JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# PERFORMANCE EVALUATION OF SELF-HEALING CONCRETE BY PARTIAL REPLACEMENT OF CONCRETE MATERIALS

**[1]CH. Sobha Rani, [2]V. Meghana**
[1&2]Assistant Professor, Department of Civil Engineering, Geethanjali Institute of Science and Technology, Nellore, AP, India.

***Abstract:*** This paper presents the making of the self-healing concrete by decreasing the quantity of the concrete materials, like fine aggregates, and coarse aggregates. These concrete materials are partially replaced by rice husk ash and coconut shells of 0%,5%,10%,15% and 20% replacement of each material respectively. The crack formation is very common phenomenon in concrete structures. To repair these cracks, it takes a lot of time. To overcome these types of cracking problems we need to add self-healing materials like self-healing bacteria like species Bacillus or bactaheal. The function of these bacteria is it can heal the cracked surface by itself when it comes into contact with heat and water. Overall, this abstract presents that self-healing of concrete by partial replacement of concrete materials with other materials which have same properties.

**Keywords:** partial replacement, self- healing, bactaheal.

## 1. INTRODUCTION

Utilization of concrete is increasing at a very high rate due to infrastructural development activities in the world. Concrete is one of the world's most widely used construction material. There are some negative impacts of more production of concrete like continuous extensive extraction of aggregate from natural resources will lead to its depletion and ecological imbalance. So many researches are in search of replacing the concrete materials in the concrete mix so that leads to ecological balance and to extend sustainable development.

The partial replacement of any concrete materials in the concrete, then the concrete is said to be lightweight concrete. The partial replacement of fine aggregate is with rice husk ash. Rice husk is an agricultural by-product obtained from the milling of paddy. The residues obtained from these processes contain approximately 90% silica by mass, the reactivity of the silica is poor, and the residues color varies from white to black.

The partial replacement of coarse aggregate is with coconut shells. The coconut shells are obtained from the by-product of the coconuts. The waste coconut shells may be utilized to replace natural coarse aggregate. Coconut shell has high strength and modulus properties. Coconut shells are naturally available in nature and which almost fulfill all the qualities of the coarse aggregate.

### *1.1 RICEHUSK ASH(RHA):*

RHA generally referred to an agricultural by-product of burning husk under controlled temperature of below 800 °C. The process produces about 25% ash containing 85% to 90% amorphous silica plus about 5% alumina, which makes it highly pozzolanic. There are two ways to burn rice hush: controlled and uncontrolled methods.

### *1.2 COCONUT SHELLS:*

Coconut is grown in more than 100 countries. India is the third largest, having cultivation in an area of about two million hectares for coconut production. Yearly output is close to approximately 8000 million nuts with an average of 4300 nuts per hectare. It also presents serious disposal problems for a local environment, is an abundantly available agricultural waste from local coconut industries. Coconut shell being a difficult and not easily degrade material if crushed to the size of sand can be a likely material to substitute coarse aggregate. The chemical composition of the coconut shell is similar to wood. It contains 33.61% cellulose, 36.51% lignin, 29.27% and ash at 0.61%. In developing countries, where abundant coconut shell waste is discharged, these wastes can be used as potential material or replacement material in the construction industry.

### *1.3 BACTAHEAL-PR:*

The BACTAHEAL-PR is a new concept in the cement industry. Cracks in concrete are a common phenomenon due to the relatively low tensile strength. Durability of concrete is impaired by these cracks since they provide an easy path for the transportation of liquids and gasses that potentially contain harmful substances. Concrete has an autogenous healing capacity as un hydrated cement is present in the matrix. When water contacts the un hydrated cement, further hydration occurs. Furthermore, dissolved CO2 reacts with Ca2+ to form CaCO3 crystals.

### *1.4 LIME:*

Lime, in the form of calcium carbonate, plays a crucial role in self-healing concrete alongside bacteria. Bacteria, when activated by water entering cracks, metabolize nutrients like calcium lactate or calcium carbonate, producing more calcium carbonate (lime) which fills the cracks and seals them, restoring the concrete's integrity. This process is known as biomineralization.

## 2. OBJECTIVES OF THE PROJECT

The objectives of the project are mentioned below:

- To determine the compressive strength of the conventional concrete at 7days,14 days and 28 days of curing respectively.
- To determine the compressive strength of the lightweight concrete by partial replacement of fine aggregate with rice husk ash at 7 days,14 days and 28 days of curing respectively.
- To determine the compressive strength of the lightweight concrete by partial replacement of coarse aggregate with coconut shells at 7 days,14 days and 28 days of curing respectively.
- To determine the compressive strength of the lightweight concrete by partial replacement of both fine aggregates and coarse aggregates with rice husk ash and coconut shells respectively at 7 days,14 days and 28 days of curing respectively.
- To determine the compressive strength of the lightweight concrete by partial replacement of both fine aggregate and coarse aggregate with rice husk ash and coconut shells respectively and also by adding the bactoheal (self-healing bacteria) at 7 days, 14 days, 28 days of curing respectively.

## 3. LITERATURE REVIEW:

**Mr. Rajandra Kumar M.E., MISTE. *1, Mr. Kamalesh. S *2, Mr. Pushparaj. S *3, Mr. Ragul. V*4 (2024)**. The results show that concrete with mechanical qualities similar to the control mix (0% rice husk) could be produced with up to 15% replacement. Nonetheless, a minor reduction in compressive strength was noted at 20% replacement. However, it was shown that adding rice husk could improve the sustainability of concrete production without compromising acceptable performance standards.

**Okafor chinedum Vincent*1, Kelvin Okolie chuks*2, Arinze unchennaokeke*3 (2023)** the result of the water absorption test performed on the concrete cube samples, it was discovered that as the percentage replacement of sand with rice husk ash increases, the rate of water absorption of the concrete also increases.

**Richard P.Wool (2008)** the crack width ranges from 0.3mm to 1.5mm, to heal the crack the concrete takes 7-14 days.

**Shrikant M. Harle (2017)** The tests were concluded that greater than 20% replacement leads to slump increase and also it decreases it’s strength.

**Rafat Siddique(2016)** Bacterial cells addition in RHA concrete further improved its compressive strength and permeation properties. Optimum dosage of RHA as cement replacement in concrete was 10%. The concrete matrix by bacterial induced calcite precipitation.

## 4. METHODOLOGY

Step by Step process of Methodology.

- Materials Utilized
- Preliminary Tests on Materials
- MIX DESIGN
- Casting of Concrete Cubes
- Experimental Investigation

### 4.1 Materials Utilized

**Table 1: Materials utilized**

| Materials | Specifications |
|---|---|
| Cement | Ordinary Portland cement (O.P.C), 53 Grade |
| Fine Aggregate | Sand |
| Coarse Aggregate | Stones, 20 mm |
| Rice husk Ash | controlled burning, 550 °C - 700 °C |
| Coconut Shells | Crushed |
| Water | Portable |
| Self-Healing Bacteria | BACTAHEAL |

### 4.2 Preliminary Tests on Materials

**Table2: Tests on Materials**

| | | |
|---|---|---|
| Cement | Finess of cement | 4.67% |
| | Standard consistency | 33% |
| | Specific gravity | 3.14 |
| | Unit weight | 1450Kg/cum |
| Fine Aggregate | Loose density (Kg/m$^3$) | 1416.5 |
| | Specific gravity | 2.66 |
| | Water absorption | 1.6% |
| | Fineness modulus | 2.75 |
| Coarse Aggregate | Specific Gravity | 2.88 |
| | Water Absorption | 0.5% |
| | Loose Density | 1578 Kg/m$^3$ |
| | Impact Value | 15.29% |
| Rice husk Ash | Color | Black |
| | Specific gravity | 1.93 |
| | Water absorption (%) | 14.2 |
| | Bulk density(Kg/m3) | 300.4 |
| Coconut Shells | Specific gravity | 1.33 |
| | Water absorption (%) | 24 |
| | Bulk density (Kg/m3) | 259.5 |
| | Shell thickness(mm) | 2-7 |

### 4.3 MIX DESIGN

**Table -3: Nominal Mix**

| Material description ($Kg/m^3$) | M30 Grade |
|---|---|
| Cement | 418 |
| FA | 684 |
| CA | 1180 |
| Water | 203 |
| W/C | 0.44 |

### 4.4 Casting of Concrete Cubes

**Fig 1: Materials utilised for mixing of concrete**

**Fig 2 Casting of Concrete Cubes**

### 4.5 Experimental Investigation

Comparison of a self-healing concrete cube before and after bacterial healing with Lime, visible cracks and rough edges indicate damage on the surface, while smooth and filled cracks indicate the effectiveness of bacterial activity as it results in the formation of calcium precipitate as shown in fig.5

**Fig-3: compression test of conctrete cube**

**Fig-4: Bacterial concrete without lime of day 28**

**Fig-5 crack healing capacity of self healing bacterial concrete for day 1and day 7**

## 5. RESULTS AND DISCUSSION ON PARTIAL REPLACED CONCRETE

The following are the results of compressive strengths of all concrete mixes prepared by replacing fine aggregate and coarse aggregate with RHA and coconut shells respectively with various percentages. The strengths of all concrete mixes are determined a 7 and 28 days of curing in water. The following are the tables showing all the results.

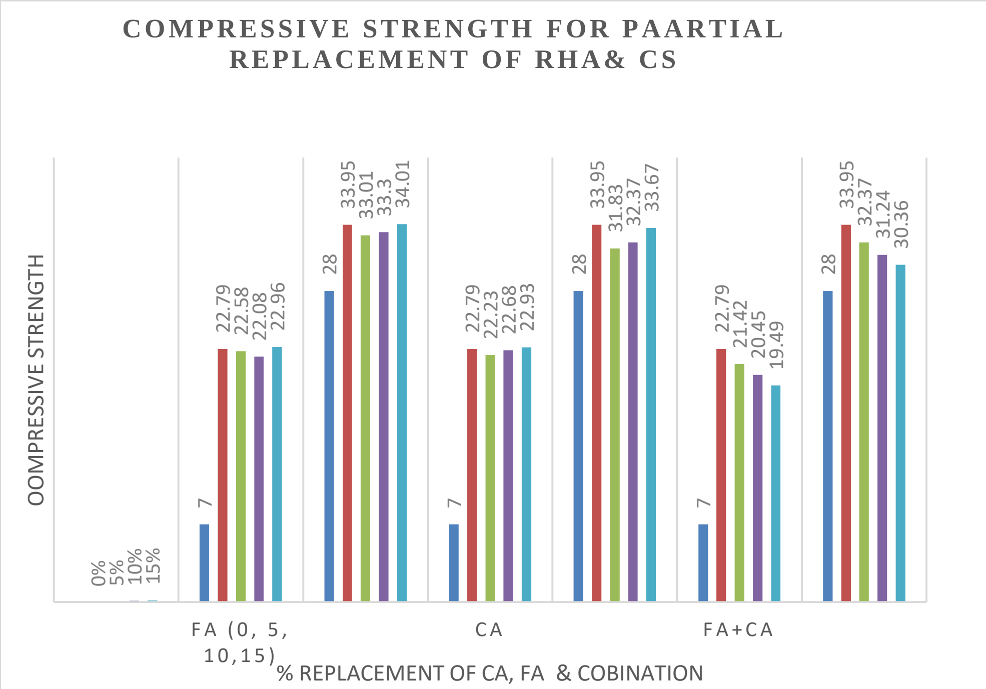
**Table -4: Compressive strength results with replacement of RHA & CS**

| Replacement | No. of days | % Replacement with FA & CA | | | |
|---|---|---|---|---|---|
| | | 0% | 5% | 10% | 15% |
| FA | 7 | 22.79 | 22.58 | 22.08 | 22.96 |
| | 28 | 33.95 | 33.01 | 33.3 | 34.01 |
| CA | 7 | 22.79 | 22.23 | 22.68 | 22.93 |
| | 28 | 33.95 | 31.83 | 32.37 | 33.67 |
| FA+CA | 7 | 22.79 | 21.42 | 20.45 | 19.49 |
| | 28 | 33.95 | 32.37 | 31.24 | 30.36 |

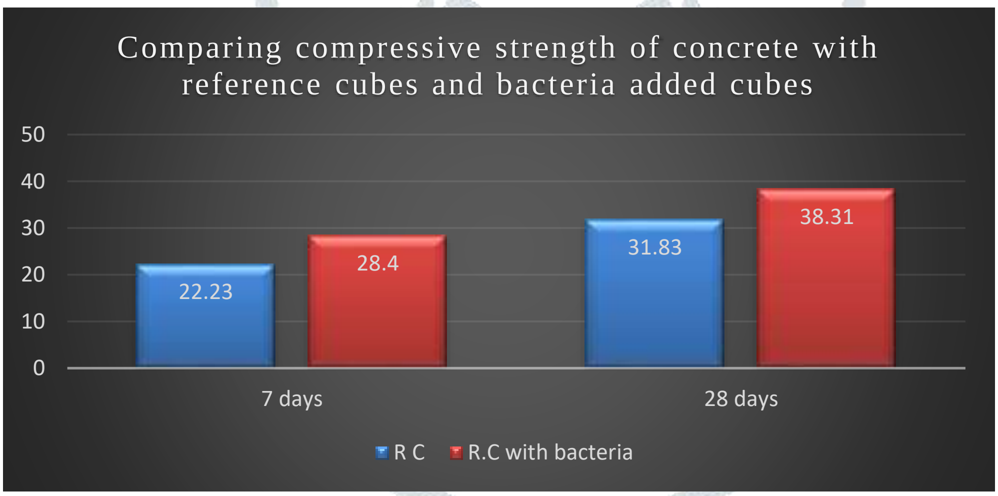
**Table-5: Compressive strength results with Bacteria**

| Type of cube | 7 Days | 28 Days |
|---|---|---|
| Nominal cube | 22.23 | 31.83 |
| 5% Combined Replacement | 21.42 | 32.37 |
| Nominal cube + Bacteria | 28.4 | 38.31 |
| Combined replacement + Bacteria | 29.84 | 39.58 |

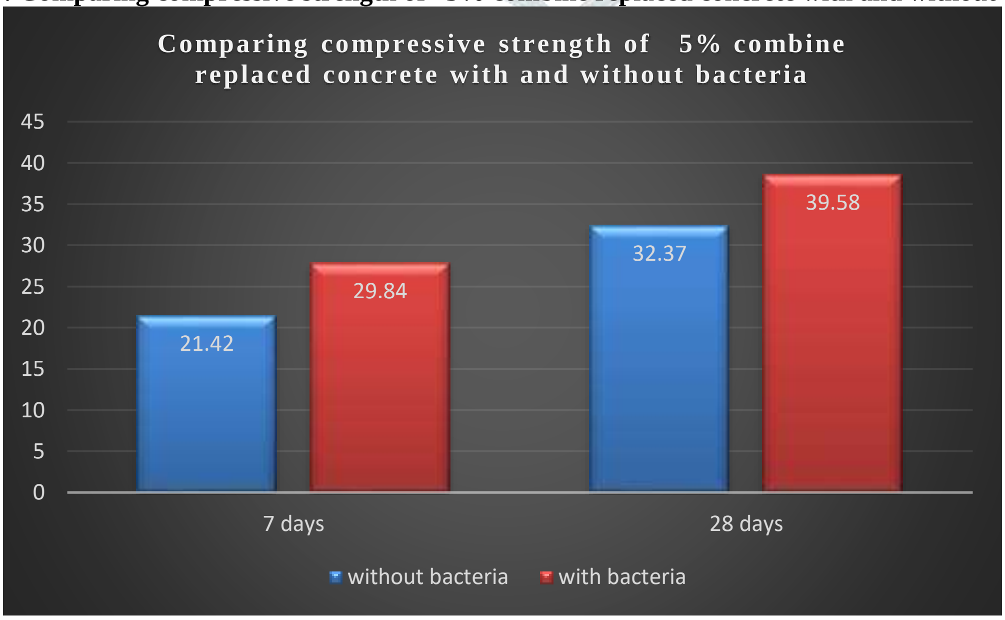
Graph 1: Compressive strength for partial replacement of RHA& CS




Graph 2: Comparing compressive strength of concrete with reference cubes and bacteria added cubes




Graph 3: Comparing compressive strength of 5% combine replaced concrete with and without bacteria



## CONCLUSIONS

- Adding the both RHA and coconut shells, the compressive strength of the light weight concrete decreases from 10%.For 10% combined replacement, the compressive strength is 31.24N/mm2.In both replaced concrete the compressive strength attains 32.37 N/mm2 for 28 days of curing for 5% replacement of both materials.
- Adding the self-healing bacteria for the 5% combine replacement, there is a slight increase of the compressive strength. The compressive strength of the concrete by 5% combine replacement after the addition of the self-healing bacteria (BACTAHEAL) is 39.58 N/mm2 for 28 days.
- The crack heals when the bacteria was exposed to the environment, when it reacts with the water then it evolves the calcium carbonate product into the crack, then the crack heals.
- The cracks heals in 7 days after the crack occurs in the concrete.
- In upcoming days the availability of the natural resources will be reduced drastically then we go for alternative concrete materials. In such cases coconut shells and rice husk ash are the best replacement ideas as coarse aggregate and fine aggregate respectively. But by replacing these material as aggregates there will be slight decrease in the compressive strength, To overcome this limitation self healing bacteria (Bactaheal) is the best solution which helps in the increment in Compressive strength as well as its self-crack healing ability.

## REFERENCES

[1] Olanipekun, E.A., K.O. Olusola and O. Ata, “A comparative study of concrete properties using coconut shell and palm kernel shell as coarse aggregates”, Building environment, 41:297- 301,2006.

[2] Teo DCL, Mannan MA, Kurian JV,” Flexural behavior of reinforced lightweight concrete beams made with oil palm shell”, Journal of advanced concrete technology, 4:1-10, 2006.

[3] Abdullah A. “Basic strength properties of lightweight concrete using agricultural wastes as aggregate”, proceedings of international conference on low cost housing for developing countries, Roorkee, 1984.

[4] Luo, M., Qian, C. X., & Li, R. Y., Factors affecting crack repairing capacity of bacteria based self-healing concrete, Construction and Building Materials. 87 (2015) 1-7.

[5] Jonkers, H. M., Thijssen, A., Muyzer, G., Copuroglu, O., & Schlangen, E., Application of bacteria as self-healing agent for the development of sustainable concrete, Ecological Engineering. 36 (2010) 230-235.