International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 12 | Dec -2016 www.irjet.net p-ISSN: 2395-0072

# INFLUENCE OF PARTIAL REPLACEMENT OF CEMENT WITH NANO-SILICA AND RICE HUSK ASH ON PROPERTIES OF RECYCLED COARSE AGGREGATE CONCRETE

**Dr. D. V. Prasada Rao[1], D. Ashok[2]**

[1]Professor
Department of Civil Engineering
Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India

[2]PG Student
Department of Civil Engineering
Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh, India

---

**Abstract -** *The aim of this experimental investigation is to understand affect of the partial replacement of cement with the combination of nano-Silica (NS) and Rice Husk Ash (RHA) on the properties of recycled coarse aggregate concrete. In this investigation, M25 Grade of concrete is prepared using recycled coarse aggregates (RCA). The recycled coarse aggregate is obtained from the crushed laboratory tested concrete cubes. Pozzolanic materials nano silica and rice husk ash were used as a partial replacement of cement by weight in varying percentages i.e. 5%, 7.5% and 1%, 2.5%, 3.5% respectively. Compressive strength, split tensile strength, flexural strength and modulus of elasticity tests were conducted the standard concrete specimens. Based on the preliminary experimental investigation, it can be observed that up to 50% replacement of natural coarse aggregate with recycled coarse aggregate the strength of the concrete is not much affected. The experimental results indicates that the concrete prepared with 50% RCA has improved strength properties with the addition of 7.5 % rice husk ash and 2.5% nano-silica compared to the controlled concrete.*

***Key word:*** *Recycled aggregate, Rice Husk Ash, Nano-Silica, Compressive strength, Spilt tensile strength, Flexural strength and Modulus of elasticity.*

## 1. INTRODUCTION

Concrete, one of the most consumed material is not known to be an ecofriendly material as a significant amount of raw materials utilized for its production. During the manufacture of cement, huge amount of carbon dioxide, sulfur compounds, nitrogen compounds and other harmful gases are emitted that cause environmental pollution. In addition to environmental pollution, enormous use of concrete causes rapid depletion of natural resources. Simultaneously, significant quantities of construction and demolition waste are generated from activities such as construction, renovation, and demolition of Civil Engineering structures. Several countries around the globe have been facing problems related to disposal of these C&D waste materials owing to lack of sufficient space for dumping of these materials. Therefore, recycling of these construction and demolition waste for the production of aggregates is a solution to a number of problems faced by human civilization. The coarse aggregate prepared by crushing and screening the waste concrete is generally termed as Recycled Coarse Aggregates (RCA). The concrete manufactured with RCA as partial and full replacement of Natural Coarse Aggregates (NCA) is normally known as Recycled Aggregate Concrete (RAC). Although, recovery waste from demolition is beneficial to the environment, it is important to study the properties of recycled aggregates before using as coarse aggregate in concrete for structural applications. In RCA, the mortar attached to the natural aggregate results in lower density, higher water absorption, and higher porosity

than those of virgin natural aggregate. Practically, the quality of concrete may be reduced due to the low density, high water absorption and weak bond of recycled aggregates. But this issue can be resolved using various kinds of admixtures which may improve the microstructure of concrete and hence will lead to improved quality of recycled aggregate concrete. Previous studies indicates that the use of Fly Ash, Silica fume, Matakaoline, Ground Granulated Blast Furnace Slag as partial replacement of cement, reduces the cement consumption and also increases the strength and durability of concrete. In this experimental work, the influence of combined use of nano-silica and rice husk ash as partial replacement of cement on properties of RCA concrete is investigated.

Rice husk is an agro-waste material which is produced in about 100 million of tons. Approximately, 20 kg of rice husk are obtained from 100 kg of rice. Rice husk ash (RHA) is obtained by the combustion of rice husk. The burning temperature must be within the range of 600 to 800$^0$C. The ash obtained has to be grounded in a ball mill for 30 minutes and its appearance in colour will be grey. RHA, produced after burning of Rice husk (RH) has high reactivity and pozzolanic property. Indian Standard code of practice for plain and reinforced concrete, IS 456-2000, recommends use of RHA in concrete but does not specify quantities. Chemical compositions of RHA are affected due to burning process and temperature. Silica content in the ash increases with higher the burning temperature. Use of RHA with cement improves workability and stability, reduces heat evolution, thermal cracking and plastic shrinkage. To improve the performance of recycled aggregate concrete further, Nano materials are now being introduced as supplementary materials.

Nano-technology is an emerging field of interest for civil engineering application. Among the nano materials presently used in concrete, nano-silica possess more pozzolanic nature. It has the capability to react with the free lime during the cement hydration and forms additional C-S-H gel giving strength, impermeability and durability to concrete.

## 2.0 OBJECTIVE

The objective of the present research work is to find the influence of the combined application of nano silica and rice husk ash on various strength properties of recycled aggregate concrete of M25 grade. Natural coarse aggregate is replaced with recycled coarse aggregate by 25%, 50%, 75% and 100%. 1%, 2.5% and 3.5% of nano-silica and 5% and 7.5% of rice husk ash are adopted as cement replacement by weight. Compressive strength, split tensile strength, flexural strength and modulus of elasticity of concrete are to be obtained and the results are to be compared with the controlled concrete.

## 3.0 EXPERIMENTAL PROGRAMME

### 3.10 Properties of Materials

### 3.11 Cement

In this investigation Ordinary Portland cement (OPC) of 53 Grade confirming to IS specifications was used.

### 3.12 Fine Aggregate

Locally available river sand confirming to IS specifications was used as the fine aggregate in the concrete preparation. The properties of fine aggregate are shown in Table 1.

**Table 1: Properties of Fine aggregate**

| S.No | Property | Values |
|---|---|---|
| 1 | Specific Gravity | 2.56 |
| 2 | Fineness Modulus | 2.60 |
| 3 | Grading of Sand | Zone-II |

### 3.13 Coarse Aggregate

Coarse aggregate of nominal size 20 mm and 12.5 mm, obtained from the local quarry confirming to IS specifications was used. The properties of coarse aggregate are shown in Table.2. The coarse aggregate used for the preparation of concrete is a mixture of 60% of 20 mm and 40% of 12.5 mm size aggregates.

**Table 2: Properties of Coarse Aggregate**

| S.No | Property | Values |
|---|---|---|
| 1 | Specific Gravity | 2.61 |
| 2 | Water Absorption | 0.4% |

### 3.14 Recycled Coarse Aggregate:

The recycled coarse aggregate used in this investigation is obtained by crushing the tested laboratory concrete cubes. Water absorption and specific gravity of recycled coarse aggregate used in this study are 1.75 and 2.56 respectively.

### 3.15 Rice Husk Ash:

Rice husk ash used in this present experimental study is obtained from ASTRRA chemicals, Chennai. Properties of rice husk ash are given in the following Tables 3 and 4.

**Table 3: Physical properties of Rice Husk Ash**

| S.No | Property | Values |
|---|---|---|
| 1 | Colour | Off White |
| 2 | Specific Gravity | 2.25 |
| 3 | Bulk Density | 0.39 gm/cc |

**Table 4: Chemical properties of Rice Husk Ash**

| | | |
|---|---|---|
| Silica | $SiO_2$ | 88.90% |
| Alumina | $Al_2O$ | 2.50% |
| Ferric Oxide | $Fe_2O_3$ | 2.19% |
| Calcium Oxide | CaO | 0.22% |
| Total Alkalies | $Na_2O + K_2O$ | 0.69% |
| Loss on Ignition | | 4.01% |

### 3.16 Nano-Silica:

In the present study colloidal form of sample **Cemsyn XFX** grade nano-silica has been used i.e. nano-silica in dispersion with water in 40:60 ratio (40% Nano-silica). Specification of nano-silica as given by the supplier is given in the following Table 5.

**Table 5: Specification of Nano-Silica**

| S.No | Parameter | Cemsyn XFX |
|---|---|---|
| 1 | Active nano content (% wt/wt) | 40.00 - 41.50 |
| 2 | pH (20°C) | 9.4 – 10 |
| 3 | Specific Gravity | 1.3 – 1.32 |
| 4 | Description | Colloidal |

### 3.17 Water

The water used for casting and curing of concrete test specimens was free from acids, organic matter, suspended solids and impurities which when present can adversely affect the strength of concrete. The local drinking water free from such impurities has been used in this experimental programme for mixing and curing

### 3.18 Water Reducing Admixture

Super plasticizer used in this investigation is MYK Save mix SP200 having a specific gravity of 1.25 and is supplied as a brown liquid instantly dispersible in water. MYK Save mix SP200 has been specially formulated to give water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability.

### 3.20 CONCRETE MIX PROPORTION

The aim of the experimental investigation is to obtain the compressive strength, split tensile strength, flexural strength and modulus of elasticity of RCA concrete. In the first part of the study, the natural coarse aggregates are replaced by recycled coarse aggregates in varying percentages i.e. 25%, 50%, 75% and 100% to produce recycled aggregate concrete. In the second phase of study, the effect of replacement of cement by nano-silica and rice husk ash in varying percentages on the various strength properties of recycled aggregate concrete was investigated. M25 grade of concrete was designed as per the Indian Standard code of practice.

### 3.30 TEST SPECIMENS

Concrete test specimens consist of 150 mm × 150 mm × 150 mm cubes, cylinders of 150 mm diameter × 300 mm height and prisms of 100 mm × 100 mm × 500 mm. Concrete cubes were tested at different curing periods (3, 7 and 28) to get the

compressive strength. Cylindrical specimens were tested at the age of 28 days to obtain the split tensile strength and the modulus of elasticity of concrete. The prisms were tested at the age of 28 days to obtain the flexural strength of concrete. The rate of loading is as per the Indian Standard specifications.

## 4.0 RESULTS AND DISCUSSIONS

### 4.10 Compressive Strength

Fig.1 shows the compressive strength of concrete prepared with replacement of natural coarse aggregate with RCA by 25%, 50%, 75% and 100%. It can be observed that the compressive strength of RCA concrete exhibits approximately the same strength compared to the control concrete up to 50% replacement of natural coarse aggregate and with further increase in the percentage of RCA the compressive strength decreases. The 28 days compressive strength of controlled concrete is 32.3 N/mm².

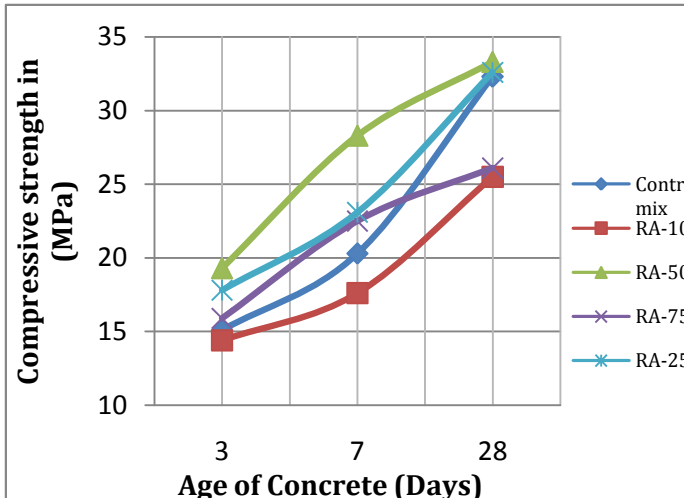


**Fig.1: Compressive strength of recycled aggregate concrete**

Fig. 2 represents the compressive strength of RAC with the use of rice husk ash as a partial replacement of cement by 5% and 7.5%. The 28 days compressive strength of controlled concrete is 32.3 MPa. It can also be observed that 50% of recycled aggregate and with the incorporation of 7.5% of RHA it enhances to 34.8 MPa.

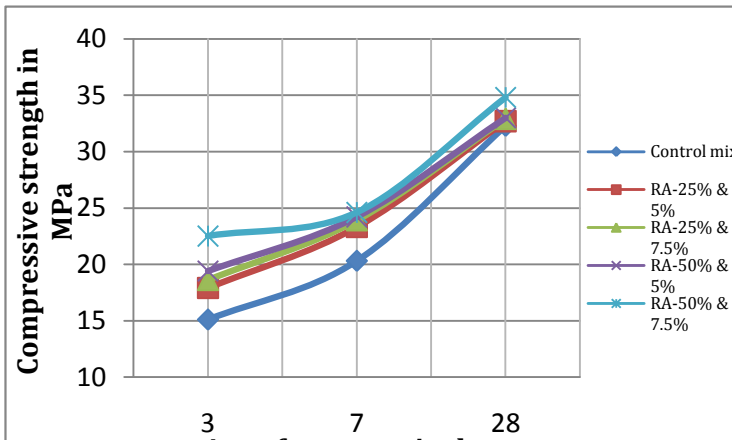


**Fig 2: Compressive strength of concrete mix containing rice husk ash and recycled aggregate**

Fig.3 represents the compressive strength of RAC containing 1%, 2.5% and 3.5% nano-silica along with 50% recycled aggregate and 7.5% rice husk ash. Further, the compressive strength of 2.5 % nano-silica, 50% of recycled coarse aggregate and 7.5% of RHA enhanced to 35.4 MPa. This indicates 9.6% increment for 28 days compressive strength of controlled concrete.

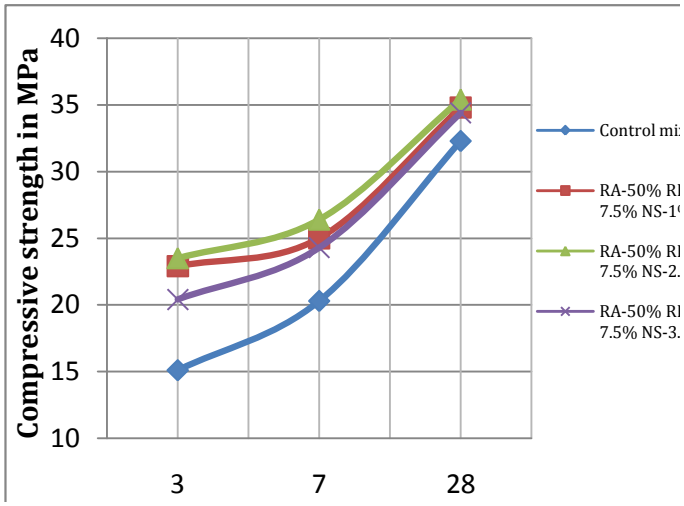


**Fig.3: Compressive strength of concrete mixes containing recycled aggregate, rice husk ash and nano silica**

### 4.20 Split tensile strength

The variation of split tensile strength of different mixes is shown in Fig. 4. The splitting tensile strength of control concrete is 3.44 N/mm². Results indicate that as the RCA content increases more than 50%, the tensile strength decreases. At 50% RCA and

7.5% RHA content the split tensile strength is increased to 4.05 N/mm². It can also be observed that at a combination of 2.5% of Nano-Silica, 7.5% rice husk ash and 50% recycled coarse aggregate the maximum split tensile strength of concrete is 4.34 N/mm².

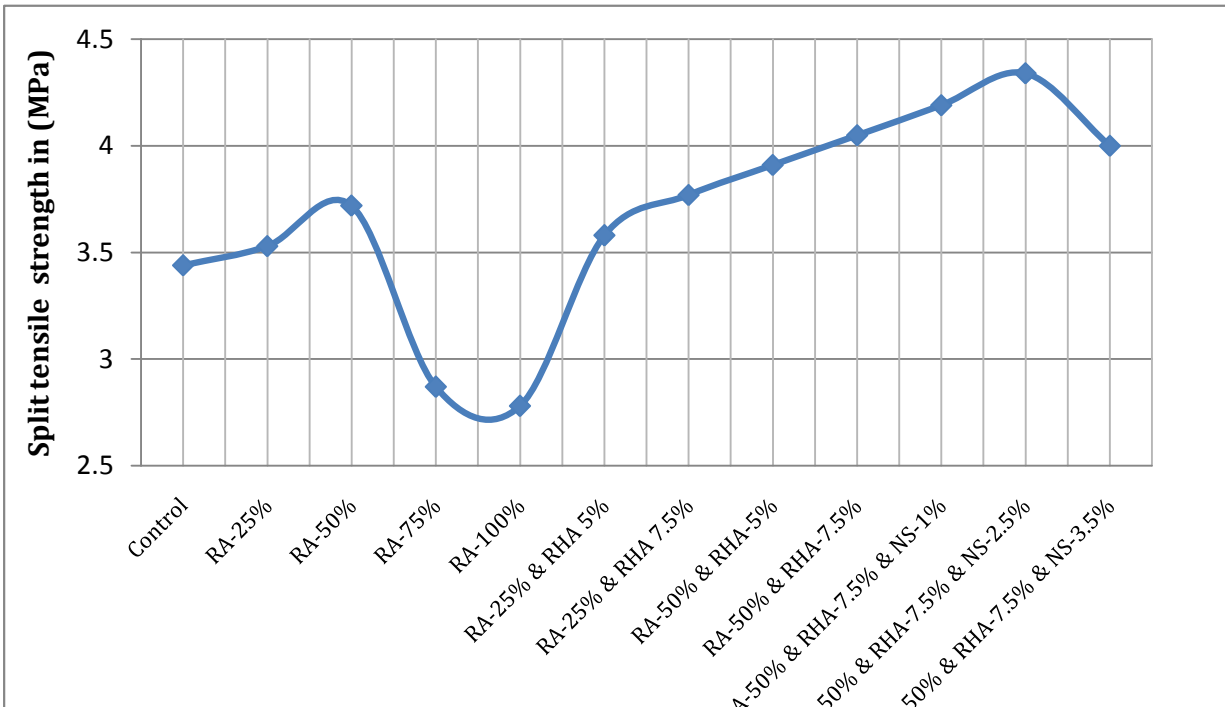


**Fig.4. Split tensile strength of various concrete mixes**

### 4.30 Flexural strength

The flexural strength variation for all mixes is shown in Fig. 5. The flexural strength of control concrete is 4.62 N/mm². From the results it can be observed that 50% RCA and 7.5% RHA content the split tensile strength is increased to 5.31 N/mm². Further, it can also be observed that at a combination of 2.5% of Nano-Silica, 7.5% rice husk ash and 50% recycled coarse aggregate the maximum split tensile strength of concrete is 5.94 N/mm².

### 4.40 Modulus of elasticity

Fig. 6 shows the variation of modulus of elasticity of concrete for various mixes. Modulus of elasticity of concrete is obtained by using the cylindrical test specimen at the age of 28 days. The modulus of elasticity of controlled concrete is 25.2 kN/mm². It can be observed that the modulus of elasticity of recycled coarse aggregate concrete with 50% RCA, 7.5% Rice husk ash and 2.5% nano-silica 2.5% is 26.8 KN/mm².

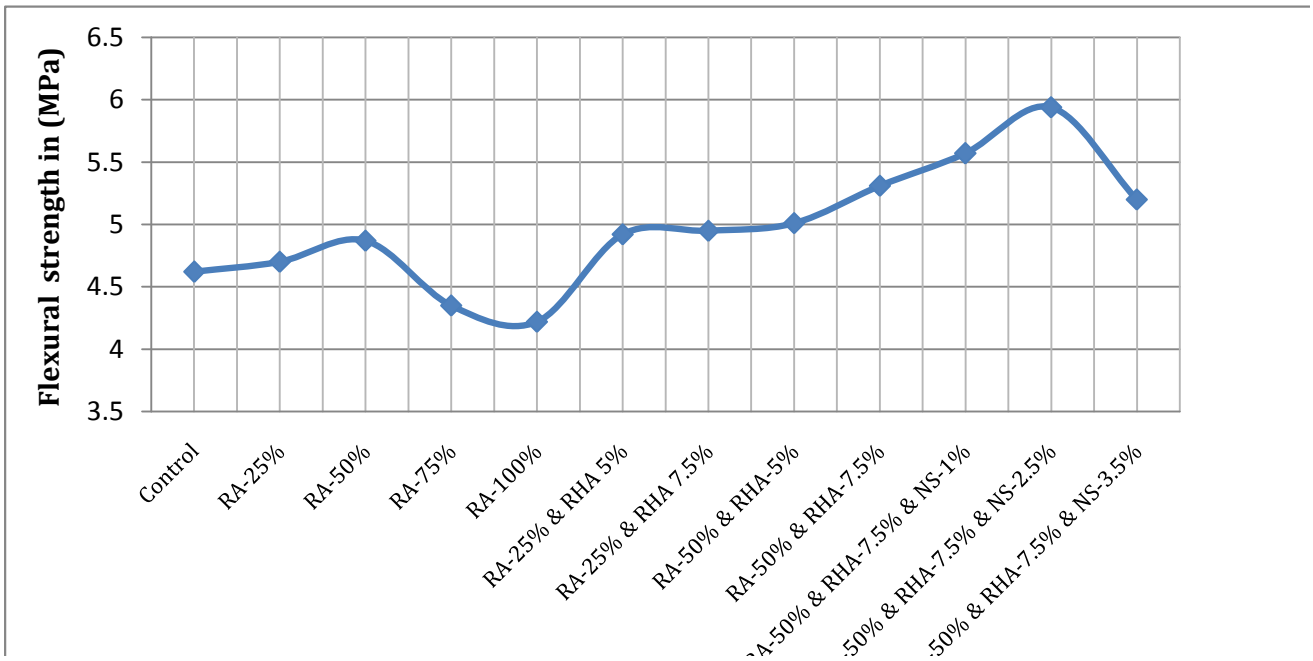


**Fig 5: Flexural strength of concrete for various mixes**

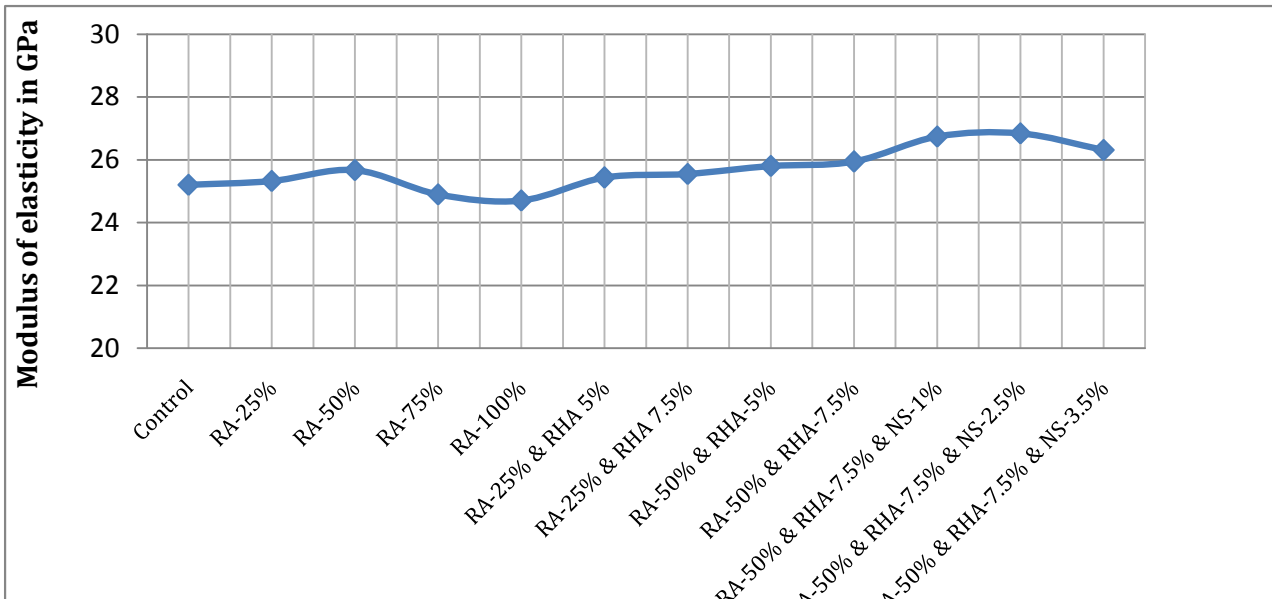


**Fig. 6: Modulus of elasticity of concrete for various mixes**

## 5.0 CONCLUSIONS

The present experimental investigation is carried out on the properties of recycled coarse aggregate concrete by partial replacement of cement with rice husk ash and nano-silica. It was observed that with increase in percentage of recycled aggregate in concrete the compressive strength decreases but was not affected up to 50% replacement of recycled coarse aggregates..

The addition of RHA 7.5% for 50% RCA results in an increase of 7.7% in the compressive strength compared to controlled concrete. To improve the performance of RCA concrete further, nano-silica has been added by 1%, 2.5% and 3.5% to 50% RCA and 7.5% RHA concrete. Based on the results, it was observed that 9.6% increment in compressive strength is achieved at nano- silica 2.5% replacement level in addition to 50% RCA and 7.5% RHA.

Based on the experimental results, the performance of concrete can be improved prepared with the combination of rice husk ash and Nano-Silica as partial replacement of cement in recycled aggregate concrete. This can be attributed to high pozzolanic activity in the presence of rice husk ash and Nano-Silica. It can also be concluded that the performance of concrete increases at a replacement levels of recycled coarse aggregate 50%, rice husk ash 7.5% and nano silica 2.5%

**REFERENCES:**

1. Vyas C.M, Bhatt D.R (2013) "Use of Recycled Coarse Aggregate in Concrete" IJSR – international journal of scientific research Vol-2/issue -1, Jan 2013.
2. Alireza N. G., Suraya A. , Farah Nora A.A. , Mohamad A. M.(2010). "Contribution of Rice Husk Ash to the Properties of Mortar and Concrete: A Review
3. Anwar, M., Miyagawa, T., and Gaweesh, M. 2001. Using rice husk ash as a cement replacement material in concrete. In the Proceedings of the 2001 first international Ecological Building Structure Conference. pp. 671 - 684.
4. Saurav (2012) " Application of nanotechnology in building materials" International Journal of Engineering Research and Applications" Vol. 2, Issue5, September-October 2012, pp.1077-1082
5. Bjornstrom J., Martinelli A., Matic A., Borjesson L. and I.Panas (2004) "Accelerating effects of colloidal nano-silica for beneficial calcium–silicate– hydrate formation in cement", Chemical Physics Letters, 392, 242–248.
6. IS 2386 (Part1&3):1963 "Methods of test for aggregates for concrete."
7. IS 516:1959 "Method of test for strength of concrete."
8. Concrete Technology by Shetty.M.S, first edition, S.Chand publications,1982.
9. IS 456-2000. Plain and Reinforced concrete code for practice. Bureau of Indian Standards, New Delhi (India).
10. IS 383-1970. Specification for coarse and fine aggregate from natural sources for concrete. Bureau of Indian Standards, New Delhi (India).
11. IS 10262:2009. Concrete Mix proportioning-Guidelines. Bureau of Indian Standards, New Delhi (India).
12. IS 12269:1987. Specifications of 53 grade OPC cement. Bureau of Indian Standards, New Delhi (India).