

An Experimental Study on Strength of Concrete by Partial Replacement of Cement by Egg Shell Powder and Aggregates by Crumb Rubber

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Abstract- Concrete is one of the most widely used construction material throughout the world. Hence, it has been labelled as the backbone to the infrastructure development of a nation. To fulfil the requirements of industries, we have to replace fully or partially the constituent materials of concrete by using waste materials. The study was carried out to evaluate the properties of concrete by replacing the cement by Egg Shell Powder (ESP) and fine aggregate by Crumb Rubber (CR) by varying the percentages of ESP (5%, 10%, 15%) and CR (2.5%, 5%, 7.5%, 10%). A comparison of partially replaced concrete with conventional concrete was also included in the study. Comparison of weights of Natural Concrete with partially replaced concrete after 28 days of curing was also carried out. The mix designs arrived for an M30 mix. Fresh properties including Slump flow test and Compaction factor test were carried out for both conventional concrete and partially replaced concrete. Hardened properties of concrete like Compressive Strength, Flexural Strength and Split Tensile Strength tests were carried out for traditional concrete and partially replaced concrete.

Index Terms - Compressive Strength, Concrete, Crumb Rubber, Egg Shell Powder, Flexural Strength, Slump Flow Test, Split Tensile 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. In India number of waste materials is produced by different manufacturing companies, thermal power plant, municipal solid wastes and other wastes. Solid as well as liquid waste management is one of the biggest problems of the whole world. During manufacturing of one tonnes Ordinary Portland Cement (OPC) we need about 1.1 tonnes of earth resources. Further during manufacturing of one tones of cement an equal amount of carbon dioxide is released in to the atmosphere which acts as a silent killer in the environment as various forms. In this backdrop, the search for cheaper substitute to OPC is a needful one.

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.

Waste tyre rubber is a promising material in the construction industry due to its light weight, elasticity, energy absorption, sound and heat insulating properties. An emerging use is the production of concrete, in which tyre rubber particles partially replace the natural aggregates. This has the additional advantage of saving in natural aggregates used in the production of concrete.

Crumb Rubber (CR) is the processing of the tyre into fine granular or powdered particles using mechanical or cryogenic processes. CR consists of particles ranging in size from 4.75 mm to less than 0.075 mm. Large amount of waste tyre rubber accumulate in the world every year, and the easy process to decompose the rubber by burning but because of burning of rubber a large amount of smoke and pollution is generated. Another method to dispose waste rubber is by landfill, but now a days availability and capacity of landfill places decreases. So we can go for partial replacement of fine aggregates with CR to obtain good engineering properties of concrete.

The primary objective of the study is to evaluate different properties of partially replaced concrete including fresh and hardened properties. Objective of project work also includes the effect of partial replacement of cement with Egg Shell Powder and fine aggregate with Crumb Rubber and to compare the weight of normal concrete with rubbercrete concrete.

II. EXPERIMENTAL PROGRAMME

Material Properties

The materials used for concrete were Binder materials, Fine Aggregate (FA), Coarse Aggregate (CA), Egg Shell Powder (ESP), Crumb Rubber (CR) and water. Binder used for this study is cement. Cement used was Portland Pozzolana Cement (PPC). The manufacturer of the cement is Ramco. Egg Shell Powder is used in the study to replace cement. Broken egg shells collected from the local sources. The shells cleaned in normal water and air dried for 5 days approximately at a temperature range of 25 – 30°C. The shells then crushed ground and sieved through 90 µm sieve. Material passed through 90 µm sieve was used for cement replacement. Fine aggregate used was M-sand from local quarry. Crumb Rubber used in the study to replace fine aggregate. The waste tyre Crumb Rubber particles passed through 1.18 mm IS sieve and retaining on 600 µm was used for replacing fine aggregate. Coarse aggregate used for the study was also collected from local quarry. Properties of materials used were tabulated in **Table 1**.

Table 1 Material Properties

Materials	Specific Gravity	Impact Value (%)	Crushing Value (%)	Fineness modulus
M-sand	2.73	-	-	3.5
CA	2.73	34.44	37.53	-
CR	1.05	-	-	-
ESP	2.37	-	-	-

Mix Proportioning

The mix design for traditional concrete was carried out as per IS 10262: 2009 [1] for an M 30 mix for a slump of 100mm. The mix proportion for M 30 mix is tabulated in **Table 2**. The nomenclature used in the study is in **Table 3**.

Table 2 Mix Proportions for M30 Concrete

Materials	Cement	Water	FA	CA
Weight (kg/m ³)	437.78	197	783.37	1025.79

Table 3 Nomenclature

No	Mix	Concrete Mix Proportion
1	NC	M30- Conventional concrete
2	CR2.5	Concrete with 2.5% CR replacement
3	CR5.0	Concrete with 5.0% CR replacement
4	CR7.5	Concrete with 7.5% CR replacement
5	CR10	Concrete with 10% CR replacement
6	CR10-ESP5	Concrete with 10% CR replacement & 5%ESP replacement
7	CR10-ESP10	Concrete with 10% CR replacement & 10%ESP replacement
8	CR10-ESP15	Concrete with 10% CR replacement & 15%ESP replacement

Fresh and Hardened Properties

Slump test and compaction factor test was conducted for determining the fresh properties of concrete. For determining the mechanical properties, the test specimens were removed from water bath and surface water was removed using dry cloth, immediately before testing. This was done to ensure that the test specimens were tested at a saturated surface dry condition. Various tests carried out on hard concrete are compressive strength, flexural strength and split tensile strength.

III. RESULT AND DISCUSSION

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Fresh Properties of Concrete

The workability of all the mixes are tabulated in **Table 4**. From the test results, it was found that the workability of the mixes decreased with increase in crumb rubber and egg shell powder percentages

Table 4 Fresh Properties of Concrete

Mix	Slump (mm)	Compaction Factor
NC	80	0.94
CR2.5	70	0.94
CR5.0	63	0.95
CR7.5	60	0.95
CR10	59	0.95
CR10-ESP5	68	0.93
CR10-ESP10	67	0.94
CR10-ESP15	65	0.94

Hardened Properties of Concrete

Compressive strength of all the mixes were obtained as: the strength decreases with increase in Crumb Rubber percentage which is shown in **Figure 1**. **Figure 2** shows slight increase in compressive strength with 5% egg shell powder replacement.

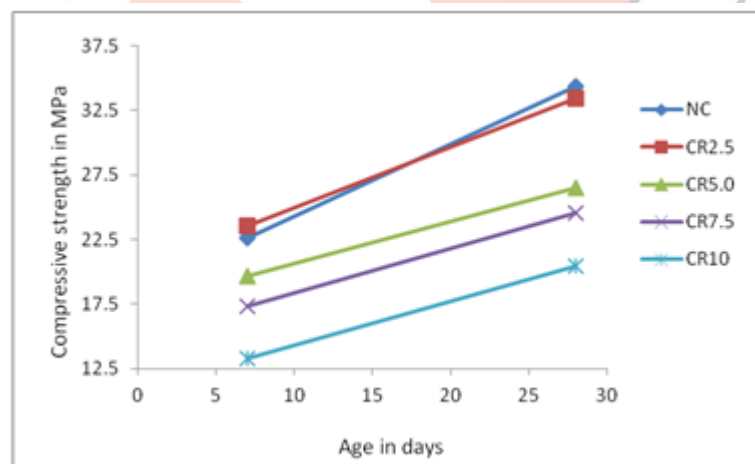


Fig. 1. Compressive Strength of Concrete with varying percentages of Crumb Rubber

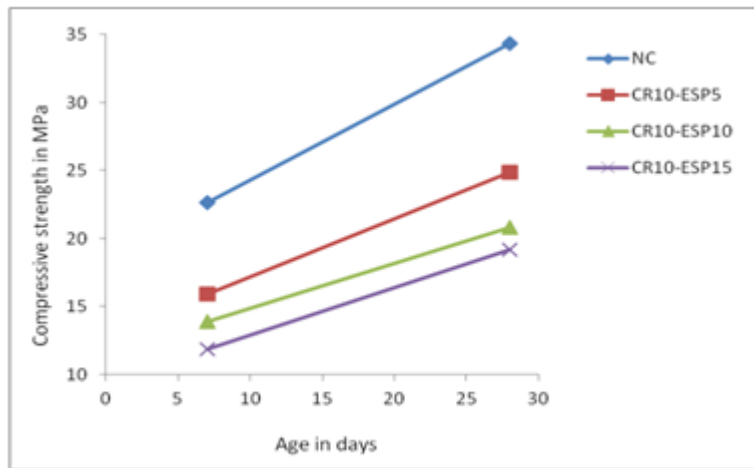


Fig. 2. Compressive Strength of Concrete with varying percentages of Egg Shell Powder

Flexural strength also decreases with increase in the crumb rubber percentages and is shown in **Figure 3**. But **Figure 4** shows slight increase in flexural strength with 5% egg shell powder replacement. Split tensile strength also shows the same variation which was shown in **Figure 5** and **Figure 6**

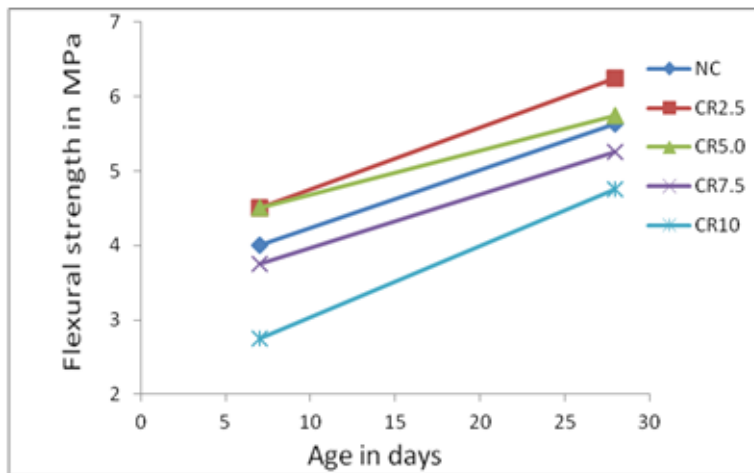


Fig. 3. Flexural Strength of Concrete with varying percentages of Crumb Rubber

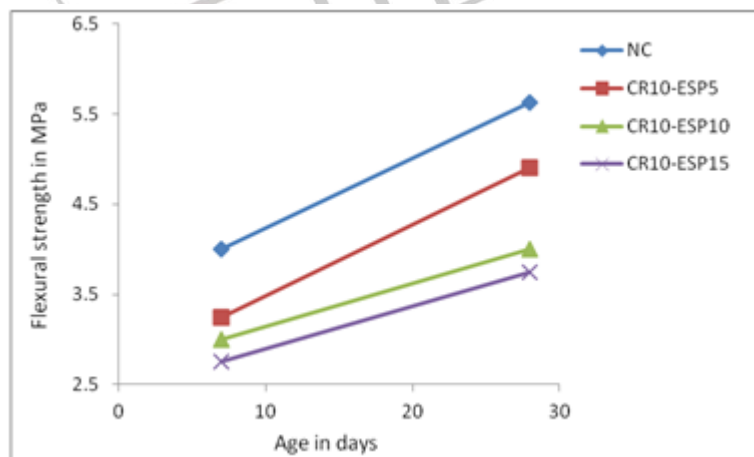


Fig. 4. Flexural Strength of Concrete with varying percentages of Egg Shell Powder

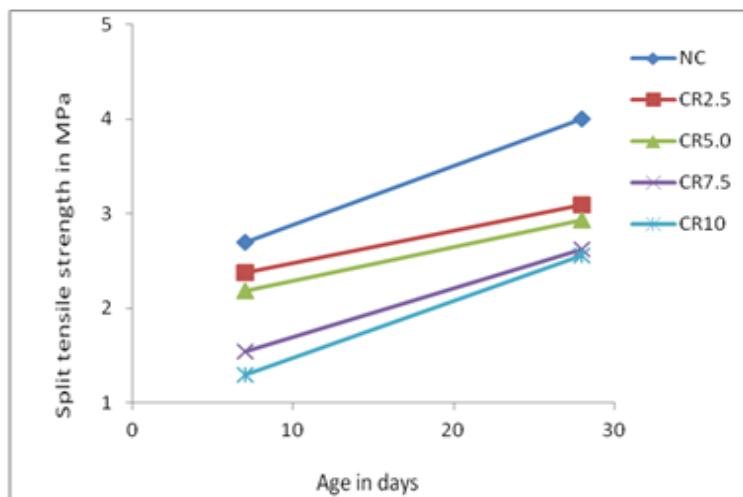


Fig.5.Split Tensile Strength of Concrete with varying percentages of Crumb Rubber

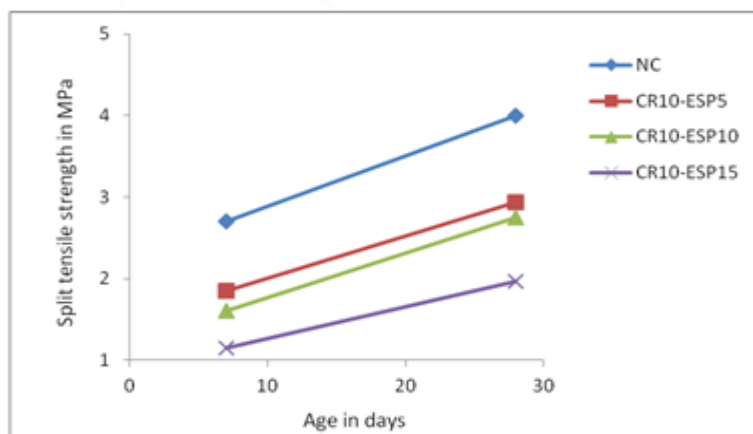


Fig.6.Split Tensile Strength of Concrete with varying percentages of Egg Shell Powder

Determination of Unit weight

The unit weight values used for the analysis of this section are measured from the concrete cube samples after 28 days of standard curing. From the results, it was found out that the reduction of unit weight was observed when the volume of fine aggregate was replaced by crumb rubber in sample

Table 5 Unit Weight of Rubberised Concrete

Type of Concrete	Unit Weight (kg/m ³)
NC	2429.62
CR2.5	2400.00
CR5.0	2340.74
CR7.5	2296.36
CR10	2254.81

IV. CONCLUSION

This study examines the compressive, flexural and split tensile behavior of the concrete when it is partially replaced with Crumb Rubber and Egg Shell Powder. The following conclusions can be drawn from experimental results:

1. The compressive strength of concrete decreased with increase in varying percentages of Crumb Rubber.
2. The compressive strength of concrete shows slight increase when 10% CR replaced concrete was replaced with 5% of ESP.
3. Both flexural and split tensile strength decreased with increase in CR content.
4. Replacing cement by 5% ESP in 10% CR replaced concrete shows increase in both flexural and split tensile strength.
5. Comparing the unit weights of normal concrete with rubbercrete concrete showing reduction in weight with increase in CR percentages.

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