Experimental Investigation on Partial Replacement of Cement with Eggshell Powder in Concrete

[1]Ganta Mounika, [2]M. Rajkumar, [3]T. Harshavardhan, [4]D. Narasimha Nayak

[1]Assistant Professor, Department of Civil Engineering, Vignana Bharathi Institute of Technology, Aushapur (V), Ghatkesar (M), Medchal (D), Telangana, India

[2,3,4]UG Student, Department of Civil Engineering, Vignana Bharathi Institute of Technology, Aushapur (V), Ghatkesar(M), Medchal(D), Telangana, India

Abstract: This project describes the effect and experimental results of partial replacement of eggshell powder in cement. The mechanical properties of concrete like compressive strength, split tensile strength, and workability will be determined at curing ages of 7 days and 28 days by replacing cement with varying percentages of eggshell powder (ESP) i.e., 5% ,10% and 15%. These values will be compared with conventional concrete results. The optimum percentage of replacement will also be determined for M20 grade mix and for a water cement ratio of 0.45.

Key words: Eggshell powder, compressive strength, split tensile strength, workability and optimum content for maximum strength.

I. INTRODUCTION

Concrete is a mixture of different materials like binder (cement), fine aggregate, coarse aggregate and water. Use of concrete is very large so availability of natural material is reduced and there is no material which plays the role of this ideal material. So, to fulfill the requirement of industries we have to replace fully or partially all the materials. Egg shells are agricultural throw away objects produced from chick hatcheries, bakeries, fast food restaurants etc. which can damage the surroundings and as a result comprising ecological issues/contamination which would need appropriate treatment. Egg shell also creates some allergies when kept for longer time in garbage. Use of egg shell waste instead of natural lime to replace cement in concrete can have benefits like minimizing use of cement, conserving natural lime and utilizing waste material. The egg shell primarily contains calcium, magnesium carbonate and protein. Egg Shell Powder (ESP) is the fine-grained powder with suitable proportion which is sieved to the required size before use with concrete/mortar.

II. MATERIALS

2.1 Cement: In the experimental investigation Ordinary Portland cement 53 grade was used. The cement procured was tested for physical properties in accordance with IS: 4031-1988.

2.2 Fine aggregate: River sand obtained from local market was used in this study. The physical properties of fine aggregate such as specific gravity, fineness modulus, porosity, void ratio etc were determined in accordance with IS: 2368-1963.

2.3 Coarse aggregate: The properties of the raw aggregate such as the size of the aggregate, the shape, the classification, the texture of the surface, etc. they play an important role in the workability and strength of concrete and the size of the raw aggregate used was 20 mm.

2.4 Egg shell powder: The chemical composition of eggshell powder and cement were almost same. Eggshells are collected at nearby Bachupally chicken hatchery Hyderabad. The eggshell powder making by using with the help of grinder and sieved by indian standard sieve 90 microns

Fig:1 Eggshells

Fig:2 Grinding the eggshells

III. MIX DESIGN

3.1 Mix proportion: M20 grade of concrete was selected and mix design is taken as per Indian standard code book i.e., IS10262-1982 and IS 383-1970, The mix proportion is 1: 1.5: 3 (1 is cement ,1.5 is fine aggregate and 3 is coarse aggregate)

3.2 Methodology: The selection of materials and their required quantities was determined using IS 10262: 2009. A rotary drum mixer was used. All the ingredients were put into the mixer and the water was added during the rotation. The workability test including slump are conducted on fresh concrete whereas the hardened concrete specimen are tested for direct compression and split tensile strength. The three tests used to measure the workability of concrete are Slump test, Compaction Factor, Vee-Bee test. As per IS: 10262-2009 workability of the concrete is considered by referring only the slump values.

IV. DESTRUCTIVE TESTS

a) COMPRESSIVE STRENGTH TEST: The 150 x 150 x 150 mm steel mould is tight and well oiled. The concrete is poured into the mould and properly tempered so as not to leave empty spaces. After 24 hours, these moulds were removed and allowed to cure in a hardening tank. They have been tested on a 200-tonne electrohydraulic closed-circuit machine. The test procedures were used according to IS: 516-1979

b) SPLIT TENSILE STRENGTH TEST: Concrete cylinders of 15 cm in diameter and 30 cm in length are used. The concrete is poured into the mold and properly tempered so as not to leave empty spaces. After 24 hours, these molds were removed and left to cure in a hardening tank and tested on a 200 tonne electro-closed-circuit machine.

V. RESULTS

5.1 Slump Test values:

Type of concrete mix	Slump in mm
Conventional concrete	10
5% partially replaced cement with eggshell powder	10
10% partially replaced cement with eggshell powder	10
15% partially replaced cement with eggshell powder	15

5.2 Concrete Test values for conventional concrete:

Tests	7 days	28 days
Compressive strength test (N/mm^2)	29.18	37.47
Split tensile strength test (N/mm^2)	2.07	2.54

5.3 Compressive strength at 7 days with ESP:

S.No	Percentage of Replacement with ESP	Compressive strength in N/mm^2
1	Conventional concrete (0%)	29.18
2	5	30.06
3	10	30.66
4	15	21.27

5.4 Compressive strength at 28 days with ESP:

S.No	Percentage of Replacement with ESP	Compressive strength in N/mm^2
1	Conventional concrete (0%)	37.47
2	5	27.106
3	10	27.18
4	15	25.48

5.5 Split Tensile strength at 7 days with ESP:

S.No	Percentage of Replacement with ESP	Split Tensile strength in N/mm^2
1	Conventional concrete (0%)	2.07
2	5	2.10
3	10	2.14
4	15	1.90

5.6 Split Tensile strength at 28 days with ESP:

S.No	Percentage of Replacement with ESP	Split Tensile strength in N/mm^2
1	Conventional concrete (0%)	2.54
2	5	2.306
3	10	2.336
4	15	2.00

VI. CONCLUSION

- **COMPRESSIVE STRENGTH TEST:**
- Compressive strength of concrete with 5% replacement of eggshell powder yielded less value when compared to conventional for 28 days by 27.65%.
- Compressive strength of concrete with 10% and 15% replacement of ESP yielded less value when compared to conventional for 28 days by 27.46% and 31.99% respectively
- Compressive strength of concrete with 5%,10% replacement of ESP yielded more value when compared to conventional for 7 days by 3.015 % and 5.07% respectively.15% of ESP replacement yielded less value when compared to conventional for 7 days.

- **SPLIT TENSILE STRENGTH TEST:**
- Split tensile strength of concrete with 5%,10% replacement of ESP yielded more value when compared to conventional for7days. 15 %of ESP replacement yielded less value when compared to conventional for 7days.
- Split tensile strength of concrete with 5% replacement of ESP yielded less value when compared to conventional for 28days by 9.21%.
- Split tensile strength of concrete with 10% and 15% replacement of ESP yielded less value when compared to conventional for 28 days by 9.21% and 8.03% respectively.

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