause formation of rust in reinforcement bars. The volume of rust is greater than volume of steel bars, this is not good for reinforced structures.

There are several chemical inhibitors used in construction field to resist corrosion. This chemical inhibitor causes harmful effect on environment. Calcium stearate is a green corrosion inhibitor which has no harmful effect on environment. Calcium stearate ($C_{36}H_{70}CaO_4$) is a carboxylate of calcium which is in the form of white waxy powder. Calcium stearate is manufactured by dissolving stearic acid in hot water and NaOH and white precipitate is formed. This precipitate is filtered, washed and dried. Calcium stearate is added to concrete by partially replacing cement. Compressive strength test is conducted to check whether calcium stearate cause any negative effect to concrete. By adding calcium stearate diameter of capillaries get reduced due to formation of waxy like substance in concrete. This cause microstructure of concrete improved and results in reduction of corrosion rate and water absorption rate.

2. Material properties

A. *Cement*

The most commonly used cement is ordinary Portland cement, which is of three grades, such as 33garde, 43grade and 53 grade. OPC of 53 grade cement is used here. Table 1 shows properties of cement.

Table 1
Physical properties of cement

S. No.	Property	Test results
1	Standard consistency	29.5%
2	Specific gravity	3.15
3	Initial setting time	65 minutes
4	Final setting time	275 minutes

B. *Fine aggregate*

Normally used fine aggregates are natural sand and M sand. The particle size less than 4.75 mm is fine aggregate. Table 2 shows properties of fine aggregate

Table 2
Physical properties of fine aggregate

S. No.	Properties	Result
1	Specific Gravity	2.5
2	Fineness modulus	4.28

C. *Coarse aggregate*

The particles retained on 4.75 mm sieve are called as coarse aggregate. Coarse aggregate of 12 to20 mm size is normally used for construction woks. Table 3 shows properties of coarse aggregate.

Table 3
Physical properties of coarse aggregate

S. No.	Properties	Result
1	Specific gravity	2.66
2	Fineness modulus	4.66
3	Aggregate crushing value	38.028%

D. *Calcium stearate*

Calcium stearate (C36H70CaO4) is a white waxy substance which is a carboxylate of calcium. It is classified as a calcium

Table 4
Physical properties of calcium stearate

S. No.	Properties	Result
1	Density	1.08 g/cm^3
2	Molar mass	607.02 g/mol
3	Melting point	155^{0}C

soap. Table 4 shows physical properties of calcium stearate.

E. Reinforcement bars

Steel is an alloy of .25 to 1.5 carbon and iron. Normally used reinforcement bars are mild steel, high tensile bars and HYSD bars. Available HYSD steel bars are Fe 415 and Fe 500. Table 5 shows physical properties of reinforcement bars.

Table 5
Physical properties of reinforcement bars

S. No.	Properties	Result
1	Yield strength	428.49 MPa
2	Ultimate strength	512.52 MPa

3. Methodology

A. Slump test

The slump test is conducted for determine the workability of concrete. Slump test was carried out on concrete with and without calcium stearate.

B. Compressive strength

The compressive strength test is carried on cubes with 150x150x150mm size. 7 days, 14 days and 28 days compressive strength is checked.

C. Water absorption

The water absorption test of concrete is tested on cubes with 150 x 150 x 150 mm. 28 days aged cubes where used for test.

Absorption (%) = [(b-a)/a] x 100% (1)

Where,

a = weight before water absorption

b = weight after water absorption

D. Accelerated corrosion test

Accelerated corrosion test is done for corroding slab specimens of 28 days age. Dc current of 12 volt is used for corrosion.

E. Weight loss method

Weight loss method is used to determine the corrosion efficiency of concrete with and without calcium stearate. It is calculated by equation 2

Percentage corrosion = [(W0 – W) / W0] × 100 (2)

Where,

W0 = weight before corrosion

W = weight after corrosion

4. Results and discussions

A. Slump test

Table 6
Slump value

% of calcium stearate	Slump value (mm)
0%	90
1%	120
3%	160
5%	190

Slump test is carried out on each of the fresh concrete (with and without calcium stearate addition) to measure workability. From the table 6 we can understand workability of concrete has been increasing with increase in % addition of calcium stearate.

B. Compressive strength

The result shows that compressive strength of concrete without calcium stearate is a little lower than the compressive strength of concrete with calcium stearate. The compressive strength of concrete with 1% and 3% is increasing and decreases when 5% is added.

Table 7
Compressive strength after 7 days, 14 days and 28 days

S. No.	% of calcium stearate	compressive strength in N/ mm^2		
		7 days	14 days	28 days
1	0%	13.21	18.31	20.34
2	1%	13.70	18.78	21.15
3	3%	14.03	19.43	21.59
4	5%	12.97	17.99	20.01

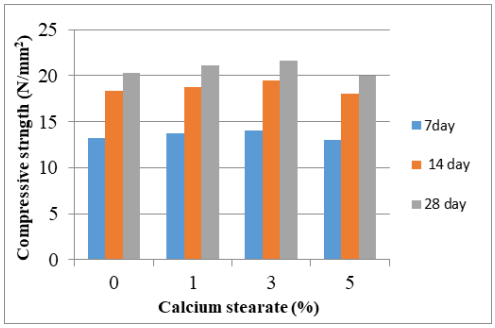

Fig. 1. Compressive strength after 7 days, 14 days and 28 days

C. Water absorption

Figure 2 represents the water absorption of concrete without and with calcium stearate in various contents. It indicates that the addition of calcium stearate to the concrete significantly reduces the water absorption. Water absorbed by cube without calcium stearate is around 2%. This absorption rate gets reduced to 0.45% when various amount of calcium stearate added. The tendency is valid when the maximum content of calcium stearate in the concrete is around 5%.

Table 8
Water absorption after 28 days

S. No.	% of calcium stearate	Average absorption (%)
1	0%	2.03
2	1%	1.41
3	3%	0.93
4	5%	0.45

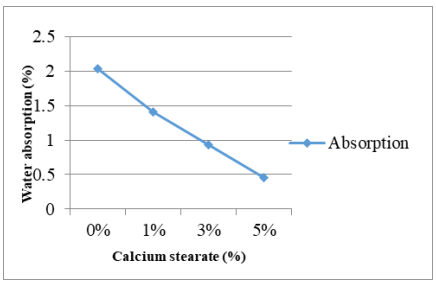

Fig. 2. Water absorption after 28 days

D. Weight loss

Figure 11 demonstrates the effect of calcium stearate usage in concrete. The graph shows the correlation between calcium stearate content and percentage corrosion. The percentage of corrosion decreases significantly due to the increasing of calcium stearate content. This result has a similar tendency to the water absorption. Corrosion rate of cube without calcium stearate is around 12%. This corrosion rate gets reduced to 3% when various amount of calcium stearate added. When the content of calcium stearate is 5%, the percentage corrosion is around 3%. The tendency is valid when the maximum content of calcium stearate in the concrete is around 5%.

Table 9
Weight loss after 28 days

S. No.	% of calcium stearate	Average weight loss (%)
1	0%	12.15
2	1%	10.37
3	3%	5.78
4	5%	2.95

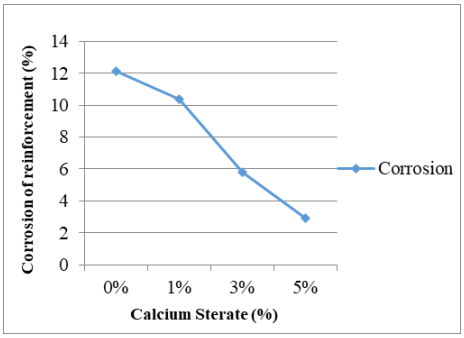

Fig. 3. Weight loss after 28 days

5. Conclusion

Water absorption, corrosion efficiency and compressive strength of concrete is already investigated by absorption test, accelerated corrosion, weight loss method and compressive strength test. Based on the results, the following conclusion are obtained:

- Calcium stearate have no side effects on the physical properties of concrete. Which is shown by a gradual increase in compressive strength up to 3% calcium stearate.
- Calcium stearate improves microstructure of concrete which is shown by reducing water absorption value. Calcium stearate 5% in concrete increases impermeability of concrete.
- Level of corrosion is also reduced when the calcium stearate is added in concrete. Concrete cube with 5% calcium stearate shows less corrosion than other cubes.

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