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AN EXPERIMENTAL INVESTIGATION ON STABILIZED MUD MORTAR WITH YELLOW-WHITE (GREY) SOIL

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ABSTRACT -- ***Masonry mortar is a homogenous mixture comprising of fine aggregate, binding material and water. In the current scenario, where the supply of sand is falling short of meeting the demand, it becomes imperative to finding an alternative. The locally available soils are intended to solve this problem. Mud mortar was commonly used for low rise masonry buildings in the past. When clay containing soil used for the mortar, problems like volume instability due to its high affinity towards water occurred. To remedies this problem, stabilization of the mortar is necessary. Cement, lime and fly ash are used as binders individually and in combination. The research is focused on an experimental study to understand the various characteristics of stabilized mud mortars. Workability and strength of 24 different combinations of stabilized mud mortars have been examined. Compressive strength tests were conducted to quantify the workability of the mortars. In the present work, the viability of replacing sand partially or fully with locally available yellow-white (grey) soil and brick dust is studied. The mortar with the alternative fine aggregates mixed with different combinations of binding materials i.e., cement, lime and fly ash was tested for 7, 21 and 28 days compressive strength. The mortar with 50% replacement of sand, 12% cement and 2 % fly ash has compressive strength in the range of 5.22 MPa which is acceptable as per the IS code 2250 specification the minimum strength requirement of mortar to be 3.0 MPa. Therefore, the use of stabilized mud mortar in construction would prove to be sustainable.***

KEYWORDS: Mud mortar, compressive strength, stabilization, cement, lime and fly ash.

I. INTRODUCTION

Construction of low cost structure demand in rural areas is on a steady rise. The present raw materials used mostly in the country are about 75% consist of the cement, sand and aggregate. Sand consumption is higher as it is utilized in mortar, concrete and all construction work. Locally available soils are the widely used in rural households apart from other material. Soil is everywhere available and does not cause pollution. It is natural and considered as a better substitute of cement and sand in mortar because it does not contain. Buy the research it can become a new source of construction material for villages. The key to the economy viability of mud mortar technology is maximizing the use of all its outputs, not just the material content of the mortar. Stabilized mud mortar refers to the production of mortar with soil, partially sand, cement, fly ash etc.

1.1 Sources of yellow-white mud - It is easily available at the excavation of new Ponds, Lakes, form, wells, foundation of sites etc.

1.2 Material used in stabilized mud mortar

A) Clay: Generally, the presence of clay in moderate amounts in a soil is desirable. Since clay has cohesive nature, it imparts plasticity to the soil when under moist conditions. Plasticity is due to the thin film of absorbed water which adheres strongly to the clay layers thus linking the particles together. Thus, the clay minerals act as natural binding agents for the cohesion less granular fractions of a soil (gravel, sand, and silt). Soils are obtained from integration of rocks.

B) Fly ash: Fly ash is also used as a binding material at the place of cement. It is also have corrosion resisting properties. Fly ash comes from thermal power plant is also used as a binding material. It is less in weight as compared to cement.

C) Cement: It possesses a high compressive strength. It is used as binding material and has no appreciable effects by atmospheric agents on it.

D) Sand: It is generally used to increase volume and increase compressive strength of mortar.

E) Lime: Lime has the capacity to stabilize clay soils through pozzolanic reaction. This reaction produces stable calcium silicate hydrates and calcium aluminate hydrates as the calcium from the lime reacts with the aluminates and silicates solubilized from the clay. The modification occurs because hydrated lime supplies calcium chloride that replaces the chloride present on the surface of the clay particles. As a result, lime treatment can produce high and long-lasting strength gains, improvements in shear strength and durability in severe environmental conditions. Lime is used as a binding material in compressed earth block or stabilized mud mortar. It is sufficiently durable, but it hardens slowly it is generally used for light loadings above ground floor.

F) Brick dust (Surkhi): Brick dust is obtained from construction and demolition waste. Brick dust finely ground into a powder can bring about a pozzolanic reaction when combined with lime given that they are composed of a type of clay that has a sufficient amount of soluble silica and alumina.

II. EARLIER INVESTIGATIONS

Much research has been done on the characteristics of mortars. Most of these studies focused on cement mortar, lime mortar, cement-soil mortar, etc. There are no dedicated studies on partial and complete replacement of sand and the optimum binders required. There have been many studies that focus on cement soil mortars which help in deducing what
parameters are to be applied in the present study. Results of some earlier researches on mortars are highlighted below. Walker and Stace studied the properties of some cement stabilized earth blocks and mortars. The effect of soil properties and cement content on the mortar was studied. They found that increase in clay fraction decreased the compressive strength while increase in cement content increased the strength of the mortar. Venkatarama Reddy and Ajay Gupta based one of their research works purely on finding the characteristics of cement-soil mortars. They carried out tests on cement-soil mortar, cement mortars and cement-lime mortars and compared the results. They used red loamy soil which contained 16% clay fraction containing kaolonite clay mineral. The trials were made on 4 different clay content percentages and three different percentages of cement. When the results were compared, it was found that composite mortars attain more flow values compared to pure cement mortars. Flow values signify the workability of the mortar. A linear relationship exists between water cement ratios and flow value of mortars. As the water-cement ratio increases, flow value increases. Very high flow value of 130% can be achieved for cement soil mortars and cement lime mortars. Venkatarama Reddy and Ajay Gupta worked on determining the strength and elastic properties of stabilized mud block masonry using cement-soil mortars. Their study was focused on finding the properties of masonry built of stabilized mud blocks and cement-soil mortars. The soil used in mortar was same as that used in the blocks i.e., locally available red loamy soil containing 16% of clay. The clay content in the sample was varied by mixing soil with natural sand. For the same workability, when the masonry was tested, it was found that the compressive strength of the masonry was 15-20% higher in the masonry with cement-soil mortar and cement-lime mortar than the masonry with pure cement mortar. The compressive strength and modulus of cement-soil mortar depends on cement content and clay fraction. The study demonstrates that cement-soil mortar, which is cheaper than conventional mortars, can be beneficially used for SMB masonry. Laura Rampezzi and Roberto Bugini studied the behavior of brick and mortar interface. The samples were taken from the Basilica di San Lorenzo in Milan. They found that thin layer of light colour was formed which was the reason for the pozzolanic reactions. This layer mostly consisted of calcium and silica. Through this study they deducted that the calcium hydroxide in the mortar and the silica in the brick dust reacted to give silicates thus forming a bond between lime and brick dust which strengthens the mortar. Venkatarama Reddy et.al. explored the enhancing bond strength and characteristics of soil-cement block masonry. The masonry was tested with two types of mortar namely cement-soil mortar (CSM) and cement lime mortar (CLM) with flow value of 100% (Gupta 2003). Mortar compressive strength was determined from 7cm cubes. A 28- day compressive strength is 3.45 and 2.93 MPa for CSM and CLM mortars, respectively.

Rashmi S al. (2014) was researched that masonry mortar is a homogenous mixture comprising of fine aggregates, binding material and water. In their research work, the viability of replacing sand partially or fully with locally available red soil and

brick dust is studied. The mortar with the alternative fine aggregates, mixed with different combinations of binding materials i.e., cement and lime was tested for 28 days compressive strength. The mortar with 50% replacement of sand and 12% cement has compressive strength in the range of 4.25MPa which is acceptable as per the IS code specification, the minimum strength requirement of mortar to be 3 MPa. Therefore, the use of stabilized mud mortar in construction would prove to be sustainable as well economical.

Thus, it is clear that using cement-soil mortars is more beneficiary than conventional cement mortars. Though studies have been conducted on mortars in which sand has been partially replaced, it is clear that an attempt has not been made to determine if yellow-white (grey) soil can completely replace sand. If so, then what amount of binder should be added to it. Also, the possibility of replacing sand by soil as well as a pozzolanic material like brick dust and fly ash in a mortar mix has been explored in the present work.

III. EXPERIMENTAL PROGRAM

The present work focuses on characterizing mud mortars. The characteristics like workability and compressive strength are determined for different proportions of mortars given below table 3.1 and 3.2. The mortar mix proportions in this study are based on weight.

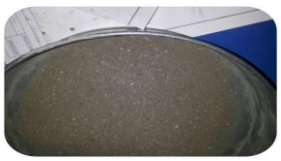
Table - 3.1: Mix Proportions stabilized with cement and lime

Mortar Designation	Mortar Proportion				
	Cement (C)	Lime (L)	Soil (S)	Sand (Sa)	Brick dust (B)
$L_{10}S_{100}$	-	10%	100%	-	-
$L_{10}S_{50}Sa_{50}$			50%	50%	-
$L_{10}S_{50}Sa_{25}B_{25}$			50%	25%	25%
$C_5L_{10}S_{100}$	5%	10%	100%	-	-
$C_5L_{10}S_{50}Sa_{50}$			50%	50%	-
$C_5L_{10}S_{50}Sa_{25}B_{25}$			50%	25%	25%
$C_{10}L_5S_{100}$	10%	5%	100%	-	-
$C_{10}L_5S_{50}Sa_{50}$			50%	50%	-
$C_{10}L_5S_{50}Sa_{25}B_{25}$			50%	25%	25%
$C_{12}S_{100}$	12%	-	100%	-	-
$C_{12}S_{50}Sa_{50}$			50%	50%	-
$C_{12}S_{50}Sa_{25}B_{25}$			50%	25%	25%

Table -3.2: Mix proportions stabilized with cement and fly ash

Mortar Designation	Mortar Proportion				
	Cement (C)	Fly Ash (F)	Soil (S)	Sand (Sa)	Brick dust (B)
$F_{10}S_{100}$	-	10%	100%	-	-
$F_{10}S_{50}Sa_{50}$			50%	50%	-
$F_{10}S_{50}Sa_{25}B_{25}$			50%	25%	25%
$C_5F_{10}S_{100}$	5%	10%	100%	-	-
$C_5F_{10}S_{50}Sa_{50}$			50%	50%	-
$C_5F_{10}S_{50}Sa_{25}B_{25}$			50%	25%	25%
$C_{10}F_5S_{100}$	10%	5%	100%	-	-
$C_{10}F_5S_{50}Sa_{50}$			50%	50%	-
$C_{10}F_5S_{50}Sa_{25}B_{25}$			50%	25%	25%
$S_{100}C_{12}F_2$	12%	2%	100%	-	-
$C_{12}F_2S_{50}Sa_{50}$			50%	50%	-
$C_{12}F_2S_{50}Sa_{25}B_{25}$			50%	25%	25%

3.1 Soil sieving: For the preparation of mix, locally available yellow-white (grey) soil in Indore is used as shown in fig.3.1 fig.3.2. This natural soil has 20% clay fraction. The clay content is varied by diluting it with natural sand and brick dust. The brick dust is obtained by manually ramming construction and demolition waste. The lime bought in the form of binding material, is slaked and used.



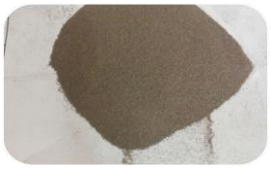


Fig. 3.1 Soil Material **Fig. 3.2 Sieved Soil**

3.2 Preparation of soil mixture: Stabilized mud blocks can be prepared by mixing of the moist mixture of soil and stabilizers in moulds as shown in fig.3.3. A number of studies are available on the properties and use of soil cement blocks for building construction. Locally available yellow-white soil was used. The liquid limit and plastic limit of the soil are 37.5% and 20 % respectively. The block making process consists of mixing the cement, lime and screened soil by hand and then mixing with water to get near optimum moisture content.

A cement content of 5% by weight of dry soil was used. After preparation of the blocks were cured for 28 days under wet burlap. The properties of the blocks are given means of 3 specimens.

Blocks of 70.6mmx70.6mmx70.6mm were used to prepare stabilized mud mortar as shown in fig.3.4 and compacted on vibrating table as shown in fig.3.5.

Fig. 3.3 Preparation of mortar mixture

Fig. 3.4 Moulds for preparation of mud mortar blocks and fig. 3.5 Mud mortar cubes on vibrator machine

IV. TESTING PROCEDURE

4.1 Determination of Workability: Workability of the mortar should be such that it can be spread easily and adheres well with the masonry unit composition of the mix and water cement ratios cement ratios are two major factors that affect workability. In the present studies the workability characters are measured by conducting flow tests .Here, the flow is maintained at 100% and the water cement ratio is determined.

4.2 Compressive Strength of Mortar: The compressive strength of mortar was determined by testing 70.6 mm size cube specimens. The specifications of I.S. 2250 code are followed. The cubes are filled in 3 layers. Each layer is tamped 25 times using a standard tamping rod the mortar cubes are de-molded after 24 hours and cured under wet burlap. After 7, 14 and 28 days of curing, the specimens are tested in compression testing machine in saturated conditions as shown in fig. 4.1 and fig.4.2.

Fig. 4.1 compressive strength test and fig. 4.2 failure of mud block

4.3 Soil properties test

For the study, locally available yellow soil is used. This natural soil has 20% clay fraction and liquid limit 37.5% found by test as shown in fig.4.6. Plastic limit of available soil obtained 20 % found by preparing threads as shown in fig. 4.7 and optimum moisture content of soil 17% fond by compaction test as shown in fig. 4.5.

Fig. 4.3 Compaction Test, fig.4.4 Liquid Limit by Casagrande Apparatus and fig.4.5 Plastic Limit

V. RESULTS AND DISCUSSIONS

For 100% flow the water content taken by weight of mortar mix and compressive strength of 7, 14 and 28 days are as given in the table 6.1. It is observed that when the water requirement of the mortar increase with the increase in clay fraction.

Table – 6.1: Water content and 7, 14, 28 days compressive strength

Mortar Designation	**Water Content (%)**	**7 day's Compressive Strength(MPa)**	**14 day's Compressive strength (MPa)**	**28 day's Compressive strength (MPa)**
$L_{10}S_{100}$	35.5	1.00	1.50	2.20
$L_{10}S_{50}Sa_{50}$	28	0.90	1.40	2.0
$L_{10}S_{50}Sa_{25}B_{25}$	30.5	1.00	1.50	2.20
$C_5L_{10}S_{100}$	36.5	1.51	1.70	2.50
$C_5L_{10}S_{50}Sa_{50}$	29	1.60	1.90	2.70
$C_5L_{10}S_{50}Sa_{25}B_{25}$	32	1.70	2.00	2.80
$C_{10}L_5S_{100}$	35	1.60	2.50	3.21
$C_{10}L_5S_{50}Sa_{50}$	24	2.00	2.70	3.61
$C_{10}L_5S_{50}Sa_{25}B_{25}$	29.5	1.90	2.60	3.41
$C_{12}S_{100}$	33	1.70	2.20	3.0
$C_{12}S_{50}Sa_{50}$	20.5	3.20	4.01	5.12
$C_{12}S_{50}Sa_{25}B_{25}$	24.5	2.90	3.61	4.42
$F_{10}S_{100}$	33.5	1.51	1.7	2.5
$F_{10}S_{50}Sa_{50}$	28	1.4	1.6	2.2
$F_{10}S_{50}Sa_{25}B_{25}$	30.5	1.51	1.7	2.4
$C_5F_{10}S_{100}$	35.5	1.7	2.2	3
$C_5F_{10}S_{50}Sa_{50}$	30	2	2.7	3.5
$C_5F_{10}S_{50}Sa_{25}B_{25}$	32	1.9	2.4	3.21
$C_{10}F_5S_{100}$	35	2.5	3	3.81
$C_{10}F_5S_{50}Sa_{50}$	24	3	3.81	4.52
$C_{10}F_5S_{50}Sa_{25}B_{25}$	29.5	2.9	3.7	4.42
$S_{100}C_{12}F_2$	33	2.2	2.7	3.61
$C_{12}F_2S_{50}Sa_{50}$	20.5	3.61	4.2	5.22
$C_{12}F_2S_{50}Sa_{25}B_{25}$	30.50	1.00	1.40	2.00

The compressive strength of mortar mix M17 with 50% soil, 50% sand, 12% cement and 2% fly ash has the highest strength of 5.22 MPa and mortar mix M5 with 50% soil, 50% sand and 12% cement has the second highest strength of 5.12 MPa. The 16 mortar mixes have compressive strength more than 3.0 Mpa. The 6 mortar mixes have lower strength between 2.0 to 2.8 MPa only.

VI. CONCLUSIONS

Stabilized mud mortar was prepared using yellow-white (grey) soil and other material in different ratios than earth blocks (cube) and tested after 7days, 14 days and 28 days. It comes to the following conclusions:

i. The mortar mix with 50% soil and 50% sand (partially replacement of sand) stabilized with 12% cement and 2% fly ash has the highest compressive strength of 5.22 MPa and mortar mix with 50% soil and 50% sand (partially replacement of sand) stabilized with 12% cement has the second highest compressive strength of 5.12 MPa, so these proportions are best suitable for masonry mortars.

ii. The fully replacement of sand (100% soil) should be stabilized with 12% cement or 10% cement + 5% lime or 12% cement + 2% fly ash or 10% cement + 5% fly ash or 5% cement + 10% fly ash for gaining compressive strength more than 3.0 MPa.

iii. It has observed that the water requirement of the mortar increase with the increase in clay fraction. The mortar mixes with lime may be used as low strength mortar.

The comparison of the compressive strength of the mortar mixes is shown in figure 6.1 and 6.2.

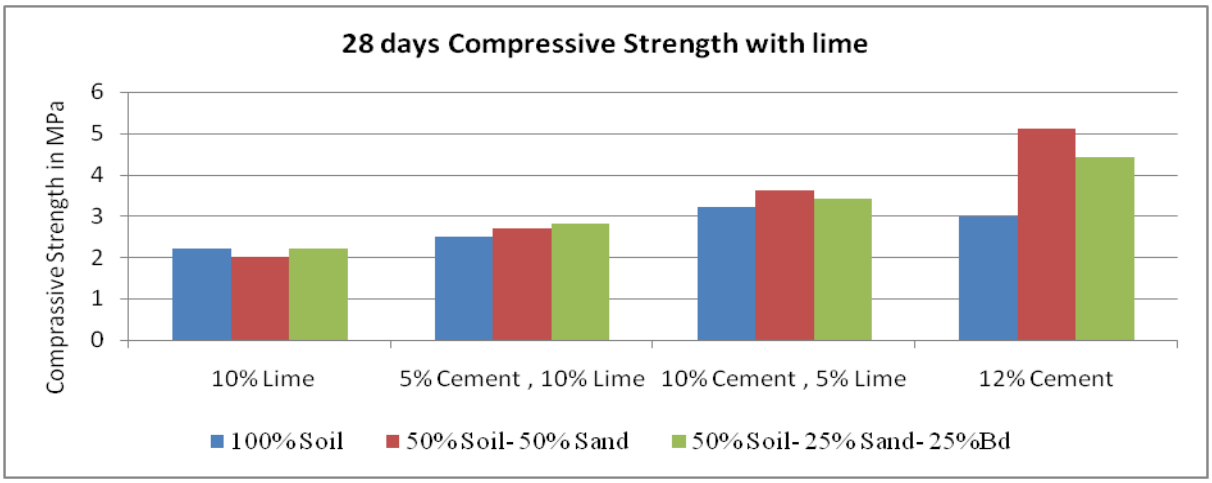


Fig.-6.1: 28 days compressive strength with lime

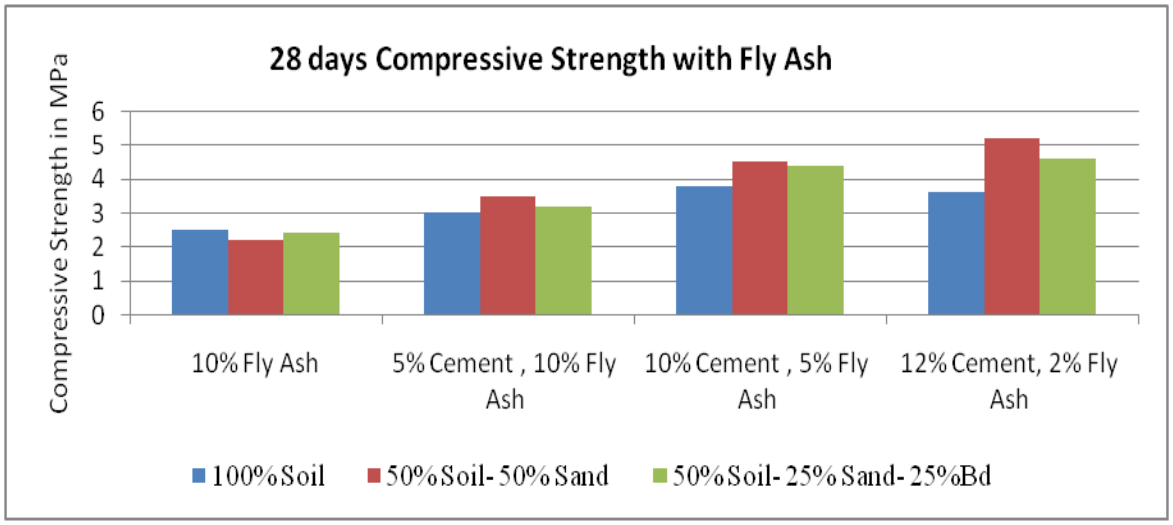


Fig.- 6.2: 28 days compressive strength with fly ash

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