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Partial Replacement of Cement with Brick Powder and Egg Shell Powder in Concrete

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ABSTRACT: This paper reports an overview of experiments evaluating the use of egg shell powder from egg production industry and waste brick powder as partial replacement for ordinary Portland cement in concrete. The main aim of this study is to investigate the feasibility of using waste brick powder and egg shell powder in concrete as partial replacement for cement. The cement concrete in which cement is partially replaced with brick powder and egg shell powder as 0%, 2.5%, 5%, 7.5%, 10% by weight of cement. The chemical composition of the egg shell powder, appropriate mix design and compressive strength of the experimental concrete will be determined. Also the performance of conventional concrete and partially replaced concrete is going to be compared. The compressive strength will be determined at curing ages 28 days. In this direction, an experimental investigation of Compressive strength, Slump test and Water Absorption test will be under taken to use egg shell powder and brick powder as partial replacement for cement in concrete.

KEYWORDS: Egg shell powder, cement mortar, brick powder, compressive strength, slump test, split tensile strength, water absorption test.

I. INTRODUCTION

The project describes the feasibility of using the brick powder and egg shell powder in concrete production as partial replacement of cement. The waste bricks that are collected from the demolished buildings and compound walls are broken into pieces and then made as powder. Then sieved using 90micron sieve and partially replaced up to 10% in cement. Bricks are made up of different types of clays and other materials like sand. Clay is responsible for the pozzolanic behavior of brick. Clay itself has no pozzolanic properties but when fired together with lime during brick making process it gains pozzolanic nature. The pozzolanic properties of brick dust waste enables it to play an important role in the strength and durability of concrete, its use in concrete will alleviate the increasing challenges of scarcity and high cost of cement and will help to strike a balance between the sustainability of the environment and the demand on construction due to increase in population growth worldwide. 0%, 2.5%, 5%, 7.5%, 10% brick powder is used for partial replacement of cement. Calcium rich egg shell is a poultry waste with chemical composition nearly same as that of limestone. Use of egg shell instead of natural lime to replace cement in concrete can have benefits like minimizing use of cement, conserving natural lime and utilizing waste material. Egg shells were collected, washed, air dried, grinded to form powder and finally sieved through 90micron sieve. 0%, 2.5%, 5%, 7.5%, 10% egg shell powder is used for partial replacement of cement. This investigation attempt analyses the strength of the concrete by using brick powder and egg shell powder as partial replacement of cement on concrete. The compressive strength and split tensile strength of the concrete is tested at the age of 7 days and 28 days. Sometimes an image may contain text embedded on to it. Detecting and recognizing these characters can be very important, and removing these is important in the context of removing indirect advertisements, and for aesthetic reasons.

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II. EARLIER RESEARCHES

Muhammad Nasir Ayaz Khan : et.al (2018) , in his research brick dust was used in plain cement concrete to check its fresh and hardened properties. Brick dust was used to check the workability and strength of concrete, using the water-cement ratio of 0.55 which was kept constant during research. Three samples were cast for each 3, 7, 14, 28 and 56 days with 0%, 5%, 10% 15% and 20% incorporation of brick dust. The test results reveals that replacing cement with brick dust shows higher workability than control sample for 5%, 10% and 15%, of which 15% was greater of all. However, strength results were quite competitive, replacing cement with 15% brick dust shows higher compressive strength. The split tensile test was also conducted, which shows high tensile strength by replacing cement with 15% brick dust. This research shows that cement can be replaced.

Praveen Kumar R:et.al (2015). In this study, the egg shell usually which are disposed is used as an alternate for the cement since the shell is made up of Calcium. Egg shells as an alternate to cement egg shell powder replaces 10%, 20% and 30% in addition with silica fume by 5%, 10%, 15% of weight of cement. Concrete is cast and Compressive test, Tensile and Flexural were carried out to find the best combination which results in optimum percentage of strength. The concrete compressive strength with egg shell powder as cement replacement material increases upto 15 percent without silica fume. Addition of silica fume also increases the strength but in economical point of view only the egg shell powder replacement is sufficient enough for getting higher strength. The split tensile strength of the egg shell powder concrete decreases with the addition of egg shell powder. This can be increased if the concrete is used with reinforcement. The flexural strength of egg shell concrete increases with the addition of egg sell powder up to 15 percent. They conclude that egg shell powder alone can be replaced as cement which increases the strength parameters meanwhile reduces the cement usage.

III. METHODOLOGY

MATERIALS

3.1Brick powder

The waste bricks are collected from the demolished buildings and compound walls and broken them into pieces and then made as powder. Then sieved using 90micron to get the grading of cement and partially replaced up to 10% in cement. 0%, 2.5%, 5%, 7.5%, 10% brick powder is used for partial replacement of cement. Bricks are made up of different types of clays and other materials like sand. Clay is responsible for the pozzolanic behavior of brick. Clay itself has no pozzolanic properties but when fired together with lime during brick making process it gains pozzolanic nature.

Table 1 Chemical constituents of brick powder

MINERALS	PERCENTAGE
Silica(sand)	50-60%
Alumina(clay)	20-30%
Lime	2-5%



Fig 1 collected bricks



Fig 2 crushing of bricks

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Fig 3 sieving of bricks



Fig 4 brick powder

3.2. Egg Shell Powder (ESP)

Calcium rich egg shell is a poultry waste with chemical composition nearly same as that of limestone. 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. Broken egg shells are collected from local sources. The shells are then washed and air dried. The shells are then hand crushed, grinded and sieved through 90micron sieve. Material passed through 90micron sieve was used for cement replacement and the retained material was discarded. 0%, 2.5%, 5%, 7.5%, 10% egg shell powder is used for partial replacement of cement.

Table 2 Chemical composition of Cement, Eggshell powder

Chemical constituents	Cement	ESP
SiO ₂	21.8	0.08
Al ₂ O ₃	6.6	0.03
Fe ₂ O ₃	4.1	0.02
CaO	60.1	52.1
MgO	2.1	0.01
Na ₂ O	0.4	0.15
K ₂ O	0.4	-
SO ₃	2.2	0.62



Fig 5 Processing of egg shell waste (i) washing (ii) air drying (iii) grinding (iv) sieving

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3.3 Cement

Cement is the individual unit of fine and coarse aggregate into a solid mass by virtue of its inherent properties of setting or hardening in combination with water. In this Ordinary Portland Cement of Grade 43, which is known for its rich quality and high durability is used.

3.4 Coarse Aggregate

The coarse aggregates passing through 20mm sieve and retained on 10mm sieve was used for the experiment.

3.5 Fine Aggregate

M-Sand passing through 4.75mm sieve was used for the experiment.

3.6 Water

Water is the key ingredient, which when mixed with cement forms a paste that binds the aggregate together. The water needs to be pure in order to prevent side reactions from occurring which may weaken the concrete. Fresh water available from local sources was used for mixing and curing of the specimens.

IV. EXPERIMENTAL WORK

4.1 Test on Brick powder

(i) Specific gravity

Table 3 Specific gravity of brick powder

Weight of empty bottle, W_1	30g
Weight of bottle + distilled water, W_2	81g
Weight of bottle + kerosene, W_3	60g
Weight of bottle + brick powder + kerosene, W_4	70g
Weight of brick powder, W_5	13g

$$\begin{aligned}\text{Specific gravity} &= \frac{W_5 (W_3 - W_1)}{(W_5 + W_3 - W_4)(W_2 - W_1)} \\ &= \frac{13 (60 - 30)}{(13 + 60 - 70)(81 - 30)} \\ &= 2.54\end{aligned}$$

Specific gravity of Brick powder obtained is 2.54

(ii) Fineness of Brick powder

$$\begin{aligned}\text{Fineness} &= (\text{weight of residue/weight of sample}) \times 100 \\ &= (3.8/100) \times 100 \\ &= 3.8\end{aligned}$$

Fineness of Brick powder obtained is 3.8%

Table 4 Properties of Brick Powder

Properties	Values obtained
Specific gravity	2.54
Fineness	3.8%

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4.2 Test on Egg Shell Powder

(i) Specific Gravity

Table 5 Specific Gravity of Egg Shell Powder

Empty weight of density bottle , W_1	31 g
Weight of bottle + Distilled water , W_2	81 g
Weight of Bottle + Kerosene , W_3	70 g
Weight of bottle + Eggshell powder + Kerosene , W_4	79 g
Weight of eggshell powder , W_5	14 g

$$\begin{aligned}\text{Specific Gravity} &= W_5(W_3 - W_1) / (W_5 + W_3 - W_4)(W_2 - W_1) \\ &= 14(70 - 31) / (14 + 70 - 79)(81 - 31) \\ &= 2.184\end{aligned}$$

Specific gravity of eggshell powder obtained is 2.184.

(ii) Fineness of Eggshell Powder

$$\begin{aligned}\text{Fineness} &= (\text{Weight of residue} / \text{Weight of sample}) \times 100 \\ &= (4 / 100) \times 100 \\ &= 4\end{aligned}$$

Fineness of egg shell powder is 4%.

Table 6 Properties of Eggshell Powder

Properties	Values obtained
Specific gravity	2.184
Fineness	4%

4.3 MIX PROPORTION

(A) Design stipulations for proportioning

- Grade designation : M30
- Type of cement : OPC 43 grade
- Minimum cement content : 320 kg / m³
- Maximum water cement ratio : 0.55
- Workability : 50 mm (slump)
- Exposure condition : Mild
- Degree of supervision : Good
- Type of aggregate : Crushed angular aggregate
- Chemical admixture : Not used

(B) Test data for materials

- a) Cement used : OPC 43 grade
- b) Specific gravity of cement : 3.14
- c) Specific gravity of
 - Coarse aggregate : 2.51
 - Fine aggregate : 2.64

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d) Water absorption

Coarse aggregate : 0.15%

e) Free (surface) moisture

Coarse aggregate : Nil (absorbed moisture full)

Fine aggregate : Nil

f) Sieve analysis

Coarse aggregate : Conforming to Table 2 of IS: 383

Fine aggregate : Conforming to Zone I of IS: 383

(C) Target strength for mix proportioning

$$f'_{ck} = f_{ck} + 1.65 s$$

Where,

f'_{ck} = Target average compressive strength at 28 days

f_{ck} = Characteristic compressive strength at 28 days

s = Standard deviation, $s = 5 \text{ N/mm}^2$

Therefore, target strength = $30 + 1.65 \times 5 = 38.25 \text{ N/mm}^2$

(D) Selection of water cement ratio

From Table 5 of IS: 456-2000, maximum water cement ratio = 0.55 (Mild exposure)

Based on experience adopt water cement ratio as 0.42

$0.42 < 0.55$, hence ok

.

(E) Selection of water content

Maximum water content = 186 litres (for 25mm – 50mm slump range)

For 20 mm aggregates

Estimated water content for 125 mm slump = $186 + (9/100 \times 186) = 203 \text{ litres}$

(F) Calculation of cement content

Water cement ratio = 0.42

Cement content = $203/0.42 = 484 \text{ kg/m}^3 > 320 \text{ kg/m}^3$ (given)

From Table 5 of IS: 456,

Minimum cement content for mild exposure condition = 300 kg/m^3

Hence OK

(G) Proportion of volume of coarse aggregate and fine aggregate content

Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.5 = 0.62

In the present case w/c ratio is 0.42. That is, it is less by 0.08 as the water cement is reduced, it is desirable to increase the coarse aggregate proportion to reduce the fine aggregate content. The coarse aggregate is increased at the rate of 0.01 for every decrease in water cement ratio 0.05.

$$\begin{aligned} \text{Increase in coarse aggregate} &= (0.01/0.05) \times 0.08 \\ &= 0.016 \end{aligned}$$

$$\text{Volume of coarse aggregate} = 0.62.$$

$$\begin{aligned} \text{Corrected proportion of volume of coarse aggregate} &= 0.016 + 0.62 \\ &= 0.636 \end{aligned}$$

$$\begin{aligned} \text{Volume of fine aggregate} &= 1 - 0.636 \\ &= 0.364 \end{aligned}$$

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(H) Mix proportions for trial number 1
Cement = 484 kg/m³
Water = 203 kg/m³
Fine aggregate = 618 kg/m³
Coarse aggregates = 1023 kg/m³
Water cement ratio = 0.42
Obtained Mix Proportion 1: 1.27: 2.11

4.4 MIXING

The concretes were mixed in machine. Firstly, coarse aggregates and fine aggregates were dry mixed. Then cement, brick powder and egg shell powder were added to the dry mix and mixed together. Water was poured into the mixer drum and thoroughly mixed until a mix of uniform color is obtained.

4.5 CASTING

The cubes were casted in steel moulds of inner dimensions 150 x 150 x 150mm and the cylinders were casted in steel cylinders of 150mm diameter and 300mm height.



Fig 6 Concrete mixing



Fig 7 Casted specimen

4.6 CURING

After 24 hours of casting specimens were cured by placing them in a curing tank for the period that preceeds laboratory testing.



Fig 8 Curing

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V.RESULT AND DISCUSSION

5.1 Compressive strength test results:

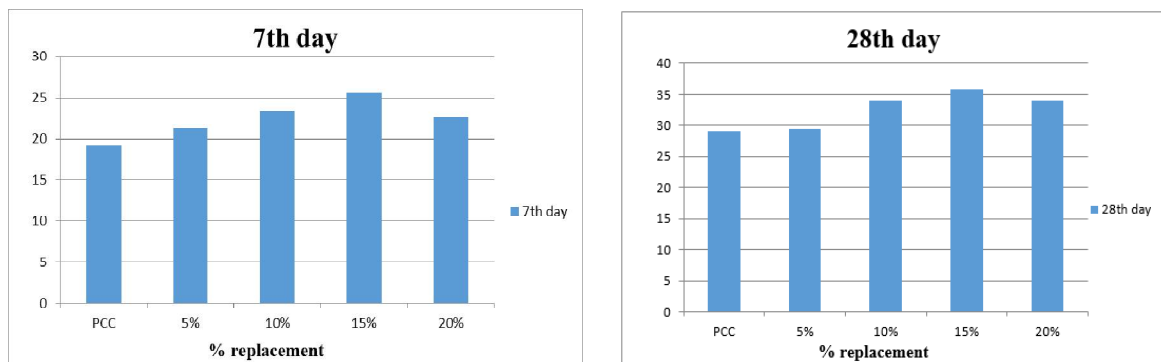


Fig 9 Comparison of Compressive strength for 7 days and 28 days

Compressive strength is higher than normal concrete at 7 and 28 days of curing ages. Compressive strength increased up to 15% replacement and reduced at 20% replacement. Maximum compressive strength was obtained at 15% replacement.

5.2 Split tensile strength test results:

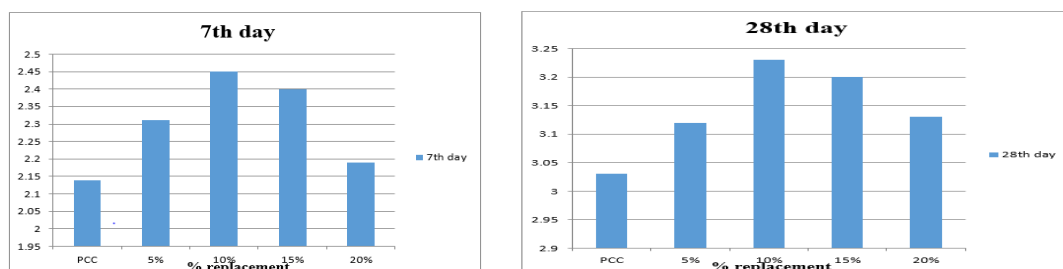


Fig 10 Comparison of tensile strength for 7 days and 28 days

Tensile strength is higher than conventional concrete at 7 and 28 days of curing ages. It was found to be maximum at 10% replacement and gradually decreased at 15% and 20% replacement.

VI. CONCLUSIONS

From the experimental study of partial replacement of cement by brick powder and egg shell powder in concrete, following conclusions were obtained.

- The compressive strength of concrete made by partial replacement of cement with egg shell powder and brick powder increases up to 15 percent.
- Compressive strength decreased at 20% replacement, but it is higher than the conventional concrete at 7 and 28 days.
- The split tensile strength increased up to 10% replacement and it is found to be reduced for 15% and 20% replacement.

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- After the curing of the concrete, it was found that the concrete got a reddish colour which increased the aesthetical view of the concrete.

The experimental results have shown that the use of brick powder obtained from the demolished buildings and egg shell powder in the replacement of cement in concrete can provide an alternative solution to minimize the environmental pollution due to unscientific disposal of these wastes. So the replacement of cement with brick powder and egg shell powder in concrete is really advisable.

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