



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 9, September 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

Experimental Study on Strength of Concrete with Partial Replacement of Ingredients with Quarry Dust and Egg Shell Powder

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ABSTRACT: This paper presents an experimental investigation of Egg Shell Powder and quarry dust as Partial Replacement with Cement and fine aggregate in Concrete. Eggshell is an industrial waste commonly disposed in the landfills and are hazardous to environment. These eggshells are collected, cleaned and used as partial replacement for cement. Due to the lack of natural construction materials, quarry dust is used as replacement for fine aggregate in concrete. Slump and compaction factor tests are performed for fresh concrete. Hardened concrete with eggshell powder and quarry dust as a partial replacement are tested for compressive, flexure and split tensile strength as per BIS codal provision. The use of eggshell waste as a cementitious material instead of ordinary lime has several advantages, including the conservation of natural lime and the utilisation of waste material. The purpose of this study is to determine whether these inexpensive materials could be used as a cement establishing material.

KEYWORDS: Eggshell powder, quarry dust, compressive strength, split tensile strength

I. INTRODUCTION

Concrete is made up of cement, aggregates, water, and other additives. Concrete is a handy material that can be mixed to fulfil a wide range of unique requirements. Even in rural places and desert regions, the construction business is thriving. Even non-renewable materials such as cement are in short supply in India and other countries. As a result, the construction industry is under pressure to find alternate materials to cement in order to cut the cost of concrete. River sand is used as fine aggregate in concrete mix and is used increasingly and thus it is expensive due to the high cost of shipping from natural sources. Due to the lack of natural construction materials, we have to think about the other alternatives available for replacement. Replacement of sand with QD by 55% to 75% is ideally used to obtain optimum compressive strength. In terms of annual egg output, India is ranked second in the globe. Garbage Disposal of these egg shells is a significant chore because they attract vermin and cause problems with human health and the environment if they're dumped in landfills. Egg shells are often high in calcium and have a limestone-like composition. The use of eggshell waste as a cementitious material instead of ordinary lime has several advantages, including the conservation of natural lime and the utilisation of waste material. The purpose of this study is to determine whether these inexpensive materials could be used as a cement establishing material. In this experimental study, the powder of waste eggshells is used as a cement replacement and by-product of crushing stone plant i.e., quarry dust is used as a sand replacement.

II. EXPERIMENTAL PROGRAM

Materials Used: OPC of 43 grade cement is used as per IS 269 (2015). River sand is procured from local quarry as fine aggregate (FA). Quarry dust (QD) is collected from local stone crushing units. Coarse aggregates (CA) are collected from local stone crusher plant is used. Eggshell is collected from local bakeries and fast-food corner and are powdered to form eggshell powder (ESP).

Concrete Mix Design: M25 grade concrete with varying percentage of ESP and QD for Cement and FA (River sand) respectively done according to IS 10262 (2019) codal provisions for severe condition. Table 1 shows the mix design proportions for M25 grade concrete.

Table 1: Mix proportion for M25 grade concrete

Sl No.	Ingredients	Value
1	Cement (kg/m^3)	380
2	CA (kg/m^3)	1170
3	FA (kg/m^3)	717
5	w/c ratio	0.5
6	Water (liters)	180

Workability of fresh concrete in terms of slump and compacting factor tests are conducted as per IS 1199-Part 2 (2018). Compressive and split tensile strengths on hardened concrete specimens is conducted as per IS 516-Part 1 (2021).

Table 2: Material quantity of different mixes used in casting of specimens for replacing cement with ESP

Mix	w/c ratio	% of replacement	Cement (Kg)	FA (Kg)	CA (Kg)	ESP (Kg)	Water (ltr)
Material quantity of different mixes used in casting for 3 cubes replacing cement with ESP							
M0	0.5	0	4.608	8.711	14.215	0	2.187
M1	0.5	10	4.147	8.711	14.215	0.460	2.187
M2	0.5	20	3.688	8.711	14.215	0.920	2.187
M3	0.5	30	3.228	8.711	14.215	1.380	2.187
Material quantity of different mixes used in casting for 3 Cylinder replacing cement with ESP							
M0	0.5	0	7.25	13.685	22.33	0	3.435
M1	0.5	10	6.525	13.685	22.33	0.725	3.435
M2	0.5	20	5.075	13.685	22.33	1.45	3.435
M3	0.5	30	2.9	13.685	22.33	2.175	3.435

Table 3: Material quantity of different mixes used in casting of specimens for replacing FA with QD

Mix	w/c ratio	% of replacement	Cement (Kg)	FA (Kg)	CA (Kg)	QD (Kg)	Water (ltr)
Material quantity of different mixes used in casting for 3 cubes replacing FA with QD							
M0	0.5	0	4.608	8.711	14.215	0	2.187
M1	0.5	10	4.608	7.8399	14.215	0.8711	2.187
M2	0.5	20	4.608	6.9688	14.215	1.7422	2.187
M3	0.5	30	4.608	6.0977	14.215	2.6133	2.187
Material quantity of different mixes used in casting for 3 Cylinder replacing FA with QD							
M0	0.5	0	7.25	13.685	22.33	0	3.435
M1	0.5	10	7.25	12.317	22.33	1.368	3.435
M2	0.5	20	7.25	10.948	22.33	2.737	3.435
M3	0.5	30	7.25	9.5795	22.33	4.1055	3.435

Table 4: Material quantity of different mixes used in casting of specimens for replacing Cement with ESP and FA with QD.

Mix	w/c ratio	% of replacement	Cement (Kg)	FA (Kg)	CA (Kg)	ESP (Kg)	QD (Kg)	Water (ltr)
Material quantity of different mixes used in casting for 3 cubes replacing FA with QD								
M0	0.5	0	4.608	8.711	14.22	0	0	2.19
M1	0.5	10	4.147	7.839	14.22	0.460	0.8711	2.19
M2	0.5	20	3.688	6.968	14.22	0.920	1.7422	2.19
M3	0.5	30	3.228	6.097	14.22	1.380	2.6133	2.19
Material quantity of different mixes used in casting for 3 Cylinder replacing FA with QD								
M0	0.5	0	7.25	13.685	22.33	0	0	3.435
M1	0.5	10	6.525	12.317	22.33	0.725	1.368	3.435
M2	0.5	20	5.075	10.948	22.33	1.45	2.737	3.435
M3	0.5	30	2.9	9.5795	22.33	2.175	4.1055	3.435

III. RESULTS AND DISCUSSIONS

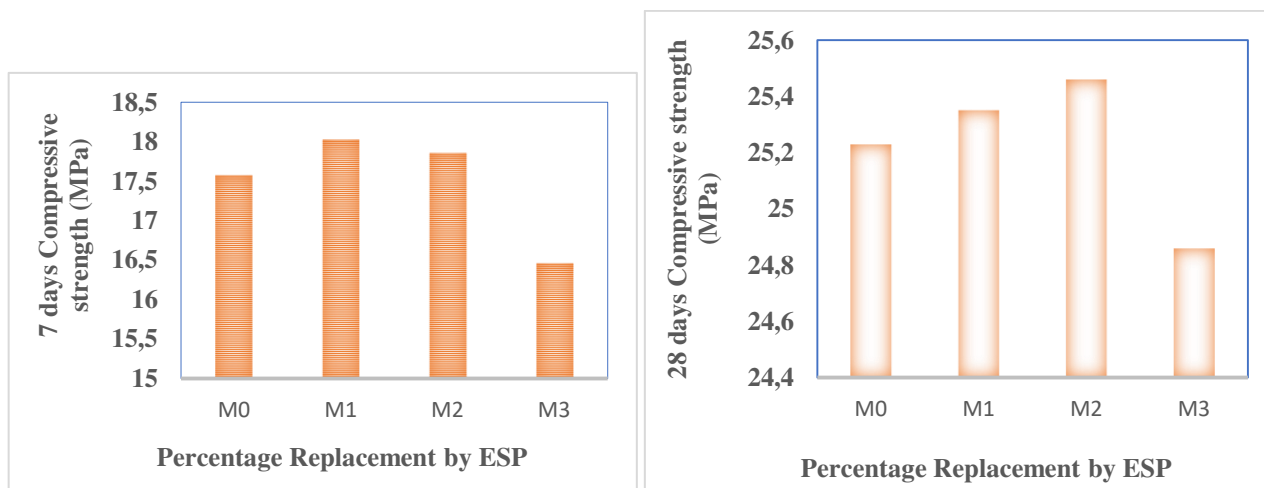
Table 5 shows the tests carried out on fresh concrete.

Table 5: Tests results of fresh concrete

Mix	Slump (mm)	Compaction Factor
M25	75	0.82

Compressive strength test results for replacement of cement with ESP

Figure 1 shows the 7 days and 28 days compressive strength of cube specimens. Compressive strength increases with increase in the % of partial replacement of cement with eggshell powder up to 20%.

**Fig. 1. Compressive strength test results for replacement of cement with ESP**

Compressive strength test results for replacement of FA with QD

Figure 2 shows the 7 days and 28 days compressive strength of cube specimens. Compressive strength increases with increase in the % of partial replacement of cement with eggshell powder up to 20%.

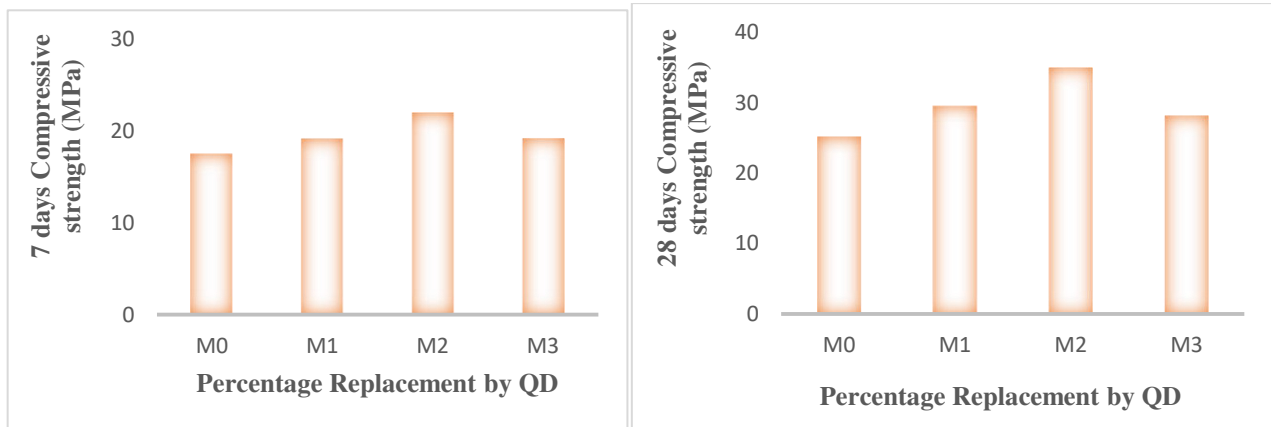


Fig. 2. Compressive strength test results for replacement of FA with QD

Compressive strength test results for replacement of Cement and FA with ESP and QD

Figure 3 shows the 7 days and 28 days compressive strength of cube specimens for replacement of Cement and FA with ESP and QD. For 7 days curing, 17.577 N/mm² compressive strength is observed for conventional concrete. The compressive strength increases with increase in replacement up to 25% and later it decreases. For 28 days curing, compressive strength increases with increases in replacement up to 25% and later it decreases. For conventional concrete, compressive strength is 25.232 N/mm².

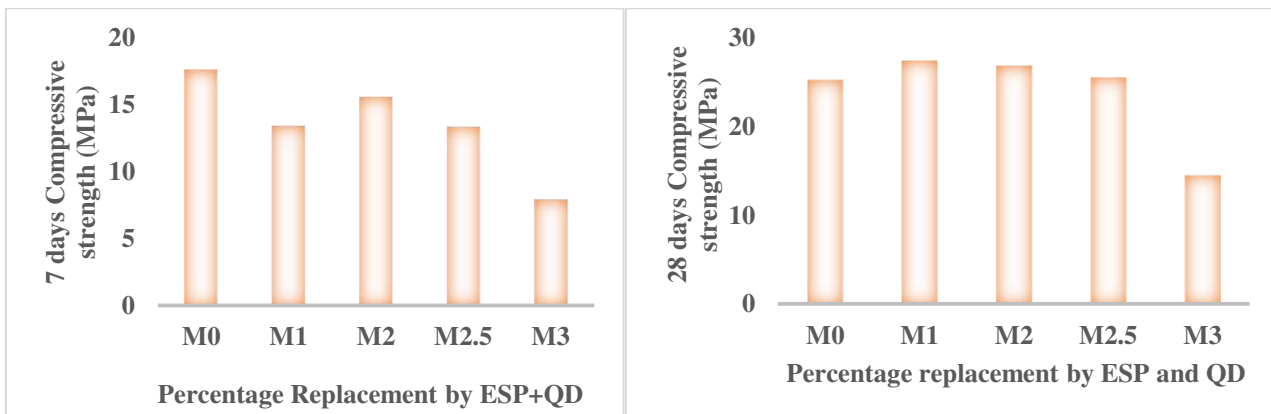


Fig. 3. Compressive strength test results for replacement of Cement and FA with ESP and QD

Split Tensile strength test results for replacement of cement with ESP

Figure 4 shows the 28 days Split Tensile strength test results for replacement of cement with ESP.

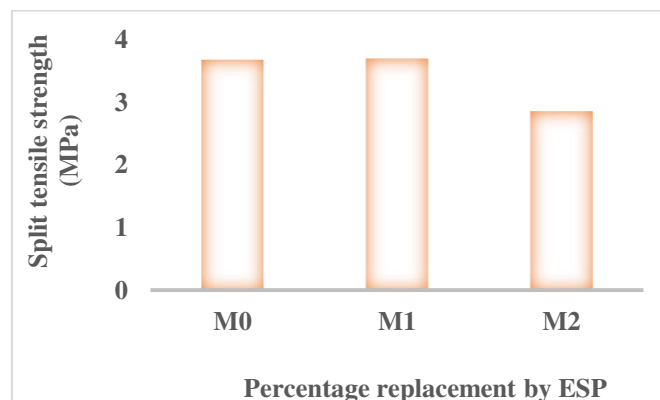


Fig. 4. Split Tensile strength test results for replacement of Cement with ESP

Split Tensile strength test results for replacement of FA with QD

Figure 5 shows the Split Tensile strength test results for replacement of FA with QD.

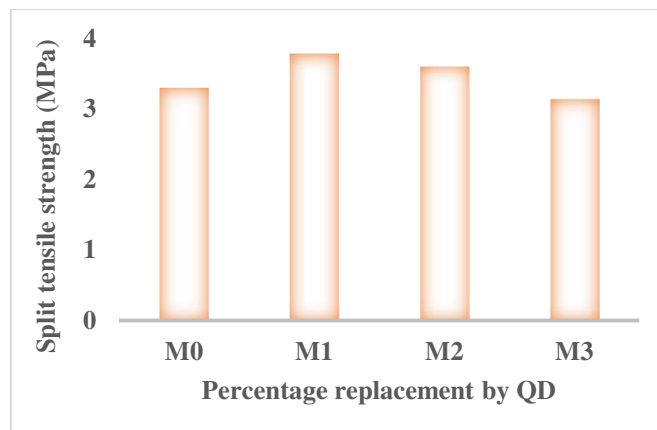


Fig. 5. Split Tensile strength test results for replacement of FA with QD

Split Tensile strength test results for replacement of cement and FA with ESP and QD respectively

Figure 6 shows the Split Tensile strength test results for replacement of cement and FA with ESP and QD respectively. Split tensile strength fails to achieve the expected strength.

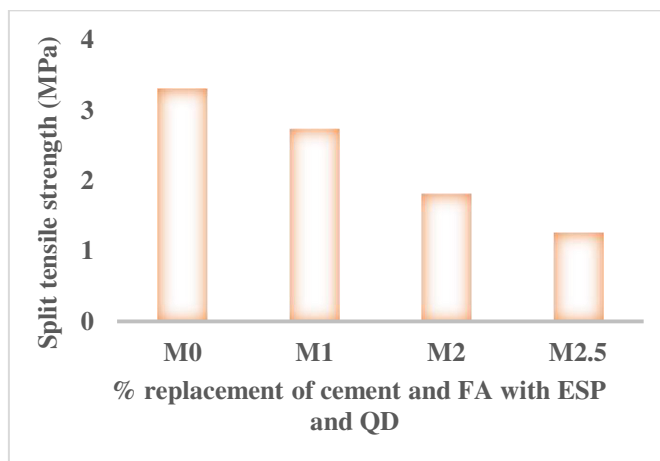


Fig. 6. Split Tensile strength test results for replacement of cement and FA with ESP and QD

IV. CONCLUSION

From the experimental test results, the following observations are made

1. Compressive strength increases with increasing proportion of fractional substitution of FA (River Sand) up to 20%.
2. From compressive strength results, increases with increase in the % of partial replacement of cement with eggshell powder up to 20%.
3. For 7 days curing, 17.577 N/mm² compressive strength is observed for conventional concrete. The compressive strength increases with increase in replacement up to 25% and later it decreases.
4. For 28 days curing, compressive strength increases with increases in replacement up to 25% and later it decreases. For conventional concrete, compressive strength is 25.232 N/mm².
5. For 28 days curing, split tensile strength fails to achieve the expected strength.
6. From the thorough inspection of tested specimen, it can be noticed that concrete specimen with replacement of ingredients split into two pieces after attaining the failure load.



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