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Investigate the Properties of Concrete as Partial Replacement of Cement With Egg Shell Powder

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ABSTRACT- Concrete is a highly consumed material in construction field due to its advantages because of this the natural resources are depleting day by day at an alarming rate and there is an immediate need for finding alternate materials to the natural materials in concrete. So, in my study M30 grade concrete is adopted and the cement was replaced with Egg Shell powder with different percentages of 5%, 10%, 15% and 20% and M-Sand with a constant percentage of 40%. Concrete was casted, cured and then Compressive, Split Tensile and Flexural tests were carried out to find the best combination which results in optimum percentage of strength. The optimum percentage egg shell powder (ESP) is obtained at15%. At optimum ESP the Fine Aggregate is replaced with M-Sand with a constant percentage of 40%. It is the best solution for disposing of used egg shell and to solve the scarcity of sand.

KEYWORDS- Egg Shell Powder, Concrete, Coarse Aggregate, Surface Texture

I. INTRODUCTION

Concrete is the material that is irrationally prevalent in the global construction sector. Fine aggregate, coarse aggregate and concrete water make up concrete. There are many other forms of concrete available today, including polymer concrete, which employs a polymer as the solidifying agent, and Portland cement, which is made with lime and other water-driven concrete varieties like found concrete, which is primarily used for street surfaces.

Semi-fluid slurry that may mostly be poured into a structure for shaping is created by combining water with dry powders, including coarse and fine sand, during the process of creating cement from most forms of concrete. The substantial cement goes through a complicated cycle called as hydration after setting, which makes it suitably firm.

The concrete responds to the water by forging a connection between its constituent parts, hardening it to the consistency of stone. In any case, it should be possible to increase the quantity of admixtures that can speed up or slow down the process of the substance solidifying, leading to an increase in rigidity and the entrainment of air and water obstruction[1-5].

Concrete is widely used to make both little and huge designs because of its natural flexibility, capacity to be projected into practically any ideal shape, and appealing appearance. For this reason, it is referred to be the development business's foundation.

Egg shell is phosphorous and won't break down right away. Egg shell decomposition causes an offensive odour and offers a significant threat to our current condition, which is why the public is worried about it. It is well known that egg shells, which are made up of 94% calcium carbonate and 6% each of magnesium, aluminum, sodium, zinc, iron, and copper, have a significant potential to reduce the need of concrete. [6-10]

We utilize a lot of sand as fine aggregate in building nowadays, which causes a shortage of suitable water-way sand. The shortage of high-quality waterway sand for construction has led to a rise in the use of artificial sand. M-Sand is easily accessible nearby and can be retrieved from hard stone shakes, which lowers the expense of shipping from a far-off canal sand bed.

II. REVIEW LITERATURE

Cement was first used in the Middle East about 6500 B.C., when Nabataea traders from Syria and Jordan built significant floors, housing structures, and underground storage facilities.

Egyptians used straw and mixed mud to tie bricks together circa 3000 B.C. The pyramids constructed at that time were constructed using gypsum and lime mortars. The Incomparable Mass of China was created in China around the same time by tying the stones together using a form of concrete.

Romans were the first to use concrete on a significant basis in 600 B.C. They successfully implemented the use of cement in a significant portion of their development. They used to add ocean water, lime, and volcanic material to their mixture. After properly integrating it, it was cast into wood moulds, and once it had gained sufficient strength, the blocks were stacked one on top of the other. Roman large constructions are therefore still regarded as the most durable ones even after more than 2000 years.

The modern era of concrete and concrete is said to have begun in 1824 when Joseph Aspdin created Portland concrete.

In 1889 A.D. San Francisco, California, saw the construction of the main supported significant scaffold. Thomas Edison proposed a proposal for big residences in the US in 1908 AD. The houses that were built back then still stand today.
A reformative stride was made in the sphere of development in 1913 AD. For the first time, a mass of prepared mixture was transported to a construction site in Maryland.
To prevent concrete from freezing and defrosting, the first air entraining technologies were introduced in 1930 A.D.

III. SCOPE OF THE STUDY

If egg shell powder is used as a midway replacement for cement without sacrificing the cement's performance properties, the use of concrete can be significantly reduced. The goal of the review is to meet the objectives, and the focus of this study will be mostly on the exploratory work. In order to focus on how cement behaves, tests for pressure strength, split elasticity, and flexural strength will be performed using a fractional replacement of concrete with egg shell powder and ordinary sand with manufactured sand. Indian Norms perform all of the tests, techniques, and strategies. [11-15]

IV. OBJECTIVES

- Examine the potential for using cement to replace some of the egg shell powder.
- Analyzing the test findings to estimate the percentage of produced sand and egg shell powder in the concrete.
- Effect on flexural strength when egg shell powder was used in place of ordinary Portland cement.
- The flexural strength, tensile strength, and compressive strength of concrete containing various amounts of egg shell powder and M-Sand are to be determined.

V. MATERIAL AND METHODOLOGY

To produce concrete, water is a necessary component. Water's moisture during the curing process gives concrete its tensile strength. When reacting with cement to create the foundation of the concrete, it begins the hydration process. Finding the right volume of water in relation to the rest of the concrete requires special consideration. The water in the concrete needs to be present in sufficient amounts to give the reaction time to complete, converting into a paste that fills the gaps in the mixture. The spacing between the particles in cement increases if the water-cement ratio is on the upper side in concrete.

$2Ca_3SiO_5 + 7H_2O \rightarrow 3\,(CaO).2(SiO_2).4(H_2O) + 3Ca(OH)_2$

Tri calcium silicate +Water → Calcium silicate hydrate +Calcium hydroxide + heat

Cement should be relieved and blended using water that is clean and free of acids, antacids, salts, and other impurities. Consumable water is often seen as being good. Additionally, water should have a pH value greater than 6.

A. Cement

A sticky substance called cement is used as a limiting material in structural design development. It is a finely powdered powder that solidifies when mixed with water. To become a powerful mass. This mixture sets and solidifies as a result of a reaction known as hydration. Hydration is a synthetic process that combines water and concrete mixtures to create submicroscopic diamonds or a substance that resembles gel and has a large surface area. OPC is created by mixing limestone with other natural materials including gypsum, argillaceous, and calcareous. Where rapid development is required, it is preferred. 43 grade OPC has been used in my trials. And cement physical property are show the according to Table 1.

Table 1: Physical Properties of Cement

S. No.	Property	Value
1	Type	Manufactured
2	Surface Texture	Smooth
3	Specific Gravity	3.13

B. Egg Shell Powder

India is a major producer of eggs each year. Every year, almost 1.61 million tons of egg shells are produced and then placed as a land fill, which has certain negative effects on the environment and human health. As we presumably already know, calcium makes up egg shell. With about 93.7% of the total composition of the egg shell, calcium carbonate is the main component of the egg shell. A typical egg shell has very little sodium, zinc, potassium, iron, copper, and manganese, and only 0.3% of magnesium. OPC is primarily composed out of four main calcium compounds, such as di-calcium silicate, tri-calcium silicate, tri-calcium aluminate, and egg shell powder, which have comparative essential synthesis. Egg shell physical property are show the according to table 2.

Table 2: Physical Properties of Egg Shell Powder

S. No.	Property	Value
1	Type	Manufactured
2	Surface Texture	Smooth
3	Color	White
4	Specific Gravity	1.9

C. Natural Sand

Fill, which has certain negative effects on the environment and human health. As we presumably already know, calcium makes up egg shell. With about 93.7% of the total composition of the egg shell, calcium carbonate is the main component of the egg shell. A typical egg shell has very little sodium, zinc, potassium, iron, copper, and manganese, and only 0.3% of magnesium. OPC is primarily composed of four main calcium compounds, including di-calcium silicate, tri-calcium silicate, tri-calcium aluminate, and tetra-calcium aluminoferite. This makes OPC and egg shell powder comparable in essential synthesis. Natural sand physical property are show the according to table 3.

Table 3: Physical Properties of Natural Sand

S. No.	Property	Value
1	Type	Natural
2	Surface Texture	Smooth
3	Specific Gravity	2.54
4	Water Absorption	1.6%

D. Manufactured Sand

Smashed rocks or stone are used to create fabricated sand, an artificial and man-made sort of sand, for use in cement or concrete. It differs from typical sand in terms of its physical and mineral characteristics. It is smaller than 4.75mm. Each and every characteristic, including synthetic, mineral, and surface, is dependent on the parent rock.

The interest in manufactured sand has increased due to a decrease in the natural sand's use for construction purposes. Additionally, the accessibility and transportation costs have decreased because they can now be obtained close to the site, which makes the entire operation more reasonable. Manufactured sand physical property are show the according to table 4.

Table 4: Physical Properties of Manufactured Sand

S. No.	Property	Value
1	Type	Manufactured
2	Surface Texture	smooth
3	Specific Gravity	2.6
4	Water Absorption	2.5%

E. Coarse Aggregate

The portion of concrete that is made up of the particles that pass through a 4.75mm screen is known as coarse aggregate. They typically serve as substantial filler components for the portion of concrete that is made up of the particles that pass through a 4.75mm screen is known as coarse aggregate. They are typically utilized as large-size concrete infill materials. It consists of clinkers, pebbles, gravel, stone chips, and brick chips. Typically, 20 mm size aggregate is used to produce concrete with high strength, and 40 mm size aggregate is utilized to achieve normal strengths. Coarse aggregate physical property are show the according to table 5.

Table 5: Physical Properties of Coarse Aggregate

S. No.	Property	Value
1	Surface Texture	Crystalline
2	Particle Shape	Angular
3	Specific Gravity	2.63
4	Water Absorption	0.21%

VI. MIX DESIGN FOR CONCRETE (M30 GRADE)

A. Stipulation For Proportioning Of Concrete

- M30 is the grade. M stands for Blend and 30 for 30 KN/mm2, which is compressive strength that significantly increases after 28 days.
- The type of concrete used in the test is IS 8112:2013-compliant 43 Grade Customary Portland Concrete.
- The 20mm coarse aggregate size is the maximum.
- The minimum amount of cement used is 320 kg/m3 (IS 456:2000). Use of cement is limited to 450 kg/mm3 at most.
- The water-cement ratio cannot exceed 0.45. (Table 5 of IS 456:2000). It is a Moderate Exposure Condition.
- The shape of coarse aggregate is angularly crushed.

B. Test Data For Material Used In Making Of Concrete

Cement has an SG of 3.13. (OPC 43 Grade).
The CA's SG is 2.63.
FA SG is 2.54.
Coarse aggregate absorbs water at a rate of 0.21%. Manufactured sand absorbs 2.5% of the total water in the fine aggregate and 1.6% of natural sand.

C. Find Target Strength

$f'ck=f'ck+1.65\times\sigma$
From code IS:10262,
σ (standard deviation)=5.
$f'ck=30+1.65\times5$
$f'ck=38.2N/mm^2$

D. Calculate Waer-Cement Ratio

According to IS: 456-2000
W.C=0.45(for Mild Exposure)

E. Findwater Content Used For The Mix

According to IS 456:2009, the maximum amount of water that can be used for 20 mm totals is 186 liters for a 25–50 mm droop range.
Downturn accepted = 100 mm
Currently, according to IS: 10262:2009,
For a total of 20 mm in size, the maximum water content is 197 litres.

F. Find Amount Of Cement Content

W.C=0.45
197/C =0.45
C =197/0.45 =438 kg/m^3
The calculated density of concrete is 438 kg/mm3.
According to IS 456:2000, the Least Concrete Substance for Light Openness Conditions should be 300 kg/m3, which is not the precise Concrete Substance determined. It is then safe to use the selected concrete material, which has a density of 438 kg/m3.
The 450kg/m3 maximum concrete substance is specified for this (IS 456:2000).

G. Calculate Total Volume Of Coarse And Fine Aggregate

According to IS 10262:2009,
When W/C = 0.45,
The coarse total's volume will be equal to 0.6 + 0.01 = 0.61.
Volume of the Fine Total = Absolute Total - Coarse Total
= 1 - 0.61
= 0.39.

H. Concrete Mix Calculation For The Trail Mix

Vol. of cement = 1 m3
Vol. of concrete = (Mass of Concrete/Explicit gravity of concrete) × (1/1000)
= (438/3.13) × (1/1000)
= 0.139 kg/m3
Vol. of water content = (Water content/Explicit gravity of water) × (1/1000)
= (197 ×1)/ (1 × 1000)
= 0.197 L/m3
Vol. of all totals = 1 - (Concrete + Water)
= 1 - (0.139 + 0.197)
= 1 - 0.335= 0.664 kg/m3
Mass of Coarse total

= Absolute vol. of total × Explicit gravity of Coarse total × Vol. of coarse total × 1000
= 0.664 × 2.63 × 0.61 × 1000
= 1075 kg/m3

Mass of Fine total
= Complete vol. of total × Explicit gravity of fine total × vol. of fine total × 1000
= 0.664 × 2.64 × 0.39 × 1000
= 684 kg/m3

I. *Calculation Of Different Mix Proportions*

Table 6: Trail Blend Extent of Concrete

S. No.	AMOUNT BY	CEMENT(KG)	F.A(SAND)(KG)	C.A.(KG)	WATER (KG)
1	WEIGHT	438	684	1078	197
2	PROPORTION	1	1.56	2.46	0.45

In my experimental work, I used 4 3D forms with aspects of 150mm x 150mm x 150mm, 4 Bars with aspects of 100mm x 100mm x 500mm, and 4 Chambers with aspects of 150mm x 300mm.
The result is that the total volume is equal to 0.05466 m3 (4 Shapes, 4 Pillars, and 4 Chambers).
Calculating the projecting materials (4 3D forms + 4 Shafts + 4 Chambers), which results in an overall volume of 0.05466 m3. The Table no. 6 are show the trail blend extent of concrete.
Blends are cast in the manner described below:

M0 (0% replacement of Sand with M-Sand and 0% replacement of Concrete with ESP) are show the table no. 7. M1 (5% Concrete replacement with ESP and 40% Sand replacement with M-Sand) are show the table no.8. M2 (replacing 10% of the concrete with ESP and 40% of the sand with M-Sand) are show the table no.9. M3 (15% Concrete replacement with ESP and 40%) are show the table no.10. and M4 (20% ESP and 40 % M-Sand) are show the table no.11.

Table 7: Mix extent and Measure of Materials utilized for blend M0 (0% Replacement)

S. No.	AMOUNT BY	CEMENT (KG)	SAND(KG)	C.A.(KG)	WATER (KG)
1	WEIGHT	23.94	37.38	58.92	10.76
2	PROPORTION	1	1.56	2.46	0.45

Table 8: Mix extent and Measure of Materials utilized for blend M1(5% ESP and 40% M-Sand)

S. No.	AMOUNT BY	CEMENT(KG)	SAND(KG)	C.A. (KG)	WATER (KG)	ESP (KG)	M-SAND (KG)
1	WEIGHT	22.74	22.43	58.92	10.76	1.19	14.95
2	PROPORTION	1	0.98	2.58	0.47	0.05	0.65

Table 9: Mix extent and Measure of Materials utilized for blend M2(10% ESP and 40 % M-Sand)

S. No.	AMOUNT BY	CEMENT (KG)	SAND (KG)	C.A. (KG)	WATER (KG)	ESP (KG)	M-SAND (KG)
1	WEIGHT	21.55	22.43	58.92	10.76	2.39	14.95
2	PROPORTION	1	1.04	2.73	0.49	0.11	0.69

Table 10: Mix extent and Measure of Materials utilized for blend M3(15% ESP and 40 % M-Sand)

S. No.	AMOUNT BY	CEMENT(KG)	SAND(KG)	C.A. (KG)	WATER (KG)	ESP(KG)	M-SAND (KG)
1	WEIGHT	20.35	22.43	58.92	10.76	3.59	14.95
2	PROPORTION	1	1.10	2.89	0.52	0.17	0.73

Table 11: Mix extent and Measure of Materials utilized for blend M4(20% ESP and 40 % M-Sand)

S. No.	AMOUNT BY	CEMENT (KG)	SAND (KG)	C.A. (KG)	WATER (KG)	ESP (KG)	M-SAND (KG)
1	WEIGHT	19.16	22.43	58.92	10.76	4.78	14.95
2	PROPORTION	1	1.18	3.07	0.57	0.24	0.79

VII. CASTING OF SPECIMENS

The standard dimensions of the 3D square examples used for testing are 150 mm x 150 mm x 150 mm, 150 mm in width by 300 mm in height for the chamber example, and 100 mm x 100 mm by 500 mm for the shaft example. Following 7 days and 28 days, these Blocks, Chambers, and Bars are then tested separately for their compressive strength, split stiffness, and flexural strength. The inward sides of each form were coated with oil for their projecting

purpose so that the example comes out without any issues when it is reshaped.
In the wake of gauging them as determined, coarse total, fine total, concrete, and egg shell powder are fanned out in layers. The ingredients are then all combined.

A. Curing Of Specimens

Cement is protected from moisture loss throughout the relieving cycle, which is necessary for the hydration process. The restoration of these examples will result in increased solidarity and, as a result, reduce the penetrability of hardened concrete. As a result, during the restoration process, the material is kept damp or soggy until the hydration cycle is complete and the specimens return to their former capacity. The samples are maintained there for a period of 7 days and 28 days after being removed from the moulds until the desired tests are carried out on them.

B. Slump Cone Test

Slump cone testing is done to determine whether a substantial mixture that has been prepared at a research facility or construction site is effective or consistent as the activity progresses. Therefore, a significant decline in value determines the usefulness, which displays the water-concrete ratio, but it also depends on other factors such as the characteristics of the material, the blending method, measurement, and admixtures.

C. Compressive Strength Test

Compressive strength is the capacity of material or construction to bear the heaps which are applied on its surface with practically no break or diversion. In the event of pressure a material will in general lessen its size.
Compressive strength of cement relies upon different elements like water-concrete proportion, nature of substantial material, strength of concrete.
Pressure testing machine is utilized for testing these examples. This testing are show the Fig. No. 1.
The blocks involved here for test has a component of 150mm x 150mm x 150mm.
Examples were kept between the two plates of CTM and load was bit by bit applied at the pace of 140 kg/cm2 each moment till the examples fizzles.

The compressive strength of the blocks was tried following 7 days and 28 days.

Compressive strength = Applied Load / Area

Figure 1: Compressive Strength Test on Cubes

D. Flexural Strength Test

Flexure strength is the capacity of a pillar or section to resist failure in twisting. Thus, it is the proportion of most extreme pressure which is available on the strain face of unreinforced cement footer or piece where disappointment happens in twisting.
Flexural testing machine is utilised to test these examples. The pillar involved here for test has an element of 100mm x 100mm x 500mm.
Flexural tests are extremely delicate to how examples are ready, dealt with and their relieving methodology and period. Thus, tests on examples was finished when they their restoring period was finished and they were wet, as a brief length of drying can deliver a drop in the flexural strength of these bars or examples.
This test bar was properly set up in the machine before being played, and it was then focused with the longitudinal hub of the pillar at the proper locations to the rollers.
Then, until it runs out of room, that heap was gradually applied and increased on the example, and the highest weight that the machine had to bear was recorded. Flexural tests are show in figure 2.

Formula

Flexural Strength = 3 P a N/mm2
Where,
P is the maximum load that the test machine has applied.
The example's width is given by b. The level of the example is d.

Figure 2: Flexural Strength Test on Beams

E. Split Tensile Strength Test

A significant example's partial elasticity can be described as malleable pressure caused by the application of compressive pressure along its length, which may result in the substantial example shattering and ultimately leading to its disappointment.
As a result, the rigidity of that significant refers to the pressure that is created because of the application of load

on the substance at which disappointment occurs. This test utilized are show the according to Fig. no.3.
These instances are put to the test using a computerized pressure machine.
The test chamber in question has a component that is 150mm wide and 300mm high.
They were properly placed on the machine and the test was run on the hollow and round examples.
After that, the heap was gradually applied to it and extended until the example broke down. This example's reading that occurs at the moment of disappointment was noted down.

Formula

T=2PN/mm^2 = πld

Where,
T is Splitting tensile strength.
P is most extreme applied load on the substantial at which example breaks.
L is length of the example.
D is measurement of barrel shaped example.

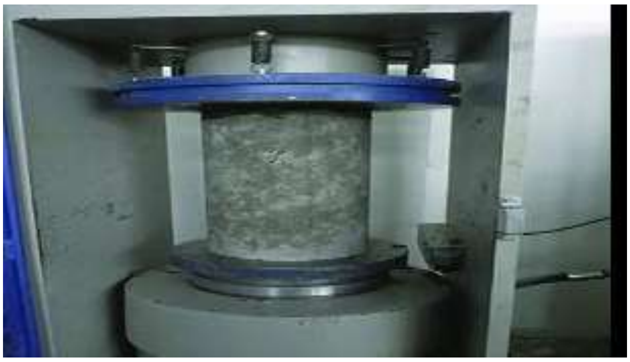

Figure 3: Split Tensile Strength Test on Cylinders

VIII. RESULTS & DISCUSSION

A. Compressive Strength Test

This test was carried out on 3D shapes using varied concentrations of egg shell powder in place of concrete and M-Sand in place of ordinary sand. The compressive strength of these solid shapes was assessed on entry of 7 days and 28 days after the restoration time, or 7 days and 28 days, respectively.
The results showed that, up until a certain breaking point, the expansion of Egg Shell powder and M-Sand increased the compressive strength of these 3D structures; however, as the level of ESP and M-Sand increased, the strength started to decline. According to the findings, the example's compressive strength was at its highest when 15% of egg shell powder and 40% of M-sand were substituted for concrete and regular sand, respectively, after 7 days and 28 days are show the table no. 12 and table no.13.

Table 12: Compressive Strength after 7days

ESP and M-SAND REPLACEMENT	COMPRESSIVE STRENGTH (N/mm^2)
0%-0%	19.53
5%-40%	21.76
10%-40%	24.98
15%-40%	26.40
20%-40%	24.25

Table 13: Compressive Strength after 28days

ESP and M-SAND REPLACEMENT	COMPRESSIVE STRENGTH (N/mm^2)
0%-0%	30.89
5%-40%	32.98
10%-40%	37.71
15%-40%	40.29
20%-40%	37.67

B. Flexural Strength Test

This test was conducted on pillars using varied concentrations of egg shell powder in place of concrete and M-Sand in place of regular sand. The compressive strength of these 3D squares was assessed on sections of 7 days and 28 days separately after the restoration time, which was 7 days and 28 days.
Similar to the compressive strength test, the results revealed that when Egg Shell powder and M-Sand were expanded to 15% ESP and 40% individually in all samples when tried on the section of 7 days and 28 days separately are show the Table no.14 and Table. No. 15, the flexural strength began to increase.

Table 14: Flexural Strength after 7 days

ESP and M-SAND REPLACEMENT	FLEXURAL STRENGTH (N/mm^2)
0%-0%	4.1
5%-40%	4.45
10%-40%	4.61
15%-40%	5.35
20%-40%	4.58

Table 15: Flexural Strength after 28 days

ESP and M-SAND REPLACEMENT	FLEXURAL STRENGTH (N/mm^2)
0%-0%	6.03
5%-40%	6.78
10%-40%	7.69
15 %-40%	8.30
20%-40%	7.65

C. Split Tensile Strength Test

This test was conducted in chambers with 150 mm of distance between objects and 300 mm of level ground.
These examples were kept for repairing for 7 days and 28 days after DE moulding are show the according to Table no.16 and Table no.17. They were tested on the sophisticated compressive machine after their individual relief period had ended.
Different rates of M-Sand and Egg Shell Powder were used for different mixtures. The example's split rigidity clearly expanded the most at 15% ESP and 40% M-Sand expansion, according to the results.

Table 16: Split Tensile Strength after 7days

ESP and M-SAND REPLACEMENT	SPLIT TENSILE STRENGTH (N/mm^2)
0%-0%	3.29
5%-40%	3.35
10%-40%	3.59
15%-40%	3.69
20%-40%	3.53

Table 17: Split Tensile Strength after 28days

ESP and M-SAND REPLACEMENT	SPLIT TENSILE STRENGTH (N/mm^2)
0%-0%	3.91
5%-40%	4.17
10%-40%	4.39
15%-40%	4.57
20%-40%	4.38

IX. CONCLUSION

- Additionally, after deconstructing the data from the tests, findings reveal that there was an increase in flexural strength when conventional Portland concrete was replaced with egg shell powder up to 15% and regular sand by manufactured sand up to 40%.
- According to the findings of the exploratory work, it is evident that common Portland concrete can be replaced with egg shell powder, and that replacing regular sand with manufactured sand will increase strength limits while also reducing the use of concrete and regular sand, helping to protect the environment and other natural resources.
- As a result, it stands to reason that 15% egg shell powder is the appropriate level for halfway replacing regular Portland concrete. As a result, it is likely that egg shell powder will eventually be used in construction materials to reduce carbon dioxide emissions.

X. FUTURE SCOPE

- It is possible to conduct more tests by varying the w/c ratios and adding different amounts of egg shell powder and M-Sand.
- By changing the proportions of egg shell powder and M-sand to concrete and leaving the substance's strength unknown, more tests can be carried out.
- Further research can be done in the future to see whether or not the various cement grades will also be helpful for our group of future residents.
- By using M-Sand, it can reduce our reliance on regular sand for the objectives of future development.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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