PARTIAL REPLACEMENT OF COURSE AGGREGATE WITH COCONUT SHELLS PIECES IN CONCRETE

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ABSTRACT

The high cost of convectional construction material affects economy of structure. With the increasing concern over excessive exploitation of natural aggregates, synthetic lightweight aggregate produced from environmental waste is a viable new source of structural aggregate material. It is becoming more difficult to find natural resources. Therefore the coconut shell as partial replacement for coarse aggregate in concrete is studied. The density, slump and compressive strength of concrete are tested. The replacement of coarse aggregate by coconut shell by 0%,5%, 15%, 20% and 25%. The tests were carried out and the results carried out and the results obtained suggested that the replacement more then 20% leads to lightweight aggregate concrete. The slump found out to be increases as the percentage replacement increased. Similarly the density is reduced as the percentage replacement increased. The compressive strength found to be decreases as the percentage replacement increases.

I INTRODUCTION

The three basic needs of man are food, clothing and shelter. Civil Engineer has relevance with all basic needs of man directly or indirectly. Man has progressed a lot in developing the method of constructing shelter. Initially man used to stay in huts and time passed it developed into house that is load bearing. Concrete is an engineered material which is most widely used in the construction world today. The popularity of concrete is due to its strength durability and low maintenance cost.

Concrete is no longer a material consisting of cement, aggregates, water and admixtures but it is an engineered material with several new constituents performing satisfactorily under differently exposed conditions. The method of specifying a concrete according to its performance and requirement, rather than its constituents and ingredients for producers of concrete so as to suit their specific requirements.

Nowadays, sustainability is the key requirement in building and constructing industry to lower environmental impacts and attentive use of natural resources. In the recent years, the construction industry is steadily implement initiatives to improve sustainability by increasing the use of recycled and manufactured aggregates in concrete production. There was a rapid depletion of natural aggregates due to their continuous extensive extraction. In this constructed environment, the rising cost of building construction materials is the factor of great concern. The cost of building materials are raising day by day.

Now a days most of the researchers have focus on use of the waste materials in concrete according to their properties. Fly ash, Rice husk, Slag and Sludge from the treatment of industrial and domestic waste water has been found suitable as partial replacement for cement in concrete. The coconut shell is a material which can be substitute for coarse aggregate.

Coconut Shell Concrete has better workability because of the smooth surface on one side of the shell. The impact resistance of coconut shell concrete is high when compared with convectional concrete. Moisture retaining and water absorbing capacity of coconut shell are more compared to convectional aggregate. Using alternative material in place of natural aggregate in concrete production makes concrete as sustainable and environment friendly construction material.

1.1 Coconut Shell

Coconut is grown more than 93 countries. India is the third largest, having cultivation on an area of about 1.78 million hectares for coconut production. Annual production is about 7562 million nuts with an average of 4248 nuts per hectare. The coconut industry in India accounts for over a quarter of the worlds total coconut oil output and is set to grow further with the global increase in demand. However, it is also the main contributor to the nations pollution problem as the solid waste in the form of shells, which involves an annual production of approximately 3.18 million tones. It also presents serious disposal problems for local environment, is an abundantly available agricultural waste from local coconut industries. In developing countries, where abundant coconut shell waste is discharged, these waste can be used as potential material or replacement material in the construction industry.

This will have the double advantage of reduction in the cost of construction material and also as the means of disposal of wastes.

Table 1: Availability of Coconut Shell:-

S.No	Country	Coconut production 2018(tonnes)	%of World Total
1	Indonesia	183,000,000	35.8%
2	Philippines	153,532,000	30.0%
3	India	119,300,000	23.3%
4	Brazil	2,890,286	5.66%
5	Sri Lanka	2,513,000	4.9%

1. Coconut shell has high strength and modulus properties

2. It has added advantage of high lignin content. High lignin content make the composites more weather resistant.

3. It has low cellulose content due to which it absorb less moisture as compare to other agriculture waste.

4. Coconuts being naturally available in nature and since its shells are non bio degradable, they can be used readily in concrete which may fulfil almost all the qualities of original form of concrete.

1.3 Coconut shell as an alternative coarse aggregate

In view of trust on energy saving and sustainable development, the use of alternative constituents of natural resources in the search of suitable alternative through conventional construction material is now global concern.

To make use of alternative aggregate in concrete which is coconut shell has never been common practise among the people, particularly in areas where light weight concrete is required for non load bearing wall and non structural floors

Concrete obtained using coconut shell as an 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 an potential material in the field of constructional industries.

The coconut shell is compactable 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 observing and moisture retaining capacity of coconut shell is more.

The presence of sugar in the coconut shell, doesn't effect the setting and strength of concrete because its 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 born in concrete matrix.

II Objective of the Present Study

In the present of work lightweight concrete has been assessed. The following are the objectives

1. To evaluate the properties of CS mixed concrete and normal concrete
2. To study the strength of characteristics of concrete having CS
3. To study and compare the durability characters of CS mixed concrete and normal concrete
4. To investigate the flexural and shear behaviour of CS mixed concrete beams
5. To ascertain the use of CS in concrete for structural applications

3. Properties of Materials.

3.1 Cement

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 most important use of cement is the production of mortar and concrete – the bonding of natural use of aggregates to form a strong building material which is the face of normal environmental effects. OPC is the most common type of cement in general use around the world, because it is the basic ingredient of concrete, mortar, stucco and most non speciality grout.

It is a fine powder produced by grinding Portland cement, clinker(more than 90%), a limited amount of calcium sulphate which controls the set time, and upto 55 minor constituents(as allowed by various standards).

1. The cement used for our experimental work is Ultratech Cement(OPC 53-grade). Conformed to the quality provisions of Indian Standards Specification.
2. A specific gravity of cement was 2.93.

3.1.1 Types of Cement and their uses

i. Hardening Cement :

Rapid Hardening Cement is very similar to Ordinary Portland Cement (OPC). It contains higher C3S content and finer grinding. Therefore it gives greater strength development at an early stage than OPC. The strength of this cement at the age of 3 days is almost same as the 7 days strength of OPC with the same water-cement ratio.

The main advantage of using rapid hardening cement is that the formwork can be removed earlier and reused in other areas which save the cost of formwork. This cement can be used in prefabricated concrete construction, road works, etc.

ii. Low Heat Cement:

Low heat cement is manufactured by increasing the proportional of C2S and by decreasing the C3S and C3A content. This cement is less reactive and its initial setting time is greater than OPC. This cement is mostly used in mass concrete construction

iii.Sulphate Resisting Cement:

Sulphate restating cement is made by reducing C3A and C4AF content. Cement with such composition has excellent resistance to sulphate attack. This type of cement is used in the construction of foundation in soil where sub soil contains very high proportion of sulphate.

Proportions of Sulphate.

iv. White Cement:

White cement is a type of ordinary Portland cement which is pure white in colour and has practically the same composition and same strength as OPC. To obtain the white colour the iron oxide content is considerably reduced. The raw materials used in this cement are limestone and china clay.

This cement, due to its white colour, is mainly used for interior and exterior decorative work like external renderings of buildings, facing slabs, floorings, ornamental concrete products, paths of gardens, swimming pools etc.

v. Portland Pozzolana Cement: Portland pozzolana cement is produced either by grinding together, Portland cement clinkers and pozzolana with the addition of gypsum or

Portland Pozzolana Cement is produced either by grinding together, Portland cement clinkers and pozzolana with the addition of gypsum or calcium sulphate or by intimately and uniformly blending Portland Cement and Fine Pozzolana It produces lower heat of hydration and has greater resistance to attack of chemical agencies than OPC. Concrete made with PPC is thus considered particularly suitable for construction in sea water, hydraulic works and for mass concrete works.

vi. Hydrophobic Cement:Hydrophobic cement is manufactured by adding water repellent chemicals to ordinary Portland cement in the process of grinding. Hence the cement stored does not spoil even during monsoon. This cement is claimed to remain unaffected when transported during rains also. Hydrophobic cement is mainly used for the construction of water structures such dams, water tanks, spillways, water retaining structures etc.

vii. Collared Cement:This Cement is produced by adding 5- 10% mineral pigments with Portland cement during the time of grinding. Due to the various colour combinations, this cement is mainly used for interior and exterior decorative works.

viii. Waterproof Portland Cement:Waterproof cement is prepared by mixing with ordinary or rapid hardening cement, a small percentage of some metal separates (Ca, Al, etc.) at the time of grinding. This cement is used for the construction of water-retaining structure like tanks, reservoirs, retaining walls, swimming pools, dams, bridges, piers etc.

ix. Portland Blast Furnace Cement:In this case, the normal cement clinkers are mixed with up to 65% of the blast furnace slag for the final grinding. This type of cement can be used with advantage in mass concrete work such as dams, foundations, and abutments of bridges, retaining walls, construction in sea water.

x. Air Entraining Cement:

It is produced by air entraining agents such as resins, glues, sodium salts of sulphate with ordinary Portland cement.

xi. High Alumina Cement:

High Alumina Cement (HAC) is a special cement, manufactured by mixing of bauxite (aluminium ore) and lime at a certain temperature. This cement is also known as calcium aluminium cement (CAC). The compressive strength of this cement is very high and more workable than ordinary Portland cement.

xii. Expansive Cement: The cement which does not shrink during and after the time of hardening but expands slightly with time is called expansive cement. This type of cement is mainly used for grouting anchor bolts and pre-stressed concrete ducts.

Sometimes it may be required to perform cement quality tests at a site within a very short period of time for evaluating the condition of the supplied cement. In most of the cases, it is not possible to have any laboratory test in the short period of time.

Therefore, the quality check is performed with the help of some basic field tests. Although these tests are not very accurate, they provide some basic idea to the civil engineer regarding the quality of the cement.

3.1.2 Field tests on cement: provide some basic idea to the civil engineer regarding the quality of the cement.

3.1.2 Field tests on Cement:

I. Date of Packing:

Date of manufacture should be seen on the bag. It is important because the strength of cement reduces with age.

ii. Colour:

The colour should be uniform in colour. In general the colour of cement is gray with a light greenish shade. The colour of cement gives an indication of excess lime or clay and the degree of burning.

iii. Rubbing:Take a pinch of cement between fingers and rub it. It should feel smooth while rubbing. If it is rough, that means adulteration with sand.

iv. Hand Insertion:Thrust your hand into the cement bag and it should give cool feeling. It indicates that no hydration reaction is taking place in the bag.

v. Float Test: Throw a small quantity of cement in a bucket of water. It should sink and should not float on the surface.

vi. Smell test:Take a pinch of cement and smell it. If the cement contains too much of pounded clay and silt as an adulterant, the paste will give an earthy smell.

vii. Presence of lumps:Open the bag and see that lumps should not be present in the bag. It will ensure that no setting has taken place.

vi. Fineness of Cement:

The fineness of cement is a measure of the size of particles of cement and is expressed in terms of specific surface area of cement. Fineness can be calculated from particle size analysis(sieve analysis) or by using air permeability method or by using sedimentation method. Sieve analysis measures the cement particle size whereas air permeability method & sedimentation method measures specific surface area.Since cement particles are very fine (smaller than 90 micron), hence sieve analysis is not suitable for cement. Due to this disadvantage, fineness of cement is always measured by air permeability method & expressed in terms of specific surface area.For a given weight of cement, the surface area is more for finer cement than for a coarser cement. Because specific surface area is inversely proportional to the size of particle.Now from above relation if the cement is finer it's specific surface area is large. Finer the cement, higher will be its surface area, more surface area is available for chemical reaction with water that increases the rate of hydration & this result in the early development of strength. But ultimate strength is not affected.

Setting time decreases with increase in fineness of cement.

As per Indian standard the residue of cement should not exceed 10% when sieved on a 90 micron IS sieve. In addition, the amount of water required for constant slump concrete decreases with increases in the fineness of cement.

Fineness of Cement:

W1=100gms

W2= 4gms

$$= \frac{W2}{W1} x100$$

$$= \frac{4}{100} x100$$

P= 4

Fineness of cement = 100-4

= 96 gems

3.2 Fine Aggregate:

The size of the fine aggregate used was 4.75 mm and below size. The properties of fine aggregate were tested as per Indian Standards BIS: 383: 1970 and it conforms. Manufactured sand was used for the experiment and it obtained from a local crusher unit. The different tests did on fine aggregate were specific gravity and water absorption. The specific gravity of fine aggregate used was 2.65.

Table 3.2 Size Variations of Different Materials

Fine Aggregate	Size Variation
Coarse Sand	2.0mm – 0.5mm
Medium sand	0.5mm – 0.25mm
Fine sand	0.25mm – 0.06mm
Silt	0.06mm – 0.002mm
Clay	<0.002

types of sand

Type of sand Fineness modulus range

Fine sand 2.2 – 2.6

Medium sand 2.6 – 2.9

Coarse sand 2.9 – 3.2

Fineness modulus limits for various zones of sand according to IS 383-1970 are tabulated below.

Table 3.2.3 sand according to various zones(Is 383-1970)

Sieve Size	Zone-1	Zone-2	Zone-3	Zone-4
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
0.6mm	15-34	35-59	60-79	80-100
0.3mm	5-20	8-30	12-40	15-50
0.15mm	0-10	0-10	0-10	0-15

Fineness Modulus 4.0-2.713.37-2.1 2.78-1.712.25-1.35

3.4 Water:

The water used of concreting purpose was free with any kind of chemical and biological impurities and also can used for drinking. The amount of water in concrete controls many fresh and hardened properties in concrete including

workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life.

Water Compendious Ratio:

The ratio of the amount of water, minus the amount of water absorbed by the aggregates, to the amount of cementations materials by weight in concrete is called the water-cementations ratio and commonly referred to as the w/cm ratio. The w/cm ratio is a modification of the historical water-cement ratio (w/c ratio) that was used to describe the amount of water, excluding what was absorbed by the aggregates, to the amount of the Portland cement by weight in concrete. Because most concretes today contain supplementary cementations materials such as fly ash, slag cement, silica fume, or natural pozzolana, the w/cm ratio is more appropriate. To avoid confusion between the w/cm and w/c ratios, use the w/cm ratio for concretes with and without supplementary cementations materials.

The w/cm ratio equation is:

w/ratio =

Upon hardening, the paste or glue consisting of the cementations materials and water binds the aggregates together. Hardening occurs because of the chemical reaction, called hydration, between the cementations materials and water. Obviously, increasing the w/cm ratio or the amount of water in the paste dilutes or weakens the hardened paste and decreases the strength of the concrete. As shown Figure 1, concrete compressive strength increases as w/cm ratio decreases for both non-air-entrained and Air-Entrained Concrete.

Decreasing the w/cm ratio also improves other hardened concrete properties by increasing the density of the paste which lowers the permeability and increases water tightness, improves durability and resistance to freeze-thaw cycles, winter scaling and chemical attack. In general, less water produces better concrete. However, concrete needs enough water to lubricate and provide a workable mixture that can be mixed, placed, consolidated and finished without problems.

Code Requirements:

Because w/c ratio controls both strength and durability, building codes have set upper limits or maximum w/cm ratios and corresponding minimum compressive strengths as shown in Table 1. For example, concrete exposed to freezing and thawing in a moist condition or to dicing chemicals shall have a maximum 0.45 w/c ratio and a minimum 4,500 psi compressive strength to ensure durability. Designers select maximum w/cm ratios and minimum strengths primarily based on exposure conditions and durability concerns not load-carrying capacity requirements. For different exposure conditions, use the code required maximum w/cm ratios and minimum strengths to reduce the permeability of the concrete. Doing so will increase the concrete's resistance to weathering.

Water content and Drying Shrinkage:

The most important factor affecting the amount of drying shrinkage and the subsequent potential for cracking is the water content or the amount of water per cubic yard of concrete. Fundamentally, concrete shrinkage increases with higher water contents. About half of the water in concrete is consumed in the chemical reaction of hydration and the other half provides the concrete's workability. Except for the water lost to bleeding and absorbed by the base material or forms, the remaining water that is not consumed by the hydration process contributes to drying shrinkage. By keeping the water content as low as possible, drying shrinkage and the potential for cracking can be minimized.

Workability:

The ease of mixing, placing, consolidating and finishing concrete is called workability. The water content of the mixture is the single most important factor that affects workability. Other important factors that affect workability include: mix proportions, characteristics of the coarse and fine aggregates, quantity and characteristics of the cementations materials, entrained air, admixtures, slump (consistency), time, air and concrete temperatures. Adding more water to the concrete increases workability but more water also increases the potential for segregation (settling of coarse aggregate particles), increased bleeding, drying shrinkage and cracking in addition to decreasing the strength and durability.

Adding Water Onsite:

If measured slumps are less than allowed by the specifications, slumps may be adjusted by one-time addition of water. However, there are requirements associated with adding water onsite:

•Do not exceed the maximum water content for the batch as established by the accepted concrete mixture proportions.

•No concrete has been discharged from the mixer except for slump testing.

•All water additions shall be completed within 15 minutes from the start of the first water addition.

•Water shall be injected into the mixer with such pressure and direction of flow to allow for proper distribution within the mixer.

•The drum shall be turned an additional 30 revolutions or more at mixing speed to ensure a homogenous mixture.

Before adding water onsite, the allowable amount of water that can be added must be known. This amount should be printed on the delivery ticket or be determined during the pre-construction meeting and be agreed upon by all parties.

Water is a key component in concrete. However, too much water can be detrimental to both the fresh and hardened concrete properties, especially strength, long term durability and potential for cracking. On your next job, be sure to know the water requirements for the concrete mixtures being used, especially the allowable water that can be added for slump adjustments.

3.5 Coconut Shells:

For the purpose of this project, the Coconut shells were obtained from local house. They were crushed manually. The crushed materials were later being transported to the laboratory where they are washed and allowed to 24 hours water absorption. The particle sizes of the coconut shell range from 20 to 25 mm. Tests conducted on coconut shell includes specific gravity, water absorption, aggregate crushing value test, and aggregate impact value test. Specific gravity of coconut shell used was 1.25

3.5.1. Properties of Coconut Shell

1. Coconut shell has high strength and modulus properties.

2. It has added advantage of high lignin content. High lignin content makes the composites more weather resistant.

3. It has low cellulose content due to which it absorb less moisture as compare to other agriculture waste. 4. Coconuts being naturally available in nature and since its shells are non-biodegradable; they can be used readily in concrete which may fulfil almost all the qualities of the original form of concrete.

RESULT

Calculations:

$Fc=2p/3.14*d*1(N/mm^2)$

Where p=load(N)

I = span of the specimen

D=diameter of the specimen

Days	Lathe Scrap(%)	Coconut shell (%)				
		5	10	15	20	25
		Split tensile strength				
7	0 0.5 1	1.7 1.6 1.7	1.6 1.5 1.6	1.4 1.3 1.4	1.1 1.2 1.3	0.8 0.9 1.1
14	0 0.5 1	2.4 2.2 2.2	2.2 2.0 2.1	2.1 2.3 1.9	2.0 1.9 1.9	1.6 1.8 1.9
28	0 0.5 1	2.6 2.4 2.6	2.4 2.2 2.3	2.4 2.0 2.1	2.1 2.1 1.9	1.9 2.0 1.7

CONCLUSION

From the test results, the coconut shell has a future as lightweight aggregate in concrete. It also reduces the total cost of concreting, because of the low cost and its ease of availability is profusion. Coconut Shell Concrete can be used in rural areas and places where coconut is profusion and the places where the regular aggregates are not economic. It is concluded that the Coconut Shells are more suitable as low strengthgiving lightweight aggregate when used to replace common coarse aggregate in production concrete. Coconut shell s more power to resist crushing, and impact compared to traditional granite aggregate. There is no need to treat the coconut shell before use as an aggregate except for water absorption

Use of coconut shell in cement concrete can help in waste reduction and reduction in pollution. The need of the hour is to encourage such a use of the wastes as construction material in low cost housing. The construction industries have identified many artificial and natural lightweight aggregate that have replaced conventional aggregates thereby reducing the size of the members in the structure. From the experimental work it is clear that the with CS percentage increase the 7 days strength gain also increased with the corresponding 28 days curing strength. Workability of concrete is increases as the replacement increases. Specific gravity of the concrete reduces as the replacement of coarse aggregate increases. The density of concrete is decreases as the replacement increases.

Overall cost of construction will reduced. The maximum compressive strength in control mix is 21.28 N/mm2 at 28 days, while the minimum strength at same days is 14.23 N/mm2. Thus compressive strength decreased as percentage of coconut shell is increased. Therefore coconut shell can be used where light weight concrete is required. Proper bonding between coconut shell and cement is not possible because of surface area of coconut shell aggregate. In future, we can increase strength of coconut shell concrete by adding admixtures.finally with the increase in the partial replacement of coconut shells above 5% in the concrete mix,the value of compressive strength decreases.

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