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Full Length Research Paper

Use of stone powder in concrete and mortar as an alternative of sand

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Stone powder produced from stone crushing zones appears as a problem for effective disposal. Sand is a common fine aggregate used in construction work as a fine aggregate. In this study, the main concern is to find an alternative of sand. Substitution of normal sand by stone powder will serve both solid waste minimization and waste recovery. The study focuses to determine the relative performance of concrete by using powder sand. From laboratory experiments, it was revealed that concrete made of stone powder and stone chip gained about 15% higher strength than that of the concrete made of normal sand and brick chip. Concrete of stone powder and brick chip gained about 10% higher strength than that of the concrete normal sand and stone chip concrete. The highest compressive strength of mortar found from stone powder which is 33.02 Mpa, shows that better mortar can be prepared by the stone powder. The compressive strength of concrete from stone powder shows 14.76% higher value than that of the concrete made of normal sand. On the other hand, concrete from brick chip and stone powder produce higher compressive value from that of brick chip and normal sand concrete.

Key words: Stone powder, concrete, mortar, concrete, compressive strength.

INTRODUCTION

Plain concrete is made by mixing cement, fine aggregate, coarse aggregate, water and admixture (Wang and Salmon, 1998). The economy, efficiency, durability, moldability and rigidity of reinforced concrete make it an attractive material for a wide range of structural applications (Ferguson et al., 1988). Fine aggregate is one of the important constituents that effects the strength of concrete (Sharmin et al., 2006). The gaps of coarse aggregate are filled by the fine aggregate and the gapes of fine aggregate is filled by the binding materials (Aziz, 1995). According to the compressive strength, concrete can be classified as follows: concrete having cube compressive strength at 28 days up to 15 Mpa is low grade concrete, between 16 to 50 Mpa is medium grade, between 51 to 100 Mpa is high grade and beyond 100 Mpa is ultra high strength concrete (Kishore, 1995). In addition the strength of concrete mainly depends on amount of water used, aggregate gradation, and aggregate size and shape, cement quality, mixing time, mixing ratios, curing etc (Kabir, 2006). Concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete (Chamberlain, 1995). However, increase in strength will be observed if angular aggregate is used in concrete than crushed aggregate, keeping ratio of water to cement (w/c ratio) and slump constant with the use of admixture (Ahmed, 1996). 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. They are not produced in laboratory or in any industry; they are obtained from the nature and processed to make it perfect for aggregate. For example, sand is carried by river water and then collected, and stones are obtained by crushing of bolder using stone

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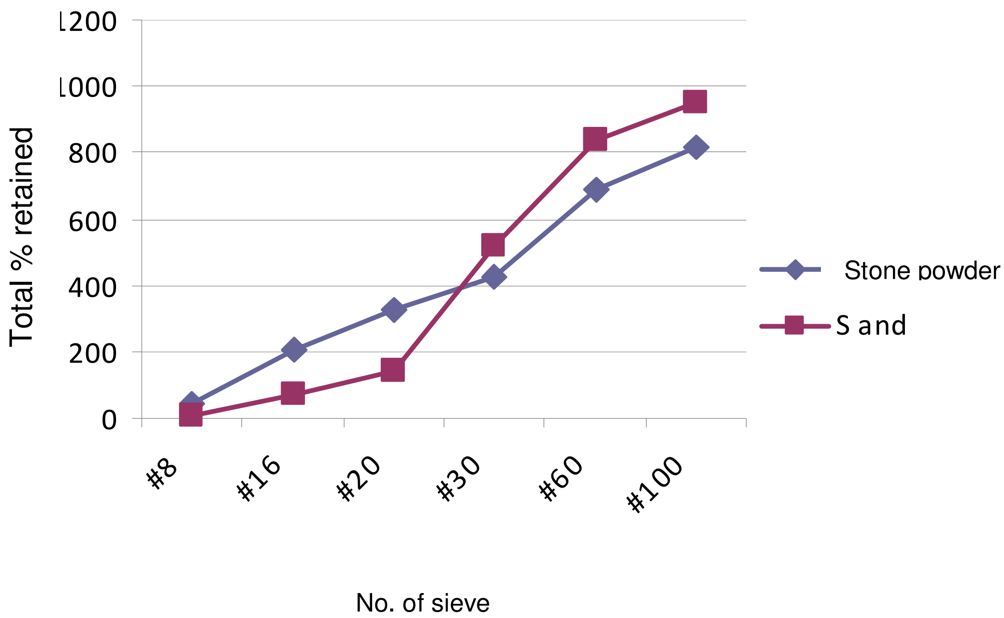

Figure 1. Sieve analysis of sand and stone powder used in laboratory experiment.

crusher. These resources of engineering materials (sand, stone) are limited and day by day the dependency on them must be minimized. So some other materials should be introduced by replacing sand and stone. Stone dust is one of such alternative of sand that can fulfill the demand of fine aggregate.

Jaflong is a tourist spot in the division of sylhet, Bangladesh (Islam et al., 2010). It is famous for its stone collections and for the location of the Khasi tribe (CIPMI, 2007). It lies sixty kilometers to the northeast of sylhet (The Star, 2009). It is widely recognized tourism spot that can play a very important role in the economy of a developing country like Bangladesh. The beauty of Jaflong is going to be destroyed day by day due to unplanned activities (Mahzuz and Tajmunnahar, 2010). Extraction of stone from river has put potential impacts on Spanish population (Isabelle et al., 1999). And same effect has been seen over the population of Jaflong. It can affect the existing condition of physical, chemical and biological process (Stones et al., 1985). In Jaflong a huge numbers of stone crushers are available, as a result of these extensively labor oriented economic activities, a large number of low income workers live in Jaflong and its surrounding. A huge amount of dust produced during stone crushing. They are often considered as a waste in the locality. They are not given any interest and thrown here and there (Ahmed and Yusuf, 2009). While landfills are commonly used for disposal of stone dust in Bangladesh, rapid urbanization has made it increasingly difficult to find suitable landfill sites (Lin and Weng, 2001). Several attempts are seen in different researchers' activity (Mahzuz et al., 2009; Sanchez et al., 2002; Shih and Lin, 2003; Kameswari et al., 2001) to find out proper utilization and disposal of waste. Another research conducted (Villalobos, 2005) on evaluation, testing and comparison between crushed manufactured sand and natural sand focuses the physical characteristics and properties (moisture content, FM, Bulk specific gravity, absorption capacity, bulk density, percentage of voids and particle shape) of natural sands (ns) and manufactured sands (ms). But the main objective of the study is to evaluate relative performance of the concrete made by normal sand and stone dust where the coarse aggregate is crushed stone, in the same way the test is performed using Brick khoa as a coarse aggregate. This study ensures the stone powder or as an appropriate alternative of sand (fine aggregate) in concrete manufacturing as a building materials. As a low cost coarse aggregate Brick chip is considered to ensure the acceptance and adequacy in construction purposes.

METHODOLOGY

In order to establish the stone powder produced during stone crushing as an alternative of normal sand a lots of laboratory test are conducted and compared with the same obtained result from the normal sand concrete. For these purposes the compressive strength of mortar (2" x 2") and concrete (6" x 6") (for 3, 7 and 28 days) is tested as per British standard. 3 samples were prepared for every single test. Therefore 9 specimens were made for one mix ratio. The concrete and mortar block were made by a standard method with proper curing and tempering. The blocks are then tested by compression testing machine. As the study focuses on the adequacy of fine aggregate and hence the fineness modulus (Figure 1) of stone powder and sand was calculated and rest of

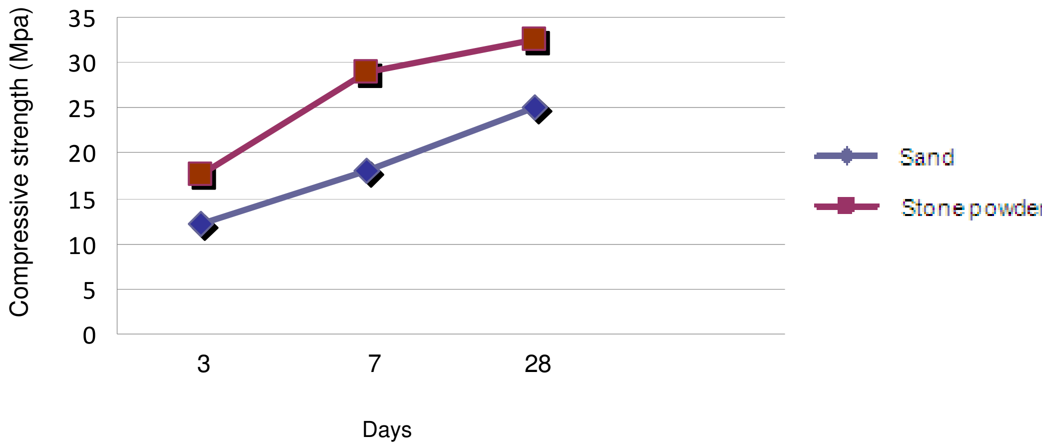

Figure 2. Compressive strength vs duration for mortar of 1:2.75.

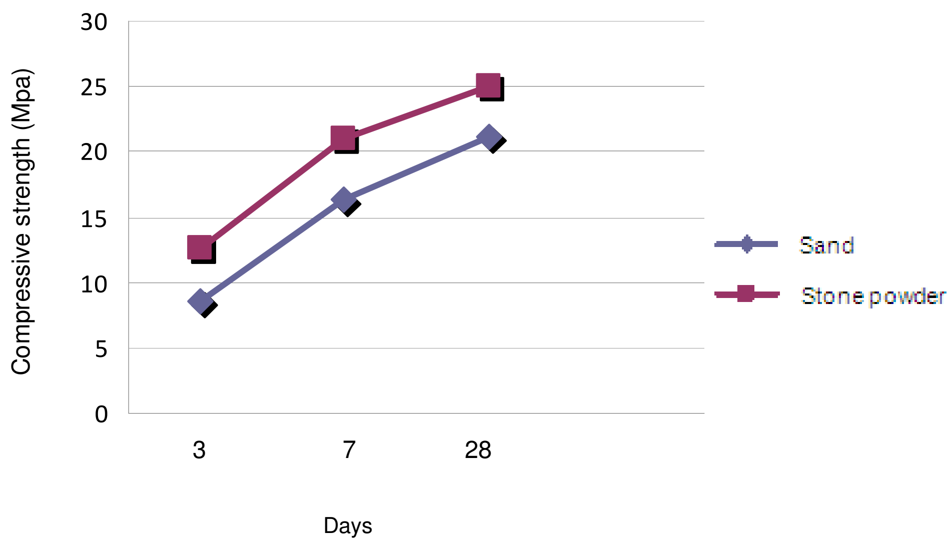

Figure 3. Compressive strength vs duration for mortar of 1:3.

sample remained constant. The obtained result is analyzed and then discussion is prepared depending on the result obtained.

RESULT AND DISCUSSION

This study shows that the compressive strength both for mortar and concrete using stone powder gives impressive result than that of normal sand for the ratio of 1:2.75, 1:3 and 1:3.5. Figure 2 shows that for the ratio of 1:2.75, for 3 days the compressive strength of mortar (2" x 2") sand is 12.17 Mpa and of stone powder are 17.51 Mpa. For 7 days it is increased by 37.64% from sand to stone powder (17.96 to 28.8 Mpa). The highest value of compressive strength of mortar is tasted for stone powder is 32.45 Mpa for 28 days whereas mortar made by sand shows a value of 24.98 which is 23.02% smaller than the value of stone powder. Figure 3 shows the compressive strength of mortars of 1:3 and it is evident that for 3 days the compressive strength of stone powder is increased by 32.85% from normal sand. The compressive strength of sand for 7 days is 16.25 Mpa which is 22.84% smaller value of stone powdered mortar compressive strength. For 28 days mortar shows the highest value for this ratio and stone powder is increased by 18.2% from normal sand value. Figure 4 shows the compressive strength of mortar sand is 7.95 Mpa for 3 days whereas 10.38 Mpa has been tasted for stone powder. For 7 days it is 13.38 and 18.9 Mpa for normal sand and stone powder accordingly. Finally for 28 days 20.52% of compressive strength is increased from normal sand to stone powdered mortar. Figure 5 shows that for the ratio of

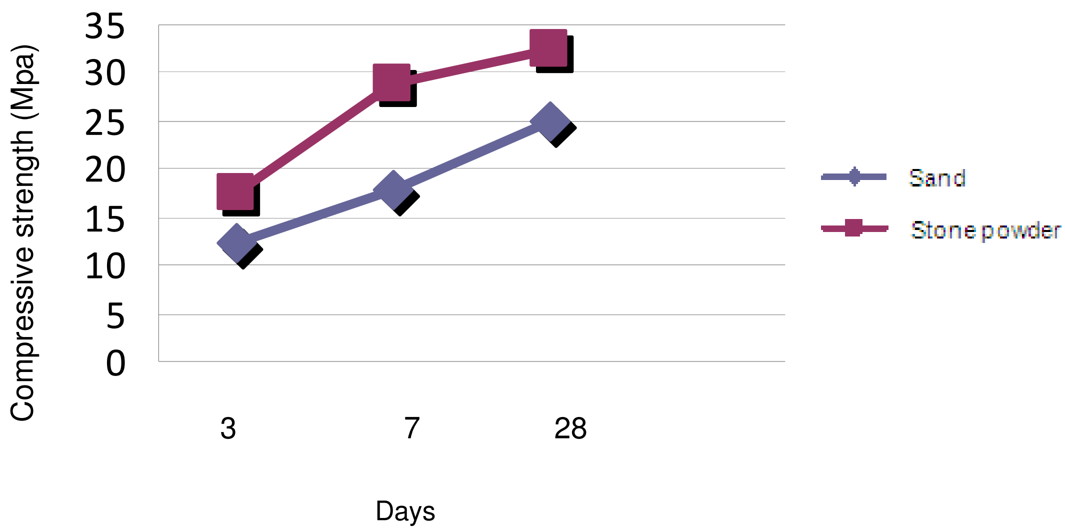

Figure 4. Compressive strength vs duration for mortar of 1:3.5.

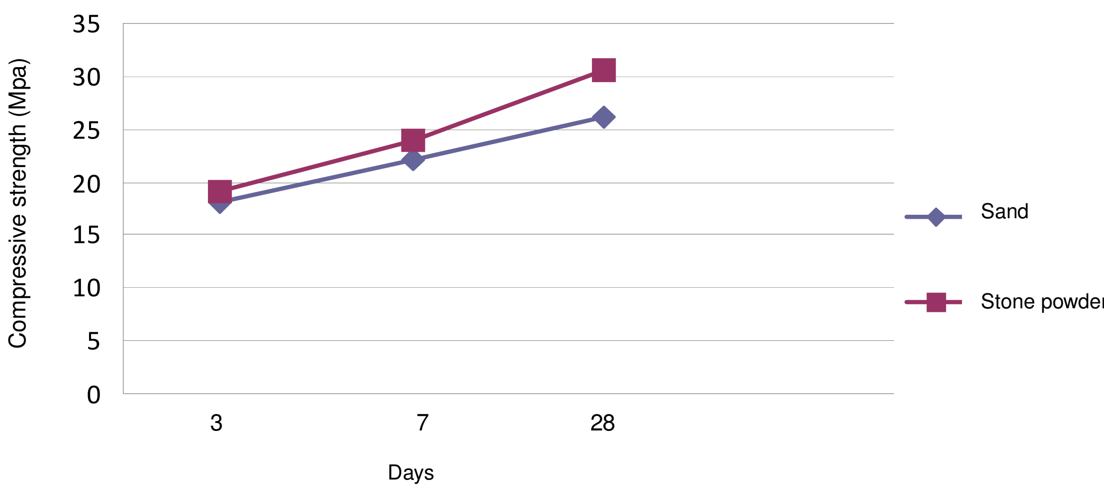

Figure 5. Compressive strength vs duration for concrete (crushed stone) of 1:1.5:3.

1:1.5:3 compressive strength of concrete by stone chip with normal sand and stone powder is quite close for 3 days which is 4.62% increased value from normal sand to stone powdered concrete. For 7 days the compressive strength of sand concrete is 22.21 Mpa whereas for stone powder it is 23.97 which is 7.34% higher value from normal sand concrete. For 28 days compressive strength of stone powdered concrete is 14.76% higher than the compressive strength of normal sand concrete. Figure 6 shows a close value for compressive strength of concrete for the duration of 3 and 28 days for the ratio of 1:2:4. For 3 days the value is 15.26 and 16.01 Mpa for sand and stone powder respectively and for 28 days it is 21.11 and 22.01 Mpa accordingly. For 7 days the compressive strength value of normal sand is 16.78 Mpa where as stone powder shows 19.87% higher value. Figure 7 shows that using 1:2.5:5 mix ratios in concrete, compressive strength for 3 days for normal sand is 12.025 Mpa and for stone powder the compressive strength is 14.21 Mpa. For 7 days it is increased by 16.63% from sand to stone powder (14.04 to 16.84 Mpa). The highest value of compressive strength of concrete is tasted for stone powder is 21.16 Mpa for 28 days whereas concrete made by sand shows a value of 18.95 which is 10.44% smaller than the value of stone powder. Figure 8 shows that the compressive strength of normal sand and powder sand of brick chip is quite close for 3 days. For 7 days the compressive strength of normal sand concrete by brick chip is 15.8Mpa whereas for stone powder it is 17.23 which is 8.3% higher value from normal sand concrete. For 28 days compressive strength of stone powdered concrete is 13.74% higher than the

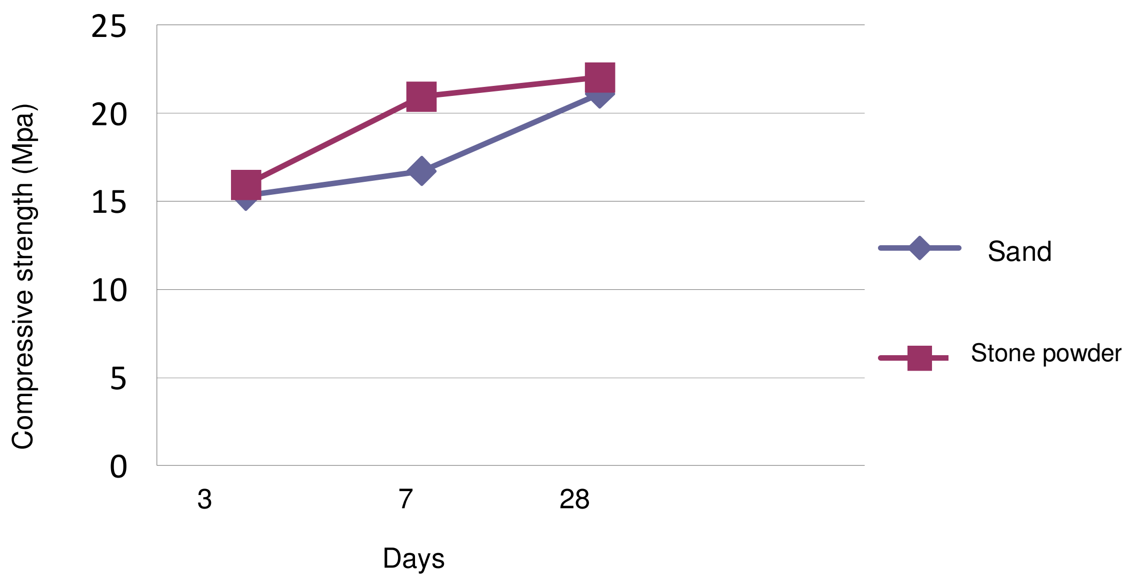

Figure 6. Compressive strength vs duration for concrete (crushed stone) 1:2:4.

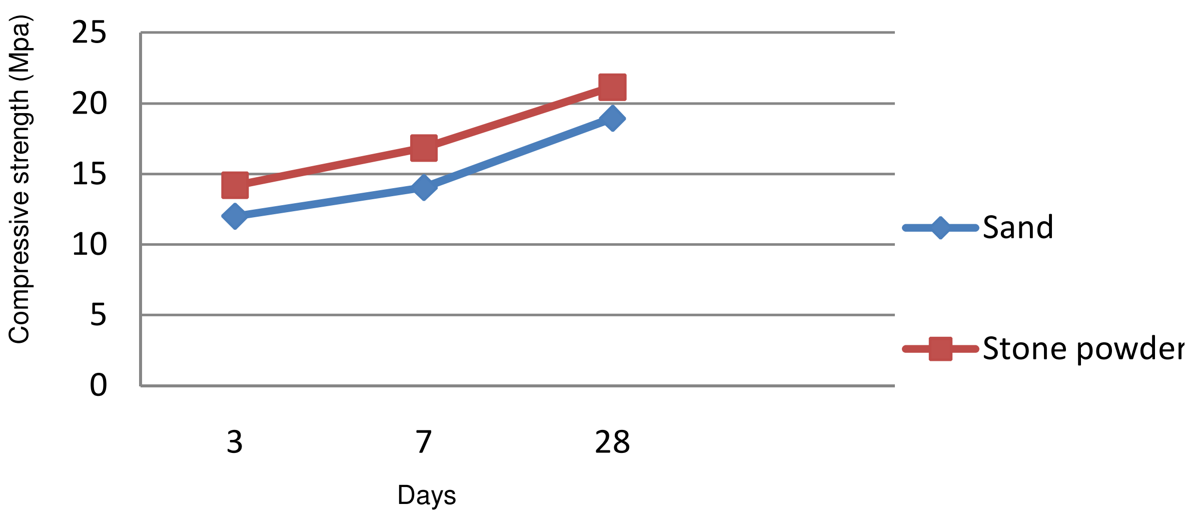

Figure 7. Compressive strength vs duration for concrete (crushed stone) 1:2.5:5.

compressive strength of normal sand concrete. Figure 9 shows a smooth increasing of the compressive strength of concrete of normal sand to stone powder. For 3 days the value is 11.82 and 13.13 Mpa for sand and stone powder respectively and for 28 days it is 19.33 and 21.94 Mpa accordingly. For 7 days the compressive strength value of normal sand is 15.25 Mpa where as powder sand shows 9.06% higher value. Figure 10 shows that for 3 days the compressive strength of concrete of normal sand is 9.63 Mpa and of stone powder are 9.5 Mpa which are very close value. For 7 days it is increased by 8.32% from sand to stone powder (12.89 to 14.06 Mpa). The highest value of compressive strength of concrete is tasted for stone powder is 19.05 Mpa for 28 days whereas concrete made by sand shows a value of 17.96 which is 5.72% smaller than the value of stone powder.

Conclusion

This study focuses the relative performance of concrete by normal sand and crushed stone and concrete by stone powder and stone chip. Same performance was evaluated using brick chip instead of stone chip. From the laboratory study, it can be concluded that stone powder is well appropriate for medium graded concrete for better

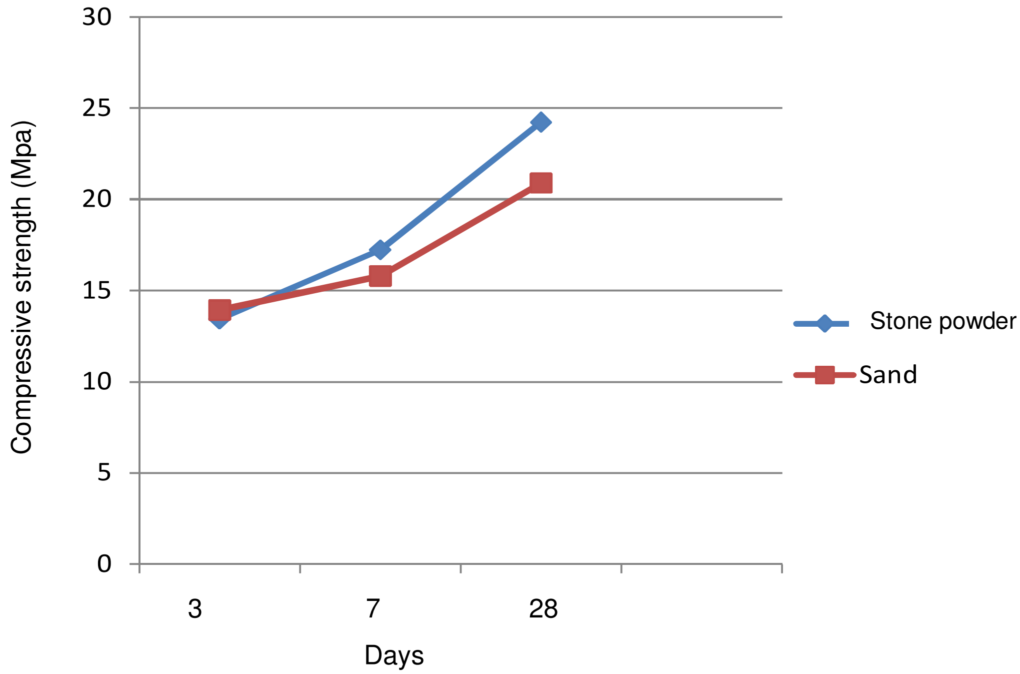

Figure 8. Compressive strength vs duration for concrete (brick chip) of 1:1.5:3.

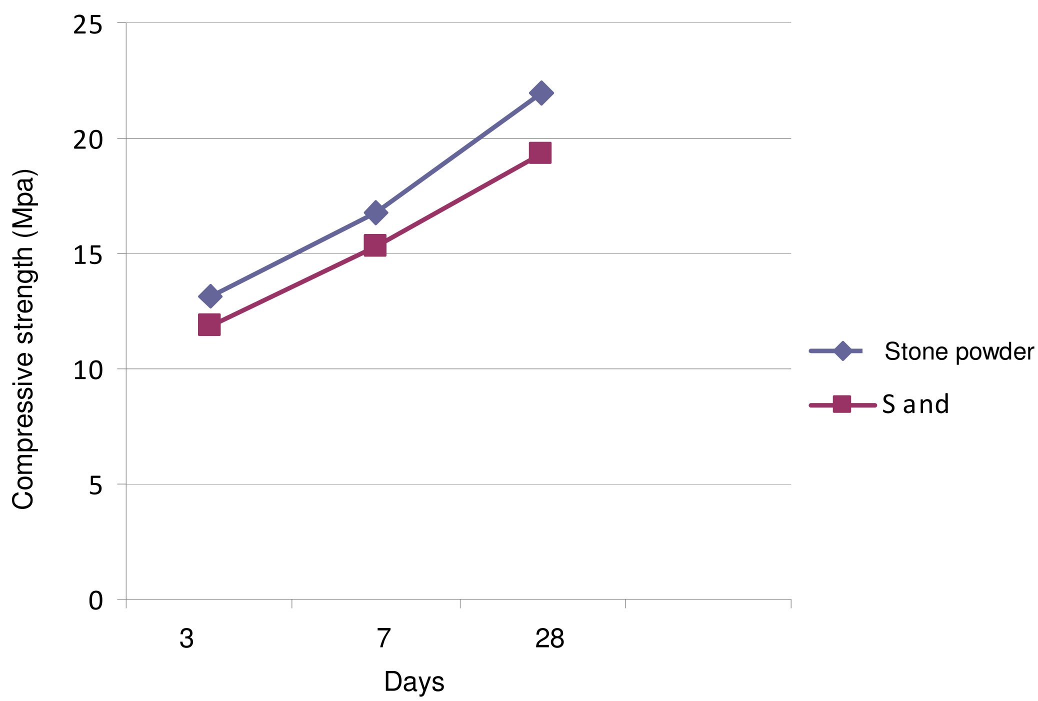

Figure 9. Compressive strength Vs. duration for concrete (brick Chip) of 1:2:4.

performance in terms of strength and economy over normal sand. Because for all the ratios of concrete using stone powder gives 14.76, 4 and 10.44%, increased value of compressive strength for the ratios of 1:1.5:3, 1:2:4 and 1:2.5:5 respectively from that of normal sand. Similarly for brick chip in all the ratios concrete give

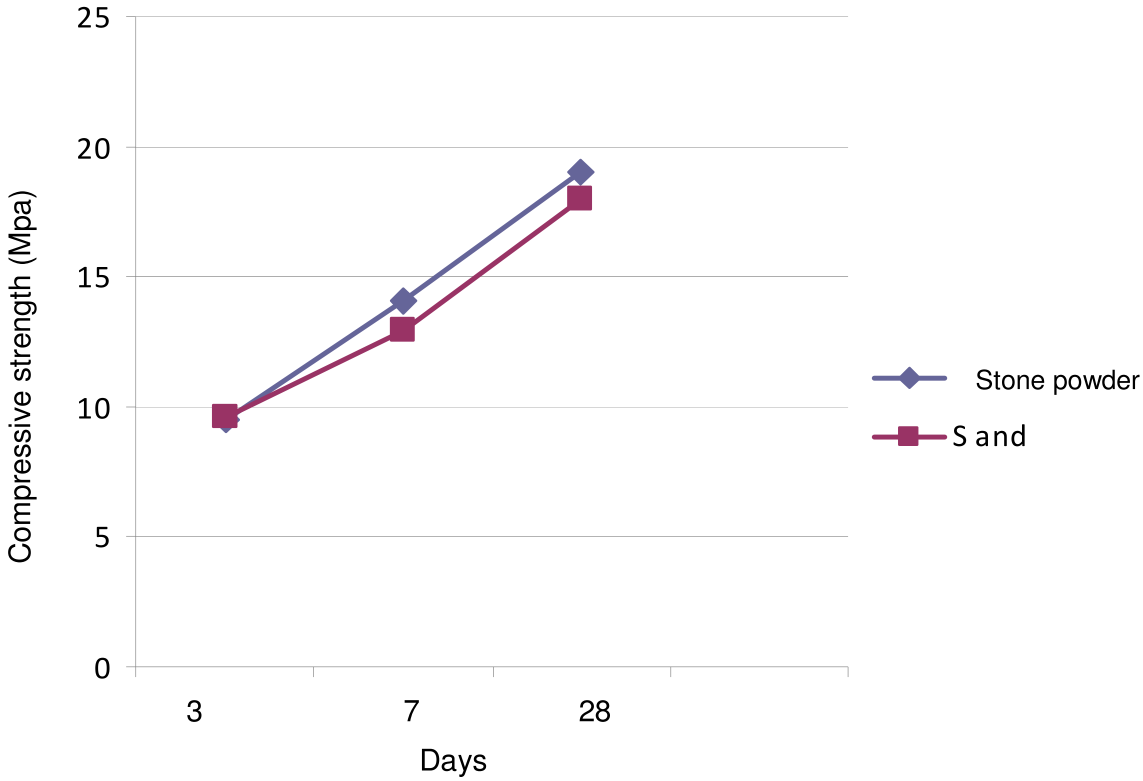

Figure 10. Compressive strength vs duration for concrete (brick chip) of 1:2.5:5.

higher compressive strength but less value than the stone chip concrete. For mortar, stone powder is well appropriate to choose it as an alternative of sand. The availability of the stone powder is limited and its price is not defined. If the stone powder can have a price value, it is not difficult to market it and use it as an alternative of sand. It is also seen from the study that the compressive strength of concrete made of brick chips is low comparing with that of the concrete made of stone chip. This may be due to low quality brick chip, weak workmanship, and wrong proportions of mixing. But as brick chip is economical and available so normally for the low strength structures it can be used.

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