Study On The Performance Of Concrete With Partial Replacement Of Cement With Silica Fume And Coarse Aggregate with Coconut Shell

Bathula Srikanth [1], P. Suneetha [2]
1- Student of, Department of Civil Engineering, Newtons College of engineering and technology.
2- Professor, Department of Civil Engineering, Newtons College of engineering and technology.

Abstract- Concrete is one of the most widely used construction materials in the world. Cement and aggregate, which are the most important constituents used in concrete production, are the vital materials needed for the construction industry. This inevitably led to a continuous and increasing demand of natural materials used for their production. Parallel to the need for the utilization of the natural resources emerges a growing concern for protecting the environment and a need to preserve natural resources (such as aggregate) by using alternative materials which are recycled or waste materials. In this research, a study was carried out on the use of recycled rubber tyres as a partial replacement for fine aggregates in concrete construction using locally available waste tires. The disposal of used tyres is becoming a major waste disposal problem throughout the world. The accumulation of used tyres is an environment threat which can cause uncontrolled fires, producing a complex mixture of chemicals harming the environment and contaminating soil and vegetation.One such effective way of disposing the used tyres is by reusing them in construction industry in an environmentally friendly manner. In the first part of this thesis, the background of the study and the extent of the problem were discussed. A review of relevant literatures was done to study previous works in the subject matter. The research was carried out by conducting tests on the raw materials to determine their properties and suitability for the experiment. Concrete mix designs are prepared using the ACI method and a total of 10 mixes were prepared consisting of M20 Grade. The specimens were produced with percentage replacements of the fine aggregate by 10, 20 and 30 % of rubber aggregate. In addition to that Silica Fume is replaced with cement in proportion 0, 10 and 15% for each Rubber mix Moreover, a control mix with no replacement of the fine aggregate was produced to make a comparative analysis. The prepared samples consist of concrete cubes, cylinders and beams.

Key words: Aggregate, Compressive strength, Concrete, Flexural strength, Recycled tyres, Rubberized concrete, Splitting tensile strength, Unit weight.

INTRODUCTION

Concrete is the premier construction material around the world and is most widely used in all types of construction works, including infrastructure, low and high-rise buildings, and domestic developments. It is a man-made product, essentially consisting of a mixture of cement, aggregates, water and admixture(s). Inert granular materials such as sand, crushed stone or gravel form the major part of the aggregates. Traditionally aggregates have been readily available at economic prices and of qualities to suit all purposes. But, the continued extensive extraction use of aggregates from natural resources has been questioned because of the depletion of quality primary aggregates and greater awareness of environmental protection. In light of this, the non-availability of natural resources to future generations has also been realized.

The word “sustainable” is becoming very common worldwide. The trend goes beyond the practice of design and construction, since the awareness of the current population is a crucial factor for the success of this tendency. Sustainable building systems can have a direct implication on the betterment of livelihood conditions of communities. Unfortunately, the extraction of natural aggregates has led to establishing human made quarries that have drastic environmental impact on the nature and surroundings.

Advantages and Disadvantages of Using Concrete as a Structural Material

Advantages 1 It has considerable compressive strength as compared to most other materials.

2 Reinforced concrete has great resistance to the actions of fire and water and, infact, is the best structural material available for situations where water is present. During fire of average intensity, members with a satisfactory cover of concrete over the reinforcing bars suffer only surface damage without failure.

3 Reinforced concrete structures are very rigid.

4 It is a low-maintenance material.

5 As compared with other materials, it has a very long service life. Under proper conditions reinforced concrete structures can be used indefinitely without reduction of their load carrying abilities. This can be explained by fact that the strength of concrete does not decrease with time but actually increases over a very long period, measured in years, due to the lengthy process of the solidification of the cement paste.

Disadvantages 1 Concrete has a very low tensile strength, requiring the use of tensile reinforcement.

2 Forms are required to hold the concrete in place until it hardens sufficiently. In addition, shoring may be necessary to keep the forms in place for roofs, walls and similar structures until the concrete members gain sufficient strength to support

themselves. Formwork is very expensive. Its costs run from one-third to two-third of the total cost of a reinforced concrete structure, with average values of about 50%.

3 The low strength per unit weight of concrete leads to heavy members. This becomes an increasingly important matter for long-span structures where concrete's large dead weight has a great effect on bending moments.

4 Similarly, the low strength per unit volume of concrete means members will be relatively large, an important consideration for tall building and long span structures.

Light weight aggregate (LWA) Natural LWA are normally obtained from the volcanic rocks such as pumice with density ranging from 500 to 900 kg/m3. Recent developments include the use of artificially manufactured LWA from various natural materials such as expanded clay, expanded shale, foamed slag, blast furnace slag, pulverized fuel ash and perlite to enable low density concrete compared to normal concrete and to achieve compressive strength up to 100 N/mm2

The main characteristic of LWA is its high porosity, which results in a low specific gravity. Porous LWA of low specific gravity can be used in low density concrete production instead of ordinary crushed stone aggregate. Though the commercially available LWA were used in many investigations in place of crushed stone aggregates to manufacture low density concrete, if waste materials are used as an aggregate in the production of low density concrete, more environmental and economical benefits may be derived. In view of the escalating environmental problems, the use of aggregates from by-products and/or solid waste materials from different industries is highly desirable

COCONUT SHELL CONCRETE (CSC) CSC has a density of less than 2400 kg/m3 and compressive strength of more than 20 N/mm2. The challenge in making CSC is in decreasing the density while maintaining strength and without adversely affecting cost. Introducing Coconut shell as lighter aggregates into the matrix is a common way to lower a concrete's density. The crushed stone and sand are the components that are usually replaced with lightweight aggregate (LWA).

PRESENT USE OF COCONUT SHELL CS has good durability characteristics, high toughness and abrasion resistant properties; it is suitable for long standing use. CS is mostly used as an ornament, making fancy items, house hold utensils, and as a source of activated carbon from its charcoal. The powdered shell is also used in the industries of plastics, glues, and abrasive materials and it is widely used for the manufacture of insect repellent in the form of mosquito coils and in agarbathis.

After the coconut is scraped out, the shell is usually discarded as waste as shown in Figure 1 The vast amount of this discarded CS resource is as yet unutilized commercially; its use as a building material, especially in concrete, on the lines of other LWA is an interesting topic for study. The study of CS will not only provide a new material for construction but will also help in the preservation of the environment in addition to improving the economy by providing new use for the CS.

Fig 1 Discarded CS at coconut industries

AIM AND SCOPE OF THE RESEARCH The aim of this study is to assess the utility and efficacy of CS as a coarse aggregate as an alternative to natural aggregate in concrete. CS has not been tried as aggregate in structural concrete. The properties of CS have to be known before it can be used as a coarse aggregate in concrete. This research focuses on properties of CS first, and then as a structural material. Hence, the scope of work for this research is limited to fulfill the objectives presented below.

OBJECTIVES OF THE RESEARCH

The main objective of this research is to determine the feasibility of using solid waste CS as coarse aggregate. The research objectives are briefly summarized below.

(i) To study the properties of CS, and to produce CSAC with 28 day compressive strength more than 20 N/mm^2.

(ii) To study the properties of CSAC like compressive strength, split tensile strength, and flexural strength.

LITERATURE REVIEW

GENERAL This chapter presents a literature review on different wastes used in concrete, types of various concretes and the various classifications of LWA are discussed. Some of the wastes used as different constituents in concrete are textile waste, used engine oil, automotive shredder residue, ceramic waste, waste polyethylene terephthalate (PET) bottles, tire rubber waste, marble quarry waste, guar and tamarind, waste glass and rubber particles, ground clay brick, recycled aggregate, carpet fiber, and mineral powder. This section presents a review on LWC properties namely general characteristics compatibility, mix design, mechanical properties, structural bond properties**.** A review of previous research works were done to accomplish the objectives of this project. Many researchers have studied the strength attainment, full replacement and partial replacement of coconut shell with coarse aggregate in concrete.

Lightweight aggregate (LWA) LWA as the name suggests have lower bulk density as compared to normal weight aggregates. There are many variations in the definition given for LWA in different codes of practice. BS 3797 [1] defines coarse LWA as aggregates having a loose bulk density of 250–1000 kg/m3, whereas ACI 213R [2] defines LWA as aggregates with a dry loose weight not exceeding 880 kg/m3. The AS 2758: Part 1 [3] defines LWA as aggregates having loose bulk density of less than 1200 kg/m3. LWA can generally be classified into four types, namely (i) naturally occurring aggregates, (ii) artificially produced aggregates, (iii) aggregates from industrial by-products and (iv) organic aggregates. The first three types comprise inorganic aggregates. Brief descriptions of these are given in the following sections.

Naturally occurring aggregates The natural aggregates most commonly used include pumice, scoria, volcanic cinders, tuff and diatomite. Pumice, scoria (basaltic pumice) and tuff are lavas that have been expanded naturally. All these natural aggregates are of volcanic origin except for diatomite, which is a siliceous sedimentary rock formed by the accumulation of highly porous, fossilized skeletal remains single celled, microscopic aquatic plants known as diatoms. These LWA can only be found in certain parts of the world and therefore, they are not extensively used in LWC production [4]. In this category, pumice, scoria, and tuff are the most commonly used aggregates for the manufacture of LWC. These aggregates are capable of producing structural concretes with densities in the range of 1630 to 1885 kg/m3 and compressive strengths in the range of about 24–55 N/mm2 [5-9].

Artificially produced aggregates In this category, the aggregates have undergone some form of manufacturing process. The raw materials for producing artificial LWA can either be obtained from natural materials or by-products from various industries. Artificial LWA are normally produced either through the process of expansion or agglomeration. Aggregates formed by expansion are produced by heating suitable raw materials in a rotary kiln to fusion point (at temperatures of 1000°C to 1200°C) where they become soft and expand because of entrapped expanding gases. Agglomeration (or pelletizing) is a process in which fine particles are bonded together to form a coarser product.

Aggregates from industrial by-products The growing concern of resource depletion and global pollution has challenged many researchers to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials for building construction. Aggregates categorized under this section are those directly used without the need for processing. These include cenospheres, expanded polystyrene foam, cork granules, broken bricks and waste glass. Cenosphere is a by-product generated from the combustion of pulverized coal in thermal power plant, which are inert and consist primarily of silica and alumina [14]. Cenospheres are somewhat similar to fly ash and are normally used as fine aggregates. Fly ash consists of solid spherical particles, whereas cenospheres are hollow and are larger in size. LWC produced from cenospheres have densities in the range of 1090–1415 kg/m3 and have compressive strengths ranging from 5 to 33 N/mm2 [15].

Aggregates from organic solid waste Waste of organic origin includes agricultural and timber by-products such as rice husk saw dust, wood chippings, coconut pith and oil palm shell (OPS). Rice is produced in many countries around the world with an estimated annual paddy production of approximately 540 million metric tons [21]. Rice husk can be used to produce LWC and good material characteristics can be achieved due to the fibrous nature of the husk and its pozzolanic effect. Concrete compressive strengths of up to 24 N/mm2 can be achieved with densities in the range of 1110–1145 kg/m3 [22].

COCONUT SHELL AS AGGREGATE

Daniel Yaw Osei (2013): To ensure low density concrete, coconut shell have been replaced with coarse aggregate in concrete, and compressive strengths were evaluated at 7 days, 14 days, 21 days and 28 days. The density and compressive strength of concrete reduced as the percentage replacement increased. Concrete produced by 20%, 30%, 40% and 50% and 100% replacement attained 28-day compressive strengths are 19.7 , 18.68 , 17.57 , 16.65 and 9.29 N/sq.mm respectively.[26].

Amarnath Yerramalaa, Ramachandrudu: To find the properties of coconut shell as aggregate replacement in concrete, Addition of CS decreases workability and addition of fly ash either as cement replacement or aggregate replacement increases workability of CS concrete. Increase in CS percentage decreased densities of the concretes. Split tensile strength is ranging from 14-17% of comp. strength[27].

SUMMARY OF LITERATURE REVIEW Many new types of low density concrete have been emerging in the modern construction industry, especially those made from waste materials and byproduct. However, the studies are mostly confined to low density concrete produced from naturally occurring aggregates, manufactured aggregates and aggregates from industrial by-products. Studies concerning low density concrete with organic agricultural solid waste are still in its infancy. Up to date studies on the development of low density concrete using CS have not been conducted, and only little work has been done so far. Therefore, there is sample scope to introduce CS as coarse aggregate in the development of low density concrete and it is need to investigate further important properties for the development of low density concrete and the use of CS as coarse aggregate in actual practice.

COMPOSITION OF CSC

INTRODUCTION This chapter provides the details of the properties of materials used and the experimental procedures used in this investigation to find the properties of concrete. The experimental procedures for determining the steel-concrete bond, durability performance, flexural and shear behavior of CSAC are presented.

The raw materials used in this investigation were locally available and these included Ordinary Portland Cement (OPC), silica fume as binder, river sand as fine aggregate, crushed granite and CS as coarse aggregate. Potable tap water was used for mixing and curing throughout the entire investigation. Detailed descriptions of each material are provided in the following sections.

CEMENT Ordinary Portland cement (OPC) is the most common type of binder used for concrete production and hence, OPC 43 Grade conforming to Indian Standard IS 12269:1987 was used as a binder. The local brand name of the OPC cement used is chettinad. Specific gravity of the cement is found to be 3.15 in the laboratory.

FINE AGGREGRATE River sand was used throughout the investigation as the fine aggregate conforming to grading zone II as per IS 383:1970. The sand was air-dried and sieved to remove any foreign particles prior to mixing. The densityof the fine aggregate is found to be 2671 kg/m^3, specific gravity is found to be 2.65, fineness modulus were determined. Fine aggregate with a fineness modulus in the range of 2.5 to 3.2 are preferable. Concrete mixtures made with a fine aggregate that has a fineness modulus of less than 2.5 may be sticky and result in poor workability and a higher water requirement.

COARSE AGGREGATE Crushed granite stone aggregate 3-12 mm sizes were used for CC for comparison. Granite concrete was produced as NWC to compare with CSAC. The particle size distributions of the crushed granite stone aggregates are presented in Figure 3.2. The bulk density, specific gravity, water absorption, aggregate impact value (AIV), aggregate crushing value (ACV), aggregate abrasion value, and particle size distribution were determined.

COCONUT SHELL AGGREGATE CSAC, which is produced using CS aggregates, was the main concrete studied in this investigation. CS is discarded at coconut industries as half-shell rounds. CS was collected from the local coconut oil mills to analyze the properties of CS in this study. CS have maximum thickness in range of 2-8 mm, they were crushed to the required sizes in the range 6-20 mm in length using the specially developed crusher.

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

Silica Fume The microsilica of silica fume, a by-product of the electrometallurgical industrial plays a double role: first as a filler and then as a pozzolonic material, which reacts with $Ca(OH)_2$ liberated by C_3S. A superplasticizer is needed for dispersing the silica particles and for avoiding the formation of a gel-like layer which leads to agglomeration. Compressive strengths as high as 270 MPa have been measured on such materials. The C-S-H form is amorphous and of low porosity. The fracture is trans granular. The pozzolanicity of the silica fume can be characterized by its ability to react with $Ca(OH)_2$. In the mixture of OPC + 30% silica all the $Ca(OH)_2$ liberated by the hydration of clinker silicates has been consumed by this microsilica. The Ca/Si ratio of C-S-H is systematically lower in calcium than that of Portland cement and the higher amount of silica fume the lower the C/S, but inversely, they contain more alkalis respectively 1.3 and 0.5%.

MATERIAL PROPERTIES

GENERAL This chapter provides the details of the properties of materials used and the experimental procedures used in this investigation to find the properties of concrete. The material specification for cement, fine aggregate, coarse aggregate and admixtures. The experimental procedures for determining the properties of CS and sieve analysis for sand, coarse aggregate to test their suitability for use in concrete.

CEMENT In the present study OPC 53 grade was used. Chettinad a local brand OPC was used. The specific gravity of cement is given in Table 1.

Table 1 specific gravity of cement

Sl. No.	Observations	Trail 1	Trail 2	Trail 3
1.	Weight of the specific gravity bottle W1, g	35.8	35.8	35.8
2.	Weight of the specific gravity bottle + 1/3rd filled cement W2, g	53.8	53.6	53.8
3.	Weight of the specific gravity bottle + 1/3rd filled cement + kerosene W3, g	89.4	89.3	89.4
4.	Weight of the specific gravity bottle W1 + kerosene W4, g	76.2	76.2	76.2
5.	Specific gravity	3.0	3.02	3.0

Average specific gravity of cement = 3.01

FINE AGGREGATE Locally available river sand conforming to grading zone-II as per IS: 383 – 1970 was used. The screened at site to remove deleterious materials. Sieve analysis and specific gravity test results of sand were given behind:

Table 2 sieve analysis of fine aggregate

Sieve size, mm	Weight retained, gms	Cumulative weight retained, gms	Cumulative % retained (%)	Percentage passing (%)
4.75	0	0	0	100
2.36	11	11	2.2	97.8
1.18	52.7	63.7	12.74	87.26
0.6	138.3	202	40.4	58.6
0.3	249.5	451.5	90.3	9.7
0.15	42.1	493.6	98.72	1.28
<0.15	6.4	500	100	0

Fineness modulus of sand = 2.45

Specific Gravity of Fine Aggregate(Table 3)

Sl. No.	Observations	Trial 1	Trial 2	Trial 3
1.	Weight of the specific gravity bottle(W_1), g	44.1	44.1	44.1
2.	Weight of the bottle + 1/3rd filled sand(W_2), g	99.6	99.8	99.8
3.	Weight of bottle + 1/3rd filled sand + water (W_3), g	141.9	141.6	142.1
4.	Weight of bottle + water (W_4), g	176.5	176.5	176.5
5.	Specific Gravity	2.65	2.67	2.63

Average specific gravity of sand = 2.65

COARSE AGGREGATE In the present study a locally available coarse aggregate (MSA,20mm) from quarry was used. The specific gravity of coarse aggregate is given in Table 4

Specific Gravity of Coarse Aggregate(Table 4)

Sl. No.	Observations	Trial 1	Trial 2	Trial 3
1.	Weight of the specific gravity bottle (W_1), g	595.2	595.2	595.2
2.	Weight of bottle + 1/3rd filled sand (W_2), g	965.2	969	961.7
3.	Weight of bottle + 1/3rd filled sand + water (W_3), g	1706.8	1710.2	1703
4.	Weight of bottle + water (W_4), g	1472.3	1472.3	1472.3
5.	Specific gravity	2.73	2.75	2.7

Average specific gravity of coarse aggregate = 2.72

PHYSICAL AND MECHANICAL PROPERTIES OF COCONUT SHELL

The crushed CS in different sizes is shown in Figure 3.4. Engineering properties tests on CS which are essentially required such as moisture content, water absorption, specific gravity, density, crushing strength, impact strength, flakiness index etc., to satisfy as an aggregate to be used in the production of concrete were conducted as per the Indian standard procedures.

Moisture content The moisture states in which an aggregate may exist [160] are Damp or wet: - Aggregates in which the pores connected to the surface are filled with water and with free water also on the surface. Saturated surface dry (SSD):- Aggregate in which the pores connected to the surface are filled with water but with no free water on the surface. Air-dry (AD):- Aggregate that has a dry surface but contains some water in the pores. Oven-dry (OD): - Aggregate that contains no water in the pores or on the surface. Two of these, SSD and OD, are used as the basis for specific gravity calculations. Total moisture content was measured by measuring the mass of a sample of the CS, drying the sample and measuring the mass again.

Water absorption CS aggregates are porous and absorptive. Porosity and absorption of aggregate will affect the w/c ratio and hence the workability of concrete. The water absorption of the CS was measured in accordance with IS 2386 (Part III): 1963 [161].

Specific gravity The specific gravity of a material is the mass of the material in air divided by the mass of an equal volume of water. Two different values of specific gravity may be calculated depending upon whether the mass is used as OD or a SSD mass. The specific gravity of the CS was measured in accordance with IS 2386 (Part III): 1963 [161].

Crushing value The relative measure of the resistance of a material to crush under a gradually applied compressive load in a monotonic condition is known as crushing value. Determination of CS crushing value was measured in accordance with IS 2386 (Part IV): 1963 [163].

Bulk density The bulk density or unit weight or some times called dry-rodded unit weight of a material is the weight of material in a given volume. The bulk density and the percentage voids of the CS were measured in accordance with IS 2386 (Part III): 1963 [161].

Thickness of CS Shells were selected randomly in different places and their thicknesses were measured using Vernier calipers at different locations in a shell itself, and the average was taken. The thickness of CS varied in the range 2-8 mm.

EXPERIMENTAL INVESTIGATIONS

MIXING

Mixing was carried out in a pan mixer machine. The mixing methodology adopted was as follows:

- 25 percent of total water, coarse aggregates and admixtures were added to the mixer machine and allowed to mix for 1 minute.
- Cement and 50 percent water were then added to the mix and mixed for 1 minute.
- Superplasticizer was blended with the balance 25 percentage water and then added to the mix. Mixing was continued for 5 minutes after adding the blend.
- Total mixing time was 7 minutes.

Fig 2 Concrete Pan Mixer used for mixing

METHOD OF CURING

Fig 3 NWC used for Curing of concrete specimens

MECHANICAL PROPERTIES The compressive strength, flexural, splitting tensile strengths of CSAC of 150 mm cubes was measured according to IS 516:1959

Compressive Strength Compressive strength of concrete can be found according to IS:516-1959. Concrete cubes are loaded uniaxially by using standard testing machine until the specimen fails. The compressive strength is defined as the maximum compressive load divided by cross-sectional area of the specimen.

Test : To calculate the compressive strength of concrete cubes the universal testing machine (UTM) having capacity of 300 tonne was used. In this test the strength obtained in tonne. The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area calculated from mean dimensions of the section and shall be expressed to the nearest N/mm2.

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10mm X 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. These specimens are tested by compression testing machine after 7 days curing, 14 days curing, 28 days curing and 56 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

$$F_c = P/A$$

Where,

F_c -Compressive strength of concrete

P -Maximum Compressive load

A -Cross sectional area

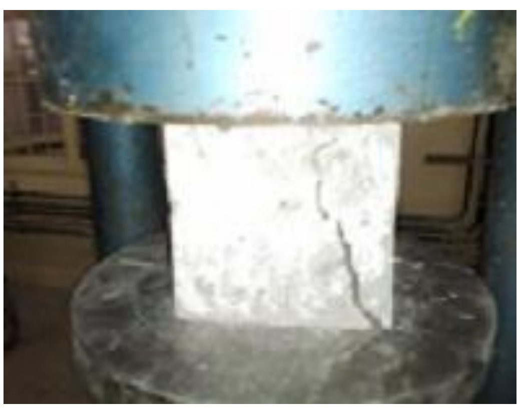


Fig 4 Concrete cube specimens testing for compressive strength

Flexural strength test

Two-point load method was adopted to measure the flexural strength of CSAC. As per ASTM C78-84 guidelines [180], beams of 100x100x500 mm size were adopted. The load was applied without shock and was increased until the specimen failed, and the maximum load applied to the specimen during the test was recorded.

Test :

For this test the beams of dimension100mmX100mmX500mm were casted. Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, [dubious – discuss] a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. The beam tests are found to be dependable to measure flexural strength.

The value of the modulus of rupture depends on the dimensions of the beam and manner of loading. In this investigation, to find the flexural strength by using third point loading. In symmetrical two points loading the critical crack may appear at any section not strong enough to resist the stress with in the middle third, where the banding moment is maximum. Flexural modulus of rupture is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used.

The flexural strength of the specimens was calculated
Modulus of rupture, fb = (P L) / (b d2)
$=(3P \times a)/(bd^2)$.
where P = Maximum load applied, N
L = Supported length of the specimen, mm
b = Measured width of the specimen, mm
d = Measured depth of the specimen at the point of failure, mm

Splitting tensile strength test

As per ASTM C496-90 guidelines [181], 100 mm diameter x 200 mm long cylinders were used for splitting tensile strength test (Fig.3.9). The test specimen was placed in the centering jig with packing strip and/or loading pieces carefully positioned along diametrically vertical planes at the top and bottom of the specimen. The maximum diametrical load applied was recorded.

Test :

As we know that the concrete is weak in tension. Tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. The usefulness of the splitting cube test for assessing the tensile strength of concrete in the laboratory is widely accepted and the usefulness of the above test for control purposes in the field is under investigation. The standard has been prepared with a view to unifying the testing procedure for this type of test for tensile strength of concrete. The load at which splitting of specimen takes place shall then be recorded. The universal testing machine (UTM) having capacity of 150tonne was used for the splitting tensile strength of the concrete cylinders.

The measured splitting tensile strength fsp of the sample was calculated

$$fsp = 2P / (\pi DL)$$

where, P = maximum load applied to the specimen, N

D = cross sectional diameter of the specimen, mm and

L = length of the specimen, mm

MIX DESIGN AND MIX PROPORTION

The concrete having compressive strength of 20N/mm^2(M20) is to be prepared by replacing the coarse aggregate by15%, 30%, 45% with coconut shell and replacing the cement 0%, 10%, 15% with silica fume. The strength performances of the modified concrete specimens are compared with conventional concrete.

6.1 CONCRETE MIX DESIGN FOR M20 GRADE

6.1.1 Material Properties

i) Cement

Type : 43 grade OPC confirming IS: 8112-1989

Specific Gravity: 3.01

Fine Aggregate

Type : Locally available river sand

Specific Gravity : 2.65

Coarse Aggregate

Maximum size :12.5 mm

Specific Gravity : 2.72

Water

PH value : 7.00

Mineral Admixture

Specific Gravity of Silica Fume:2.2

Mix Design(Table 5)

Stage	**Item**	**Reference or Calculation**	**Values**
1	**SELECTION OF TARGET W/C RATIO.**		
	Characteristic strength	Specified	20 N/mm^2 at 28 days
1.1	Standard deviation (σ)	M=Kσ	4
1.2	Margin	fc= fck+M	K=1.65 M=6.6 N/mm^2
1.3		specified	20 + 6.6 =

1.4	Target mean strength		26.6 N/mm^2
1.5	Cement Type	specified	OPC
1.6	Aggregate type		Coarse – crushed,fine-uncrushed
1.7	Free water/cement ratio		0.55
1.8	Maximum free water/cement ratio		0.55
2	**SELECTION OF FREE WATER CONTENT**		
2.1	Slump	Specified	50 -75 mm
2.2	Max-Aggregate size	Specified	20mm
2.3	Free-water content		192 kg/m^3
3	**DETERMINATION OF CEMENT CONTENT**		
3.1	Cement content		350 kg/m^3
3.2	Max cement content	Specified	
3.3	Min cement content	Specified	320 kg/m^3

4	**SELECTION OF FINE AND COARSE AGGREGATE CONTENT**		
4.1	Grading of fine aggregate	Zone II	MSA 20mm
4.2	Coarse aggregate content		0.66x1680=1108 kg/m^3
4.3	Fine aggregate content		615 kg/m^3

Table 6 Finalised Mix proportion

Finalised Mix	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (kg/m^3)	Water (l/m^3)
Proportion	1	1.79	3.17	0.55
CCM (M20) (IS:10262-2009	350	615	1110	192

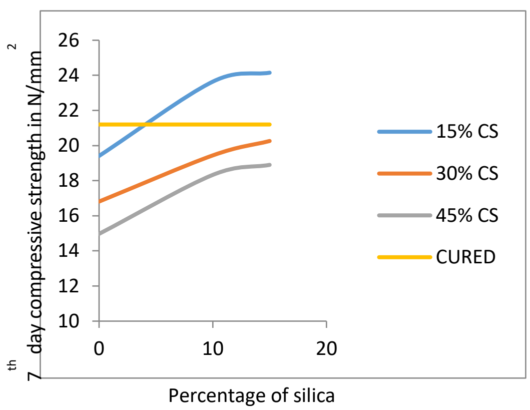
RESULTS AND DISCUSSIONS

GENERAL Experimental studies have been undertaken to evaluate the compressive strength, splitting tensile strength, flexural strength test of Rubberized Concrete using mineral admixtures(silica fume).

The densities at various proportions are shown below:

Table 7

Percentage of coconut shell	**Density (kg/m^3)**
0	2421
15	2315
30	2231
45	2136



COMPARISION OF COMPRESSIVE STRENGTH

Compression test according to IS: 516(1959) was carried out on the 150 x 150 x 150 mm cubes were tested for the compressive strengths of concrete specimens were determined after 7 and 28 days of standard curing. For coconut shell concrete, the results show that the addition of coconut shell as aggregate resulted in a significant reduction in concrete compressive strength compared with the control concrete. This reduction increased with increasing percentage of rubber aggregate. Table 7.1 below shows the results of the 7th and7.2 below shows the results of the 28th day compressive strength tests. The comparison of the results with the control concretes are shown graphically in Table 8 below:

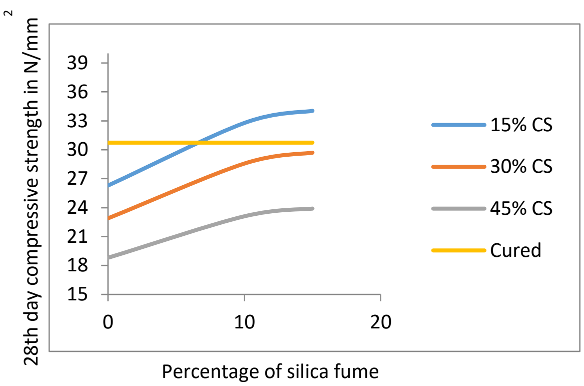
Table 8: Compressive Cube Strength at 7 days

Mix	Mean load at failure (kN)	Compressive strength (Mpa)	Reduction in strength (%)
CCM (M20)	477.9	21.24	--
CS-15,SF-0%	436.7	19.41	-8.6
CS-15,SF-10%	532.1	23.64	+11.3
CS-15,SF-15%	543.3	24.15	+13.7
CS-30,SF-0%	378.5	16.81	-20.8
CS-30,SF-10%	437.4	19.44	-8.5
CS-30,SF-15%	455.8	20.26	-4.6
CS-45,SF-0%	336.8	14.97	-29.5
CS-45,SF-10%	412.4	18.33	-13.7
CS-45,SF-15%	425.2	18.9	-11.4

Table 9: Compressive Cube Strength at 28 days

Mix	Mean load at failure (kN)	Compressive strength (Mpa)	Reduction in strength (%)
CCM (M20)	691.6	30.74	--
CS-15,SF-0%	590.4	26.29	-14.63
CS-15,SF-10%	737.5	32.78	+6.6

CS-15,SF-15%	765.9	34.04	+9.7
CS-30,SF-0%	515.1	22.89	-25.5
CS-30,SF-10%	642.8	28.57	-7.06
CS-30,SF-15%	668.4	29.71	-3.36
CS-45,SF-0%	423.2	18.81	-38.8
CS-45,SF-10%	534.8	18.33	-22.6
CS-45,SF-15%	558.9	18.92	-19.2



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