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Soil Cement Mortar

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Abstract
In the present development, where the supply of sand is declining short of meeting the demand, it becomes imperative to find a different alternative. Mud mortar was generally used for low-rise masonry buildings in the past. When the soil used for the mortar consists of clay, difficulties like volume instability due to its high affinity towards water are faced. To negate this action, stabilization of the clay is essential. Cement is used as binding agent. This paper address on an experimental study to understand the various inclination of soil-cement mortars. Workability and compressive strength of soil-cement mortars have been studied. Flow table tests are conducted to gauge the workability of the mortars. In this paper, the vitality of replacing river sand with locally available red soil is studied. The soil cement mortar with 110% flow is tested for 7 and 28 days compressive strength and the results are discussed.

Keywords
Soil-Cement Mortar, Stabilized soil Mortar, Red Soil, Mortar

I. Introduction

In order to come up with new technologies and methodologies, it is important to look back at history where our ancestors adopted simple yet smarter ways of construction from pre-historic days by using earth as the main ingredient for construction.
Local availability of mud makes its use beneficial, and flexibility of processing makes it the better energy efficient building material. Mud has been broadly used for construction in India and abroad since very long time. Mud wall construction is casual even now in some rural parts of India. About 55% of all Indian homes still use the raw earth for walls. From history, it is found that mud is a dependable material. Some of the main advantages of the earth are: low price, availability in large amount, good fire resistance and easy to use etc. It has some disadvantages, like its durability, which can be influenced by the activity of rain, wind, and others, but being an energy efficient and cost effective material, it is very dependable for low-rise buildings in general and especially in low-cost buildings. Researchers have discovered ways to enhance earth's quality and durability as a construction material for low-cost buildings. Stabilization is one such process used to outcome the disadvantages of pure mud construction.
Normally moderate amounts of clay content is acceptable in soil. As clay has cohesive nature, it yields plasticity to the soil under moist conditions. Plasticity is because of a thin layer of absorbed water which adheres to clay layers thus linking the particles together. Thus, the clay minerals act as binding material for the cohesionless granular fractions of soil like gravel, sand, and silt. Despite, certain drawbacks of clay like high affinity towards water. Clayey soils swell in the existence of water and shrinks in the unavailability of it. Such volume instability is highly undesirable in mortars. Hence, the soil has to be stabilized using cement.

A. Red soil in India

Red soil in India is formed by weathering of the old metamorphic and crystalline rocks. The color is red due to very high iron content. They are found in regions of low rainfall and is less leached than laterite soils. They are less clayey and sandier soils.

Fig. 1: Red soil used for this study

The red soils occupy a large area of land in India. It is found in states such as Tamil Nadu, southern Karnataka, north-eastern Andhra Pradesh, some parts of Madhya Pradesh, Chhattisgarh and Odisha [1].Red soil is created as an after effect of the draining down of old crystalline rock, sandier and less clayey in nature. These have a rich content of iron plus small humus content. The amount of essential nutrients like nitrogen, lime, and phosphorus are very less in red soils. Little acidic, it is incapable of retaining moisture. It is due to the iron oxide deposits, that red soils get the red tint and are infertile due to lime deficiency and soluble salt content [2]. As the red soil is infertile and also abundantly available in India, it is eco-friendly to be used for construction.

II. Literature Review

Ample studies have been completed on the properties of mortars. Maximum number of these researchconcentrated on cement mortar, cement-soil mortar, lime mortar, etc. There is no committed research on complete and partial replacement of sand and the binders required. There have been ample papers that target on cement soil mortars which assist in considering what guideline are to be adapted in the present research. The conclusions of some previous studies on mortars is displayed below. Reddy and Gupta [3] conducted research work on soil cement block masonry. Their paper focused on an experimental study in understanding the various characteristics of cement soil mortars in the fresh and hardened state. Workability, strength, water retentivity, shrinkage and stress-strain characteristics of cement soil mortars and bond strength of soil-cement block couplets using such mortars were

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examined. From the results obtained, they concluded that the composite mortars like cement-soil and cement-lime mortar can attain higher flow values without segregation of constituent materials. Cement-soil mortar possesses better water retentivity when compared to cement mortar and cement-lime mortar. The drying shrinkage value for cement-soil mortar is very high as compared to cement mortar. Cement-soil mortar gives higher bond strength with the decrease in clay percent. In soil cement mortar, flow value is controlled by clay fraction of the mortar mix rather than cement content of soil mortar. Whereas in the case of cement mortar and cement-lime mortar, cement content of the mix controls the flow value. Cement-soil mortar leads to better tensile bond strength when compared to cement mortar and cement-lime mortar. Reddy and Gupta [4] conducted research on SMB masonry using cement-soil mortars. Their paper focussed on understanding the characteristic properties of SMB masonry using cement-soil mortars. The compressive strength, stress-strain relationships and elastic properties of SMB masonry using three different SMBs and cement-soil mortars were examined. From the results obtained, they concluded that for any type of mortar, the compressive strength of masonry increases with the increase in block strength. Masonry compressive strength and mortar compressive strength have no definite relationship between each other. The examination of cement-soil mortar showed that the masonry strength was more dependent on cement content than the clay content of the mortar. As the cement content increases from 10 to 15% in cement-soil mortar, there was also increase in masonry compressive strength by about 20%. The masonry of cement-soil mortar had higher modulus (40–50% more) when compared to cement-lime mortar or cement mortar. The experimental study showed that, the cement soil mortar could be effectively utilised for SMB masonry and it is also economical. Reddy et.al.[5] conducted a study on soil cement block masonry without varying the characteristics of mortar. Their paper dealt with various methods of improvising shear bond strength and also studying the influence of shear bond strength on compressive strength of soil-cement block masonry. Some of the methods like, altering the textures of bed faces of the block, size and area of the frog, and certain surface coatings were adopted in order to improve the shear-bond strength. From the results obtained they concluded that when cement-soil mortar was used for soil cement block masonry, it resulted in much higher shear bond strength than the cement-lime mortar masonry. Also, shear bond strength could be varied by altering the surface either by manipulating it or by utilising surface coatings. Blocks with frogs were not effective in improving the bond strength when compared to other methods. Methods like altering the surface and cement slurry coating for soil cement block could be easily adopted in construction. It was found that when the masonry unit modulus was higher than the mortar, the variation in shear bond strength does not significantly affect the compressive strength and stress-strain characteristics. Walker and Stace [6] conducted research on blocks which were fabricated using stabilized composite soil. The study focussed on finding the suitable mortar among cement:lime:sand and soil:cement for stabilized composite soil block masonry. The results showed that by increasing the cement content and decreasing the clay content, the mortar compressive strength increases. Due to the reduction in compaction and increased moisture content, soil:cement mortar strength were usually less corresponding to stabilized composite soil block strength values. Based on these results, they concluded that soil:cement mortar could be used with its corresponding blocks without using any additional cement stabilizers.

III. Experimental Programme

This study targets on defining the characteristics of soil-cement mortar. Characteristics like compressive strength and workability are computed for the mortar. Mix proportions are shown in table 1. The mix proportions used are based on volume.

Table 1: Mix proportion

Mortar Title	% Replacement of soil with fine aggregate	% replacement of soil with cement
M1	0%	15%
M2		12%
M3		10%
M4	25%	15%
M5		12%
M6		10%
M7	50%	15%
M8		12%
M9		10%

1. Materials Used

For this study, locally available red soil is utilized. This soil has 28% clay fraction and liquid limit 40.7%. The cement used for this study was of OPC 53 grade.

IV. Testing Procedure

A. Determining the Workability of Mortar

Workability of fresh mortar is determined using flow table test and is expressed in flow value. Procedure for determining the flow of mortar is done according to IS 2250. In this study, the water content is determined for 110% flow.

B. Compressive Strength of Mortar

In order to determine the compressive strength, 70.7mm sized mortar cubes are tested in a compression testing machine. The tests are conducted as specified in IS 2250 [7]. A thin film of release agent is applied to the interiors of the moulds using a clean brush and then the paste of soil-cement mortar is poured into the mould. Then the moulds are taken to the vibrating machine which vibrates at 2800 rpm and the mould is compacted for 2 minutes. The mortar cubes are left in the moulds inside a moist room for a period of 24h. The cubes are now removed from the mould and placed inside the curing tank at a temperature of 27±2 °C for 7 and 28 days.

V. Results And Discussions

The results of 7days and 28days compressive strength along with its corresponding water content for 110% flow is shown in table 2.

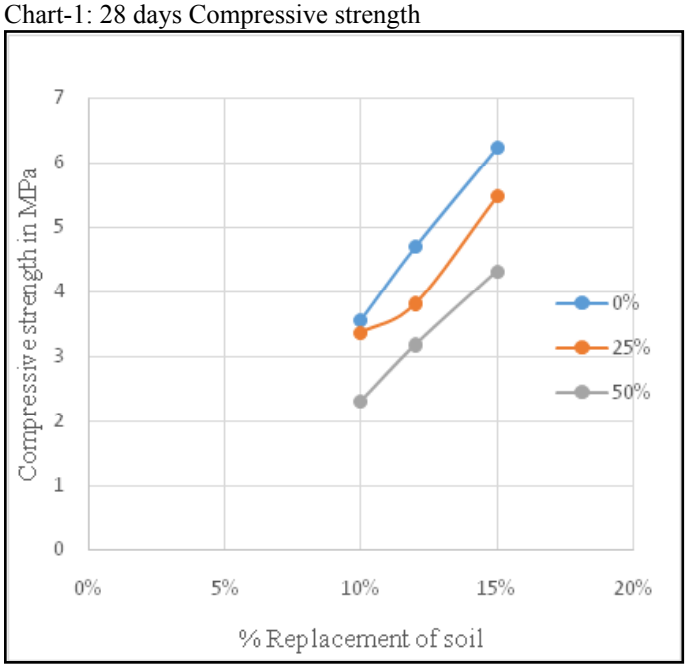
Fig. 2: Flow Table Test

Fig. 3: Showing testing of mortar cubes in Compression testing machine and Failed Mortar cubes respectively

Table 2 : Water content for 110% flow and 7, 28 days Compressive strength

Mortar Title	Water Content (%)	7 days compressive strength (MPa)	28 days compressive strength (MPa)	Grade of Mortar as per IS 2250
M1	41.02	3.26	6.24	MM5
M2	42.17	2.48	4.7	MM3
M3	43.23	2.22	3.56	MM3
M4	30.08	2.93	5.48	MM5
M5	32.21	1.93	3.82	MM3
M6	32.98	1.63	3.37	MM3
M7	24.89	2.1	4.32	MM3
M8	26.21	1.35	3.18	MM3
M9	27.06	1.25	2.31	MM2

Chart-1: 28 days Compressive strength



It can be observed that the compressive strength of mortar with 0% sand and 15% cement has the highest strength. The water need of the mortar to attain 110% flow increases as the clay content increases.The compressive strength increases with the increase in clay content.

VI. Conclusion

As the IS 2250 specifies that a mortar must have a minimum compressive strength of 3MPa in order to be used for construction, we can conclude that the soil-cement mortar is viable as it is visible from the experimental results that the maximum compressive strength of 6.24MPa is obtained. Hence we can also conclude that the construction becomes eco-friendly and economical when soil-cement mortar is used.

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