International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

# An Optimum use of Coconut Shell as Partial Replacement of Coarse Aggregate in Light Weight Concrete: An Environmental Approach

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**Abstract-**The increasing cost of construction material is reason for finding alternative materials in stead of natural resources. With increasing in concern over the excessive utilization of natural aggregates, synthetic lightweight aggregate produced from environmental waste is a viable new source of structural aggregate material. The uses of structural grade lightweight concrete considerably reduce the self-load of a structure and permit larger precast units .Recently in the environmental issues, restrictions of local and natural access or sources and disposal of waste material are gaining great importance. Today, it becomes more difficult to find a natural resource. Use of the waste materials not only helps in getting them utilized in cement, concrete and other construction materials, but also has numerous indirect benefits such as reduction in land fill cost, saving in energy, and protecting environment from possible pollution effect. It also helps in reducing the cost of concrete manufacturing. In the present work, coconut shell as partial replacement for coarse aggregate in concrete is studied.The concrete made with coconut shell was found to be durable in terms of its resistance in water, acidic, alkaline and salty. Density of coconut shell is in the range of 550 - 650kg/m$^3$ and these are within the specified limits for lightweight aggregate. Coarse aggregate was replaced by crushed coconut shells in three different percentages such as 5%,10%,20%,30%,40%and 50% .The physical characteristic properties of concrete such as compressive strength, split tensile strength and flexural strength using the mix made by replacing coarse aggregate with coconut shell aggregate were studied in the present research work and mixes were compared with normal concrete properties. The results from the study were expected to promote the use of coconut shell as a substitute for conventional light weight coarse aggregates.

***Keywords:***Coarse aggregate, Coconut shell, compressive strength, workability, light weight concrete.

## 1.INTRODUCTION

Cement and aggregate, which are the most important constituents materials used in production of concrete. These materials are the vital materials needed for the construction industry. Due to this led to a continuous and increasing demand of natural materials used for their production. Infrastructure development across the world created demands for construction material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Where crushed stone is available, its high cost as coarse aggregate is a major problem to tackle people in the developing countries like India. The need for the utilization of the natural resources for protecting the environment and a need to preserve natural resources, such as aggregate, by using alternative materials that are recycled as a waste. Use of natural aggregates in such a rate leads to a question about the preservation of natural aggregates sources. In addition, operation associated with aggregates extraction and processing is the principal causes environmental concern. In bright of this in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environmentally friendly construction material.

Coconut shell being a hard and not easily degrade material if crushed to size of sand can be a potential material to substitute sand. At present, coconut shell has also been burnt to produce charcoal and activated carbon for food and carbonated drink and filtering mineral water use. However, the coconut shell is still under utilized in some places. 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%. The aim of this study is to investigate the effect of the use of coconut shell as partial replacement of coarse aggregate in concrete production.

## 2.LITERATURE REVIEW

Kanojia and Jain (2015) also reported that coconut shell has added advantage of high lignin content that makes the composites more weather resistant.Daniel Yaw Osei (2013) investigated concrete was produced in the study for 20%,

30%, 40 %, 50% & 100% replacement of crushed granite by coconut shell by volume. The several concrete cubes were produced & density as well as compressive strengths of concrete was evaluated at 7 days, 14 days, 21 days & 28 days. The result showed that the concrete produced by replacing 18.5% of the crushed granite by coconut shells can be used in reinforced concrete construction. The use of coconut shell as partial replacement for conventional aggregates encouraged through the study as an environmental protection as well as construction cost reduction measure. Amarnath Yerramalaet al,(2012) study was made for the properties of concrete with coconut shells as the replacement of aggregate .The concrete with normal aggregate as well as coconut shell (CS) concrete with 10-20% coarse aggregate replacement with coconut shell were made. The result showed that the density of concrete decreases with increase in coconut shell percentage. It was also observed that the compressive as well as split tensile strength of CS concrete was found to be lower than the normal aggregate concrete. Also permeable voids, absorption & sorption were found to be higher for CS replaced concrete than normal aggregate concrete. Maninder Kaur et al,(2012) in Asia, the construction industry is yet to realize the advantages of light weight concrete in high rise buildings .Coconut shells are not commonly used in construction industry and are often dumped as agricultural waste. The aim of this research is to spread awareness of using coconut shell as partial replacement of coarse aggregate in concrete and determining its compressive strength and density. Until now, Industrial by products and domestic wastes has been utilized in concrete, but the use of agricultural waste in concrete is in its infancy stage. Coconut shell is an agricultural waste. The materials are proportioned by their weights. The water cement ratio is obtained by conducting various workability tests. The obtained results are compared with that of conventional mix. Tests are as per the specified procedure of Indian Standard Codes. U. J. Alengaram et al,(2010) and E. A. Olanipekun et al,(2006)studied Periwinkle shell was chosen as a substitute for coarse aggregate in concrete and palm kernel shell was used as a replacement for fine aggregate in concrete. Certain investigations used crushed, granular coconut and palm kernel shells as substitutes for conventional coarse aggregate and the results of the tests showed that the compressive strength of the concrete decreased as the percentage of the shells increased. The properties of concrete using coconut shell as coarse aggregate were investigated in an experimental study and the study concluded coconut shell concrete can be classified under structural lightweight concrete. U. J. Alengaram et al,(2008) the experimental investigation was carried out for the effect of cementitious materials, fine & coarse aggregate content on workability & compressive strength of palm kernel shell concrete. The specimens were cured under three different curing environments & studied the effect on compressive strength. The 28 day compressive strengths of the mixes containing cementitious material were found in the range of 26 to 36 MPa. It was also observed that the difference in strength between water cured & specimen cured under controlled environment was found to vary between 3% & 5%. U. J. Alengaram et al,(2008) the experimental investigations [10] was carried out on the use of kernel shell as lightweight aggregate which produced grade 35 lightweight concrete. In the study, the cementitious materials included 10% of silica fume as additional cementitious materials & 5% fly ash as cement replacement materials. It had been found that the increase in sand content had positive influence on the mechanical properties of concrete. The sand content found likely to increase density as well as compressive strength. Adeyemi (1998) recommended the suitability of coconut shells as substitute for either fine or coarse aggregate in concrete production.Because of the smooth surface on one side of the shells, concrete made with coconut shell presents better workability

## 3.OBJECTIVES OF THE RESEARCH

Introduction of new construction material
To prepare lightweight concrete by using coconut shell as course aggregate.
To find economical solution for high cost construction material.
To study the coconut shell concrete as waste management in constructions and make Eco-Friendly Environment.

## 4.MATERIALS USED

### 4.1Cement

The cement used in this research should confirm IS specifications. There are several types of cements available commercially in the market of which Portland cement is very common and it is well known and available everywhere. PPC 43 grade was used for this study. The physical properties of the cement tested according to standard procedure confirm to the requirement of IS 12269:1989. The physical properties of the cement are listed in the Table 1.

**Table 1** :Physical properties of cement

| Sl.No | Material | Cement |
|---|---|---|
| 1 | Fineness by Sieving (%) 90 micron mesh | 6% |
| 2 | Normal Consistency | 32% |
| 3 | Initial Setting Time (minutes) | 45 |
| 4 | Final Setting Time(minutes) | 520 |
| 5 | Specific Gravity | 3.17 |

### 4.2Fine Aggregate

Locally available river sand passing through 4.75mm sieve conforming to the recommendation of IS 383:1970 is used. Specific Gravity of fine aggregate of the sand is 2.54 shown in Table 2 and the particle size distribution is listed below in the Table 3. From the sieve analysis results fine aggregate is graded to Zone II and medium sand shown in Figure 1.

**Table 2:** physical properties of Fine aggregate

| Physical Property | Values |
|---|---|
| Specific Gravity | 2.54 |
| Water Absorption (%) | 17 |
| Fineness modulus | 3.7 |

**Table 3**: Particle size distribution for fine aggregate

| Sl.No | Sieve size | Weight of Aggregate retained | Weight retained(%) | Cumulative % weight retained | Percentage passing (%) | IS 383-1970 Requirements |
|---|---|---|---|---|---|---|
| 1 | 4.75 | 0 | 0 | 0 | 100 | 90-100 |
| 2 | 2.36 | 15 | 15 | 1.5 | 98.5 | 75-100 |
| 3 | 1.18 | 200 | 215 | 21.5 | 78.5 | - |
| 4 | 0.6 | 390 | 605 | 60.5 | 39.5 | - |
| 5 | 0.3 | 210 | 815 | 81.5 | 18.5 | 8-30 |
| 6 | 0.15 | 160 | 975 | 97.5 | 2.5 | 0-10 |
| 7 | 0.075 | 15 | 990 | 99 | 1 | - |
| 8 | Pan | 10 | 1000 | 100 | 0 | - |

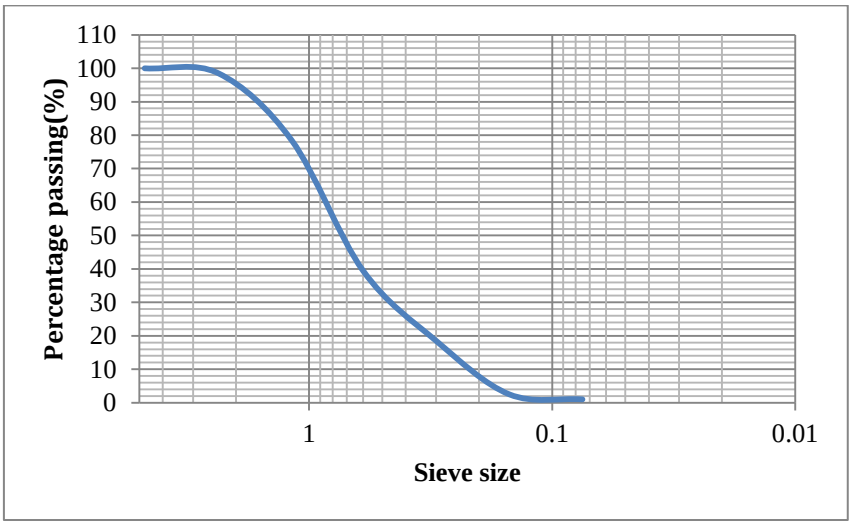


**Fig 1**: Particle size distribution cure of fine aggregate

### 4.3Coconut Shell

Coconut shells were collected from coconut oil industries to analyze the properties of coconut shell. The physical properties of Coconut shell are shown in Table 4.

**Table 4**: physical properties of Coconut shell

| Physical Property | Values |
|---|---|
| Specific Gravity | 1.35 |
| Water Absorption (%) | 27 |
| Bulk Density(kg/m3) | 850 |
| Shell Thickness (mm) | 2-9 |

From the sieve analysis results of coconut shell as coarse aggregate is shown in Table.5.

**Table 5:** Particle size distribution for coconut shell as coarse aggregate

| Sl.No | Sieve size (mm) | Weight of Aggregate retained | Weight retained(%) | Cumulative % weight retained | Percentage passing(%) |
|---|---|---|---|---|---|
| 1 | 40 | 0 | 0 | 0 | 100 |
| 2 | 20 | 1500 | 1500 | 50 | 56 |
| 3 | 16 | 800 | 2300 | 76 | 25 |
| 4 | 12.5 | 400 | 2700 | 90 | 16 |
| 5 | 10 | 240 | 2940 | 98 | 12 |
| 6 | 4.75 | 0 | 2940 | 98 | 5 |

### 4.4Coarse Aggregate

Coarse aggregate to be used for production of concrete must be strong, impermeable, durable and capable of producing a sufficient workable mix with minimum water cement ratio to achieve proper strength. Locally available coarse aggregate retaining on 4.75 mm sieve is used. The physical properties of coarse aggregate is shown in Table 6 and the particle size distribution for coarse aggregate is listed below in Table 7. From the sieve analysis results shown in Figure 2 it was found that the combined aggregate of in the range of nominal size of coarse aggregate is 20mm.

**Table 6**: physical properties of Coarse aggregate

| Physical Property | Values |
|---|---|
| Specific Gravity | 2.77 |
| Water Absorption (%) | 1.5 |
| Fineness modulus | 3.5 |

**Table 7**:Particle size distribution cure of normal coarse aggregate

| Sl.No | Sieve size (mm) | Weight of Aggregate retained | Weight retained(%) | Cumulative % weight retained | Percentage passing(%) |
|---|---|---|---|---|---|
| 1 | 40 | 0 | 0 | 0 | 100 |
| 2 | 20 | 1660 | 1660 | 55.33 | 44.66 |
| 3 | 16 | 704 | 2364 | 78.8 | 21.2 |
| 4 | 12.5 | 360 | 2724 | 90.8 | 9.2 |
| 5 | 10 | 240 | 2964 | 98.8 | 1.2 |
| 6 | 4.75 | 36 | 3000 | 100 | 0 |

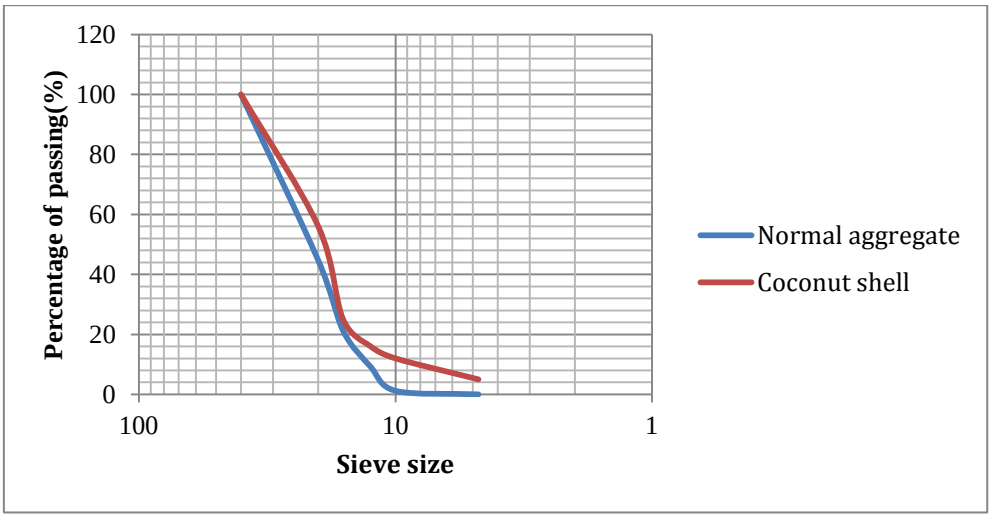


**Fig 2**:Particle size distribution cure of granite aggregate and coconut shell

### 4.5water

The water used in this research work was , the water available in the laboratory has used. Its PH value is 6.5 to 8. It must be absolutely free from vegetable substances, soils, acids, alkalis and other organic and inorganic impurities to made concrete or even reinforcement. Also it must be totally free from iron. Mostly it should be fit for drinking purpose. Portable water available inside the laboratory it was used for mixing and curing of concrete.

**Fig .3:** a) Natural river sand b) Coconut Shell and crushed C.S

## 5.EXPERIMENTAL METHODOLOGY

### 5.1Mix Proportions

The concrete mix was designed as per IS: 10262-1982], IS: 456-2000 for the normal concrete. The grade of concrete, which adopted, is M20. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1:1.5: 3 by volume and a water cement ratio of 0.45.

## 6.EXPERIMENTAL INVESTIGATION

The study is conducted to analyze the compressive strength, Split tensile strength and Flexural strength of concrete when the natural coarse aggregate is partially replaced with waste coconut shell .Compressive strength and split tensile strength tests were done on compression testing machine of 200 tonne capacity available in the laboratory using cube specimens. The flexural strength test was conducted in flexural testing machine of capacity of 40 tonne. Three samples per batch were tested with the average strength values reported in this article. The natural coarse aggregates were replaced as 0%, 5%, 10%, 20%, 30%, 40% and 50% by weight of M-20 grade concrete. The size of cube of 150mm × 150mm × 150mm, cylinder of 150 mm dia and 300mm height and beam prism of 150mmx150mmx750mm of size were used to examine and results were analyzed after curing of 7days, 14days and 28 days. Due to high water absorption of coconut shell, they were pre-soaked in water for 24 hours, prior to mixing. The workability of fresh concrete was measured in terms of slump values. The ingredients of concrete were thoroughly mixed till uniform consistency was achieved. The cubes, beams and cylinders

were compacted on a vibrating table. Results obtained from the coconut shell replacement concrete specimens were compared with data from a Conventional concrete.

## 7.RESULTS AND DISCUSSIONS

### 7.1Workability: Slump Test

Slump test is the most commonly used method of measuring workability of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. Workability of concrete made by using coconut shell was determined with different replacement level. The values of workability in terms of slump is given in Table.8.The same results are shown in graphical form in Figure.4 for visual observation. From the results it evident that from the table and figure that workability of concrete made using coconut shell decreased with increase in replacement level. All the measured slumps in this research were true slumps.

**Table.8**: Slump value of normal sand and ceramic waste concrete

| Sl.No | Designation of the Specimen | Replacement Level (%) | Slump (mm) |
|---|---|---|---|
| 1 | NMC | 0 | 90 |
| 2 | CSCA10 | 10 | 75 |
| 3 | CSCA 20 | 20 | 70 |
| 4 | CSCA30 | 30 | 60 |
| 5 | CSCA40 | 40 | 50 |
| 6 | CSCA50 | 50 | 40 |

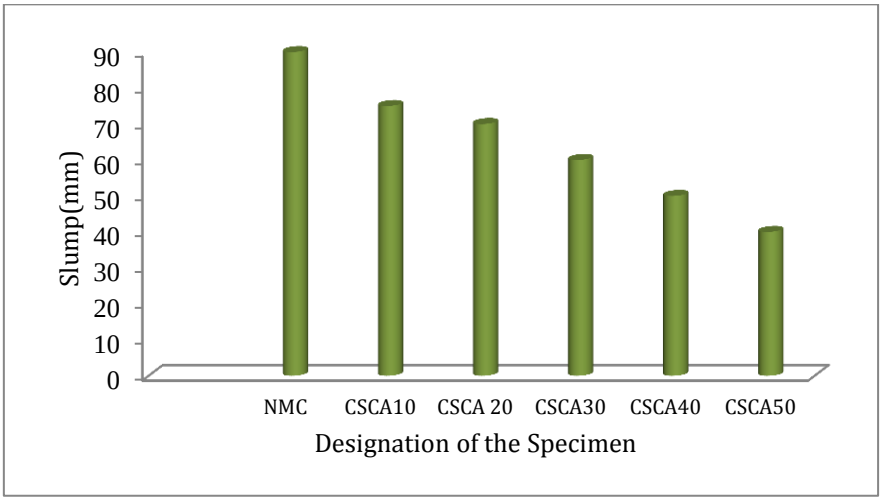


**Fig.4**: Slump value of normal aggregate and coconut shell aggregate concrete

### 7.2The Compression Strength test

The compressive test was conducted in universal testing machine (UTM) in a capacity of 40 tonne was used. Three concrete cubes of 150mm size for M20 using the above mentioned mix ratio were prepared. For each mix ratio, three waste replacement cubes plus one with normal aggregates cubes were casted for testing. The compressive strength test values displayed in Figure 5 shows that coconut shell has effect on the compressive strength of concrete. The compressive strength values were decreased when increases of coconut shell replacement level of percentage in concrete. The maximum compressive strengths were recorded for concrete is 10% replacement of coconut shell. The highest percentage of coconut shell aggregate concrete was recoded as 8% for 7 days curing age and 16% for 14 day curing age , for 28 days age of concrete its strength increases 21%. A steady fall of strength with waste replacement beyond this optimum point was observed. However, the compressive strength of all age is consistently lower than the control specimen.

**Table 9**:Compressive strength values of ceramic waste concrete for 7,14 and 28days

| Sl.No | Specimen | Compressive Strength (MPa) | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | NMC | 21.00 | 28.00 | 32.00 |
| 2 | CSCA10 | 19.41 | 23.56 | 25.45 |
| 3 | CSCA 20 | 16.34 | 19.67 | 22.23 |

| | | | | |
|---|---|---|---|---|
| 4 | CSCA30 | 15.67 | 18.78 | 20.78 |
| 5 | CSCA40 | 14.78 | 16.90 | 19.23 |
| 6 | CSCA50 | 12.34 | 13.67 | 17.23 |

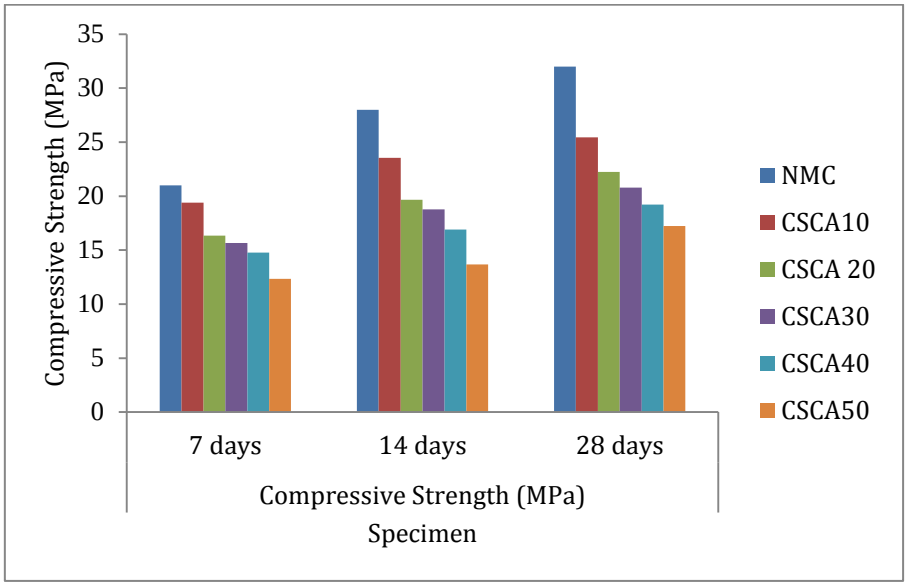


**Fig.5** :Compressive strength values of coconut shell aggregate concrete for 7,14 and 28days

### 7.3The split tensile strength test

The test was conducted using the same UTM to determine the tensile strength of concrete specimens. The split tensile test was done using cylindrical specimens of 150mm diameter, and 300mm length. The specimens also were tested immediately after taking them from water at 7th, 14th and 28th day. From it was observed that after beyond 10% replacement of coconut shell the strength was reduced. Table 10 shows the split tensile strength of the coconut shell and normal concrete specimens and Figure.6 shows its visual observation.

Split tensile strength decreases steadily with increasing percentage of coconut shell waste replacement and the optimum strength is at 10% for 7 and 28 curing ages. At 10% replacement level, split tensile strength increased as 9% for 7 days , 20% for 14 days and 7% for 28 curing ages when compare to another replacement percentage of coconut shell aggregate concrete. Also It is evident that at 28 day the split tensile strength is consistently higher than the other replacement level of coconut shell aggregate.

**Table 10:** Split Tensile strength values of ceramic waste concrete for 7,14 and 28days

| Sl.No | Specimen | Split Tensile strength (MPa) | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | NMC | 2.0 | 2.20 | 2.67 |
| 2 | CSCA10 | 1.87 | 1.77 | 2.50 |
| 3 | CSCA 20 | 1.50 | 1.60 | 2.30 |
| 4 | CSCA30 | 1.25 | 1.40 | 2.05 |
| 5 | CSCA40 | 1.05 | 1.20 | 1.75 |
| 6 | CSCA50 | 0.75 | 0.95 | 1.25 |

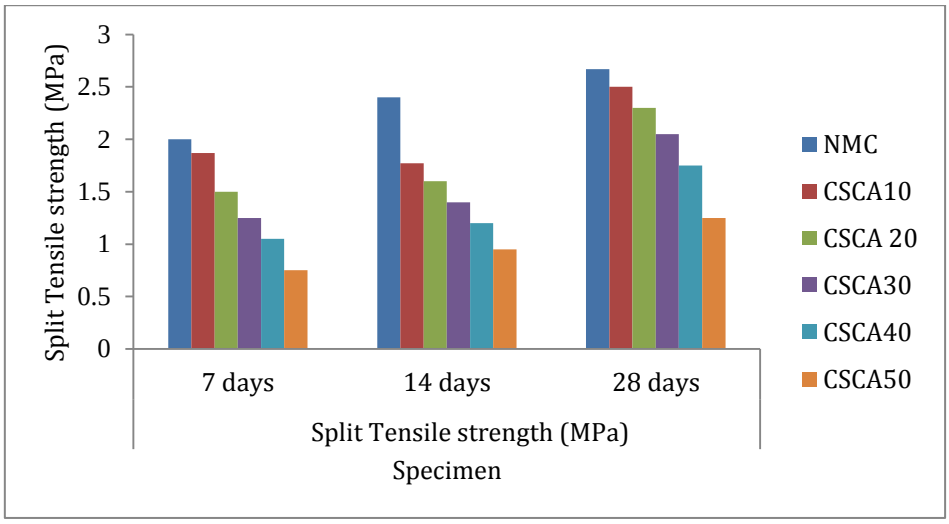


**Fig .6**: Split tensile strength values of coconut shell aggregate concrete for 7,14 and 28days

### 7.4The Flexural Strength Test

The test was to check the ability of concrete to resist against failure in bending. It was measured by loading an unreinforced concrete beam of 100x100x750 mm size. The material placed under load in a two point loading testing setup. The strength of a material in bending, expressed as the stress on the outermost fibres of a bent test specimen, at the instant of failure. The average value of specimens for each category at the age of 7 days, 14 days and 28 days is tabulated as shown in Table.11 . There is consistency in the flexural strength of concrete with the inclusion and increase in the percentage of coconut shell coarse aggregate upto 10% when compared to other percentage of replacement of coconut shell.

The flexural strength results is shown in Figure.7. Optimum flexural strength was obtained at 10% replacement than the other the replacement of coconut shell.

**Table.11:** Flexural strength values of ceramic waste concrete for 7,14 and 28days

| Sl.No | Specimen | Flexural Strength (MPa) | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | NMC | 3.05 | 3.40 | 4.70 |
| 2 | CSCA10 | 2.85 | 3.05 | 4.10 |
| 3 | CSCA 20 | 2.65 | 2.80 | 3.80 |
| 4 | CSCA30 | 2.55 | 2.60 | 3.55 |
| 5 | CSCA40 | 2.35 | 2.35 | 3.25 |
| 6 | CSCA50 | 2.10 | 2.25 | 3.15 |

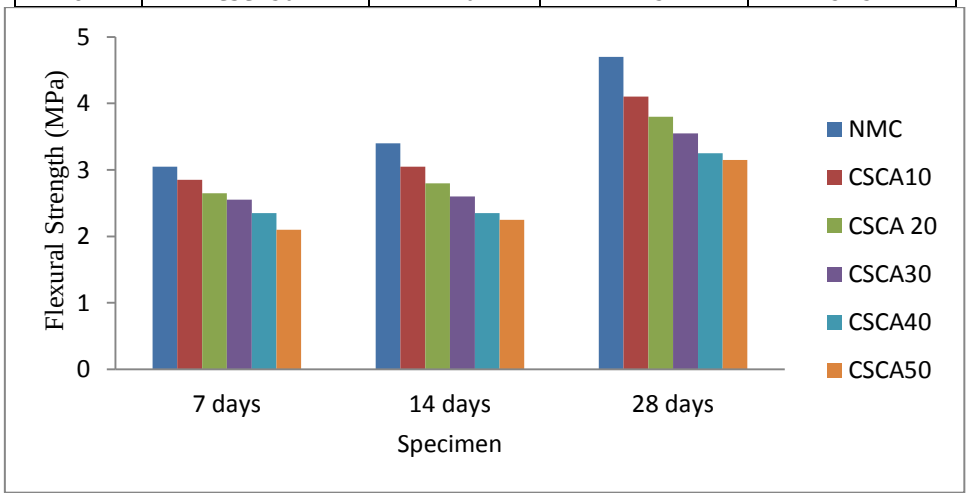


**Fig**.7: Flexural strength values of coconut shell aggregate concrete for 7,14 and 28days

## 8. CONCLUSIONS

Based on the experimental study for the use of ceramic waste in concrete as a replacement of coarse aggregate, the following conclusions were observed.

The addition of coconut shell as decrease the workability.

The percentage of coconut shell as deceased compressive strength, split tensile strength and flexural strength as compared to conventional concrete.

The replacement of coconut shell up to 10% as to good result of compressive strength, split tensile strength and flexural strength as compared to conventional concrete.

To enhance green construction environment coconut shell can use structural lightweight concrete.

The waste disposal problem is solved if coconut shell is gainfully utilized.

The possibility creates for the partial replacement of coarse aggregate with coconut shell to produce lightweight concrete.

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