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EFFECT OF CACTUS ON THE RHEOLOGICAL PROPERTIES OF CEMENT

R. AMARAN* and R. RAVI

Department of Civil Engineering, SRM University, CHENNAI (T.N.) INDIA

ABSTRACT

In this investigation, cactus extract is used as a natural organic admixture in an ordinary portland cement. It is seen that cactus extract improves the plasticity of the mortar, workability and compressive strength of the concrete. Setting time of cement has been delayed due to moisture holding capacity of carbohydrates present in the cactus. FT-IR for organic analysis and SEM for microstructure was studied. Organic test on cactus was done to determine the presence of fat, protein and carbohydrates. Scattered formation of calcite from SEM image indicates the improvement in compressive strength of the concrete.

Key words: Cactus, Cement, Consistency, Setting time, Concrete, Workability, Strength, FT-IR, SEM.

INTRODUCTION

In olden days, Lime was the mostly used binding materials. Lime gave good strength in ancient times, but which gave poor performance on durability properties of lime based mortar and concrete. Hence, people used natural organic admixture in lime mortar and concrete to improve the strength and durability of structure, which in turn showed the better performance. This, being one of the reasons many ancient structures still exists. Whereas, now-a-days people started using natural organic admixture in cement. Use of cactus in mortars and concrete was studied by Chandra et al. (1998)[1], which improved the plasticity of mortar and freeze salt resistance. Traditional organic additives were used by L.Ventolà et al. (2011)[2] for restoration of architectural heritage and modern architecture, where natural stone is used. Influence of Black gram was studied in cement mortar and concrete by Chandra et al. (1982)[3], which improved hydrophobic property of cement mortar and concrete. Sea weed was used as a natural polymer by Rr. M. I. Retno Susilorini et al. (2014)[4] for green construction material innovation of sustainable concrete. Nopal mucilage and marine brown algae extract was used by F.M. Leon-Martinez et al. (2013)[5] as viscosity enhancing admixtures for cement based materials.

*Author for correspondence; E-mail: amaran39@gmail.com, ravistrucl@yahoo.in

EXPERIMENTAL

Materials used

Cement

Ordinary Portland cement of 53 grade cement was used as a binder. Initial and final setting time of cement have been found as per IS: 4031-5 (1988)[7] using Vicat apparatus.

Opuntia ficus indica (Cactus)

In this study, Opuntia Ficus Indica was used as natural organic admixture. The image of the cactus used is shown in Fig. 1. The leaves of cactus were cut in into very small pieces and put in water. The extract was prepared in the proportion of 1:3 (One part cactus and three part water by weight). The leaves are then squeezed by hand and then it is filtered which is called as Cactus Extract Solution (CEX) which is shown in Fig. 2.

Fig. 1: Cactus figure

Fig. 2: CEX Solution

Methods

Consistency

Consistency of cement was performed conforming to IS: 4031-4 (1988)[6] using Vicat apparatus. The consistency of cement was carried out on the reference sample as well as 10%, 20% proportions of CEX.

Setting time

Initial and final setting time of cement was performed conforming to IS: 4031-5 (1988)[7]. The initial and final setting time of cement was carried out on the reference sample as well as 10%, 20% proportions of CEX.

Workability

Workability of concrete by slump cone test was performed as per IS: 7320-1974[8]. In this investigation medium workability was assumed i.e. the slump value ranges from 25 mm to 75 mm and M20 grade concrete was used.

Compressive strength

The compressive strength on concrete cube was performed as per IS: 516 – 1959[9]. The Compressive strength was carried out on reference sample as well as 10%, 20% proportions of CEX using 100 mm concrete cube.

Fourier transform infrared spectroscopy (FT-IR)

Fourier transform infrared spectroscopy (FT-IR) analysis was performed on Perkin-Elmer 1000. FT-IR analysis of hardened concrete has been performed, in order to examine the possible chemical changes in the concrete due to the addition of admixtures. The presence of organics such as OH hydroxyl groups, C-O-C stretching vibrations has been identified.

Scanning electron microscopy (SEM)

Scanning electron microscopy (SEM) used on polished specimens, allows the internal structure of concrete to be clearly seen. Analysis of hydraulic concrete using SEM is more fruitful since the hydraulic compounds include silicon in the form of silicates and sometimes aluminum (atomic weight 27) in the form of aluminates. SEM with EDX is extremely powerful for the analysis of hydraulic cement (Stutzman 2004).

RESULTS AND DISCUSSION

Physical properties of cement, fine aggregate and coarse aggregate

Specific gravity and fineness modulus values of cement, fine and coarse aggregate are shown in Table 1.

Table 1: **Physical properties of cement, fine aggregate and coarse aggregate**

Materials	Specific gravity	Fineness modulus
Cement	3.13	4%
Fine aggregate	2.71	3.53%
Coarse aggregate	2.73	2.97%

Grain size distribution of sand have been determined as per IS: 2386 (Part 1) - 1963[12] on mechanical sieve shaker with sieve series (square mesh) of size 2.36 mm, 1.18 mm, 0.6 mm, 0.3 mm, 0.15 mm and 0.075 mm, with sieving time of 10 min. Individual fractions were weighed, and the results were plotted, which shown in Fig. 3.

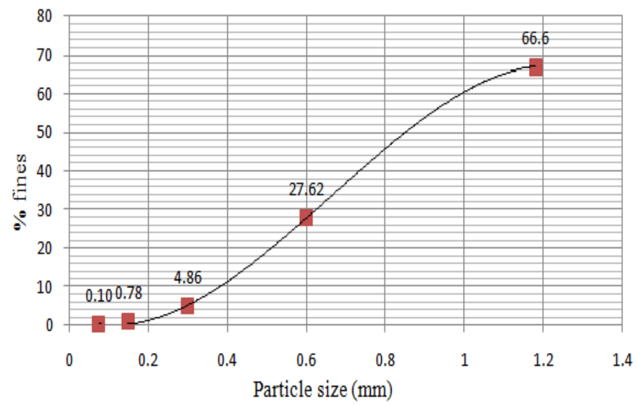

Fig. 3: Grain size distribution

Fourier transform infrared spectroscopy (FT-IR)

The deeper bands at 3417, 1631 and 1406, cm^{-1} seen in Fig. 4 indicates the presence of carbohydrates in Cactus. An important application of FT-IR to protein structure has been in the detection of hydrogen bonding. They cause a shift in the characteristic frequencies of N-H vibrations. Sharper bands at 1080 cm^{-1} and bands of 1030 cm^{-1} indicates the presence of proteins in cactus.

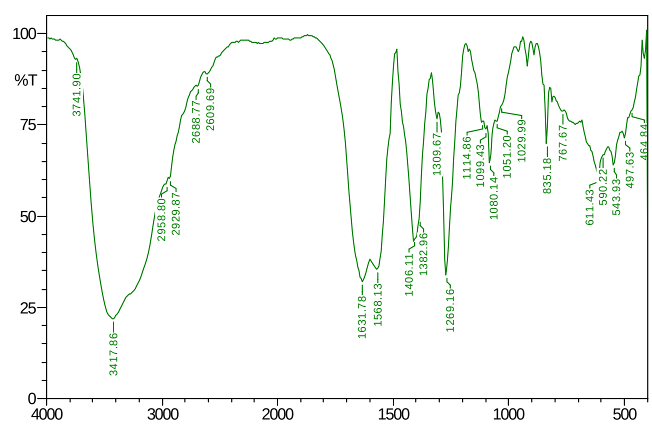

Fig. 4: FT-IR of cactus

Organic tests on cactus

Based on the qualitative results of FT-IR, Organic tests were carried out on the cactus sample conforming to IS: 7874 (Part I) – 1975[13]. The presence of Carbohydrates, Protein and fats content were found to be 4.7%, 1.92% and 0.16% and the values are shown in Table 2.

Table 2: Organic tests on cactus

Sample	Carbohydrates (%)	Protein (%)	Fats (%)
Opuntia Ficus Indica	4.7	1.92	0.16

Consistency and setting time of cement

Standard consistency of reference sample was found to be 29%, when no CEX is added with water. When the water was replaced by 10% of CEX, the consistency is increased by 0.5%. When the water was replaced by 20% of CEX, the consistency is increased by 1%. Since for every 10% CEX addition, the consistency is increased by 0.5% which is shown in Table 3.

Table 3: Consistency, initial and final setting time of cement

Sample	Consistency (%)	Initial setting time (min.)	Final setting time (min.)
Reference	29	38	510
10% CEX + 90% Water	28.5	44	535
20% CEX + 80% Water	28	47	560

Initial setting time of reference sample was found to be 38 minutes when no CEX is added with water. When the water was replaced by 10% of CEX, the initial setting time increased by 6 min. When the water was replaced by 20% of CEX, the initial setting time increased by 9 minutes. Final setting time of reference sample was found to be 510 min when no CEX is added with water. When the water was replaced by 10% of CEX, the final setting time increased by 25 min. When the water was replaced by 20% of CEX, the final setting time increased by 50 min. Therefore, initial and final setting time was increased with increase in the CEX, which is shown in Table 3.

Workability of admixture modified concrete

The optimum W/C ratio of reference sample is found to be 0.5 for medium workability when no CEX is added with water. When the water was replaced by 10% of CEX, the optimum W/C ratio is found as 0.49. When the water was replaced by 20% of CEX, the optimum W/C ratio is found as 0.46. Table 4 shows the workability is increased with increase in the CEX solution.

Table 4: Workability of admixture modified concrete

Sample	Optimum W/C ratio
Reference	0.5
10% CEX + 90% Water	0.49
20% CEX + 80% Water	0.46

Compressive strength

The compressive strength test was carried out on 7, 14 and 28 days and compressive strength of the admixture modified concrete was found higher than the reference concrete. Fig. 5 shows that, the compressive strength of concrete cube is increased with increase in the CEX solution compared to the reference concrete cube.

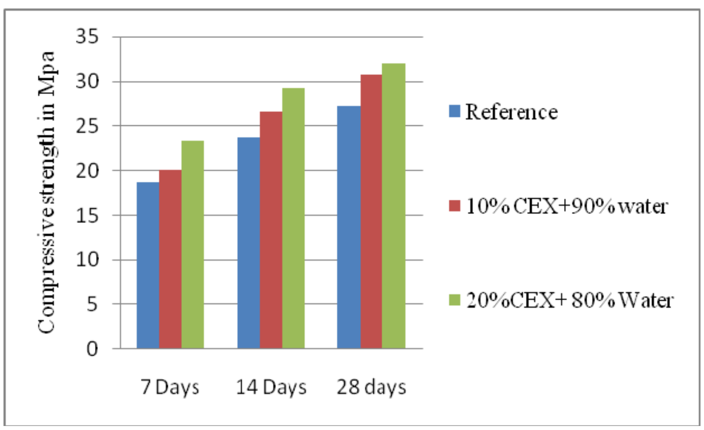

Fig. 5: Self curing property of concrete

Scanning electron microscopy (SEM)

In the SEM image shown in Fig. 6 of Reference concrete, scattered formation of calcite along with aggregate is seen. Whereas, in the SEM images of admixture modified concrete (20% CEX) formation of well-developed calcite is seen in Fig. 7, which proved the better compressive strength of admixture modified mortar in comparison to the reference concrete.

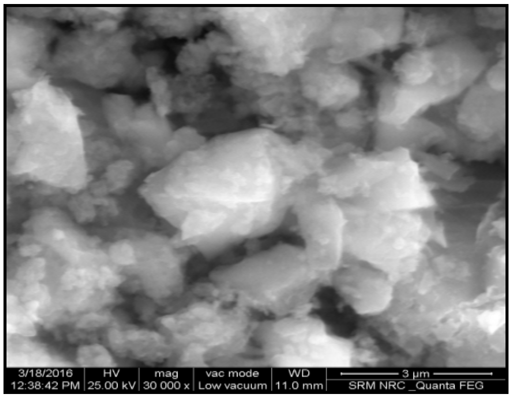

Fig. 6: SEM image of Reference concrete

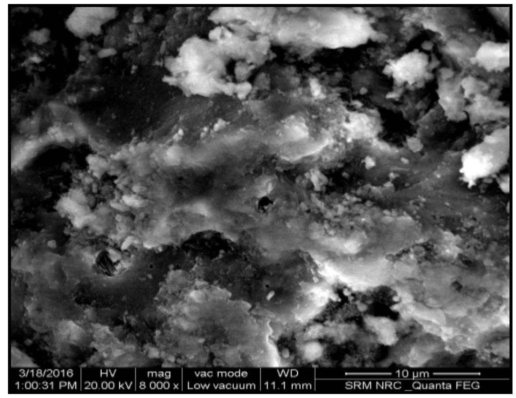

Fig. 7: SEM image of admixture modified concrete

CONCLUSION

Use of cactus in the cement improves the plasticity, workability and strength of the concrete.

(i) The consistency of cement is increased by 0.5 % for every 10% addition of CEX.

(ii) The optimum W/C ratio is reduced with increase in the CEX.

(iii) Self curing property obtained with addition of CEX.

REFERENCES

1. S. Chandra, L. Eklund and R. R. Villarreal, Use of Cactus In Mortars and Concrete, Cement and Concrete Research, **28(1)**, 41-51 (1998).

2. E. L. Ventolà, M. Vendrell, P. Giraldez and L. Merino, Traditional Organic Additives Improve Lime Mortars: New Old Materials for Restoration and Building Natural Stone Fabrics, Construct. Build. Mater., **25**, 3313-3318 (2011).

3. S. Chadra and J. Aavik, Influence of Black Gram Addition as Admixture in Cement Mortar and Concrete, Cement and Concrete Research, **13**, 423-430 (1982).

4. Rr. M. I. Retno Susilorini, Harianto Hardjasaputra, Sri Tudjono, Galih Hapsari, S. Reksa Wahyu, Ginanjar Hadikusumo and Joko Sucipto, The Advantage of Natural Polymer Modified Mortar with Seaweed:Green Construction Material Innovation for Sustainable Concrete, Sustainable Civil Engg Struct. Construct. Mater., **95**, 419-425 (2014).

5. F. M. Leon-Martinez, P. F. de J. Cano-Barrita, L. Lagunez-Rivera and L. Medina-Torres, Study of Nopal Mucilage and Marine Brown Algae Extract as Viscosity-Enhancing Admixtures for Cement Based Materials, Construct. Build. Mater., **53**, 190-202 (2013).

6. IS 4031 (Part 4), Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standards, New Delhi (1988).

7. IS 4031 (Part 5), Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standards, New Delhi (1988).

8. IS 7320, Specification for Concrete Slump Test Apparatus, Bureau of Indian Standards, New Delhi (1974).

9. IS 516, Method of tests for Strength of Concrete, Bureau of Indian Standards, New Delhi (1959).

10. IS 4031 (Part 11), Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standards, New Delhi (1988).

11. IS 2720 (Part 3/sec 1), Methods of Test for Soils, Bureau of Indian Standards, New Delhi (1980).

12. IS 2386 (Part 1), Methods of Test for Aggregates for Concrete, Bureau of Indian Standards, New Delhi (1963).

13. IS 7874 (Part 1), Methods of Tests for Animal Feeds and Feeding Stuffs, Bureau of Indian Standards, New Delhi (1975).

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