Effect Of Coconutshell As A Partoal Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu, Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE,
MIGS., HOD, Principal, Bonam Venkata Chalamayya Engineering College, Odalarevu, Andhra Pradesh, India.

ABSTRACT
Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials. Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also be reduced by making use of these waste products from agriculture. The coconut shell mainly aims to prepare lightweight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5 %, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION
Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Two billion of aggregate are produced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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.

Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due to following reasons:-

Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc.

After the kernel is consumed, the shell is thrown away here and there causing environmental pollution.

Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems.

Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

SCOPE OF THE WORK

The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

OBJECTIVES OF THE RESEARCH

If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm².

To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

COCONUT SHELL AS A ALTERNATIVE COURSE AGGREGATE
In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using itas coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concretematrix.

EXPERIMENTAL INVESTIGATION

Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Initial and Final setting times, Compressive strength of cement, Specific gravity, Fineness modulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.

Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares. Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30 C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

![Coconut Shells](image)

**Fig: Coconut Shells Water:**
The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.

**Tests on Materials:**

- **Cement:**
  - Normal Consistency of Cement
  - Initial and Final Setting Times of Cement
  - Compressive Strength of Cement
  - Specific Gravity of Cement
  - Fineness of Cement
  - Coarse Aggregate:
    - Specific Gravity of Aggregates
    - Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

Fineness modulus
Specific gravity
Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
<tr>
<td>Fineness of Cement</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Fineness Modulus</strong></td>
<td></td>
</tr>
<tr>
<td>Fineness modulus</td>
<td>2.88</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.6</td>
</tr>
<tr>
<td>Bulk density in loose state</td>
<td>1550 kg/m³</td>
</tr>
<tr>
<td><strong>Coarse Aggregate</strong></td>
<td></td>
</tr>
<tr>
<td>Fineness modulus</td>
<td>7.22</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.74</td>
</tr>
<tr>
<td>Bulk density in loose state</td>
<td>1654 kg/m³</td>
</tr>
</tbody>
</table>

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

Water Cement Ratio (w/c):

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: M25
Method used: IS code method

\[ F_{ck} = F_{ck} + t_s = 33.25 \quad (t = 1.65, \ s = 5) \]
Water cement ratio: 0.45
Compaction factor: 0.85

Maximum size of aggregate: 20 mm
Specific gravity of cement \( S_c \): 3.12
Specific gravity of fine aggregate \( S_{fa} \): 2.6
Specific gravity of coarse aggregate \( S_{ca} \): 2.74

Cement content: 138 kg/m³

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>437</td>
<td>599.04</td>
<td>1171.52</td>
<td></td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
<td></td>
</tr>
</tbody>
</table>

CASTING:
For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 × 150, 150 × 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Fig: Curing of concrete cubes

Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain it density. The compression strength of each sample was determined as follows:

Compressive strength = Crushing Load (kN) / Effective Area (mm²)

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>7days strength(N/mm²)</th>
<th>14 days strength(N/mm²)</th>
<th>28days strength(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

FLEXURAL TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Flexural strength of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

TENSILE TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Split- tensile strength Of 7 days (Mpa)</th>
<th>Split-tensile strength Of 14 days (Mpa)</th>
<th>Split- tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15%CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHS:
Compressive strength:

Split Tensile Strength:
Flexural Strength:

CONCLUSIONS:
The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm$^2$ at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where light weight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell are 5.23 Mpa at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7 Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5% replacement of coconut shell with aggregates.

REFERENCES:
Effect Of Coconutshell As A Partial Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu, Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE, MIGS.,H0D, Principal,Bon am Venkata Chalamayya Engineering College, Odalarevu, Andhra Pradesh, India.

ABSTRACT
Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials. Mainly gravel and sand are used in the preparation of conventional concrete. While the use of agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also reduce by making use of these waste products from agriculture. The coconut shell mainly aims to prepare lightweight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5%, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION
Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Twobillion of aggregate are produced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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.
Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due following reasons:-
Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc.
After the kernel is consumed, the shell is thrown away here and there causing environmental pollution.
Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems.
Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

**SCOPE OF THE WORK**
The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

**OBJECTIVES OF THE RESEARCH**
If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.
To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm².
To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

COCONUT SHELL AS A ALTERNATIVE COURSEAGGREGATE

In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concretematrix.

EXPERIMENTAL INVESTIGATION

Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Intial and Final setting times, Compressive strength of cement, Specific gravity, Finenessmodulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.

Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares.

Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30 C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells Water:
The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.

Tests on Materials:

Cement:

Normal Consistency of Cement
Initial and Final Setting Times of Cement
Compressive Strength of Cement
Specific Gravity of Cement
Fineness of Cement
Coarse Aggregate:

Specific Gravity of Aggregates
Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

- Fineness modulus
- Specific gravity
- Bulk density in loose state

### RESULTS

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
<tr>
<td>Fineness of Cement</td>
<td>8%</td>
</tr>
</tbody>
</table>

**Fineness Modulus**

- Fineness modulus       2.88
- Specific gravity       2.6
- Bulk density in loose state 1550 kg/m³

**Coarse Aggregate**

- Fineness modulus       7.22
- Specific gravity       2.74
- Bulk density in loose state 1654 kg/m³

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

**Water Cement Ratio (w/c):**

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: **M25**
Method used: IS code method

Fck = fck + t s = 33.25 ( t =1.65, s =5) Water cement ratio: 0.45
Compaction factor: 0.85

Maximum size of aggregate: 20 mm Specific gravity of cement Sc : 3.12 Specific gravity of fine aggregate Sfa: 2.6
Specific gravity of coarse aggregate Sca : 2.74

Cement content: 138 kg / m3

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>437</td>
<td>599.04</td>
<td>1171.52</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:
For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 x 150, 150 x 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Fig: Curing of concrete cubes

Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

\[
\text{Compressive strength} = \frac{\text{Crushing Load (kN)}}{\text{Effective Area (mm}^2\text{)}}
\]

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>7 days strength (N/mm²)</th>
<th>14 days strength (N/mm²)</th>
<th>28 days strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

FLEXURAL TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Flexural strength of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

TENSILE TEST:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>Split- tensile strength Of 7 days (Mpa)</th>
<th>Split-tensile strength Of 14 days (Mpa)</th>
<th>Split- tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHS:
Compressive strength:

Split Tensile Strength:
Flexural Strength:

<table>
<thead>
<tr>
<th></th>
<th>7 Days</th>
<th>14 Days</th>
<th>28 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
<tr>
<td>10%CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>5%CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.83</td>
</tr>
<tr>
<td>Conventional</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
</tbody>
</table>

CONCLUSIONS:

The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where light weight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell are 5.23 Mpa at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7 Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5% replacement of coconut shell with aggregates.

REFERENCES:


Effect Of Coconutshell As A Partial Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu, Andhra Pradesh, India.

GUIDE
DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE,
MIGS, HO, Principal, Bonam Venkata Chalamayya Engineering College, Odalarevu, Andhra Pradesh, India.

ABSTRACT
Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials. Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also be reduced by making use of these waste products from agriculture. The coconut shell mainly aims to prepare lightweight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5%, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION
Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Two billion of aggregate are produced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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. Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due following reasons:

Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc. After the kernel is consumed, the shell is thrown away here and there causing environmental pollution. Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems. Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

SCOPE OF THE WORK
The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

OBJECTIVES OF THE RESEARCH
If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm².

To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are re-studied.

COCONUT SHELL AS A ALTERNATIVE COURSE AGGREGATE

In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concretematrix.

EXPERIMENTAL INVESTIGATION

Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Initial and Final setting times, Compressive strength of cement, Specific gravity, Fineness modulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.

Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares. Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30°C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells Water:

The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.

Tests on Materials:

Cement:

- Normal Consistency of Cement
- Initial and Final Setting Times of Cement
- Compressive Strength of Cement
- Specific Gravity of Cement
- Fineness of Cement
- Coarse Aggregate:

- Specific Gravity of Aggregates
- Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

- Fineness modulus
- Specific gravity
- Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
</tbody>
</table>

- Fineness of Cement: 8%
- Fineness Modulus
  - Fineness modulus: 2.88
  - Specific gravity: 2.6
  - Bulk density in loose state: 1550 kg/m³

<table>
<thead>
<tr>
<th>Coarse Aggregate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fineness modulus</td>
<td>7.22</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.74</td>
</tr>
<tr>
<td>Bulk density in loose state</td>
<td>1654 kg/m³</td>
</tr>
</tbody>
</table>

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

Water Cement Ratio (w/c):

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: **M25**
Method used : IS code method

\[
Fck = fck + ts = 33.25 \quad (t =1.65, s =5)
\]
Water cement ratio: **0.45**
Compaction factor: **0.85**

Maximum size of aggregate: **20 mm** Specific gravity of cement **Sc : 3.12** Specific gravity of fine aggregate **Sfa : 2.6**
Specific gravity of coarse aggregate **Sca : 2.74**

Cement content : **138 kg / m3**

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>437</td>
<td>599.04</td>
<td>1171.52</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:
For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 x 150, 150 x 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Fig: Curing of concrete cubes

Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

Compressive strength = Crushing Load (kN) / Effective Area (mm²)

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x 200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>7days strength(N/mm²)</th>
<th>14 days strength(N/mm²)</th>
<th>28days strength(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

FLEXURAL TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Flexural strength Of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

TENSILE TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Split- tensile strength Of 7 days (Mpa)</th>
<th>Split-tensile strength Of 14 days (Mpa)</th>
<th>Split- tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15%CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHS:
Compressive strength:

Split Tensile Strength:
Flexural Strength:

CONCLUSIONS:
The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where light weight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell are 5.23Mpa at 28days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5% replacement of coconut shell with aggregates.

REFERENCES:

Effect Of Coconutshell As A Partoal Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Techin STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu ,Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE, MIGS.,HOD,Principal,Bon am VenkataChalamayyaEngineering College, Odalarevu , Andhra Pradesh,India.

ABSTRACT

Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also be reduce by making use of these waste products from agriculture. The coconut shell mainly aims to prepare light weight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5 %, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in thispaper.

INTRODUCTION

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non- decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Twobillion ofaggregateareproducedeachyearintheUnitedStates.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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.

Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due following reasons:-

Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc. After the kernel is consumed, the shell is thrown away here and there causing environmental pollution.

Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems. Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

**SCOPE OF THE WORK**

The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

**OBJECTIVES OF THE RESEARCH**

If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm².

To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

**COCONUT SHELL AS A ALTERNATIVE COURSE AGGREGATE**

In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concrete matrix.

**EXPERIMENTAL INVESTIGATION**

Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Intial and Final setting times, Compressive strength of cement, Specific gravity, Fineness modulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.

Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares. Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30 C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells

Water: The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.

Tests on Materials:

**Cement:**

- Normal Consistency of Cement
- Initial and Final Setting Times of Cement
- Compressive Strength of Cement
- Specific Gravity of Cement
- Fineness of Cement
- Coarse Aggregate:

- Specific Gravity of Aggregates
- Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

Fineness modulus
Specific gravity
Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
<tr>
<td>Fineness of Cement</td>
<td>8%</td>
</tr>
</tbody>
</table>

**Fineness Modulus**

| Fineness modulus                  | 2.88             |
| Specific gravity                  | 2.6              |
| Bulk density in loose state       | 1550 kg/m³       |

**Coarse Aggregate**

| Fineness modulus                  | 7.22             |
| Specific gravity                  | 2.74             |
| Bulk density in loose state       | 1654 kg/m³       |

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

Water Cement Ratio (w/c):

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: **M25**
Method used : IS code method

\[ F_{ck} = f_{ck} + t \cdot s = 33.25 \ (t = 1.65, \ s = 5) \]

Water cement ratio: 0.45
Compaction factor: 0.85

Maximum size of aggregate: 20 mm
Specific gravity of cement \( S_c : 3.12 \)
Specific gravity of fine aggregate \( S_{fa} : 2.6 \)
Specific gravity of coarse aggregate \( S_{ca} : 2.74 \)

Cement content : 138 kg / m³

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>437</td>
<td>599.04</td>
<td>1171.52</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:
For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 x 150, 150 x 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

\[
\text{Compressive strength} = \frac{\text{Crushing Load (kN)}}{\text{Effective Area (mm}\,2)}
\]

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
**TEST RESULTS:**

Compressive strength test results:

<table>
<thead>
<tr>
<th>S. N o</th>
<th>Grade of concrete</th>
<th>7days strength(N/mm²)</th>
<th>14 days strength(N/mm²)</th>
<th>28days strength(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15%CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

**FLEXURAL TEST:**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Flexural strength Of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15%CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

**TENSILE TEST:**

<table>
<thead>
<tr>
<th>S. N o</th>
<th>Grade of concrete</th>
<th>Split- tensile strength Of 7 days (Mpa)</th>
<th>Split-tensile strength Of 14 days (Mpa)</th>
<th>Split- tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15%CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHs:
Compressive strength:

![Compressive Strength Graph](image)

Split Tensile Strength:

![Split Tensile Strength Graph](image)
Conclusions:
The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where light weight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell at 5.23Mpa at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5% replacement of coconut shell with aggregates.

References:
Effect Of Coconutshell As A Partoal Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu, Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE,
MIGS.,HOD,Principal,Bonam Venkata Chalamayya Engineering College, Odalarevu, Andhra Pradesh, India.

ABSTRACT

Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials. Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also be reduced by making use of these waste products from agriculture. The coconut shell mainly aims to prepare light weight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5%, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Two billion of aggregate are produced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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.

Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due following reasons:-

- Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc.
- After the kernel is consumed, the shell is thrown away here and there causing environmental pollution. Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems.
- Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings. Serves as an environment-friendly construction material.

**SCOPE OF THE WORK**

The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

**OBJECTIVES OF THE RESEARCH**

If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

- To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm².
- To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

COCONUT SHELL AS A ALTERNATIVE COURSEAGGREGATE
In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concrete matrix.

EXPERIMENTAL INVESTIGATION
Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Intial and Final setting times, Compressive strength of cement, Specific gravity, Fineness modulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.

Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares. Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30 C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells Water:

The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.

Tests on Materials:

Cement:

Normal Consistency ofCement
Initial and Final Setting Times ofCement
Compressive Strength ofCement
Specific Gravity ofCement
Fineness ofCement
Coarse Aggregate:

Specific Gravity ofAggregates
Bulk density in loosestate
Fineness Modulus of Aggregates

Fine Aggregate:

Fineness modulus
Specific gravity
Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
</tbody>
</table>

Fineness of Cement 8%

Fineness Modulus

Fineness modulus 2.88
Specific gravity 2.6
Bulk density in loose state 1550 kg/m³

Coarse Aggregate

Fineness modulus 7.22
Specific gravity 2.74
Bulk density in loose state 1654 kg/m³

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concrete, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

Water Cement Ratio (w/c):

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: M25
Method used: IS code method

\[ F_{ck} = f_{ck} + ts = 33.25 \quad (t = 1.65, s = 5) \]
Water cement ratio: 0.45
Compaction factor: 0.85

Maximum size of aggregate: 20 mm
Specific gravity of cement \( S_c : 3.12 \)
Specific gravity of fine aggregate \( S_{fa} : 2.6 \)
Specific gravity of coarse aggregate \( S_{ca} : 2.74 \)

Cement content: 138 kg/m³

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>197</td>
<td>437</td>
<td>599.04</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:
For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 x 150, 150 x 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Fig: Curing of concrete cubes

Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

\[
\text{Compressive strength} = \frac{\text{Crushing Load (kN)}}{\text{Effective Area (mm}^2)}
\]

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x 200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>7days strength(N/mm$^2$)</th>
<th>14 days strength(N/mm$^2$)</th>
<th>28days strength(N/mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

FLEXURAL TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Flexural strength Of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

TENSILE TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Split- tensile strength Of 7 days (Mpa)</th>
<th>Split-tensile strength Of 14 days (Mpa)</th>
<th>Split- tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
**GRAPHS:**

**Compressive strength:**

![Compressive Strength Graph](image)

**Split Tensile Strength:**

![Split Tensile Strength Graph](image)
**Flexural Strength:**

![Graph showing flexural strength over time for different coconut shell percentages and conventional concrete.](image)

**CONCLUSIONS:**

The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore, coconut shell concrete can be used where lightweight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates at 28 days, upon increasing the coconut shell percentage the strength decreases. Therefore, the optimum strength is taken as 5% replacement of coconut shell with aggregates.

**REFERENCES:**

Effect Of Coconuts Shell As A Partial Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu ,Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE, MIGS.,HOD,Principal,Bonam VenkataChalamayyaEngineering College, Odalarevu , Andhra Pradesh,India.

ABSTRACT

Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials. Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also reduce by making use of these waste products from agriculture. The coconut shell mainly aims to prepare light weight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5%, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Two billion of aggregate are produced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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. Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due following reasons:-

Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc. After the kernel is consumed, the shell is thrown away here and there causing environmental pollution. Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems. Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

SCOPE OF THE WORK

The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

OBJECTIVES OF THE RESEARCH

If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm2.

To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are...
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

**COCONUT SHELL AS A ALTERNATIVE COURSEAGGREGATE**

In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where lightweight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concretematrix.

**EXPERIMENTAL INVESTIGATION**

**Materials:**
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Initial and Final setting times, Compressive strength of cement, Specific gravity, Fineness modulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares.

Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30 C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells Water:

The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking. Tests on Materials:

**Cement:**

- Normal Consistency of Cement
- Initial and Final Setting Times of Cement
- Compressive Strength of Cement
- Specific Gravity of Cement
- Fineness of Cement
- Coarse Aggregate:

- Specific Gravity of Aggregates
- Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

Fineness modulus
Specific gravity
Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
</tbody>
</table>

| Fineness of Cement               | 8%      |
| **Fineness Modulus**             |         |
| Fineness modulus                 | 2.88    |
| Specific gravity                 | 2.6     |
| Bulk density in loose state      | 1550 kg/m³ |
| **Coarse Aggregate**             |         |
| Fineness modulus                 | 7.22    |
| Specific gravity                 | 2.74    |
| Bulk density in loose state      | 1654 kg/m³ |

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

Water Cement Ratio (w/c):

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: **M25**
Method used : IS code method

\[ F_{ck} = f_{ck} + t \cdot s = 33.25 \quad (t = 1.65, s = 5) \]

Water cement ratio: **0.45**

Compaction factor: **0.85**

Maximum size of aggregate: **20 mm**

Specific gravity of cement \( S_c : 3.12 \)

Specific gravity of fine aggregate \( S_{fa} : 2.6 \)

Specific gravity of coarse aggregate \( S_{ca} : 2.74 \)

Cement content : **138 kg/m³**

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>437</td>
<td>599.04</td>
<td>1171.52</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:

For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 x 150, 150 x 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

Compressive strength = Crushing Load (kN) / Effective Area (mm²)

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>7 days strength (N/mm²)</th>
<th>14 days strength (N/mm²)</th>
<th>28 days strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

FLEXURAL TEST:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>Flexural strength of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

TENSILE TEST:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>Split-tensile strength of 7 days (Mpa)</th>
<th>Split-tensile strength of 14 days (Mpa)</th>
<th>Split-tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHS:
Compressive strength:

Split Tensile Strength:
CONCLUSIONS:
The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where light weight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell are 5.23 Mpa at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7 Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5% replacement of coconut shell with aggregates.

REFERENCES:
Effect Of CoconutsHELL As A Partial Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu, Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE, MIGS., H.O.D, Principal, Bonam Venkata Chalamayya Engineering College, Odalarevu, Andhra Pradesh, India.

ABSTRACT

Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials. Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also reduce by making use of these waste products from agriculture. The coconut shell mainly aims to prepare light weight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5 %, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Two billion of aggregate are reproduced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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. Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due following reasons:- Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc. After the kernel is consumed, the shell is thrown away here and there causing environmental pollution. Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems. Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

SCOPE OF THE WORK
The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

OBJECTIVES OF THE RESEARCH
If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm².

To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

COCONUT SHELL AS A ALTERNATIVE COURSEAGGREGATE
In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concretematrix.

EXPERIMENTAL INVESTIGATION
Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Intial and Final setting times, Compressive strength of cement, Specific gravity, Fineness modulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.

Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares. Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30°C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells Water:
The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.

Tests on Materials:

**Cement:**

- Normal Consistency of Cement
- Initial and Final Setting Times of Cement
- Compressive Strength of Cement
- Specific Gravity of Cement
- Fineness of Cement
- Coarse Aggregate:

- Specific Gravity of Aggregates
- Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

Fineness modulus
Specific gravity
Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
<tr>
<td>Fine ness of Cement</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Fineness Modulus</strong></td>
<td></td>
</tr>
<tr>
<td>Fineness modulus</td>
<td>2.88</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.6</td>
</tr>
<tr>
<td>Bulk density in loose state</td>
<td>1550 kg/m³</td>
</tr>
<tr>
<td><strong>Coarse Aggregate</strong></td>
<td></td>
</tr>
<tr>
<td>Fineness modulus</td>
<td>7.22</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.74</td>
</tr>
<tr>
<td>Bulk density in loose state</td>
<td>1654 kg/m³</td>
</tr>
</tbody>
</table>

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

Water Cement Ratio (w/c):

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: **M25**
Method used : IS code method

\[ F_{ck} = f_{ck} + t \cdot s = 33.25 \] ( t =1.65, s =5) Water cement ratio: 0.45

Compaction factor: 0.85

Maximum size of aggregate: 20 mm Specific gravity of cement Sc : 3.12 Specific gravity of fine aggregate Sfa : 2.6

Specific gravity of coarse aggregate Sca : 2.74

Cement content : 138 kg / m3

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>437</td>
<td>599.04</td>
<td>1171.52</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:

For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 x 150, 150 x 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Fig: Curing of concrete cubes

Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

\[
\text{Compressive strength} = \frac{\text{Crushing Load (kN)}}{\text{Effective Area (mm}^2)}
\]

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x 200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>7days strength(N/mm²)</th>
<th>14 days strength(N/mm²)</th>
<th>28days strength(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

FLEXURAL TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Flexural strength Of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

TENSILE TEST:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Split- tensile strength Of 7 days (Mpa)</th>
<th>Split-tensile strength Of 14 days (Mpa)</th>
<th>Split- tensile Strength Of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHS:
Compressive strength:

Split Tensile Strength:
Flexural Strength:

![Flexural Strength Graph]

**CONCLUSIONS:**

The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where light weight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell at 5.23Mpa at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5 % replacement of coconut shell with aggregates.

**REFERENCES:**

Effect Of Coconutshell As A Partoal Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu , Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE,
MIGS., HOD, Principal, Bonam Venkata Chalamayya Engineering College, Odalarevu , Andhra Pradesh, India.

ABSTRACT

Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also reduce by making use of these waste products from agriculture. The coconut shell mainly aims to prepare light weight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5 %, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non- decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Two billion of aggregate are produced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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. Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due to following reasons:- Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc. After the kernel is consumed, the shell is thrown away here and there causing environmental pollution.

Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems.

Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

SCOPE OF THE WORK
The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

OBJECTIVES OF THE RESEARCH
If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm2.

To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

COCONUT SHELL AS A ALTERNATIVE COURSE AGGREGATE

In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concretematrix.

EXPERIMENTAL INVESTIGATION

Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Intial and Final setting times, Compressive strength of cement, Specific gravity, Fineness modulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.
Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares.
Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30 C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells Water:
The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.
Tests on Materials:

**Cement:**

- Normal Consistency ofCement
- Initial and Final Setting Times ofCement
- Compressive Strength ofCement
- Specific Gravity ofCement
- Fineness ofCement
- Coarse Aggregate:

- Specific Gravity ofAggregates
- Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

Fineness modulus
Specific gravity
Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
</tbody>
</table>

Fineness of Cement 8%

**Fineness Modulus**

Fineness modulus 2.88
Specific gravity 2.6
Bulk density in loose state 1550 kg/m³

**Coarse Aggregate**

Fineness modulus 7.22
Specific gravity 2.74
Bulk density in loose state 1654 kg/m³

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

**Water Cement Ratio (w/c):**

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

**Mix Design for M25 Grade Concrete:**

Grade of concrete: **M25**
Method used: IS code method

\[ F_{ck} = f_{ck} + t_s = 33.25 \quad (t = 1.65, s = 5) \]
Water cement ratio: 0.45
Compaction factor: 0.85

Maximum size of aggregate: 20 mm
Specific gravity of cement \( S_c : 3.12 \)
Specific gravity of fine aggregate \( S_{fa} : 2.6 \)
Specific gravity of coarse aggregate \( S_{ca} : 2.74 \)

Cement content: 138 kg/m³

Cement content = 437

Fine aggregate content = 599.04
Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>437</td>
<td>599.04</td>
<td>1171.52</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:
For casting the test specimens, standard size of 150 × 150 × 150 mm cubes and cylinders 150 × 150, 150 × 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

\[
\text{Compressive strength} = \frac{\text{Crushing Load (kN)}}{\text{Effective Area (mm}^2)}
\]

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>7 days strength (N/mm²)</th>
<th>14 days strength (N/mm²)</th>
<th>28 days strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

FLEXURAL TEST:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>Flexural strength of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

TENSILE TEST:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of concrete</th>
<th>Split-tensile strength of 7 days (Mpa)</th>
<th>Split-tensile strength of 14 days (Mpa)</th>
<th>Split-tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2.</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3.</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4.</td>
<td>15% CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHS:

Compressive strength:

![Compressive Strength N/mm² Graph](image1)

Split Tensile Strength:

![Split Tensile Strength (MPA) Graph](image2)
Flexural Strength:

![Flexural Strength Plot]

CONCLUSIONS:
The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where lightweight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell are 5.23 Mpa at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7 Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5% replacement of coconut shell with aggregates.

REFERENCES:

Effect Of Coconutshell As A Partial Replacement Of Coarse Aggregates On Strength Characteristics Of Concrete

Y S V Samantha received the B.Tech degree in civil engineering from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, JNTU KAKINADA, Andhra Pradesh, India, in 2016 year, and perusing M.Tech in STRUCTURAL ENGINEERING from BONAM VENKATA CHALAMAYYA ENGINEERING COLLEGE, Odalarevu, Andhra Pradesh, India.

GUIDE

DR. D S V PRASAD, M.E, Ph.D., MIE, MISTE, MIGS., HOD, Principal, Bonam Venkata Chalamayya Engineering College, Odalarevu, Andhra Pradesh, India.

ABSTRACT

Now-a-days, the rising cost of building materials for construction purposes is a factor of great concern. The price of building materials is rising day by day as a result most of the researchers are paying much attention on the available materials which can reduce the construction cost of buildings as well as increase the strength properties of concrete by adding different materials. Mainly gravel and sand are used in the preparation of conventional concrete. While the use of an agricultural by-product i.e. coconut shell as a partial replacement with coarse aggregates is expected to serve the purpose of developing housing developers in the field of building construction. Environmental impact can also reduce by making use of these waste products from agriculture. The coconut shell mainly aims to prepare light weight concrete which may be reduces the self-load of a structure and permits large precast units. The coconut shell is more resistant to acidic, salty and alkaline attack as for the climatic conditions. The main characteristic properties of concrete such as compressive strength, split tensile strength, flexural strength, impact resistance, bond strength using the mix made by replacing 5%, 10%, 15% of coconut shell aggregates with coarse aggregates were reviewed in this paper.

INTRODUCTION

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Two billion of aggregate are produced each year in the United States.

Production is expected to increase to more than billion tons per year by the year similarly; the consumption of the primary aggregate was 110 million tons in the UK in year 1960 and reached nearly 275 million tons by 2006. 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 cause’s environmental concern. In light 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. Apart from the above mentioned waste materials, coconut shell can also be used as aggregates in concrete due following reasons:-

Large scale cultivation of coconut in coastal regions of India including Kerala, Andhra Pradesh, Goa, Tamil Nadu, Odisha etc. After the kernel is consumed, the shell is thrown away here and there causing environmental pollution. Due to its tough made tissue, the shell is not decomposed easily and remains as solid waste for years. Hence utilizing it in a proper manner reduces environmental problems. Very little percentage of shells are used in ornamental preparations, making fancy items, household utensils etc. but majority of it are discarded as waste. Helpful in cost effective housing and low rise buildings Serves as an environment-friendly construction material.

SCOPE OF THE WORK

The aim of this study is to assess the utility and efficacy of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete. Coconut shells have not been tried as aggregate in structural concrete.

OBJECTIVES OF THE RESEARCH

If structural LWC can be developed from coconut shells, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using solid waste coconut shells as coarse aggregate for structural LWC. The research objectives are briefly summarized below.

To study the properties of coconut shells, compatibility of coconut shells with cement and to produce coconut shell aggregate concrete with 28 day compressive strength more than 25N/mm².

To study the strength properties of concrete in replacement of coarse aggregate, To study the behavior of compressive, flexural and split tensile strengths. The basic properties of coconut shells such as physical, chemical, mechanical properties, and the compatibility of coconut shells with cement were studied. Based on the standard procedures and methods followed for the production of conventional LWC, the coconut shell aggregate concrete were produced. Numerous trial mixes were conducted by varying cement content, sand, coconut shells and water-cement (w/c) ratio. The acceptable trial mixes were then identified and finally, the workability, strength, density and durability requirements for different applications of LWC were taken into consideration during the selection of the optimum coconut shell aggregate concrete mix. Also, the concrete mix was optimized for coconut shells cement ratio and w/c ratio. This optimum mix was then used throughout the entire investigation for the production of coconut shell aggregate concrete specimens. Control concrete (CC) using crushed granite stone aggregate concrete (normal weight concrete – NWC) was also produced for comparison purposes. Comparison studies between CC and coconut shell aggregate concrete were conducted only on the fresh concrete properties, compressive strength, basic and mechanical properties. The behavior of NWC, namely the structural bond, durability and temperature properties are well established. Therefore these properties were not investigated for CC in this study. Structural properties such as flexural and shear behavior of reinforced coconut shell aggregate concrete beams were studied by making prototype elements and the results are
compared with the other LWA used in concrete. Comparisons of some properties for coconut shell aggregate concrete were made using some codes of practice and other LWC. Also, tests conducted on temperature characteristics of coconut shell aggregate concrete are studied.

COCONUT SHELL AS A ALTERNATIVE COURSEAGGREGATE

In view of thrust on energy saving and sustainable development, the use of alternative constituents of natural resources and the search of suitable alternative to conventional construction material is now a global concern. To make use of alternative aggregate in concrete which is coconut shell has never been a common practice among the people, particularly in areas where light weight concrete is required for non-load bearing walls and non-structural floors. Concrete obtained using coconut shell as a coarse aggregate satisfies the minimum requirements of concrete. Coconut shell aggregate resulted acceptable strength which is required for structural concrete. Coconut shell may present itself as a potential material in the field of construction industries. The coconut shell is compatible with cement and no need to pre-treatment for using it as coarse aggregate. Because of the smooth surface on one side of the shells concrete made with coconut shell presents better workability. Coconut shell concrete shows good impact resistance. As compared to conventional aggregate water absorbing and moisture retaining capacity of coconut shell is more. The presence of sugar in the coconut shell, does not affect the setting and strength of concrete because it is not in a free sugar form. It is found that wood based materials being hard and of organic origin, will not contaminate or leach to produce toxic substances once they are bound in concretematrix.

EXPERIMENTAL INVESTIGATION

Materials:
The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. Due to these results we were define what type of materials are used. We are using cement, coarse aggregate, fine aggregate, coconut shells and water.

Cement:
Ordinary Portland cement of OPC 53 grade conforming to both the requirements of IS:12269 and ASTM C642-82 type-1 was used. We are conducting different types of tests on cement, those are Normal Consistency, Intial and Final setting times, Compressive strength of cement, Specific gravity , Finenessmodulus.

Coarse Aggregate:
Normal aggregate that is crushed blue granite of maximum size 20 mm was used as coarse aggregate. We are conducting tests on coarse aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of coarse aggregate.

Fine Aggregate:
Well graded river sand passing through 4.75 mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. We are conducting tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of
fine aggregate.

Coconut Shell:

The coconut palm is one of the most useful plants in the world. Coconut is grown in 92 countries in the world. Global production of coconut is 51 billion nuts from an area of 12 million hectares.

Coconut shells which were already broken into two pieces were collected from local temple; air dried for five days approximately at the temperature of 25 to 30 C; removed fiber and husk on dried shells; further broken the shells into small chips manually using hammer and sieved through 12.5mm sieve. The material passed through 12.5mm sieve was used to replace coarse aggregate with coconut shells. The material retained on 12.5mm sieve was discarded. Water absorption of the coconut shells was 8% and specific gravity at saturated surface dry condition of the material was found as 1.33.

Fig: Coconut Shells Water:

The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concretemaking.

Tests on Materials:

**Cement:**

- Normal Consistency ofCement
- Initial and Final Setting Times ofCement
- Compressive Strength ofCement
- Specific Gravity ofCement
- Fineness ofCement
- Coarse Aggregate:

- Specific Gravity ofAggregates
- Bulk density in loose state
Fineness Modulus of Aggregates

Fine Aggregate:

Fineness modulus
Specific gravity
Bulk density in loose state

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES OF MATERIALS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td></td>
</tr>
<tr>
<td>Normal consistency</td>
<td>32%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.12</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>52 min</td>
</tr>
<tr>
<td>Final setting time</td>
<td>452 min</td>
</tr>
</tbody>
</table>

| Fineness of Cement               | 8%      |

**Fineness Modulus**

| Fineness modulus                    | 2.88   |
| Specific gravity                    | 2.6    |
| Bulk density in loose state         | 1550 kg/m³ |

**Coarse Aggregate**

| Fineness modulus                    | 7.22   |
| Specific gravity                    | 2.74   |
| Bulk density in loose state         | 1654 kg/m³ |

Mix Proportion:

Mix design is the process of selecting an optimum proportion of cement, fine and coarse aggregates and water to produce a concrete with specified properties of workability, strength, and durability. The best mix involves a balance between economy and the required properties of concrete.

In order to investigate properties of coconut shells concretes, five mixes were employed. Control mix (M1) that is, without coconut shells was made. Coarse aggregate was then replaced with coconut shells in 5% (M2), 10% (M3), 15% (M4) percentages to study effect of CS replacement.

Water Cement Ratio (w/c):

It is difficult to specify the optimal w/c ratio for all kinds of cement composite. Hence, it is necessary to optimize the coconut shells aggregate - cement ratio and w/c ratio. It is seen that with the increase of w/c ratio, the strength of coconut shell aggregate concrete reduced. Therefore w/c ratio was considered as 0.45.

Mix Design for M25 Grade Concrete:

Grade of concrete: M25
Method used : IS code method

\[ F_{ck} = f_{ck} + t s = 33.25 \] ( \( t = 1.65 \), \( s = 5 \)) Water cement ratio: 0.45

Compaction factor: 0.85

Maximum size of aggregate: 20 mm Specific gravity of cement \( S_c : 3.12 \) Specific gravity of fine aggregate \( S_{fa} : 2.6 \)
Specific gravity of coarse aggregate \( S_{ca} : 2.74 \)

Cement content : 138 kg / m³

Cement content = 437

Fine aggregate content = 599.04 Coarse aggregate content = 1171.52

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>FA</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>197</td>
<td>437</td>
<td>599.04</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.37</td>
<td>2.68</td>
</tr>
</tbody>
</table>

CASTING:
For casting the test specimens, standard size of 150 × 150 × 150mm cubes and cylinders 150 x 150, 150 x 100 mm made with cast iron, metal moulds are used to cast the test specimens. The moulds have been cleaned to remove the dust particles from the mould and mineral oil is applied on all sides of the mould, before concrete is poured into the mould. Thoroughly mixed concrete is filled into the mould and vibrated by pin vibrator. Excess concrete was removed with travel and top surface is finished level and smooth.

Figure: Casting of concrete cubes
Fig: Curing of concrete cubes

Test program:

The main objective of the present investigation was to study the performance of coconut shells concretes in terms of strength. The specimens were tested for compression and split tensile strengths and flexural strengths at 7, 14 and 28 days.

Compressive Strength:

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000 kN. For the compressive strength test, a loading rate of 2.5 kN/s was applied as per IS: 516–1959. The test was conducted on 150mm cube specimens at 7, 14 and 28 days. Each sample was weighed before putting into the crushing machine to ascertain its density. The compression strength of each sample was determined as follows:

Compressive strength = Crushing Load (kN) / Effective Area (mm$^2$)

Split Tensile Strength:

Split tensile strength test was conducted in accordance with ASTM C496. Cylinders of 100 x200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the compressive strength test was performed. The specimens were tested for 7, 14 and 28 days.
Flexural Strength:

Flexural tests are generally used to determine the flexural modulus or flexural strength of a material. A flexural test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is flexural strength of that particular sample.
### TEST RESULTS:

Compressive strength test results:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>7 days strength (N/mm²)</th>
<th>14 days strength (N/mm²)</th>
<th>28 days strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CONVENTIONAL CONCRETE</td>
<td>24</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>5% CS</td>
<td>25</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>3</td>
<td>10% CS</td>
<td>23</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>15% CS</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

Flexural test:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Flexural strength of 7 days (Mpa)</th>
<th>Flexural Strength of 14 days (Mpa)</th>
<th>Flexural Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.38</td>
<td>3.01</td>
<td>3.62</td>
</tr>
<tr>
<td>2</td>
<td>5% CS</td>
<td>2.52</td>
<td>3.17</td>
<td>3.89</td>
</tr>
<tr>
<td>3</td>
<td>10% CS</td>
<td>2.95</td>
<td>3.83</td>
<td>5.23</td>
</tr>
<tr>
<td>4</td>
<td>15% CS</td>
<td>3.36</td>
<td>4.82</td>
<td>5.12</td>
</tr>
</tbody>
</table>

Tensile test:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Grade of concrete</th>
<th>Split- tensile strength of 7 days (Mpa)</th>
<th>Split- tensile strength of 14 days (Mpa)</th>
<th>Split- tensile Strength of 28 days (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CONVENTIONAL CONCRETE</td>
<td>2.83</td>
<td>4.63</td>
<td>6.5</td>
</tr>
<tr>
<td>2</td>
<td>5% CS</td>
<td>2.81</td>
<td>4.51</td>
<td>6.7</td>
</tr>
<tr>
<td>3</td>
<td>10% CS</td>
<td>2.6</td>
<td>4.36</td>
<td>5.6</td>
</tr>
<tr>
<td>4</td>
<td>15% CS</td>
<td>2.7</td>
<td>4.48</td>
<td>6.12</td>
</tr>
</tbody>
</table>
GRAPHS:
Compressive strength:

![Compressive Strength N/mm² Graph](image)

Split Tensile Strength:

![Split Tensile Strength (MPA) Graph](image)
Flexural Strength:

CONCLUSIONS:
The compressive strength for 5 percentages of coconut shell aggregates is 37 N/mm² at 28 days. The compressive strength decreases as the percentage of coconut shell is increased. Therefore coconut shell concrete can be used where light weight concrete is used.

The maximum flexural strength is obtained by replacing the coarse aggregates with 10% coconut shell are 5.23 Mpa at 28 days.

The maximum split tensile strength is obtained at 5% replacement of coconut shell aggregates is 6.7 Mpa for 28 days upon increasing the coconut shell percentage the strength decreases. Therefore the optimum strength is taken as 5% replacement of coconut shell with aggregates.

REFERENCES: