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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT BY COAL ASH AND COARSE AGGREGATE BY COCONUT SHELL IN CONCRETE

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Abstract— Different waste materials such as fly ash, silica flumes, copper slag, brick bat, demolished concrete has been successfully employed to produce various materials for building construction such as concrete, flush door, plywood, jute boards etc.Due to rapid growth of construction activities, conventional aggregate sources are depleting very fast leading to significant increase in cost of construction. For sustainable development, the alternative materials should be used wisely and need to be searched to replace conventional aggregate. The material we have taken in our project is coconut shell and coal ash. The waste coconut shell may be used to replace conventional coarse aggregate and the coal ash for replacing the cement.The ordinary Portland cement is significant because its production emits large amount of CO_2. A considerable amount of coal ash and coconut shells remain in the environment as waste, so utilization of these materials for construction will be an important step to improve sustainability and eco-friendly construction. One of the most attractive options of managing such wastes is to look into the possibility of waste minimization and re-use. An effort has been made to study the suitability of replacing the 20% of coal ash obtained from Ennore is kept as constant for all mixes with simultaneously replacing 10%, 15%, 20% of coconut shell as coarse aggregate for concrete grade of M35.Test for grade as per specified procedure of IS codes. The materials are proportioned by their concrete.

Key Words - coal ash, coconut shell, M35

I. INTRODUCTION

Concrete is a mixture of different waste material like binder (cement), fine aggregate, coarse aggregate and water. Normal practice of concreting is batching of this common raw material, mixing of raw material, transporting of concrete (mixture of all raw materials), compaction of concrete, finishing and finally curing of concrete is followed by industries. Use of concrete is very large so availability of natural material is reduced and there is no material which plays the role of this ideal material (concrete) so to fulfill the requirement of industries we have to replace fully or partially all the materials. In India numbers of waste materials are produced by different manufacturing companies, thermal power plant, municipal solid wastes and other wastes. Solid as well as liquid waste management is one of the biggest problems of the whole world. With disposal of waste in to the land causes serious impact on environment. It spoils the land. This paper is based on the review of literature which gives the idea about different waste available and possibility of use of this waste material in concrete. The high cost of conventional building materials is a major factor affecting construction in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used for various purposes in construction industry. This will have double the advantages, reduction in the cost of construction material and also as a means of disposal of wastes. Thus the approach is logical, worthy and attributable. Coal ash and coconut shells are new materials in the field of construction, so a study on various strength, chemical and durability properties of these materials is required. Also suitable measures have to be adopted for attaining the target strength.

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II. MATERIALS USED

- Cement
- Coal ash (Pulverized fuel ash)
- Fine aggregate

- Coarse aggregate
- Coconut shells
- Water

A. CEMENT

Cement is used right from ancient periods in construction industry. In the most general sense of the word, cement is a binder, a substance which sets and hardens independently, and can bind other materials together. The word "Cement "traces to the Romans, who used the term "opus caementicium" to describe masonry which resembled concrete and was made from crushed rock with burned lime as binder. Cements used in construction are characterized as hydraulic or non hydraulic..

Properties of Ordinary Portland Cement

S. No	Properties	Cement Value
1	Grade	53Mpa
2	Specific gravity	3.13
3	Initial setting time	30Min
4	Final setting time	300Min
6	Bulk density	0.9

B. COAL ASH

Coal ash is also known asfuel-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fuel ash usually refers to ash produced during combustion of coal. Coal ash is generally captured by electrostatic precipitators of other particle filtration equipment before the flue gases reach the chimneys of coal fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of coal ash vary considerably, but all coal ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata.

Coal ash has been used extensively in concrete for many years. Coal ash much more variable than silica fumes in both their physical and chemical characteristics. In general, coal ash is used at about 15-25% of the cement content.This helps to increases the strength properties of concrete. It also makes the concrete economical and eco friendly.

Properties of Coal Ash

S.No	Parameter	Test Results	Specifications As Per IS: 3812 - 1981
1	Bulk density(Kg/m^3)	1010	1120
2	Specific gravity	2.22	2.14 to 2.42

C. FINE AGGREGATE

Well graded river sand passing through 4.75 mm was used as fine aggregate. It consists of natural sand or, subject to approval, other inert materials with similar characteristics, or combinations having hard, strong, durable particles. Sand is naturally occurring granular material composed of finely divided rock and mineral particles. The most common constituent of sand is silicon dioxide, usually in the form of Quartz. Normally fine aggregate is used as fine aggregate for preparing concrete. An individual particle in this range is termed as sand grain. These sand grains are between coarse aggregate (2mm to 64mm) and silt (0.004mm to 0.0625mm). Aggregate most of which passes 4.75mm IS sieve is used.

Properties of Fine Aggregate

Particulars	Test Values
Optimum moisture content	6%
Fineness Modulus	2.8
Specific Gravity	2.54

D. COARSE AGGREGATE

Coarse aggregates are the most mined material in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Coarse aggregate of size 20mm is sieved and used. Aggregates are collected from approved quarry and aggregates having size ranging from 10 mm to 20 mm are used. The tests are carried out or coarse aggregate as per IS 2386-1963 and the results are given in table.

The specific gravity of coarse aggregate is defined as the ratio between the mass of equal volumes of coarse aggregate and water at the same constant temperature.As coarse aggregates in concrete occupy 35 to 70% of the volume of the concrete. Usually an aggregate with specific gravity more than 2.55 and absorption less than 1.5% (except for light weight aggregates) can be regarded as being of good quality.

Properties of Coarse Aggregate

Properties	Values
Specific gravity	2.83
Water absorption (%)	0.75
Aggregate Crushing Value (%)	16.60
Aggregate Impact Value (%)	11.01
Size	Passing through 20mm sieve and retained in 10mm sieve

E. COCONUT SHELLS

Coconuts are referred to as "man's most useful trees", "king of the tropical flora" and "tree of life". Global production of coconut is 51 billion nuts from an area of 12 million hectares. South East Asia is regarded as the origin of coconut. Although the lignin content is higher and the cellulose content is lower, coconut shells are similar in chemical composition to hard wood.. The coconut palm is a champion amongst the most supportive plants on the planet. Coconut is created in 92countries on the planet.

Properties of Coconut Shell

S.No.	Physical properties	Test results
1.	Maximum Size (mm)	20
2.	Specific Gravity	1.56
3.	Bulk Density(kg/m^3)	560
4.	Water Absorption (%)	12
5.	Aggregate Crushing Value (%)	2.49
6.	Aggregate Impact Value(%)	8.55
7.	Moisture Content (%)	4.2
8.	Shell Thickness(mm)	3

F. WATER

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. As per IS 456-2000 water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugars and organic materials. The water used was taken from the college campus.

III. TEST RESULTS FOR CONCRETE SPECIMENS COMPRESSIVE STRENGTH OF CONCRETE CUBES

Compressive Strength of Concrete Cubes

S.No	Curing Period	Compressive Load (KN)	Stress (N/mm^2)
1	7 days	798	35.52
2	14 days	882	39.2
3	28 days	971	43.18

CALCULATION

1. For 7 days
   Compressive strength of concrete cube = P/A
   = (798x1000) / (150x150)

= 35.52 N/mm^2

2. For 14 days
   Compressive strength of concrete cube = P/A
   = (882x1000) / (150x150)
   = 39.2 N/mm^2
3. For 28 days
   Compressive strength of concrete cube = P/A
   = (971x1000) / (150x150)
   = 43.18 N/mm^2

Compressive Strength of Concrete Cubes

(Coal Ash 20% + Coconut Shell 10%)

S.No	Curing Period	Compressive Load (KN)	Stress (N/mm^2)
1	7 days	730	32.44
2	14 days	842	37.36
3	28 days	951	42.28

CALCULATION

1. For 7 days
   Compressive strength of concrete cube = P/A
   = (730x1000) / (150x150)
   = 32.44 N/mm^2
2. For 14 days
   Compressive strength of concrete cube = P/A
   = (842x1000) / (150x150)
   = 37.36 N/mm^2
3. For 28 days
   Compressive strength of concrete cube = P/A
   = (951x1000) / (150x150)
   = 42.28 N/mm^2

Compressive Strength of Concrete Cubes

(Coal Ash 20% + Coconut Shell 15%)

S.No	Curing Period	Compressive Load (KN)	Stress (N/mm^2)
1	7 days	751	33.37
2	14 days	822	36.52
3	28 days	928	41.25

CALCULATION

1. For 7 days
   Compressive strength of concrete cube = P/A
   = (751x1000) / (150x150)
   = 33.37 N/mm^2
2. For 14 days
   Compressive strength of concrete cube = P/A
   = (822x1000) / (150x 150)
   = 36.52 N/mm^2
3. For 28 days
   Compressive strength of concrete cube = P/A
   = (928x1000) / (150x150)
   = 41.25 N/mm^2

Compressive Strength of Concrete Cubes

(CoalAsh 20% + Coconut Shell 20%)

S.No	Curing Period	Compressive Load (KN)	Stress (N/mm^2)
1	7 days	723	32.12
2	14 days	806	35.84
3	28 days	858	38.32

CALCULATION

1. For 7 days
   Compressive strength of concrete cube = P/A
   = (723x1000) / (150x150)

= 32.12 N/mm^2

2. For 14 days
   Compressive strength of concrete cube = P/A
   = (806x1000) / (150x150)
   = 35.84 N/mm^2
3. For 28 days
   Compressive strength of concrete cube = P/A
   = (858x1000) / (150x150)
   = 38.32 N/mm^2

IV. SPLIT TENSILE STRENGTH OF CONCRETE CYLINDERS

Split Tensile Strength of Concrete Cylinders

S.No	Curing Period	Tensile Load (KN)	Stress (N/mm^2)
1	7 days	185	2.62
2	14 days	223	3.15
3	28 days	256	3.59

CALCULATION

1. For 7 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x185x1000) / (π x150x300)
   = 2.62 N/mm^2
2. For 14 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x223x1000) / (π x 150x300)
   = 3.15 N/mm^2
3. For 28 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x256x1000) / (π x150x300)
   = 3.59 N/mm^2

Tensile Strength of Concrete Cylinders

(CoalAsh 20% + Coconut Shell 10%)

S.No	Curing Period	Tensile Load (KN)	Stress (N/mm^2)
1	7 days	175	2.47
2	14 days	210	2.99
3	28 days	248	3.52

CALCULATION

1. For 7 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x175x1000) / (π x150x300)
   = 2.47 N/mm^2
2. For 14 days
   Tensile strength of concrete cylinder= 2P/πDL
   = (2x210x1000) / (π x150x300)
   = 2.99 N/mm^2
3. For 28 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x248x1000) / (π x150x300)
   = 3.52 N/mm^2

Tensile Strength of Concrete Cylinders

(Coal Ash 20% + Coconut Shell 15%)

S.No	Curing Period	Tensile Load (KN)	Stress (N/mm^2)
1	7 days	181	2.55
2	14 days	216	3.05
3	28 days	253	3.57

CALCULATION

1. For 7 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x181x1000) / (π x 150x300)
   = 2.55 N/mm^2
2. For 14 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x216x1000) / (π x150x300)
   = 3.05 N/mm^2
3. For 28 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x253x1000) / (π x 150x300)
   = 3.57 N/mm^2

Tensile Strength of Concrete Cylinders

(CoalAsh 20% + Coconut Shell 20%)

S.No	Curing Period	Tensile Load (KN)	Stress (N/mm^2)
1	7 days	175	2.47
2	14 days	211	2.98
3	28 days	250	3.56

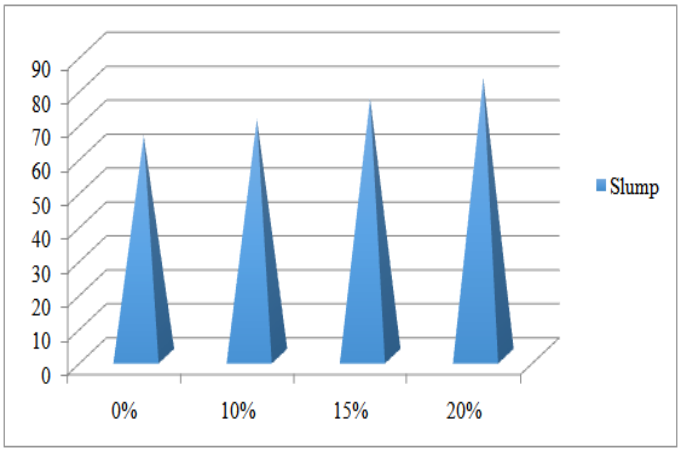
CALCULATION

1. For 7 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x175x1000) / (π x 150x300)
   = 2.47 N/mm^2
2. For 14 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x211x1000) / (π x 150x300)
   = 2.98 N/mm^2
3. For 28 days
   Tensile strength of concrete cylinder = 2P/πDL
   = (2x250x1000) / (π x 150x300)
   = 3.56 N/mm^2

V. BAR CHARTS

The bar charts are drawn for compressive strength, split tensile strength results. These are drawn between strength and percentage replacement of coal ash + coconut shell at 7 days, 14 days, and 28 days to observe the variation of strength.

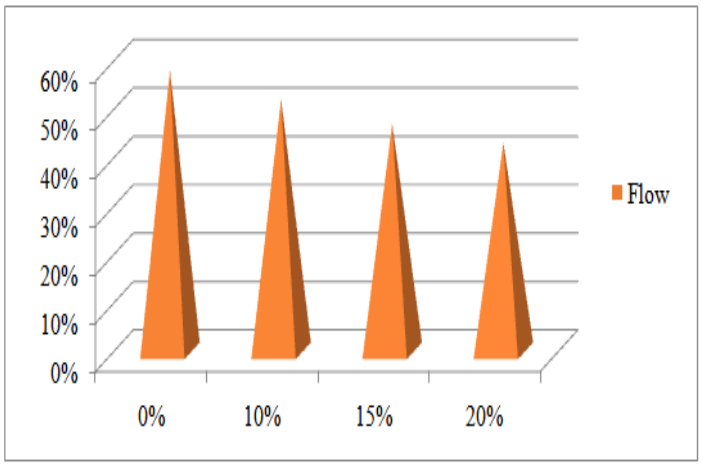
Slump Cone Test



Replacement of cement using 20% of coal ash and various proportions of coconut shell

Slump (mm) Vs % of replacement of coconut shell

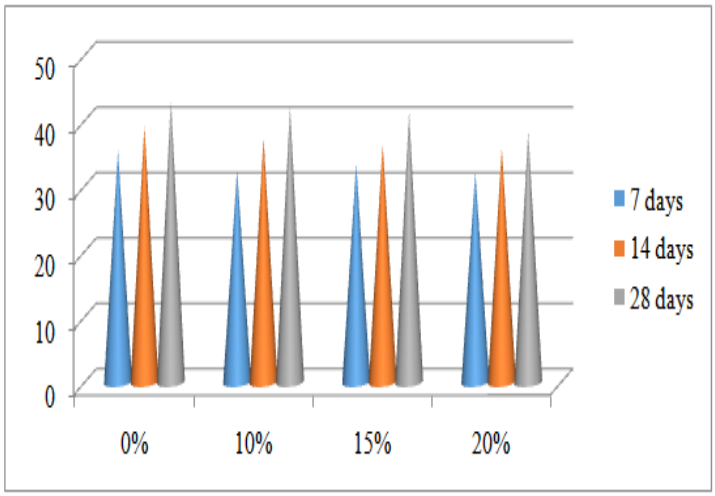
Flow Table Test



Replacement of coconut shells in %

Flow of concrete Vs % of replacement of coconut shell

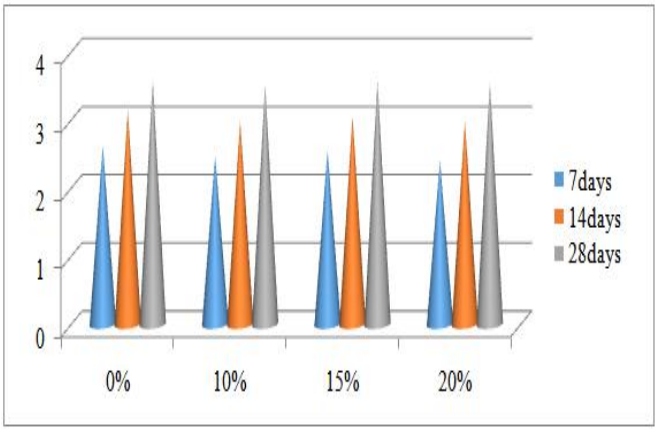
Compression Strength Test



Replacement of coconut shells in %

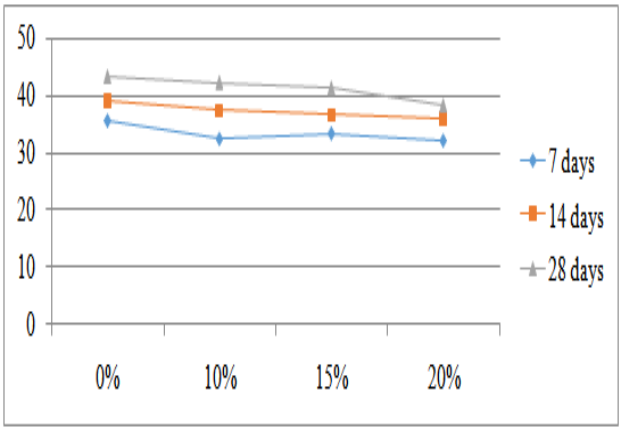
Compressive Strength Vs % of replacement coal Ash + coconut Shells

Split Tensile Test

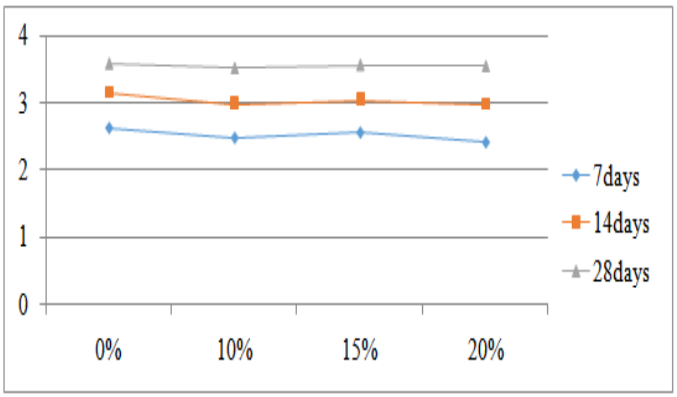


Replacement of coconut shells in %

Compressive Strength Vs % of replacement coal Ash + coconut Shells



Tensile strength vs % of replacement coal ash + coconut shells



VI. CONCLUSION

Use of coconut shell in cement concrete can help in waste reduction and reduction in pollution. The replacement of aggregate only using coconut shell will tend to decrease the compressive strength of concrete because the coconut shell in nature it absorbs the moisture content which is normally higher than the conventional coarse aggregate. This character will reduce the workability too. To overcome this disadvantage, coal ash being added to the concrete which improves its flow property. The optimum quantity of coconut shell blended with coal ash is determined. The Concrete with 15% replacement of coconut shell and 20%of coal ash shown relatively higher strength than other proportions. From the test results, addition of coconut shells above 20 % decreases workability. Increase in coconut shells percentage tends to decrease the density of concrete. The concrete with 20% replacement get compressive strength value nearer to conventional concrete. The increase of coal ash above 20% shows a marginal decrease in concrete strength.

Coconut shell concrete of 15% and the 20% coal ash addition shows increase in compression strength. The concrete with coconut shell and coal ash of 10% and the 20% shows increase in split tensile strength compared with adding only coconut shell in the concrete. Coconut shell concrete of 15% and the 20% coal ash addition shows nearer value of flextural strength to the conventional concrete. For future work the concrete proportion with 15% replacement in coconut shell and 20% addition of coal ash is may be recommended. The flexural strength is analysed and compared with conventional concrete which results to 6.95N/mm^2 which is normally higher than other replacements.

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