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Experimental Studies on Incorporation with Eco Sand and Foundry Sand in Concrete

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ABSTRACT
It is necessary to seek the possibility of recycling the industrial waste products, once their durability has expired. The recycled materials can be used effectively in the architectural and civil engineering fields. They can stand up to the concept of green concrete, which is compatible with the environment. Foundry sand from casting industries is a waste material that is dumped extensively, and in this study, an attempt has been made to evaluate the usage of this waste material in concrete. The constant depletion of sand beds at all major sources of availability is a major concern, and thus efforts are taken to replace sand in construction activities. Eco sand is a by-product obtained from the cement manufacturing process. This research investigates the utilisation of eco sand and foundry sand in concrete, where both eco sand and foundry sand combinations, at varying percentages with replacement by sand, were added in M20 grade concrete mixes, and the water-to-cement ratio of 0.50 was kept constant in the concrete mixes. Foundry sand and Eco sand are substituted in various amounts for the natural river. A total replacement is maintained at 50%. Mix combination beginning with fifty percent (50%) Foundry sand and zero percent (0%) eco sand. then, with each mix, the FS will be gradually reduced by 10% and the ES will be increased by 10%. In this study, effect of foundry sand & eco sand as fine aggregate replacement on the mechanical strength properties are investigated at the various curing days.
Key words: *Eco sand, Foundry sand, Mechanical strength,*

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I. INTRODUCTION

Concrete is one of the most utilized materials in the world. Each year, more than ten billion tonnes of concrete are consumed. Conventional concrete is a versatile material composed of cement, sand, aggregate, and water. Aggregates comprise between 65 and 80 percent of the entire volume of concrete and influence its fresh and hardened qualities. Fine aggregate accounts for around 20 to 30 percent of the total volume of aggregates. Sand is the most commonly employed fine aggregate in the production of concrete. Fundamentally, concrete is economical, strong, and durable. Although concrete technology across the industry continues to rise to the demands of a changing market place. The construction industry recognizes that considerable improvements are essential in productivity, product performance, energy efficiency and environmental performance. The industry will need to face and overcome a number of institutional competitive and technical challenges. One of the major challenges with the environmental awareness and scarcity of space for land-filling is the wastes/by-products utilization as an alternative to disposal. Throughout the industrial sector, including the concrete industry, the cost of environmental compliance is high. This research work aims to investigating with concrete made with Eco sand and Foundry sand.

Pathariya and Ranajay (2013) studied the compressive strength of the concrete by replacement of the local sand by foundry waste sand by 0%, 20%, 40% and 60% and they found that for 60% replacement of local sand by waste foundry sand they had obtained maximum compressive strength values.

In their study, Siddique et al. (2009) conducted an investigation on the impact of utilizing waste foundry sand as a partial substitute for fine aggregate in concrete. The focus of their research was to assess the effect of this substitution on the compressive strength and modulus of elasticity of the concrete. The compositions comprising both foundry sand and those without foundry sand were assessed at various time intervals of 7, 28, 56, 91, and 365 days throughout the curing process. The incorporation of foundry sand as a partial substitute for ordinary sand resulted in a little improvement in the compressive strength of the concrete mixtures.

The study conducted by Prabhu et al. (2015) examined the impact of incorporating Foundry Sand into concrete on its strength and durability. The findings of their study demonstrated that the compressive strength of the control combination was approximately 6.3% greater when compared to the concrete mixtures with a substitution rate of 30%. The durability test outcomes of concrete mixtures with foundry sand at levels of up to 30% exhibited a degree of proximity to those of the control mixture.

Sakthieswaran (2019) looked into what happens to the strength and longevity of M40 grade concrete when marble powder and green sand are used as partial replacements for fine aggregate. When compared to normal concrete, the data showed that the properties of concrete were much better when marble powder and green sand were used as fine aggregate. The microscopic tests also showed that green sand and marble powder could be used as fine particles. Kumar et al. 2020 looked into whether quarry dust and industrial sand could be used as fine aggregate. Using compression, split tensile, and flexural tests after 3, 7, 14, 21, and 28 days to figure out how firm concrete is. They decided that a mix of 80% quarry sand and 20% foundry sand worked better than regular concrete. In the study conducted by Shubham Gupta (2019), eco sand was substituted for natural river sand in variable proportions. 15% eco-sand replacement improved the strength. Beyond 15%, the force was progressively diminished.

Sathish Kumar and others (2020). This project investigates the experimental properties of concrete containing eco sand and demolished concrete in lieu of fine aggregate and coarse aggregate. 20% of the FA is substituted with eco-sand for all trail mixtures. The potency was significantly greater than the control mix.

Guney et al. (2010) investigated the impact of waste foundry sand (WFS) on concrete collapse. Fine aggregates were partially supplanted with WFS at percentages of 0, 5, 10 and 15%. It was observed that the addition of refuse foundry sand decreased the fluidity and slump value of fresh concrete. This is likely due to the presence of clayey-type fine materials in the refuse foundry sand, which reduce the fluidity of fresh concrete. Etxeberria et al. (2010) measured the subsidence of concrete containing both chemical and green foundry sand. The mixture proportion on concrete made with chemical foundry sand was 300 kg cement, 447.5 kg foundry sand, 399.6 kg natural sand and 1150 kg coarse aggregates per cubic meter of concrete, with water/cement ratio of 0.61, whereas, proportion of concrete with green foundry sand was 300 Kg cement, 326 kg foundry sand, 458 kg natural sand and 1150 kg coarse aggregates with water/cement ratio of 0.69. The collapse values for concrete made with chemical foundry sand and green foundry sand were 150 mm and 75 mm, respectively.

II. MATERIALS AND METHODS

During the course of the experiment, a specific batch of Portland Pozzolana Cement (PPC) 43 grade from the Ultratech brand was utilized. The specific gravity of the substance was determined to be 3.14. The initial and final settings of the system were recorded as 94 and 262 minutes, respectively. The present study utilized locally sourced coarse aggregates with a maximum size of 20mm. The testing of coarse aggregates was conducted in accordance with the guidelines specified in the Indian Standard IS: 383-2016. The sand utilized in the experimental program was obtained from a local source and adhered to the specifications outlined in grading zone II, as stipulated by the IS : 383-1970 standard. Eco sand refers to finely grained particles that are derived as a by-product from the manufacturing of cement. These particles have the potential to enhance the efficiency of concrete.

The micro-filling effect of this substance leads to a reduction in the size of pores inside concrete, resulting in enhanced moisture resistance and improved durability. Extracted aggregates often exhibit less consistent grading compared to this particular entity. Eco sand offers several advantages, including energy efficiency, fire resistance, reduced dead load, environmental friendliness, durability, lightweight composition, low maintenance requirements, and cost-effectiveness in construction projects. The origin of the material may be traced back to the ACC cement mill located in Coimbatore. The substance in question is a residual product derived from the process of casting metal alloys, characterized by a notable concentration of silica. Silica sand is commonly utilized in the material casting process, where it is coupled with either clay or chemicals. The sample was acquired from the Steel producing enterprises located at SIPCOT, Perundurai. Table 1 presents a comprehensive overview of the characteristics associated with materials used.

Table 1 Properties of aggregates

Materials	Specific gravity	Fineness modulus	Bulk density (kg/m^3)
Eco sand	2.429	2.82	1485
Foundry sand	2.57	2.75	1618
River sand	2.60	2.507	1252
Stone aggregate	2.76	7.18	1384

2.1 MIX DESIGN

Concrete mix has been designed based on Indian Standard Recommended Guidelines IS 10262 – 1982. The proportions for the concrete, as determined were 1:1.76:3.07 with water cement ratio of 0.50 by weight. Table 2 illustrates the ingredients required for each trial mixture.

Table 2 Ingredients required per one m³

Mix Designation	C kg/m³	CA kg/m³	FA kg/m³	FS kg/m³	ES kg/m³	Water lit/m³
CC(Control Concrete)	384	1190	677	0	0	192
M-1	384	1190	338.50	338.50	0	192
M-2	384	1190	338.50	270.08	67.70	192
M-3	384	1190	338.50	203.10	135.40	192
M-4	384	1190	338.50	135.40	203.10	192
M-5	384	1190	338.50	67.7	270.08	192
M-6	384	1190	338.50	0	338.50	192
C-cement ; CA- Coarse aggregate ; FA- Fine aggregate ; Foundry Sand FS ; ES- Eco Sand						

III. MECHANICAL PROPERTIES

The experimental data for the compressive strength and split tensile strength tests were obtained for different mixtures incorporating eco sand and foundry sand. These results are presented in Figures 1 to 3. The test results for the modulus of elasticity following a 28-day period of water curing are illustrated in Figure 4.

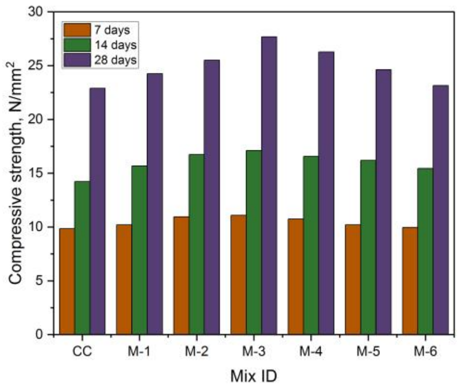

Figure 1 Test results of compressive strength

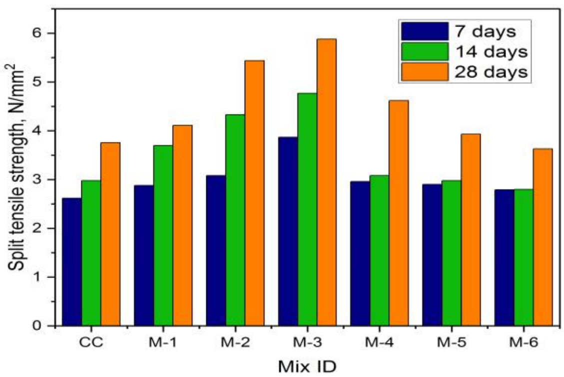

Figure 2 Test results of splitting tensile strength

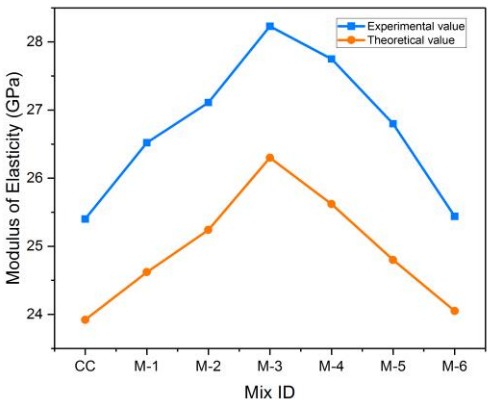

Figure 3 Test results of splitting tensile strength

3.1 Discussion on test results for mechanical properties

After duration of 28 days, the compressive strength values vary between 27.68 and 23.15 N/mm^2, whereas standard concrete has a compressive strength of 22.89 N/mm^2. The specimen identified as M-3 exhibited the highest level of strength. The optimal value was attained when a mixture consisting of 30% foundry sand and 20% eco sand was used. Mix ID M-3 exhibited a 20.92% increase in compressive strength compared to standard concrete.

The split tensile strength values observed after 7 days of testing range from 2.62 to 2.79 N/mm2. After a period of 28 days, the standard concrete exhibited a compressive strength of 3.76 N/mm2. The split tensile strength of alternative mixtures varies between 3.63 N/mm2 and 5.88 N/mm2 following a 28-day period. Mix ID M-3 had the highest level of strength compared to all other mixes. A proportion of 30% of eco sand was found to have attained the optimal strength. Furthermore, it is observed that the level of strength begins to diminish.

The range of values observed is from 28.23 GPA to 25.44 GPA. The comparison is made between the modulus of elasticity values obtained from theoretical calculations and those obtained from experimental measurements. All of the measured experimental values surpassed the corresponding theoretical values.

IV. NON DESTRUCTIVE TEST

4.1 Ultra-sonic pulse velocity test

UPV tests were conducted using 150 mm cubes. The experimental examination revealed that the ultrasonic pulse velocity of all the mixes exhibited a range of variation between 3.85 km/s and 4.65 km/s. The findings suggest that the concrete quality, as defined by the Indian Standard IS 13311 (Part I): 1992, is of high quality and meets the criteria for both good and excellent standards. The results derived from the ultrasonic pulse velocity test are presented in Table 3.

Table 3 Results of UPV test

Mix designation	Pulse velocity at 28 days , (Km/sec)	Quality of concrete as per IS code
CC	4.45	Good
M-1	4.62	Excellent
M-2	4.65	Excellent
M-3	4.34	Good
M-4	4.14	Good
M-5	3.98	Good
M-6	3.85	Good

V. CONCLUSION

- The specimen identified as M-3 exhibited the highest level of strength.
- The optimal value was attained when a mixture consisting of 30% foundry sand and 20% eco sand was used.
- A correlation was established between the rise in the proportion of eco sand and a decrease in the slump value. The compaction factor value varies within the range of 0.84 to 0.90.

- Mix ID M-3 exhibited a 20.92% increase in compressive strength compared to standard concrete.
- The observed values span from a minimum of 25.44 GPA to a maximum of 28.23 GPA. A comparison is conducted between the modulus of elasticity values derived from theoretical calculations and those obtained through experimental observations. All of the measured experimental values exceeded the identical theoretical values.
- The experimental investigation demonstrated that the ultrasonic pulse velocity of all the mixtures had a range of fluctuation ranging from 3.85 km/s to 4.65 km/s. The results indicate that the concrete quality, as per the Indian Standard IS 13311 (Part I): 1992, exhibits a high level of quality and satisfies the requirements for both good and excellent categories.

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