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## Experimental Investigation of Concrete with Eggshell Powder In Addition To Discarded Fish Net

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**Abstract:** This study investigates the performance of concrete incorporating eggshell powder (ESP) as a partial cement replacement and discarded fish net (DFN) fibers as reinforcement. M25 concrete mixes were prepared using 5% ESP with 0.2%, 0.4%, and 0.6% DFN, while conventional concrete served as the control. The specimens were evaluated for workability, compressive strength, split tensile strength, and water absorption after 7, 14, and 28 days of curing. The results indicate that the mix containing 5% ESP and 0.2% DFN achieved the best overall performance, with a 28-day compressive strength of 18.77 N/mm<sup>2</sup> and split tensile strength of 1.42 N/mm<sup>2</sup>. Higher DFN contents reduced workability and compressive performance, likely due to fiber entanglement, poor bonding, and clustering. The findings demonstrate that optimized use of ESP and DFN can reduce cement consumption, utilize waste materials, enhance concrete properties, and support sustainable construction practices while contributing to environmentally responsible and cost-effective material development.

**Keywords:** Eggshell Powder; Discarded Fish Net; Sustainable Concrete; Cement Replacement; Compressive Strength; Split Tensile Strength; Waste Utilization

### I. Introduction

Concrete is one of the most essential materials in the construction industry due to its strength and durability. However, the production of cement, a key component of concrete, is a major contributor to carbon dioxide (CO<sub>2</sub>) emissions and environmental degradation. To promote sustainability, researchers are exploring alternative materials that can partially replace cement and improve concrete properties while reducing its environmental impact. One such approach is the incorporation of waste materials such as eggshell powder (ESP) and discarded fish net (DFN) fibers in concrete. 10 Eggshell powder (ESP), primarily composed of calcium carbonate (CaCO<sub>3</sub>), has been studied as a partial replacement for cement due to its similar chemical composition to limestone, a primary raw material in cement production. Utilizing ESP in concrete can help reduce cement consumption while maintaining or even improving compressive strength. Meanwhile, discarded fish nets (DFN) fibers, made from synthetic polymers like nylon and polyethylene, can be used as fiber reinforcement to enhance tensile strength, ductility, and crack resistance in concrete. The improper disposal of fish nets poses environmental risks, and their reuse in concrete presents an effective waste management solution. This study aims to compare conventional concrete with ESP and DFN fiber modified concrete, focusing on workability, compressive strength, and tensile strength. Concrete specimens were prepared with 5% ESP replacement for cement and DFN additions of 0.2%, 0.4%, and 0.6% by weight of concrete, and tested at 7, 14, and 28 days of curing. The goal is to determine whether these waste materials can enhance concrete properties while promoting sustainability in

construction. The findings contribute to the development of eco-friendly, durable, and cost-effective concrete solutions, supporting global efforts to reduce carbon emissions and waste accumulation.

### II. Objectives of The Study

1. To determine the impact of adding eggshell powder and discarded fish net on the compressive, tensile, and flexural strength of concrete.
2. To assess how the inclusion of these additives affects the durability of concrete in terms of resistance to water absorption, chemical attack, and freeze-thaw cycles.
3. To analyze the effect of eggshell powder and discarded fish net on the workability, mix consistency, and slump behavior of fresh concrete.
4. To identify the optimal percentage of eggshell powder and discarded fish net that maximizes concrete strength, durability, and sustainability.
5. To explore the environmental advantages of utilizing waste materials as concrete additives in reducing landfill waste and carbon footprint.
6. To analyze the cost-effectiveness of incorporating ESP and DFN in concrete production, comparing it to the cost of conventional concrete.
7. To assess the long-term mechanical and durability performance of concrete containing eggshell powder and discarded fish net.
8. To analyze the reduction in environmental impact through the use of waste products in concrete production, promoting sustainable construction practices.

### III. Scope of The Study

1. Investigates the feasibility of using eggshell powder as a partial replacement for cement in concrete.
2. Analyzes the physical and chemical properties of eggshell powder to determine its suitability in concrete production.
3. Evaluates the mechanical properties, including compressive strength, tensile strength.
4. Investigates the role of discarded fish net in improving impact resistance, abrasion resistance, and crack control.
5. Evaluates the thermal conductivity and fire resistance of concrete with eggshell powder and discarded fish net.
6. Conducts laboratory experiments to compare fresh and hardened properties with conventional concrete.
7. Assesses the economic feasibility of using eggshell powder and discarded fish net in concrete production.
8. Examines the environmental benefits of replacing cement with eggshell powder, including reduction in carbon footprint and waste utilization.

### IV. Literature Review

1. Naveen Kumar, Sandeep Nasier, "A Review on Mechanical Properties of Concrete by Partial Replacement of Cement with Eggshell Powder and Fly Ash," Civil Engineering and Architecture, Vol. 12, No. 3A, pp. 1946 - 1957, 2024. The study by Naveen Kumar and Sandeep Nasier reviews the mechanical properties of concrete when cement is partially replaced with eggshell powder (ESP) and fly ash. Eggshell powder, being rich in calcium, acts as a sustainable alternative to cement, while fly ash, a pozzolanic material, enhances the durability and long-term strength of concrete. The research examines key properties such as compressive strength, flexural strength, split tensile strength, workability, and durability. Findings suggest that partial replacement with ESP and fly ash improves the mechanical performance of concrete up to an optimal limit, typically around 15-20%. Beyond this percentage, the strength properties tend to decline. The study highlights the environmental and economic benefits of using these waste materials in concrete production, promoting sustainability in construction practices. 13

2. Vasudevan and H. Cong, "Palm kernel ash and eggshell ash as partial replacement of cement in interlocking brick production," Mater. Sci. Forum, vol. 1047, pp. 174-178, 2021. Vasudevan and Cong (2021) investigated the use of palm kernel ash and eggshell ash as partial replacements for cement in interlocking brick production. Their study, published in Materials Science Forum, explored the potential of these waste materials to enhance sustainability in construction. The research focused on the mechanical and durability properties of bricks incorporating these ashes, analyzing their compressive strength, water absorption, and overall performance. The results indicated that partial substitution of cement with palm kernel ash and eggshell ash could improve certain properties of the bricks while reducing environmental impact. This study highlights the feasibility of utilizing agricultural and industrial by-products in sustainable building materials.

3. Bandhavya G.B, Sandeep K, and Bindhushree G.B, " An Experimental Study on Partial

Replacement Of Cement With Egg Shell Powder In Concrete," International Research Journal of Engineering and Technology (IRJET)., vol. 4, no. 6, pp. 2318–2323, Jun. 2017. This study by Bandhavya G.B, Sandeep K, and Bindhushree G.B explores the partial replacement of cement with eggshell powder (ESP) in concrete. The research aims to evaluate the feasibility of using ESP as a supplementary cementitious material by analyzing its impact on the mechanical properties of concrete. Various replacement percentages of ESP were tested, and the results were compared with conventional concrete. The study found that an optimal percentage of ESP replacement can enhance certain properties of concrete while also promoting sustainable construction practices by utilizing waste materials.

4. Jayasankar. R, Mahindran. N, and Ilangoan. R, "Studies on Concrete Using Fly Ash, Rice Husk Ash and Egg Shell Powder," International Journal of Civil and Structural Engineering, vol. 1, pp. 362–372, 2010. The study by Jayasankar R., Mahindran N., and Ilangoan R. explores the use of fly ash, rice husk ash (RHA), and eggshell powder (ESP) as partial replacements for cement in concrete. The objective was to enhance sustainability and reduce cement consumption while improving concrete properties. Fly ash, an industrial byproduct, was used to improve workability and durability, while RHA, known for its pozzolanic properties, contributed to increased strength and durability. Eggshell powder, rich in calcium carbonate ( $\text{CaCO}_3$ ), served as an alternative cementitious material. Various mix proportions were tested, and mechanical properties such as compressive strength, split tensile strength, and flexural strength were evaluated. The findings indicated that partial replacement of cement with these materials improved concrete strength up to an optimum percentage. RHA and ESP contributed to pozzolanic activity and increased calcium content, enhancing overall performance. The study concluded that fly ash, RHA, and ESP can effectively be used as additives, promoting eco-friendly and sustainable concrete while reducing environmental impact.

5. Ashish Kumar Singh et al., "A Study on Concrete by partial replacement of cement and aggregate by Silica fume, Egg shell powder and E-waste," International Conference on Recent Innovations in Science and Engineering, vol. 7, no. 1, pp. 34–41, 2018. The study by Ashish Kumar Singh et al. explores the partial replacement of cement and aggregates in concrete using silica fume, eggshell powder (ESP), and e-waste. It evaluates the effects of these materials on compressive strength, tensile strength, and durability of concrete. The findings suggest that incorporating waste materials in optimal proportions can enhance concrete performance while promoting sustainable and eco-friendly construction by reducing waste and cement consumption.

6. Amarnath Yerramala, "„Properties of concrete with eggshell powder as cement replacement,"" The Indian Concrete Journal., vol. 88, no. 10, pp. 94–105, 2014. The study by Amarnath Yerramala examines the properties of concrete when eggshell powder (ESP) is used as a partial replacement for cement. Various

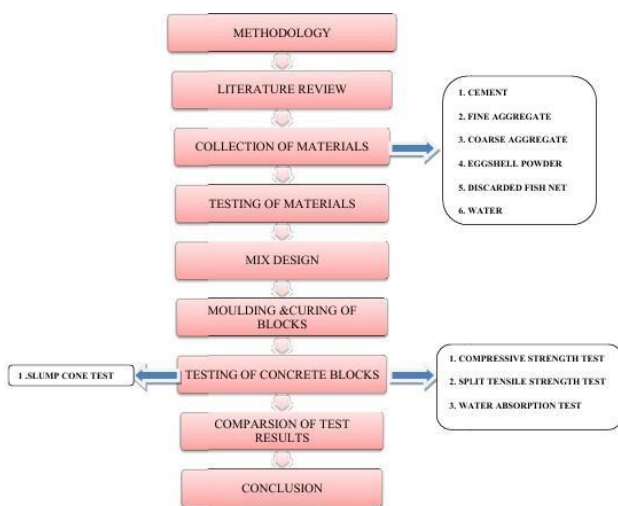
percentages of ESP replacement were tested to evaluate its impact on compressive strength, workability, and durability of concrete. The results indicate that ESP can be a viable supplementary material, improving some properties of concrete while 15 promoting sustainable construction by reducing cement consumption and utilizing waste materials effectively.

7. D. Gowsika, S. S. Kokila, and K. Sargunan, "Experimental Investigation of Egg Shell Powder as Partial Replacement with Cement in Concrete," International Journal of Engineering Trends and Technology, vol. 14, no. 1, pp. 65–68, Aug. 2014. The study by D. Gowsika, S. S. Kokila, and K. Sargunan investigates the use of eggshell powder (ESP) as a partial replacement for cement in concrete. Different ESP replacement levels were tested to analyze their effects on compressive strength, workability, and durability. The results indicate that ESP can be effectively used as a supplementary cementitious material, contributing to cost reduction and sustainability in construction by utilizing waste materials efficiently.

8. S. Raji and A. Samuel, "Egg shell as A fine aggregate in concrete for sustainable construction," International Journal of Scientific & Technology Research, vol. 4, no. 9, 1956 pp. 8– 13, 2015. The study by S. Raji and A. Samuel explores the use of eggshell (ES) as a fine aggregate replacement in concrete to promote sustainable construction. Various proportions of ES were tested to evaluate their effects on workability, compressive strength, and durability. The findings suggest that eggshells can be a viable alternative to traditional fine aggregates, helping to reduce construction costs and environmental waste while maintaining acceptable concrete properties.

## V. Methodology

The methodology for concrete refers to the steps, techniques, and practices involved in the design, preparation, and placement of concrete for construction projects.



## VI. Materials

Concrete is a composite material consisting of a binder, which is typically cement, sand, gravel, eggshell powder, nylon fiber, and water. These comprise the constituent material of concrete. But because of the many variables of the raw materials and how they

are processed and combined there are many opportunities for problems to appear in concrete.

### Portland Cement

Cement Portland cement is the binder used most widely. Although Portland cement is named after an area in England where its use was originated, today it is manufactured al over the world. Consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulphate as a inter ground addition. Portland cement is made by fusing calcium bearing materials with aluminum bearing materials. The calcium may come from isolate, shells, chalk or marl, which is a soft , or hard mud, sometimes, that is rich in time.

### Fine Aggregate

Fine aggregate Fine aggregate is a construction material consisting of small particles, such as sand, that pass through a 4.75 mm sieve. It is used in concrete, mortar, and plaster to fill spaces between coarse aggregates, improve workability, and enhance the strength of the final structure. The fine aggregate serve the purpose of filling all the open space in between the coarse particles thus it reduce the porosity of the final mass and considerable increase its strength. Usually, natural river sand is used as a fine aggregate. However, at place a natural sand is not available economically finally we use M sand as a fine aggregate.

### Coarse Aggregate

Coarse aggregate Coarse aggregate is the larger, granular material used in concrete that is typically retained on a 4.75 mm sieve. It primarily consists of crushed stone or 19 gravel and serves to provide bulk, strength, and stability to concrete. Coarse aggregate is essential for reducing the volume of cement and enhancing the overall mechanical properties and durability of concrete.

### Egg Shell Powder

Egg Shell Powder Eggshells, which are primarily composed of calcium carbonate ( $\text{CaCO}_3$ ), can be used as a partial replacement for cement in concrete to enhance sustainability and reduce waste.

### Discarded Fish Net

Discarded Fish Net is a synthetic fiber added to concrete to improve its tensile strength, durability, and crack resistance. It is commonly used in fiber reinforced concrete (FRC) to enhance performance and reduce shrinkage cracks.

### Water

The quantity of water in the mix place a vital role on the strength of the concrete. Some water which has adverse effect on hardened concrete sometime may not be harmless or even beneficial during mixing. So clear distinction should be made between the effect on hardened concrete and the quality of mixing water.

### Material Testing

Specific gravity tests were carried out for cement and aggregates. The reported values are 3.29 for cement, 2.68 for fine aggregate and 2.93 for coarse aggregate. Water absorption was reported as 1.73% for coarse aggregate and 0.80% for fine aggregate.

The slump test was used to determine fresh concrete workability. The reported trial used a water-cement ratio of 0.5 and produced a slump of 100 mm.

### Mix Design

The concrete was designed as M25 using the stated IS 10262:2019 and IS 456:2000 guidelines. The maximum nominal aggregate size was 20 mm and the stated water-cement ratio was approximately 0.5. The reported material quantities for the base design were 394 kg/m<sup>3</sup> cement, 197 kg/m<sup>3</sup> water, 698 kg/m<sup>3</sup> fine aggregate and 1022 kg/m<sup>3</sup> coarse aggregate.

| Mix ID | Cement (%) | ESP (%) | DFN (%) | Water/Cement |
|--------|------------|---------|---------|--------------|
| M1     | 100        | 0       | 0       | 0.50         |
| M2     | 95         | 5       | 0.2     | 0.50         |
| M3     | 95         | 5       | 0.4     | 0.48         |
| M4     | 95         | 5       | 0.6     | 0.46         |

### Mixing, Moulding and Curing

Eggshells were processed into fine powder and discarded fish nets were cut into approximately 10–20 mm lengths. Cement, eggshell powder, aggregates and fish-net fibers were dry mixed, followed by gradual addition of water. The concrete was mixed for about 3–5 minutes to achieve uniformity. Fresh concrete was placed into clean, oiled moulds and compacted. Specimens were demoulded after initial setting and cured for 7, 14 and 28 days.

## VII. Experimental Tests And Results

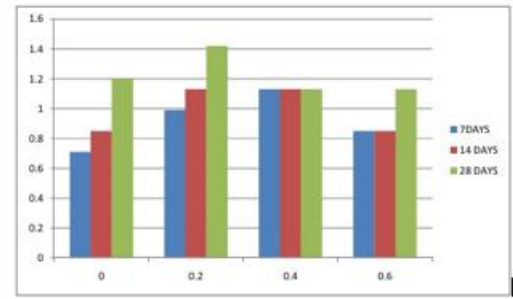
### 7.1 Split Tensile Strength

Cylindrical specimens were cured for 7, 14 and 28 days. The maximum load at failure was recorded and split tensile strength was calculated using  $T_s = 2P/(\pi DL)$ .

The highest reported 28-day split tensile strength is 1.42 N/mm<sup>2</sup> for the 5% ESP + 0.2% DFN mix.



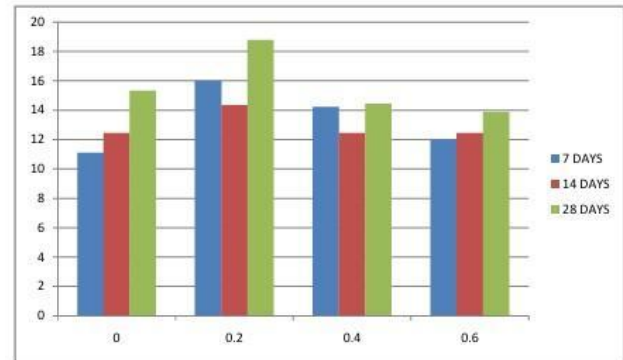
| Eggshell powder(%) | Discarded fish net(%) | 7days (N/mm <sup>2</sup> ) | 14days (N/mm <sup>2</sup> ) | 28days (N/mm <sup>2</sup> ) |
|--------------------|-----------------------|----------------------------|-----------------------------|-----------------------------|
| 0%                 | 0%                    | 0.71                       | 0.85                        | 1.20                        |
| 5%                 | 0.2%                  | 0.99                       | 1.13                        | 1.42                        |
| 5%                 | 0.4%                  | 1.13                       | 1.13                        | 1.13                        |
| 5%                 | 0.6%                  | 0.85                       | 0.85                        | 1.13                        |



### 7.2 Compressive Strength

Concrete specimens were tested in a compression testing machine after 7, 14 and 28 days of curing. The compressive strength was calculated from the maximum failure load divided by the cross-sectional area.

| Eggshell powder(%) | Discarded fish net(%) | 7days (N/mm <sup>2</sup> ) | 14days (N/mm <sup>2</sup> ) | 28days (N/mm <sup>2</sup> ) |
|--------------------|-----------------------|----------------------------|-----------------------------|-----------------------------|
| 0%                 | 0%                    | 11.11                      | 12.44                       | 15.33                       |
| 5%                 | 0.2%                  | 16.00                      | 14.22                       | 18.77                       |
| 5%                 | 0.4%                  | 14.22                      | 12.45                       | 14.44                       |
| 5%                 | 0.6%                  | 12.00                      | 12.45                       | 13.88                       |

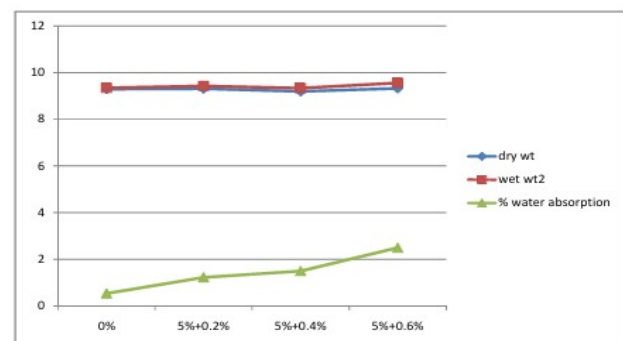


The reported maximum 28-day compressive strength is 18.77 N/mm<sup>2</sup> for 5% ESP + 0.2% DFN.

### 7.3 Water Absorption

Water absorption was determined by comparing the oven-dried specimen weight with the saturated specimen weight after 24 hours of immersion.

| Time Period | % Replacement of Cement Eggshell & Discarded Fish Net | Dry Wt(kg) | Wet wt(kg) | % Water Absorption |
|-------------|-------------------------------------------------------|------------|------------|--------------------|
| 24 hours    | 0%                                                    | 9.29       | 9.34       | 0.54               |
| 24 hours    | 5%+0.2%                                               | 9.31       | 9.42       | 1.23               |
| 24 hours    | 5%+0.4%                                               | 9.19       | 9.33       | 1.50               |
| 24 hours    | 5%+0.6%                                               | 9.32       | 9.55       | 2.50               |



### VIII. Discussion

The reported results show that the combination of 5% eggshell powder and 0.2% discarded fish net give the strongest overall performance among the investigated mixes. At 0.2% DFN, both compressive and split tensile strength are improved compared with conventional concrete. Increasing the DFN content to 0.4% and 0.6% does not provide the same compressive-strength benefit. The project attributes the reduction at higher fiber content to fiber entanglement, poor bonding and clustering, which can also reduce workability.

The water absorption values increase with increasing DFN content in the reported data. Therefore, the optimum mix should be selected by considering strength, workability and durability together rather than relying on a single property.

### IX. Conclusion

Concrete containing 5% eggshell powder and 0.2%, 0.4% and 0.6% discarded fish net was evaluated against conventional concrete. The results indicate that 5% ESP with 0.2% DFN provides the best balance of the investigated properties. The mix achieved the highest reported 28-day compressive strength of 18.77 N/mm<sup>2</sup> and split tensile strength of 1.42 N/mm<sup>2</sup>. Higher DFN contents were associated with reduced workability and lower compressive performance. The use of eggshell powder provides a route for reducing cement consumption and utilizing waste, while discarded fish net provides fiber reinforcement and improved crack resistance. Thus, the investigated waste materials show potential for sustainable concrete when used at optimized proportions.

### X. References

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