Effect of partial replacement of Eco sand on high performance concrete

Eniyachandramouli Gunasekaran\textsuperscript{1*}, Govindhan Shanmugam\textsuperscript{1}, Ranjith Selvan Karuppusamy\textsuperscript{1}, Vijay Manoharan\textsuperscript{1} and Preetha Vellaichamy\textsuperscript{2}

\textsuperscript{1} Undergraduate Students, Civil Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu, India
\textsuperscript{2} Assistant Professor, Civil Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu, India

Corresponding author’s e-mail address*eniyachandramouli.ce16@bitsathy.ac.in

Abstract. The concrete plays a vibrant role in infrastructural developments. The major dispute of environmental degradation with sources of river sand is been substituted by M sand substantially at faster rate. The efforts to minimize the usage of Portland cement in concrete by other supplementary cementitious materials are also forging to control the environment-related problems. The study involves the behaviour of high performance concrete using partial replacement of cement by silica fume and partial replacement of M sand by Eco sand for M60 grade of concrete. Eco sand is an industrial waste product obtained from the cement industry is utilized as per the gradation analysis to evolve a better waste utilization and management system. The experimental works were conducted to evaluate the mechanical properties of high performance concrete containing cementitious materials of silica fume replaced by cement with 1-5%, M sand replaced by Eco-sand of 15-20%. Super plasticizer also added of about 1% to improve the workability of concrete. The results shows that the compressive strength gradually increased with 25% replacement of Eco sand and the optimal percentage of silica fume replacement identified as 5% by weight. The flexural strength at 28 days shows better for 20% replacement of eco sand than the control mix.

Keywords: High performance, Eco sand, M sand

1. Introduction

High Performance Concrete (HPC) is employed at construction sector for most of the massive structures by utilizing ordinary cementitious materials and admixtures with distinctive blending, setting and better curing practices. The enhanced intention of choosing industrial wastes such as silica fume, blast furnace slag and fly ash to improve the strength and durability characteristics in high performance concrete. The silica content present in these supplementary materials react with the calcium hydroxide during the hydration of cement and forms extra calcium silicate hydrate (C – S – H), which also enhances the strength and the mechanical properties of concrete. To reduce the cement content the silica fume has been partially replaced and the combination of M sand by eco sand plays a major role in strength enhancement. However eco sand a bi-product from cement manufacturing unit can perform as supplementary replacement for fine aggregate with finer particles. Its micro-filling effect condenses the pores in concrete by providing better durability criteria and also ensures moisture...
resistivity. Since, eco sand as the waste products dumped at the cement industry are effectively managed by proper utilization with an optimal percentage limits to reduce cost of concrete. The experimental study involves the comparison of various limiting percentage values to check the compressive strength, tensile strength and flexure strength of concrete at 7, 14 and 28 days respectively using eco sand, silica fume, cement and super plasticizer.

2. Review of Literature

S. Lavanya Prabha et al.,[1] developed a high strength concrete using copper slag as partial replacement for river sand to achieve high strength and durability. Materials involving a trail mix of silica fume, fumed silica and quartz powder for high strength concrete. An alternate slag was identified to replace the river sand. The coarse aggregate is completely avoided resulting in high dense concrete. The studies performed on mechanical properties of concrete and compared the results for compressive strength, split tensile strength and flexural strength as 76.88, 11.24 and 10.13MPa, respectively. P. Magudeaswaran et al.,[2] investigates on green high performance concrete with the materials like silica fume, fly ash, eco sand and coarse aggregates. The experimental studies to evaluate the physical and mechanical properties with the replacement of cement with silica fume of about 7.5-15% and fly ash of about 15-30%. The replacement of sand with eco-sand, along with 1% super plasticizer to improve the workability of concrete. The mechanical properties are evaluated using compressive strength, tensile strength and flexure. Also the durability characteristics were also investigated in terms of alkalinity and water absorption. D. Dharshnadevi et al.,[3] carried out the research on characteristics of eco sand for the replacement of non-availability of river sand with the percentage variation of 5%, 10%, 15%, 20%, 22%, 25%, 27%, 30%, and 35%. The experimental studies on M30 grade of concrete are made and tested for its compressive strength and flexural strength at 7, 14 and 28 days. The results were analyzed and the optimal percentage as 25% of replacement of eco sand was identified. Shubham Gupta et al.,[4] carried out the research on replacement of Eco sand ranges from 5 to 20% for fine aggregates and analyzed the mechanical properties involves Compressive strength, Spilt Tensile strength and Flexural strength. The grade of concrete adopted for the study is M40 and the rheological studies are also analyzed to check the demand of water. The results observed from the compressive strength, flexural strength and split tensile strength that 15% replacement of ecosand gives the most optimum percentage. D. Loganathan et al.,[5] investigates the high strength concrete using Eco sand with 50% replacement in concrete for its mechanical properties. Experimental study involves the compressive strength, flexural strength, splitting tensile strength. Moreover the comparison on structural behavior of beam with eco sand and river sand such that the combination of these fine aggregates can be increased efficiency in concrete. The gradation of aggregate ranges under zone II or zone III. D. Dakshnamoorthy et al.,[6] investigates the study on replacement of M sand for river sand and metakaolin, silica fume instead of cement at certain percentage. The metakaolin and silica fume are added on the cement individually as well as mixed state in different combinations. The main theme of this project is to find the strength and durability characteristics of the hardened concrete at these host materials on the concrete on various proportions. Nandini Suri et al.,[7] investigate the concrete with eco-sand and steel sag. The aim is to increase the strength of the concrete by replacing coarse aggregate by steel slag and also 30% replacement of eco sand as fine aggregate. The mix composed of 30 to 45 % of slag. It is evident that 50 % replacement and above reduces the strength found when compared to conventional mix. S. Suresh et al. investigates the high strength concrete replaced M sand along with admixture. They examined the workability, compressive strength and split tensile strength. The use of M-sand in concrete is gaining strength comparatively and experimental studies observed that effects of M sand on strength properties of concrete. Vertriselvi and Elangovan [8] investigated the superior performance of M sand with Eco sand in constructions. The study was reported with the replacement of 0 to 60% of eco sand. The optimal percentage was identified as 40% of Ecosand shows better performance in terms of workability and strength of concrete. M.Prabu et al.,[9] investigates the study
with GGBS and Eco Sand in the combination of 0%, 10%, 20%, 30% and 40% by weight of cement and sand in concrete. The study involves both Fresh concrete tests and the hardened concrete tests at the age of 7, 14 and 28 days for M20 grade of concrete. Test results are compared between conventional concrete and Ultimate Concrete with GGBS and Eco sand with different percentages as partial replacement. Shanmugapriya T et al.[10] investigates the study strength properties of High performance concrete in presence of silica fume. The investigations were carried out on high performance concrete with silica fume under various proportions of about 0, 5, 10, 15 percentages by weight of cement as partial replacement and for each proportions natural sand with M-Sand in proportions of 20, 40, 60 and 80%. The High performance concrete prepared for M60 grade concrete. The results indicate that the replacement by 10% Silica fume and 60% M-Sand showed significant improvement in strength.

3. Materials and Testing

3.1 Material properties

Ordinary Portland cement (OPC) of 53 grade is used for concrete mix. The combination of eco sand and M sand is used as fine aggregate. Silica fume is replaced by cement of about 1 to 5% in mix proportions. Conplast SP 430, super plasticizer is used to improve the workability of concrete mix. Eco sand as shown in figure.1 fine powdered crystalline silica that replace up to a varying percentage of M sand usage in concrete. The micro-filling effect of eco sand reduces the pores in concrete and ensures durability. In this study, specimens of grade M60 with various mix proportions are prepared to study the compressive strength, split tensile and flexural strength properties of the concrete at the age of 7, 14 and 28 days. Tests were conducted to obtain the specific gravity and fineness modulus and bulk density of fine aggregate and coarse aggregate as shown in table: 1. The mix ratio is prepared based on various proportions of replacement of cement and fine aggregate as shown in table: 2.

![Figure.1. Eco sand](image)

**Table.1. Physical properties of materials**

| Materials         | Specific gravity | Fineness modulus | Bulk density (kg/m³) |
|-------------------|------------------|------------------|---------------------|
| M sand            | 2.66             | 3.08             | 1530                |
| Eco sand          | 2.47             | 4.33             | 1500                |
| Coarse Aggregate  | 2.83             | 5.07             | 1312                |
| Cement            | 3.15             | -                | -                   |
| Superplasticizer  | 1.18             | -                | -                   |
Table 2. Mix ratio

| Mix  | Percentage replacement of materials |  |
|------|-------------------------------------|---|
|      | M sand | Eco sand(ES) | Silica fume(SF) |
| M11  | M60    | CONTROL MIX | 1% |
| M12  | 85,80,75 | 15,20,25  | 2% |
| M13  | 85,80,75 | 15,20,25  | 3% |
| M14  | 85,80,75 | 15,20,25  | 4% |
| M15  | 85,80,75 | 15,20,25  | 5% |

Figure 2. Curing and testing of specimens

4. RESULT AND DISCUSSION

4.1 Test for Compressive strength

The results of the compressive strength of concrete for various mix proportions at 7, 14 and 28 days were tested as shown in figure 3. For the control mix of concrete having M-sand as fine aggregate of M60 grade with addition of 1% superplasticizer had shown same strength as replaced by 15% of eco sand. As the percentage of eco sand increases from 15 to 25%, the strength gradually increases with gradual increase of Silica fume content. The optimum percentage of silica fume of about 5% increase shows better strength with 25% replacement of eco sand.
4.2 Test for Split tensile strength
The results of the split tensile strength of concrete for various mix proportions at 7, 14 and 28 days were tested as shown in figure 4. For the control mix (M60) having M-sand with addition of 1% superplasticizer had shown lower strength when compared to replaced material strength. As the percentage of Eco sand increases from 15 to 25%, the strength gradually increases with gradual increase of Silica fume. The optimum percentage of silica fume of about 2% increase shows better strength with 25% replacement of eco sand.

4.3 Test for flexural strength
The results of the flexural strength of concrete for various mix proportions at 7, 14 and 28 days were tested are presented in figure 5. For the control mix (M60) having M-sand with addition of 1% superplasticizer had shown lower strength when compared to replaced material strength. As the
percentage of Eco sand increases from 15 to 25%, the strength gradually increases with gradual increase of Silica fume. The optimum percentage of silica fume of 4% increase shows better strength with 25% replacement of eco sand.

![Flexural strength results](image)

5. Conclusion
On the basis of the experimental test results obtained from this research work, the following conclusions have been arrived:

(i) The compressive strength of high performance concrete increased at all ages with the partial replacement of M sand by Eco sand. The maximum compressive strength is obtained with the optimum percentage of about 25% Eco sand and 5% silica fume.

(ii) The maximum split tensile strength was obtained with the optimum percentage of about 4% Silica fume and 25% Eco sand.

(iii) The maximum limit of 25% of Eco sand replacement shows better strength in combination with silica fume content of 4%, though the Eco sand is predominant in silica content.

(iv) The maximum flexural strength was obtained with the optimum percentage of about 25% eco sand and 4% silica fume at the age of 28 days than the control mix.

(v) The replacement of Eco sand up to 25% in high performance concrete gives better results in strength enhancement and further studies are employed for higher percentage levels.

References

[1] Lavanya Prabha S,Gopalakrishnan M,Neelamegam M 2019 *International Journal of management, Technology and Engineering* **IX**.

[2] Magudeaswaran P, Eswaramoorthi P, Pradeep Kumar D 2015 *International Journal of Chemical Science* **13(2)**

[3] Dharshnadevi D, Aravindsamy B, Guru Saravanan C, Sowdharyan J, Tamil Selvi R. 2017 *International Conference on Latest Innovations in Applied Science, Engineering and Technology* **2017**
[4] Shubham Gupta, Indira M 2019 *International Journal of Innovative Technology and Exploring Engineering* 8(5)
[5] Loganathan D, Nithyalakshmi B 2016 *International Journal of Engineering Sciences & Research Technology* 5(11)
[6] Dakshnamoorthy D, Gunasekaran P, Vivekanananthan C, Kavitha A, Saravanan G 2015 *International Journal of Engineering and Management Research* 5(4)
[7] Nandini Suri, Anandh Babu Y 2016 *International Journal of Civil Engineering and Technology*, 7 (5) pp. 322–328.
[8] Vetriselvi K, Elangovan G 2018 *International Journal of Advances in Civil Engineering* 1(1):004
[9] Prabu M, Logeswaran S, Sunilaa George 2015 *International Journal of Innovative Research in Science, Engineering and Technology* 4(6)
[10] Shanmugapriya T, Uma R N 2016 *Asian Journal of Research in Social Sciences and Humanities* 6(6).