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Using Coconut Shells as a Partial Replacement for Coarse Aggregate in Concrete

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Abstract - The increasing cost of conventional aggregates affects the economy of our country. Due to this, excessive exploitation of aggregates occurs. It creates environmental issues and as a result, certain restrictions were put forward by the government, in order to stop these exploitations. Now, it is essential to find out a new source of aggregates. In the present work, coconut shell is selected as a partial replacement of coarse aggregate in concrete. Coconut shell is a waste material, and the amount of these wastes is increasing day by day. Usage of these as aggregates will reduce its presence as a waste material from earth. Coconut shell is a lightweight material thus producing light weight concrete. The high cost of conventional construction material affects economy of structure. With increasing concern over the excessive exploitation of natural aggregates, synthetic lightweight aggregate produced from environmental waste is a viable new source of structural aggregate material. The uses of structural grade lightweight concrete reduce considerably the self-load of a structure and permit larger precast units to be handled. Recently in the environmental issues, restrictions of local and natural access or sources and disposal of waste material are gaining great importance. Today, it becomes more difficult to find a natural resource. Use of the waste materials not only helps in getting them utilized in cement, concrete, and other construction materials, but also has numerous indirect benefits such as reduction in land fill cost, saving in energy, and protecting environment from possible pollution effect. It also helps in reducing the cost of concrete manufacturing. In the present work, coconut shell as partial replacement for coarse aggregate in concrete is studied.

In this project, coarse aggregate is replaced by 5%, 10%, 15%, 20%, 25% and 30% of coconut shell. Design mix used is M15 grade and the testing of specimens was conducted after 7, 14 and 28 days of curing. Its usage is cost effective.

CHAPTER 1

INTRODUCTION

Concrete is a composite material which composed of aggregates, cement, and water. Concrete is used more than any other manmade material in the world. In addition, concrete is the 2nd most consumed substance in the world behind water. About 7.23 billion tons of concrete is produced every year. Annual production represents one ton for every person on the planet. Production of concrete is increasing due to high growth of infrastructure development and construction activities in the world, Production of concrete demands its constituents like aggregates, cement, water, and admixtures. Sources of conventional aggregates occupy the major part of the concrete. The large-scale production of concrete in construction activities using conventional coarse aggregate such as granite immoderately reduces the natural stone deposits and affecting the environment hence causing ecology imbalance.

Extraction and processing of aggregates is also a major concern for environment. Therefore, consumption of alternative waste material in place of natural aggregate in concrete production not only protects environment but also makes concrete a sustainable and environment friendly construction material. Different waste material like rubber, fly ash, glass, bottom ash, artificial sand etc. has been used as alternative for replacing natural aggregates. Apart from the abovementioned waste material, a few studies shows that agriculture waste coconut shell can also be used as coarse aggregate for concrete.

Infrastructure development across the world created demands for construction material. Concrete is the premier civil engineering materials used in the structure. Concrete manufacturing involves consumption of ingredients like cement, aggregates, water and admixtures. Among all the ingredients, aggregates form the major parts. Production is expected to increase to more than billions of tons per year by the year. Use of natural aggregates in such a rate leads to a question about the preservation of natural aggregate sources. Using alternative materials in place of natural aggregates in concrete production makes concrete as sustainable

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and environmentally friendly construction material. The chemical composition of coconut shell is similar to wood, and it contains 33.61% cellulose, 36.51 % lignin and 0.61% ash.

Lightweight aggregate concrete can be used produced using a variety of lightweight aggregate. Lightweight aggregate can be originated from natural materials like pumice, the thermal treatment of natural raw materials like clay slate or shale. The other byproduct may include fly ash. The required properties will have bearing on the best type of lightweight aggregate used. the benefit of using lightweight aggregate concrete includes reduction in dead load, improved thermal properties, improved fire resistance and reduction in formwork.

In developed countries, many natural materials like Pumice, scoria and volcanic debris and manmade materials like expanded blast-furnace slag, vermiculite and clinker are used in construction works as substitutes for natural stone aggregates. In India, commercial use of non-conventional aggregates in concrete construction is not so popular. India is the third largest producer of coconut products in the world. Coconut trees are widely cultivated in the southern states of India. Coconut shells thus get accumulated in the mainland without being degraded for around 100 to 120 years. Disposal of these coconut shells is therefore a serious environmental issue. In this juncture, the study on use of coconut shells as a substitute for coarse aggregates in concrete is gaining importance in terms of possible reduction of waste products in the environment and finding a sustainable alternative for nonrenewable natural stone aggregates.

In recent years, researchers have also paid more attention to some agriculture wastes for use as building material in construction. Periwinkle shell was chosen as a substitute for coarse aggregate in concrete and palm kernel shell was used as a replacement for fine aggregate in concrete by some researchers. Certain investigations used crushed, granular coconut and palm kernel shells as substitutes for conventional coarse aggregate and the results of the tests showed that the compressive strength of the concrete decreased as the percentage of the shells increased. The properties of concrete using coconut shell as coarse aggregate were investigated in an experimental study and the study concluded coconut shell concrete can be classified under structural lightweight concrete.

From the research works reviewed above, it can be understanding that coconut shells can be successfully used as a substitute for coarse aggregate in concrete. The study presented here is focusing on finding out the optimum range of replacement of coarse aggregate with coconut shells based on its strength properties. The study also aims to find out the advantage of commercially produced coconut shell concrete work in terms of self-weight reduction.

Figure 1. Coconut Shell

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Figure 2. Coconut Shell in Aggregate size

1.2 History of Coconut shell

Structural lightweight aggregate concrete is a significant and resourceful material in up-to-date construction. This type of concrete has various applications such as construction of multistory building frames and floors, bridges, offshore oil platforms, and prestressed or precast elements (ACI 213R-87). Moreover, it solves weight and durability problems in buildings and exposed structures. According to Expanded Clay, Shale and Slate Institute, structural lightweight concrete provides design flexibility and considerable cost savings through providing less dead load, improved seismic structural response, longer spans, better fire ratings, thinner sections, decreased story height, smaller size structural members, less reinforcing steel, and lower foundation costs. Adeyemi (1998) recommended the suitability of coconut shells as substitute for either fine or coarse aggregate in concrete production. Because of the smooth surface on one side of the shells, concrete made with coconut shell presents better workability (Kanojia and Jain, 2015). Kanojia and Jain (2015) also reported that coconut shell has added advantage of high lignin content that makes the composites more weather resistant. Olanipekun et al. (2006) stated that there is a cost reduction of 30% and 42% for concrete produced from coconut shell and palm kernel shell respectively. Aminah et al. (2009) replaced the coarse aggregate by coconut shell and grained palm kernel in their study and concluded that the combination of these materials has potential of being used as lightweight aggregate in concrete and also has reduce the material cost in construction.

Olutoge (2010) studied the saw dust and palm kernel shells (PKS). Olutoge (2010) replaced fine aggregates by saw dust and coarse aggregates by palm kernel shells in reinforced concrete slabs casting and found that at 25% sawdust and PKS can produce lightweight reinforced concrete slabs that can be used where low stress is required at reduced cost. Moreover, 7.4% reduction can be achieved in terms of cost for every cubic meter of slab production with use of sawdust/PKS (Olutoge, 2010). Shraddha (2014) reported that 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. This research mainly investigates the performance of strength characteristics of concrete using crushed coconut shell as substitutes for conventional coarse aggregate. The research aims to encourage the use of these apparently waste product as construction materials in the construction industry in light-weight applications of concrete. It is also expected to serve the purpose of encouraging housing developers to investigate in house construction incorporating these materials.

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CHAPTER 2

REVIEW OF LITERATURE AND NEED FOR THE STUDY

2.1 Literature Review

It was studied that palm kernel shell and coconut shell, both of which belongs to the family of palm shells. These are agricultural waste products and are available in large quantities in the tropical regions of the world. Research showed that coconut shell are more suitable as low strength giving light weight aggregate when used to replace common coarse aggregate in concrete production.

The researcher suggested that one of the alternatives for coarse aggregate is coconut shell. It is one of the most common agricultural solid wastes in many tropical countries. Density of coconut shell concrete of the typical mixes ranged from 1930 kg/cum to 1970 kg/cum. There was researched on the coconut shell use as aggregate in the study which showed that with global economic recession coupled with the market inflator trends. The average compressive strength for concrete cubes with coconut shell 15.6 N/mm2 for 28 days.

It was studied the compressive strength, split tensile strength, water absorption and sorption for different coconut shell replaced concrete. By replacement of coconut shells in place of aggregates, 10% &20% replacement will have been decreased marginally the strength properties of concrete compared to the normal concrete.

The researcher experimented three different concrete mixes namely M20, M35 and M50 grade with different combination of natural material CS content in the proportion 0%, 10%, 20%, 30% and 40% replaced. It was studied that coconut shells are suitable as low strength giving lightweight aggregate. Also the researcher experimented to determine the compressive strength, split tensile strength and flexural strength cube, cylinder and beam section. It was concluded that when coconut shell aggregates in proportions of 15% was used in the conventional concrete comparable compressive strength results were obtained.

There was study on experimentation that coconut shell can be grouped under lightweight aggregate because 28 days air dry densities of coconut shell aggregate concrete are less than 2000 kg/cum. It was concluded that this type of concrete can be used in rural areas and wherever the natural aggregates are costly. The experimentation conducted that density of concrete decreases with increases in CS percentage. Workability decreases with increase in CS percentage. Compressive and split tensile strength of CS concrete were lower than normal concrete. It was observed that coconut shell concrete is very suitable for low-cost construction in rural areas. It can replace the natural coarse aggregate up to certain limits. This type of aggregate will serve to counteract the scarcity of natural aggregates.

2.2 Need for the Study

The concrete as time goes on through a process of hydration of the cement paste, producing a required strength to withstand the load. The use of coconut shell as coarse aggregate in concrete has never been a usual practice among the average citizens, particularly in areas where light weight concrete is required for non-load bearing walls, non-structural floors, and strip footings. Although coarse aggregate usually take about 30% of the overall self-weight of concrete. The cost of construction materials is increasing day by day because of high demand, scarcity of raw materials, and high price of energy. From the standpoint of energy saving and conservation of natural resources, the use of alternative constituents in construction material is now a global concern. For this, the extensive research and development works towards exploring new ingredients are required for producing sustainable and environment friendly construction material. Coconut shell represents more than 60% of the domestic waste volume. Coconut shell, which presents serious disposal problems for local environment. this will have the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes.

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CHAPTER 3

MATERIALS AND METHODS

3.1 General

This chapter describes the methodology and materials used to achieve the objectives. The main materials characterized in the present study are cement, fine aggregate, coarse aggregate, and coconut shell; experimental methodology followed for characterization of these materials are discussed. A brief introduction about the above materials and methodology is presented in the following section in this chapter.

3.2 Material Specification

For the production of concrete, the constituent materials are cement, fine aggregate, coarse aggregate, and water. To get better workability and strength, the material used should have better quality. To maintain the safety of any structure, provisions are provided as per IS 456:2000.

3.2.1 Cement

Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property. Cement used in construction are sometimes named after their commonly reported place of origin, such as Roman cement, or for their resemblance to other materials, such as Portland cement, which produces a concrete resembling the Portland stone used for building in Britain. The term cement is derived from the Latin word Cementum, which is meant stone chippings such as used in Roman mortar not-the binding material itself. Cement, in the general sense of the word, described as a material with adhesive and cohesive properties, which make a capable of bonding mineral fragments in to a compact whole. The first step of reintroduction of cement after decline of the Roman Empire was in about 1790, when an Englishman, J. Smeaton, found that when lime containing a certain amount of clay was burnt, it would set under water. This cement resembled that which had been made by the Romans. Further vestigations by J. Parker in the same decade led to the commercial production of natural hydraulic cement.

Chemical compounds of Portland cement

The raw material used in the manufactures of Portland cement comprises four principal compounds. These compounds are usually regarded as the major constituents of cement and tabulated with their abbreviated symbols

Table 2.1 Typical composition of ordinary Portland cement

Name of compound	Oxide Composition	Abbreviation
Tricalcium Silicate	$3CaO.SiO_2$	C_3S
Dicalcium Silicate	$2CaO.SiO_2$	C_2S
Tricalcium Aluminate	$3CaO.Al_2O_3$	C_3A
Tetra calcium Alumino ferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_3AF

These compounds interact with one another in the kiln to form a series of more complex products. Portland cement is varied in type by changing the relative proportions of its four predominant chemical compounds and by the degree of fineness of the clinker grinding A small variation in the composition or proportion of its raw materials leads to a large variation in compound composition Calculation of the potential composition of Portland cement is generally based on the Bogue composition (R.H Bogue). In addition to the main compounds, there exist minor compounds such as MgO, TiO2, K20 and Na20; they usually amount to not more than a few percent of the mass of the cement. Two of the minor compounds are of particular interest: the oxides of sodium and potassium, K20 and Na20, known as the alkalis. They have been found to react with some aggregates, the products of the reaction causing disintegration of the concrete and have also observed to affect the rate of gain of strength of cement. Present knowledge of cement chemistry indicates that the major cement compounds have the following properties.

Tricalcium Silicate: C_3S hardens rapidly and is largely responsible for initial set and early strength development. The early strength of and cement concrete is higher with increased percentages of C_3S.

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Dicalcium Silicate: C2S hardens slowly and contributes largely to strength increase at ages beyond one week.

Tricalcium aluminate: C_3A liberates a large amount of heat during the first days of hardening. It also contributes slightly for early strength development. Cements with low percentages of this compound an especially resistant to soils and waters containing sulphates, Concrete made of Portland cement with CIA contents as high as 10.0%, and sometimes greater, has shown satisfactory durability, provided the permeability of the concrete in low.

Tetra calcium aluminoferrite: CAF reduces the clinkering temperature. It will act as a flux in burning the clinker. It hydrates rather rapidly but contributes very little to strength development. Most colour effects are due to C_4AF series and its hydrates. The compounds tricalcium aluminate and tricalcium silicate develop the greatest heat, then follows tetracalcium aluminoferrite, with dicalcium silicate developing the least heat of all.

Tests on Cement

The following tests on cement in the laboratory,

1. Fineness Test of Cement
2. Consistency Test of Cement
3. Setting Time Test of Cement
4. Soundness Test of Cement
5. Heat of Hydration Test
6. Specific Gravity Test of Cement
7. Tensile Strength Test
8. Chemical Composition Test

3.2.2 Fine Aggregate

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete.

The concrete or mortar mixture can be made more durable, stronger, and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface moisture.

Role of Fine Aggregate in Concrete Mix

Fine aggregates are the structural filler that occupies most of the volume of the concrete mix formulas. Depending on composition, shape, size and other properties of fine aggregate you can have a significant impact on the output. The role of fine aggregate can be described in few points:

- Fine aggregates provide dimensional stability to the mixture
- The elastic modulus and abrasion resistance of the concrete can be influenced with fine aggregate
- Fine aggregates quality also influence the mixture proportions and hardening properties
- The properties of fine aggregates also have a significant impact on the shrinkage of the concrete.

Properties of Fine Aggregates

While making the selection for appropriate aggregate to be used in particular concrete mix, few properties needs to be considered, such as:

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- Void content: How much amount of cement paste will be required for the mix eventually depends on the empty spaces between the aggregate particles. Always keep in mind that angular aggregates increase the void content, whereas well-graded aggregate and improved grading decreases the void content.
- Shape and texture: Size and shape greatly influence the quality of the concrete mix. For the preparation of economical concrete mix, you should know that rough-textured, angular, and elongated particles require more water for the formula. However, you will need less water to produce workable concrete when the aggregates are smooth, rounded compact aggregate.
- Absorption and surface moisture: The fine aggregate density depends on the inside solid material and void content, thus you need to measure the absorption rate prior to ensure how much water will be required in the concrete mixture.
- Abrasion and skid resistance: In order to minimize the wear in high traffic areas, such as heavy-duty floors and pavements you can consider the relative measure when the fine aggregate is rotated in a cylinder along with some abrasive charge.

Grading Zone of Fine Aggregate

A good concrete mix must include aggregates that are clean, hard, strong and free of absorbed chemicals or coatings of clay and other fine materials. Ignorance of these characteristics can cause the deterioration of concrete, thus regulatory authorities have decided grading zone of fine aggregate**,** where each zone defines the percentage of fine aggregate passed from the 600 microns sieve size:

1. Zone I: 15% to 34%
2. Zone II: 34% to 59%
3. Zone III: 60% to 79%
4. Zone IV: 80% to 100%

You can assess the quality of fine aggregate with help of the grading zones. However, for precise assessment, you can seek help from experts who are well versed in performing tests for bulk density, bulkage, and specific gravity to find the best-in-class material.

3.2.3 Aggregates

Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However, it is now known that the type of aggregate used for concrete can have considerable effects on the plastic and hardened state properties of concrete. They can form 80% of the concrete mix so their properties are crucial to the properties of concrete. Aggregates can be broadly classified into four different categories: these are heavyweight, normal weight lightweight and ultra-lightweight aggregates. However, in most concrete practices only normal weight and lightweight aggregates are used. The other types of aggregates are for specialist uses, such as nuclear radiation shielding provided by heavyweight concrete and thermal insulation using lightweight concrete.

Aggregate tests

In order to decide the suitability of the aggregate for use in pavement construction, following tests are carried out:

- Crushing test
- Abrasion test
- Impact test
- Soundness test
- Shape test
- Specific gravity and water absorption test
- Bitumen adhesion test

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Crushing Test

One of the models in which pavement material can fail is by crushing under compressive stress. A test is standardized by IS:2386 part-IV and used to determine the crushing strength of aggregates. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied crushing load. The test consists of subjecting the specimen of aggregate in standard mould to a compression test under standard load conditions (Figure 1). Dry aggregates passing through 12.5 mm sieves and retained 10 mm sieves are filled in a cylindrical measure of 11.5 mm diameter and 18 cm height in three layers. Each layer is tampered 25 times with at standard tamping rod. The test sample is weighed and placed in the test cylinder in three layers each layer being tampered again. The specimen is subjected to a compressive load of 40 tones gradually applied at the rate of 4 tones per minute. Then crushed aggregates are then sieved through 2.36 mm sieve and weight of passing material (W_2) is expressed as percentage of the weight of the total sample (W_1) which is the aggregate crushing value.

$$\text{Aggregate crushing value} = \frac{W_1}{W_2} \times 100$$

A value less than 10 signifies an exceptionally strong aggregate while above 35 would normally be regarded as weak aggregates.

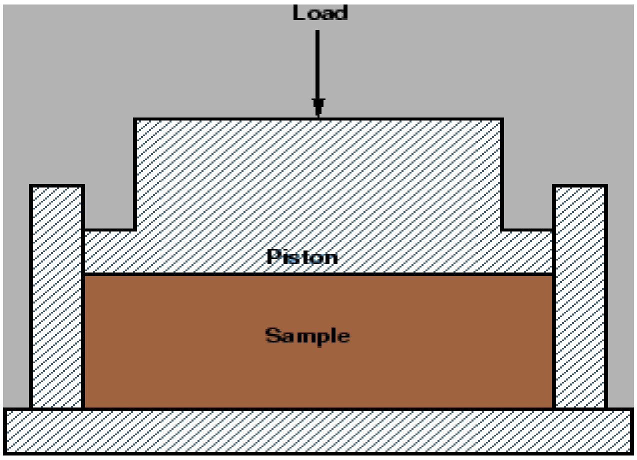

Figure 3. Crushing test setup

Abrasion Test

Abrasion test is carried out to test the hardness property of aggregates and to decide whether they are suitable for different pavement construction works. Los Angeles abrasion test is a preferred one for carrying out the hardness property and has been standardized in India (IS:2386 part-IV). The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.

Los Angeles machine consists of circular drum of internal diameter 700 mm and length 520 mm mounted on horizontal axis enabling it to be rotated (see Figure 2). An abrasive charge consisting of cast iron spherical balls of 48 mm diameters and weight 340-445 g is placed in the cylinder along with the aggregates. The number of the abrasive spheres varies according to the grading of the sample. The quantity of aggregates to be used depends upon the gradation and usually ranges from 5-10 kg. The cylinder is then locked and rotated at the speed of 30-33 rpm for a total of 500 -1000 revolutions depending upon the gradation of aggregates.

After specified revolutions, the material is sieved through 1.7 mm sieve and passed fraction is expressed as percentage total weight of the sample. This value is called Los Angeles abrasion value.

A maximum value of 40 percent is allowed for WBM base course in Indian conditions. For bituminous concrete, a maximum value of 35 is specified.

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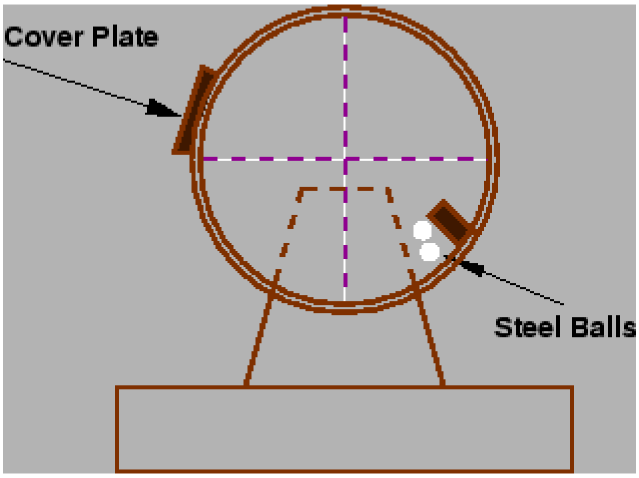

Figure 4. Los Angeles abrasion test setup

Impact Test

The aggregate impact test is carried out to evaluate the resistance to impact of aggregates. Aggregates passing 12.5 mm sieve and retained on 10 mm sieve is filled in a cylindrical steel cup of internal dia 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine. The material is filled in 3 layers where each layer is tamped for 25 number of blows. Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 number of blows. The crushed aggregate is allowed to pass through 2.36 mm IS sieve. And the impact value is measured as percentage of aggregates passing sieve (W_2) to the total weight of the sample (W_1).

Aggregate impact Value = W_1/W_2 X 100

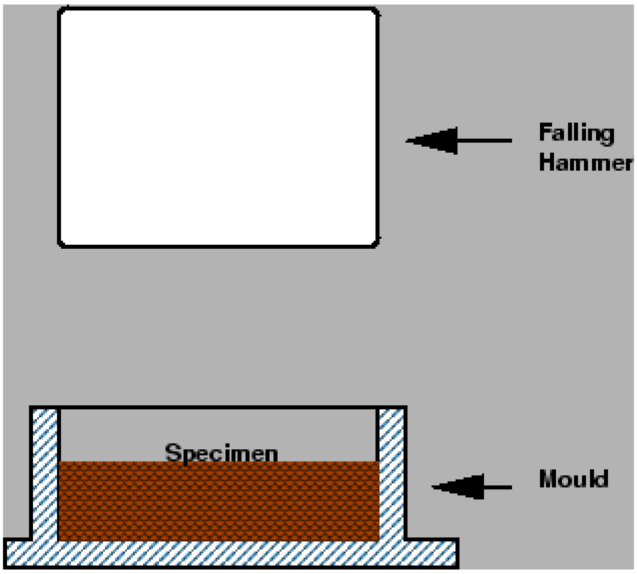

Figure 5. Impact test setup

Aggregates to be used for wearing course, the impact value shouldn't exceed 30 percent. For bituminous macadam the maximum permissible value is 35 percent. For Water bound macadam base courses the maximum permissible value defined by IRC is 40 percent

Soundness Test

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Soundness test is intended to study the resistance of aggregates to weathering action, by conducting accelerated weathering test cycles. The Porous aggregates subjected to freezing and thawing are likely to disintegrate prematurely. To ascertain the durability of such aggregates, they are subjected to an accelerated soundness test as specified in IS:2386 part-V. Aggregates of specified size are subjected to cycles of alternate wetting in a saturated solution of either sodium sulphate or magnesium sulphate for 16 - 18 hours and then dried in oven at 105 – 110^{o}c to a constant weight. After five cycles, the loss in weight of aggregates is determined by sieving out all undersized particles and weighing. And the loss in weight should not exceed 12 percent when tested with sodium sulphate and 18 percent with magnesium sulphate solution.

Shape Test

The particle shape of the aggregate mass is determined by the percentage of flaky and elongated particles in it. Aggregates which are flaky or elongated are detrimental to higher workability and stability of mixes.

The flakiness index is defined as the percentage by weight of aggregate particles whose least dimension is less than 0.6 times their mean size. Test procedure had been standardized in India (IS:2386 part I)

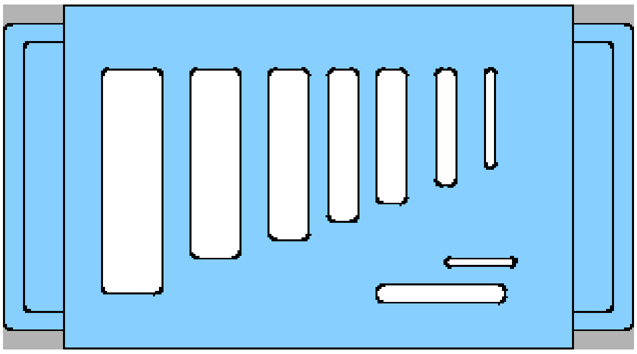

Figure 6. Flakiness gauge

The elongation index of an aggregate is defined as the percentage by weight of particles whose greatest dimension (length) is 1.8 times their mean dimension. This test is applicable to aggregates larger than 6.3 mm. This test is also specified in (IS:2386 Part-I). However, there are no recognized limits for the elongation index.

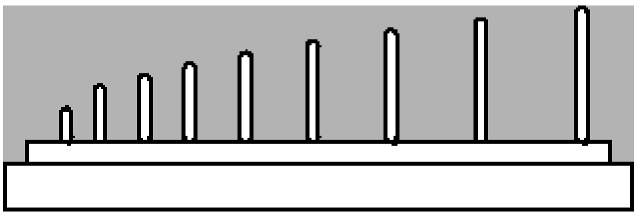

Figure 7. Elongation gauge

Specific Gravity and water absorption

The specific gravity and water absorption of aggregates are important properties that are required for the design of concrete and bituminous mixes. The specific gravity of a solid is the ratio of its mass to that of an equal volume of distilled water at a specified temperature. Because the aggregates may contain water-permeable voids, so two measures of specific gravity of aggregates are used: *apparent* specific gravity and *bulk* specific gravity.

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- Apparent Specific Gravity 'G_{app}' is computed on the basis of the net volume of aggregates i.e. the volume excluding water-permeable voids. Thus

$$G_{app} = \frac{M_D/V_N}{W}$$

- where, M_D is the dry mass of the aggregate, V_N is the net volume of the aggregates excluding the volume of the absorbed matter, W is the density of water.
- Bulk Specific Gravity, $G_{bulk,}$ is computed on the basis of the total volume of aggregates including water permeable voids. Thus

$$G_{bulk} = \frac{M_D/V_B}{W}$$

- where, N_B is the total volume of the aggregates including the volume of absorbed water.
- Water absorption, The difference between the apparent and bulk specific gravities is nothing but the water-permeable voids of the aggregates. We can measure the volume of such voids by weighing the aggregates dry and in a saturated, surface dry condition, with all permeable voids filled with water. The difference of the above two is M_W. M_W is the weight of dry aggregates minus weight of aggregates saturated surface dry condition. Thus

$$\text{water absorption} = \frac{M_W}{M_D} \times 100$$

- The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 2.9. Water absorption values ranges from 0.1 to about 2.0 percent for aggregates normally used in road surfacing.

3.2.4 Coconut Shell

Coconut shells used in the study are brought from local temple. The coconut shells are sundried for five days before using it as an aggregate. The cleaning of coconut shell is carried with the help of sandpaper, the smaller extractions on the outer face of coconut is cleaned with the help of water. The outer shell is then broken in smaller parts up to 20 mm. The broking of coconut shell is done with the help of 30 kg hammer. Then the broken pieces are passed through IS 20 mm sieve and pieces are retained on a IS 16mm sieve are used.

3.2.5 Water

Water is a key ingredient in the manufacture of concrete. Water used in concrete mixes has two functions: the first is to react chemically with the cement, which will finally set and harden, and the second function is to lubricate all other materials and make the concrete workable. Although it is an important ingredient of concrete, it has little to do with the quality of concrete. One of the most common causes of poor-quality concrete is the use of too much mixing water. Fundamentally "the strength of concrete is governed by the nature of the weight of water to the weight of cement in a mix, provided that it is plastic and workable, fully compacted, and adequately cured".

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CHAPTER 4

METHODOLOGY

4.1.1 Material and grade of mix

1. Selection of type of grade of mix, mix design by an appropriate method, trial mixes final mix proportions. 2. Easting total quantity of concrete required for the whole project work. 3. Easting quantity of cement, fine aggregate, Coarse aggregate, coconut shells required for the Experimental work. 4. Testing of properties of cement, fine aggregate, coarse aggregate, and coconut shells.

4.1.2 Production of concrete mixes

Production of mix (normal concrete of grade M- 15) in the laboratory is carried out by IS method of concrete mix design (IS 10262-1982). Coconut shell concrete is produced by adding coconut shells in different percentage (i.e. 0% to 30%) replacement in concrete.

4.1.3 Test on ingredients

Materials the ingredients of concrete i.e. cement, fine aggregate, and fine aggregate, coconut shells are tested before producing concrete. The respective Indian standard codes are followed for conducting various tests on ingredients materials of the concrete.

4.1.4 Mix Design for M15 Grade of Conventional Concrete (Mix ratio = 1:2:4)

Assumptions: Compressive strength required for 28 days = 15Mpa, Maximum size of aggregate = 20mm (angular) Degree of quality control = Good Types of exposure = Mild Data: Specific Gravity of Cement = 3.15, Specific Gravity of fine Aggregate = 2.60, Specific Gravity of Coarse Aggregate = 2.65, Water Absorption of Fine Aggregate = 0.5%, Water Absorption of Coarse Aggregate =1%, Slum required =150x150x150mm, Free moisture in sand =2%, Mix ratio = 1:2:4

4.1.5 Preparation of Specimen

4.1.5.1 Measurements of Ingredients

All cement, sand, coarse aggregate, and coconut shell measured with digital balance. Water is measured measuring cylinder of capacity 1 lit and measuring jar of capacity 100 ml and 200 ml.

4.1.5.2 Mixing of concrete

The ingredients are thoroughly mixed in concrete mixer. The sand, cement and aggregate are measured accurately and are mixed in dry state for normal concrete. Whereas for coconut shell concrete, first measured quantity of cement and other required ingredients as per mix design and then added in concrete mixer. Care is taken to avoid segregation of concrete.

4.1.5.3 Placing of Concrete

The fresh concrete is placed in the moulds by trowel. It is ensured that the representative volume is filled evenly in all the specimens to avoid accumulation of aggregate, segregation etc. While placing concrete in moulds compaction is done to remove entrapped air or voids in concrete.

4.1.5.4 Finishing of Concrete

Concrete is worked trowel to give uniform surface. Care is taken not to add any extra cement, water, or cement mortar for achieving good surface finish. The additional concrete is chopped off from the top surface of the mould for avoiding over sizes etc. Identification marks are given on specimens by embossing over the surface after initial drying.

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4.1.5.5 De-moulding of Specimens

The plain cement concrete specimens are demoulded after 24 hours of casting and kept in water tank for curing. Similarly coconut shells concrete specimens are demoulded after 24 hours of casting and kept in water tank for curing at 7 days,14 days and after 28 days.

4.1.5.6 Curing of Specimens

The specimens are demoulded after 24 hours of casting and immediately stored for curing. M15 grade conventional concrete and coconut shell concrete (CSC) specimens with partial replacement of 0% to 30% are cured in curing tank for 7 days and 28 days.

4.1.5.7 Testing

Compressive strength and Split tensile test are carried out on compressive testing machine (CTM) of capacity 2000 KN. Cube and Cylinders are tested for 7 days, 14 days and 28 days.

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CHAPTER 5

EXPERIMENTAL WORK

5.1.1 Test Conducted On Hardened Concrete

Confirming to IS 516-1959 In present study cube compression test, flexural test on beams, slit tensile test on cylinders on conventional concrete and coconut shell concrete are carried out. The experimental results and discussion results for various tests are described below.

5.1.2 Compressive Strength Test

A cube compression test is performed on standard cubes of conventional concrete and coconut shell concrete with partial replacement of 25% and 30% of size 150mm x 150mm after 7 days and 28 days of immersion in water for curing. The results for the test are shown in table. The compressive strength of the specimen is calculated by the following formula: fcu = P/A Where, P = Failure load in compression (KN) A = Loaded area of cube (mm2)

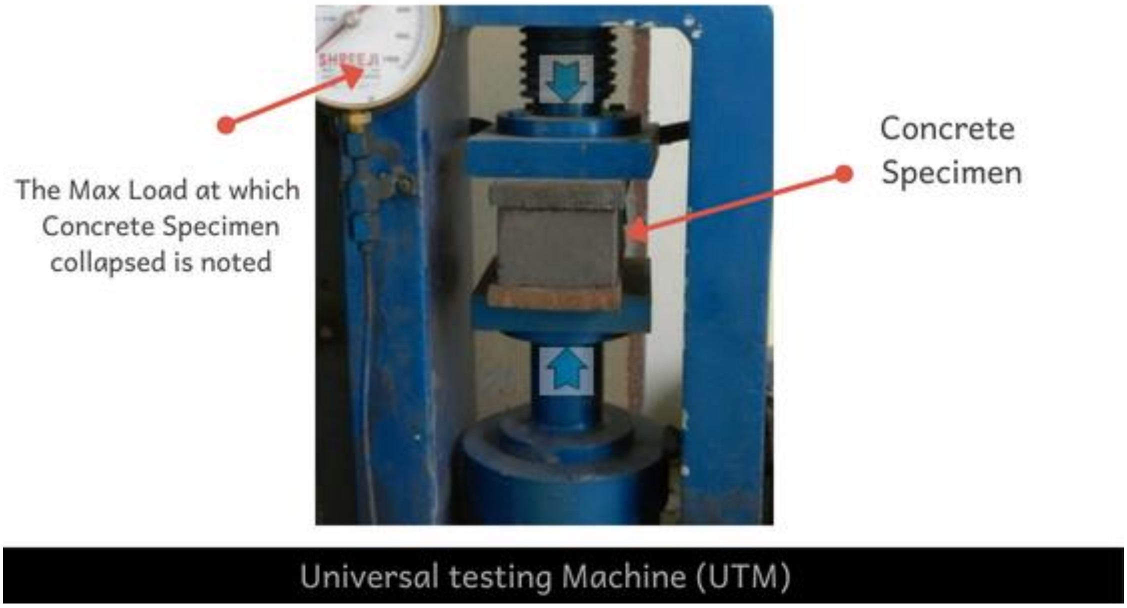

Figure 8. Universal Testing Machine (compressive strength test)

5.1.3 Flexural Strength

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by fbt = $Pl\ bd2$. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined.

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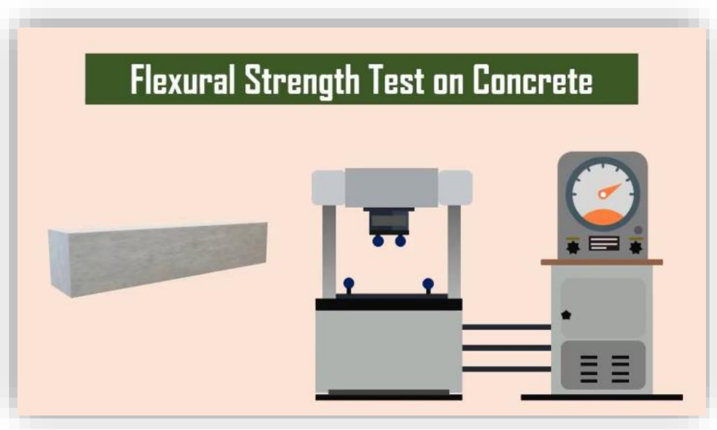

Figure 9. Flexural Strength Test Machine

5.1.4 Split tensile Test

Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Calculated formula: ft= $\boldsymbol{2P\ \pi DL}$ Where, P= Compressive Load at failure L=length of cylinder D= dia. Of the cylinder.

Figure 10. Split Tensile Test Machine

6.1 MATERIAL CALCULATION

6.1.1 Material calculation of conventional concrete

Volume of the cube = (150*150*150) mm^3

Unit weight of concrete = 2400 Kg/m^3

Total concrete required for 1 cube = Unit weight of concrete*Volume

= 2400*3.375*10^{-3} = 8.1 Kg

Material required for M15 grade concrete,

(M15 = 1:2:4)

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Total weight of concrete = Total part

=>1 part = Total weight of concrete/Total part

Total part of concrete, x+2x+4x =7x

=>7x = 8.1 Kg

=>x = 8.1/7 = 1.15 Kg(Cement)

Sand =>2x = 2*1.15 = 2.3 Kg

C.A =>4x = 4*1.15 = 4.6 Kg

6.1.2 Material calculation of 5% replacement

Total weight of coarse aggregates =4.6 kg (for one cube)

5% of coarse aggregate = 4.6*5/100 = 0.23kg (C.S)

Sand = 2.3kg

Cement = 1.15kg

Coarse aggregate = 4.37kg

6.1.3 Material calculation of 10% replacement

Total weight of coarse aggregates =4.6 kg (for one cube)

10% of coarse aggregate = 4.6*10/100 = 0.46 kg (C.S)

Sand = 2.3kg

Cement = 1.15kg

Coarse aggregate = 4.14kg

6.1.4 Material calculation of 15% replacement

Total weight of coarse aggregates =4.6 kg (for one cube)

15% of coarse aggregate = 4.6*15/100 = 0.69 kg (C.S)

Sand = 2.3kg

Cement = 1.15kg

Coarse aggregate = 3.91kg

6.1.5 Material calculation of 20% replacement

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Total weight of coarse aggregates =4.6 kg (for one cube)

20% of coarse aggregate = 4.6*20/100 = 0.92 kg (C.S)

Sand = 2.3kg

Cement = 1.15kg

Coarse aggregate = 3.68kg

6.1.6 Material calculation of 25% replacement

Total weight of coarse aggregates =4.6 kg (for one cube)

25% of coarse aggregate = 4.6*25/100 = 1.15 kg (C.S)

Sand = 2.3kg

Cement = 1.15kg

Coarse aggregate = 3.45kg

6.1.7 Material calculation of 30% replacement

Total weight of coarse aggregates =4.6 kg (for one cube)

30% of coarse aggregate = 4.6*30/100 = 1.38 kg (C.S)

Sand = 2.3kg

Cement = 1.15kg

Coarse aggregate = 3.22kg

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CHAPTER 6

TEST RESULTS

0% Replacement

Days	Compressive strength		
	1	2	Mean (N/mm^2)
7 days	12.8	10.6	11.7
14 days	14.2	13.7	13.92
28 days	17.5	17.5	17.5

Table 1. 0% Replacement

5% Replacement

Days	Compressive strength		
	1	2	Mean (N/mm^2)
7 days	10.5	10.1	10.3
14 days	12.5	11.9	12.2
28 days	17.5	17.3	17.4

Table 2. 5% Replacement

10% Replacement

Days	Compressive strength		
	1	2	Mean (N/mm^2)
7 days	9.1	8.7	8.9
14 days	10.6	9.8	10.2
28 days	14.5	13.9	14.2

Table 3. 10% Replacement

15% Replacement

Days	Compressive strength		
	1	2	Mean (N/mm^2)
7 days	8.4	7.1	7.75
14 days	9.3	9.1	9.2
28 days	10.8	10.5	10.65

Table 4. 15% Replacement

20% Replacement

Days	Compressive strength		
	1	2	Mean (N/mm^2)
7 days	5.3	5.1	5.2
14 days	7.9	7.3	7.6
28 days	9.3	8.9	9.1

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Table 5. 20% Replacement

25% Replacement

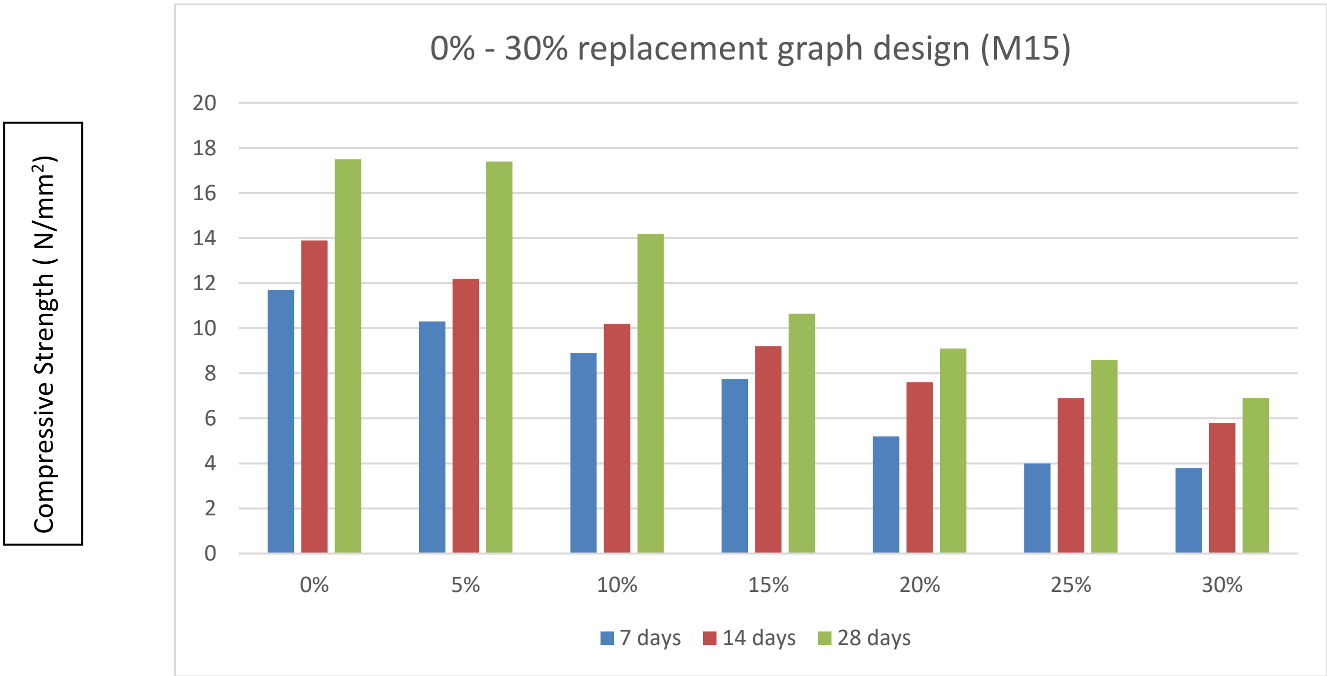
Days	Compressive strength		
	1	2	Mean (N/mm^2)
7 days	4.1	3.9	4
14 days	7.1	6.7	6.9
28 days	8.9	8.3	8.6

Table 6. 25% Replacement

30% Replacement

Days	Compressive strength		
	1	2	Mean (N/mm^2)
7 days	8.4	7.1	3.8
14 days	5.9	5.7	5.8
28 days	7.1	6.7	6.9

Table 7. 30% Replacement



Column Chart

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CHAPTER 7

CONCLUSION

To increase the speed of construction, enhance green construction environment we can use lightweight concrete. The possibility exists for the partial replacement of coarse aggregate with coconut shell to produce lightweight concrete. Coconut shell exhibits more resistance against crushing, impact, and abrasion, compared to crushed granite aggregate. The study gave a deeper understanding of the effects of replacing the coarse aggregate with coconut shells. Even though the results are based a few tests, the following conclusions can be made from the study. Coconut shell concrete has better workability because of the smooth surface on one side of the shells and the size of coconut shell used in this study.

Till now from our experiment, we have concluded that, in addition of 5% replacement of coconut shell as coarse aggregate we will got compressive strength of concrete nearly same as the conventional concrete. In addition of 10%, 15%, 20%, 25%, and 30% replacement of coconut shell as coarse aggregate we will get that the compressive strength of concrete as compared to conventional concrete decreases so we used this percent of replacement in temporary work like garden, walking area, parking area, etc. we can use 5% of replacement of coconut shell in permanent construction work like building, road construction, boundary wall, partition wal, etc

CHAPTER 8

FUTURE SCOPE

- keeping insight the economic condition and cost-effective construction this project has really very good future scope.
- We have done various tests on the concrete by partially replacing the coarse aggregate by 5%, 10%, 15%, 20%, 25% and 30% with coconut shell.
- For future development in the project there can be some improvement in the materials and can add some admixture to increase in the properties and strength of the concrete.
- This concrete can be used in any type low/medium load bearing structure.
- This concrete applicable on partition wall, compound wall, low-cost housing.

CHAPTER 9

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