

ALTERNATIVES TO CONVENTIONAL CEMENT-SAND MORTAR FOR SUSTAINABLE MASONRY CONSTRUCTION

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ABSTRACT

Masonry Mortar is basically a binding agent that is composed of acementitious material, fine aggregates and water. The main purpose of the mortar is to sew masonry units (blocks/bricks) into the single integral unit. Conventionally used mortar is cement sand mortar in the proportion 1:6 (Cement: River Sand). Over the past few decades, man has exploited the natural resources at a severe rate. Good quality Natural River Sand stands first in the list of construction materials that are on the verge of extinction due to excessive and unnecessary consumption in the construction process. One has to adapt to alternative materials that can be used as an effective replacement over 'Natural River Sand' in Masonry Mortar without affecting its efficiency. This paper focuses on the experimental analysis of six such alternatives that have the potential to replace Natural River Sand in a mortar. Mortars prepared from these alternatives satisfy the minimum strength requirement as per IS code. Thus, the use of such alternatives to natural sand for mortars in masonry construction would deliver an efficient economical and sustainable structure.

Keywords: Natural River Sand, M. Sand, LD Slag, GBFS, Quarry Dust, Granite Powder, Cement-Lime-Soil-Paste (CLSP), Mortar, Masonry

I. INTRODUCTION

The field of Civil Engineering and Construction technology has evolved from bamboo huts to multi-storeyed skyscrapers and man-made islands. Such mega structures consume a huge amount of natural resources which may have irreversible ill-effects on the environment. Sand being the most widely consumed material in construction is on the verge of causing such ill-effect on the environment. In the present day, sand mining is banned and this has resulted in a severe imbalance in the supply-demand chain of Natural River Sand. Construction with River sand in the present case scenario is highly expensive. Hence one has to adapt to alternative materials in the construction process that has a negligible impact on the environment.

II. EARLIER INVESTIGATIONS

Several investigations have been carried out on alternatives that can be used as a partial or total replacement of sand in conventional cement sand mortar. Rashmi S, Jagadish K S and Nethravathi S (2014) [1] carried out studies on stabilized mud mortars. Masonry Mortar plays a major role in the strength gaining parameters of the masonry structures. This study focuses on the utilization of locally available and economical resources as an alternative to conventional construction practices. Mortars were prepared with various mix proportions of soil, brick dust, lime, sand and cement. The various mortar mix proportions were prepared with the varied percentage of water content and tested for its 28-day cube compressive strength. The mortar proportion M5 with 50% soil and sand with 12% cement stabilization showed a compressive strength of 4.25 MPa at 28 day which satisfies the standards of IS 2250:1981. Hence it is clear that partial replacement of sand using soil works out to be an economical mix. Costigan.A and S.Pavia (2005) [2] carried out analysis on the compressive strength flexural strength and bond strength of Masonry using Lime based mortars. Both the hydraulic Lime and Non-hydraulic Lime was used as mortar. Masonry wall test specimens were built using non-hydraulic Lime and Hydraulic Lime as mortar and were tested for its compressive strength and flexural strength. The mortar was also tested for its cube compressive strength at 28 days and 56 days. The non-hydraulic Lime had a 28-day cube compressive strength of 0.89MPa which was slightly lower from the specified standard values of 1.20MPa; Hydraulic lime had a mortar cube compressive strength of 4.39MPa which was satisfactory as per standards. Venkatarama Reddy and Ajay Gupta (2006) [3] carried out tests to determine the strength and elastic properties of stabilized mud block masonry using cement-soil mortar. Soil used in the blocks and mortar is same. Soil being Loamy contained 16% clay. The clay content was varied by blending the soil with natural sand. Workability was maintained constant and the compressive strength was evaluated. It was found that the compressive strength of cement-soil mortar and cement-lime mortar was 20% higher than pure cement mortar. The study showed that mud mortars and lime mortars that are cheaper when compared to pure cement mortar can be used effectively in Stabilized mud block masonry. Till date, several alternative materials have been considered for partial replacement of sand in conventional cement sand mortar. In the present work, an attempt is made on various alternatives that can be used as a complete replacement of sand in masonry mortar.

III. MATERIALS AND METHODOLOGY

The step by step procedure followed in the present study in preparation of mortars using alternative materials have been discussed below

3.1 Materials

The various ingredients or alternative materials that have been used as fine aggregate for total replacement of sand in conventional Cement Sand mortar and their description is given below.

3.1.1 Manufactured Sand (M. Sand)

M. Sand or Manufactured sand is the latest alternative for natural river sand being used widely in the construction process. It is derived from crushing of aggregates in a controlled process as per required specification in terms of shape, size and surface texture.

3.1.2 Granulated Blast Furnace Slag Sand (GBFS)

This sand is basically a slag material obtained when manufacturing Iron from its ore. The slag is initially derived in its molten state which upon rapid cooling results in the formation of sand-sized particles. These particles are non-metallic and have surface texture similar to that of natural river sand

3.1.3 Quarry Dust

Quarry Dust is a by-product generated during the stone quarrying process. These are extremely fine particles with grain lesser than 75 microns. Hence it can be used effectively as a filler material because of its tendency to occupy the large surface area.

3.1.4 Granite Powder

Granite powder is initially collected as a slurry in large storage tanks. When the slurry is left undisturbed for weeks, the particles undergo sedimentation which is later collected as Granite Powder. Granite slurry disposal has become a nuisance to the dealers and hence its application in the field of civil engineering has been explored in the present study.

3.1.5 LD Slag

The slag gets its name from the process developed by scientists Linz and Donawitz in the manufacture of steel. Calcium oxide comprises of 46% of the total constituent of the Slag. Hence the slag exhibits cementitious property. Other constituents include oxides of Silica, Magnesium, Manganese and Iron.

3.1.6 Cement-Lime-Soil-Paste (CLSP)

Over the past few decades, with the advancements in the field of stabilization techniques, we have seen the effective use of soil as partial replacement of sand in Cement-Soil mortar [3]. Hence an attempt has been made to use locally available soil as a complete replacement to natural sand in Cement-Lime-Soil Paste (CLSP) as mortar. CLSP has been used in two different proportions (1:1:2 and 1:1:1.5 – Cement:Lime:Soil). Soil used in the study is locally sourced and had a clay content of about 20%. Quick Lime was procured from Bijapur and slaked to obtain Hydrated Lime. This hydrated lime was blended effectively with cement and soil to obtain a paste that has been used as mortar for complete replacement of river sand in conventional cement sand mortar. 43 Grade Cement has been used as a binder for all the mortars used in the present study.

3.2 Methodology

The first step in the present study was the procurement of various alternative materials that was intended to be used as fine aggregates in masonry mortar. The binding agent in all these materials was cement. The alternatives considered as a complete replacement of sand in the mortar was first sieved and the sand portion i.e. passing 4.75mm sieve and retained on 75-micron sieve was collected for use in preparing mortar. The proportion of cement and fine aggregates in the various mortars that have been studied was 1:6 (Binder: Fine Aggregate). Mode of preparation of mortar was followed as per Standard specifications [4]. Granite powder being extremely fine had 0% retained on 75-micron sieve. The details of various alternative materials used and water content maintained at the time of preparation of mortar cubes have been tabulated in table 1.

Table 1: List of Various Mortar Cubes along with its initial water content

Sl. No	Mortar Type	Water Content
1	1:1:1.5 - CLSP	50%
2	1:1:2 - CLSP	50%
3	1:6 - Cement: Natural Sand	40%
4	1:6 - Cement: Quarry Dust	60%
5	1:6 - Cement: Granite Powder	80%
6	1:6 - Cement: M.Sand	60%
7	1:6 - Cement: GBFS	50%
8	1:6 - Cement: LD Slag	80%

IV. TESTINGPROCEDURE - COMPRESSIVE STRENGTH OF MORTAR CUBES

The various alternatives that have been mentioned above were cast in mortar cubes of 70.6mm dimension. The cubes were greased thoroughly before filling the mortar mix. Filling of themix was done in 3 layers as per standard specifications [4]. The prepared mortar cube was allowed to set for a period of 24 hours after which they were demoulded and cured for 28 days and 56 days and tested for its compressive strength under Universal Testing Machine.

V. RESULTS AND DISCUSSION

Workability and Compressive Strength are the two important parameters that govern the efficiency of mortar. In the present study, Workability being fairly a relative parameter has been adopted based on trial mixes. Strength parameter has been evaluated by testing the mortar cubes for it compressive strength at 28 days and 56 days respectively. The test results have been comparatively analyzed with respect to the strength of conventional cement sand mortar cube compressive strength at corresponding curing period. Compressive strength results are tabulated in table 2. The different alternatives that would be suitable for complete replacement of sand in mortar were studied by analyzing the compressive strength results of mortar cubes over different curing periods.

Table 2: Compressive Strength of Mortar Cubes

Sl No	Mortar Type	Cube Surface Area (mm ²)	28 days Comp. Strength		56 days Comp. Strength	
			Failure Load (kN)	Average (MPa)	Failure Load (kN)	Average (MPa)
1	1:1:1.5 - CLSP	4984.36	70.43	14.13	90.02	18.06
2	1:1:2 - CLSP	4984.36	56.27	11.29	68.63	13.77
3	1:6 - Cement: Natural Sand	4984.36	34.14	6.85	52.34	10.50
4	1:6 - Cement: Quarry Dust	4984.36	72.67	14.58	82.59	16.57
5	1:6 - Cement: Granite Powder	4984.36	10.22	2.05	17.64	3.54
6	1:6 - Cement: M.Sand	4984.36	25.27	5.07	40.82	8.19
7	1:6 - Cement: GBFS	4984.36	9.42	1.89	16.25	3.26
8	1:6 - Cement: LD Slag	4984.36	35.89	7.20	53.58	10.75

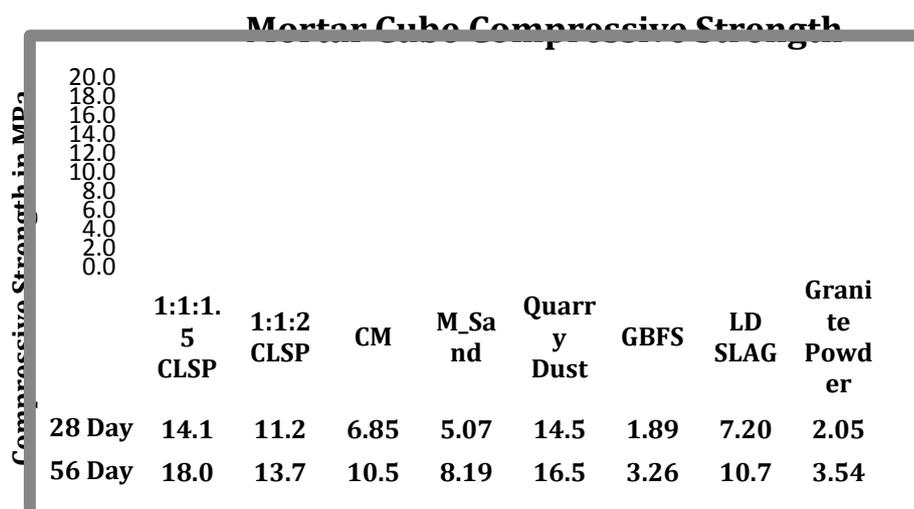


Figure 1: Mortar Cube Compressive Strength

Except for Granite powder and GBFS, all the alternatives have satisfactory compressive strength as per IS codes. However, it can be seen that quarry dust and 1:1:1.5 CLSP mortar have the highest strength. It is interesting to note that at 28days quarry dust mortar had slightly higher strength as compared to 1:1:1.5 CLSP mortar. However at 56day the compressive strength of 1:1:1.5 CLSP is much greater than that of mortar using Quarry Dust. This can be attributed to the lower hydration rate of lime based mortar.

VI. CONCLUSION

From the present study, we have seen that there are several alternatives for complete replacement of sand as fine aggregate in mortar. With advancements in technology, we have to adapt to eco-friendly alternatives rather than relying on conventional methods that have been exploiting our environment from decades. Any advancement in the field of civil engineering should be towards exploring new innovative methods that conserve our environment rather than developing techniques that exploit our environment at a faster rate. Cement-Granite Powder mortar and Cement-GBFS mortar have comparatively low compressive strengths. Such mortar can be used for works with low strength requirements.

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