EXPERIMENTAL INVESTIGATION OF PARTIAL REPLACEMENT OF OPC (43 GRADE) CEMENT BY EGG SHELL POWDER FOR M-35 CONCRETE GRADE

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ABSTRACT - Eggshell is produced at large amounts by egg processing industries and considered as useless. Egg shell waste have serious hazards material because the protein rich membrane which adheres to the shell attracts rats & other vermin. An eggshell is made of calcium carbonate, which is also the main ingredient in some antacids. Each medium sized egg shell has about 750-800 gms of calcium. The shell makes up 9-12 percent of an egg's total weight, & contains pores that allow oxygen in & carbon dioxide and moisture out. According to previous observations, An egg shell takes minimum six years to completely decompose & it is not good for the soil either. Of its total composition, 95% is Calcium & others are protein and other organic material. To minimize the problem from egg shells. It is better to use it in some other ways. It has been found from various previous researches that egg shell can be used in construction industry in concrete. It was observed in earlier studies that replacement of egg shell powder with cement may be possible upto certain extent. In the present study, grinded Egg shell powder passing through 90 microns is used as cement replacement with various replacement levels as 0%, 1%, 2%, 3%, 4% & 5% to evaluate the influence of Egg shells on the properties of cement. Various tests on Cement were carried out i.e. Consistency test, Setting time test, Soundness test, Compressive strength test were carried out. Egg shell powder is further used as cement replacement in concrete as 0%, 1%, 2%, 3%, 4% & 5% replacement levels for M-35 concrete grade, for which various tests were carried out i.e. Slump test to evaluate workability of different mixes, Compressive strength test, Flexural test at 7 days & 28 days.

Keywords: Egg shell powder, Workability, Compressive strength, Flexural strength

1. Introduction

1.1.1 Waste Generation

India ranks fifth in the world with annual egg production of 1.61 million tones. The state of Andhra Pradesh is the largest egg producer in India. The cement production causes extensive power consumption, gas emissions, noise pollution environmental heating & emission of fuel eg. CO, CO2,NOX SO2 from kilns. Egg consumption is rising due to its affordability & growing consumer preferences for nutritional diets. A lot of consumers also enjoy eating various egg-based preparations bought from street vendors in cities as well as smaller towns. Changes in egg consumption are driven both by poultry industry & various campaigns to promote egg consumption.

1.1.2 Egg Production:

Egg production is forecast at 84 billion eggs, up five percent in as compared to 2016 for Calender Year 2017. Production of eggs during 2013-14: The top 5 states i.e. Andhra Pradesh, Tamil Nadu, Maharashtra, West Bengal, Haryana accounted for 68.01% of the total egg production estimate in India as a whole in 2013-14. The above mentioned 10 states accounted for 88.23% of the total egg production estimate in India as a whole in 2013-14. Production of eggs during 2014-15: The top 5 states i.e. Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, West Bengal, Haryana accounted for 63.11% of the total egg production estimate in India as a whole in 2014-15. The above mentioned 10 states accounted for 85.81% of the total egg production estimate in India as a whole in 2014-15. Production of eggs during 2014-15 to 2015-16: It has been seen that annual growth of 4.99% to 5.66% in production of eggs during 2014-15 to 2015-16. The top 5 states i.e. Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, West Bengal, Haryana accounted for 63.67% of the total egg production estimate in India as a whole in 2014-15. The above mentioned 10 states accounted for 86.27% of the total egg production estimate in India as a whole in 2014-15.

1.1.3 Egg shell waste disposal problems:

Egg shell waste is a serious matter. Egg processors face the problem of the disposal of egg shell waste. An egg produces about 15g of shell. When they are ground up, eggshells can quickly turn into tiny particles that, in turn, *may* lead to a clog in your garbage disposal, or even in your pipes. Putting egg shells down the disposal will create "sand-like particles". The shells get compacted with fat and create huge blockages. Simply tossing the shells in your yard and crushing them with your hands or feet is not going to provide the soil with any sort of timely benefits. The decomposition process is incredibly slow. Eggshells have a thin membrane that can't be broken down in a garbage disposal. This can cause long-term problems. Also the protein rich membrane which adheres to the shell attracts rats & other vermin. It also creates a very bad odour if egg shells are remain disposed openly for a long duration.

1,2 Scope of Study:

- To use Egg shell as a useful material in construction so as to reduce the disposal problems of Egg shells resulting in reduced environmental problems associated with Egg shells.

- To study the effect of Egg shells on properties of Cement.
- To evaluate the effect of Egg shell on concrete by investigating properties of concrete i.e. Workability, Compressive strength, Flexural strength & Split tensile strength of M-35 concrete grade, by replacing cement with Egg shell Powder.
- To generalize the optimum % of replacement level.

2. Experimental Investigation

After review of literature on use of egg shell powder as partial replacement of cement, it was finalized to use egg shell powder in cement mortar & in concrete. Egg shell powder was sieved through 90microns sieve. A schematic representation of the experimental program conducted in this study as shown in figure below. Effectiveness of egg shell powder can be judge by extensive experimental investigation which is mainly divided into 4 phases. Phase I & II deals with the study of physical composition & chemical composition of eg shell powder. Phase III deals with the experimental testing of strength parameters of cement mortar. Phase IV deals with the experimental testing of strength parameters of concrete mix. Following roadmap of the whole study has been finalized before performing testing in different phases.

3.1 Materials

3.1.1 **Cement:** OPC- 43 Grade of cement is used in the present study.

3.1.2 **Aggregates:**

a) Coarse aggregates: 20mm & 10mm coarse aggregates are used in present work.

b) Fine aggregates: Fine aggregates passing through a 4.25 mm sieve is taken into use in the present work.

3.1.3 Egg shell Powder: Egg shells are collected from street vendors. Egg shells are grinded & sieved through 90 microns sieve.

3.1.4 Water : Water is the key ingredient , when mixed with cement, forms a paste that binds the aggregates together. Concrete is produced by mixing binding materials & inert materials with water. Thus, Water & its quality plays an important role in evaluation of strength or quality of concrete. Tap water is used in present work.

3.2 Phase-I: Physical Properties of Materials

3.2.1 CEMENT: Cement is a binder, a substance used for construction that sets, hardens & adheres to other materials, binding them together. Cement is the main component of concrete. It is a high quality construction material used in construction projects worldwide. Ordinary Portland Cement (OPC- 43 Grade) of specific gravity 3.01 is used in this study. Table 3.2.1 below represents the physical properties of Cement & Table 3.3.1 indicates the composition of cement.

Table 3.2.1 Physical Properties of Cement

S.NO.	PHYSICAL PROPERTIES	VALUE
1.	Specific gravity	3.01
2.	Consistency	29%
3.	Initial Setting time	53 minutes
4.	Final Setting time	582 minutes

3.2.2 AGGREGATES: Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water & Portland cement, are an essential ingredient in concrete. Aggregates, which account for 60-75% of the total volume of concrete, are divided into two distinct categories as Fine aggregates & Coarse aggregates.

3.2.2.1 FINE AGGREGATES: Fine aggregates are soil particles that pass through a 4.25 mm sieve. The main purpose of fine aggregates is to fill the voids in the coarse aggregates & to act as a workability agent. Table below represents the variation of size of fine aggregates:

Basically, according to IS specification, fine aggregates are classified into four zones as Zone-I, zone-II, zone-III & zone-IV. In this present study, Banas sand of grade zone-II is used as fine aggregates for which various properties was evaluated as follows:

Table 3.2.2 Properties of Fine Aggregates

S.NO.	PROPERTIES	VALUES
1.	Specific gravity	2.537
2.	Water absorption(%)	1.05%
3.	Fineness modulus	2.651

Fineness modulus of Natural sand= % Cumulative weight retained/100

= 265.1/100

Table 3.2.4 Physical Properties of Coarse Aggregates

S.NO.	PROPERTIES	VALUES	
		10 mm	**20 mm**
1.	Specific gravity	2.64	2.673
2.	Water absorption	0.53	0.45

3.2.3 EGG SHELLS: Eggshells were collected from locally available vendors. Initially egg shells were washed through tap water. Then they were boiled & kept for drying for 24 hours at room temperature. After drying, shells were grinded into powder. Egg shell powder was then sieved through 90 micron sieve, & the material passed through 90 micron sieve is further used as cement replacement in this study. Table 5 represents the basic properties of Egg shell. Table 6 represents the composition of Egg shell.

Egg Shells

Egg Shell Powder

S.NO.	PROPERTIES	VALUES
1.	Specific gravity	3.64
2.	Water absorption	1.5

Table 3.2.9 Physical Properties of Egg shell Powder

3.3 Phase-II: Chemical Composition of Materials

Chemical properties of materials i.e. Cement & Egg shell powder has been investigated as follows:

Table 3.3.1 Chemical Composition of Cement

S.NO.	CONSTITUENT	COMPOSITION (%)
1.	CaO	62.5
2.	SiO2	22.5
3.	Al2O3	5.4
4.	Fe2O3	3.23
5.	SO3	2.78
6.	MgO	2.61
7.	K2O	0.84
8.	LOI	0.75
9.	Na2O	0.29

Table 3.3.2 Chemical composition of Egg shell Powder

CONSTITUENT	COMPOSITION (%)
CaO	48.3
Fe_2O_3	2.4
K_2O	1.88
SO_3	0.28
Na_2O	0.14
SiO_2	0.11
Al_2O_3	0.06

3.4 Mix Design:

Concrete mix of grade M35 is designed as per IS 456:2000 and as per IS 10262:2009. In the present study, cement was replaced by egg shell powder in replacement levels of 0%, 1%, 2%, 3%, 4%, 5%.

Table 3.4.1 Stipulations for concrete mix proportions for M35

S.NO.	DESCRIPTION	DETAILS	REF: IS CODES
1.	Concrete grade	M-35	IS: 456-2000 (Table-5)
2.	Type of Cement	OPC 43	IS: 269-2016
3.	Brand	Ultratech	-
4.	Type of Coarse Aggregate	Crushed Angular	IS: 383-2015
5.	Maximum Nominal size of Aggregate	20 mm	IS: 456-2000 (Table-6)
6.	Minimum Cement Content	300 kg/m^3	As per work specification
7.	Adopted cement content (For present work)	492.5 kg/m^3	As per work specification
8.	Maximum water-cement Ratio	0.45	IS: 456-2000 (Table-5)
9.	Adopted water-cement Ratio (For present work)	0.40	As per work specification
10.	Exposure Condition	Moderate	IS: 456-2000 (Table-3)
11.	Degree of Workability	High	IS: 456-2000 (Clause 7.1)
12.	Pumpable/Non-Pumpable	Pumpable	IS: 10262-2009

Table 3.4.2 Control mix proportions for M35 Concrete Grade

S.NO.	Material	Weight (kg/m^3)
1.	Cement	492.5
2.	Coarse aggregate (20mm)	591.73
3.	Coarse aggregate (10mm)	389.3
4.	Fine aggregate	673.73
5.	Water	197

Table 3.4.3 Mix proportions for M35 Concrete Grade with partial replacement of cement by Egg shell powder:-

S.No.	Mix	Cement (kg)	Egg shell Powder (kg)	Coarse aggregate (kg)		Fine aggregate (kg)	Water (kg)
				20mm	**10mm**		
1.	CE_0	492.5	0	591.73	389.3	673.73	197
2.	CE_1	487.575	4.925	591.73	389.3	673.73	197
3.	CE_2	482.65	9.85	591.73	389.3	673.73	197
4.	CE_3	477.725	14.775	591.73	389.3	673.73	197
5.	CE_4	472.8	19.7	591.73	389.3	673.73	197
6.	CE_5	467.875	24.625	591.73	389.3	673.73	197

3.6 Phase-III: Experimental investigation of Cement mortar:

Following tests were carried out on cement to evaluate the effect of eggshells on cement properties at different replacement levels:

1) Consistency
2) Setting time:
   a. Initial Setting time
   b. Final Setting time
3) Soundness
4) Compressive strength test for cement mortar

3.6.1 Consistency:

The standard consistency of cement paste is defined as the amount of water required which will permit the vicat plunger to penetrate 5 mm to 7 mm from the bottom of the vicatmould.

Vicat apparatus is used to find out the consistency of cement paste. In this work, consistency of cement paste is evaluated at different replacement levels of cement by Egg shell powder as 0%, 3%, 6%, 9%, 12%, 15%, where CE0, CE1, CE2, CE3, CE4 & CE5 represents the cement paste with respective replacement percentage of cement by Egg shell.

$$\text{Standard Consistency} = \frac{[\text{Quantity of water for 5-7 mm penetration}]}{\text{Weight of cement}} * 100$$

Table 3.6.1.1 Proportion of paste for Consistency test

S.NO.	Cement Mix	Cement (gms)	Egg shell (gms)	Egg shell (%)
1.	CE0	400	0	0
2.	CE1	396	4	1
3.	CE2	392	8	2
4.	CE3	388	12	3
5.	CE4	384	16	4
6.	CE5	380	20	5

3.6..2 Setting time test:

Setting time is a specified time required for concrete or mortar to change from liquid state to plastic state & plastic state to solid state such that its surface will be sufficiently rigid to withstand a certain amount of pressure. Initial & Final setting time are calculated as per IS: 4031 (Part 5) – 1988.

In the present work, Initial & Final setting time of cement mortar paste is evaluated at different replacement levels of cement by Egg shell powder as 0%, 1%, 2%, 3%, 4%, 5%.

Setting time is further studied in terms of Initial setting time & Final setting time; that can be determined by using Vicat's apparatus conforming to IS: 5513 - 1976:

- Initial setting time: The time at which cement paste loses its plasticity is known as the Initial setting time or we can say that initial setting time is the time period between the time of addition of water to the cement & time at which 1mm square needle fails to penetrate the cement paste, placed in the vicat'smould 5mm to 7 mm from the bottom of the mould.

For OPC; it should not be less than 30 minutes.

- Final setting time: The time period between the time of addition of water to the cement & the time at which 1 mm needle makes an impression on the paste in the mould but 5 mm attachment does not make any impression.

For OPC; it should not be more than 10 hours.

- Amount of water added= 0.85*P , where P is the standard consistency of cement.
- Gauging time was taken between 3 to 5 minutes.

Table 3.6.2.1 Proportion of paste for Setting time:

S.NO.	Cement Mix	Cement (gms)	Egg shell (gms)	Egg shell (%)
1.	CE0	400	0	0
2.	CE1	396	4	1
3.	CE2	392	8	2
4.	CE3	388	12	3
5.	CE4	384	16	4
6.	CE5	380	20	5

3.6..3 Soundness Test:

Soundness means the ability to resist the volume expansion.

Also, we can say that Soundness of cement is the property by virtue of which the cement does not undergo any appreciable expansion (or change in volume) after it has set, thus eliminating any chances of disrupting the mortar or concrete. Test is performed with the help of Le-Chatelier apparatus as shown in figure below. It consists of a brass mould of diameter 30 mm and

height 30 mm. There is a split in mould and it does not exceed 0.50 mm. On either side of split, there are *two* indicators with pointed ends. The thickness of mould cylinder is 0.50 mm.

IS:4031(Part 3):1988-Methods of physical tests for hydraulic cement (Determination of soundness)

- Deficiency of lime: Makes the cement set quicker and affects the property of cement.
- Excessive amount of lime: Makes the cement unsound. It means it cause the cement expands more after it gets hardened.
- Volume expansion in cement mortar or in cement concrete is caused by the presence of unburnt lime (CaO), dead burnt MgO and also CaSO4.
- By Le-chatelier method we can only find out presence of unburnt lime (CaO).
- Presence of unburnt lime may develop cracks in the cement because of increase in volume.
- Free lime (CaO) and magnesia (MgO) are known to react with water very slowly and increase in volume considerably, which result in cracking, distortion and disintegration.

Before conducting the test lightly oil the apparatus such as Le-Chateliermould, Glass plates.Take cement of 200g. Paste of cement was prepared by adding 0.78*P where P= water required for standard consistency.Then mixing the cement paste well using the trowel & placing the lightly oiled Le-Chateliermould on the glass plate.Mouldwas then filled with the prepared cement paste up to the top. While placing the cement hold the mould edges gently together.Now place another glass plate on the top and put weight on it. Whole assembly was submerged into the water pot at a room temperature and keep it undisturbed for 24 hours. The whole assembly was removed from water and measure the distance between the mould edges. Note that distance as L1. The measuring pointers should indicate to the nearest 0.5 mm. The mouldwas again submerged into the water and bring it to the boiling point and cool down it to room temperature.Now again measure the mould edges distance as L2.

Calculation: (For Soundness due to Lime by Le-chatelier Apparatus):

- Soundness/expansion of cement = L_1-L_2

L_1=Measurement taken after 24 hours of immersion in water at a temp. of 27 ± 20 C

L_2=Measurement taken after 3 hours of immersion in water at boiling temperature.

- Calculate the mean of two values to the nearest 0.5 mm.
- This value must not exceed 10 mm for Ordinary or OPC.

3.6..4 Compressive Strength Test:

Compression testing machine (CTM) is used to evaluate the compressive strength of cement mortar as per IS Code 4031- Part 6. The mix ratio of mortar used in the present work is 1:3with the cube size 70.6 mm were casted & tested for 3, 7th& 28th days. Load at the time of failure was noted. Test was conducted for 3 cubes for same mortar at each test duration for each level of partial replacement of cement by Eggshell powder & the average value of all three readings was considered for 3, 7th& 28th day as compressive strength value of each test result.

Compressive strength=P/A N/mm^2

Where, P= Applied load

A= Cross sectional area of specimen

3.7 Phase-IV: Tests for Concrete Specimens:

1) Workability test
2) Compressive strength test
3) Flexural strength test

3.7.1 Workability / Slump test:

Concrete is a mixture of cement, aggregate, water & admixture. Workability of concrete describes how easily freshly mixed concrete can be mixed, placed, consolidated & finished with minimum loss of homogeneity. Workability of concrete is affected by ingredients in it & their proportions. Various factors such as water content, aggregate/cement ratio, shape & size of aggregate, grading & surface texture of aggregate, & use of admixture affect workability of concrete. In the present work, mix design was done by considering or on the basis of slump 100 mm. Slump cone is used to calculate the slump value. This mould for the test is in the form of frustum of a cone of height 30 cm, top diameter 10 cm & bottom diameter 20 cm. Tamping rod used is of steel with 60 cm long & 16 mm diameter, with its one end rounded.

Slump test was done as per IS: 1199- 1959. In this test, mould was filled with concrete mix in 4 layers. Each layer was tamped with 25 strokes of tamping rod (rounded end of the rod). Excess concrete was removed & surface was leveled with trowel. The mould is removed, it is lifted up slowly in vertically direction, without any rotational movement.

Finally the slump was measured in terms of millimeters as the difference between the height of the mould & that of highest point of the specimen being tested.

3.7.1 Compressive Strength Test:

Compressive strength of concrete cubes gives an idea about characteristics of concrete, which depends on certain factors like water-cement ratio, quality & properties of concrete material, strength of cement, etc.

For the present work, The compressive strength testing machine (CTM) was used for the test as per (IS:516-1959), by using cubical moulds of size 150 mm* 150 mm* 150 mm.

Three specimens were tested at each selected age for each composition of testing. These specimens are testedafter 7 days curing or 28 days curing, by applying the load gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Calculation:

Size of the cube =150mm x150mm x150mm

Cross- sectional area of the specimen = 22500 mm^2

Compressive strength= Maximum Load/Cross- area of the specimen

= P/A

3.7.2 Flexural Strength Test:

The size of the specimen is 150 mm width & 150 mm depth & 700 mm length. Tamping steel bar of 2kg, 40 cm long was used for tamping having section size 25mm*25mm. Concrete was filled in the mould in 3 layers, each layer tamped 3 times using the tamping bar. Load applied at a rate of loading of 400 kg/min.

4. Results

4.1. Consistency Test Results-

Table 4.1.1 : Consistency of cement with partial replacement of Cement by Egg shell:

S.NO.	CEMENT MIX (Cement %+ Eggshell %)	Standard Consistency (%)
1.	CE0 (100+0)	29
2.	CE1 (99+1)	29.3
3.	CE2 (98+2)	29.5
4.	CE3 (97+3)	29.5
5.	CE4 (96+4)	29.5
6.	CE5 (95+5)	29.7

Table 4.2.1 Setting time of cement with partial replacement of Cement by Egg shell:

S.NO.	CEMENT MORTAR MIX (Cement % + Eggshell %)	STANDARD CONSISTENCY (%)	VOLUME OF WATER [0.85*P] (ml)	INITIAL SETTING TIME (minutes)	FINAL SETTING TIME (minutes)
1.	CE0 (100+0)	29	24.65	53	582
2.	CE1 (99+1)	29.3	24.905	47	569
3.	CE2 (98+2)	29.5	25.075	41	473
4.	CE3 (97+3)	29.5	25.075	39	386
5.	CE4 (96+4)	29.5	25.075	27	294
6.	CE5 (95+5)	29.7	25.245	21	286

4.1 Compressive strength test Results-

Table 4.3.1 3 days Compressive strength of cement mortar cubes by using Eggshell powder as partial replacement of cement:

S.No.	Cement Mortar Mix (Cement %+ Eggshell %)	Trial NO.	Dimension (mm*mm)	Area (mm^2)	Load (KN)	Compressive strength (N/mm2) 3 days	Avg. Compressive strength (N/mm2) 3 days
A.	CE0 (100+0)	1	71.19*70.62	5027.4378	67.5	13.42	16.01
		2	72.04*72.23	5203.4492	86.0	16.52	
		3	70.96*70.24	4984.2304	90.3	18.11	
B.	CE1 (99+1)	1	70.01*71.06	4974.91	84.2	16.92	16.33
		2	70.63*70.92	5009.07	82.4	16.45	
		3	71.21*71.03	5058.04	79.1	15.63	
C.	CE2 (98+2)	1	71.14*71.06	5055.2084	103.6	20.49	18.89
		2	70.92*71.03	5037.4476	90.8	18.02	
		3	71.76*70.09	5029.6584	91.4	18.17	
D.	CE3 (97+3)	1	71.06*70.22	4989.83	97.8	19.59	19.08
		2	71.62*71.41	5114.38	136.6	26.71	
		3	70.38*70.42	4956.15	95.4	19.24	
E.	CE4 (96+4)	1	70.86*70.93	5026.09	100.5	19.99	19.24
		2	72.40*72.09	5219.31	96.2	18.43	
		3	71.43*71.26	5090.10	98.3	19.31	
F.	CE5 (95+5)	1	72.46*71.87	5207.7002	70.4	13.52	12.29
		2	71.96*71.78	5165.2888	50.1	9.69	
		3	71.23*70.26	5004.61	68.4	13.66	

4.2 Workability Results:

Table: 4.4.1 Slump of concrete mix of M35 with partial replacement of cement by Eggshell powder:

S.NO.	Mix (Cement %+Egg shell powder %)	Slump (mm)
1.	CE_0 (100+0)	100
2.	CE_1 (99+1)	90
3.	CE_2 (98+2)	84
4.	CE_3 (97+3)	79
5.	CE_4 (96+4)	56
6.	CE_5 (95+5)	34

4.5 Compressive Strength Test Results:

Table 4.5.1 7 and 28 days Compressive Strength of concrete cubes for 28 days target mean strength= 43.25 N/mm^2, using Egg shell powder as partial replacement of cement in control mix for M35grade :-

S.No.	Mix (Cement %+Eggshell powder %)	7 days Avg. Compressive strength (N/mm$^{2)}$	28 days Avg. Compressive strength (N/mm$^{2)}$
1.	CE_0 (100+0)	30.3	44.1
2.	CE_1 (99+1)	30.72	44.38
3.	CE_2 (98+2)	30.98	44.96
4.	CE_3 (97+3)	31.7	45.07
5.	CE_4 (96+4)	32.56	45.83
6.	CE_5 (95+5)	28.3	40.19

5. Cost Analysis:

Table 5.1 Cost analysis inclusive of Egg shell Powder as cement replacement at an optimum replacement dose:

Description	Cement	FA	CA
Qty. used	492.5 kg	58	0.42
Cost (per cubic feet)	5/-	35/-	25/-
Optimum replacement level (cement only)	4%	-	-
Cement qty. after replacement(-4%)	472.8 kg	-	-
Difference in qty.(cement saved)	19.7 kg	-	-
Cost of difference qty. cement	19.7 kg * 5/-	-	-
Saved cost (for 492.5 kg cement)	98.5/-	-	-

From above cost analysis, we can see that by using Egg shell powder as a cement replacement material i.e. at requirement of total 492.5 kg cement, replacement of 4% cement with egg shell powder results in saving of Rs. 98.5/- which concludes that it reduce the cost of construction without compensating the strength of concrete mix.

6. Conclusions:

This investigation was mainly undertaken to examine performance of Concrete mixes containing Eggshell processed material, laboratory evaluation of concrete mixes with different combinations of Eggshell was replace cement. Based on the findings of the experimental results, the following conclusions can be drawn:

1. Consistency is of paste increases very slowly as the percentage of egg shell powder of cement increases. The consistency of replacement of cement by egg shell powder is highest at 5% replacement level as compared to the control mortar paste.
2. Setting time including both Initial & final setting time shows decrement as replacement level increases as compared to conventional mortar paste.
3. As the replacement level of egg shell powder gets increased, the expansion value or mortar mix gets reduced, which shows that egg shell powder has ability to expand less.
4. It has been found that the compressive strength at 7 days for mortar cubes when cement replaced by egg shell powder shows gradual increment in compressive strength. Beyond 4% replacement of cement by egg shell power, Compressive strength gets decreased as compared to conventional mix. The compressive strength of cement mortar cubes upto a replacement level of 4% of egg shell powder has shown greater value of compressive strength as compared to conventional mortar mix. So, it can be suggested that cement can be replaced by egg shell powder upto 4% by weight of cement in mortar mix.
5. Workability gets reduced as percentage of replacement level of egg shell powder increased when egg shell mixed mortar compared with conventional mortar mix. This mix can be in pavement as workability required in pavement construction is around 30-40mm.
6. Cost Analysis: It has been concluded that the cost of construction can be reduced by using Egg shell that can be used in construction works.

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