RESEARCH ARTICLE OPEN ACCESS

Partial Replacement of Rice Husk Ash and Egg Shell Powder for Cement on Normal Concrete

AKHILA T[1], Dr.M.S.SHOBHA[2]

ABSTRACT:
Nowadays the conventional concrete construction industry is not sustainable due to huge consumption of natural materials and environmental pollution created during its production. The use of waste product as a cementitious material in concrete will reduce the use of cement and ultimately the construction cost. In the present investigation Rice Hush Ash and Egg Shell Powder are used as a replacement of cement. The compressive strength, spit tensile strength and flexural strength of these mixes are tested and compared with the normal concrete at the end of 7 and 28 days and also the microstructure of rice husk ash and egg shell of varying percentages was determined by Scanning Electron Microscope (SEM).

Date of Submission: 01-09-2022 Date of Acceptance: 13-09-2022

I. INTRODUCTION

Normal concrete is another term for this type of concrete. It is the most widely utilised in the industry and is easily available to clients. It is typically utilised in the house to complete building tasks. However, in extreme weather conditions, concrete is not suggested for building operations. Sands is utilized as an aggregate in concrete, along with other minerals that are combined in makeshift containers. The normal setting time for concrete is 30 to 90 mins.

Rice Husk Ash

The husk encircles the paddy grain. Rice husk is one of the most common agricultural byproducts in many rice-producing regions worldwide. Each year, around 600 million tonnes of rice paddies are produced worldwide. On average, 20% of rice paddy is husk, for a total yearly yield of 120 million tonnes. The majority of rice-producing countries burn or discard much of the husk produced during rice processing. When RH is burned in the open air, it produces a residue known as rice husk ash. For every 1000kg of rice milled, around 220 kg (22%) of husk is produced, and when this husk is burned in boilers, approximately 55 kg (25%) of RHA is created. Due to a lack of economic interest, rice husk removal during rice refining presents a disposal difficulty. RH is also difficult to handle and carry because of its low density. RHA is a significant environmental risk, causing harm to the soil and surrounding region where it is dumped. As a result, the commercial usage of rice husk and ash provides an alternate answer to the recycling industry.

Fig 1 Rice Husk Ash

Egg Shell Powder

India primarily exports eggs, egg powder, frozen egg yolk, and albumin powder to Europe, Japan, and other destinations. After Tamil Nadu, Andhra Pradesh comes second in egg exports. Eggshells are biodegradable trash from chicken hatcheries, bakeries, and fast food restaurants. This, like other biodegradable wastes, can harm the environment, resulting in ecological issues/contamination that would require proper treatment. The efficacy of turning eggshells to good use becomes a notion worth embracing in the ever- increasing efforts to convert waste to income. It is scientifically proven that eggshell is mostly constituted of calcium compounds.

Fig 2 Egg Shell Powder

Objectives

The primary goals of this research are as follows

1. To investigate the mechanical characteristics of M20 grade concrete.
2. The mechanical properties of M40 grade concrete will be investigated by adding superplasticizer.
3. Rice husk ash's effect on the mechanical behavior of M40 grade concrete
4. The influence of egg shell powder on the mechanical properties of M40 grade concrete.
5. The effect of combining rice husk ash and egg shell powder on the mechanical qualities of M40 grade concrete.
6. To investigate the compressive strength of M20 grade concrete, M40 grade concrete with superplasticizer, and M40 grade concrete with rice husk ash and egg shell powder using a scanning electron microscope.
7. Positive use of industrialised trash.

II. LITERATURE REVIEW

Nurul Shahadahtul Afizah Asman, Salinah Dullah, Janice Lynn Ayog, Adriana Amaludin, Hassanel Amaludin, C. H. Lim, and Aslina Baharum carried out work on 'Mechanical Properties of Concrete Using Eggshell Ash and Rice Husk Ash As Partial Replacement Of Cement' They investigated the optimal proportion of eggshell ash and rice husk ash (RHA) as partial replacement for cement. The materials were mechanically evaluated using concrete grade M30, a cube mould (100mmx100mmx100mm), and prisms (100mmx100mmx 500 mm). The samples were combined with varying concentrations of eggshell ash and RHA admixture (2%:8%, 4%:6%, and 6%:4%). The samples were subjected to a variety of tests, including the slump, compressive, and flexural tests. Previous study has shown that replacing concrete with eggshells reduces the strength of the concrete. When partial cement is replaced with eggshell ash, most studies show a similar pattern. To boost strength, an additive with pozzolanic reactivity known as rice husk ash (RHA) is incorporated into the mix design, that has been shown to assist increase strength of concrete.

The offered result would be that workability in slump test can only be obtained by combining 4% eggshell ash and 6% RHA with a slump of 30mm. Meanwhile, with 3mm and 6mm slumps, normal concrete M30 and concrete with 2% eggshell ash and 8% RHA are less workable. Concrete with 2% eggshell and 8% RHA has a very low degree of workability and a 6mm slump, and it may be used to make roads. However, concrete containing 4% eggshell ash and 6% RHA has a poor level of workability with such a slump of 30mm and may be used for road construction and mild reinforcing of concrete. Finally, concrete with 6% eggshell ash and 4% RHA has a moderate level of workability with a slump of 50mm and may be used to make roads and substantial reinforcing of concrete.

Generally, the flexural and compressive strength of the concrete with eggshell ash and RHA substituted is lower than that of regular concrete with completely OPC. Even so, the strength was increased from day 7 to day 28 due to the pozzolanic effect, which refers to a large concentration of amorphous silica that has a favourable impact on the concrete strength.

Soumyan K, Aswathi Viswanath K are carried out work on 'Experimental Study to Check the Effect of Egg Shell Powder and Rice Husk Ash on the Property of Concrete' wherein they investigated the use of rice husk ash and egg shell powder as cement substitutes At the conclusion of 7 and 28 days, the compressive strength, spit tensile strength, and flexural of these mixes are measured and compared to conventional concrete using the mix 1:1.5:3.

Cube specimens of 150x150mm, cylinder of 150x300mm, and beam of 500x100x100mm were formed to test the compressive, split, and flexural strength of concrete. The initial control mix was created without the use of RHA or ESP. The concrete examples were then constructed using various amounts of egg shell powder (2.5, 5, 7.5, and 10%). The ideal egg shell powder concentration in concrete was discovered after evaluating these examples. Consequently Specimens with varied percentages of RHA (5,7.5,10,15,&20%) were created and evaluated while maintaining the ESP level equal. For test results, three to six specimens of each mixture were created. Concrete was made with a mix percentage of 1:1.5:3 and a ratio of water cement of 0.45. However, because to limited flowability, the water cement ratio was adjusted to enhance the proportion of RHA. The concrete (also RHA,ESP) and fines aggregate were mixed dry until thoroughly combined and uniform in colour. This gravel then was added and blended with cemented and fine and coarse until the coarse aggregate was evenly distributed all through the batch. Waters then was poured, and the whole batch was mixed until the concrete appeared homogeneous and had the appropriate texture. Immersion in freshwater was used to cure the specimen for 7 and 28 days of examination.

This same given result that when cement is partly replaced with Rice husk ash and egg shell powder, the quantity of water required to produce a slurry of standard consistency increases, the compressive, split tensile, and flexural strength of each and every Rice husk ash and egg shell powder concrete mix is greater that of the mix proportion with the exception of 20% Rice husk ash substitute, the optimum amount of egg shell powder concrete is acquired as 5%, as well as the maximum split tensile and bend, The flexural modulus of Rice husk ashes and eggshell powder concrete is comparable to conventional concrete. Compared to Rice husk ashes concrete, Eggshell powder concrete had marginally greater initial strength development, RHA in concrete rises water requirements due to its cell structure, The the findings of this study reveal that there is great potential for using ESP and RHA as a substitute for cement.

Mr. G.S. Harish Kumar, A. Pavan Kalyan, M. Ramya Sree, R. Sai Priya are carried out work on 'Assessment of the Strength of Concrete by Employing Eggshell Powder and Rice Husk Ash for Partial Replacement of Cement' Wherein they looked into the characteristics of the compressive strength, spit tensile strength, and flexural strength of these mixtures and compared them to normal concrete at the end of 7 and 28 days. The major constituents of concrete mixture, cement, fine aggregate, gravel, and water, were used in laboratory studies. In the meantime, in the design mix, eggshell ash and RHA were used as that the for cement. Following that, testing such as slump and compressive strength tests were performed, as indicated in this research. Additional tests, such as spit tensile strength and flexural strength, also were performed. Therefore the information for all trials were collected again for study. The test samples were combined with eggshell ash and RHA mixture. During in the blending of the conventional concrete, incomplete concrete will be supplanted with eggshell ash and RHA in the percentages ascertained.

The stated result is that a attempt was made to illuminate the usage of rice husk ash and egg shell powder in concrete based on their competency. The findings of this study suggest that a mixture of 6% eggshell ash and 4% RHA may achieve workability in a slump test. Meanwhile, ordinary concrete and concrete with 3% eggshell ash and 7% RHA are less practical.

III. METHODOLOGY

The following components and qualities were discovered by employing the essential instruments for the investigation of partial substitute of rice husk ash and egg shell powder for cement on standard concrete. The mix design for M20 and M40 grade concrete was completed utilising the attributes of the components. Cube specimens (150x150x150mmsize), Beam specimens(100x100x750mm), and Cylinder specimens (150mmdia)were casted.

Table 1 Cement Properties

Material Specification	Results
Specific Gravity	3.08
Normal Consistency	31%
Initial Setting Time	55 Minutes
Final Setting Time	08 hours 35 minutes
Compressive Strength (28days)	47.62 N/mm^2

Table 2 Properties of Sand

Material Specification	Results
Specific Gravity	2.65
Fineness Modulus	3.4%
Water Absorption	1%

Table 3 Properties of Coarse Aggregate

Material Specification	Results
Specific Gravity	2.70
Fineness Modulus	7.42%
Water Absorption	0.6%

Table 4 Rice Husk Ash Properties

Material Specification	Results
Specific Gravity	2.14
Fineness	3458 m^2/kg
Bulk Density	696 kg/m^3

Table 5 Egg Shell Powder Properties

Material Specification	**Results**
Specific Gravity	0.84
Fineness Modulus, %	41
Bulk Density	1081 kg/m^3

Fig 3 Casting of Specimens

Table 6 Mix Designations

Designation	Mix
M1	M20
M2	M40+1%SP
M3	M40+1%SP+3%ESP
M4	M40+1%SP+5.5%ESP
M5	M40+1%SP+7.0%ESP
M6	M40+1%SP+5.5%RHA
M7	M40+1%SP+10.5%RHA
M8	M40+1%SP+15.5%RHA
M9	M40+1%SP+10.5%RHA+5.5%ESP

IV. RESULTS AND DISCUSSIONS

Slump Test

Fig 4 Slump Test

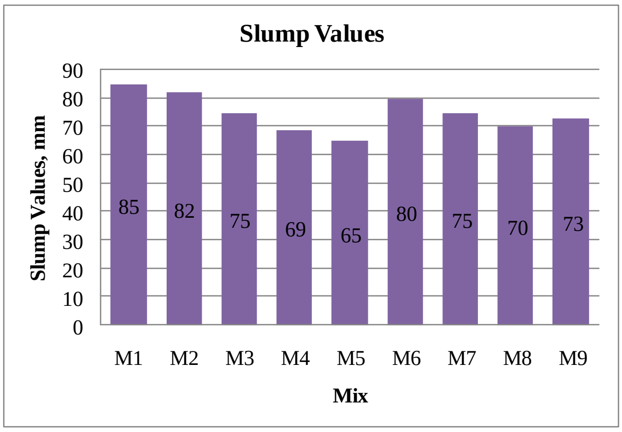

Fig 5 Slump Values

The graph above shows that by adding cement replacement to the concrete using egg shell powder (ESP) and rice husk ash (RHA), the slump values decrease as the percentages increase.

Compressive Strength Test

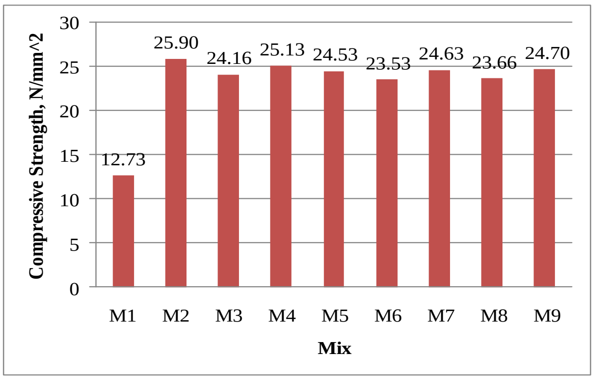

Fig 5 Compressive Strength for 7 Days

The compressive strength increases by 5.5% egg shell powder (M4) and 10.5% rice husk ash (M7) when cement is replaced.

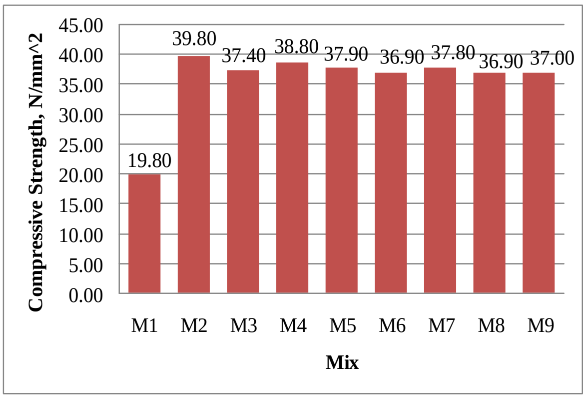

Fig 6 Compressive Strength for 28 Days

According to the above figure, the compressive strength increases by 5.5% egg shell powder (M4) and 10.5% rice husk ash (M7) when cement is replaced.

Splitting Tensile Strength Test

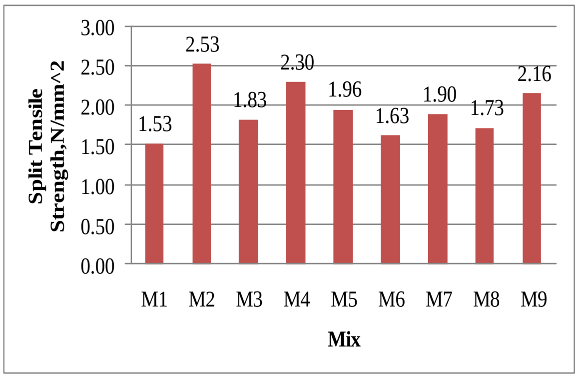

Fig 7 7 Days Split Tensile Strength

According to the figure, the split tensile increases as the egg shell powder increases up to 5.5% (M4) and 10.5% rice husk ash (M7), after which the split tensile strength test decreases.

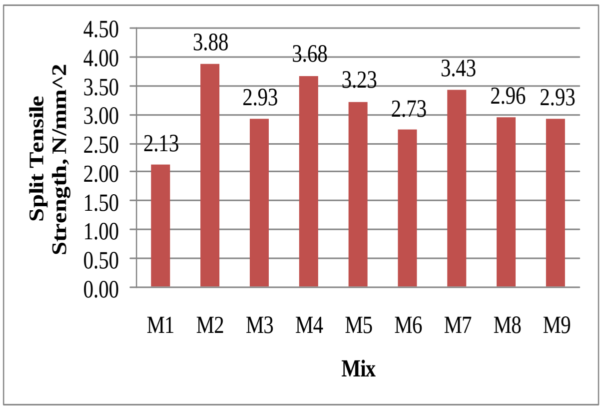

Fig 8 28 Days Split Tensile Strength

According to the graph, the split tensile increases as the egg shell powder increases up to 5.5% and 10.5% rice husk ash, after which the split tensile strength test decreases.

Flexural Strength Test

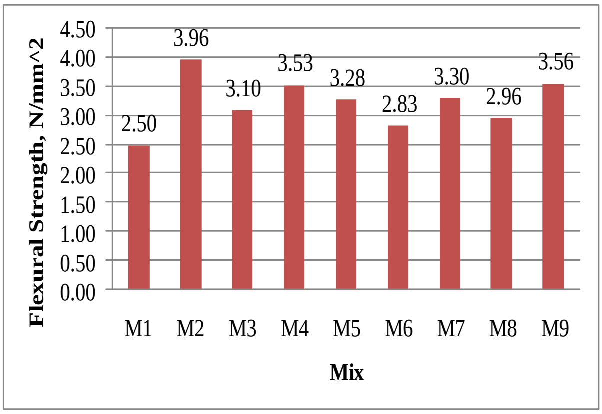

Fig 9 7 Days Flexural Strength

The greatest flexural strength was derived from the figure for the percentages of 5.5% egg shell powder (M4) and 10.5% rice husk ash (M7) when compared to the other percentages.

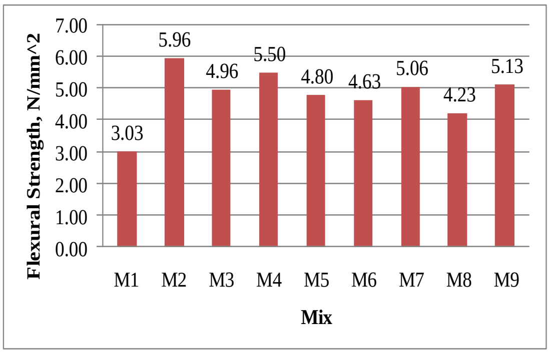

Fig 10 28 Days Flexural Strength

According to the graph, the percentages of 5.5% egg shell powder and 10.5% rice husk ash yielded the highest flexural strength when compared to the other percentages.

Scanning Electron Microscope

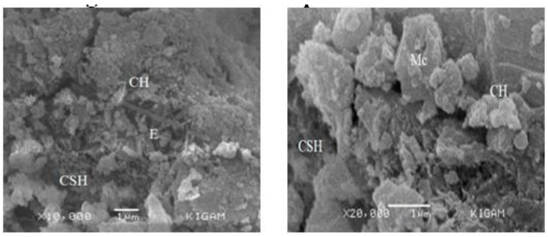

Fig11 a. SEM image of OPC and **b**. Samples Containing Egg Shell Powder

The following graphic depicts the morphology of regular Portland cement (OPC) and an eggshell powder (ESP) sample. The principal hydration products in both samples are portlandite (plate-like form) and CSH (sheet-like structure). A needle-like structure is seen in OPC (Figure 11a), indicating the presence of ettringite. Because of the presence of calcium carbonate in the sample, ettringite is not visible in ESP samples (Figure 11b); instead, monocarboaluminate, a crystalline structure, is visible. Ettringite's stability is quite low in the absence of calcium carbonate.

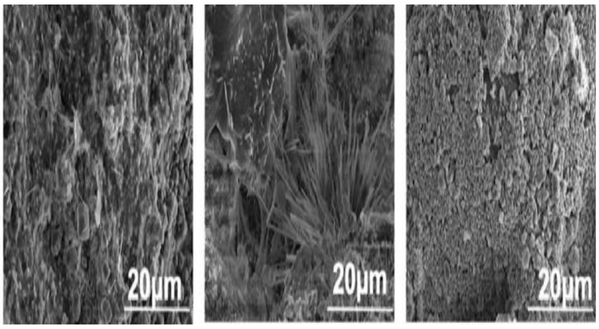

Fig 12 SEM images of Egg Shell Powder Replaced with 3% (M3), 5.5% (M4) and 7.0% (M5) in Cement

The SEM structure of 3% eggshell powder and 5.5% eggshell powder substituted with cement displayed pointed tentacles, which corresponded to the Calcium-Silicate-Hydrate (C-S-H) in cement. The morphological 7% egg shell powder replaced with cement sample was found to be less permeable compared to the other samples. This also suggested a thick structure. Because lime or calcium oxide is already a substance used in the making of cement, increasing the quantity may cause the mortar to set faster. Si content is also important in creating mortar strength. Better strength may be produced with a 5.5% replacement of egg shell powder in cement in the concrete than with a 7% replacement of egg shell powder. Because cement is a very heterogeneous substance, numerous compounds develop during the hydration process.

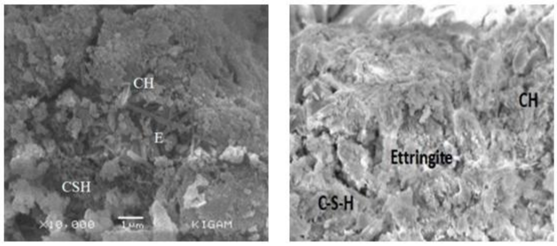

Fig 13 a. SEM image of OPC and **b**. Samples Containing Rice Husk Ash

Because the pozzolanas actions of the RHA paste were much more significant at older times than at younger ages, the addition of RHA slowed cement hydration at an early age. This is because the RHA particles have a porous structure. Water absorbed in porous RHA acts as an internal curing agent, boosting cement hydration later in the process. As a result, the pozzolanas response of RHA in Portland cement is affected by the porosity of the RHA. Because of the linked filling effects, the particle size of the RHA impacts the permeability and toughness of the mortar. The SEM images revealed that the response between RHA and CH remained extremely weak. The amount of C-S-H gel as RHA grew, yet RHA was still present in the cement paste; this was most noticeable in the 15.5% RHA sample.

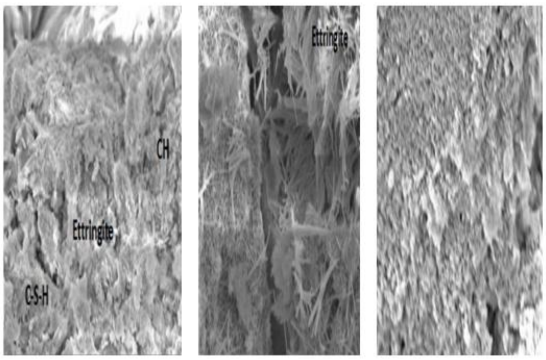

Fig 14 SEM (20μm) image Rice Husk Ash 5.5% (M6), 10.5% (M7) and 15.5% (M8) replaced with cement.

The CSH gel in RHA samples remains lower than in control samples, and the more RHA added, the less CHS gel owing to less Portland cement (replaced by RHA), whereas the reaction between RHA and Ca(OH)2 remains low even after

28 days. We can observe from the SEM picture that the RHA filled the cement mortar paste gap. The less pozzolanic reaction of RHA leads the paste to be less thick and the strength of RHA blended to be reduced. At 28 days, the 5.5% and 15.5% RHA blended mortars had greater CH and porosity than the 10.5% RHA blended mortar.

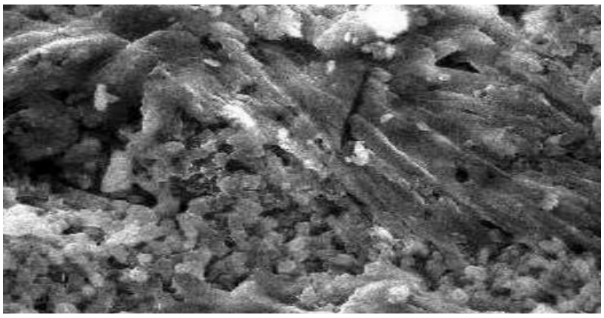

Fig 15 SEM (20µm) image Rice Husk Ash 10.5% and Egg Shell Powder 5.5% (M9) replaced with cement.

The top graphic depicts SEM images of concrete containing 10.5% RHA and 5.5% ESP. Internal grains are densely packed, and the near particles form a solid mass. The dark grey patches in the photograph are thought to represent hydration products. However, there are a few voids/cracks (limited black spots) and un-hydrated cement particles (white regions). The data suggest that the intake of CH, egg shell powder, and rice husk ash paste is more efficient in providing the extra side reactions to strength enhancement in additional concrete comprising 10.5% RHA and 5.5% ESP.

V. CONCLUSION

In this investigation, it was possible to illuminate the use of rice husk ash and egg shell powder in concrete based on their proficiency. The following conclusions are drawn from the findings of compressive strength, split tensile strength, and flexural strength tests.

1. By using this rice husk ash and egg shell powder in concrete as replacement the emission of greenhouse gases can be decreased to a greater extent.
2. The workability of concrete got in the 3% egg shell powder in replacement of cement and 5.5% rice husk ash in replacement of cement when compared to the other percentages of egg shell powder and rice husk ash. When the egg shell powder and rice husk ash both added for the replacement of cement there is decrease in the workability when compared to the individual replacement to the cement.
3. The optimum dosage of the egg shell powder is 5.50% and for rice husk ash is 10.50%.
4. For 7 days and 28 days compressive strength, split tensile strength and flexural strength, the egg shell powder replacement gain more strength when compared to the rice husk ash replacement. There is 2 to 3% increased when replacement of cement with egg shells powder, when compared with the rice husk ash replacement.
5. Eggshells have been proven to be of good quality to react with other materials by the activity test. The addition of eggshell powder to Portland cement accelerates the hydration reaction by reacting with tri-calcium silicate (C_3S) and also influences the hydration product of cement paste by providing nucleation sites. The precipitation of CSH is also promoted by the nucleation effect of ESP.
6. SEM images show that the CSH in RHA samples was still less than that of the control samples, and if more RHA was added, less CHS gel was produced as the reaction of RHA and $Ca(OH)_2$ was still low, even at 28 days. However, we can see from the SEM image that the RHA filled the gaps in the cement mortar paste.
7. The effect of addition concrete containing 10.5% RHA and 5.5% ESP, the findings indicate that the consumption of CH, egg shell powder and rice husk ash paste is more effective in contributing the additional reaction products to strength enhancement

REFERENCES

[1]. Nurul Shahadahtul Afizah Asman, Salinah Dullah, Janice Lynn Ayog, Adriana
[2]. Amaludin, Hassanel Amaludin, C. H. Lim, and Aslina Baharum, “Mechanical Properties of Concrete Using Eggshell Ash and Rice Husk Ash As Partial Replacement Of Cement”, MATEC Web of Conferences 103, 01002 (2017), ISCEE 2016.
[3]. Soumyan K, Aswathi Viswanath K, ”Experimental Study to Check the Effect of Egg Shell Powder and Rice Husk Ash on the Property of Concrete”, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, NCCETCE – 2016.
[4]. K. Omprakash, K. Jaya Chandra, B. Balakrishna Bharath, “An Experimental Study On Strength Properties Of Concrete Using Ggbs, Rice Husk Ash (RHA) And Egg Shell Powder (ESP)”, International Journal of Scientific Research and Review, Volume 7, Issue 7, 2018.
[5]. Arun Kumar C, Sri Ruban D, Suresh Kumar P, Nagarajan N,Sudeendra B, “A Partial

Replacement Of Egg Shell Powder For Cement In Concrete", International Journal of Creative Research Thoughts (IJCRT), Volume 6, Issue 1 February 2018.

[6]. Manzoor Ahmad Allie, Er. Anand, "Behaviour Of Concrete Containing Egg Shell Powder As Cement Replacing Material", International Journal of Scientific Development and Research (IJSDR), May 2018.

[7]. Nisar Ahmed Gabol, Fareed Ahmed Memon, Mian Jawaduddin , Zaheer H Zardari, "Analysis of eggshell powder as a partial replacing material in concrete", International Journal of Modern Research in Engineering & Management (IJMREM), September 2019.

[8]. Mr. G.S. Harish Kumar, A. Pavan Kalyan, M. Ramya Sree, R. Sai Priya, "Assessment of the Strength of Concrete by Employing Eggshell Powder and Rice Husk Ash for Partial Replacement of Cement", International Research Journal of Engineering and Technology (IRJET), Volume: 08 Issue: 06 | June 2021.

[9]. L.Sathish, M.Lalith Kumar, "Experimental Investigation Of Eco-Friendly Concrete Using Rice Husk Ash & Egg Shell Partially Replacement With Cement & Fine Aggregate", International Journal Of Current Engineering And Scientific Research (IJCESR), ISSN (PRINT): 2393-8374, (ONLINE): 2394-0697, VOLUME-4, ISSUE-12, 2017.

[10]. Mr. Laiq Ahmad Khan, Mr. Jahid Khan, "An Experimental Investigation On Mechanical Properties of M25 Concrete Using Egg Shell Powder and Flyash Rice Husk Ash", Journal of Interdisciplinary Cycle Research, Volume XII, Issue VII, July/2020.

[11]. G.K.Deepapriya, M.Jayapratha, P.Karthika ,R. Madhuvanthi, Mr.K.Saravanakumar, "An Experimental Investigation On Concrete With Partial Replacement Of Cement By Eggshell Powder And Rice Husk Powder", International Journal of Science and Engineering Research (IJ0SER), Vol 6 Issue 4 April -2018.

[12]. K.G.Vinothan, T.Janani, R.Revathi, R.Bhuvaneshwari,S.Santhiya,Hemath Naveen.K.S, "Study and Experimental Investigation of Partial Replacement of Eggshell Powder as Cement in Concrete", SSRG International Journal of Civil Engineering (SSRG - IJCE) – Volume 4 Issue 3 – March 2017.

[13]. Bantu Sravanthi, M. Saikrishna, "Strength, Durability And Properties Of Concrete By Using Fly Ash, Rice Husk Ash And Egg Shell Powder As Partial Replacement Of Cement", International Journal of Research, Volume 7, Issue VII, JULY/2018.

[14]. M. Sivakumar, Dr.N. Mahendran, "Strength And Permeability Properties of Concrete Using Fly Ash (FA), Rise Husk Ash (RHA) and Egg Shell Powder (ESP)", Journal of Theoretical and Applied Information Technology 20th August 2014.

[15]. A Vinay Rathnam, K Raja Revanth kumar, Y SomBabu, "A Comprehensive Enhancement in Finding the Properties of Eggshell Concrete With Replacement of Cement by Flyash", Pramana Research Journal, Volume 9, Issue 3, 2019.

[16]. DR.S.G.Makarande, C. H. Lohabare, PROF.G.D.Dhawale, PROF. A. B. Dehane, "Study the Strength Property of Concrete Using Fly Ash (FA), Rise Husk Ash (RHA) and Egg Shell Powder (ESP)", ICONIC Research and Engineering Journals, Volume 3 Issue 4, OCT 2019.

AUTHORS PROFILE

AKHILA T
PG Scholar
Department of Civil Engineering
RYMEC, Ballari.
akhilat2200@gmail.com

DR.M.S.SHOBHA
Professor
Department of Civil Engineering
RYMEC, Ballari.
shobha@rymec.in