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***Review Article***

# Superior Performance of Eco-Sand in Constructions

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## Abstract

Concrete is generally known as a composite construction material produced primarily using aggregate, cement and water. The aggregate is coarse gravel or crushed rocks such as limestone or granite along with the fine aggregate such as sand. Sand mining causes adverse effects to natural environment and ground water table. Manufacture of cement also causes environmental problems such as introduction of large amount of carbon dioxide (a major contributor for greenhouse effect causes global warming) into the atmosphere and disposal of by-products. To minimize these concerns, it is great to use the by-product of fine aggregates called eco-sand as a cost effective, eco-friendly and innovative material. It is very fine particles obtained as a by-product during the manufacture of cement. It differs from natural sand in terms of certain characteristics such as gradation, particle shape and texture. These characteristics have some influence namely cement requirements, water requirements, additive requirements, workability and finishing of the concrete. This material completely passes through 4.75 mm sieve and not in 150 mm sieve. Present study includes the workability and compressive strength of M25 grade concrete for water and cement ratio of 0.45 (without admixture) and 0.43 (with admixture). This study is also well explained about the superior performance of concrete when river water is replaced by eco- sand with the ratio of 0, 10, 20, 30, 40, 50, and 60. The presence of fines in eco-sand increases the workability and gives more strength to the concrete. The non-absorbing nature and smooth surface texture of eco-sand reduce water requirement during constructions. The cost is reduced by 22 percentages when compared to the use of conventional concrete. The best performance shows at the percentage of 40 with 0.8 liter of admixture.

Keywords: Eco-sand; Fine aggregates; Natural sand replacement; Conventional concrete insert

## Introduction

At the present time, construction activities are taking place on huge scale all over the world. Due to this there is great increase in cost of construction. Natural river sand is one of the key ingredients for making concrete, and it is expensive due to excessive cost of transportation from the source to construction site and also large- scale depletion of sources creates environmental problems [1-2]. Unfortunately, production of cement also involves large amount of carbon dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming [3]. To overcome these problems there is a need of cost effective, alternative and innovative materials. Eco sand is very fine particles, a by-product from cement manufacture which can be used to increase the efficiency of concrete [4]. Its micro-filling effect reduces pores in concrete and provides better moisture resistivity and thus durability. It has more consistent grading than many extracted aggregates. The use of eco- sand rather than extracted or dredged natural sand will help designers and contractors address issues of sustainability. The eco - sand has various advantages such as energy

efficient, fire resistant, reduction of dead load, environmentally friendly, durable, light weight, and low maintenance low construction cost [5-8]. It is completely passes through 4.75 mm sieve and retains on 150 mm sieve. Composition of various constituents present both in natural sand and

Table1. Composition of Various Constituents in Natural and Eco sand

| Sl. No. | Constituents | Composition (%) | |
|---|---|---|---|
| | | Natural Sand | Eco-sand |
| 1 | $SiO_2$ | 80.78 | 68.1 |
| 2 | $Al_2O_3$ | 10.52 | 10.7 |
| 3 | $Fe_2O_3$ | 1.75 | 1.7 |
| 4 | CaO | 3.21 | 2.2 |
| 5 | MgO | 0.77 | 0.5 |
| 6 | $Na_2O$ | 1.37 | 0.6 |
| 7 | $K_2O$ | 1.23 | 4.3 |
| 8 | Loss of ignition | 0.37 | 11.5 |

## Methods and Materials

### Collection of Materials

The Ordinary Portland Cement (OPC) of 53 Grade is used for the production of the concrete. Aggregate comprises about 55% of the volume of mortar and about 85% volume of mass concrete. Mortar contains of size of 4.75 mm and concrete contains aggregate up to a maximum size of 150 mm. Eco - sand, an economic and eco-friendly durability improver and is a good sand substitute for this project and it is obtained from Madukkarai cement works (ACC Pvt. Ltd).

### Fine Aggregate (Rriver Sand) and Eco-sand

The fine aggregate used in this study is natural river sand and it has fineness modulus of 2.65. The specific gravity and unit weight is found to be 2.71 and 1651 kg/m$^3$ respectively. The sieve analysis revealed that the fine aggregate falls in the zone of IS 383:1972. The fine aggregate (Eco-sand) has fineness modulus of 2.64. The specific gravity and unit weight is found to be 2.3 and 958 kg/m$^3$ respectively [9-10].

### Concrete Mix Proportioning

The concrete mix proportioning for the different water cement ratio and percentage of replacement of river sand by manufactured sand is done as per IS 10262-2009.

### Mould Preparation and Casting Of Cubes

The cubes are prepared for 150 × 150 × 150 mm size in the pre oiled mould. Each group consists of water cement ratio 0.45, with partial replacement of river sand by eco sand at 7, 14 and 28 days curing period. All the specimens were remoulded after 24 hours and cured in water. The specimens were dried in air for one day before testing. As per IS 383-1970, Clause 4.3: The grading of fine aggregates was determined as described in IS: 2386 (Part 1)-1963 and falls within the limits. For crushed stone stands, the permissible limit on 150 micron of IS sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted clause 4.3 of IS 383-1970 [11-13].

### Compressive and Tensile Strength Procedure

The specimens are tested by compression testing machine after 7, 14 and 28 days curing. Load was applied gradually at the rate of 140 kg/cm2 per minute till the specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. Average splitting tensile strength tests were carried out according to the ASTM C 496 standard. After the specified curing period was over (7, 14 and 28 days), the concrete cubes were subjected to splitting tensile test by using universal testing machine. The tests were carried out triplicately to confirm the repeated values are same.

## Results and Discussion

### Compressive Strength and Splitting Tensile Strength of Concrete Cubes

Compressive strength is used to characterize the newly designed concrete cubes. Using this test only judge that whether Concreting has been done properly or not. Compressive strength varies from 15□30 MPa based on the method on the preparation of the concrete cubes. Compressive strength also depends on many factors like water- cement ratio, cement strength, quality of the concrete material and method of control during the production of concrete [14] (Table 2).

Table 2. Compressive and Splitting Tensile Strength of Concrete Cubes

| Sl. No. | % of Eco-sand | Compressive Strength (MPa) | | | | | | Splitting Tensile Strength (MPa) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | With admixtures | | | Without admixtures | | | With admixtures | | | Without admixtures | | |
| | | 7 Days | 14 Days | 28 Days | 7 Days | 14 Days | 28 Days | 7 Days | 14 Days | 28 Days | 7 Days | 14 Days | 28 Days |
| 1 | 0 | 28 | 32 | 42.4 | 16 | 19 | 27.5 | 1.5 | 1.8 | 2.3 | 0.8 | 0.9 | 1.7 |
| 2 | 20 | 41.2 | 44.4 | 50.3 | 18.4 | 20.7 | 30.3 | 2.3 | 2.4 | 2.8 | 0.8 | 1.3 | 1.6 |
| 3 | 30 | 43.7 | 47.0 | 53.2 | 19.4 | 21.4 | 32.8 | 2.4 | 2.5 | 2.9 | 1.1 | 1.3 | 1.8 |
| 4 | 40 | 43.8 | 47.6 | 55.7 | 20.7 | 22.5 | 34.3 | 2.4 | 2.6 | 3.0 | 1.2 | 1.4 | 1.9 |
| 5 | 50 | 30.5 | 34.5 | 48.3 | 17.3 | 19.3 | 26.5 | 1.7 | 1.9 | 2.7 | 0.8 | 0.9 | 1.7 |
| 6 | 60 | 29.1 | 32.7 | 45.7 | 16.5 | 17.5 | 25.7 | 1.6 | 1.8 | 2.4 | 0.8 | 0.8 | 1.6 |

For this study we have tested the compressive strength of newly produced concrete cubes when river sand is partially replaced by eco-sand. The concrete cubes were prepared based on IS 10262-2009 standard, grade of M25 and with admixtures (0.8liter/100 kg of cement) and without admixtures. The curing periods were 7, 14 and 28 days from the preparation of the concrete cubes (Figure 1).

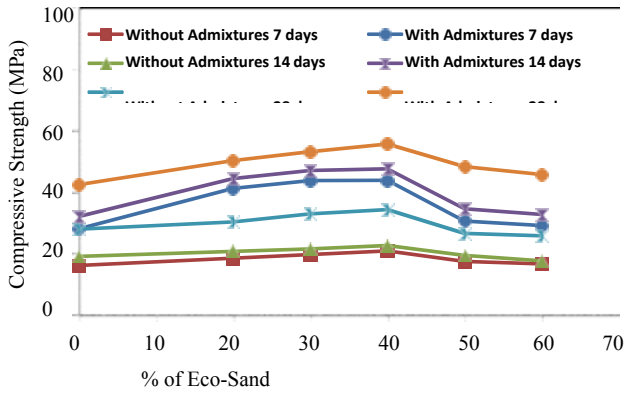



Figure1. Compressive strength of concrete cubes

The test results in show that the compressive strength of concrete by using admixtures has attained maximum level of 43.80 MPa at 7 days, 47.59 at 14 days and 55.70 MPa at 28 days through the eco-sand replacement of 40 percentage. The compressive strength is decreased after reaching the optimum percentage of 40% replacement of eco-sand, this clearly indicates that the replacement of more amount of eco-sand will not be effective for the production of concrete cubes and decreases the workability of concrete (Figure 1). The splitting tensile strength also agrees with the trend of compressive strength of the concrete cubes (Table 2 and Figure 2).

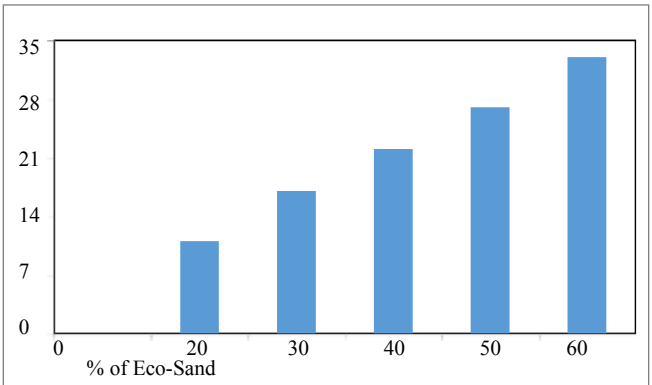



Figure 2. Percentage of Cost Analysis

## Optimum Mix Proportion

The test results show that the maximum compressive strength of M25 grade concrete keeping 0.43 w/c ratio with replacement of 40% were 43.80 MPa at 7 days, 47.59 MPa at 14 days and 55.70 MPa at 28 days. Above the optimum percentage (50-60 %), the replacement of eco-sand will reduce the compressibility and workability of the concrete cubes (Table3).

From this investigations, it is confirmed that upto 40% replacement of natural sand by eco-sand will produce an effective concrete and is almost insignificant beyond 40% [15-16].

Table3. Optimum mix proportion

| Sl. No. | % of Eco- sand Replace-ment | W/C Ratio | Wt. of River sand (Kg/m3) | Wt. of Eco-sand (Kg/m3) | Coarse Aggregate (Kg/m3) |
|---|---|---|---|---|---|
| 1. | 40 | 0.43 | 504.12 | 285.23 | 986 |

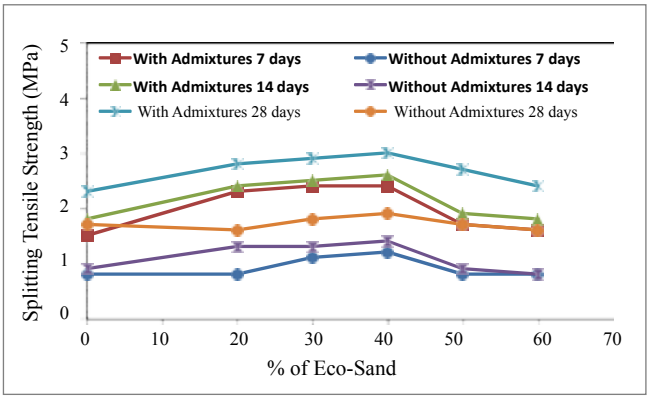
## 5.3 Cost Analysis of River Sand Vs Eco-Sand

The observations also concentrated on the production of 840 kg/m3 of concrete by eco-sand. The cost analysis results from the table 4 shows that the percentage of cost saving is increased when the percentage of eco-sand is increased and usage of river sand decreased (Table 4).

Table 4. Cost analysis of River sand versus Eco-sand

| Sl. No. | Percentage of Re-placement | Cost, Indian Rupees (Rs.) | | Total Cost (Rs.) | Percent-age of Cost Saving |
|---|---|---|---|---|---|
| | | Natural River Sand | Eco-sand | | |
| 1 | 0 | 1092 | - | 1092 | 0 |
| 2 | 20 | 874 | 100 | 974 | 11 |
| 3 | 30 | 765 | 150 | 915 | 17 |
| 4 | 40 | 655 | 200 | 855 | 22 |
| 5 | 50 | 546 | 250 | 796 | 27 |
| 6 | 60 | 437 | 300 | 737 | 33 |

This results will be helpful to contractors when involve in low cost and high strength construction (Figure 3).




## Conclusion

The concept of partial replacement of natural fine aggregate by eco-sand was investigated in this study. The proper management of by-producted eco-sand during the manufacture of cement will reduce the space required storage, reduces the extra cost for disposal of the waste and drastically reduces the effect of environmental pollution at the disposal site. Strength of the concrete is purely dependent on bonding of the fine aggregates which fills the voids of the coarse aggregates. It was found that the compressive strength of concrete is more when natural sand is replaced with eco- sand at the w/c of 0.43. From the experimental study, it is concluded that the eco-sand can be used as a good replacer for fine aggregate. It was found that 40% replacement of natural sand by eco-sand gives maximum result in strength compared to normal concrete. The compressive strength is decreased when the natural sand replaced by 50-60% and also reduces the workability of the concrete. The results proved that replacement of natural sand by eco-sand up to 40% induce higher compressive strength and the workability of concrete. The percentage of cost saving is also increased in the same manner. Finally, the replacement of natural sand by eco-sand gave superior performance in terms of increasing compressive strength, saving cost for the production of concrete and minimizes the environmental degradation significantly.

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