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Research Article

INFLUENCE OF *TERMIANALIA BELLERICA* ON AIR LIME MORTAR: FRESH STATE PROPERTIES AND STRENGTH ANALYSIS

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ABSTRACT

The rehabilitation practice of historical structure is growing trend in current scenario, consists of restoration and maintenance. One of the practices is replacing the damaged material with a modified material of compatible characteristics. In this study use of sustainable, eco-friendly and economical natural polymer admixture is encouraged. The polymer extract which is incorporated into the lime mortar is Terminalia bellirica known as Belleric myrobalan. The main aim of this study is to study the change in fresh state properties and mechanical properties of air lime mortar using natural admixture. The admixture added in the air lime is added in different concentrations of 3% and 5%. The fresh state properties such as consistency, workability, and setting time test were done on modified air lime. The mechanical properties such as compressive, flexural strength test were done after 28 days. The admixture found to be influencing the properties on air lime to a greater extent. The addition of natural admixture showed positive result in the fresh state and mechanical properties when compared with the conventional mortar.

INTRODUCTION

Lime was the most widely used material since from ancient times. Many notable past structure had been built using lime. Initially people from Egypt started using lime, and then it started gaining importance across all civilization. People started using different binders such as mud initially, followed by lime and now cement. Lime based mortar were poor in carbonation, and mechanical properties, which paved way for cement mortar to gain importance in construction field. But cement based mortar impact on environment and eco-sustainability remains concern for their usage on archeological structure for reparation work. Therefore many research are going on to modify the lime mortar for restoration work.

In ancient time in India between 4th and 6th century, different admixture were used in lime mortar such as beans, flowers, fruit pulps and leaves soaked in oils for painting purpose (Chandra and Aavik, 1987). Few plant extract were found to be effective for increasing the life span of building or structure. Cactus plant is used as an admixture in Mexican structure has water repellant properties (Ernesto, *et al*., 1988). Indian inhabitants used cactus mucilage for construction of structure after invasion of Spain (Chandra, *et al*., 1998). (Chandra, et al., 1998) has also studied the effect of Cactus plant admixture in cement mortar, where increment in water absorption and also salt crystallization resistance was observed. In the Portland cement, the calcium hydroxide interacted with the cactus extract forming 'polycarbides of proteins'.

The air lime mortar (hydrated lime) sets under carbonation and it initially hardens through drying. For carbonation, water is necessary element to be

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present, in which carbon di oxide dissolves reacts with calcium hydroxide (Lawrence, *et al*., 2007; Cultrone, *et al*., 2005).

Many study deals about the aspect of carbonation and about the durability properties of lime mortar, but very little known on the application of natural admixture on lime based mortar (Atzeni, *et al*., 1996; Cazalla, *et al*., 2000; Vanbalen, 2005). It is due to the requirement in lime based mortar whether it will be physically or chemically compatible with organic admixture (Degrise, *et al*., 2002; Genestar and Pons, 2002; Maravelaki, *et al*., 2003). In this research the focus is to study the behavior of fresh state properties of air lime based mortar and their mechanical properties. The replacement of synthetic admixture to organic admixture for sustainable development is the motivation of this study. These organic admixtures are known as Bio-admixtures.

The admixture used in this research is Belleric myrobalan. It is widely grown in South Asia. It has very good antioxidant property and healing properties used as an remedy for throat infections and chest. The present study purpose is to study the effect of admixture on the fresh state properties and mechanical properties of mortar. Therefore, the results obtained from this research will helps us to draw the conclusion regarding lime mortar with admixture and its effectiveness for restoration application.

MATERIALS AND METHODS

The lime used in this study was purchased from Manali, Chennai. The ratio of binder:aggregate for preparing lime mortar chosen as 1:3 commonly used in many archaeological structure and for restoration purpose (Ravi, *et al*., 2015). The water:lime ratio was maintained at 0.8. The composition of the binder i.e., air lime was ($Ca(OH)_2$) content of 85% (min 60%), SiO_2- 0.5%, MgO– 0.9%, and Residues – 13.61%. In (IS: 6932-Part 11, 1983) the procedure is mentioned to determine the setting time such as initial and final. The consistency and workability, according to (IS: 6932-Part 8, 1973).

The aggregate used in this research was fine sand of specific gravity 2.68. It was sieved under 2.36 mm, cleansed and sundried, in order to eliminate the inorganic impurities. The particle size distribution was determined according to (IS: 2386 (Part I), 1963).

The admixture Belleric myrobalan is grounded and soaked in water for a fermentation period of three days in a tightly packed container. The extract obtained after three days of fermentation after three days was referred by the code BMX.

Initially, the lime mortar mix prepared with different concentration of admixture of 3% and 5% with the fermentation period of three days. The casting of lime mortar had been done according to (IS: 6932 Part VII, 1973). The mortar was then filled into non-corrosive steel mould of (50 × 50 × 50 mm) for cube and 40 × 40 × 160 mm for beam and compacted by using thumb. The demoulding was done after three days from the date of casting, maintained in a room temperature of 27 ± 2°C, and 90 percent RH.

The code for different mortars are namely Reference mortar – (R), 3 day fermentation of 3% BMX extract – (BMX-3%), 3 day fermentation of 5% BMX extract – (BMX-5%).

The compressive strength of lime mortar after was done according to (IS: 6932 (Part VII), 1973). The flexural strength was done according to BS EN 1015-11:1999 (UNE-EN1015-11, 2006). Both the test was done after 28 days.

RESULTS AND DISCUSSION

Fresh State Properties

The consistency of air lime is one of the important parameter shows the workability and liquidity of lime mortar (Wei, *et al*., 2012). The admixture modified lime showed better consistency than the reference lime. For one bump, the average spread of lime mix was noted indicates the consistency of the respective mortar as per (IS: 6932 (Part VIII), 1973). It was noted that the spread of admixture modified mix was 100 mm and 109 mm in contrast to reference mix of 89 mm (Table 1). Notably, the workability test for a spread of 190 mm, the bumps required for BMX-3% and BMX-5% were 12 and 9, lower than the reference mix of 17 bumps. It is evident from these results that the admixture used has made the mortar more plastic improving the consistency and workability of lime mortar.

The initial setting time and final setting time of lime listed in Table 2. From the tabulation the initial setting time of reference lime found to be 2 hours and 40 minutes against the admixture modified mix BMX-

Table 1. Workability and consistency of reference and admixture modified mortar

Sample	Consistency (mm)	Workability
R	89	17
BMX-3%	100	12
BMX-5%	109	9

5% of 3 hours 30 minutes. The final setting time was about 12 hours 50 minutes for reference mix, which is lower than the BMX-5% of 14 hours 15 minutes. The admixture property of restraining the moisture, which was already evident from the consistency result supported by the setting time result.

Mechanical Properties

The addition of admixture into the lime mortar showed increase in the mechanical properties. The compressive strength of admixture mortar BMX-5% was 30.65% greater than the reference mortar after 28 days (Fig. 1). The BMX-3% showed slight increase of 14.52%. Similarly, the flexural strength of the admixture modified mortar (BMX-5%) was 33.33% higher than the reference mortar and for BMX-3% was 16.67% against the reference mortar (Fig. 2). The polysaccharides present in the admixture were possibly the reason for the increased strength of the modified mortar which behaves as an adhesive lead to the formation of strong microstructure (Vicat, 1997). The development of calcium carbonate from $Ca(OH)_2$ progressed by the humid environment provided by the moisture content present in the modified mortar due to the presence of polysaccharide.

Table 2. Setting time test

Sample	Initial Set (hr: mins)	Final Set (hr: mins)
R	2:40	12:50
BMX-3%	3:00	13:45
BMX-5%	3:30	14:15

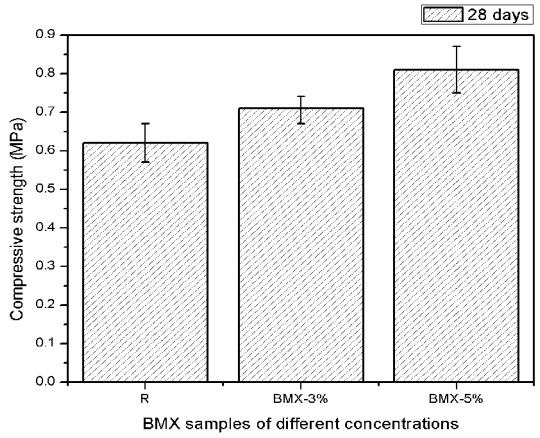

Fig. 1 Compressive strength of mortar.

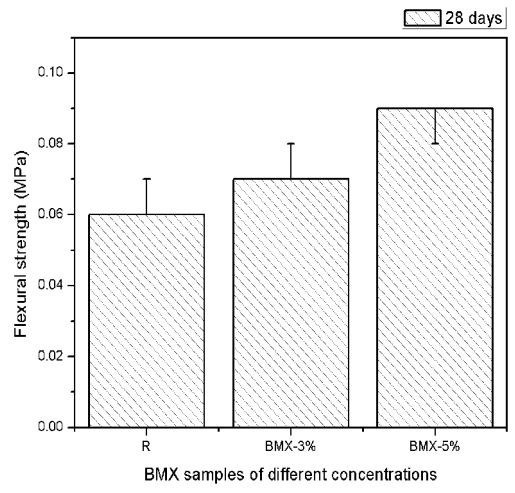

Fig. 2 Flexural strength of mortar.

CONCLUSION

The incorporation of admixture into the lime mortar in varying concentration led to following conclusions:

1. The addition of admixture BMX-5% improved the fresh state properties such as consistency and workability test. In addition to that, it also influenced the setting time result which made clear that the admixture tends to make the mortar more plastic by retaining water.

2. A massive improvement seen in mechanical properties - compressive strength and flexural strength test. It further affirmed that admixture modified mortar had a positive impact on the strength characteristics of mortar.

Hence, the natural admixture proved to be superior in fresh state properties and mechanical properties which can replace the synthetic admixture for restoration applications.

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