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EFFECT OF PARTIAL REPLACEMENT OF CEMENT BY EGGSHELL POWDER AND COARSE AGGREGATE BY CERAMIC TILE WASTE IN CONCRETE

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Abstract: *The main objective of this research is to determine the workability, compressive strength, split tensile strength, and flexure strength of concrete prepared by using ceramic tile waste and eggshell powder. On the basis of previous researches which has been done we make a comparison of strength properties of concrete made with replacement and conventional concrete. Cement is replaced by eggshell powder in the following percentages 4%, 8%, 12%, 16%,20%,24% and coarse aggregate is replaced by ceramic tile waste in the following percentages 7%, 14%, 21%, 28%, 35%, 42%. The graded of concrete used for this research work is M30. Different specimens of the material are tested for strength. The result shows that concrete workability is fine and within limits after replacing cement with eggshell powder and coarse aggregate by ceramic tile waste. However, workability gets reduced at higher replacement of materials. The strength parameters such as compressive strength, flexural strength, and split tensile strength also increase and show an optimum value at 12% cement replacement and 21% replacement of coarse aggregate by eggshell powder and ceramic tile waste, respectively. Test results are satisfactory up to 16% and 28% replacement of ESP and CTW resp. After this, there is a decrease in the strength of concrete. So, after this research work, we are able to find out that the replacement can be done to this extent but there may be chances of higher percentage of replacement by doing further investigations.*

Keywords-Eggshell Powder, Ceramic Tile Waste, Compressive Strength, Flexural Strength, Split Tensile Strength.

1.INTRODUCTION

Any construction activity requires several materials such as steel, bricks, concrete, wood etc. However, concrete is the main material required in construction industry. Concrete itself is made up of different constituent materials such as cement, coarse and fine aggregates, water etc. concrete is considered as the backbone of the construction industry. It is because most of the constructions uses concrete as compared to the other materials. Since concrete is made up of different materials, so its strength, adaptability and suitability depend upon the properties of materials from which it is made. Cement is considered as the main component in concrete as it binds the other materials in the concrete. Maximum volume of concrete is occupied by the aggregates i.e. (75-80 %). Coarse aggregates provide strength to the concrete and fine aggregates acts as filler material. It is estimated that concrete consumption on earth is in the order of 11.5 billion tons per year. Also, the waste disposal is the major problem nowadays. Various wastes have been generated daily on a large scale by different industries as well as by other sources and there is no proper way of disposing such wastes. Accumulation of these wastes is increasing day by day and such accumulation of wastes poses a serios threat to our society as well as to our environment. So, it is a very good idea if we are able to use such wastes in a productive way which are otherwise dangerous for our environment. To use such wastes in a productive way we have to study about the properties of different wastes separately and their composition also so that we can utilize different wastes according to their potential and in the right place where we can get maximum benefit of such wastes because different wastes generating from different locations have different properties as well as different uses.

1.1 Eggshell Powder (ESP)

Among the different wastes eggshell is also one of the wastes. India is third largest egg producer in the world. Every day egg company in the world process nearly one million eggs. If it is to be estimated, about 10,000 tons of eggshells have to be willing each year. Most of the eggshell waste is put out in the landfill without any pretreatment because it is useless and, in many countries, requires pretreatment before dumping. Eggshell waste also attracts vermin due to the membrane attached to it. So, it is a threat to the environment and human health. The utilization of this waste will lead to a sustainable environment. Also, utilizing eggshell powder in place of cement will reduce carbon dioxide emissions during the production of cement and decrease air pollution. This will lead to the economic growth and development of countries. Eggshell waste evolves from poultry farms, restaurants, and hotels where there is the consumption of eggs. Eggshells are rich in calcium and have the same limestone composition as cement. Researchers have reported that eggshell mainly contains calcium in the form of Calcium Carbonate (90%) and the remaining masses contain Phosphorus, Magnesium, traces of sodium, zinc, manganese, iron, and copper. The research done so far suggests that eggshell powder shows the binding property of the cement. So, the need arises for the bioconversion of waste into usable energy. Eggshell powder is also a cheap alternative material in place of cement which can reduce the overall cost of construction and impact on the environment to a large extent. The Eggshell Powder is shown in Fig.1.

Fig-1 Eggshells

1.2 Ceramic Tile Waste

Ceramic tile waste is the waste of tiles generated from ceramic industry as well as from construction sites because most of the tiles get wasted during construction. ceramic tile waste is the waste which is produced on a large scale as compared to other wastes that are being used in replacement. India ranked third in the production of tiles. Ceramic wastes are created in different forms some of which are produced in companies during and after production process due to errors in construction, human activities and also inappropriate raw materials. Some others are produced in transportation and distribution process and finally the most bulk of them are created as a result of destroying constructions. It is predicted that about 30 % of daily production of ceramic materials in India gets converted into wastage and this amount of wastage reaches to million tons per year. This waste is not recycled in any form at present. Therefore, they cause environmental and disposal problems. So, it is a good idea to use this waste in the place of coarse aggregates in concrete so that on one hand our natural resources get saved and the disposal problem of this waste also get solved. Ceramic waste is durable, hard and highly resistant to different attacks of environment. Ceramic waste consists of 15 to 45 % of sand, 30 to 50 % of clay, 10 to 13 % of limestone, and 5 to 30 % of granite. Ceramic tile waste is a waste material which is generated at a very fast rate so it is a very good step to use it as a useful material but with proper care and handling. In this research work ceramic tile waste was collected from various construction sites and also from tile stores and this tile waste was converted into required size i.e., in the range of 10-20 mm by manual hammering. Flaky aggregates were removed. The properties of the concrete made with ceramic waste are well within the range of the values of concrete made with virgin aggregates. Ceramic Tile Waste is shown in the Fig.2.

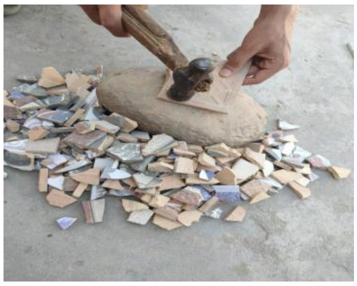


Fig-2 Ceramic Tile Waste

2. OBJECTIVE

a. To perform the following test and to compare the results with and without replacement of eggshell powder and ceramic tile waste
   - Compressive Strength Test.
   - Flexural Strength Test.
   - Split Tensile Strength Test.

b. To reduce the overall environmental effects of concrete production using eggshell powder and ceramic tile waste as partial replacement.

c. Workability of concrete.

3. LITERATURE REVIEW

Kamran Basit et al. (2019): This paper studies the various strength parameters of concrete made with varying proportions of egg shell powder viz 0%, 5%, 10%, 15% and 20% as replacement of cement and concluded that the highest strength is achieved at 10% replacement of cement with ESP. Also concluded that split elastic qualities of ESP cements were practically similar to traditional cement up to 15% ESP replacement. The workability characteristics of the concrete with varying ratio of ESP were also studied through slump cone test.

Bikash Subedi et al. (2020): In this study the physical characteristics of ceramic tile aggregates are measured. They are used in concrete as the substitute for the coarse aggregates with 0%, 5%, 10% ,15%, 20%, 25%, 30% and 35% substitution. The optimum percentage is 10% for 7 days compressive strength and 25% for 28 days compressive strength. With the addition of tile aggregate in the making of concrete split tensile strength was also increased.

4. MATERIAL AND PROPERTIES

4.1 Cement

Cement is a binding material used in the preparation of concrete. It binds the coarse aggregates and fine aggregates with the help of water and it also fills the voids in the concrete. The name ordinary Portland cement (OPC) is reserved for a cement which is an extremely finely grounded product obtained by burning calcareous and argillaceous raw materials at high temperature. Cement used in this study is OPC 43 grade cement conforming to IS: 8112 throughout the work. The relevant lab has provided information on the cement's physical qualities.

Fig-3 43 Grade OPC Cement

Table 1 Properties of Cement

S.No.	Properties	Test Results	IS: 8112-1989
1.	Normal Consistency	31%	<34%
2.	Initial Setting Time	65 min	>30 min
3.	Final Setting Time	450 min	<600 min
4.	Specific Gravity	3.14	3.1-3.15
5.	Fineness	4%	<10%

4.2 Fine Aggregate

Fine aggregate consists of crushed sand particles or natural river sand passing through a 4.75mm sieve. In general, river sand is used as a fine aggregate having a particle size of 0.07mm. Fine aggregates used in this research was locally available sand from Akhnoor in district Jammu. Sieve analysis was done to determine the sand zone as per IS: 383-1970. Physical properties of sand like fineness modulus, specific gravity was determined. The physical properties of sand were provided by the concerned lab. It conforms to IS 383 1970 comes under zone II.

Fig.4- Fine Aggregate

4.3 Coarse Aggregate

Aggregate which has a size larger than 4.75 mm or which retrained on 4.75 mm IS Sieve are known as Coarse aggregate. Coarse aggregates must be tough, pristine, and devoid of any chemical coating of clay and dust on the surface in order to make a decent concrete mix Coarse aggregates used in this research were locally available crushed aggregates of size 20mm and 10mm in the proportion of 60 and 40 respectively. Grading of coarse aggregate was done according to IS: 383-2016. Detailed sieve analysis of coarse aggregates shown in Table 3.5. Specific gravity and water absorption of coarse aggregates were determined according to IS: 2380 (Part 3) of 1963. The concerned lab provided the properties of coarse aggregate.

Fig.5- Coarse Aggregate

4.4 Eggshell Powder (ESP)

Eggshell waste evolves from poultry farms, restaurants, and hotels where eggs are consumed. Instead of damping, it can be used as supplementary material in place of cement. Eggshells are rich in calcium and have the same limestone composition as cement. Eggshells were collected, cleaned, dried and then converted into fine powder to use as a supplementary material with cement.

Table 2: Chemical Composition of Eggshell Powder

Chemical Composition	Cement(%)	ESP (%)
SiO_2	21.8	0.09
Cao	60.1	52.1
Al_2O_3	6.7	0.04

Fe_2O_3	4.1	0.03
MgO	2.2	0.01
K_2O	0.4	-
Na_2O	0.4	0.15
SO_3	2.2	0.62

4.5 Ceramic Tile Waste (CTW)

It is predicted that about 30 % of daily production of ceramic materials in India gets converted into wastage and this amount of wastage reaches to million tons per year. Therefore, they cause environmental and disposal problems. So, it is a good idea to use this waste in the place of coarse aggregates in concrete so that on one hand our natural resources get saved and the disposal problem of this waste also get solved. Ceramic tile waste is a waste material which is generated at a very fast rate so it is a very good step to use it as a useful material but with proper care and handling. In this research work ceramic tile waste was collected from various construction sites and also from tile stores and this tile waste was converted into required size i.e., in the range of 10-20 mm by manual hammering. Flaky aggregates were removed. The properties of the concrete made with ceramic waste are well within the range of the values of concrete made with virgin aggregates.

Table 3: Chemical Composition of Ceramic Waste

Chemical Composition	CTW%
SiO_2	64.55%
AL_2O_3	15.08 %
Fe_2O_3	6.02 %
Cao	4.14%
K_2O	2.21%
MgO	2.05%

4.6 Water

Water is to be considered as the main constituents in the production of concrete. The normal portable tap water must be used in the production of concrete. Water which is to be use in the research work should be free from all kinds of impurities. The ph. of the water should be in desired range. Potable water was used in this research for mix as well as for curing specifications conforming to IS 456-2000.

5. METHODOLOGY

5.1 Batching: Different constituents of concrete are collected and weighed appropriately. The materials to be replaced are also measured and there is proper mixing of materials. The water is added properly to prepare a better mix and after preparing the mix, the mixture is transferred to respective moulds.

Fig.6- Mixing of Material

5.2 Casting: The workability test is performed for each mix via slump cone test before transferring the concrete into moulds. The moulds are properly oiled or greased. Concrete is transferred into the moulds along with proper compaction. After filling the mould, the top of the mould is properly levelled and the extra material is removed off.

Fig.7- Casting of specimens

5.3 Curing: After the preparation of mould, it is allowed to set for 24 hours. After 24 hours, moulds are opened and the specimens are placed in a water tank for curing for 28 days. The specimens must be marked for identification so that there must not be any error. Curing of specimens was done in portable water which is free from all kinds of impurities otherwise it will affect the concrete strength. The specimens must be dried before putting under testing machine.

Fig.8- Curing

5.4 Slump cone test: Concrete slump test is performed on freshly mixed concrete to determine the workability or consistency of concrete mix. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction. In our project, we performed slump cone test for every set of specimens to check the uniformity and workability of the mix. The apparatus of slump cone test cone test consists of a frustum cone of 20 cm dia at top and 10 cm at bottom. Height of cone is 30 cm. It also consists of a tamping rod of length 600mm and dia 16mm, base plate and measuring scale.

Fig.9- Slump Test

5.5 Compressive Strength Test: Compressive strength test provides the characteristic strength of concrete. Compressive strength of concrete depends upon many factors such as water-cement ratio, material quality and quality control during production of concrete etc. Compressive strength test is generally performed on cubes of concrete of size 15cm x 15cm x 15cm or 10cm x 10cm x 10cm. In this project, we use cubes of size 15cm x 15cm x 15cm for compressive strength test. The compressive strength test is performed in compression testing machine.

Fig.10- Compression Test

5.6 Flexural Strength Test: Flexural strength of concrete is the ability of concrete beam or slab to resist failure in bending. Many structural components such as beams and slabs are subjected to flexing or bending and it is necessary that such components should be able to resist bending or tensile forces. For performing the flexural strength test, we use specimen in the form of a beam of size 150mm x 150mm x 700mm. For testing, the beam is placed longitudinally in the steel rollers. Apparatus consists of: tamping rod of 600mm length and 16mm dia, weighing balance, a beam mould.

Fig.11- Flexural Strength Test

5.7 Split Tensile Strength Test: The split tensile strength test is an indirect tensile test generally used to determine the tensile strength of concrete. It is known that the concrete is good in compression but weak in tension, so cracks develop when tensile forces exceed the tensile strength of concrete. This test can be performed on UTM. Apparatus consists of: tamping rod of length 600mm and dia 16 mm, weighing balance, cylindrical mould of size 150mm x 300mm.

Fig.12-Split Tensile Strength Test

6. RESULT AND DISCUSSION

6.1 Concrete Mix Design

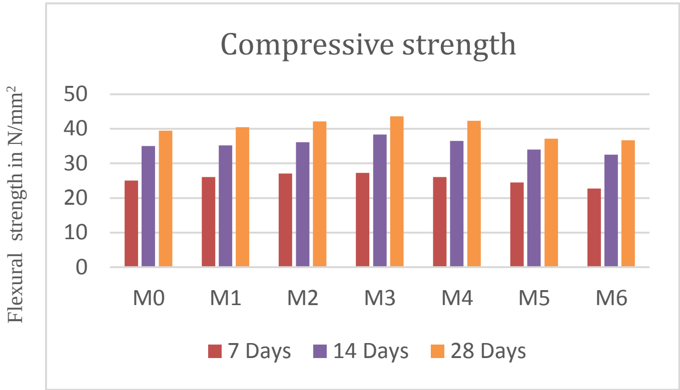
Based on trial mixes for different proportions of ingredients, the final design mix was prepared for M30 grade of concrete as per IS 10262:2009. The concrete mix proportion and w/c ratio was considered as 0.43 and with varying percent of eggshell powder and ceramic tile waste and design was done. The different specimens as per the requirement for test were casted. The specimens were tested after 7,14 and 28 days of curing. In each category the specimens to be tested and average value is reported in the form of graphs.

6.2 Compression Test

The total of 63 cubes was tested at 7 days, 14 days, 28 days. The value of each test is provided in the table below:

Table-8: Compressive Strength Results

Mix	Specimen Details	Compressive Strength (N/mm²)		
		7 Days	14 Days	28 Days
M0	Convention Concrete	25.04	34.99	39.44
M1	4% ESP + 7% CTW	26.07	35.24	40.46
M2	8% ESP + 14% CTW	27.12	36.15	42.18
M3	12% ESP + 21% CTW	27.24	38.39	43.58
M4	16% ESP + 28% CTW	26.10	36.53	42.28
M5	20% ESP + 35% CTW	24.53	33.97	37.17
M6	24%ESP+42%CTW	22.74	32.51	36.68



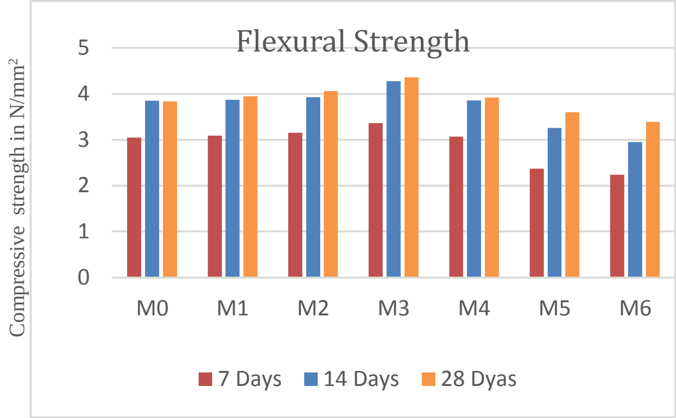
Graph 1-: Compressive Strength Results

6.3 Flexural Strength

Results including the flexural strength (for fractured samples) and the yield strength (samples that did not fracture). The test results conducted for 7,14 and 28 days are tabulated below.

Table-9: Flexural Strength Results

Mix	Specimen Details	Flexural Strength (N/mm²)		
		7 Days	14 Days	28 Days
M0	Convention Concrete	3.05	3.85	3.84
M1	4% ESP + 7% CTW	3.09	3.87	3.95
M2	8% ESP + 14% CTW	3.15	3.93	4.06
M3	12% ESP + 21% CTW	3.36	4.28	4.36
M4	16% ESP + 28% CTW	3.07	3.86	3.92
M5	20% ESP + 35% CTW	2.37	3.26	3.60
M6	24%ESP+42%CTW	2.24	2.95	3.39



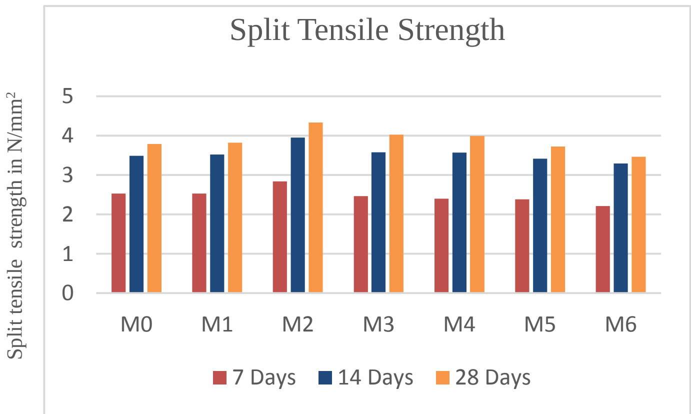
Graph 2 -Flexural Strength Results

6.4 Split Tensile Strength

A standard test cylinder of concrete specimen is placed horizontally between the loading surfaces of compression testing machine. The compression load is applied diametrically and uniformly along the length of cylinder until the failure of the cylinder along the vertical diameter. The test results conducted for 7, 14 and 28 days are tabulated below.

Table-10: Split Tensile Strength Results

Mix	Specimen Details	Split Tensile Strength (N/mm²)		
		7 Days	14 Days	28 Days
M0	Convention Concrete	2.53	3.49	3.79
M1	4% ESP + 7% CTW	2.53	3.52	3.82
M2	8% ESP + 14% CTW	2.84	3.95	4.33
M3	12% ESP + 21% CTW	2.46	3.58	4.02
M4	16% ESP + 28% CTW	2.40	3.57	3.99
M5	20% ESP + 35% CTW	2.38	3.41	3.72
M6	24%ESP+42%CTW	2.21	3.29	3.46



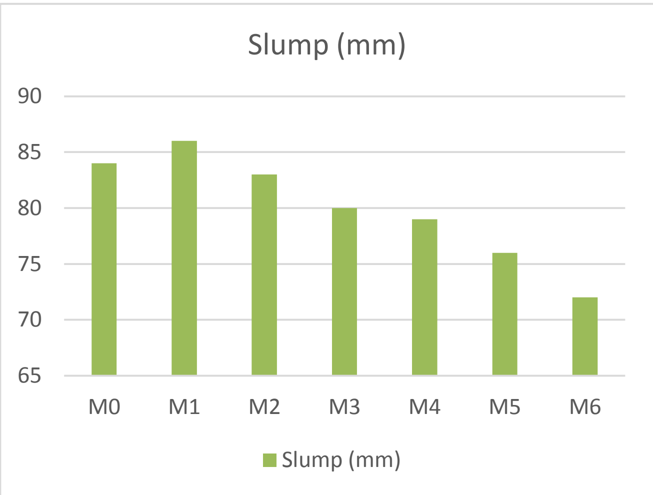
Graph 3-: Split Tensile Strength Results

6.5 Slump Test

The results of the slump cone test performed on different mixes of M30 grade concrete are shown in the table:

Table-7: Slump test Results

Mix	Specimen Details	Slump(mm)
M0	Convention Concrete	84
M1	4% ESP + 7% CTW	86
M2	8% ESP + 14% CTW	83
M3	12% ESP + 21% CTW	80
M4	16% ESP + 28% CTW	79
M5	20% ESP + 35% CTW	76
M6	24%ESP+42%CTW	72



Graph 4- Slump cone test

7. CONCLUSION

Based on the experimental investigation carried out on the strength behavior of Partial replacement of coarse aggregate with ceramic tile waste and cement with eggshell powder, the following conclusions are drawn:

- Workability results show that if we replace cement with eggshell powder up to 8% and coarse aggregate with ceramic tile waste up to 14%, there is no significant decrease in the workability.
- Compressive Strength is maximum at 12% eggshell powder and 21% ceramic tile waste replacement.
- Flexural Strength is maximum at 12% eggshell powder and 21% ceramic tile waste replacement.
- Split Tensile Strength is maximum at 8% eggshell powder and 14% ceramic tile waste replacement.

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