ICACE

2nd International Conference on Advances in Civil Engineering

26-28 December 2014

Conference Proceedings

Edited by:
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ID: SEE 066

STRENGTH EVALUATION OF MORTAR BY INCLUSION OF STONE DUST AS A CEMENT AND SAND REPLACING MATERIAL

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ABSTRACT

Mortar, a matrix of concrete which is a masonry product, composed of binder and fine aggregates. It is an essential associate in any reinforced structural construction. The strength of mortar is a special concern to the engineer because mortar is responsible to give protection in the outer part of the structure as well as at a brick joint in masonry wall system. The lack of mortar strength sometimes throws the whole structure in a great danger. Cement, sand and water are the key parameters of mortar which are dealing with the strength directly. The purpose of this research is to investigate the compressive and tensile strengths of mortar by replacing the cement and sand by stone dust. This research is focused on the comparison between fresh mortar and modified mortar. For sand replacement, the gradation and fineness modulus of stone dusts was kept similar to that of sand. Stone dusts passing by No. 200 sieve was used as cement replacing material. The portion of dusts which was retained on No. 100 sieve was separated to substitute sand and the remaining part of dusts was made finer by abrasion machine. Then the stone dusts were screened again by No. 200 sieve and the dusts passing by No. 200 was used as the cement. The compressive and tensile strengths of modified mortar were investigated by replacing of 20%, 30% and 40% of fine aggregates as well as replacing of 5% of cement by stone dusts. Several numbers of cube and briquette samples were cast with aforementioned proportions to investigate compressive and tensile strengths at 7 days and 28 days of curing. From tested results, it was found that the compressive strength of samples of 30% of sand replacing stone dust with 0% of cement replacing stone dust increases by 12% and 17% at 7 and 28 days while for the tensile strength it was increased by 8.7%. However, the mechanical properties of mortar with stone dusts as replacement of cement shows no satisfactory results.

Keywords: Mortar, Cement, Sand, Compressive Strength, Stone Dust, Replacement

INTRODUCTION

Mortar is a product composed of cement and sand. When water is mixed in with this product, the cement is activated. Whereas concrete can stand alone, mortar is used to hold together bricks, stones or other such hardscape components (Aziz, 1995).

A complete understanding of mortar and its application is huge to accomplish effective execution. When water blended with Portland cement creates pitiless, solid glue that is very unworkable, getting to be hard rapidly. Some Portland cement aids the workability and versatility of the mortar. It likewise gives early quality to the mortar and rates setting. Fine aggregate is basically sand extracted from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5 mm sieve. For concrete sand FM range is 2.3 - 3.1 (Mobasher, 1999).

The main constituents of concrete such as sand, stone and water are mainly natural resources. Sand is the general segment of mortar which provides for its different shade, surface and cohesiveness. Sand must be free of polluting influences, for example, salts, earth or other remote materials. The three key

characteristics of sand are particle shape, gradation and void ratio. Sand is mainly used as inert material to give volume in mortar for economy. It offers requisite surface area for film of cementing material to adhere and spread, prevents shrinkage and cracking of mortar. The strength of mortar or concrete is largely affected by the fine aggregates (Sharmin et al., 2006). Fine aggregate is usually sand from river (Lohani et al., 2012). The main constituents of mortar is sand are mainly natural resources. The presence of very fine materials in excessive quantities influences the performance and properties of fresh and hardened mortar or concrete.

In fresh concrete, the workability, air content and bleeding are reduced depending on the amount and composition of the very fine materials in concrete, the cement content and the grading of the sand (Popovics, 1979 ; Kalcheff, 1977 ; Malhotra, 1985). In the hardened state, the presence of fine materials can be beneficial for low strength concrete but it may have adverse effects on high strength concrete, since the shrinkage of concrete increases (Ahmed, 1989) and its durability is impaired (Popovics, 1979).

Alternative material of sand should be explored to mitigate the increasing demand of sand. A considerable amount of dust is produced at the time of stone crushing. They are often considered as a waste in the locality. Saving of natural resources and environment is the essence of any advancement (M.Veera Reddy, 2010).

Numerous attempts have been done since the ancient time and it is still continued to use the waste materials in construction work. Stone dust, fly ash, silica fume, rice husk etc are the waste materials. Exchange of normal sand by stone dust will assist both solid waste minimization and waste recovery (H.M.A.Mahzuz, 2011). Several researches have been made (A.A.M.Ahmed, 2010; Lohani et al., 2012) to discover a proper way of using the stone dust without affecting the strength of cementitious product.

For Mortar, stone dust is well appropriate to choose it as an alternative of sand. According to Masrur (2010) about 100000 cft of stone dust is generated during stone crushing which is almost equivalent to 1.6 million BDT.

With the rapid growth of contraction industries consumption of construction material is increased. Again with the industrial development waste material generation is occurring in a massive quantity. In this present work the main objective is to determine the acceptability of stone dust as replacing substance of both binding material and fine aggregate in mortar in respect of the normal strength. This study ensures the stone powder as an appropriate alternative of sand (fine aggregate) in concrete manufacturing as a building materials

MATERIALS & SPECIMENS PREPARATION

For this study we have used high strength Portland cement. The physical & chemical properties of cement are tabulated in Table 1.1

Table 1

Portland Cement Properties	
Physical Properties	
Initial Setting Time (minute)	64
Final Setting Time (minute)	121
Specific Surface Area (cm^2/gm)	3907
28 Days Compressive Strength (MPa)	22.06
Chemical Properties	
Calcium Oxide (CaO)	62.25%
Silicon Dioxide (SiO_2)	21%

Aluminium Oxide ($Al_2 O_3$)	5.9%
Sulphur Trioxide (SO_3)	2.4%
Ferric Oxide (Fe_2O_3)	3.4%
Magnesium Oxide (MgO)	1.5%
Sodium Oxide (Na_2O)	0.2%
Potassium Oxide (K_2O)	0.45%
Loss of Ignition	1.1%

- Graded river sand (Sylhet Sand) was used to conduct the tests. The fineness modulus of the sand used was 2.8. Sand samples were washed and dried so that there should not remain any dust particle. They were free from organic chemicals & unwanted clay.
- Stone dusts were processed in two forms, one for the replacement of sand and another for the replacement of cement. For sand replacement the gradation & fineness modulus of stone dust was tried to keep similar to the sand. Stone dust retained at no. 100 sieve was selected for sand replacing stone dust. Stone dust passing by No. 200 sieve was used as cement replacing material. Stone dust was collected from nearby stone crushing plant to have exact quality in field.
- Normal drinking water was used collected from available source.
- The specific surface area of stone dust replaced for cement in mortar sample was 2529 cm^2/gm and for cement was 3907 cm^2/gm. It signifies that the size of dust particle is larger than the cement particle. This scenario also defines the negative impact of using stone dust as replacement of cement.

Mortar Sample Preparation & Curing

Cube & Briquette samples were tested in this research purpose to get some clear idea about both tensile and compressive strength. Mortar materials were mixed according to ASTM C109 standard.

The water cement ratio for mortar without stone dust was 0.41. Water cement ratio for the mortar samples with stone dust was varied from 0.41 to 0.51. Water demand increases with the increase of stone dust content in mortar.

Dimension of the cube mould for compressive strength test was 5.08 cm x 5.08 cm x 5.08 cm. Figure 1 shows the cube casting in molds.

[Fig 1] Cube Mortar Sample Casting

Standard dimension briquette molds were used for preparing briquette specimens for tensile strength test. Seven different sample types were prepared for casting. Three samples were examined replacing sand only. The percentages were 20, 30 & 40. Where one sample was casted as a replacement of

cement at the percentage was 5. Two more samples were also experimented to observe the strength while replacing both cement & sand. The mixture proportions of all specimens are tabulated in Table 2.

The replacement percentage was fixed in a proportion that, we can get some clear specification while for different dosage of stone dust. As from different previous researches it is found that, if cement is replaced with more than 5% stone dust- the strength quality is not noticeably increase. So in this case, replacing the percentage was fixed for 5%.

The cube moulds were tested after 7 & 28 days. Meanwhile, briquette samples were tested after 28 days.

Table 2

Sample Name	Details
M1	0% of Sand Replacing Stone Dust + 0% of Cement Replacing Stone Dust
M2	20% of Sand Replacing Stone Dust + 0% of Cement Replacing Stone Dust
M3	30% of Sand Replacing Stone Dust + 0% of Cement Replacing Stone Dust
M4	40% of Sand Replacing Stone Dust + 0% of Cement Replacing Stone Dust
M5	0% of Sand Replacing Stone Dust + 5% of Cement Replacing Stone Dust
M6	20% of Sand Replacing Stone Dust + 5% of Cement Replacing Stone Dust
M7	40% of Sand Replacing Stone Dust + 5% of Cement Replacing Stone Dust

In case of sample preparation, sand & binder materials were mixed perfectly in dry condition & then according to water binder ratio, weighted amount of water was added to the homogenous mixture. Cement-Sand ratio was taken as 2.5. For both cube & briquette moulds were prepared with mould oil so that the surfaces of the moulds remain free from disturbance. A total of 21 times temping were performed on each cube mortar sample.

Compressive strength test was performed via Universal Testing Machine at a constant loading rate. In Figure 3, the arrangement of sample is shown. The average from two sample of each type was recorded for the compressive strength of each type which was tested at 7 & 28 days.

[Fig 2] Mortar Samples is in Universal Testing Machine

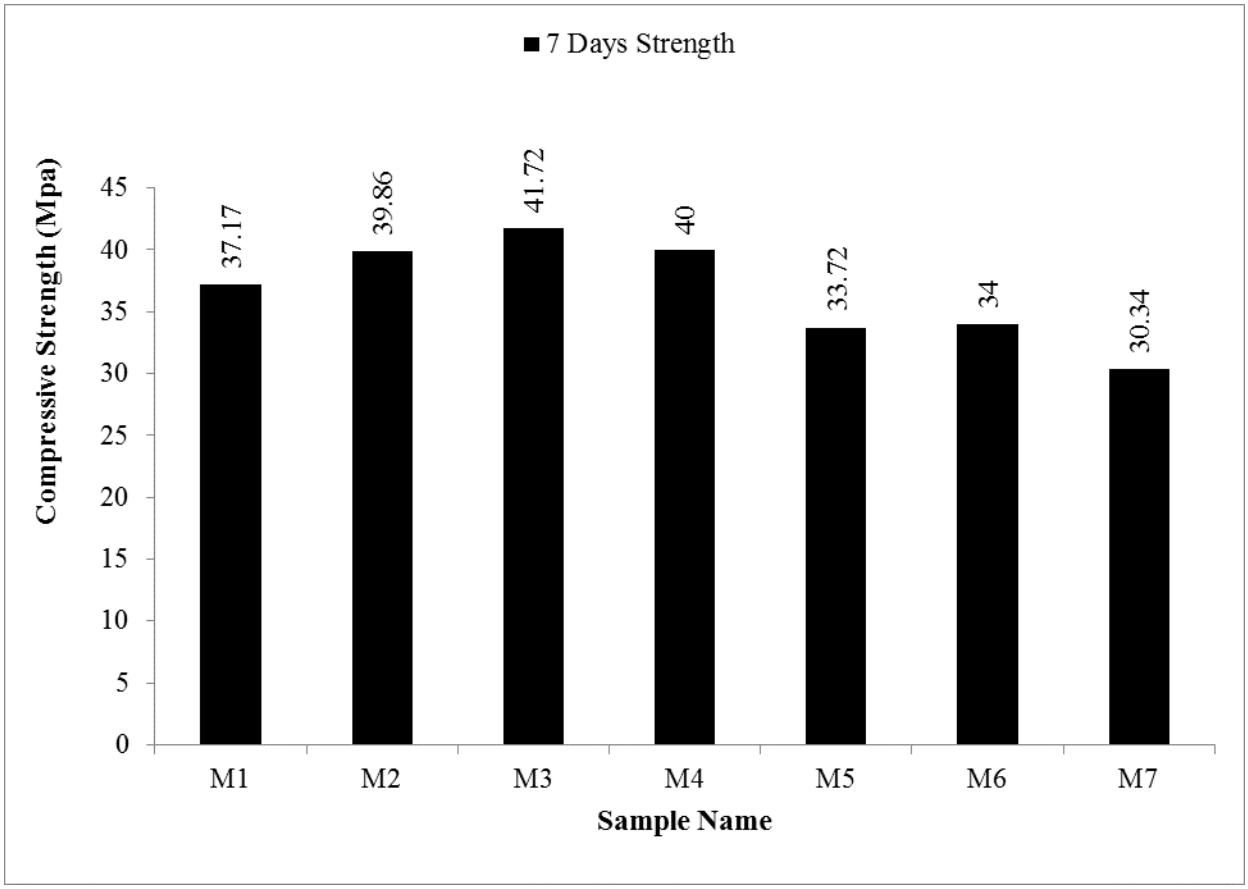
Tensile strength test of briquette sample was also performed with the same mixture of different types & an average of two sample of each type was recorded for the tensile strength.

Underwater curing process was followed in this experiment. The mortar samples were removed from moulds after 24 hours of casting. Then they were kept under water in a bowl and were kept

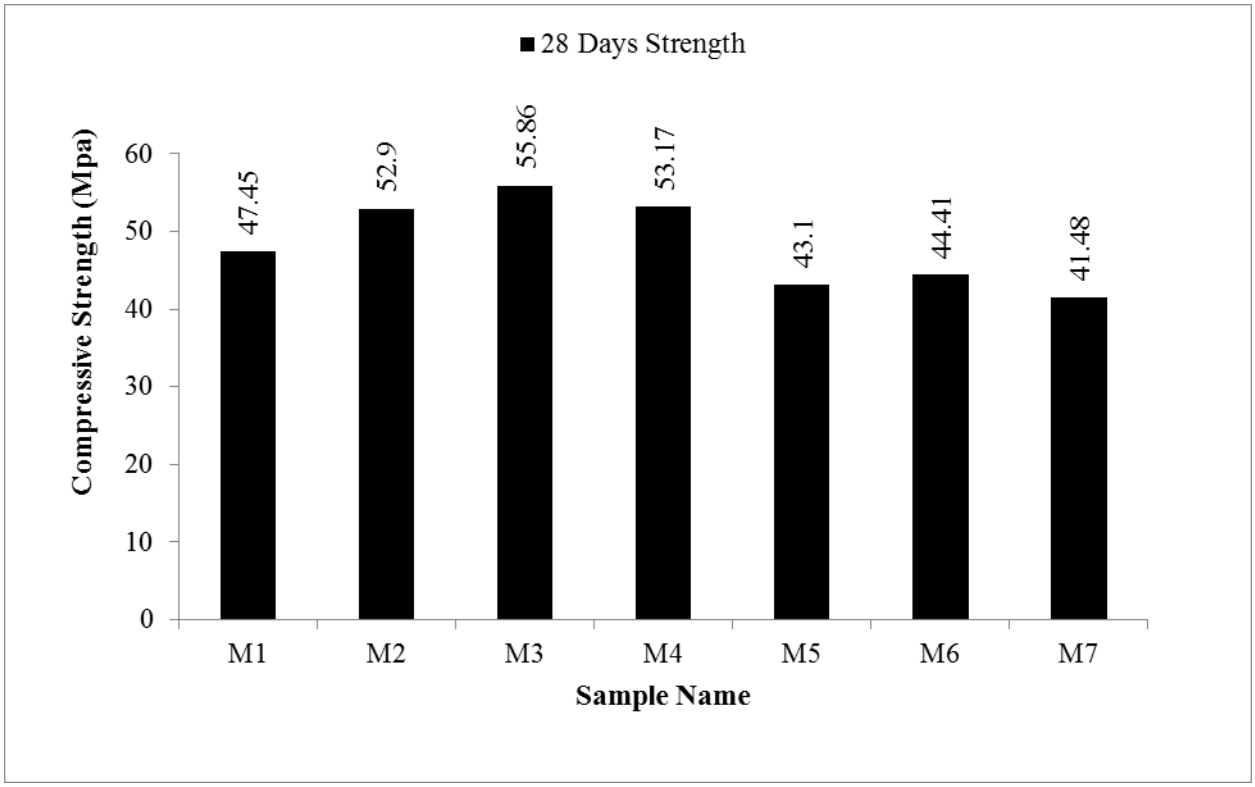
undisturbed before the time of crashing. Just before placing UTM the mortar samples were kept under sun for some period, so that they can overcome the effect of water at its surface.

RESULT & DISCUSSION

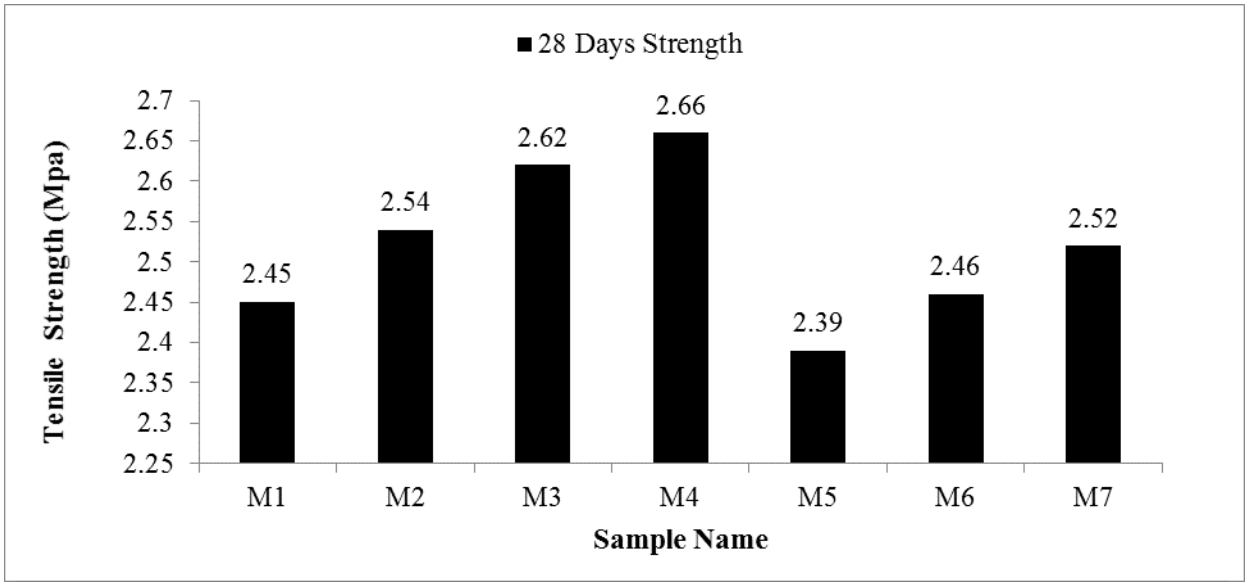
The development of compressive strength at 7 & 28 days are shown in Figure 2 & 3 respectively. The Figures shows that, the highest value of compressive strength for 7 days is 41.72 MPa & for 28 days it is 55.86 MPa. In both cases Mortar Sample M3 gives the highest value. M3 is a mixture of 30% Sand Replacing Stone Dust & 0% Cement Replacing Stone Dust. At 7 & 28 days compressive strength of M3 sample increases around 12% & 17% respectively than the control specimen (M1).
Moreover, M4 (40% of Sand Replacing Stone Dust + 0% of Cement Replacing Stone Dust) gives 2nd highest value (40 MPa for 7 days and 53.17 MPa for 28 days) of compressive strength. At 7 & 28 days compressive strength of M4 sample increases around 7.5% & 12% respectively than M1. But in case of cement replacement there was a decrease in strength compared to control specimen.
As mentioned earlier we took the 28 days tensile strength value for tensile strength determination. From Figure 4, it is shown that, the highest tensile strength value is for 40% sand replacing stone dust (M4). The value is 2.66 MPa and it is around 8.7% increased than control mortar sample M1.



[Fig. 2] 7 days Compressive Strength



[Fig. 3] 28 days Compressive Strength



[Fig. 4] 28 days Tensile Strength

CONCLUSION

According to the analysis of the whole study following conclusion can be drawn,

- We can use stone dust as a replacement of sand in case of mortar preparation which gives some good results in strength.
- Using stone dust as 30% replacement of sand gives the highest strength and after increasing the percentage the strength becomes lower.

- Using stone dust as a replacement of cement is case of mortar preparation cannot give any satisfactory result.
- Stone dust is quite appropriate to be selected as the substitution of fine aggregate but not as the replacement of cement.
- Stone dust has a potential to provide alternative to fine aggregate minimizing waste products. Thus the stone dust will introduced as a functional construction materials.

From this intensive research we can able to know that depending on the percentage of using & type of replacing stone dust may have positive or negative effect on mortar strength. We may use the favorable site of the replacement of stone dust which truly helps to make best use of some waste material and ensure some sustainable development.

ACKNOWLEDGEMENT

The authors wish to thank Dr. G. M. Sadiqul Islam of Chittagong University of Engineering & Technology for his outstanding support throughout the research. Special gratitude to Prof. Dr. Chang-Su Shim and Prof. Dr. Seongcheol Choi of Chung-Ang University for their inspiration and help to conduct this study. Technical support from Chittagong University of Engineering & Technology and Materials support from Engineer A.T.M. Nazir is highly acknowledged.

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