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Experimental study on behavior of concrete by partial replacement of coarse aggregate by coconut shells

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Abstract- The reason for increase in cost is high demand of concrete and scarcity of raw material. Hence the concrete technologists must search for some economical alternative to the coarse aggregate. Coarse aggregate is replaced with coconut shell in concrete. Constant water to cement ratio of 0.45 was maintained for all the concretes. In this study, M 30 grade of concrete was produced by replacing coarse aggregate by coconut shell. Concrete produced by 0%, 10%, 20%, 30% replacement of coarse aggregate by coconut shell. Twenty four cubes were casted and their compressive strength was evaluated at 7 and 28 days. Twelve cylinders and twelve beams were casted and their split tensile strength and flexural strength were evaluated at 28 days. The compressive strength of concrete reduced as the percentage replacement increased. These results showed that Coconut shell in concrete can be used in lightweight concrete construction. Its utilization is cost effective and eco friendly.

Keywords — coarse aggregate, coconut shell, compressive strength, flexural strength, partial replacement, tensile strength.

I. INTRODUCTION

Concrete is a composite material which is composed of aggregates, cement and water, used more than any other manmade material in the world. The possibility of a complete depletion of aggregate resources has rendered continued use of aggregates for construction unsustainable. In view of this challenge, researchers throughout the world have been investigating ways of replacing aggregates to make construction sustainable and less expensive.

While wastes generated by industrial and agricultural processes have created disposal and management problems, it can be significant to contribution to the conservation of natural resources and maintenance of ecological balance.

Coconut shell is an agricultural waste which is a by-product of coconut oil production and a light weight aggregate. The coconut shell when dried contains cellulose, lignin and ash in varying percentage. Cost reduction of 48% can be achieved if the waste utilization can be used in the concrete mixtures.

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 conventional concrete. Moisture retaining and water absorbing capacity of coconut shell are more compared to conventional aggregate. Using alternative material in place of natural aggregate for concrete production makes concrete sustainable and environment friendly construction material.

1.1 Coconut Shell- For the purpose of this research, the Coconut shells were obtained from college canteen. They were sun dried for 1 month before being crushed manually. The particle sizes of the coconut shell range from 6.3 to 20 mm.

1.2 Aim and scope of present investigation- To study the effect of partial replacement of coarse aggregate by coconut shell in different percentages at 7 and 28 days compressive strength, split tensile strength and flexural strength.

II. LITERATURE REVIEW

In this chapter few investigations on concrete where coarse aggregate is partially replaced with coconut shell are mentioned.

Maninder Kaur & Manpreet Kaur (2012) reviewed and concluded that use of coconut shells in cement concrete can help in waste reduction, pollution reduction and encourages housing developers in investing these materials in house construction. It is also concluded that the Coconut Shells are more suitable as low strength-giving lightweight aggregate when used to replace common coarse aggregate in concrete production.

Dewanshu Ahlawat & L.G.Kalurkar (2014) explored the possibility of producing M20 grade of concrete by replacing conventional aggregate of granite by coconut shell. Forty five cubes were casted. Percentage of replacement of conventional coarse aggregate by coconut shell were 2.5%, 5%, 7.5%, 10%. Compressive strength were 19.71, 19.53, 19.08, 18.91 N/mm^2 respectively at 28 days. Workability and compressive strength had been evaluated at 7, 14 and 28 days. The compressive strength of concrete reduced as the percentage replacement increased. By these results it can be concluded that coconut shell concrete can be used in reinforced concrete construction. Author concluded that its utilization is cost effective and eco

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friendly.

Damre Shraddha and Shrikant Varpe (2014) replaced conventional coarse aggregate with coconut shell and concluded that- with 50% replacement of coarse aggregates by coconut shells, the strength attained reduces invariably from 10%-20% as compared to the conventional coarse aggregate concrete. With 50% replacement of coarse aggregates by coconut shells, the flexural strength attained reduces invariably from 10%-15% as compared to the coarse aggregate concrete.

B. Damodhara Reddy ET al. (2014) investigated the use of coconut shell as light weight aggregate in concrete. They analyzed flexural and compressive strength characteristics of concrete with partial replacement of coarse aggregate using M30 grade concrete.The conclusions for the result are, CSC where 25% of the coarse aggregate is replaced, shows properties similar to the nominal mix and 50% replaced CSC shows properties similar to light weight concrete which can be used as filler materials in framed structures, flooring tiles, thermal insulating concrete etc.

III. MATERIALS USED

3.1. Cement: Cement is the basic ingredient of ready-mix concrete obtained from the calcinations of a mix of limestone, clay, and iron ore at 1,450°C. The product of the calcination process is clinker the main ingredient of cement that is finely grounded with gypsum and other chemical additives to produce cement. We used Ordinary Portland Cement (OPC) of 53 grade.

3.2. Coconut shell: Presenting serious disposal problems for local environment, coconut shell is an abundantly available agricultural waste from local coconut industries. These wastes 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 a means of disposal of wastes.

3.2.1 Properties of coconut shell

1. Coconut shell has high strength and modulus properties.

2. It has added advantage of high lignin content which 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 fulfill almost all the qualities of the original form of concrete

Coconut shells which were already broken into two pieces were collected from college canteen; air dried for 15 days approximately at the temperature of 25 to 30 C; fiber and husk on dried shells was removed; further the shells were broken into small chips manually using hammer and sieved through 20 mm sieve. The material passing through 20 mm sieve can be used to replace coarse aggregate with coconut shells.

3.2.2 Use of Coconut shell in concrete

Some of the benefits of coconut shell in concrete are

1. Reduction in dead weight

2. Lowered cost

3. Environmental friendly

3.3 Manufactured Sand

3.3.1 Introduction: Natural or River sand are weathered and worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. Now-a-days good sand is not readily available; it is transported from a long distance. Those resources are also exhausting very rapidly. So it is a need of the time to find some substitute to natural river sand.

The artificial sand produced by proper machines can be a better substitute to river sand. The sand must be of proper gradation (it should have particles from 150 microns to 4.75 mm proportion).

When fine particles are in proper proportion, the sand will have fewer voids. The cement quantity required will be less. Such sand will be more economical. Demand for manufactured fine aggregates for making concrete is increasing day by day as river sand cannot meet the rising demand of construction sector. Natural river sand takes millions of years to form and Because of its limited supply, the cost of Natural River sand has sky rocketed and its
Consistent supply can be guaranteed. Under circumstances use of manufactured sand River sand in many parts of the country is not graded properly and has excessive silt and organic impurities and these can be detrimental to durability of steel in concrete whereas manufactured sand has no silt or organic impurities

However, many people in India have doubts about quality of concrete/mortars when manufactured or artificial sand are used. Manufactured sand have been regularly used firstly, there is a lack of natural sand reserves. Urban expansion, local legislation and environmental constraints have made the extraction of natural sand and gravel an

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expensive activity. Application processes for Greenfield sand and gravel extraction are often long, expensive affairs with a high chance of site applications being rejected.

The increasing difficulty in extraction has had a negative effect on the bottom line for many producers. Concrete plants require a consistent, quality sand to optimize their production and minimize their cement usage.

The huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced using natural sand from river beds as fine aggregate. Decreasing natural resources poses the environmental problem and hence government restriction on sand quarrying resulted in scarcity an significant increase in its cost. Normally particles are not present in river sand up to required quantity. Digging sand, from river bed in excess quantity is hazardous to environment. The deep pits dug in the river bed, affects the ground water level. In order to fulfill the requirement of fine aggregate, some alternative material must be found. The cheapest and the easiest way of getting substitute for natural sand is obtained from limestone quarries, lateritic sand and crushing natural stone quarries is known as manufactured sand. Concrete made with limestone filler as replacement of natural sand in concrete can attain more or less same compressive strength, tensile strength, permeability, modulus of rupture and lower degree of shrinkage as the control concrete. Concrete using various combinationsof lateritic sand and quarry dust as complete replacement for conventional river sand. The result is found better workability and high compressive strength.

3.3.2 Manufacturing process of M- sand: The global trend is to utilize dry classification solutions to produce manufactured sand. The dry separation process separates fine and coarse particles. This allows a reduced percentage of super fines in manufactured sand, thereby meeting specifications and achieving quality products. The gravitational inertial classifier is typically fed 0/4mm or less and makes separations between 300 microns and 63 microns. These units are ideal for use in the manufacturing of concrete and asphalt sands that typically require a reduction in the amount of 63 microns present. This unit is designed with an internal recirculating function that allows the efficiency of the separation to be adjusted depending on the desired grading curve.

When finer separations are required, the centrifugal classifier can make separations of between 100 microns and 20 microns. This makes these units suit-able for the production of very fine products such as lime, fly ash and fertilizers.

Metro's air classifier range provides versatile, economic technology that can be combined with a range of different crushing and screening equipment to produce a tailored plant. It allows for the production of dry products so there are no dewatering or drying costs.

Study of behavior of concrete by partially replacing coarse aggregate with coconut shell Process water is not required, which significantly reduces the quarries' water demand, settling pond requirements and makes arid regions viable. No moving parts and ceramic linings mean exceptionally low maintenance and wear parts costs, even with the most abrasive of rock types. Highly efficient separation, even at very fine particle sizes, produces quality product and limits the amount of product in waste.

3.3.3 General Requirements of Manufactured Sand

1. All the sand particles should have higher crushing strength.

2. The surface texture of the particles should be smooth.

3. The edges of the particles should be grounded.

4. The ratio of fines below 600 microns in sand should not be less than 30%.

5. There should not be any organic impurities

6. Silt in sand should not be more than 2%, for crushed sand.

3.4 Coarse aggregate: Aggregate has a significant influence on the compressive strength of concrete, crushed coarse aggregate produces a concrete with higher strength than one with uncrushed coarse aggregate (smooth and rounded aggregate). Coarse Aggregate in concrete occupies 35 to 70% of the volume of the concrete. Smaller sized aggregates produce higher concrete strength. Particle shape and texture affect the workability of fresh 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. Where aggregates strength is higher, concrete strength is also higher. Fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse aggregate are obtained from a local quarry, conforming to IS 383:1970 is used.

IV. EXPERIMENTAL PROGRAM

4.1 General

An experimental study is conducted to determine the effects on compressive strength, flexural strength and split tensile strength by replacing coarse aggregate with coconut shell in nominal mix.

4.1.1 Test program

To evaluate the effect of different percentages of only coconut shell (0, 10, 20 and 30) with a w/c ratio of 0.45

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In all mixes the same type of aggregate i.e. crushed aggregates, manufactured sand, and the same proportion of the fine aggregate to the total aggregate is used.

4.1.2 The Parametric studies are:

• Percentage of coconut shell 0, 10, 20, and 30%.

• For each mix 6 cubes, 3 beam and 3 cylinders were casted and tested for compressive strength flexural strength and split tensile strength respectively.

• The test program consisted of conducting compressive test of cubes, flexural strength on beam split tensile strength on cylinders.

The experimental program has been planned and carried out in three stages.

Stage I: Procurement of materials and its testing

Stage II: Molding of specimens and curing Stage III: Testing of specimens

4.1.3 Procurement of materials

Main constituents of the concrete viz., fine Aggregate (M sand), cement have been procured from outside and coconut shell is procured from canteen.

4.2 Cement

Locally available Ordinary Portland Cement of 53 grade confining to ISI standards has been procured, and the following tests have been carried out.

a) Specific gravity of cement.

b) Fineness of cement.

c) Initial setting time.

d) Final setting time.

The results of above tests are tabulated in Table below

4.2.1 Physical properties of cement

Sl. No.	Property	Value
1	Fineness of cement	10 %
2	Specific gravity	3.12
3	Normal consistency	29 %
4	Setting time i.Initial setting time ii.Final setting time	30 Mins 10Hours

4.3 Coconut shell: The coconut shell is obtained from Canteen of NEW HORIZON COLLEGE OF ENGINEERING.

Table 4.3 - Physical propertie Of Coconut shell

Sl. No.	Property	Value
1	Specific Gravity	1.132

4.4 Fine aggregate (M-Sand): The M-sand was the cheapest resources of sand.

4.4.1 Properties of fine aggregate

Sl. No.	Property	Value
1	Specific Gravity	2.6
2	Bulk density	1628 kg/m3

4.5 Coarse aggregate: Machine Crushed granite confining to IS 383-1970 [23] consisting 20 mm maximum size of aggregates have been obtained from the local quarry. It has been tested for Physical and Mechanical Properties such as Specific Gravity, Sieve Analysis, Bulk Density, Cushing and Impact values and the results have been shown in the Table below:

Table 4.7 -Properties of Coarse aggregates

Sl. No.	Property	Value
1	Specific Gravity	2.79
2	Bulk Density	15.00 N/mm3
3	Water Absorption	2.02%

4.6 Water: Potable water has been used in this experimental program for mixing and curing with pH of water 6.5.

4.7 Mix design consideration

In the present investigation grade of concrete M50 has been considered. The concrete mix is designed. Subsequently mixes were designed with a partial replacement of Coarse aggregate by coconut shell at percentages of 0, 10, 20, & 30 by weight of cement for cubes, cylinders and beam.

4.7.1 Mix design

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the objective of producing concrete of certain minimum strength and durability as economically as possible. The design of concrete mix is not a simple task on account of widely varying properties of the constituent materials, the condition that prevail at the work and the condition that are Demanded for a particular work for which mix is designed.

Design of concrete mix requires complete knowledge of various properties of the constituent materials, the complications, in case of changes on these conditions at the site. The design of concrete mix needs not only the knowledge of material properties of concrete in plastic condition; it also needs wider knowledge and experience of concerning. Even then the proportion of the material of the concrete found out at the laboratory requires modifications and readjustments to suit the field conditions.

4.7.2 Mix design of M-30 grade concrete

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Grade of concrete = M30

Type of cement = OPC -53- GRADE

Maximum size of aggregate = 20mm

Min cement content = 250kg/m3

Maximum W/C ratio = 0.5 (as per IS 456:2000, Table 5, page number 20)

Workability = 75 mm (slump)

Exposure condition= Severe

Method of concrete placing= Pumping

Degree of supervision= Good

Specific gravity of cement= 3.12

Specific gravity of coarse aggregates = 2.79

Specific gravity of fine aggregates= 2.6

Water absorption of coarse aggregates = 2.02%

Moisture content of fine aggregates= 1.91%

Reference code = IS 10262: 2009

Grading of coarse aggregate confirming to table- 2 of IS 383 and grading of FA confirming to zone II

Calculations of Target mean strength

Target Mean Strength fck' = fck + 1.65 * S

fck' = 30 + 1.65 * 5 = 38.25 N/mm2

Calculation of water content

For 20mm size aggregate water content 186kg (IS 10262 2009 table 2, Page number 2)

Water content = 186 + (3/100) X186 = 197kg

Calculation of cement content

Cement content= water content/water cement ratio=192/0.45 =427kg/m3 >250 kg/m3

Calculation of CA and FA

Total volume of concrete = 1m3

Absolute volume of cement = (427/3.12)/1000 = 0.137m3

Volume of water= (192/1)*(1/1000) = 0.192m3

Volume of (CA+FA) E = 0.1-(0.137+0.192) = 0.671m3

From table-3 IS-10262

Volume of CA to total aggregate =0.62 for W/C =0.5

Volume of CA to total aggregate =0.63

Reduce volume of CA to total aggregate by 10% due to pumping... Volume of CA = 0.9*0.63 = 0.567 ... Volume of FA = 1-0.567 = 0.433

Weight of CA = E*Volume of CA*sp. gr of CA*1000= 0.671*0.433*2.6*1000= 1061 kg

Weight of FA= 0.671*0.433*2.6*1000 = 756kg

Site correction

Water absorption of CA = 2% of coarse aggregate by weight= ((2/100)*1061) = 21.22 litre

Initial water content in FA =1.9 % of FA= ((1.9/100)*756) = 14.3 liter

Actual water content = 192-14.3 + 21.22= 199 litre

Quantity of CA = 1061-21.22 = 1040 kg

Quantity of FA = 756+14.3 = 770kg

Materials required per m3 concrete Weight of cement = 427 kg Volume of water = 199 litre

Weight of CA = 1061-21.22 = 1040 kg

Weight of FA = 756+14.3 = 770 kg

Mix proportion

C : FA : CA

1 : 1.8 : 2.43

4.8 Mixing of concrete Ingredients.

Initially the ingredients of concrete viz., cement and fine aggregate were mixed, to which the coarse aggregate and coconut shell were added and thoroughly mixed. Water was measured exactly. Then it is applied to the dry mix and it was thoroughly mixed until a mixture of uniform color and consistency were achieved which is then ready for casting. Prior to casting of specimens, Workability is measured in accordance IS 1199-1959 and is determined by slump test.

Table 4.9-Mix Proportion for grade of Concrete

Water Cement Ratio	0.45
Cement	427 kg
Fine Aggregate	770 kg
Course Aggregate	1040 kg
Water	199 liter

Note: Maximum size of Coarse Aggregate is: 20 mm

4.8.1 Moulding of specimen

After the completion of workability tests, the concrete has been placed in the standard metallic moulds in three layers and has been compacted each time by tamping rod. Now, vibrating the concrete in the moulds, using vibrator and the surface of the specimens finish smoothly. After vibration the top surface of the beam specimens based on IS 10262-1962[8].

4.9 Details of test specimen

a) Compressive Strength of concrete: Compressive strength test is done for 6 cubes for each mix.

b) Split Tensile Strength of concrete: Split Tensile Strength test is done for 3 cylinders for each mix.

c) Flexural Strength of concrete: Flexural strength test is done for 3 beams for each mix.

4.9.1 Compressive strength of concrete

Compression tests are used to determine how a product or material reacts when it is compressed, squashed, crushed or flattened by measuring fundamental parameters that determine the specimen behavior under a compressive load. These include the elastic limit, which for "Hookean" materials is approximately equal to the proportional limit, and also known as yield point or yield strength, Young's Modulus (these, although mostly associated with tensile testing, may have compressive analogs) and compressive strength.

Compressive strength = load/area

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Table 4.10 - Sample calculation of 7 days compression strength

Age (days)	Concrete mix	Trial	Maximum Load (kN)	Area (mm²)	Compressive strength=(load/area) N/mm²
7	Standard	1	640	150X150	27.70
		2	610		
		3	620		
7	10% replaced	1	560	150X150	22.67
		2	530		
		3	440		
7	20% replaced	1	380	150X150	21.78
		2	540		
		3	530		
7	30% replaced	1	410	150X150	20.30
		2	500		
		3	460		

Table 4.11 -Sample calculation of 28 days compression strength

Age (days)	Concrete mix	Trail	Maximum Load (kN)	Area (mm²)	Compressive strength=(load/area) N/mm²
28	Standard	1	990	150X150	39.85
		2	790		
		3	910		
28	10% replaced	1	670	150X150	31.10
		2	720		
		3	710		
28	20% replaced	1	560	150X150	28.30
		2	700		
		3	650		
28	30% replaced	1	470	150X150	25.80
		2	580		
		3	690		

4.10 Split tensile strength of concrete

4.10.1 Testing of cylinders for split tensile strength

Age (days)	Concrete mix	Trail	Maximum Load (kN)	Flexural strength N/mm²
28	Standard	1	18.5	8.10
		2	22.0	
		3	21.0	
28	10% replaced	1	16.5	6.33
		2	15.5	
		3	15.5	
28	20% replaced	1	11.0	4.33
		2	11.5	
		3	10.0	
28	30% replaced	1	8.0	3.13
		2	8.5	
		3	8.0	

This test is conducted in a 200 tones capacity of the compression testing machine by placing the cylindrical specimen of the concrete, so that its axis is horizontal between the plates of the testing machine. Narrow strips of the packing material i.e., plywood is placed between the plates and the cylinder, to receive compressive stress. The load was applied uniformly at a constant, rate until failure by splitting along the vertical diameter takes place. Load at which the specimens failed is recorded and the splitting tensile stress is obtained using the formula.

The following relation is used to find out the split tensile strength of concrete

$Ft = (2*p)/(\Pi*D*L)$

Where

P = Compressive load on the cylinder

L = Length of the cylinder

D = Diameter of the cylinder

Table 4.12 - Sample Calculation of 28 days Tensile strength

Age (days)	Concrete mix	Trail	Maximum Load (kN)	Split tensile Strength=(2*p)/ (Π*D*L) N/mm²
28	Standard	1	210	2.90
		2	200	
		3	205	
28	10% replaced	1	180	2.52
		2	170	
		3	185	
28	20% replaced	1	170	2.43
		2	180	
		3	165	
28	30% replaced	1	165	2.26
		2	150	
		3	165	

4.11 Flexural strength of concrete

Concrete is relatively strong in compression and weak in tension. In RCC concrete members, little dependence is placed on tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces. However, tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradient and many other reasons. Therefore, the knowledge of tensile strength of concrete is of importance.

The theoretical maximum tensile stress at the bottom face at failure is termed the modulus of rupture. It is about 1.5 times the tensile stress determined by the splitting test. The flexural strength of the specimen shall be expressed as the modulus of rupture. The theoretical maximum tensile stress reached in the bottom fiber of the test beam is known as the modulus of rupture fcr, which, if 'a' equals to the distance between the line of fracture and nearest support, measured on the center line of support, measured on the center line of the tensile side of the specimen, in cm, shall be calculated as follows:

$fcr = (PxL)/(bxd2)$

When 'a' greater than 13.3 cm for a 10 cm specimen

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fcr= (3xPxa)/(bxd2)

When 'a' is less than 13.3 cm but greater than11 cm for a 10 cm specimen

Table 4.13 Sample calculation of 28 days Flexural strength

4.12 Curing of test specimen

Concrete specimens are cured at 7 days and 28 days for Compressive Strength and for

28 days for Split Tensile Strength and Flexural Strength.

4.12.1 Curing procedure

After the casting cubes, cylinders and beams the molds are kept for air curing for one day and the specimens were removed from the molds after 24 hours period of molding of concrete. Marking has been done on the specimens to identify the % Coconut Shell replacement. To maintain the constant moisture on the surface of the specimens, they were placed in water tank for curing. All the specimens have been cured for the desired age.

4.13 Test for measuring workability of concrete

4.13.1 Slump test

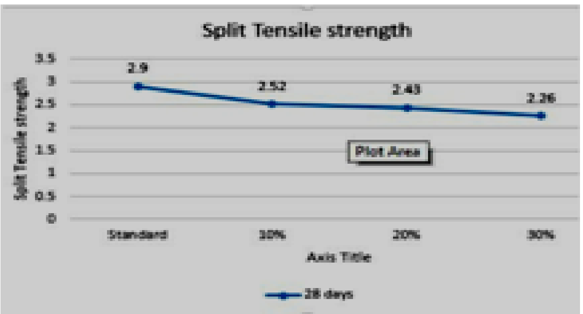
Slump test is a most commonly used method for measuring the consistency of concrete, which can be employed either in laboratory or at site of work. It is used conveniently as a control test, and gives an indication of the uniformity of concrete from batch to batch. The slump test is performed as per standard procedure with standardized apparatus.

Bottom diameter of frustum of cone - 20cm

Top diameter of frustum of cone - 10cm

Height of the cone - 30cm

%of Coconut shells	1 Standard	2 10%	3 20%	4 30%
28 days N/mm2	2.90	2.52	2.43	2.26



The initial surface of the mold is thoroughly cleaned. The mold is placed on a smooth horizontal right and non-absorbent surface. The mold is then filled in four layers each approximately one fourth of the height of the mold. Each layer is tamped twenty five times by tamping rod, taking care to distribute the strokes evenly over the cross-section. After the top layer has been robbed the concrete is struck of level with a trowel and tamping rod. The mold is removed from the concrete immediately by raising it slowly and carefully in vertical direction.

This allows the concrete to subside. This subsidence is referred as slump of concrete. The difference in level between the height of the mold and that of the highest point of the subsided concrete is measured. This difference in height in "mm" is taken as slump of concrete.

The Slump value of standard concrete = 70 mm

V. RESULTS AND DISCUSSIONS

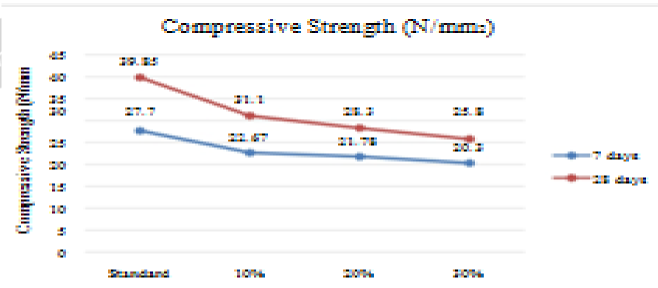
5.1 General

Both in tabular and Graphical forms indicated variation in the properties of concrete with different % of Coconut Shell. In the following text, these variations/deviations and the performance of concrete is discussed.

5.2 Effect of percentage replacement of coarse aggregates by coconut shell on 7 and 28 days compressive strength of Concrete:

Table 5.1 – Cube Compressive Strength at 7 and 28 Days in N/mm2

% of Coconut shells	1 Standard	2 10%	3 20%	4 30%
7 days N/mm2	27.70	22.67	21.78	20.30
28 days N/mm2	39.85	31.10	28.30	25.80



From the graph and table, it can be observed that the strength of concrete decreases as the percentage of Coconut shells increases. The strength obtained by 10% mix is nearly equal to the target strength of the mix design. The minimum compressive strength has been attained for mixes containing 30 % of Coconut shells 28 days. From the chart it is clear that, as % of Coconut shells increases Compressive strength will be reduced.

5.3 Effect of percentage replacement of coarse aggregate by Coconut shell on 28 days Split Tensile strength of Concrete:

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Table 5.2 – Split Tensile strength concrete at 28 days in N/mm2

From the graph and table, it can be observed that maximum split tensile strength has been attained for standard mix at 28 days. As the percentage of Coconut shell increases, the 28days split tensile strength of concrete started decreases. The overall decrease of split tensile strength of 30% Coconut Shell replaced concrete is 22% in comparison with standard concrete. From the graph and table, it can be observed that maximum split tensile strength has been attained for standard mix at 28 days. As the percentage of Coconut shell increases, the 28 days split tensile strength of concrete started decreases. The overall decrease of split tensile strength of 30% Coconut Shell replaced concrete is 22% in comparison with standard concrete.

From the graph and table, it can be observed that maximum Flexural strength has been attained for standard mix at 28days. As the percentage of Coconut shells increases, the 28 days Flexural tensile strength of concrete started decreases. The overall decrease of Flexural strength of 30% Coconut Shell replaced concrete is 60% in comparison with standard concrete.

COST AND ESTIMATION PER m3 CONCRETE

TABLE NO 6.1 COST OF CONCRETE INGREDIENT

INGREDIENTS	RATE
CEMENT (Per 50 kg)	Rs 350/-
FINE AGGREGATE PER TON	Rs 1600/-
COARSE AGGREGATE PER TON	Rs 750/-

TABLE NO 6.2 RATE ANALYSIS OF CONCRETE PER m3 FOR DIFFERENT PERCENTAGE OF REPLACEMENT OF COARSE AGGREGATE WITH COCONUT SHELL.

Ingredient	Rate of materials in "Rs"			
	Standard	10%	20%	30%
Cement	2989	2989	2989	2989
Fine aggregate	1232	1232	1232	1232
Coarse aggregate	780	702	624	546
Total	5001	4923	4845	4767
Profit	0%	1.15%	3.11%	4.67%

VI. CONCLUSIONS

The following conclusions have been arrived from the study

1) With 10% replacement we can get 30 N/mm2 Compressive strength on 28th day and for 30% replacement overall reduction 35%.

2) The overall reduction in split tensile strength for 30% replacement is 22%, which is appreciable.

3) The overall reduction in flexural strength is about 60%, which is not appreciable and we can conclude that Coconut shell replaced concrete cannot be used in flexural beams.

4) Addition of Coconut shell partially replacing coarse aggregates in the concrete mix results in achieving economy and reduction in self weight.

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