# EFFECTS ON PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF COARSE AGGREGATES : RECYCLED COARSE AGGREGATES AND COCONUT FIBRES AS SUBSTITUTE

**Submitted in partial fulfilment of the requirements**

**of the degree of**

**MASTER OF TECHNOLOGY**

**in**

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**by**


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# DECLARATION

I, Vishal Kumar Rattan (41400039), hereby declare that this thesis report entitled **"Effects on properties of concrete with partial replacement of coarse aggregates with recycled coarse aggregates and coconut fibres"** submitted in the partial fulfilment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter exemplified in this report has not been submitted in part or full to any other university or institute for the award of any degree.

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# CERTIFICATE

Certified that this project report entitled **““Effects on properties of concrete with partial replacement of coarse aggregates with recycled coarse aggregates and coconut fibres” s**ubmitted exclusively by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my observation for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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# ABSTRACT

Concrete, which is termed as “life line of Construction Industry” these days has a vital role in accelerating the construction industry. Ever since the manufacturing of Cement has been come into consideration, the Concrete has evolved very much innovatively and since then, various other improvements in it have been continuously coming into the limelight. Concrete is a composite material which is made with amalgamation of Cement, Fine aggregates (mainly sand) Coarse Aggregates and Water in desired quantities. The individual ratio of these components can be varied as per the properties required for the concrete. Researches are continuously been carried out to further enhance the properties of concrete whether it be the addition of various chemical admixtures to vary the strength gaining capacity of it, or delaying/retarding the setting time or increasing the flexural strength of the concrete. Recent innovation in concrete is the formation of Concrete Canvas in which the roll of concrete is laid along the surface and just by sprinkling water over it, the sheet hardens rapidly. The addition of Coconut fibres impart enhanced flexural rigidity of concrete and use of recycled coarse aggregates may result in saving the cost of construction but not beyond a certain limit. Though the researches have been carried out already for partial replacement of virgin coarse aggregates with recycled coarse aggregates and addition of coconut fibre individually, I have tried to find out the most optimum combination of both (RCA and CF). Various tests on concrete like compressive strength test, slump cone test, split tensile strength etc. shall be conducted. In my experimental approach I would also find the variation of cost of the modified and unmodified concrete as well, which may help in reducing the cost construction without compromising on strength parameters.

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## BACKGROUND

The evolution of concrete takes us back to 3000 BC when Egyptians used mud and straws to make bricks and gypsum along with addition of lime was used to make mortar. It was when Romans during 300 BC - 476 AD modified the constituents of binders along with addition of animal products to enhance the binding properties for the construction of the remarkable structures like the Pantheon and Colosseum. The substitute to concrete was found in about 1300 BC when builders from Middle-East found that the exterior of their mud coated walls when covered with burnt limestone, it reacted chemically under the action of atmospheric elements like rain, sun, air etc. to form a hard & durable coating of rock solid layer. Then later on crushed gypsum/limestone when burnt and added with sand and water formed modern mortar, which was widely used to adhere stones with each other. Over thousands of year these construction material have been improving at an enormous rate. Then later on, it was Joseph Aspdin of England in 1824 patented so called "Cement" of today's era. The official first strength testing of Concrete was done in 1836 in Germany. With the never ending improvements in the manufacturing of concrete, the first high-rise building was raised in Cincinnati, Ohio which stands 210 feet tall or 16 stories. Then came the French engineer Eugene Freyssinet who incorporated the use of Reinforced cement concrete. He built two parabolic arched airship hangar for Airport in Paris in 1928. The improvements in concrete and its applications kept on modifying and defying the laws of nature. Various other structures like Sydney's Opera house or Hoover Dam shows the versatility in the construction industry. The concrete and it's variation to be used in innovative form has always been the heart of Civil engineering.

# CHAPTER-2

# INTRODUCTION

## 2.1 General

Concrete is one of the remarkable and prominent material in field of construction. It is formed by adding cement, fine aggregates (sand), coarse aggregates and water in some fixed proportion. Cement when added in water starts reacting with it and forms a semi solid paste at the initial stage and then later on forms a hard matrix which has high strength and durability. These properties are due to presence of various elements in concrete and if these elements are varied during concrete manufacturing, the properties of concrete can be changed as well, as per the design requirements. Chemical admixtures can be added in concrete to delay or accelerate the setting time of the concrete. The requirement of these properties are different for different purpose of concrete construction. For instant if a concrete structure is to be casted under water, then it setting time needs to be reduced where as if the concrete is to be transported from the place of its manufacturing to the place of its casting, then it's setting time needs to be increased so that the concrete does not harden. Some alterations in concrete can be like:

- Reinforcement is embedded in concrete to impart high tensile strength because concrete is strong in compressive strength but has low tensile strength.
- Mineral admixtures like silica fume, fly ash, glass powder etc. are now being used these days to enhance the properties like workability, air entrainment in fresh concrete.
- Chemical admixtures are also being used during the manufacturing of concrete to deal with the setting time, initial strength, final strength and durability of the concrete.

Once the concrete has been casted, vibrations are induced in fresh concrete using mechanical vibrators, so that any air entrapped in concrete is removed. After that the concrete allowed to cure under water. As water is very essential in strength gaining in concrete, the quality of water is also to be considered for desired type of concrete. Each and every ingredient in concrete has its own role to play and their ratio during manufacturing of concrete is to be highly monitored.

## 2.2 Objectives

The main objective of this study is to find the most suitable combination of recycled coarse aggregates and percentage of coconut fibres for manufacturing of concrete which is economical and is complying the needs of minimum requirement of strength parameters as per standard codes. Following points shall be experimented:

- Effect of various combinations of RCA and CF on Compressive strength
- Effect of various combinations of RCA and CF on Split tensile strength
- Effect of various combinations of RCA and CF on the workability of concrete
- Analysis of concrete having various percentages of recycled coarse aggregates and coconut fibres.
- Variation of cost from standard concrete

## 2.3 Concrete and its composition

As already discussed the concrete is a hard matrix formed by mixing cement, sand, coarse aggregates, water and chemical/ mineral admixtures in the desired ratio.

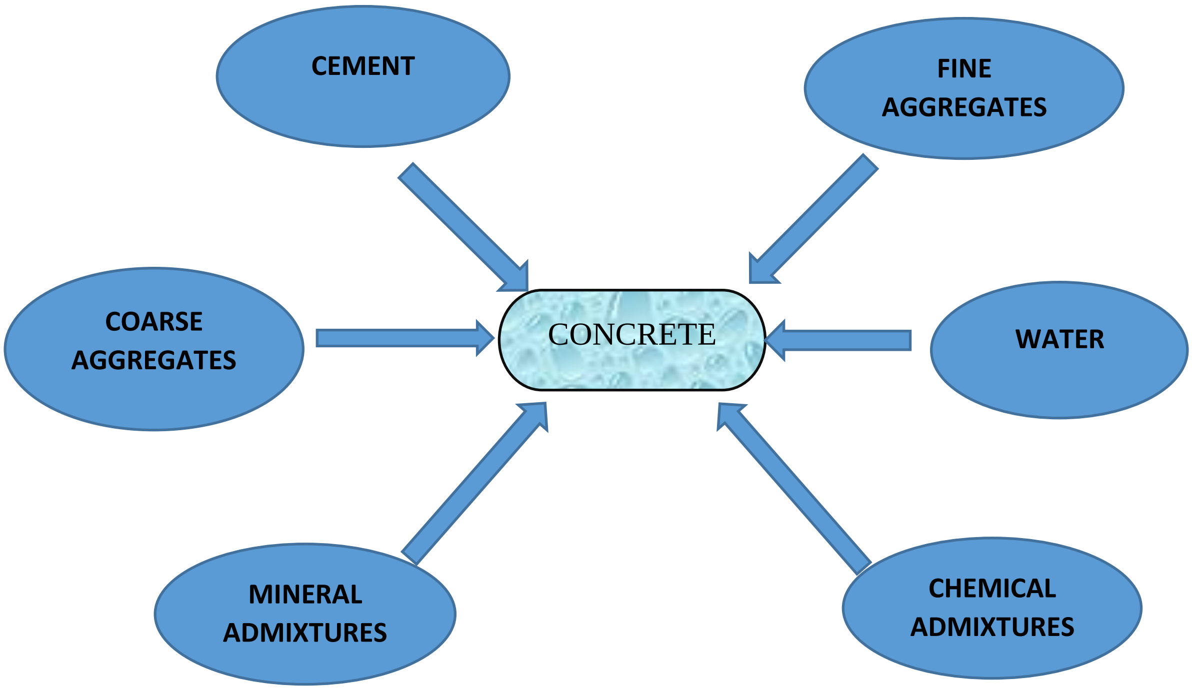



**Figure: 1 Composition of concrete**

## 2.3.1 Cement

Cement is one of the major constituent of concrete formation. It acts as a binder in concrete and is responsible for adhering the components of concrete. Cement used in construction industry is inorganic and is used in the powder form. It was Joseph Aspdin in 1824 of England who made cement.

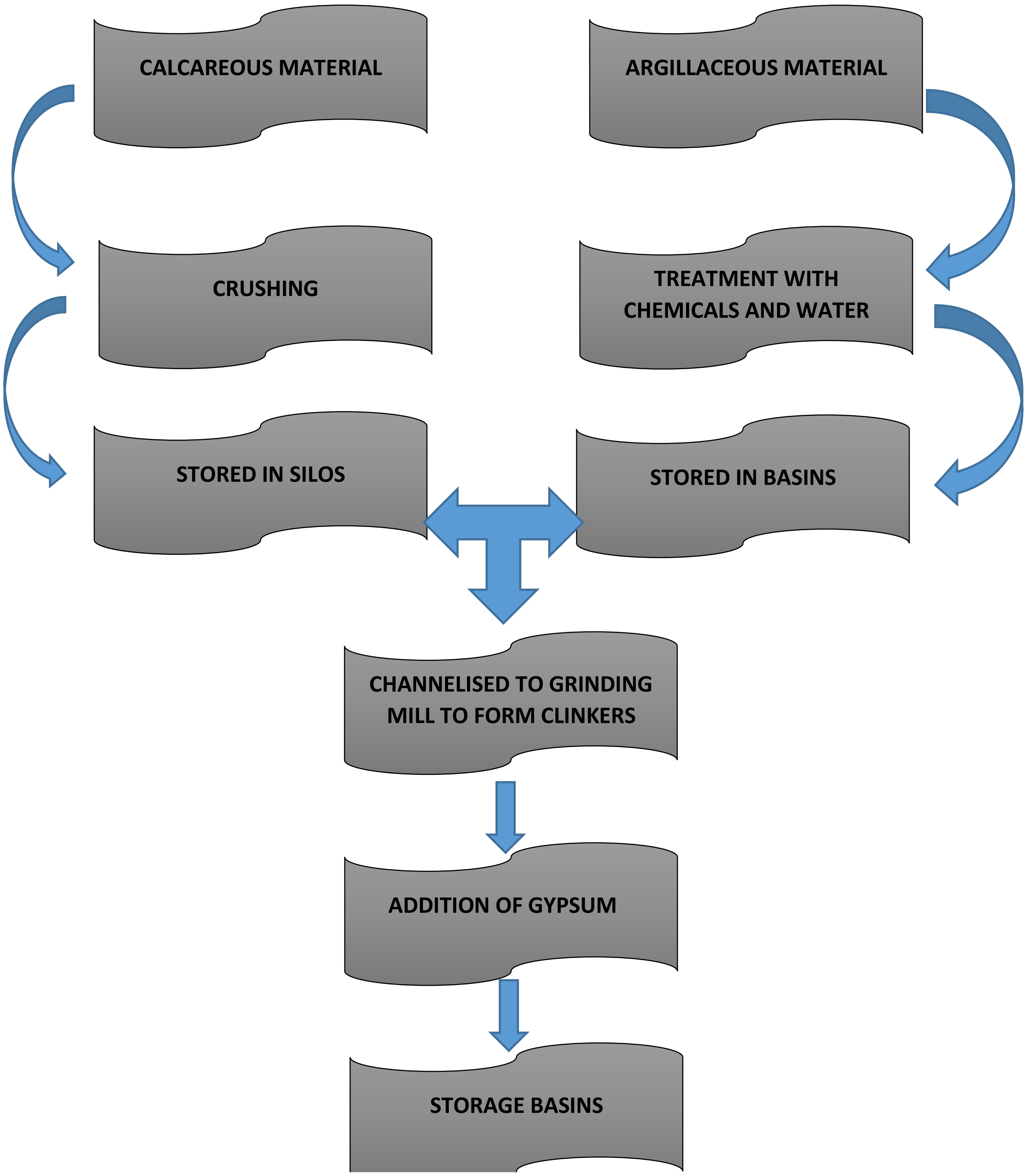



**Figure: 2 Flow chart of cement manufacturing process**

### 2.3.1.1 Chemistry of cement

First of all Calcium oxide is produced from Calcium carbonate by calcination at temperature around $820^0$C for about 10 hours.

$CaCO3 \rightarrow CaO + CO_2$

The calcium oxide is then slaked mixing it with water to make slaked lime (calcium hydroxide):

$CaO + H_2O \rightarrow Ca(OH)_2$

Once the excess water is completely evaporated the carbonation begins:

$Ca(OH)^2 + CO_2 \rightarrow CaCO_3 + H_2O$

### 2.3.1.2 Types of cement

Various types of cements can be classified on the basis of varying the composition during its manufacturing. Some of them are:

- Portland pozzolan cement
- Portland Silica fume cement
- Masonry cement
- Expansive cement
- Coloured cement
- Supersulphated cement
- Geopolymer cement
- Polymer cement

On the basis of requirements the type of cement is selected and is used in the production of concrete. At present China is the largest producer of cement followed by India and Iran. Manufacturing of cement has environmental effects as well. It's production emits huge amount of carbon dioxide in the atmosphere but in modern cement kilns many advanced features are used to lower the consumption for every ton of clinker produced. Around 3.7-3.8 gigajoules of energy is required to produce one ton of clinker and grind it to cement. From all the other ingredients of concrete, cement manufacturing is the most prominent one from energy consumption point of view. The by-products of cement manufacturing like fly ash are being produced in high amount every year and it has been very difficult to dispose it off. So some of the percentage of fly ash is added in cement and concrete to improve the workability of the concrete.

## 2.3.2 Water

Water is said to be the catalyst for concrete production. Unless water is added in the mixed ingredients of concrete, the matrix is of no use. The quality is to be highly monitored before using it for concrete production. It should have the following maximum limit standards:

- Turbidity should not exceed 2000 ppm
- Chloride content should be more than 500 ppm
- Alkali carbonates and Bicarbonates should not be more than 1000 ppm
- Sulphur trioxide ($SO_3$) should not exceed 1000 ppm
- pH of water to be used should be in range of 6 - 7.1

## 2.3.4 Admixtures

Chemical admixtures are the ones in liquid or powder form to be used to ensure certain characteristics in concrete which is not possible with plain concrete. Some of the types of chemical admixtures are:

- Accelerators
- Retarders
- Superplasticizers
- Air entraining agents
- Corrosion inhibitors
- Colouring pigments

Other class of admixtures is mineral admixtures, which are mostly in powdered form can be added during concrete manufacturing. Some of the mineral admixtures are:

- Fly ash
- Silica fume
- Ground granulated blast furnace slag (GGBS)
- Metakaolin

These admixtures are highly in demand these days as for same proportions of concrete ingredients different properties of concrete can be obtained just by altering the composition of these admixtures.

### 2.3.5 Aggregates

Aggregates are mainly responsible for imparting strength to the concrete. They are the one which consumes bulk of the concrete. Sand and coarse aggregates are mostly used for serving the purpose. Now a days recycled aggregates are being used as partial replacement of virgin coarse aggregates. Aggregates are mainly having much strength as compared to the binder. Different properties for aggregates are influenced by weathering action on the rocks with gradual variation of time. Also the cost of concrete is influence by the shapes and sizes of concrete used. Different strengths can be obtained by varying the redistribution of aggregates in concrete during compaction. Properties of aggregates are influenced by properties of the rock and properties of rocks are greatly influenced by the properties of constituent material.

Various types of natural rocks on the basis of their origin are:

- Metamorphic rocks
- Igneous rocks
- Sedimentary rocks

The specification of rock is sometimes defined by the texture it carries. Various other forms of rocks classification can be their shape and grain size distribution which is done by passing the aggregates through a set of sieves of defined sieve sizes. Desirable properties of aggregates are:

1. Strength:- Aggregates used for concrete construction should possess the required strength because they are mainly responsible for upholding the under the action of loads imparted from the structure.
2. Toughness:- Toughness is also one of the desired properties of the aggregates. In case of impact loading like in case of machine foundations, where the concrete is subjected to vibratory loading, these toughness parameters of the aggregates plays a vital role.
3. Durability:- The aggregates should be durable in order to enhance the life of concrete.
4. Shape of aggregates:- The shape of the aggregates is also important as the shape effects the adhesion between the aggregates and the binder. For example: round plane aggregates will be having weak bonds with the binder whereas the irregular aggregates shall be having higher bond strength with the binder and thereby resulting in high bond strength of the concrete.

### 2.3.6 Coconut fibres

Coconut fibres or coir fibres originate between the outer coat and hard shell of the coconut. The fibres are made of cellulose and their colour changes as they mature along the shell of the coconut.

Length of fibres can vary from 5 cm to 30 cm. They come in two varieties:

- Brown fibres: Brown fibres are thick and strong as they are obtained from fully ripened coconuts. These fibres are mainly used in manufacturing of mats, sacks and brushes. White coir fibres harvested from coconuts before they are ripe are white or light brown in colour and are smoother and finer, but also weaker. They are generally spun to make yarn used in mats or rope.
- White fibres: These fibres are immature fibres. They have lesser strength as compared to the brown fibres. They are immersed in water for about 6 months to promote the micro-organisms to break them/ loosen them. This process is also known as "Retting". Then the segments are beaten to separate the fibres and then they are dried and are spun in yarns to further manufacture products like mats etc.

Basically the coir fibres are available in three forms:

1. Bristle fibres ( long fibres)
2. Mattress fibres ( shorter length fibres)
3. Decorticated fibres ( Mixed length fibres)

For different purposes, different types of fibres can be used. For instant these fibres can be used in concrete to change its properties. The flexural strength can be increased and therefor the behaviour of concrete can be altered.

Advantages of CF:

- They repel the growth of moth
- Fungi resistant and rot proof
- Excellent insulators against sound and temperature
- Better durability and toughness

- Less effected by moisture
- Robust
- Better flexibility
- Not easily combustible

The husk of the coconut is derived from the natural surface of the matured coconut. The walls of the fibres are hollow are made up of cellulose. The presence of lignin ensures that the fibres are stronger and cellulose imparts flexibility of the fibre. The fibres are water proof and even salt water does not deteriorate the conditions of fibres.

Physical properties of coir fibres:

**Table: 1 Physical properties of coir fibres**

| Properties | Value |
|---|---|
| Ultimate length | 0.7 mm |
| Diameter | 17 micron |
| Density | 1.62 gm/cc |
| Breaking elongation | 30 % |
| Air filled porosity | Upto 65 % |
| pH | 5.8-6.5 |
| Swelling | 5 % in diameter ( for water) |
| Water holding capacity | Upto 35 % |

Coir fibres basically comprises of:

- Cellulose
- Lignin

- Hemi-cellulose

Various properties of coir fibres are highly effected by the composition of the above stated elements

Apart from physical properties of the fibres, the study of chemical properties is also essential

Chemical properties:

**Table:2 Chemical properties of coir fibres**

| Properties | Values |
|---|---|
| Soluble in water | 5.3% |
| Pectin and related compounds | 3.25% |
| Hemi-cellulose | 0.3% |
| Cellulose | 44% |
| Lignin | 46% |
| Ash | 1.15% |

In civil engineering, these coir fibres has vital role to play in enhancing the properties of concrete and plaster. Its insulating properties promote the use of coir fibres in platers. Also the addition of fibres in concrete impart flexural strength to the concrete and various percentages of fibres along with different lengths of the fibres shows different results. It prevents cracking in concrete as it increases the aspect ratio and surface of the aggregates in concrete. The detailed effects of properties of concrete with partial replacement of coarse aggregates with recycled coarse aggregates along with coir fibres is discussed in the coming context.

# CHAPTER-3

## LITERATURE REVIEW

1. **Alidea Abdullah*_et al_,** conducted various tests on concrete with varying percentages of coconut fibres. Various samples were casted and after that compressive strength was found out w.r.t percentages of coir fibres.

**Table:3 Compressive strength of the samples**

| Sample | Cement:Sand | Fibre(%) | Comp Strength (MPa) |
|---|---|---|---|
| 0 | 1:1.00 | 0 | 41.3 |
| 3 | 1:0.97 | 3 | 33.6 |
| 6 | 1:0.94 | 6 | 38.5 |
| 9 | 1:0.91 | 9 | 43.9 |

2. **M Etxeberia _et al._,** Conducted experiments on recycled coarse aggregates obtained by crushing on concrete. Four different samples of recycled aggregates concretes were produced with various percentages of 0%, 25%, 50% and 100% of recycled coarse aggregates, respectively. It was found that the moisture requirement in concrete increased as compared to standard concrete. The shape and texture of the aggregates can also affect the workability of the concrete. Concrete crushed by an impact crusher achieves a high percentage of coarse aggregates recycled without adhering mortar. Concrete made with 100% recycled gross aggregate requires a large amount of cement to achieve high compressive strength and therefore is not an economic proposition as it is not cost effective. Concrete made with 100% recycled coarse aggregates has 22-26% less compressive strength than conventional concrete at 28 days, with the same effective w / c ratio and amount of cement.

3. **Jianzhuang Xiao _et al._,** Conducted experiments on various percentages of recycled coarse aggregates and found out that with increase in percentages of recycled coarse aggregates the

values of compressive strength, elastic modulus and toughness decreased. Various other tests like workability and electrical conductivity were also conducted.

4. **Jiabian Li *et. al.*,** carried out various tests on concrete on different percentages of recycled coarse aggregates and found the following:

**Table: 4 Physical properties of Recycled coarse aggregates (RCA) and normal aggregates (NA)**

| Coarse Aggregate | Grading (mm) | Bulk Density ($kg/m^3$) | Apparent Density ($kg/m^3$) | Water absorption (%) |
|---|---|---|---|---|
| Normal | 5-31.6 | 1453 | 2820 | 0.4 |
| Recycled | 5-31.6 | 1290 | 2520 | 9.25 |

**Table: 5 Compressive strengths of Recycled coarse aggregates**

| No. | Slump (mm) | Density ($kg/m^3$) | $f_{cu}$ (MPa) | $f_c$ (MPa) | $f_c/f_{cu}$ |
|---|---|---|---|---|---|
| NC | 42 | 2402 | 35.9 | 26.9 | 0.75 |
| RC-30 | 33 | 2368 | 34.1 | 25.4 | 0.74 |
| RC-50 | 41 | 2345 | 29.6 | 23.6 | 0.80 |
| RC-70 | 40 | 2316 | 30.3 | 24.2 | 0.80 |
| RC-100 | 44 | 2280 | 26.7 | 23.8 | 0.89 |

5. **Khaldoun rahal *et al.*, (2007),** compared the mechanical properties of recycled aggregate concrete (RAC) and conventional normal aggregate concrete (NAC). Ten mixes of concrete with target compressive cube strength ranging from 20 to 50MPa were cast using normal or recycled coarse aggregates. The development of the cube compressive strength and the indirect shear strength at ages of 1, 3, 7, 14, 28 and 56 days, the compressive strength, the strains at maximum compressive stress and the modulus of elasticity tested by using concrete cylinders at 28 days are reported. The 28-day target compressive strength for all five mixes was achieved except for the 40 and 50MPa RAC where the observed strength was slightly

lower than the target strength. On the average, the 56-day cube strength was 5% and 3% higher than the 28-day strength for RAC and NAC respectively.

6. **Noor Md. Sadiquul Hasan, *et. al (2001)*** from Malaysia, have investigated the physical and mechanical characteristics of concrete after adding coconut fiber on a volume basis. They conducted a micro structural analysis test using a scanning electron microscope for understanding the bonding behaviour of the coconut fibres. They also studied the strength and durability of coconut fiber reinforced concrete in aggressive environments. Their aim was to mitigate the development of cracks in marine structures by introducing coconut fibres which would provide a localized reinforcing effect. Yalley, et.al, from United Kingdom performed various tests to study the enhancement of concrete properties after addition of coconut fiber. Their study focused on the coconut fiber obtained from Ghana Africa.They investigated the compressive strength, tensile strength, torsional strength, toughness and its ability to resist cracking and spalling. They also investigated compressive and flexural strength of coconut fibre reinforced mortar. Two cement-sand ratios by weight, 1:2.75 with water cement ratio of 0.54 and 1:4 with water cement ratio of 0.82 were considered. Fibre content was 0.08%,0.16% and 0.32% by total weight of cement, sand and water. The mortars for both design mixes without any fibres were also tested as reference. Cylinders of 50 mm diameter and 100 mm height and beams of 50 mm width, 50 mm depth and 200 mm length were tested. The curing was done for 8 days only. It was found that, compared to that of plain mortar of both mix designs, all strengths were increased in the case of fibre reinforced mortar with all considered fibre contents. However, a decrease in strength of mortar with an increase of fibre content was also observed.

7. **Cook *et al.*** reported the use of coconut fibre reinforced cement composites as low cost roofing materials. The parameters studied were fibre lengths (2.5, 3.75 and 6.35 cm), fibre volumes (2.5%, 5%, 7.5%, 10% and 15%) and casting pressure (from 1 to 2 MPa with an increment of 0.33 MPa). They concluded that the optimum composite consisted of fibres with a length of 3.75 cm, a fibre volume fraction of 7.5% and is casted under the pressure of 1.67 MPa. A comparison revealed that this composite was much cheaper than locally available roofing materials.

8. **Aziz *et al.*** cited the work of Das Gupta et al. who studied the mechanical properties of cement paste composites for different lengths and volume fractions of coconut fibres. Aziz et al. concluded that the tensile strength and modulus of rupture of cement paste increased when fibres up to 38 mm fibre length and 4% volume fraction were used. A further increase in length or volume fraction could reduce the strength of composite. The tensile strength of

cement paste composite was 1.9, 2.5, 2.8, 2.2 and 1.5 MPa when it was reinforced with 38 mm long coconut fibre and the volume fractions of 2%, 3%, 4%, 5% and 6%, respectively. The corresponding modulus of rupture was 3.6, 4.9, 5.45, 5.4 and 4.6 MPa, respectively. 4% volume fraction of coconut fibres gave the highest mechanical properties amongst all tested cases. With 4% volume fraction, they also studied the tensile strength of cement paste reinforced with different lengths of coconut fibres. With the fibre lengths of 25, 38 and 50 mm, the reported tensile strength was 2.3, 2.8 and 2.7 MPa, respectively. The results indicated that coconut fibres with a length of 38 mm and a volume fraction of 4% gave the maximum strength

.

9. **Li *et al.*** studied untreated and alkalized coconut fibres with the lengths of 20 mm and 40 mm as reinforcement in cementitious composites. Mortar was mixed in a laboratory mixer at a constant speed of 30 rpm, with cement: sand: water: super plasticizer ratio of 1:3:0.43:0.01 by weight, and fibres were slowly put into the running mixer. The resulting mortar had a better flexural strength (increased up to 12%), higher ability of energy absorption (up to 1680%) and a higher ductility (up to 1740%), and is lighter than the conventional mortar.

10. **Yasuamichi Koshiro *et al*., (2014),** investigated an entire concrete waste reuse model for producing recycled aggregate class H concrete established with the objective of recycling concrete waste generated during probable demolition of older buildings in urban areas. In a redevelopment project of Obayashi Technical Research Institute, a 24-year old building was demolished and concrete waste was used to produce high-quality recycled fine and coarse aggregate using a heat grinder system. Then the quality of concrete using these recycled materials was tested and applied to fair-faced concrete structures of a new building. Fine powder, a by-product in the recycling process, was also reused as a material for clay tiles to cover the floor of the new building. This model enabled all the concrete waste to be recycled.

# CHAPTER-4

## METHODOLOGY ADOPTED

Specimen to be prepared for testing is prepared by casting cubes of dimension 15cm*15cm*15cm. The process of making of concrete cubes and the apparatus required for the same is discussed in the following lines.

**Apparatus:**

- Cube Mould (150x150x150 mm)
- Tamping bar (16 mm diameter and bull-nosed)
- Steel Float/Trowel

**Procedure of Making Concrete Cube:**

Making concrete-cube specimen is simple and it is done in three simple steps:

1. **Cleaning & Fixing moulds**

- Clean the cube-mould properly and apply oil on inner surface of mould. But no oil should be visible on surface.
- Fix the cube mould with base plate tightly. No gap should be left in joints so that cement-slurry doesn't penetrate.

**Figure: 3 Fixing cube with base plate**

**Figure: 4 Applying oil on inner surface of the moulds**

**2. Placing, Compacting & Finishing concrete**

- Take concrete from three or four random mixes.
- Place concrete into mould in three layers. Compact each layer by giving 25 blows of tamping bar.
- Remove excess concrete from the top of mould and finish concrete surface with trowel. Make the top surface of concrete cube even and smooth.
- Leave the mould completely undisturbed for first four hours after casting.
- After ending undisturbed period, put down casting date and item name on the top of concrete specimen with permanent marker.
- Also care should be taken while placing the moulds so that the samples do not mix up with other samples.

**Figure: 5 Concrete prepared**

**Figure: 6 Moulds prepared (should be left undisturbed)**

**3. Curing**

- After 8 to 10 hours of casting, wrap the cube mould with wetted hessian cloth. Cover the mould's top portion with a polythene sheet so that water doesn't fall on concrete surface.
- Uncover and remove the cube specimens from mould after 24±½ hours of casting. For removing specimen from mould, first loosen all nut-bolts and carefully remove specimen because concrete is still weak and can be broken.
- Immediately after removing, put the specimen into a tank of clean water for curing. Make sure cube specimen is fully submerged in water.

**Figure: 7 Cubes taken out from moulds for curing**



**Figure: 8 Curing of cubes**

Generally three cube specimens are tested separately at laboratory and the average result is counted as concrete compressive-strength. So three specimens on site at a time were made and tested for different combinations of RCA and Coconut fibres.

## 4.1 SLUMP CONE TEST

The concrete slump test is an empirical test that measures workability of fresh concrete. The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the ease with which concrete flows. It is used to indicate degree of wetness.

Consistency affects workability of concrete. That is, wetter mixes are more workable than drier mixes, but concrete of the same consistency may vary in workability. The test is also used to determine consistency between individual batches.

The test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformity for different batches of concrete under field conditions and to ascertain the effects of plasticizers on their introduction. In India, this test is conducted as per IS specification.

### Principle

The slump test measures the resulting behaviour of a compacted inverted cone of concrete under the action of gravity. It indicates consistency or wetness of concrete

### Apparatus

Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 100 mm and bottom internal diameter 200 mm with a height of 300 mm. A 600 mm long bullet nosed metal damping rod, 16 mm in diameter.

**Figure: 9 Apparatus of Slump Cone Test**

**Procedure**

- The test is carried out using a mould known as a slump cone or Abrams cone.
- The cone is placed on a hard non-absorbent surface.
- This cone is filled with fresh concrete in three stages.
- Each time, each layer is tamped 25 times with a rod of standard dimensions.
- At the end of the third stage, concrete is struck off flush to the top of the mould.
- The mould is carefully lifted vertically upwards with twisting motion, so as not to disturb the concrete cone.

Concrete subsidence:- This subsidence is termed as slump, and is measured to the nearest 5 mm if the slump is <100 mm and measured to the nearest 10 mm if the slump is >100 mm.

**Figure:10 Layer by layer compaction**

**Figure:11 Lifting the mould vertically**

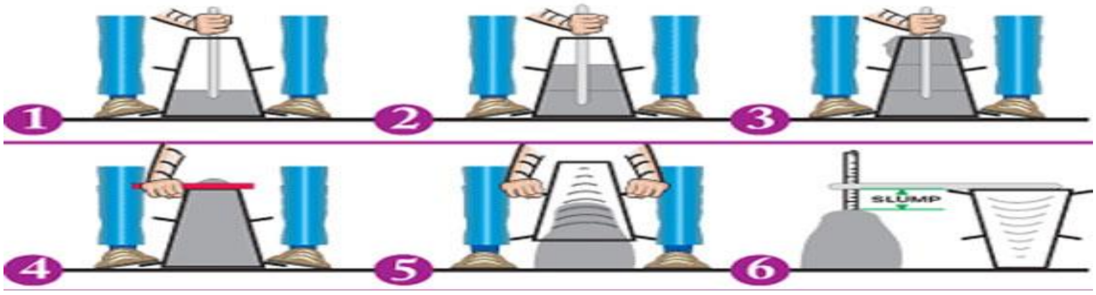



**Figure: 12 Diagrammatic representation of step by step procedure of the slump cone test**

## 4.2 TEST FOR COMPRESSIVE STRENGTH

Out of many tests applied to the concrete, this is the utmost important one which gives an idea about all the characteristics of concrete. By this single test one can judge that whether concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc.

**Principle**

Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommends concrete cylinder or concrete cube as the standard specimen for the test. Since the compressive strength test is to be carried out for a cube, so cubical moulds of size 15*15*15cm are used.

**Procedure (outline for cube preparation )**

- The prepared concrete is poured in the moulds and tempered properly so as not to have any voids.
- After 24 hours these moulds are removed and test specimens are put in water for curing.
- The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.
- These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load at the failure divided by area of specimen gives the compressive strength of concrete.

**Apparatus**

Compressive strength testing machine

**Specimen**

54 cubes of 15 cm size, Mix. M20

**Mixing**

Mixing of concrete is done by hand.

**Hand Mixing**

- Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform colour
- Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.
- Add water and mix it until the concrete appears to be homogeneous and of the desired consistency

**Sampling**

- Clean the mounds and apply oil.
- Fill the concrete in the moulds in layers approximately 5cm thick.
- Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end).
- Level the top surface and smoothen it with a trowel

**Curing**

The test specimens are stored in moist air for 24hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

**Procedure**

- Remove the specimen from water after specified curing time and wipe out excess water from the surface.

- Take the dimension of the specimen to the nearest 0.2m
- Clean the bearing surface of the testing machine


**Figure:13 Placing of specimen on test plate**


**Figure:14 Preparing the machine**

- Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
- Align the specimen centrally on the base plate of the machine.
- Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

**Figure:15 Specimen under compression**

**Figure:16 Failing of specimen**

- Apply the load gradually without shock and continuously till the specimen fails.
- Record the maximum load and note any unusual features in the type of failure.

# CHAPTER-5

## CALCULATIONS

**Cubes with RCA-30% and 3% Coconut Aggregates.** Concrete cube of M20 were made by replacing 30% of Coarse Aggregates with Recycled Coarse Aggregates and by Adding 3% of Coconut Fiber to the weight of cement. Following were the readings:

**<u>Compressive Strength and Tensile Strength Readings on 7$^{th}$ Day with RCA-30% and Coconut Fiber-3%</u>**

**<u>Compressive Strength Readings</u>**

C1=compressive strength of cube C-1 on 7$^{th}$ day with replacement of 30%, 3 %(recyclable coarse aggregates, coconut fiber).

C2= compressive strength of cube C-2 on 7$^{th}$ day with replacement of 30%,3% (recyclable coarse aggregates,coconut fiber).

C3= compressive strength of cube C-3 on 7$^{th}$ day with replacement of 30%,3% (recyclable coarse aggregates, coconut fiber).

C1=249.95KN

C2=225.19KN

C3=235.28KN

Calculated strength

C1(stress)=force/area (249.95*10^3)/150*150)=11.10N/mm$^2$

C2(stress)=force/area (225.19*10^3)/150*150)=10N/mm$^2$

C3(stress)=force/area (235.29*10^3)/150*150)=10.45N/mm$^2$

Average strength=(11.10+10+10.45)/3

**Therefore, Average Compressive strength=31.5/3=10.51 N/mm$^2$**

**Tensile Strength Readings**

T1= Tensile strength of concrete of cube T-1 on 7$^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T2= Tensile strength of concrete of cube T-2 on 7$^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T3= Tensile strength of concrete of cube T-3 on 7$^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T1=64.44KN

T2=68.82KN

T3=70.56KN

T1(stress)=force/area (64.44*10^3)/150*150)=2.86N/$mm^2$

T2(stress)=force/area (68.82*10^3)/150*150)=3N/$mm^2$

T3(stress)= force/area (70.56*10^3)/150*150)=3.13N/$mm^2$

Average strength=(2.86+3+3.13)/3

**Therefore, Average Tensile strength=9/3=3N/$mm^2$**



**Figure:17 (Tensile Concrete Cubes)** **Figure:18 (Compression Concrete Cubes)**

## Compressive Strength and Tensile Strength Readings on $14^{th}$ Day with RCA-30% and Coconut Fiber-3%

### Compressive Strength

C4 = compressive strength of cube C-4 on $14^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

C5 = compressive strength of cube C-5 on $14^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

C6 = compressive strength of cube C-6 on $14^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

C4 (stress) = force/area (316.6*10^3)/150*150) = 14.07N/mm^2

C5 (stress) = force/area (285.19*10^3)/150*150) = 12.67N/mm^2

C6 (stress) = force/area (298.29*10^3)/150*150) = 13.25N/mm$^2$

Average strength = (14.07+12.67+13.25)/3

**Therefore, Average Compressive strength is = 40/3 = 13.33N/mm^2**

### Tensile Strength

T4 = Tensile strength of concrete of cube T-4 on $14^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T5 = Tensile strength of concrete of cube T-5 on $14^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T6 = Tensile strength of concrete of cube T-6 on $14^{th}$ day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T4 (stress) = force/area (82*10^3)/150*150)=3.64N/mm^2

T5 (stress) = force/area (86.82*10^3)/150*150)=3.85N/mm^2

T6 (stress) = force/area (88.56*10^3)/150*150)=3.93N/mm^2

Average strength=(3.64+3.85+3.93))/3

**Therefore, Average Tensile strength is =11.42/3=3.80N/mm^2**

## Compressive Strength and Tensile Strength Readings on 28th Day with RCA-30% and Coconut Fiber-3%

### Compressive Strength

C7 = compressive strength of cube C-7 on 28th day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

C8 = compressive strength of cube C-8 on 28th day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

C9 = compressive strength of cube C-9 on 28th day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

C7 (stress) = force/area (422.6*10^3)/150*150) = 18.78N/mm$^2$

C8 (stress) = force/area (462*10^3)/150*150) = 20.53N/mm$^2$

C9 (stress) = force/area (482*10^3)/150*150) = 21.55N/mm$^2$

Average strength = (18.78+20.53+21.55)/3

**Therefore, Average Compressive strength=60.83/3=20.23N/mm$^2$**

### Tensile Strength

T7 = Tensile strength of concrete of cube T-7 on 28th day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T8 = Tensile strength of concrete of cube T-8 on 28th day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T9 = Tensile strength of concrete of cube T-9 on 28th day with replacement of 30%, 3% (recyclable coarse aggregates, coconut fiber).

T7 (stress) = force/area (106*10^3)/150*150) = 4.71N/mm$^2$

T8 (stress) = force/area (108.82*10^3)/150*150) = 4.83N/mm$^2$

T9 (stress) = force/area (110.56*10^3)/150*150) = 4.91N/mm$^2$

Average strength = (4.71+4.83+4.91))/3

**Therefore, Average Tensile strength = 14.42/3 = 4.81N/mm$^2$**

**Cubes with RCA-40% and 4% Coconut Fiber**

Concrete cube of M20 were made by replacing 40% of Coarse Aggregates with Recycled Coarse Aggregates and by Adding 4% of Coconut Fiber to the weight of cement. Following were the readings:

**Compressive Strength And Tensile Strength Readings On 7$^{th}$ Day with RCA-40% and Coconut Fiber-4%**

**Compressive Strength**

C10 = compressive strength of cube C-10 on 7$^{th}$ day with replacement of 40%, 4%(recyclable coarse aggregates, coconut fiber).

C11 = compressive strength of cube C-11 on 7$^{th}$ day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

C12 = compressive strength of cube C-12 on 7$^{th}$ day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

C10 (stress) = force/area (208.10*10^3)/150*150) = 9.24N/mm$^2$

C11 (stress) = force/area (216.19*10^3)/150*150) = 9.61N/mm$^2$

C12 (stress) = force/area (223.38*10^3)/150*150) = 9.92N/mm$^2$

Average strength = (9.24+9.61+9.92)/3

**Therefore, Average Compressive Strength = 28.77/3 = 9.59N/mm$^2$**

**Tensile Strength**

T10 = Tensile strength of concrete of cube T-10 on 7$^{th}$ day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

T11 = Tensile strength of concrete of cube T-11 on 7$^{th}$ day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber)

T12 = Tensile strength of concrete of cube T-12 on 7$^{th}$ day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

T10 (stress) = force/area (59*10^3)/150*150) = 2.62N/mm$^2$

T11 (stress) = force/area (54.82*10^3)/150*150) = 2.43N/mm$^2$

T12 (stress) = force/area (55.56*10^3)/150*150) = 2.46N/mm$^2$

Average strength=(2.62+2.43+2.46)/3

**Therefore, Average Tensile Strength=7.51/3=2.50N/mm$^2$**

## Compressive Strength And Tensile Strength Readings On 14th Day with RCA-40%and Coconut Fiber-4%

### Compressive Strength

C13 = compressive strength of cube C-13 on 14th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

C14 = compressive strength of cube C-15 on 14th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

C15 = compressive strength of cube C-15 on 14th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

C13 (stress) = force/area (264*10^3)/150*150) = 11.73N/mm$^2$

C14 (stress) = force/area (276.19*10^3)/150*150) = 12.26N/mm$^2$

C15 (stress) = force/area (297*10^3)/150*150) = 13.2N/mm$^2$

Average strength = (11.73+12.26+13.2)/3

**Therefore, Average Compressive Strength = 37.19/3 = 12.39N/mm$^2$**

### Tensile Strength

T13 = Tensile strength of concrete of cube T-13 on 7th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

T14 = Tensile strength of concrete of cube T-14 on 7th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber)

T15 = Tensile strength of concrete of cube T-15 on 7th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

T13 (stress) = force/area (75*10^3)/150*150) = 3.33N/mm$^2$

T14 (stress) = force/area (72.82*10^3)/150*150) = 3.23N/mm$^2$

T15 (stress) = force/area (73.56*10^3)/150*150) = 3.26N/mm$^2$

Average strength = (3.33+3.23+3.26))/3

**Therefore, Average Tensile Strength = 9.82/3 = 3.27N/mm$^2$**

**Compressive Strength And Tensile Strength Readings On 28th Day with RCA-40% and Coconut Fiber-4%**

**Compressive Strength**

C16 = compressive strength of cube C-16 on 28th day with replacement of 40%, 4%(recyclable coarse aggregates, coconut fiber).

C17 = compressive strength of cube C-17 on 28th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

C18 = compressive strength of cube C-18 on 28th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

C16 (stress) = force/area (343*10^3)/150*150) = 5.24N/mm$^2$

C17 (stress) = force/area (358.19*10^3)/150*150) = 15.93N/mm$^2$

C18 (stress) = force/area (386.12*10^3)/150*150) = 17.16N/mm$^2$

Average strength = (15.24+15.93+17.16)/3

**Therefore, Average Compressive Strength=48.33/3=16.11N/mm$^2$**

**Tensile Strength**

T16 = Tensile strength of concrete of cube T-16 on 28th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

T17 = Tensile strength of concrete of cube T-17 on 28th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber)

T18 = Tensile strength of concrete of cube T-18 on 28th day with replacement of 40%, 4% (recyclable coarse aggregates, coconut fiber).

T13(stress)=force/area (97*10^3)/150*150)=4.33N/mm$^2$

T14(stress)=force/area (92.82*10^3)/150*150)=4.13N/mm$^2$

T15(stress)=force/area (95.56*10^3)/150*150)=4.26N/mm$^2$

Average strength=(4.33+4.13+4.26))/3

**Therefore, Average Tensile Strength=12.72/3=4.24N/mm$^2$**

**Cubes with RCA-50% and 5% Coconut Fiber**

Concrete cube of M20 were made by replacing 50% of Coarse Aggregates with Recycled Coarse Aggregates and by Adding 5% of Coconut Fiber to the weight of cement. Following were the readings:

**Compressive Strength and Tensile Strength Readings On 7$^{th}$ Day with RCA-50% and Coconut Fiber-5%**

**Compressive Strength**

C19 = compressive strength of cube C-19 on 7$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C20 = compressive strength of cube C-20 on 7$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C21 = compressive strength of cube C-21 on 7$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C19=249.95KN

C20=225.19KN

C21=235.28KN

Calculated strength

C19 (stress) = force/area (199*10^3)/150*150)=8.84N/mm$^2$

C20 (stress) = force/area (183*10^3)/150*150)=8.13N/mm$^2$

C21 (stress) = force/area (192.8.29*10^3)/150*150)=8.56N/mm$^2$

Average strength=(8.84+8.13+8.56)/3

**Therefore, Average Compressive strength=25.53/3=8.51N/mm$^2$**

**Tensile Strength Readings**

T19 = Tensile strength of concrete of cube T-19 on 7$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T20 = Tensile strength of concrete of cube T-20 on 7$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T21 = Tensile strength of concrete of cube T-21 on 7$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T19 = 64.44KN

T20 = 68.82K5

T21 = 70.56KN

T19 (stress)=force/area (48.44*10^3)/150*150)=2.14N/mm$^2$

T20 (stress)=force/area (52.82*10^3)/150*150)=2.34N/mm$^2$

T21 (stress)= force/area (54.56*10^3)/150*150)=2.42N/mm$^2$

Average strength = (2.14+2.34+2.42))/3

**Therefore, Average Tensile strength=6.9/3=2.3N/mm$^2$**

**Figure:19 (Tensile Concrete Cubes)** **Figure:20 (Compression Concrete Cubes)**

## Compressive Strength and Tensile Strength Readings On 14th Day with RCA-50% and Coconut Fiber-5%

### Compressive Strength

C22 = compressive strength of cube C-22 on 14th day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C23 = compressive strength of cube C-22 on 14th day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C24 = compressive strength of cube C-24 on 14th day with replacement of 50%,5% (recyclable coarse aggregates, coconut fiber).

C22 (stress) = force/area (232.19*10^3)/150*150) = 10.31N/mm$^2$

C23 (stress) = force/area (242.32*10^3)/150*150) = 10.67N/mm$^2$

C24 (stress) = force/area (252.9*10^3)/150*150) = 11.25N/mm$^2$

Average strength = (10.31+10.67+11.25)/3

**Therefore, Average Compressive strength is = 32.23/3 = 10.73N/mm$^2$**

### Tensile Strength

T22 = Tensile strength of concrete of cube T-22 on 14th day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T23 = Tensile strength of concrete of cube T-23 on 14th day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T24 = Tensile strength of concrete of cube T-24 on 14th day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T22 (stress) = force/area (60*10^3)/150*150) = 2.64N/mm$^2$

T23 (stress) = force/area (64.82*10^3)/150*150) = 2.85N/mm$^2$

T24 (stress) = force/area (66.56*10^3)/150*150) = 2.93N/mm$^2$

Average strength = (2.64+2.85+2.93))/3

**Therefore, Average Tensile strength is = 8.42/3 = 2.80N/mm$^2$**

## Compressive Strength And Tensile Strength Readings On 28$^{th}$ Day with RCA-50% and Coconut Fiber-5%

### Compressive Strength

C25 = compressive strength of cube C-25 on 28$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C26 = compressive strength of cube C-26 on 28$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C27 = compressive strength of cube C-27 on 28$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

C25 (stress) = force/area (332*10^3)/150*150) = 14.75N/mm$^2$

C26 (stress) = force/area (305.61*10^3)/150*150) = 13.58N/mm$^2$

C27 (stress) = force/area (321.97*10^3)/150*150) = 14.39N/mm$^2$

Average strength = (14.75+13.58+14.39)/3

**Therefore, Average Compressive strength=42.72/3=14.23N/mm$^2$**

### Tensile Strength

T25 = Tensile strength of concrete of cube T-25 on 28$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T26 = Tensile strength of concrete of cube T-26 on 28$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T27 = Tensile strength of concrete of cube T-27 on 28$^{th}$ day with replacement of 50%, 5% (recyclable coarse aggregates, coconut fiber).

T25 (stress) = force/area (80.2*10^3)/150*150) = 3.55N/mm$^2$

T26 (stress) = force/area (84.62*10^3)/150*150) = 3.70N/mm$^2$

T27 (stress) = force/area (86.36*10^3)/150*150) = 3.83N/mm$^2$

Average strength = (3.55+3.70+3.83)/3

**Therefore, Average Tensile strength = 11.02/3 = 3.69N/mm$^2$**

# CHAPTER-6

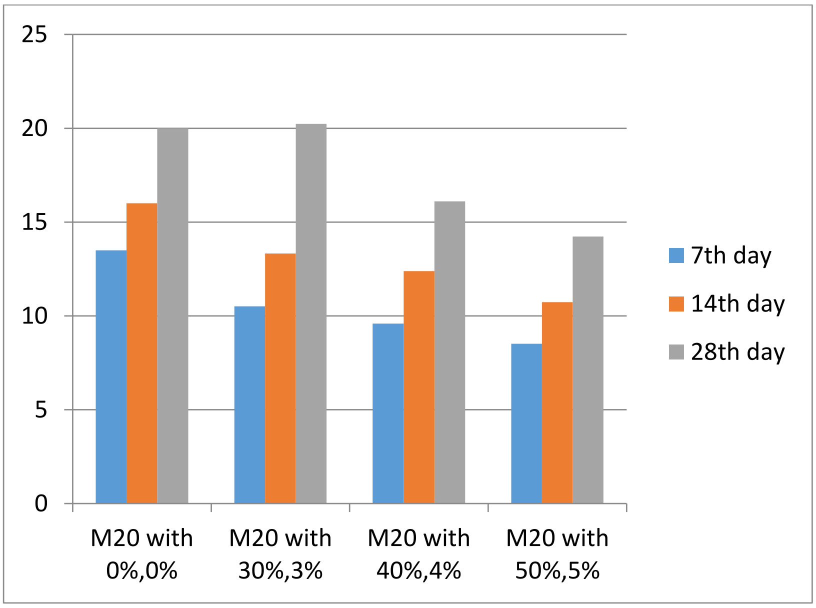
## RESULT AND ANALYSIS

### 6.1 Average Compressive Strength

**Table: 6 Average compressive strength**

| Combination | 7-day (N/mm$^2$) | 14-day (N/mm$^2$) | 28-day (N/mm$^2$) |
|---|---|---|---|
| M20 with 0%, 0% | 13.5 | 16 | 20 N/mm^2 |
| M20 with 30%, 3% | 10.51 | 13.33 | 20.23 |
| M20 with 40%, 4% | 9.59 | 12.39 | 16.11 |
| M20 with 50%, 5% | 8.51 | 10.73 | 14.23 |

It was analyzed that on replacing 30% coarse aggregates with recycled coarse aggregates and adding 3% coconut fiber gives a strength of 20.23 for curing them for 28 days which is equivalent to the strength of basic M20 therefore the desired strength of M20 can also be achieved by replacing 30% of coarse aggregates with RCA and adding 3% of coconut fiber to it.




X- axis – RCA and CF

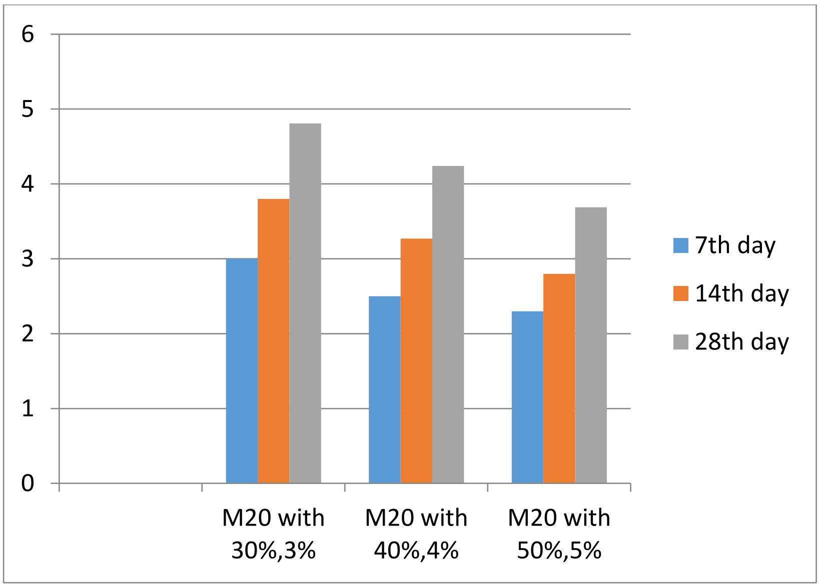
**Figure:21 Compressive strength graph** Y-axis – Strength(N/mm$^2$)

### 6.2. Average Tensile Strength

**Table: 7 Average Tensile Strength**

| Combination | 7-day (N/mm$^2$) | 14-day (N/mm$^2$) | 28-day (N/mm$^2$) |
|---|---|---|---|
| M20 with 30%, 3% | 3 | 3.8 | 4.81 |
| M20 with 40%, 4% | 2.5 | 3.27 | 4.24 |
| M20 with 50%, 5% | 2.3 | 2.8 | 3.69 |

It was analyzed that on replacing 30% coarse aggregates with recycled coarse aggregates and adding 3% coconut fiber gives the tensile strength of 4.81 N/mm^2 for curing them for 28 days. It was also analyzed that the tensile strength was increasing when the cubes are cured for more days in water but the maximum tensile strength was achieved by M20 with 30%, 3% if cured for 28 days in water.




X- axis – RCA and CF

**Figure:22 Tensile strength graph**

Y-axis – Strength(N/mm$^2$)

### 6.3. Slump Test Results

Slump test with different concrete made with the replacement of RCA and addition of Coconut fiber were done and therefore observations were taken. Following were the observations:-

M20 with 0%, 0% - 36mm

M20 with 30%, 3% - 29mm

M20 with 40%, 4% - 26mm

M20 with 50%, 5% - 22mm

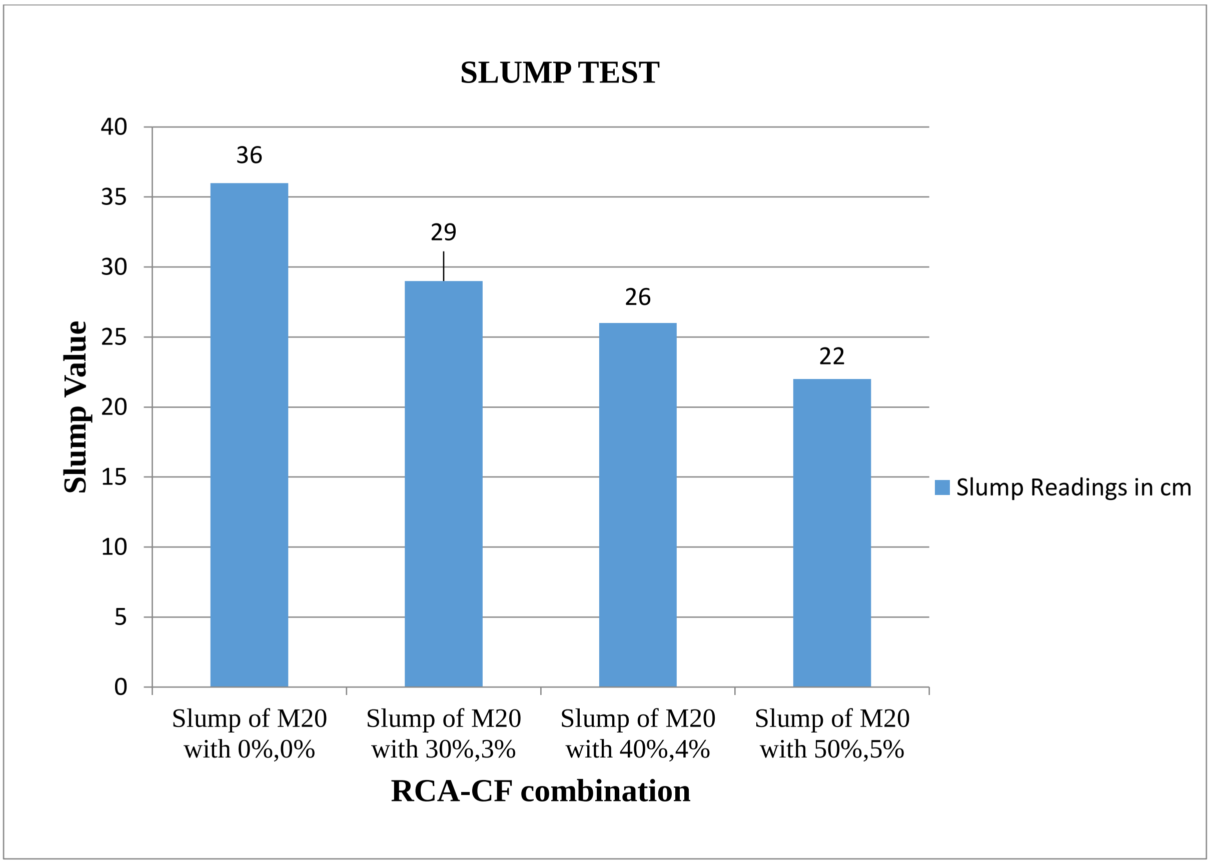



**Figure:23 Slump Test graph**

It was observed that on increasing the quantity of RCA and Coconut fiber, the slump value of the concrete mix is decreasing. This was due to the addition of more coconut fiber as they were absorbing water.

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