ABSTRACT

Concrete is the foremost vital requirement of any development, without concrete no development industry may ever exist. Concrete comprises of Cement, Sand or (Fine Total), Rock (Coarse Total), Water, Admixtures, Added substances. In this study partial replacement of cement is done by Ground Shell Ash in certain percentage (15%) replacement and with addition of various percentages of Sisal fiber (0%, 0.5%, 1%, 1.5% & 2%) in concrete.

This section deals with common introduction on the concept of Use of Groundnut Shell Ash as Partial substitute of Cement with the addition of Sisal fiber in Concrete. Groundnut Shell Ash is waste material produced by local markets on shops, carts etc and in large amount by oil industry and many other large scale industry where the shell emerges as waste product. A large of waste is produced by such regular use of groundnut. This can be used as a construction material by partially replacing cement that can reduce overall cost and in addition to this waste management is also taking place. A little research is done in this field to find the strength properties of Ground Shell Ash utilized concrete.

Since the plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. Strength and durability of concrete produced by such secondary materials can be enhanced by making suitable changes in its ingredients like cementitious material, aggregate and water and by adding some special ingredients like fibers. Fibers like steel fibers, plastic fibers and glass fibers etc. The function of randomly dispersed fibers is to bridge across the cracks that provides some post cracking ductility. If the fibers like Sisal fibers which perfectly bonded to the material, permits the FRC to carry noteworthy stresses over a relatively large strain capacity in post cracking state.

Key Words: FRC (Fiber Reinforced Concrete), GSA (Ground Shell Ash Powder), Sisal Fiber, Durability etc.

CHAPTER: 1

INTRODUCTION

1.1 General Introduction

Concrete is the composition of coarse aggregate, fine aggregate, cement, sand and water. It may also have admixtures and other additives. It is the most popular building material in the world and used from prolong time. In concrete, aggregate is the major component after cement. The yearly production of cement is nearly 3 billion tons. The construction industry relies heavily on cement for production of concrete. Nearly 7% of the global CO2 emission is contributed by cement industries. Reducing the consumption of cement in the concrete will thus reduce the emission. Its great adaptability and relative economy in filling wide range of needs has made it a competitive building material. The demand of concrete for today's infrastructural expansion is increasing gradually.

Since the plain, unreinforced concrete is a brittle material, with a low tensile strength and possess low strain capacity. Sometimes concrete structures have to survive in adverse conditions under chemical attacks like chloride attack, sulphate attack and acid attack. These chemical attacks interferes with the durability of concrete structure. For hardened reinforced concrete chloride attack is considered as a cause for corrosion. Chemicals percolate through the cracks developed in the concrete structures and corrode the reinforcement provided in the concrete and thus the deterioration of structure starts and the durability of structure get affected.

The use of fibres in concrete is from ancient times, to increase the tensile strength and flexure strength of concrete various researchers investigated the effects of fibres on various properties of concrete. Since then Fibres such as steel, glass, carbon and Sisal are use in concrete. Addition of fibre in concrete also intervenes with properties like brittle behaviour and ductility.

Sisal fiber is derived from an agave, Agave sisalana. It is valued for cordage because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and, like coir, it is resistant to deterioration in saltwater. The higher-grade fiber is converted into yarns for the carpet industry. The function of randomly dispersed fibers is to bridge across the cracks that provides some post cracking ductility.

If the fibers like Sisal fibers which are strong enough and perfectly bonded to the material, permitting the FRC to carry noteworthy stresses over a relatively large strain capacity in post cracking state. Different types of Sisal fibers can be used to reinforce concrete. Use of Sisal fibers reduces the generation of cracks.

This research investigates the effect of Sisal fibre on M 30 grade of concrete mix when some proportion of cement is replaced with Ground Shell Ash. And also analyse a cost-effective parameter

The percentage of replacement of cement with Ground Shell Ash has been kept constant that is 15% by weight and the proportion of Sisal fibre are varied in the percentage (0%, 0.5%, 1%, 1.5% & 2%)

For this research Ground Shell Ash used was obtained from local vendor, Jaipur, Rajasthan having following properties

Constituent	% Composition (GSA)	% Composition OPC
Ferrous oxide (Fe_2O_3)	1.80	4.65
Silica (SiO_2)	16.21	22.00
Calcium Oxide (CaO)	8.69	62
Aluminum Oxide (Al_2O_3)	5.93	5.03
Magnesium Oxide (MgO)	6.74	2.06
Sodium Oxide (Na_2O)	9.02	0.19
Potassium Oxide (K_2O)	15.73	0.40
Sulphite (SO_3^{2-})	6.21	1.43

1.2 Objectives of Study

The main objective of this study is addition of Sisal fiber and partially replacement of cement with Ground Shell Ash to gain the best result in conjunction with the compressive strength, split tensile strength, flexural strength and workability etc.

- To reduce the crack developed in concrete due to shrinkage of concrete.
- To increase the compressive, tensile and flexural strength of concrete using Sisal fiber.
- To reduce the freezing and thawing damage in concrete and fire damage also.
- To increase in resistance to failure due to impact load in concrete.
- To analyze workability of fresh concrete.

1.3 Advantages and Disadvantages

1.3.1Advantages: Sisal fibres with high elastic modulus and stiffness increase the toughness and compressive strength of concrete. Moreover, the main life cycle benefits of using Sisal fibre are as follow:

- Increased fatigue, impact and absorption resistance;
- It increases tensile and flexural strength, enhances ductility of concrete, controls the crack propagation and its ability to resist load after cracking.
- Research is required to establish the effects on long-term Durability of Concrete containing Sisal fibres.
- The Microstructure properties of Concrete can be explored.
- Further investigation can be done by adding chemical admixtures to increase the workability of Sisal fiber concrete. SF is resistant to most chemicals so it improves the overall performance of structure.
- SF and Ground Shell Ash increases the strength of concrete as compressive strength, split tensile strength and flexural strength.
- They also provides more resistance to impact load and resistance to cracking, freezing and thawing effect etc.

- Sisal fiber is a light weight fiber which does not increase dead load of structure and keeps structural component light and thin.

As SF, the advantages of use of Ground Shell Ash in concrete with partial replacement of cement are following:

- Ground Shell Ash is waste material which is added in concrete in some quantity instead of cement which directly affects the cost of concrete and makes it economical.
- Ground Shell Ash also improves strength properties of concrete by filling the voids of concrete.

1.3.2. Disadvantages: Some of disadvantages of SF and Ground Shell Ash in concrete are as given below-

- Sisal fibers are a bit costlier so SF reinforced concrete can't be used for normal construction work.
- SF influences flexural strength of concrete but in small quantity so it cannot replace structural steel reinforcement which impart in moment resisting of structure.
- After some proportion SF reduces the workability of concrete.
- Concrete with Sisal fiber and Ground Shell Ash require a proper supervision in designing, mixing and placing.
- After a certain limit Ground Shell Ash reduces the strength of concrete.

1.4 Selection of Topic

After literature study and research on present scenario, we came to know that Earth is facing environment pollution in terms soil, air, and water. Waste material from industries is dumped in land which makes the land unsuitable for agricultural purpose. These waste materials can be used or recycled to reduce the pollution.

1.5 Scope

- Foundation piles, pre-stressed piles & piers.
- In road pavement of highways.
- Industrial flooring.
- Bridge decks, facing panels.
- Flotation units for walkways.
- Heavyweight coatings for underwater pipe.

CHAPTER-2

LITERATURE SURVEY

A literature review is must to know about the research area and what problem in that area has been solved and what needs to be solved in future. A proper literature review provides solid background for a noble research work.

To start a research work, the initial step is to identify and mark the problems of research and to choose specific objectives and remedies of need. There has been many procedures and processes defined by the researchers to undergo through and arrive at certain conclusion of research objectives. In order to choose specific objectives of research one need to follow a typical process to arrive at the conclusion of uniqueness, novelty and significance of the problem in a specific area / sub area. One has to start with a broader domain of some area / sub area and while doing study of literature narrow down the domain to specific point of issue to decide upon

In order to choose specific objectives of research one need to follow a typical process to arrive at the conclusion of uniqueness, novelty and significance of the problem in a specific area. It comprises of finding the related material from magazines, books, research articles, scientific research papers published in various conferences, journals & transactions. Study and understanding the literature other than scientific research papers is bit easy as it elaborates the concepts in simple and refined manner. At the same time these contents cannot be considered as base to arrive at the conclusion of framing research objectives as it is not supported through proper review by various researchers working in that area. Review of a scientific research paper is a tedious job. It requires prior knowledge of that area of research. The scientific research papers are highly structured, compact and in precise manner which makes them easily understandable.

Literature survey incorporates the study of numerous sources of literature in the area of research.

2.1 Historical Background

Addition of fiber in concrete is carried from a very long time. First reinforced concrete is developed in 1849 by Joseph Monier. In 1950 fiber reinforced concrete became the field of interest. First paper on FRC was published in 1963 by Romualdi and Batson.

2.2 Literature Review Papers

[1] MALUGU RAVI PRASANTH (2019) The Compressive Strength and spilt tensile of Concrete is increased when the replacement of Cement with groundnut shell ash up to 10% replaces by weight of Cement. The Flexural Strength of Concrete is increased when the replacement of Cement with groundnut shell ash up to 15% replaces by weight of Cement.

[2] Nadiminti Venkata Lakshmi, Polinati Satya Sagar (2017) this experimental investigation was carried out to evaluate the strength of concrete, in which cement was replaced with ground nut shell ash for cubes, cylinders, and Prisms with different percentages which vary from 0% to 30% at an interval of 5% were performed. Concrete was batched by weight on adopting a ratio of 1:2:4 with water–cement ratio of 0.6. Concrete cubes of 150*150*150 mm in dimensions, cylinders of 150*300 mm in dimensions and 100*150 mm prisms are used. These Cubes, cylinders, and prisms were tested for 7, 14 and 28 days for compression, flexural and split tensile strengths. It is observed that 10% replacement of ground nut shell ash shown the highest strength values when compared with other percentages and for 15% replacement of ground nut shell ash the compressive and split tensile strength obtained the highest strength rather than other flexural strength.

[3] Jamilu Usman 1 , Nasiru Yahaya , **(2013)** . This paper presents the effect of groundnut shell ash (GHA) on the properties of cement paste. Cement pastes containing GHA as cement replacement in different proportions up to 50% by weight were prepared. At fresh state, the consistency and setting times of the pastes were checked, while at hardened state, soundness and compressive strength of the pastes were determined. In addition, the microstructure of the hardened paste was investigated using the Fourier Transformed Infrared (FTIR) technique. The results show that GHA increased water demand and delayed setting times, but improved soundness of cement paste. Moreover, compressive strength enhancement of hardened cement paste due pozzolanic reaction as evidenced by the microstructure analysis (FTIR) was observed with up to 10% GHA replacing cement.

[4] DR. F. A. Olutoge1 Buari T.A2 (2013) The principal characteristic measured was the compressive strength of Ordinary Portland Cement (OPC) concrete and OPC/GSA concrete at varying substitution levels of 0%, 5%, 10% and 15% after curing in water and three chemical solutions (MgSO4 , NaSO4 and Ca2 SO4) of varying concentrations of 0.5%, 1.5% and 2.5% each at 56 day hydration period. The results showed that the OPC/GSA concrete performed best in these chemical solutions, especially at 10% GSA replacement which exhibited a convincing increase in compressive strengths above that obtain with the use of Ordinary Portland cement. The study concluded that OPC/GSA concrete having showed resistant to calcium sulphate, magnesium sulphate and Sodium Sulphate media would perform better in environments or soils containing these sulphates. (MgSO4 , NaSO4 and Ca2 SO4).

[5] T.C. Nwofor and S. Sule (2012) this study investigates the use of considerable volume of groundnut shell ash as the partial replacement for cement in concrete production. A total of 100 specimens of the GSA/OPC concrete was cured in cubes of 100mm dimension for 7, 14, 21 and 28 days and the compressive strength and density determined. The percentage replacement of Ordinary Portland Cement (OPC) varies to the control (0% replacement) about 40%. The results generally show a decrease in density and compressive strength as the percentage replacement with GSA increases suggesting less hydration with cement. Based on a general analysis of the results as well as the logical comparison to the acceptable standard, a percentage replacement of 10% is suggested for sustainable construction, especially in mass concrete constructions.

[6] Adole, M. A., Dzasu (2011) The empirical investigation reported the effects of chemicals on the properties of concrete with cement partially replaced with Groundnut Husk Ash (GHA). The principal characteristic measured was the compressive strength of Ordinary Portland Cement (OPC) concrete and OPC/GHA concrete after curing in three chemical solutions (MgSO4, NaCl and H2SO4) at 14, 21 and 28 days hydration periods. The results revealed that the OPC/GHA concrete performed best in most of the chemical solutions at 28 days hydration period with compressive strength values of 21.05N/mm2 in MgSO4 solution and 22.55Nmm2 in NaCl solution. The study concluded that OPC/GHA concrete having proven resistant to magnesium sulphate and sodium chloride media would perform better in soils containing MgSO4 and NaCl.

2.3 Strengths and Weaknesses

This chapter will be enlisting the strengths and weaknesses of the various methods and algorithms used.

2.3.1 Strengths:

- The width of cracks found was less in SFC than of that in plain cement concrete beam.
- Due to addition of Sisal fibers in concrete cracks got ceased which resulted into the ductile behavior of SFC.
- The inclusion of Sisal fiber made the concrete corrosion free.
- A clear and detailed mechanism of chloride attack and effects.
- Sisal fibers effectively held the micro cracks in concrete mass.

2.3.2 Weaknesses:

- Construction cost increased when the Sisal fibers were introduced in concrete mix as reinforcement.
- Workability of concrete mix reduced with increment in dose of Sisal fiber fraction.
- To increase the workability of fiber reinforced concrete admixtures were added to concrete, which again interferers with the construction cost.
- Due to the stiffness of Sisal fibers, micro-defects such as voids and honeycombs could occur during placing of fiber reinforced concrete.
- High percentage of Sisal fibers in concrete mix generates air cavity issue in concrete.

2.4 Gaps in the Research Paper

- Sisal fiber provides more strength and ductility but its plant production is an issue, so it can’t be used in large amount.

- Further research is required as the diversity of composition was not included in past research.
- Waste materials like plastic bottles, rubber tires, waste paper, marble dust, kiln dust and other industrial wastes can be used in mix to make it eco-friendly and in addition to this waste management is also taking place.
- Limited research work is done on workability of fiber reinforced concrete this is the issue that needs more research as this is one of the most important property to be studied.
- Durability of fibers is also a field that can be studied more.

CHAPTER-3

MATERIAL AND METHODOLOGY

3.1 Material Used

A good and effective project/research can be carried out by selecting raw material according to suitability and availability in local market. In this project work various types of materials have been used which are described as follows:

3.1.1 Cement

Cement was invented by an English mason Joseph Aspdin in 1824. He referred it as Portland cement because it possessed similarities in its color after setting, to a variety of sandstone found in bulk in Portland. Cement is obtained by burning at a very high temperature a mixture of calcareous and argillaceous materials. The mixture of ingredients should be intimate and they should be in correct proportion. The approximate composition of key components Portland cement is given below.

Table-3.1: OPC Ingredient and Their Percentage

OPC Ingredient	Percentage Range
CaO	60 – 67
SiO2	17 – 25
Al2O3	3.0-8.0
Fe2O3	0.5-6.0
MgO	0.1-4.0

Following three distinct operations are involved in the manufacturing of Ordinary Portland Cement

- Mixing of raw materials
- Burning
- Grinding

When cement is mixed with water, it becomes firm over a phase of time. This is called setting of cement. Gypsum is added to Portland cement to control the setting action of cement. It works as a retarder and hence allows the cement to be mixed with the aggregates and to be placed.

Grades of Cement

The grade of OPC cement have three types which are classified on the basis of the strength of cement attained at 28 days when tested as per IS 4031-1988.

- 33 Grade OPC (IS: 269-1998): Minimum Compressive strength after 28 days is 33 N/mm2
- 43 Grade OPC (IS: 8112-2000): Minimum Compressive strength after 28 days is 43 N/mm2
- 53 Grade OPC (IS: 12269-1999): Minimum Compressive strength after 28 days is 53 N/mm2

Physical Properties of Cement

Portland cements are commonly characterized by their physical properties for Quality control purposes. Best quality cement feels smooth when touched or rubbed between the fingers. If it felt rough, it indicates that cement is adulterated with sand. In order to determine the quality of Ordinary Portland Cement various laboratory tests are conducted. Following are the standard tests for OPC:

- Fineness
- Compressive strength
- Setting time
- Soundness
- Specific gravity

i. ***Fineness***

Fineness or particle size of cement have important effects on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement attains strength faster because it offers a larger surface area for hydration. Maximum number of particles in a sample of cement should have a size less than about 100 microns. Smallest particle may have size of about 1.5 microns. If the cement particles are coarser, hydration starts on the surface of the particles. So the coarser particles possibly will not be entirely hydrated. This causes low strength and low durability. For a fast development of strength, a high fineness is required.

ii. ***Compressive strength***

The compressive strength of hardened cement is one of the most important characters that's why the cement is always tested for its strength in laboratory before the cement is used in field works. Strength test are not carried out on fresh cement paste because of difficulties of extreme shrinkage and consequent cracking of neat cement. Strength of cement is determined indirectly by cement-sand mortar in specific proportions. Strength of cement is checked for different durations as:

- 1 day (for high early strength cement).
- 3 days, 7 days, 28 days and 90 days (for monitoring strength progress)

28 days strength is recognized as a basis for control in most codes. The strength of cement affected by various factors such as w/c ratio, cement-fine aggregate ratio, curing conditions, size and shape of specimen, type and grading of fine aggregate, loading conditions and age.

iii. ***Setting time***

A random separation has been made for the setting time of cement as initial setting time and final setting time. It is difficult to draw a rigid line between these two random divisions. The initial setting time is described as the time span between the instant when the water is added to the cement to the time that the paste starts losing its plasticity. The final setting time is the time span between the water is added to the cement and the time when the paste has lost its plasticity completely and has attained sufficient firmness to resist certain definite pressure. In construction work dealing with cement paste, mortar or concrete a certain setting time is required for mixing, transporting, placing, compacting and finishing. Setting time of cement is affected by a number of factors which include the cement fineness, w/c ratio, chemical content (especially gypsum content) and admixtures. Setting tests are used to characterize how a particular cement paste sets.

iv. ***Soundness***

Soundness means the ability to resist volume expansion. It is very important that the cement after setting shall not endure any significant change of volume. Unsoundness of cement will cause severe difficulties for the durability of structure when such cement is used. Unsoundness of cement is due to excess of lime, excess of magnesia or excessive proportion of sulphates. Free lime (CaO) and magnesia (MgO) are reacting with water very slowly and increase in volume considerably, which result in cracking, deformation and crumbling. Therefore the content of magnesia is allowed in cement is restricted to 6 percent. If the addition of quantity of gypsum increases than 3-5% it could combine with C3A, excess of gypsum will remain in cement in free condition. This excess of gypsum leads to an unnecessary expansion and subsequent disruption of the set of cement paste.

v. ***Specific gravity***

Specific gravity is the ratio of weight of a particular material to the weight of the same volume of water at a specified temperature. It is a value to calculate whether the material is able to sink or float on water. Every material has some specific gravity. The value is normally in digits like 0.1 – 100. If the value is less than 1, then the material will float on water. If the value is greater than 1, then the material will sink. Cement thrown in water should sink and should not float on the surface.

Chemical Properties of Cement

The raw materials used for the manufacture of cement consist mostly of lime, silica, alumina and iron oxides. These oxides interact with one another in the kiln at high temperature to form more complex compounds. The various proportions of oxides of lime, silica, alumina and iron compositions are accountable for influencing the different properties of cement.

To manufacture a cement of stipulated compound composition, it becomes absolutely necessary to closely control the oxide composition of the raw materials.
When the lime content is increased beyond a certain limit makes it difficult to combine with other materials and free lime will exist in the clinker which causes unsoundness in cement. If there is an increase in silica content at the expense of the content of alumina and ferric oxide will make the cement difficult to fuse and form clinker. Alumina and high ferric oxide content are responsible for high early strengths in cement. Bogue's compounds C3S, C2S, C3A and C4AF are sometimes called in literature as Alite, Belite, Celite and Felite.

Ultra tech Cement (OPC) of grade 43 was used for this research, having specific gravity 3.1645 and fineness 93%, which was collected from Kuber Building Material store, Pratap Nagar, Jaipur.

3.1.2 Aggregates

Aggregates are the inert or chemically inactive materials which impart a bulk proportion in concrete. The aggregates are bound together by means of cement. The aggregates are classified into two categories: fine and coarse.

The material which is passed through BIS test sieve no. 480 is termed as a fine aggregate. If the natural river sand is not available economically then finely crushed stone may be used as fine aggregate. The material which is retained on BIS test sieve no. 480 is termed as coarse aggregate. The broken stone is generally used as coarse aggregate. The nature of work decides the maximum size of coarse aggregate. For thin slabs and walls, the maximum size of coarse aggregate should be limited to one-third the thickness of the concrete section.

The aggregates to be used for cement concrete work should be hard, durable and clean. The aggregates should be completely free from lumps of clay, organic and vegetable matter, fine dust etc. The presence of all such wreckage prevents adhesion of aggregates and hence reduces the strength of concrete.

The aggregates may also be classified in the following two categories:

- Natural aggregates
- Artificial aggregates

i. ***Natural Aggregates***

The term natural aggregate is used loosely to designate aggregate which need only be removed from either natural deposit as unconsolidated sediments. The aggregates obtained from such deposits are called gravel and sand while those produced from ledge rock, boulders or cobble stone are known as crushed stones.

Thus the natural aggregates can be divided into the following three types:

- Crushed rock aggregates
- Gravel
- Sand

a. ***Crushed Rock Aggregates***

The crushed rock aggregate is obtained by crushing rock pieces into suitable size. It is evident that the quality of the crushed rock aggregate will be controlled by the nature and type of rock from which it is crushed. The rocks are classified into three major divisions according to their origin, namely, igneous rocks, sedimentary rocks and metamorphic rocks.

The igneous rocks are formed originally by cooling from a molten rock material known as magma. They are further classified as plutonic rocks, hypabyssal rocks and volcanic rocks. The plutonic varieties are brittle due to the presence of large crystals and the main types of rocks under this variety are granite, syenite, diorite, etc. The hypabyssal igneous rocks are medium grained and they generally possess inter grown texture and hence, they are among the best road stones. The main types of rocks under this group are porphyry, dolorite, pophyrite and diabase. The volcanic types of igneous rocks are fine-grained with basalt and andesite as main verities. They are excellent for building construction.

The sedimentary rocks are formed by the deposition of products of weathering on the pre-existing rocks. They are further classified as calcareous, siliceous and argillaceous. I the calcareous variety, the calcium carbonate predominant and the main types include limestone, dolomites and chalk. The limestone and dolomites are suitable because they have excellent adhesion to cement and bituminous binder. The chalk is not suitable for construction purpose. In siliceous variety, the silica predominant and sandstones and quartzite are the main types of stone of this group. The sandstones are frequently used in construction work as road stones where they are locally available. The quartzite is quite hard and its adhesion to cement is very good but to bitumen is poor. In argillaceous variety, the clay predominates and the main types are clay, shale and mudstone. They are all poor stones for construction purpose.

The metamorphic rocks have either igneous or sedimentary origins but, as a result of intense heat or pressure or both, they have been altered or metamorphosed into rocks having significantly different properties. The hornfels which are formed due to the thermal metamorphism are considered the best form the point of view of road construction.

b. ***Gravel***

The term gravel is used to mean the coarse material resulting from the disintegration of natural rock due to weathering and carried away by water and subsequently deposited on river banks. The properties of gravel will by and large governed by the properties of the basic rock constituents and basically, the hard varieties of gravel are found dumped along river banks or along strata which had earlier been under water. The larger varieties of gravel, known as boulders, do not require special tests, if they are to be used as soling or base course.

c. ***Sand***

The final residue of resistant mineral grains resulting from the weathering action upon rocks is known as sand and the final form has often been reached after many cycles of deposition and weathering. The most important mineral in sand is quartz and it is hardly affected by the ordinary weathering agents.

ii. ***Artificial Aggregates***

The blast furnace slag is perhaps the only artificially prepared aggregate which is used in the construction. It is obtained as a by-product in the Sisal manufacturing. If slag is specially manufactured under controlled conditions, it can certainly prove to be an excellent aggregate of uniform quality. Concrete made with blast furnace slag has good fire resisting qualities. Other artificial aggregates such as foamed slag, expanded clay, fly ash aggregates, shale and slate are also used for producing light weight concrete.

Characteristics of Aggregates

- Size
- Shape
- Texture
- Strength
- Specific gravity
- Water absorption

i. ***Size***

The largest maximum size of aggregate practicable to handle under a given set of conditions should be used. Perhaps 80 mm size is maximum size that could be conveniently used for concrete making. Using largest possible maximum size will result in:

- ✓ Reduction of the cement content
- ✓ Reduction in water requirement
- ✓ Reduction of drying shrinkage

For heavily reinforced concrete member the nominal maximum size aggregate should usually to be restricted to 5 mm less than the minimum clear distance between the main bars or 5 mm less than the minimum cover to the reinforcement, whichever is smaller. But from various other practical considerations, for reinforced concrete work, aggregates having maximum size of 20 mm are generally considered satisfactory.

ii. ***Shape***

The shape of aggregates influences the workability of concrete. According to cement requirement for a given water/cement ratio generally rounded aggregates are preferable to angular aggregates. On the other hand, additional cement required for angular aggregate is offset to some extent by the higher strengths and sometimes by greater durability as results of the interlocking texture of the hardened concrete and higher bond characteristic between aggregate and cement paste. Flat particles in concrete aggregates will have particularly objectionable influence on the workability. Cement requirement, strength and durability. In general, excessively flaky aggregate makes very poor concrete.

iii. ***Texture***

Surface texture is the property which measure that the particle surfaces are polished or dull, smooth or rough. Surface texture depends on hardness, grain size, pore structure, structure of rock and the degree to which forces acting on the particle surface have smoothed or roughed. Generally smooth fracture surfaces found in Hard, dense, fine-grained materials. Laboratory experiments have shown that the adhesion between cement paste and aggregate is influenced by several complex factors in addition to the physical and mechanical properties. As surface smoothness increases, contact area decreases, hence a highly polished particle will have less bonding area with the matrix than a rough particle of the same volume. A smooth particle however will require a thinner layer of paste to lubricate its movements with respect to other aggregate particles. It will, therefore, permit denser packing for equal workability hence; will require lower paste content than rough particles. It has been also shown by experiments that rough textured aggregates develop higher bond strength in tension than smooth textured aggregate.

iv. ***Strength***

When we talk about the strength of aggregates we do not imply the strength of the parent rock from which the aggregates are produced, because the strength of does not exactly represent the strength of aggregate in concrete. Since concrete is an assemblage of individual pieces of aggregate bound together by cementing material, its properties are based primarily on the quality of cement paste. If either the strength of the paste or bond between the paste and aggregate is low, a concrete of poor quality will be obtained irrespective of the strength of the rock of aggregate. But when cement paste of good quality is provided and its bond with aggregate is satisfactory, then the mechanical properties of the rock or aggregate will influence the strength of concrete. So it is very clear that form a weak rock or aggregate strong concrete cannot be made.

v. ***Specific Gravity***

In concrete technology, specific gravity of aggregate is made use in design calculations of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregates is also required in calculating the compacting factor in connection with the workability measurements. Similarly, specific gravity of aggregate is required to be considered when we deal with light weight and heavy weight concrete. Average specific gravity of the rocks varies from 2.6 to 2.8.

vi. ***Water Absorption***

Some of the aggregates are porous and absorptive. Porosity and absorption of aggregate will affect the water/cement ratio and hence the workability of concrete. The porosity of aggregate will also affect the durability of concrete when the concrete is subjected to freezing and thawing and also when the concrete is subjected to chemically aggressive liquids.

The water absorption of aggregate is determined by measuring the increase in weight of an oven dry sample when immersed in water for 24 hours. The ratio of increase in weight of aggregate to the weight of dry sample expressed as percentage is known as absorption of aggregate. The aggregates absorb water in concrete and thus affect the workability and final volume of concrete. The rate and amount of absorption within a time interval equal to the final set of the cement will only be a significant factor rather than the 24 hours absorption of aggregate. It may be more realistic to consider that absorption capacity of the aggregates which is going to be still less owing to the sealing of pores by coating of cement particle particularly in rich mixes. In allowing for extra water to be added to a concrete mix to compensate for the loss of water due to absorption, proper appreciation of the absorption in particular time interval must be made rather than estimating on the basis of 24 hours.

Aggregates are granular materials consisting of gravel, or crushed stone. Aggregates alone consist of 60 to 75 percent of the total volume of concrete. Roughly crushed 20mm course aggregates of of specific gravity 2.76 and water absorption of 0.5% was use for this research which was collected from Shree Balaji Building Material store, vaishali Nagar, Jaipur.

3.1.2 Sand

Sand are naturally Occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand is silica (silicon dioxide, or sio2), usually in the form of quartz.

Natural river sand of specific gravity 2.66 and water absorption of 1% was use for this research which was collected from Kuber Building Material store, Pratap Nagar, Jaipur.

3.1.3 Sisal Fiber

Sisal fiber is derived from an agave, Agave sisalana. It is valued for cordage because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and, like coir, it is resistant to deterioration in saltwater. The higher-grade fiber is converted into yarns for the carpet industry.

3.1.4 Groundnut Shell Ash

The shells were sun dried and then ground using rice milling machine to reduce its size to a size conforming to coarse aggregates as specified in BS 882 (1992). The ash was obtained by burning of ground nut shells on an iron sheet or iron tin in an open air under normal temperature.

3.2 Design of proposed work

Previous chapter discussed about theoretical aspects of addition of Sisal fiber and use of Ground Shell Ash as partial replacement of cement in concrete. In this chapter the details of Mix-Design, preparation of cube, cylinder, beam, materials used, tests conducted, for the experiment of strength properties based performance analysis of modified Sisal fiber concrete is discussed.

3.3 Design Specification

The principal objective of this work is to analyze the behavior of the specimen based on the concept of Strength Properties based Performance analysis of modified Sisal fiber concrete for strength and durability. The design method used is the Mix-Design Proportion- Guidelines IS 10262: 2009. In the thesis the mix proportioning for a concrete of M 30 grade adding Sisal fiber and use of granite dust as partial replacement of cement is designed mentioned as per the entire guidelines mentioned in the IS 10262: 2009. Even the entire Mix-Design was done under the control environment favorable for accomplishment of anticipated data and result. Some of the general data/details are mentioned below that are essential for the initial stage of Mix-Design.

3.4 Data for Mix Proportioning

The following data is required for mix proportioning of a particular grade of concrete:

a. Grade designation
b. Type of cement
c. Maximum nominal size of aggregate
d. Minimum cement content
e. Maximum water-cement ratio
f. Workability
g. Exposure conditions as per Table 4 and Table 5 of IS 456: 2000

h. Maximum temperature of concrete at the time of placing
i. Method of transporting and placing
j. Type of aggregate
k. Maximum cement content

3.5 Experimental Procedure

Procedure followed in this experimentation is as follow:

3.5.1 Materials Selection and Finalization

Materials used in this experimentation with their specific qualities are as follows:

A. Cement

43 grade Ordinary Portland Cement (IS: 8112-2000) most widely used cement for general construction work. It provides minimum 28 days strength of 43 N/mm2. It is used for construction of residential, commercial and industrial buildings, roads, bridges, flyovers, irrigation projects and other general civil construction works. It is also suitable for all types of applications RCC, plastering and masonry. Cement used in present experimentation is ‘43 Grade OPC Ultra Tech Cement’.

Fig. 3.1: Cement

B. Aggregates

Aggregates are important constituent of concrete mix. Aggregates are generally thought of as inert filler within a concrete mix. But a closer look reveals the major role and influence aggregate plays in the properties of both fresh and hardened concrete. Changes in gradation, maximum size, unit weight, and moisture content can all alter the character and performance concrete mix.

a. Fine Aggregate

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforming to grading Zone I of Table 4 of IS 383:1970.

Specific gravity = 2.66

Fineness modulus = 2.74

Fig. 3.2: Fine Aggregate

b. Coarse Aggregate

The coarse aggregate used conforms to IS 383: 1970. Coarse aggregates of different sizes may be combined in suitable proportions so as to result in an overall grading conforming to Table 2 of IS 383:1970 for particular nominal maximum size of aggregate.

Crushed gravel of 20 mm & 10 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383: 1970 for graded aggregates.

Specific gravity = 2.746

Fineness Modulus = 6.9

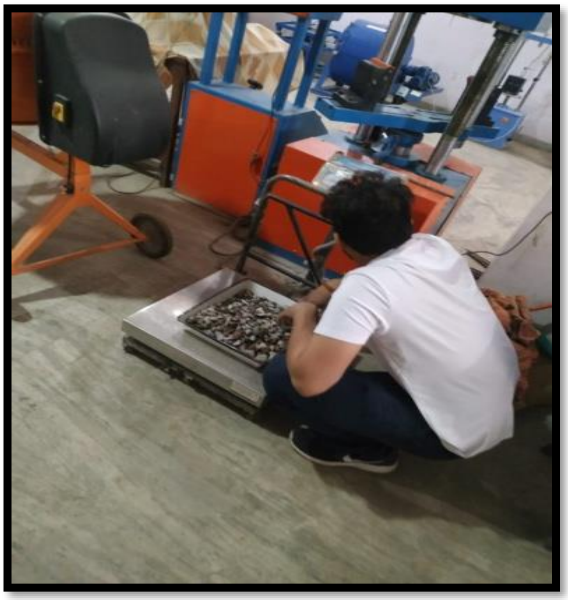

Fig. 3.3: Coarse Aggregate

C. Water

Water is an important constituent of concrete as it actively participates in the chemical reaction with cement. It helps to form the strength giving cement gel. Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions. In this project clean potable water was obtained from water tap in concrete laboratory for mixing and curing of concrete.

Fig. 3.4: Water

D. Sisal fiber

Sisal fiber is extracted from the leaves of the plant *Agave sisalana*. In India four varieties of sisal plants are found—*Sisalana*, *Vergross*, *Istle,* and *Natale*. Different varieties of plants have different yields of fibers. Leaves from the first two varieties yield more fibers than those from the other two. The fiber content also varies with age and source of the plant.

Fig. 3.5: Sisal Fiber

In this project SF used as described by manufacturer:

Table No.3.2 Properties of Sisal Fibers

S.No.	PROPETIES	SPECIFICAION
1	Length	Multiples of 150-180 mm.
2	Construction	Combination of straight, fibrillated mesh fibre
3	Aspect ratio	200-300
4	Absorption	11
5	Acid Resistance	medium

6	Alkali Resistance	Completely resistant
7	Elongation at break	2-3%
8	Salt Resistance	High.
9	Tensile strength	68 MPa

E. Groundnut shell ash

Groundnut Shell Ash is a waste material obtains from the production of ground nut and its oil.

Fig. 3.6: Groundnut Shell Ash

3.5.2 Mix Proportioning of M-25 Concrete (Using Sisal fiber and Ground Shell Ash as Partial Replacement of Cement)

The mix proportions considered for each addition of Sisal fiber by 0%, 0.5%, 1%, 1.5% & 2.0% volume of concrete and a fixed 15% replacement of cement with groundnut shell ash in M-30 Grade Concrete shown in Annexure.

Ratio of Ingredients in Mix:

Cement: Fine Aggregate: Coarse Aggregate = 1: 1.53: 2.72

3.5.3 Preparation of Materials

All materials were brought to room temperature, preferably 27º ± 3 ºC before initiation of the results. The cement samples, on arrival at the site, were thoroughly mixed dry by transit mixture in such a manner as to ensure the greatest possible blending and uniformity in the material, care is being taken to avoid the intrusion of foreign matter. The cement was stored in a dry place, in air-tight metal containers. Samples of aggregates for each batch were of the desired grading and were in an air-dried condition. Before mixing, all the material collected in required quantity.

A. *Weighing*

The quantities of cement, aggregate and water for each batch was determined by weight, to an accuracy of 0.1% of the total weight of the batch. Ground Shell Ash and SF were taken by weight of cement.

B. *Mixing*

The concrete batch was mixed on a water-tight, non-absorbent platform with a shovel, trowel or similar suitable implement, using the following procedure: The cement and fine aggregate was mixed dry until the mixture is thoroughly blended and was uniform in colour. The coarse aggregate was then added and mixed with the cement and fine aggregate until the coarse aggregate was uniformly distributed throughout the batch, and the water was then added and the entire batch was mixed until the concrete appeared to be homogenous and had the desired consistency. Repeat mixing was necessary, because of the addition of water growths while adjusting the consistency, the batch was discarded and fresh batch was made without interrupting the mixing.

Fig. 3.7: Transit Mixture

3.5.4 Preparation of Specimen

A. Cube

After the sample was mixed evenly, immediately the cube mould was filled. Any air trapped in the concrete would reduce the strength of the cube. Therefore, the cubes were fully compacted. Precautions were also taken not to over compact the concrete as it might have cause segregation of the aggregates and cement paste in the mix. It might also reduce the final compressive strength. Dimensions of cubes were 150×150×150 mm.

Fig 3.8 Cube Casting

B. Cylinder

After the sample was mixed the cylinder mould was filled immediately. Any air entrapped in the concrete would reduce the strength of the cylinder. Therefore, the cubes were fully compacted. Precautions were also taken not to over compact the concrete as it might have cause segregation of the aggregates and cement paste in the mix. It might also reduce the final strength. Dimensions of cylinders were 150 mm (dia.) and 300mm (length).

Fig 3.9 Cylinder Casting

C. Beam

After the sample was mixed evenly, immediately the beam mould was filled. Any air trapped in the concrete would reduce the strength of the beam. Therefore, the cubes were fully compacted. It might also reduce the final strength. Dimensions of beams were 100×100×500 mm.

Fig. 3.10 Beam Casting

D. Demoulding& Curing of Concrete

Test specimens were demoulded after 24 hours of casting. Test specimens were stored in place free from vibration, in moist air of at least 90% relative humidity and at a temperature of 27º ± 2 ºC for 24 hours ± ½ hour from the time of addition of water to the dry ingredients. After this period, the specimens were marked and removed from the moulds and unless required for the test within 24 hours, immediately submerged in clean fresh water and kept there for curing for 14 and 28 days prior to test. The water or solution in which the specimens were submerged, were renewed every seven days and were maintained at a temperature of 27º ± 2 ºC. The specimens were not allowed to become dry at any time until they have been used.

3.6 Experimental Methodology

3.6.1 Fineness Test

Take a sample in a dish and heat it in oven at a temperature of 100 – 110oC. After drying take known amount of the sample and note down as W.

- Now we will arrange the sieves in descending order with the largest sieve on top . If mechanical shaker is used then put the ordered sieves in position and pour the sample in the top sieve and then close it with sieve plate. Then switch on the machine and shaking of sieves is done for at least 15 minutes.
- If shaking is done with hands then pour the sample in the top sieve and close it then hold the top two sieves and shake it inwards and outwards, vertically and horizontally.
- After sieving, record the sample weights retained on each sieve. Then we will calculate the cumulative weight retained. Finally we will determine the cumulative percentage retained on each sieves. After this the all cumulative percentage values are divided with 100 then we will get the value of fineness modulus.

Table No.3.3 Fineness Modulus of Fine Sample

S.No.	Material	Sieve size	Fineness Modulus
1	Cement	90 micron sieve	93%
2	Sand	>4.75mm to 0.15mm	27.5%

3	Groundnut Shell Ash	>4.75mm to 0.15mm	24.4%,

3.6.2 Specific Gravity Test

A. *Fine Aggregates (Sand, Cement and GSA)*

- Firstly dry the pycnometer and weigh it with its cap assembly (W1)
- Take about 200 g to 300 g of oven dried soil passing through 4.75mm sieve in the pycnometer and weigh this assembly again (W2)
- Add water to cover the soil and screw on the cap.
- Shake the pycnometer well and connect it to the vacuum pump so as to remove entrapped air for about 10 to 20 minutes.
- After the air has been removed, fill the pycnometer with water and weigh it (W3).
- Clean the pycnometer by washing thoroughly.
- Fill the cleaned pycnometer completely with water up to its top with cap screw on.
- Weigh the pycnometer after drying it on the outside thoroughly (W4).

Fig 3.11 Pycnometer Apparatus

$$Sp.Gravity(Gs) = \frac{(W2 - W1)}{((W2 - W1) - (W3 - W4))}$$

B. *Coarse Aggregates*

- About 2kg of the aggregate sample is washed thoroughly to remove fines, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 to 32^0C with a cover of at least 50 mm of water above the top of the basket
- Immediately after the immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and the aggregate should remain completely immersed in water for a period of 24±0.5 hours afterwards.
- The basket and the sample are then weighed while suspended in water at a temperature of 22 to 32^0C. The weight is noted while suspended in water (W1) g.
- The basket and the aggregate are then taken out from water and allowed to drain for a few minutes, after which the aggregates are transferred to one of the dry absorbent clothes and are surface dried.
- The empty basket is then returned back to the tank of water, jolted 25 times and weighed in water (W2) g.
- The aggregates placed in the dry absorbent clothes are surface dried till no further moisture could be removed by this cloth.
- Then the aggregate is transferred to the second dry cloth spread in a single layer, covered and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. 10 to 60 minutes drying might be needed. The surface dried aggregate is then weighed (W3)g.
- The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110^0C for 24 hours. It is then removed from the oven, cooled in air tight container and weighed (W4)g.

Fig 3.11-A Wire Mesh Bucket For Specific Gravity of Coarse Aggregate

$$Sp.Gravity(Gs) = \frac{(W4)}{(W3) - (W1 - W2)}$$

Table No.3.4 Specific Gravity of Sample

S.No.	Material	Equipment	Reference Standard Liquid	W1g	W2g	W3g	W4g	G
1	Cement	Pycnometer	Kerosene (0.79)	623	945	1496	1313	3.1621
2	Sand		Water	619	1076	1791	1508	2.64
3	GSA		Water	621	1232	1892	1511	2.35
4	Coarse Aggregates	Wire basket	Water	2000	696	1987	1896	2.75

3.6.3 Water Absorption Test :

- Take a known amount of sample , oven dry it by maintaining 110^{0}C of temperature for 24 hours
- Now allow the sample to cool down at room temperature.
- After cooling weight the sample as W_A.

- Now immerse the sample in water for 24 hours at 23^0C.
- Remove the sample, dry it with cotton cloth and weigh the sample as W_B
- Use below mention formula to calculate the amount of water absorbed by the sample.

$$Water\ Absorption(Wa) = \frac{(WA - WB)}{WB}\ X100$$

Table No.3.5 Water Absorption

S.No.	Material	W_A g	W_B g	W_b %
1	Corse Aggregate	1005.08	1000	0.5
2	Fine Aggregate	250.48	250	~ 1
3	GSA	506.92	500	~ 1

3.6.4 Test on Fresh Concrete : Slump Test

The slump test of concrete is used to measures the consistency of fresh batch before it sets. Slump test is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows is referred to as workability. Workability can also be expressed as an indicator of an improperly mixed batch. Higher value of slump refers to higher workability of concrete mix.

Fig 3.13 Slump Test

- Clean the internal surface of the mould and grease it with oil.
- Place the mould on a smooth horizontal non- porous base plate.
- Fill the mould with the prepared concrete mix in 4 approximately equal layers.
- Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer.
- Remove the excess concrete and level the surface with a trowel.
- Clean away the mortar or water leaked out between the mould and the base plate.
- Raise the mould from the concrete immediately and slowly in vertical direction.
- Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

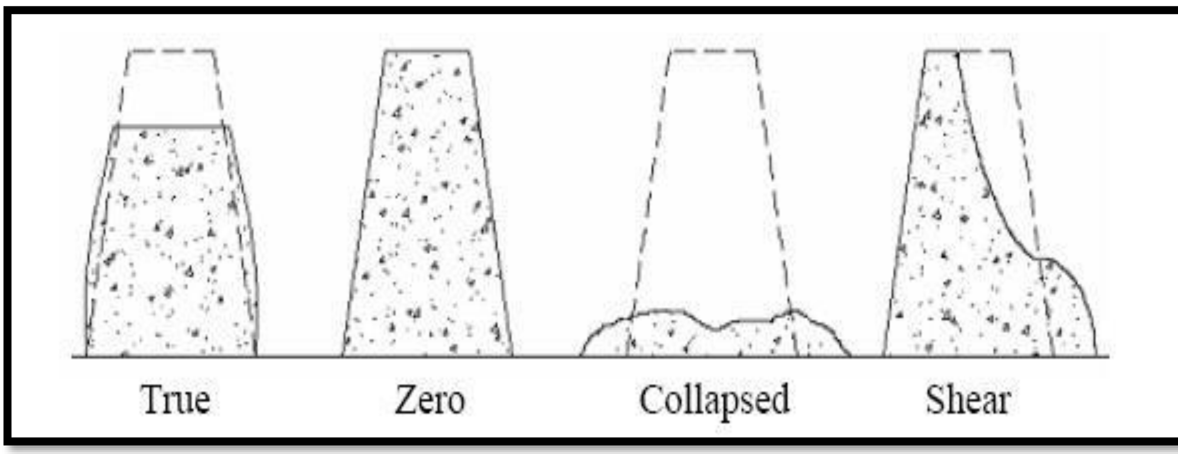

Fig 3.14 Slump Parameter

Note- The value of slump of concrete mix is mentioned in result section for every percentage of replacement of Sisal fibres and Ground Shell Ash powder.

3.6.6. Test on Hardened Concrete

A. Compressive strength Test

- Remove the specimen from water after specified curing time and excess water should be wiped out from the surface.
- Measure the dimension of the specimen
- Bearing surface of the testing machine should be cleaned

- Then specimen is placed 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.
- Apply the load gradually without shock and continuously at the rate of 140 kg/cm2/minute till the specimen fails
- Record the maximum load and note any unusual features in the type of failure.

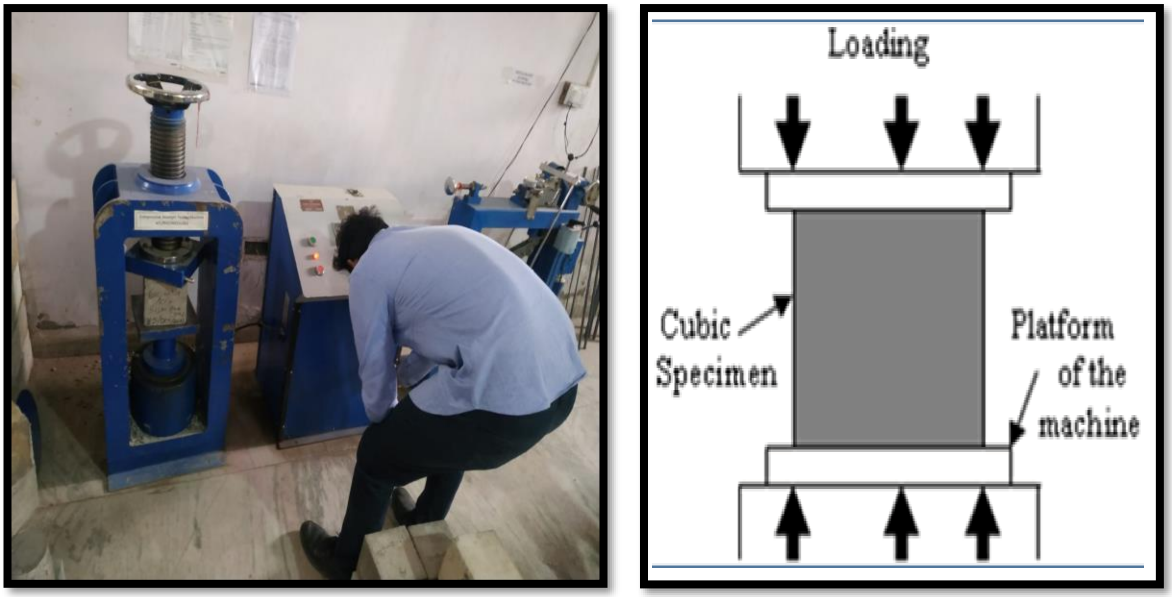

Fig. 3.15 Compressive Strength Testing

B. Split Tensile Test

- Take the wet specimen from water after specified curing time
- Wipe out water from the surface of specimen
- Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
- Note the weight and dimension of the specimen. Set the compression testing machine for the required range.
- Place the specimen on the lower plate.

- Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.
- Bring down the upper plate to touch the specimen.
- Apply the load continuously without shock at a rate of approximately 14-21kg/cm2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute)
- Record the maximum load and note any unusual features in the type of failure.

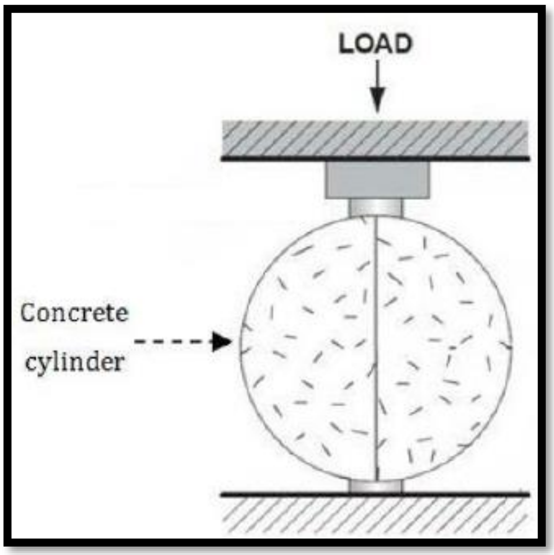

Fig. 3.16 Split Tensile Strength Testing of Cylinder

C. Flexure Test

- Take the wet specimen from water after specified curing time.
- The test should be conducted on the specimen immediately after taken out of the curing condition so as to prevent surface drying which decline flexural strength.
- Clean the bearing surfaces of the supporting and loading rollers.
- Place the specimen in such a way that the distance between the outer rollers (i.e. span) shall be **3d** and the distance between the inner rollers shall be **d**.
- The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.
- Bring down the upper plate to touch the specimen.

- The load shall be applied at a rate of loading of 180 kg/min for the 10.0 cm specimens.
- Record the maximum load and note any unusual features in the type of failure.

  Note- The test should be conducted in on specimen immediately curing period so as to prevent surface from drying which decline flexural strength

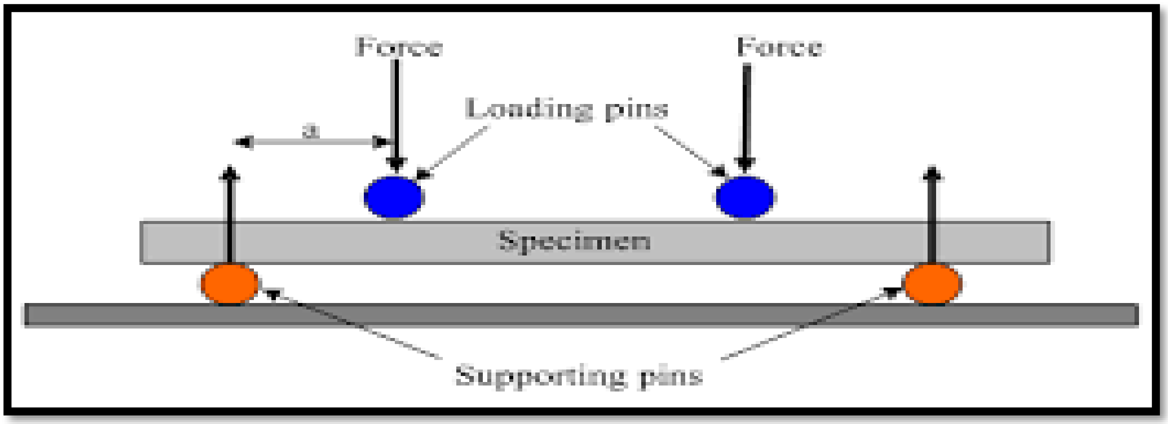

Fig. 3.17 Flexure Testing

RESULT AND DISCUSSION

4.1 Workability of Concrete

Workability of concrete is an important property to determine before placing of concrete. Concrete with high compaction factor is said to be more workable.

Table 4.1: Compaction Factor of Concrete W.R.T. Sisal Fiber Percentage

Sisal Fiber Percentage	Compaction Factor
0%	0.91
0.5%	0.87
1.0%	0.85
1.5%	0.83
2.0%	0.81

Table 4.1 shows values of compaction factor for the different values of Sisal fiber content in concrete. Concrete without fiber has high compaction factor whereas concrete with maximum fiber content showed lowest compaction factor.

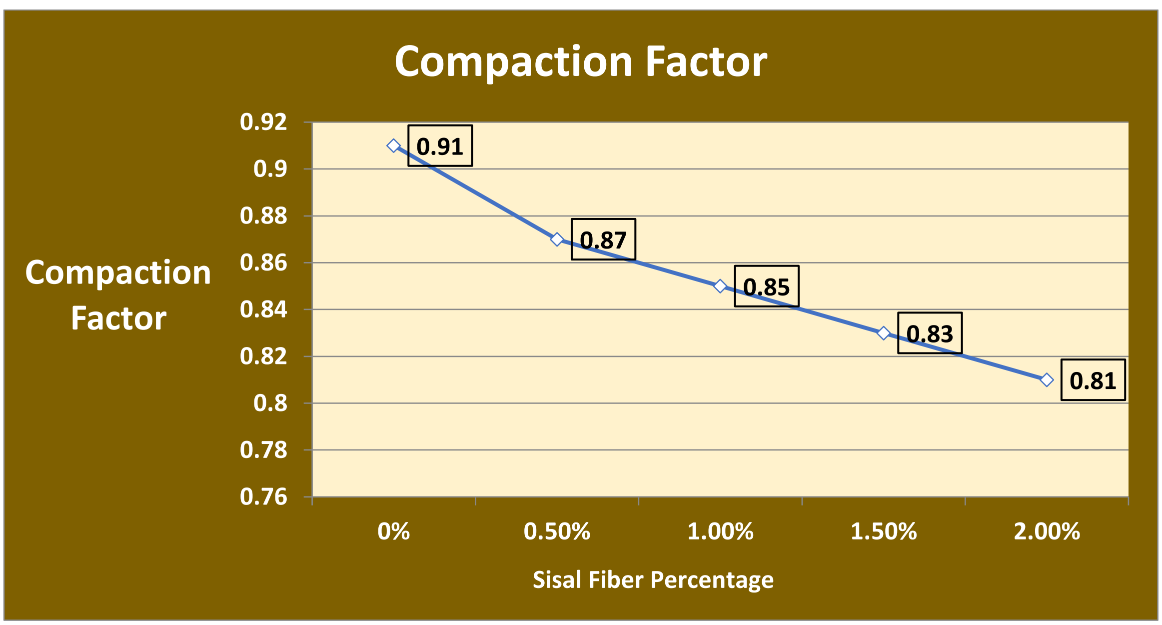

Fig 4.1: Compaction Factor of Concrete with Varying % of Sisal Fiber

Figure 4.1 shows the comparison of Compaction factor for various fiber content percentages. It is observed that as the Sisal fiber content in concrete increases compaction factor of concrete decreases accordingly hence the workability decreases. So concrete with 0% fiber has high workability and concrete with 2.0% has lowest workability.

4.2 Slump Test

Table No. 4.2 Slump for Control mix of M30 Grade

S. No.	Control Mix	Slump (mm)
1	M30	90

Table No. 4.3 Slump with 15% GSA and Sisal Fibre

S. No.	Sisal Fiber %	M30
1	0.0	80
2	0.5	78
3	1.0	74
4	1.5	71
5	2.0	70

4.3 Compressive Strength of Concrete

Compressive strength of concrete is utmost property of concrete. Cubes of dimensions 150×150×150 mm were cast and testes for compressive strength on compression testing machine.

Table 4.4 Compressive strength of M30 grade

Sisal Fiber %	Compressive Strength (N/mm2)	
	14 Days	28 Days
0.0	27.51	29.62
0.5	31.08	33.52
1.0	35.22	38.79
1.5	36.47	41.48
2.0	34.15	36.63

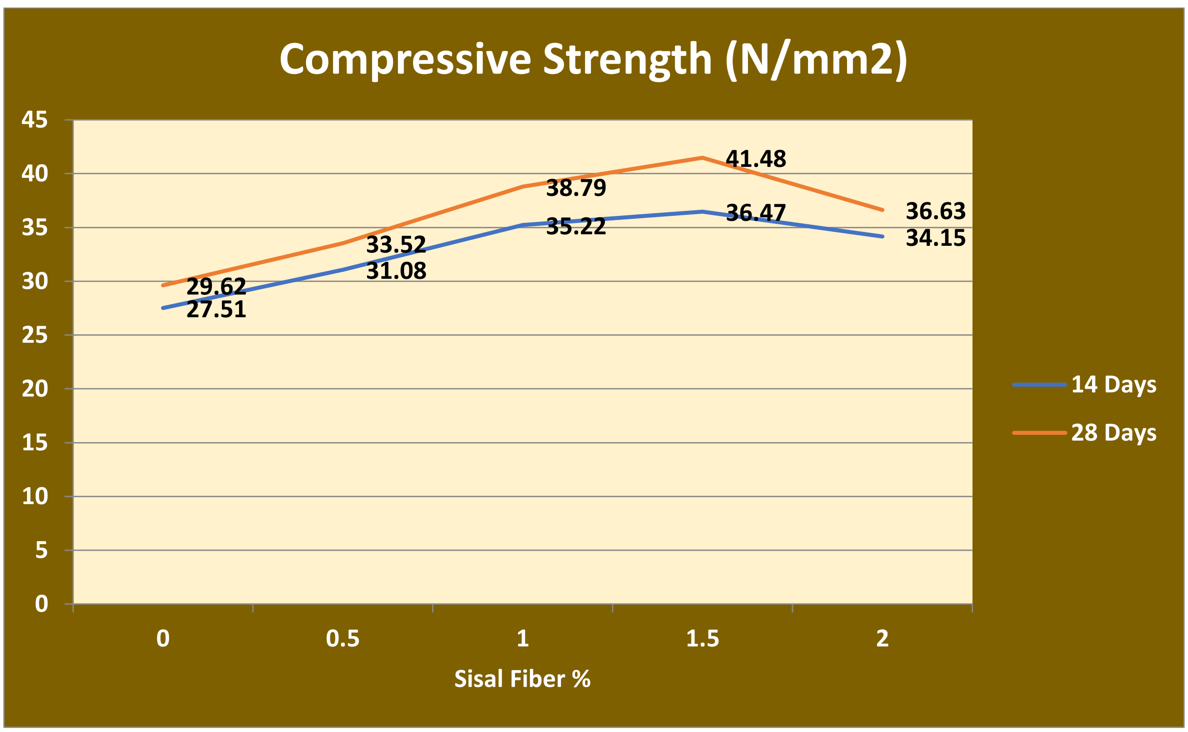

Fig 4.2 Comparative Compressive Strength of M30 Grade

4.3 Split Tensile Strength of Concrete

Concrete is weak in tension so the testing of cylinder specimen for tensile strength is required. Cylinders of dimension 150mm (dia.) and 300mm (length) were cast and tested for split tensile strength on universal testing machine.

Table 4.5 Splitting Tensile Strength of M30 grade

Sisal Fiber %	Splitting Tensile Strength (N/mm2)	
	14 Days	28 Days
0.0	2.93	3.35
0.5	3.51	4.09
1.0	3.59	3.92
1.5	3.31	3.59
2.0	3.08	3.38

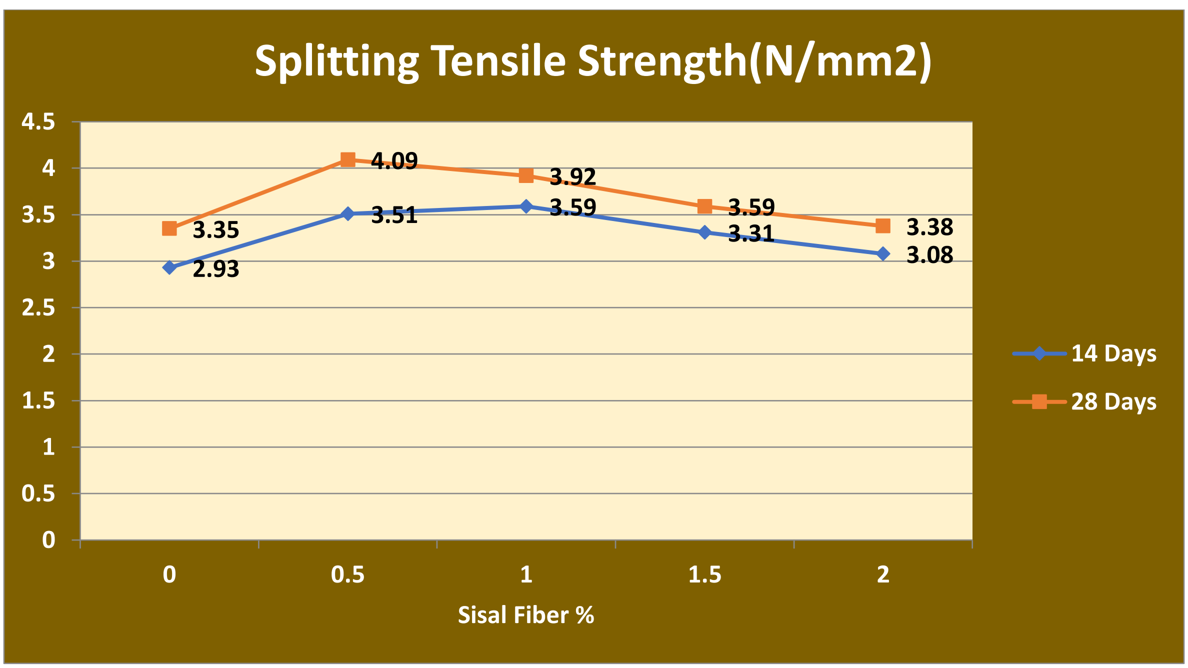

Fig 4.3 Comparative Splitting Tensile Strength of M30 Grade

4.4 Flexural Strength of Concrete

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. For flexural strength test beams of dimensions 100×100×500 mm were cast and tested on flexural testing machine.

Table 4.7 Flexural Strength of M30 grade

Sisal Fiber %	Flexural Strength (N/mm2)	
	28 Days	Percentage Increased
0.0	2.7	-
0.5	2.92	10
1.0	3.41	25.13
1.5	3.29	20.74
2.0	3.15	15.56

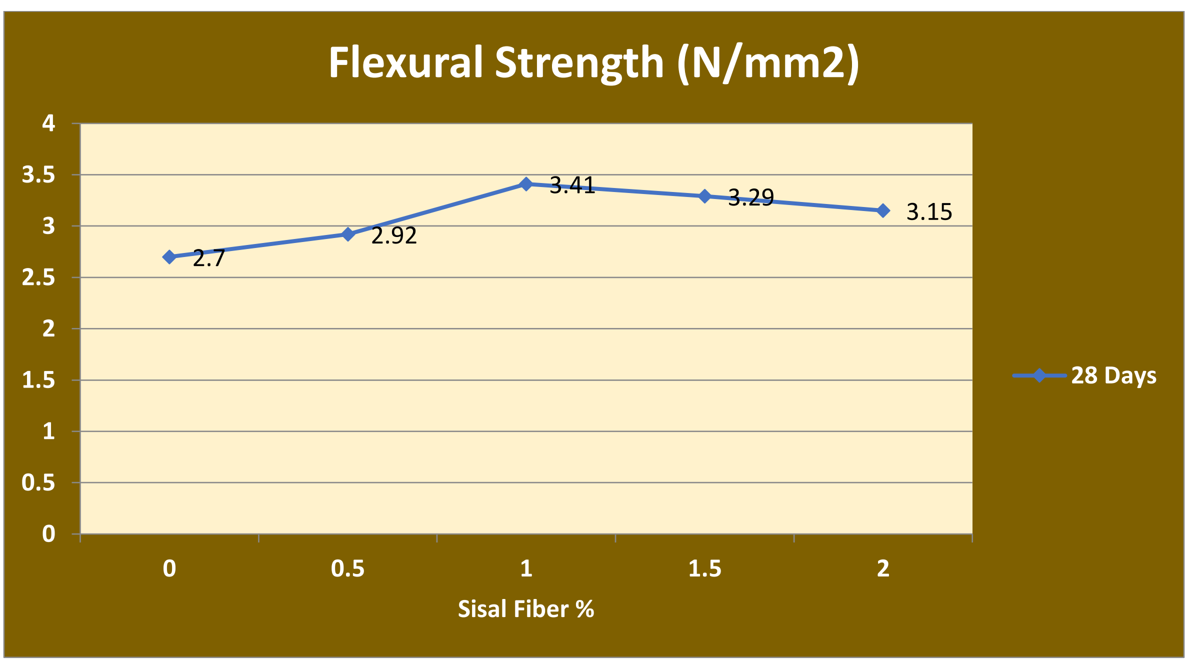

Fig 4.4 Comparative Flexural Strength of M30 Grade

CHAPTER 5

CONCLUSION

The review of research papers has been carried out in the area of strength properties based analysis of modified Sisal fiber concrete to investigate and find out current challenges and scope of work in the area. After the review, three issues were found in the literatures which were based on experimental approach. Study of literature was carried out in depth of common findings of research works, strengths and weaknesses and gaps to build problem statement and objective.

5.1 General Experimentation Result

In the project work these Experimental Scenarios were considered during experimentation.

- Accomplish Compressive strength test, split tensile test and flexural strength on concrete having different Percentage (0%, 0.5%, 1.0%, 1.5% and 2.0%) of Sisal fiber.

Results: In this experimental work, Mix-Design of M-30 grade concrete; reference IS 10262: 2019, having water-cement ratio 0.45 is considered. Percentage of Sisal fiber (0% to 2%) is added in concrete. Total 60 specimens of Sisal Fiber Reinforced Concrete were casted with great precision and were cured for 14 days and 28 days. During concreting/casting of cubes, compaction factor test and slump test on fresh concrete were conducted for verification of workability with above percentage (%) addition of Sisal fiber i.e. (0% to 2%). After completion of maturity period of concrete Compressive strength test, split tensile test and flexural strength test were conducted on all the specimens with respective date of casting. From the study it was observed that compressive strength increased as increase the percentage (%) of Sisal fiber (0% to 1.5%) after 1.5% of SF compressive strength decreases for both 14 days & 28 days cube strength. it was also observed that optimum percentage increment in compressive strength of concrete was 32.3% for 14 days curing and 39.6% after 28 days curing (from 0% to 1.5% addition of Sisal fiber).

The optimum percentage increment in split tensile strength was 22.19% for 14 days curing at 1.0% SF and 23.69% for 28 days at 0.5% SF.

It was also noted that flexural strength of concrete increase gradually with addition of Sisal fiber and minimum flexural strength was obtained at 0% (2.7 N/mm2). 3.35 N/mm2 optimum flexural strength was obtained with addition of 1.0% Sisal fiber after 28 days of curing.

5.2 Conclusion

Result revels that the Sisal fibres (SF) reduce early age shrinkage and moisture loss of the concrete mix even when low volume fractions of SF are used. From the result of this research, it was found that the use of fiber in the concrete decreases the workability of the fresh concrete. It was concluded that the increasing percentage volume of fiber added into the concrete would lead the workability decreased. High volume dosage rate above 1.5% showed that the concrete was significantly stiff and difficult to compact and strength also decreases. However, it also reduced the bleeding and segregation in the concrete mixture. Compressive strength of concrete increases with increase in fiber dosage up to 1.5%, then it starts decreasing. The addition of Sisal fibres at low values actually increases the 28 days compressive strength but when the volumes get higher than the 1.5 % SF decreases from original. The tensile strength increases about 23.73 % up to 1.0% after which it decreases. There is about 25.28% increase in flexure strength by adding 1.0% fibres in concrete after which strength starts reducing with further increment in fiber ratios. There is a remarkable increase in load carrying capacity up to first crack appears.

The concrete mix became economical by using Ground Shell Ash in replacement of cement at 10% by weight of cement. It has been seen that the concrete mix having Ground Shell Ash became economical (approximate ₹150/m^3) than plain concrete mix.

5.3 Recommendations for Future Studies

Many studies were carried out on the utilization of Sisal fiber Concrete. Most of the studies are focused on the enhancement of physical and mechanical properties of concrete. For hardened concrete chemical attack is the main reason for the corrosion in concrete so Sisal fiber reinforced concrete is observed by experimental studies. After increasing its tensile strength, it can be used for dynamic structures also.

- After increasing tensile and flexural strength of concrete it be can replace mechanically compacted concrete.
- If Sisal fiber aggregate become successful in increasing Concrete strength it can be used in place of fine aggregate instead of recycling which is not economical at all.
- There is a huge scope in cost comparison of SF reinforced concrete with different additives as marble dust, fly ash, furnace slag etc.
- After increasing the strength of concrete it can also be used in heavy structure as bridges, dames, foundation work etc.
- Similarly, after strength of concrete increases it can also be used for precast structures.
- SF reinforced concrete can also use in rigid pavement for impact load resistance on express way and highways which can use for landing of military tanks and aircraft landing.

Sisal fiber in concrete is extensively used in the construction of concrete frames, which also constitute one of the key application segments in the global fiber market. As the concrete industry growing in the process of designing and building in-situ frame buildings, the demand from the segment will continue to rise.

Following are some scope in Sisal fiber concrete having Ground nutshell Ash:

- Sisal fibers make the concrete light weight so it is very useful in making of precast blocks of concrete.
- SF is also helpful to make corrosion resistance concrete which makes concrete durable.
- Ground Shell Ash use as cost optimizer in concrete because it reduce the quantity of cement.
- Lots of research scope is exists in concrete with Ground Shell Ash and Sisal fiber with another additives which make a concrete strong, durable and economical with efficiency.

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ANNEXURE

CONCRETE MIX DESIGN OF M30 GRADE AS PER IS 10262-2009

S. No.	Steps for design	Values	Description
1	**STIPULATIONS FOR PROPORTIONING**		
a)	Grade designation	M 30	
b)	Type of cement	OPC 43 grade	conforming to **IS:8112**
c)	Maximum nominal size of aggregate	20 mm	
d)	Minimum cement content	320 kg/m^3	As per Table – 5 of **IS 456:2000**
e)	Maximum water-cement ratio	0.45	
f)	Workability	60 mm (slump)	
g)	Exposure condition	Severe (for reinforced concrete)	
h)	Method of concrete placing	Placing by hand	
i)	Degree of supervision	Good	
j)	Type of Aggregate	Crushed angular aggregate	
k)	Maximum cement content	450 kg/m^3	As per clause 8.2.4.2 of **IS 456:2000**
l)	Chemical admixture	No	
2	**TEST DATA FOR MATERIALS**		
a)	Cement used	OPC 43 grade	Conforming to **IS:8112** (ultra tech Cement OPC 43 grade)
b)	Specific gravity of cement	3.17	

c)	Specific gravity of cement	2.77	
d)	Specific gravity 1) Coarse aggregate 2) Fine aggregate	 2.78 2.62	
e)	Water absorption 1) Coarse aggregate 2) Fine aggregate	 0.50 percent 1.00 percent	
f)	Free (surface) moisture 1) Coarse aggregate 2) Fine aggregate	 NIL (absorbed moisture also nil) NIL	
g)	Sieve analysis 1) Coarse aggregate 2) Fine aggregate	 Graded aggregates Grading zone II	 Confirming to Table 2 of **IS:383** Confirming to Table 4 of **IS:383**
3	**TARGET STRENGTH FOR MIX PROPORTIONING**		
	Target average compressive strength at 28 days i.e. $f'_{ck} = f_{ck} + 1.65\ s$ $= 30 + 1.65 \times 5.0$ $= 38.25$ N/mm^2	38.25 N/mm^2	$\boldsymbol{f'_{ck}}$= Target average compressive strength at 28 days, $\boldsymbol{f_{ck}}$= Characteristic compressive strength at 28 days i.e. 30 N/mm^2 $\boldsymbol{s}$ = Standard deviation i.e. 4 N/mm^2, from Table 1 of **IS:10262**
4	**SELECTION OF WATER-CEMENT RATIO**		

	From Table 5 of **IS:456**, maximum water-cement ratio = 0.45 Water-cement ratio	0.45	Adopt water-cement ratio as 0.47 for trial 0.45 ≤ 0.45, hence O.K.
5	**SELECTION OF WATER CONTENT**		
	From Table 2 of **IS:10262**, maximum water content for 20 mm aggregate = 186 litre (for 25 to 50 mm slump range) For slump range between 50 to 75 mm water content increase 3% Final water content =186+(186*3/100) = 191.58 liter	191.58 liter	
6	**CALCULATION OF CEMENT CONTENT**		
	Water-cement ratio = 0.45 Water content = 191.58 litre Cement content $= \frac{\text{water content}}{\text{water−cement ratio}}$ $= \frac{191.58 \text{ litre}}{0.45}$ = 425.73 kg/m^3	425.73 kg/m^3	From Table 5 of **IS:456**, minimum cement content for ‘moderate’ exposure condition = 320 kg/m^3 425.73 kg/m^3> 320 kg/m^3 Hence, O.K.
7	**PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT**		
	From Table 3 of IS:10262, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of		In the present case water-cement ratio is 0.45 i.e. it is lower by 0.05.

	0.50 = 0.62 The coarse aggregate is increased at the rate of 0.01 for every decrease in water-cement ratio of 0.05. So, $\rightarrow \frac{0.01}{0.05}$ x 0.05 = 0.01 Volume of coarse aggregate = 0.62 Corrected proportion of volume of coarse aggregate for water-cement ratio of 0.45 = 0.62 + 0.01 = 0.63 Volume of fine aggregate content = 1 – 0.63 = 0.37	0.63 0.37	Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. The proportion of volume of coarse aggregate is increased by 0.006(at the rate of -/+ 0.01for every $\pm$0.05 change in water-cement ratio).
8	**MIX CALCULATIONS**		
a)	Volume of concrete	1 m^3	
b)	Volume of cement $= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \text{x} \frac{1}{1000}$ $= \frac{425.733}{3.17} \text{x} \frac{1}{1000}$ = 0.1344 m^3	0.1344 m^3	
c)	Volume of water $= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \text{x} \frac{1}{1000}$ $= \frac{191.58}{1} \text{x} \frac{1}{1000}$ = 0.19158 m^3	0.19158 m^3	
d)	Volume of all in aggregate = [a - (b + c)] = 1 – (0.1344 + 0.1958)	0.670 m^3	

	= $0.6698m^3$		
e)	Mass of coarse aggregate = d x Volume coarse aggregate x Specific gravity of coarse aggregate x 1000 = 0.670 x 0.63 x 2.76 x 1000 = 1165 kg	1165 kg	
f)	Mass of fine aggregate = d x Volume fine aggregate x Specific gravity of fine aggregate x 1000 = 0.670 x 0.37 x 2.66 x 1000 = 660 kg	660 kg	
9	**MIX CALCULATIONS**		
	Cement Water Fine aggregate Coarse aggregate Water-cement ratio	425.73 kg/m^3 191.58 kg/m^3 660 kg/m^3 1165 kg/m^3 0.45	The quantity of aggregates is based on saturated and surface dry (SSD) condition.
	Note: Now if the aggregates (fine & coarse) are to be used in dry condition for mix preparation. The aggregates are absorptive and there is no surface moisture. Then, it is required to make the necessary correction for the actual practical condition of the aggregates with respect to absorption characteristics.		
	CORRECTION IN QUANTITY OF AGGREGATES DUE TO THEIR WATER ABSORPTION PROPERTY		
a)	Absorption of fine aggregates = 1.0 %	6.6 litre	

b)	$= \frac{1.0}{100} \times 660$ $= 6.6$ litre Absorption of coarse aggregates = 0.50 % $= \frac{0.50}{100} \times 1165$ = 5.825 litre Total absorption = 6.6 + 5.825 = 12.425 litre Actual amount of water to be used = 191.58 + 12.425 = 204 litre Actual mass of fine aggregates to be used = 660 – 6.6 = 653.4 kg Actual mass of coarse aggregates to be used = 1165 – 5.825 = 1159.17 kg	5.825 litre 12.425 litre 204 litre 653.4 kg 1159.17 kg	
	CORRECTED PROPORTION OF MATERIALS		
	Cement Water Fine aggregate Coarse aggregate Admixture	425.73 kg/m^3 204 kg/m^3 653.4 kg/m^3 1159.17 kg/m^3 3.30 kg/m^3	The quantity of aggregates is based on dry condition.

	Water-cement ratio	0.45	
10	**TRIALS OF MIX**		
	Two more trials have been performed having variation of $\pm$ 5 percent of water-cement ratio. And a graph between three water-cement ratios and their corresponding strengths are plotted to work out the mix proportions for the target strength for different trials.		

ANNEXURE