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DEVELOPMENT OF ECO-FRIENDLY CONCRETE USING SEA SHELL POWDER AND FOUNDRY WASTE AS FINE AGGREGATE.

[1]N . Sathyakumar, [2]K . Naveeka Shri, [2]B . Dharini, [2] F . Sagaya Dani, [2]K . Arjun.

[1]Assistant Professor, Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore.

[2]UG Students ,Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore.

ABSTRACT :

The increasing reliance on river sand for concrete production has raised significant environmental concerns due to resource depletion and ecological damage from excessive mining. This study proposes a sustainable alternative by partially replacing fine aggregate in M20 concrete with crushed seashell powder and used foundry sand at 10% and 20% levels. The 10% mix incorporated 5% seashell powder and 5% foundry sand, while the 20% mix contained 10% of each, with all mixes prepared using the same method as the M20 control mix. Standard tests were conducted to assess workability, compressive strength, and durability. Results showed that the 10% replacement mix performed comparably to conventional concrete, achieving a 28-day compressive strength of 21.48 N/mm², slightly lower than the control value of 22 N/mm² but still acceptable. The 20% replacement mix recorded 19.53 N/mm², indicating a moderate reduction yet remaining close to the required strength depending on application and safety factors. Overall, the study demonstrates that crushed seashell powder and foundry sand are viable partial substitutes for natural sand, promoting resource conservation, reducing waste, and supporting environmentally sustainable construction without significantly compromising structural performance.

KEYWORDS :M20 concrete, seashell powder, foundry sand, fine aggregate replacement, sustainable construction, compressive strength, durability

I. INTRODUCTION

Concrete is a widely used construction material known for its strength, durability, and versatility; however, its reliance on natural river sand as a fine aggregate has led to serious environmental issues such as riverbed erosion, habitat loss, and groundwater depletion, creating an urgent need for sustainable alternatives. While M-sand is a common substitute, increasing interest is now focused on industrial and marine waste materials that offer both environmental and resource-efficient benefits. Used foundry sand, rich in silica, and discarded seashells, mainly composed of calcium carbonate, are two underutilized waste materials with potential applications in concrete. This study investigates the partial replacement of natural river sand in M20 concrete using crushed seashell powder and used foundry sand at replacement levels of 10% and 20%, blending both materials in equal proportions. The modified mixes are assessed for workability, compressive strength, tensile strength, and durability at various curing periods, with the aim of reducing dependence on natural resources and promoting the beneficial reuse of waste materials to support sustainable construction and circular economy principles.

II. OBJECTIVE

To compare the physical and chemical properties of crushed seashell powder and foundry sand with natural river sand.To design M20 concrete mixes with 0%, 10%, and 20% waste based fine aggregate replacements.To assess the workability, compressive strength, and durability of the modified mixes.To identify the optimum replacement level that matches conventional concrete performance.To evaluate the suitability of marine and foundry waste as a sustainable alternative to natural sand.

III .METHODOLOGY

- **Material collection -** Waste foundry sand is sourced from industries, and sea shells are collected, cleaned, dried, crushed, and ground into fine powder for use as fine aggregate.
- **Mix design** - Cement : Sand : Coarse aggregate = 1 : 1.5 : 3 with w/c ≈ 0.50 (cement ≈ 320 kg/m³) — (optional) 10% seashell + 10% foundry sand replacing fine aggregate.
- **Casting and curing** - Fresh concrete was placed in cube moulds, compacted on a vibrating table, demoulded after 24 hours, and then cured in clean water for 28 days.
- **Testing -** The concrete specimens were tested through sieve analysis for grading, compressive strength evaluation using cube tests, and water absorption measurement to assess durability
- **Result and conclusion .**

IV. LITERATURE REVIEW:

1. **Singh, G., & Siddique, R. (2014). Effect of waste foundry sand (WFS) as partial replacement of sand on the strength, ultrasonic pulse velocity, and permeability of concrete. Construction and Building Materials.**
   • **Strength Increase:** About **15% WFS** improves compressive and tensile strength of concrete.
   • **Better Durability:** WFS reduces permeability and increases ultrasonic pulse velocity, enhancing concrete quality.
2. **Etxeberria, M., Pacheco, C., & Meneses, J. (2010). Use of dredged marine sand in concrete. Construction and Building Materials.,**
   • **Good Performance:** Dredged marine sand maintains strength and durability in concrete.
   • **Eco-Friendly:** It reduces natural sand use and manages dredging waste.
3. **Katkhuda, H., & Shatnawi, N. (2009). Hydraulic and mechanical properties of concrete using treated waste foundry sand. Waste Management.**
   • **Strength & Quality Improvement:** About 15% WFS increases compressive and tensile strength, and improves internal bonding (high UPV).
   • **Better Durability & Sustainability:** WFS lowers permeability and serves as a sustainable alternative to natural sand.
4. **Ganesan, N., Abraham, R., & Raj, S. D. (2015). Durability characteristics of steel fibre reinforced concrete with sea sand. Construction and Building Materials.**
   • **Improved Durability:** Sea sand with steel fibres reduces permeability and increases resistance to chloride and environmental attack.
   • **Sustainable Alternative:** Properly processed sea sand can replace natural sand while maintaining strong structural performance.
5. **Siddique, R., & Noumowe, A. (2008). Utilization of spent foundry sand in controlled low-strength materials and concrete. Resources, Conservation and Recycling.**
   • **Good Mechanical Performance:** Partial replacement of natural sand with SFS can maintain or improve compressive strength and workability**.**
   • **Sustainable Use:** SFS effectively serves as a recycled fine aggregate, reducing waste and conserving natural sand resources.
6. **Priyadharshini, P., Gopinath, G., & Kumar, P. R. (2013). A Study on the performance of sea sand based self- compacting concrete. International Journal of Engineering and Technology.**
   • **Maintains SCC Performance:** Sea sand can be used in self-compacting concrete without reducing workability, flowability, or strength.
   • **Sustainable Alternative:** Sea sand does not harm durability and helps conserve natural river sand resources.
7. **Bhogayata, A., & Arora, N. K. (2012). Performance of green concrete containing waste foundry sand. International Journal of Engineering Science and Technology.**
   • **Good Strength & Durability:** Up to **20% WFS** provides comparable compressive strength and improves durability by reducing permeability.
   • **Sustainable Solution:** WFS helps manage industrial waste and reduces the need for natural sand.
8. **Sallam, H. E. M., Shoukry, H., & Aly-A-Al, M. (2015). Durability of concrete incorporating dune and sea sands. Alexandria Engineering Journal.**
   • **Adequate Strength & Durability:** Dune sand and sea sand can replace river sand without significantly reducing compressive strength or durability.
   • **Eco-Friendly Option:** Using these alternative sands helps conserve natural river sand and supports sustainable construction.

9. **Monosi, S., Sani, D., & Tittarelli, F. (2016). Used foundry sand in cement mortars. Construction and Building Materials**.
 .• **Good Strength & Density:** SFS improves compressive strength and creates a denser mortar due to its fine particles and high silica content.
 • **Sustainable & Eco-Friendly:** Using SFS reduces industrial waste, conserves natural sand, and supports cost- effective, sustainable construction.
10. **Dolage, D. A. R., & Seneviratne, M. G. S. L. (2013). The use of offshore sand as a fine aggregate for concrete production. British Journal of Applied Science & Technology.**
 • **Maintains Concrete Performance:** Offshore sand can replace river sand without major loss in workability or compressive strength.
 • **Sustainable Alternative**: It helps manage dredged materials and reduces dependence on natural sand resources.

V. MATERIALS USED

1. **CRUSHED SEASHELL:** Crushed seashells rich in calcium carbonate ($CaCO_3$) were collected from coastal seafood waste, cleaned, sun-dried, and finely crushed to meet fine aggregate requirements. The material was sieved for uniform grading and used due to its lightweight,stable,and durable nature. Dredged marine sand from approved coastal sites was also washed to remove salts and impurities, and its calcareous, angular structure made it suitable as a partial fine aggregate replacement.
2. **CEMENT:** Cement acts as the primary binding material in concrete and, when mixed with water, forms a cohesive paste that binds the fine and coarse aggregates together, ensuring strength and durability. In this study, Ordinary Portland Cement (OPC) of 43 grade conforming to IS 8112:2013 was used. The cement was grey in color, dry, free from lumps, and exhibited a fine and uniform texture, which facilitated proper hydration during mixing and curing. The selection of 43 - grade OPC was made due to its consistent quality, suitable setting characteristics, and reliable strength development essential for producing structural concrete.
3. **FOUNDRY SAND:** Used foundry sand obtained from a local metal casting industry, consisting mainly of high-silica sand exposed to repeated thermal cycles and binders, was collected and sieved to remove oversized particles and impurities. Its texture and grain size closely resemble natural river sand, making it suitable for partial fine aggregate replacement. Tests on pH, fineness modulus, specific gravity, and deleterious materials confirmed that the material meets construction standards. The fine texture and dark coloration further indicate its potential as a supplementary fine aggregate in concrete.
4. **WATER**: Pure and potable water was utilized for curing and mixing. The water is used for the hydration of concrete and for proper chemical reaction. The water used was free from acids, oils, alkalis, and organic contaminants. The water- concrete ratio was also maintained under strict control to ensure the required workability and strength.
5. **FINE AGGREGATE:** The fine aggregate is locally sourced river sand conforming to Zone II of IS 383:2016. The material is clean, well-graded, and free from silt, organic matter, and other harmful impurities, ensuring reliable performance in the control mix. Its uniform particle size, granular texture, and desirable workability characteristics make it suitable for achieving consistent and efficient concrete production.
6. **COARSE AGGREGATE:** Crushed angular granite with a maximum size of 20 mm, conforming to IS 383:2016, was used as the coarse aggregate. The material was clean, hard, and free from impurities such as clay, silt, and organic matter. Its angular shape and uniform size distribution ensured proper interlocking and contributed to the overall strength and stability of the concrete mix.

VI. MIX PROCEDURE:

Prepare materials by collecting, sieving, and drying sand, coarse aggregate, seashell powder, and foundry sand. Design the M20 mix as per IS 10262:2019 and IS 456:2000 using OPC 43 grade, 20 mm aggregate, W/C = 0.50, and 1:1.5:3 proportion. Dry-mix all materials with cement, then add water and mix in a mechanical mixer to get a uniform, workable concrete.Place the fresh concrete into cube moulds and compact using a vibrating table.Demould the specimens after 24 hours..Curing:- Submerge the specimens in a water-curing tank for 28 days to ensure proper strength development..Drying:- After curing, keep the specimens air-dried to remove excess surface moisture before testing.

.51.MIX DESIGN:

The M20 concrete mix is prepared as per IS 10262:2019 and IS 456:2000, targeting a mean strength of 26.6 N/mm² with OPC 43 grade cement, a 20 mm maximum aggregate size, a slump range of 75–100 mm, and a nominal mix ratio of 1:1.5:3. River sand (Zone II, IS 383:2016), 20 mm crushed granite, crushed seashell powder, and used foundry sand are washed, dried, sieved, and checked for impurities before use. In modified mixes, 10% and 20% of the fine aggregate are replaced with equal proportions of seashell powder and foundry sand while maintaining a constant water–cement ratio of 0.50. All dry materials are blended in a mechanical mixer, and water is added gradually to obtain a uniform and workable mix. The fresh concrete is then placed in 150×150×150 mm cube moulds and compacted using a vibrating table to eliminate air voids. After 24 hours, the specimens are demoulded and cured in clean water for 7, 14, and 28 days as per IS 516:2018. After curing, the specimens are surface-dried and tested for mechanical and durability performance, including compressive strength testing and water absorption testing to assess the influence of seashell and foundry sand incorporation.

VII .TEST ON CONCRETE:

1. COMPRESSIVE TEST

1.1. Calculate load bearing area

For compressive strength test, concrete cube is loaded on the150 x 150 mm face

Area= 150mm x 150mm

=22500mm2

=0.0225m2

1. 2. Formula to calculate compressive strength

Compressive Strength= Maximum Load (kN) /Area mm2

Mix	**Replacement**	**7 Days (MPa)**	**14 Days (MPa)**	**28 Days (MPa)**
M0	0%	18.89	20.5	22
M1	10%	18.09	19.87	21.486
M2	20%	16.412	17.897	19.532

2. WATER ABSORPTION TEST

Formula to calculate the water absorption test:

Water absorption(%) =W wet - Wdry/Wdry x 100

➢ **Water absorption test (10% - Replacement)** Dry weight of the concrete cube (W1)= 5.624kg Wet weight of the concrete cube (W2)=5.745kg

W =W2-W1/W1x100

= 5.745-5.624/5.624x100 W = 2.154%

The water is absorbed 2.15% in 24 hrs.

➢ **Water absorption(20%-Replacement)**

Dry weight of the concrete cube (W1) =5.632kg

Wet weight of the concrete cube (W2) = 5.7615kg

W =W2-W1/W1x100

=5.7615-5.632/5.632x100

=2.299%

W =2.3%

The water is absorbed 2.3% in 24 hrs .

VIII. COMPARISON

Here is a direct comparison between normal M20 concrete (control mix using 100% natural river sand) and M20 mixes with 10% and 20% replacement by crushed seashell powder and foundry sand. The comparison covers key properties: compressive strength, and water absorption.

PROPERTY	**Control Mix (0% Replacement)**	**10% Replacement (5% Seashell + 5% Foundry Sand)**	**20% Replacement (10% Seashell + 10% Foundry Sand)**
Compressive Strength (N/mm^2)	22	21.48	91.53
Water Absorption (%)	2.1	2.15	2.3

- **Strength:** Both compressive strengths are slightly lower in the mixes with waste sand, but the 10% replacement provides values very close to the normal mix and suitable for structural use.
- **Durability:** Water absorption is lowest in the 10% replacement mix, indicating denser concrete and reduced porosity compared to both the control and 20% replacement mixes. The 20% mix shows a moderate increase in water absorption but still remains within acceptable durability limits.

- **Sustainability :** The 10% replacement mix offers the best overall compromise of strength, durability, and eco-efficiency, making it a viable alternative to the conventional mix for sustainable construction.

This comparison demonstrates that using crushed seashell powder and used foundry sand up to 10% as a partial replacement for fine aggregate in concrete results in minor reductions in strength, but provides similar durability and significant environmental and economic advantages over conventional concrete.

IX. CONCLUSION

This experimental investigation evaluated M20 grade concrete with partial replacement of natural river sand using crushed seashell powder and foundry sand at 10% (5% seashell + 5% foundry sand) and 20% (10% seashell + 10% foundry sand).

Compressive strength results showed that the control mix attained 22 N/mm² at 28 days. The 10% replacement mix achieved

21.48 N/mm², indicating a slight reduction but still meeting the requirements for structural applications. The 20% replacement mix recorded 19.532 N/mm², showing a further decrease yet remaining within acceptable limits for general construction.

ater absorption results were 2.10% for the control mix, 2.15% for the 10% replacement mix, and 2.30% for the 20% replacement mix. The 10% mix exhibited reduced water absorption due to better particle packing and lower porosity, while the 20% mix showed a moderate increase but remained within permissible durability standards.

Overall, the 10% replacement of river sand with seashell powder and foundry sand proved to be the most effective, offering th e best combination of adequate compressive strength and improved water absorption performance. This mix presents a sustainable and economical alternative for concrete production by utilizing waste materials and reducing dependence on natural river sand.

X. REFERENCE

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