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Research Article

A STUDY ON THE INFLUENCE OF SUPPLEMENTATION OF NATURAL ADMIXTURES ON THE PROPERTIES OF HYDRATED LIME MORTAR

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ABSTRACT

Lime has been the most preferred choice of binding material used in the rehabilitation and preservation of antique historic monuments, owing to its competence to remain compatible. Incorporation of natural admixtures into lime mortars has optimistic influence on the improvement of mortar properties. Natural admixtures to be employed remain efficient and eco-friendly thereby can be utilized as a cover for existing synthetic additives. Modified mortars were produced from the extract obtained from Pedalium Murex species (referred as PMEX) at varying concentrations of 5% and 10%. An investigation on the behaviour of these modified mortar subjected to particular period of fermentation, towards the fresh state and hardened state properties was carried out. The outcome of the study showed that mortars modified with 10% natural admixture extract showcased enhanced mechanical characteristics along with improved workability due to the presence of polysaccharides present in the extract.

INTRODUCTION

Lime has been a universally accepted building material for rendering and reinstating several historical structures that have been constructed years back. The history of usage of lime dates back to 4000 B.C. with the Egyptians using it in the construction of the world famous Pyramid, especially for plastering purpose. Lime also has multi-faceted properties like durability, breathability, hydrophobicity, adhesiveness, compatibility, etc., that could enlighten the behaviour of the ancient buildings in which they are being utilized (Thirumalini and Sekar, 2013). Of the two most commonly used limes, non-hydraulic lime which is also referred as hydrated or air lime is a type of lime that exhibits a flexible behaviour upon their application (CerenInce, *et al*., 2015; Hassibi, 1999) stated that stirring of lime had a positive impact in bringing about homogeneity to the mixture by maintaining them in a better condition. (Boynton, 1980) studied that agitating the mixture provokes proper diffusion of small particles of lime thereby halting overheating which is confined to a particular area. Europeans especially the Greeks had good knowledge on the beneficial outcomes of grinding lime for various purposes (Cowper, 1998). But grinding demands large utility of human energy with requirement of extreme labour. Achieving the desired strength with satisfactory durability characteristics is of prime importance. The implementation of natural admixture like Opuntia into lime mortars improved certain important aspects like mechanical strength, pore size reduction, impermeability, etc., due to the availability of proteins, polysaccharides and fatty acids which in turn made them more durable (Ventola, *et al*., 2011). In Ancient China, the utilization of paste obtained from sticky rice gained importance because of the advancement in the structural performance of the ancient buildings with enhanced mechanical strength (Yang, *et al*., 2016). Our motto isto attain better results with the supplementation

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of natural admixtures on comparison with grinding. This paper focuses on the effect of addition of natural admixtures into the lime mortars on the behaviour of fresh and hardened state properties.

MATERIALS AND METHODS

Materials

The hydrated lime incorporated in the research was industrially manufactured and was brought from New Manali Town, Chennai. As per (IS 6932(Part I), 1973), the chemical characterisation was done to determine the constituents present in the lime and it included the following ingredients: CaO= 84.29%, MgO=0.9%, SiO_2=0.8%, moisture content=0.4% & Residues=13.61%. The fine aggregate employed was river sand that passed through 2.36 mm sieve. The sand thus obtained was cleaned with water and was then made to dry in sun. According to (IS: 2386 (Part I), 1963), the particle size distribution was performed. Initial and final setting times of the mortar were determined according to the procedure explained in (IS: 6932 Part 11, 1983). Consistency and workability tests were conducted as per norms stated in (IS: 6932 Part VIII, 1973). The natural admixture extract to be employed is obtained from Pedalium Murex plant commonly known as Anai Nerunji. This grows abundantly in the coastal regions of peninsular India and also in the regions of tropical Africa, Sri Lanka, Mexico and Madagascar. The plant leaves are enriched with proteins, resins, flavonoids, saponins, steroids, etc. The extract was produced by mashing the leaves with appropriate quantity of water and then allowing fermentation for three days with subsequent filtration for removal of wastes. The extract was referredas Pedalium Murex Extract (PMEX)and it was infused in the mortar mix at 5% and 10% concentrations.

Preparation of mortar specimen

1:3 was the lime to sand ratio opted for this study since it was accepted by various researchers who had knowledge in restoration works (Ramdoss, *et al.*, 2016; Moropoulou, *et al.*, 2002; Malinowski, 1981). The sizes of beam and cube moulds were 40 mm × 40 mm × 160 mm and 50 mm × 50 mm × 50 mm respectively. Reference mortars (RG) were made with grinders by adding lime and sand appropriately. Mortars subjected to regular agitation were also prepared with one day fermentation period (1-DF) without incorporation of admixtures. Furthermore, mortars made out of PMEX extract were also made. These mortars were cast as per (IS: 6932 Part VII, 1973) into cubes and beams by properly compacting them in the moulds and demoulding them after 3 days duration during which the temperature was kept at 27 ± 2°C and RH (Relative Humidity) at 90%. Cubes and beams thus produced were tested for compressive strength as well as flexural strength at the end of 28 days as per specifications detailed in (IS: 6932 Part VII, 1973) and (BS EN 1015-11, 1999) respectively.

RESULTS AND DISCUSSION

The fine aggregate employed was subjected to sieve analysis and the results are shown in (Fig. 1). The sand was well graded since the curvature co efficient obtained was 1.07 which was lying between 1 and 3.

Fresh state properties

The time taken for the initial set to take place in the reference mortar was three hours and fifteen minutes while the maximum time for initial set was taken by PMEX-3F-10 at four hours and thirty minutes. Similar observation was seen in the final setting time also with increment in duration for modified mortars. The final setting time for PMEX-3F-10 was noticed after fourteen hours and forty five minutes as against thirteen hours and fifteen minutes for reference grind mortar samples. The increase in the setting time for the admixture modified mortars might due to the ability to retain moisture for longer period which in turn prevents the mortar from getting dried up earlier. Results are tabulated in Table 1.

The results obtained from consistency and workability tests are tabulated in Table 2. The average spread that is formed on account of a single bump is known as the consistency. The natural admixture employed mortar mix had the maximum average spreads of 104 mm and 110 mm for PMEX-3F-5 and PMEX-3F-10 respectively. The average

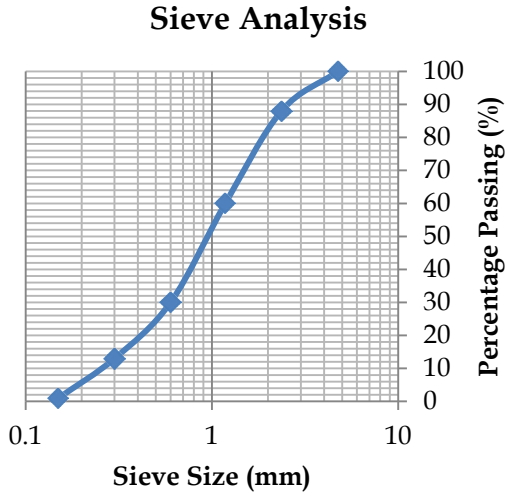

Fig. 1 Grain size distribution curve.

spread for Reference sample was the minimum with 102 mm while that for 1-DF mix was 98 mm. The number of bumps required for PMEX-3F-10, PMEX-3F-5 and 1-DF were 8, 10 and 14 respectively as against 12 bumps for reference mix. A noticeable improvement was there for the admixture modified mortars which was because of the proteins present in it which consequently makes them to exhibit plastic characteristics.

Hardened state properties

Compressive strength results for various lime mortar specimens after 28 days are shown in (Fig. 2). Even though these values are low compared to that of those obtained from mortars made out of hydraulic lime and cementitious material, this study focuses on upgrading the compressive strength by supplementing natural admixtures at different concentration levels. Reference grind samples (RG) that were made by grinding developed 0.585 Mpa compressive strength at the end of 28 days. But lime mortar specimens that were prepared with one day fermentation (1-DF) without any additives showed only 0.424 Mpa strength which was 1.37 times lesser than that of the reference mortars. The compressive strength increased greatly with the incorporation of natural admixture extract into the lime mortars. The increment in compressive strength was by about 15.38% for PMEX-3F-5 (0.675 Mpa) as against the reference samples. The strength got further escalated with increased concentration of the extract. For 10% extract supplementation i.e., for PMEX-3F-10, the strength was 0.738 Mpa which was about 26.15% more than that of the reference grind samples.

Flexural strength values (Fig. 3) also showed similar behaviour to that compressive strength values. 1-DF samples had flexural strength of 0.1406 Mpa which was 1.5 times lesser than that of the reference samples which was at 0.2109 Mpa. The natural admixture employed in the lime mortar had a positive impact on the flexural strength values. There was gradual increment in strength values with higher supplementation of natural admixture. PMEX-3F-5 had 0.2671 Mpa strength which was 26.64% greater than that of the reference sample. A maximum strength increment of about 40% was observed for PMEX-3F-10 sample. The improved mechanical properties upon addition of natural admixtures was due to the availability of polysaccharide content in the natural admixture which in turn makes it to exhibit adhesive and sticky characteristics.

Table 1 Initial setting time and final setting time

Identification of sample	Setting Time (hrs : mins)	
	Initial	Final
RG	3:15	13:15
1-DF	3:30	13:30
PMEX-3F-5	4:15	14:30
PMEX-3F-10	4:30	14:45

Table 2 Consistency and workability

Identification of sample	Average spread of lime paste for a single bump (mm)	No. of bumps required for 190 mm spread
RG	102	12
1-DF	98	14
PMEX-3F-5	104	10
PMEX-3F-10	110	8

CONCLUSION

The developments that were achieved due to the infusion of natural admixtures into the lime mortars have been sketched out as follows:

1. The setting time and workability of the modified mortars (PMEX-3F-5 & PMEX-3F-10) were well improved compared to RG and 1-DF mortars due to the presence of proteins in the extract which eventually makes it to exhibit moisture retaining capacity.

2. PMEX-3F-10 exhibited superior compressive as well as flexural strength results than all the other

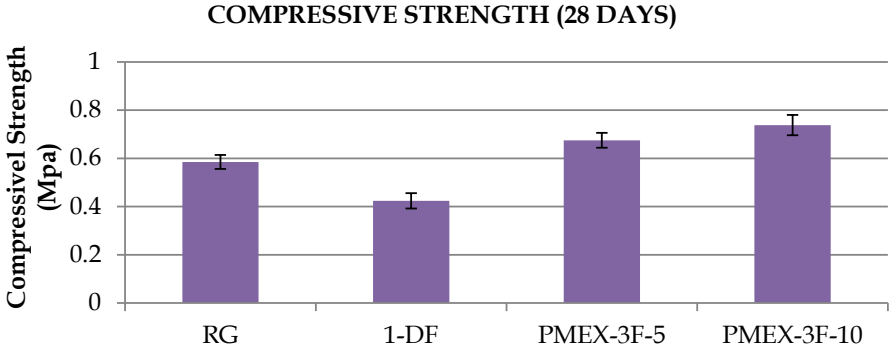

Fig. 2 Compressive strength of lime mortar samples.

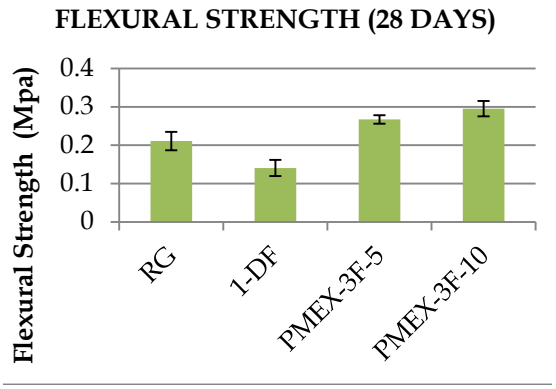

Fig. 3 Flexural strength of lime mortar samples.

samples. The maximum compressive strength was exhibited by PMEX-3F-10 which was 26.15% more than RG samples while the same sample showed maximum flexural strength which was 40% better than that of reference mortar sample. This improvement was due to polysaccharide content present in the admixture modified mortars.

REFERENCES

Boynton, R.S. (1980). Chemistry and technology of lime and limestone, 2nd edn, John Wiley & Sons, New York.

BS EN 1015-11. (1999). Methods of test for mortar for masonry: Determination of flexural and compressive strength of hardened mortar, British Standards Institution, London, UK.

Cereninc e., Derogar, S., Tiryakioğlu, N.Y. and Toklu, Y.C. (2015). The influence of zeolite and powdered bayburt stones on the water transport kinetics and mechanical properties of hydrated lime mortars. *Construction and Building Materials*. 98 : 345-352.

Cowper, A. (1998). Lime and lime mortars. Donhead Publishing Ltd, Dorset.

Hassibi, M. (1999). An overview of lime slaking and factors that affect the process. Chemo systems, L.P.

IS 6932 (Part I) (1973). Method of tests for building limes. Bureau of Indian Standards, New Delhi, India.

IS: 2386 (Part I). (1963). Method of test for aggregate and concrete-particle size and shape, Bureau of Indian Standards, New Delhi, India.

IS: 6932 (Part 11). (1983). Method of tests for building lime-Determination of setting time of lime. Bureau of Indian Standards, New Delhi, India.

IS: 6932 (Part VII). (1973). Methods of tests for building limes - Determination of compressive and transverse strengths. Bureau of Indian Standards, New Delhi, India.

IS: 6932 (Part VIII). (1973). Methods of tests for building Limes- Determination of workability. Bureau of Indian Standards, New Delhi, India.

Malinowski, R. (1981). Ancient mortars and concretes, durability aspects, mortars, cements and grouts used in conservation of historic buildings. In: Proceedings of the symposium, ICCROM, Rome. 341-350.

Moropoulou, A., Cakmak, A.S., Biscontin, G., Bakolas, A. and Zendri E. (2002). Advanced byzantine cement based composites resisting earthquake stresses: the crushed brick/lime mortars of Justinian's Hagia Sophia. *Construction and Building Materials*. 16 : 543-552.

Ramdoss, R., Thirumalini, P. and Sekar, S.K. (2016). Characterization of hydraulic lime mortar containing opuntia ficusindica as a bio-admixture for restoration applications. *International Journal of Architectural Heritage*. 10 : 714-725.

Thirumalini, P. and Sekar, S.K. (2013). Review on herbs used as admixture in lime mortar used in ancient structures. *Indian Journal of Applied Research.* 3 : 295-298.

Ventola, L., Vendrell, M., Giraldez, P. and Merino, L. (2011). Traditional organic additives improve lime mortars: New old materials for restoration and building natural stone fabric. *Construction and Building Materials*. 25 : 3313-3318.

Yang, T., Xiao, M., Zhang, B. and Zhang, H. (2016). Investigations into the function of sticky rice on the microstructures of hydrated lime putties. *Construction and Building Materials.* 102 : 105-112.