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Non Destructive Investigation on the Effect of Locally Available Manufactured Sands in Concrete

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Abstract: Three fourth of the concrete is made of aggregate. The extensive construction of structures has led to exploitation of the river sand, due to absence of a good alternative in large quantities. Fine aggregate is an integral part of the concrete that influences the properties of concrete to a considerable extent. In this study the effects of aggregate properties of various locally available manufactured sands on the strength properties of the concrete were investigated. The properties of concrete made with different manufactured sand, in comparison with concrete containing river sand showed variations due to the presence of varying aggregates. The properties of aggregates were studied for various locally available manufactured sands. The variation of strength properties of all the mixes was a result of the aggregate properties of concrete. In addition to the mechanical properties the dynamic modulus of elasticity of the concrete mixes was determined based on the UPV values of the concrete, density and poisson's ratio. The dynamic modulus of elasticity and strength properties of the various mixes are compared and their correlation is studied.

Keywords: *Manufactured sand, UPV, Dynamic modulus, fine aggregate, strength*

1. Introduction

Concrete has become the primary construction material at present age. Hence the consumption of concrete is more, which leads to the depletion of the materials from which the concrete is made. Concrete is made of cement, which act as the binder and aggregates which acts as the filler and also contribute to strength. These aggregate constitutes of most volume of the concrete mixture.

River sand has been used as the most prominent fine aggregate in concrete. This has led to depletion of the river sand at an enormous level. The river sand is formed by the continuous erosion of river for centuries, which enhances the properties of river sand to suit it for construction purpose. Since it is non-renewable resource considering the time taken, there comes an immediate need to find an alternative fine aggregate.

Tahir Celik et al(1996) investigated the effect of crushed stone dust in concrete as partial replacement for fine aggregate and strength properties showed increase upto 10% [2]. Ilangovan et al.(2008) carried out study on properties of concrete with 100% replacement of quarry dust and reported the increase in strength with decrease in durability properties [3]. Durability of quarry dust was studied by Gamerio et al.(2013) which were produced from marble quarrying. Their results showed decrease in workability but a good improvement with increase in replacements [4]. Raman et al.(2007) reported on the study of non-destructive properties of concrete containing quarrying dust as the partial replacement of natural mining sand [5].

This paper reports on the study of manufactured sand as a complete replacement of fine aggregate and the variation in some of its properties is investigated. Non-destructive evaluation was performed on the concrete specimens and then compressive strength of the mixes was also determined.

2. Research Significance

From the literature survey carried out, it was evident that the replacement for fine aggregate that were already studied were not feasible because of their availability. Even, alternatives having good performance were used only as a partial replacement and did not show good characteristics in concrete while used as a full replacement for fine aggregate. Non- destructive properties such as an ultrasonic pulse velocity, dynamic modulus of elasticity and quality of concrete were determined and their correlation with the variation of strength of various concrete mixes is examined.

3. Materials

3.1. Cement

Ordinary Portland Cement of Grade 43, conforming to specification provided in IS 8112 – 1989 was used.

Various tests were conducted to determine the properties of cement, which are shown in Table.1.

Table 1: *Properties of Ordinary Portland cement*

Physical test	Results	Specifications of IS 8112-1989
Specific gravity	3.11	-
Consistency	32%	-
Initial setting time	42	30 min
Final setting time	255	600 max

3.2. Aggregates

For a comparative study of behavior of the manufactured sand to standard natural fine aggregate, locally available river sand was used. The properties of river sand(RS) were tested as per IS: 2386 and the grading of the river sand and manufactured sand are shown in Figure 1. The manufactured sand was obtained from two districts of Tamil Nadu, MS1 from Hosur and MS2 from Karur.

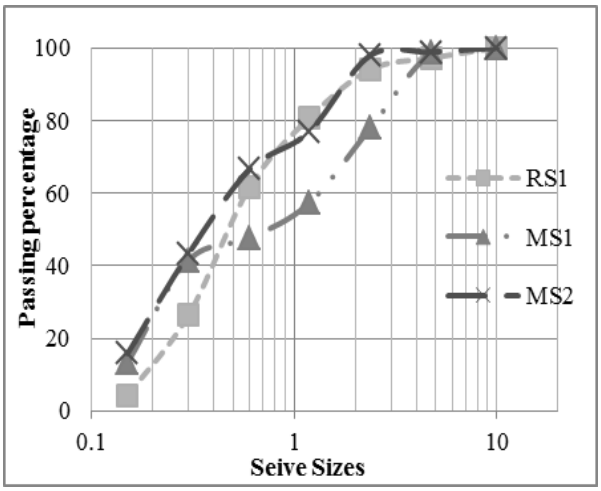

Figure 1 *Grading of fine aggregates*

The manufactured sand is produced from crushing smaller stones obtained from hard rock (granite) mining. The material characteristics of the samples were determined by tests conducted as per IS: 383-1970 and the values are shown in Table.2.

Coarse aggregates of maximum size of 12.5 mm were used and the physical properties were satisfying as per IS: 383-1970. Potable water was used for mixing of concrete.

Table 2: *Properties of fine aggregates*

Type of fine aggregate	Specific Gravity	Fineness Modulus
RS1	2.65	2.35
MS1	2.52	2.63
MS2	2.62	2.01

3.3. Super Plasticizer

Sika Viscocrete 20HE is the water reducing admixture that was used for present study. It is polycarboxylates based, has a density of 1.08 kg/lit and pH value of 4.3.

4. Experimental Investigation

4.1. Mix Proportions

A control mix with river sand as fine aggregate and two other mixes with manufactured sand MS1 and MS2 respectively as fine aggregate were made. Proportion of control mix was made as per Indian Standard Specifications IS: 10262 – 2009, for M40 grade of concrete. The mix was made by weight batching for control as well as other mixes. Detailed mix proportions of control mix M0 and mixes M1 and M2 with replaced fine aggregate are given in Table.3. All the concrete mixes were prepared using drum mixer.

Table 3: *Concrete Mix Proportions*

Mixture No.	Cement	Fine aggregate	Coarse aggregate	Water cement ratio
M0	1	2.118	2.272	0.4
M1	1	2.014	2.272	0.4
M2	1	2.095	2.272	0.4

4.2. Scope of Tests

For compressive strength test of concrete 150 mm concrete cubes were cast. The 150x300mm cylinders were cast for determining modulus of elasticity of the concrete. The concrete was casted and compacted with vibrating table and finished properly. All the specimens casted were demoulded after 24 hours. The type of curing was water curing. Hence the specimens were immersed into a water-curing tank. The compressive strength and the non-destructive evaluation of the concrete were done on the cube specimens at ages of 7, 28 and 56 days. The modulus of elasticity of concrete specimens determined at ages of 28 days using cylinder specimens.

5. Results and Discussion

5.1. Compressive Strength

Compressive strength of concrete mixes made with various aggregates is tested as per IS 516-1959. The results obtained from the tests at ages of 7, 28 and 56 days are illustrated in Figure 2. The compressive strength of all the mixes exceeded the target mean strength for which the mix was designed. The strength obtained by the mixes shows a predominant increase in strength at 7 days and reaches a minimal increase in strength after 28 days of age. The compressive strength of M1 with respect to M0 is less by 7.25%, 5.01% and 3.32% at 7, 28 and 56 days respectively. But the M2 show a marginal improvement in strength of concrete in

comparison with control mix M0. The strength of mix M2 is 9.82%, 9.71% and 7.81% more than mix M0 at 7, 28 and 56 days respectively. This variation is influenced by the variation of fine aggregate in concrete composition which is pretty evident from the Figure 2. The increased fine present in mix M2 improves the density as well as the strength of the concrete. Also the rougher surface of the manufactured sand in comparison with the river sand implies to the possible increase in strength.

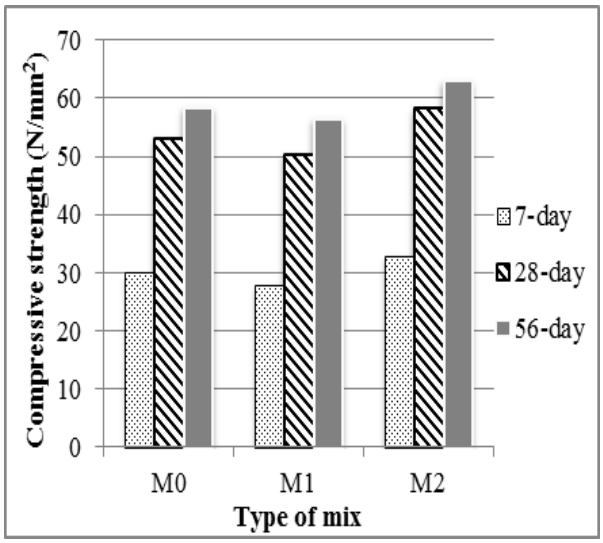

Figure 2.*Compressive strength of the concrete mixes*

5.2. Ultrasonic Pulse Velocity

Ultrasonic pulse velocity is a predominant and a well-established non-destructive evaluation techniques used in hardened for determining the quality of the concrete. The ultrasonic pulse velocity values are influenced by the density and porosity of the concrete. The samples were tested by direct transmission method for all cubes, before they were tested to determine the compressive strength. The results of the ultrasonic pulse velocity of the concrete specimens of all the mixes at 7, 28 and 56 days ages are presented in Figure 3. It is quite obvious from the Figure 3 that the velocities of all mixes are more than 4000km/s, which specifies the quality of concrete as very good. There is a progressive increase in the ultrasonic velocity of concrete with the increase in age. This signifies the increase in quality of concrete with age and the improvement in microstructure of the concrete. This suggests that the cement aggregate matrix keeps increasing with age and thereby reducing the pores, and ultimately improving the velocity with age. The increase in velocity of the mixes after age of 28 days is relatively low in comparison with difference in velocity between 7 and 28 days in mixes M1 and M2, whereas in control mix M0, there is a gradual increase in velocity.

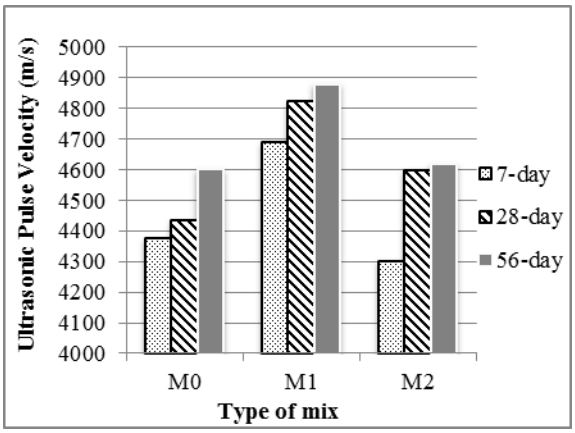

Figure 3.*Ultrasonic pulse velocity of the concrete mixes*

5.3. Dynamic Modulus of Elasticity

The dynamic modulus of elasticity of concrete is the property of the concrete that is can be determined empirically based on the velocity of the pulse, elastic constants such as poisson's ratio and density of the material based on the wave propagation theory [4]. The result of the dynamic modulus of elasticity of concrete is shown in Figure 4 and it is determined from the following empirical equation (a).

$$E = \frac{V_p^2 \rho(1+\mu)/(1-2\mu)}{(1-\mu)} \qquad \text{(a)}$$

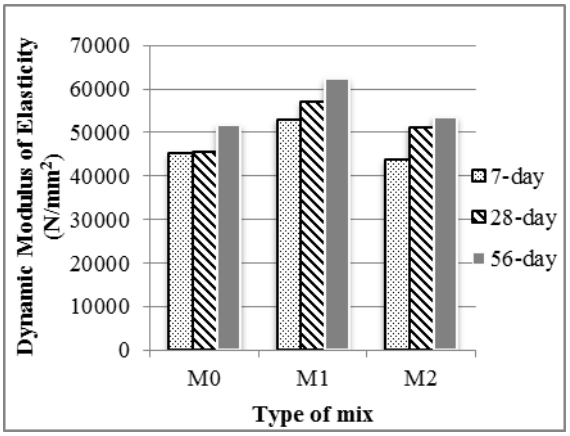

Figure 4 *Dynamic Modulus of elasticity of the concrete mixes*

The dynamic modulus of elasticity of mixes M1 and M2 is higher than that of the control mix, except for the 7 days result of mix M2. The increase in manufactured sand is due to the more fines content present in them and their packing of cement aggregate matrix. The surface of the manufactured sand is rougher than river sand and hence offers more rigid interface and thereby increasing the density of concrete. Figure 5 and Figure 6 shows the variation of dynamic modulus of elasticity

with compressive strength and ultrasonic pulse velocity with compressive strength of concrete respectively.

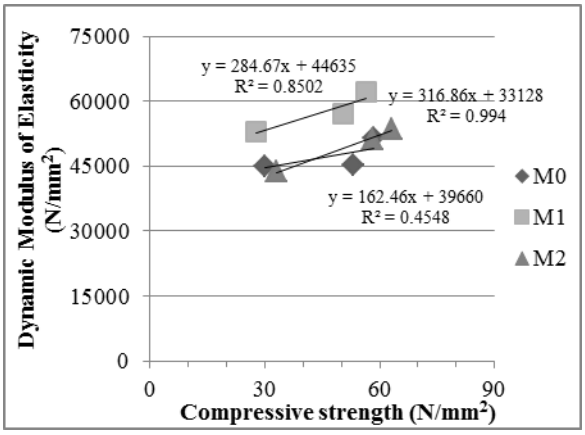

Figure 5 *Variation in Dynamic modulus of elasticity with compressive strength*

The modulus of elasticity of mix M1 shows good results in comparison with the other mixes. The results are matched with trendlines and mix M2 show a good conformation with 'R' of 0.994, followed by the mix M1 with 'R' value of 0.8502.

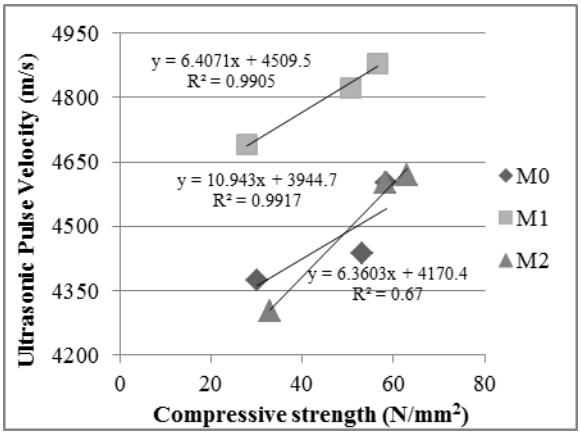

Figure 6 *Variation in Ultrasonic pulse velocity with compressive strength*

The ultrasonic pulse velocity results are well matching with the trendlines for mixes M1 and M2 having 'R' values of 0.9917 and 0.9905 respectively. Mix M0 is not in conformation with this curve. This nonlinear behaviour of mix M0 is because of the gradual increase in strength of the concrete. From Figure 5 and Figure 6 separate trendlines were obtained for each individual mixes for the dynamic modulus of elasticity and ultrasonic pulse velocity test based on compressive strength of concrete.

6. Conclusion

The use of manufactured sand as a fine aggregate alternative and its effect on few properties of the concrete was discussed in this study. The following are the conclusions arrived from the present investigation.

- The compressive strength of the mixes with manufactured sand showed good improvement in strength with ages. The variation in strength of mixes is owing to the replaced fine aggregate properties. The small variation in strength is because of the similarities in the properties of the fine aggregates used.
- The ultrasonic pulse velocity results shows that the complete replacement of fine aggregate with manufactured sand did not hamper the quality of the concrete. Also mix M2 show excellent quality of the concrete. The improved quality is supposedly due to the presence of more fines content in the manufactured sand.
- Dynamic modulus of elasticity of the concrete with various mixes showed the behaviour of the concrete and gave an outlook on the possible development of the microstructure of the concrete.

Correlation among the compressive strength, ultrasonic pulse velocity and the dynamic modulus of elasticity of the concrete was studied. The correlations of the mixes were not able to be generalized but they were normalized based on the mixes. The non-homogeneity of the concrete and the unpredictable microstructural characteristics are the prime reason for the variation in the trendlines of the corellations between the properties of the concrete. From the following studies, it was concluded that manufactured sand is a sustainable alternative for river sand in concrete.

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