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EXPERIMENTAL INVESTIGATION OF CONCRETE BEHAVIOR WITH CERAMIC WASTE AS A PARTIAL CEMENT SUBSTITUTE AND SISAL FIBER REINFORCEMENT

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Abstract: This project aims to evaluate the compressive strength and performance characteristics of concrete by partially replacing cement with ceramic waste and reinforcing it with sisal fibre. The objective is to promote sustainable construction practices by utilizing waste materials and natural fibres, thereby reducing cement consumption and enhancing the mechanical properties of concrete. The experimental study involves designing concrete mixes with 80% cement and varying proportions of ceramic waste at 10%, 20%, 30%, and 40%, combined with sisal fibre at 0.5%, 1.0%, 1.5%, and 2.0%, respectively. A control mix containing 100% cement without ceramic waste or sisal fibre is also included for baseline comparison. Concrete specimens are cast in standard cube molds and cured for 7 and 28 days. The compressive strength test is conducted as per IS: 516-1959 standards using a Universal Testing Machine (UTM). This study highlights the potential benefits of using ceramic waste as a partial replacement for cement, which enhances the pozzolanic reaction, while sisal fibre improves crack resistance and reduces shrinkage. The combination of these materials aims to develop eco-friendly, cost-effective, and durable concrete, promoting sustainable construction by reducing cement dependency and recycling waste products effectively.

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I.INTRODUCTION:

Concrete is one of the most widely used construction materials, consisting of cement, fine aggregate, coarse aggregate, and water, which hardens over time. Due to its ability to be moulded into various shapes and its high strength and stability, concrete is often preferred over brick and stone masonry.

Fiber-reinforced concrete incorporates fibres along with cement, fine aggregate, and coarse aggregate to enhance its properties. One key characteristic of fibers is the aspect ratio, which is defined as the ratio of their length to diameter. The use of natural fibers in concrete offers several benefits, including waste reduction and resource conservation.

Adding fibers improves concrete's properties by increasing tensile strength, impact resistance, durability, and shrinkage control. Additionally, fibers help control shrinkage cracks and reduce water bleeding. Extensive research has been conducted to evaluate the effects of natural fibres on reinforced concrete.

Natural fibres, derived from plants, animals, and minerals, have been used for centuries to enhance construction materials. One such Fiber is sisal Fiber, which is extracted from the leaves of the sisal plant. Known for its durability and high tensile strength, sisal fiber presents an eco-friendly and effective solution for improving the mechanical properties of concrete

The addition of fibers improves concrete properties such as tensile strength, impact resistance, durability, and shrinkage control. Fibers also help minimize shrinkage cracks and reduce water bleeding. Extensive research has been conducted to evaluate the effects of natural fibers on reinforced concrete. Natural fibers, derived from plants, animals, and minerals, have long been used to improve the strength and durability of construction materials. One such fiber is sisal fiber, which is extracted from the leaves of the sisal plant. Known for its high tensile strength and eco-friendly nature, sisal fiber serves as an effective reinforcement in concrete.

1.1 RAW MATERIALS

The materials used in this study include cement, aggregates, ceramic waste, and sisal fiber. Each component plays a crucial role in determining the properties of the final concrete mix.

1.2 CEMENT

Cement is the primary binding material in concrete, responsible for holding the aggregates together. Ordinary Portland Cement (OPC) is commonly used due to its high compressive strength, durability, and hydration properties.

1.3 AGGREGATES

Aggregates form the bulk of concrete and significantly influence its mechanical and durability properties.

They are classified into two types:

i) Fine Aggregates:
Fine aggregates, such as sand, fill the voids between larger particles, improving the workability and finish of the concrete. Proper gradation of fine aggregates ensures optimal strength and cohesion.

ii) Coarse Aggregates:
Coarse aggregates provide structural strength and stability to the concrete mix. They consist of crushed stone or gravel, which enhances the load-bearing capacity of the final product.

1.4 SISAL FIBER

Sisal fiber, a natural fiber extracted from the leaves of the sisal plant, is incorporated into the concrete mix to improve its tensile strength, impact resistance, and shrinkage control. It enhances the durability of concrete while offering an eco-friendly alternative to synthetic fibers.

1.5 CERAMIC WASTE

Ceramic waste, obtained from discarded tiles, ceramics, and sanitary ware, is used as a partial replacement for cement. It is available in powdered form and enhances the toughness and durability of concrete while promoting sustainability by reducing industrial waste.

1.6 CEMENT

Cement is the key binding material in concrete, responsible for holding the aggregates together and providing strength and durability. It undergoes a chemical reaction with water, known as hydration, which allows the concrete to harden over time.Cement is a fine, powdered material widely used in the construction industry. It is a binding substance that sets, hardens, and adheres to other materials, making it an essential component of concrete.

1.7 SISAL FIBER:

INTRODUCTION TO SISAL FIBER

Sisal fiber is a natural fiber obtained from the leaves of the sisal plant (Agave sisalana). It is known for its high tensile strength, durability, and resistance to moisture, making it a valuable reinforcement material in construction. Due to its eco-friendly nature and availability, sisal fiber is a sustainable alternative to synthetic fibers in concrete applications.

Figure 1 Sisal fiber

1.8 CERAMIC WASTE

Ceramic waste is a by product from the ceramic industry, including discarded tiles, sanitary ware, and pottery waste. It is generated during manufacturing, cutting, polishing, and finishing processes. Typically, available in powdered or crushed form, ceramic waste can be used as a partial replacement for cement or aggregates in concrete, enhancing its sustainability and reducing environmental impact.eramic waste is a byproduct generated during the manufacturing, finishing, and polishing of tiles, floor coverings, and sanitary ware.

A significant amount of ceramic waste powder is produced during the polishing process, where water is used, resulting in a wet-state waste material. Once dried, this waste consists of asymmetric and angular particles, which have a texture similar to cement particles.

Figure 1 Ceramic waste

1.9 OBJECTIVE OF THE WORK

The primary objective of this study is to evaluate the behavior of concrete when cement is partially replaced by ceramic waste and reinforced with sisal fiber. This research aims to enhance the mechanical properties, durability, and sustainability of concrete while reducing environmental impact and material costs.

THE PRIMARY OBJECTIVES

- To assess the feasibility of using ceramic waste powder as a partial replacement for cement in concrete.
- To evaluate the effect of sisal fiber as an admixture on the mechanical properties of concrete.
- To determine the optimal percentages of ceramic waste powder and sisal fiber that result in the best concrete performance in terms of compressive strength, flexural strength, and split tensile strength.
- To Analyze improvements in tensile strength, impact resistance, and crack resistance.
- To Study the workability and durability of fiber-reinforced concrete.
- Reduce cement consumption to lower carbon emissions.
- Promote waste utilization and environmental conservation.
- Conduct compressive strength, tensile strength, and flexural strength tests.
- Assess the impact of ceramic waste and sisal fiber on the longevity of concrete.
- Reduce construction costs by using waste materials.
- Provide an economical alternative to conventional concrete.

1.10 SPECIFIC OBJECTIVES:

- To analyze the feasibility of using ceramic waste as a partial replacement for cement
- Determine the optimal replacement percentage that maintains or improves concrete strength.

- Assess the pozzolanic activity and binding properties of ceramic waste.
- To study the effects of sisal fiber reinforcement on concrete properties
- Improve tensile strength, crack resistance, and impact resistance.
- Evaluate the workability and durability of sisal fiber-reinforced concrete.
- To enhance the sustainability of concrete production
- Reduce the carbon footprint associated with cement manufacturing.
- Promote the use of industrial waste (ceramic waste) and natural fibers (sisal fiber) for eco-friendly construction.
- To evaluate the cost-effectiveness of the modified concrete mix
- Analyze the economic benefits of using ceramic waste and sisal fiber compared to conventional concrete.
- To conduct laboratory tests for performance validation
- Perform compressive strength, tensile strength, flexural strength, and durability tests.

Compare the results with standard concrete mix designs to assess improvements.

This research focuses on enhancing the properties of concrete by partially replacing cement with ceramic waste and incorporating sisal fiber as reinforcement. The study aims to explore the mechanical strength, durability, sustainability, and economic feasibility of the modified concrete mix.

1.11 SCOPE OF THE STUDY INCLUDES:

Material Selection & Characterization

- Identifying optimal replacement levels of ceramic waste in cement.
- Analyzing the physical and chemical properties of ceramic waste and sisal fiber.
- Ensuring proper gradation of fine and coarse aggregates to maintain mix stability.

Mix Design & Proportioning

- Developing different concrete mix designs with varying ceramic waste replacement percentages.
- Determining the ideal fiber content to enhance tensile strength without compromising workability.
- Evaluating water-cement ratios to optimize strength and durability.

Experimental Testing & Analysis

- Conducting compressive strength, split tensile strength, and flexural strength tests.
- Assessing workability, water absorption, shrinkage, and impact resistance.
- Evaluating the durability properties, including resistance to chemical attacks and permeability.

Environmental & Economic Impact

- Studying the sustainability benefits of using ceramic waste as an alternative to cement.
- Reducing construction costs by using industrial waste materials and natural fibers.
- Assessing the long-term performance of the modified concrete for structural applications.

1.12PRACTICAL APPLICATIONS & FUTURE RECOMMENDATIONS

- Exploring the suitability of ceramic waste and sisal fiber-reinforced concrete for pavements, roads, bridges, and low-cost housing.
- Providing recommendations for large-scale adoption in construction projects.
- Suggesting further research on alternative industrial waste materials and natural fiber reinforcements

II.LITERATURE REVIEW

[1] Amrutha M et al (2021) A Study on Compressive Strength Characteristics of Sisal Reinforced Concrete, This work investigated to find the compressive strength of sisal reinforced cement concrete with different mix proportions and different percentage of fiber addition. Fibers were brushed, lined up and cut to obtain 1cm length. Materials were hand mixed with different percentage of addition of fiber, the fibers were chemically modified in order to improve their workability. Sisal fibers were treated with super plasticizer in M20 mix design and casted in cubes. The obtained specimens were subjected to tests aimed to evaluate the property (compressive strength) of the sisal reinforced concrete. The results of the investigation of the effect of surface treatment on the mechanical properties of sisal fiber reinforced concrete revealed that the chemical treatment actually enhanced the mechanical properties; the observed enhancement was due to the stronger bond that exists between the treated fiber and the matrix. The rate of increase in compressive strength is dependent on the percentage of sisal fiber varying between 0.5-1.5 percent. . At low fiber length the compressive strength is seen to be maximum, and will decrease the strength with the increase of fiber length. The optimum length of fiber is 10 mm to 150 mm .Addition of 3% volume fraction of sisal fiber which may be regarded as high fiber content and have created more voids volume in concrete.

[2]. A Study on Structural Characteristics of Sisal Fibre Reinforced Concrete et al (2019) Concrete is strong in compression but weak in tension. So we will provide the reinforcement to the concrete. Majorly steel is used as the reinforcement. Many of the researches are in progress to find a substitute to this material. Many investigations proposed artificial fibres. The study focuses on the compressive strength, split tensile strength, performance of the blended concrete containing Na2CO3 treated sisal fibre. In this project study of Na2CO3 treated sisal fibres for 5 days on the strength parameters normal concrete had been carried out by varying percentages of 0%, 0.5%, 1%, 1.5%and 2% for M30 grade of concrete design by using IS10262-2009. Concrete cubes and cylinder are tested at the age of 7, 14, and 28 days of curing. From the experimental investigations, it has been observed that, the optimum percentage of Na2CO3 treated sisal fibre is 1% for M30 grade.

[3]. Mr. Mithun K1,R.M. Mahalinge Gowda. 2, H.S Suresh Chandra3 et al (2016) A Study on Structural Characteristics of Sisal Fibre Reinforced Concrete: Concrete is strong in compression but weak in tension. So we will provide the reinforcement to the concrete. Majorly steel is used as the reinforcement. Many of the researches are in progress to find a substitute to this material. Many investigations proposed artificial fibres. The study focuses on the compressive strength, split tensile strength, performance of the blended concrete containing Na2CO3 treated sisal fibre. In this project study of Na2CO3 treated sisal fibres for 5 days on the strength parameters normal concrete had been carried out by varying percentages of 0%, 0.5%, 1%, 1.5%and 2% for M30 grade of concrete design by using IS10262-2009. Concrete cubes and cylinder are tested at the age of 7, 14, and 28 days of curing. From the experimental investigations, it has been observed that, the optimum percentage of Na2CO3 treated sisal fibre is 1% for M30 grade.

[4]. Mr. Mithun K1 ,R.M. Mahalinge Gowda. 2 , H.S Suresh Chandra3 , et al (2016) Concrete is strong in compression but weak in tension. So we will provide the reinforcement to the concrete. Majorly steel is used as the reinforcement. Many of the researches are in progress to find a substitute to this material. Many investigations proposed artificial fibres. The study focuses on the compressive strength, split tensile strength, performance of the blended concrete containing Na2CO3 treated sisal fibre. In this project study of Na2CO3 treated sisal fibres for 5 days on the strength parameters normal concrete had been carried out by varying percentages of 0%, 0.5%, 1%, 1.5%and 2% for M30 grade of concrete design by using IS10262-2009. Concrete cubes and cylinder are tested at the age of 7, 14, and 28 days of curing. From the experimental investigations, it has been observed that, the optimum percentage of Na2CO3 treated sisal fibre is 1% for M30 grade.

[5]. Shishir Kumar Sikder Amit et al (2020) A review of the use of sisal in concrete and its effects on the environment Based on the findings of many studies, this document summarizes the potential use of e-waste in concrete. 2020 IJSRET 3247 International Journal of Scientific Research & Engineering Trends Volume 6, Issue 5, September–October 2020, ISSN (Online): 2395–5666 there is a good chance that e-waste will be added to aggregate and have an influence on the environment. If various types of byproducts are utilized as a substitute material in concrete, the use of natural aggregates in concrete will be reduced. Renovation of the trash is also more crucial. The strength development pattern of sisal concrete has been shown to be similar to that of conventional concrete. E-waste is a potentially useful resource that can be exploited.

[6]. Ashwini Manjunath B T et al. (2016) They have analyzed the utilization of natural fibers as sisal as coarse aggregate in concrete with a percentage replacement ranging from 0%, 10%, 20% and 30% on the strength criteria of M20 concrete with w/c ratio of 0.5. By scrutiny the obtained results with standard concrete at 28 days the compressive strength, split tensile durability and flexural strength of concrete is reduced by 52.98%. This proves that the strength of concrete gets reduced when coarse aggregate was replaced by natural fibers as sisal. Thus, they have concluded that the introduction of plastic in concrete becomes fails in strength aspect. However, plastic will be wanted to replace some of the aggregates in a concrete mixture to reduce the unit weight of the concrete. This is useful to produce lightweight concrete such as concrete panels used in facades.

[7]. Aditya Gavhane et. al. (2016) to support the use of natural fibers as sisal as a partial replacement for both fine and coarse aggregate in concrete, an experimental investigation was carried out. They conduct an experiment using two different mixtures: one with standard M-30 grade concrete and the other with fine aggregate that has been replaced with e-waste to the tune of 10%. After conducting an experiment, they discovered that natural fibers as sisal may replace materials to the tune of 10%. After 7, 14, and 28 days, there is hardly any strength fluctuation for 10 percent replacement. Additionally, they said that concrete containing e-waste is easier to work with than traditional concrete and costs less to add admixtures. Concrete that contains natural fibers as sisal has a lower density and can be used to create lightweight concrete buildings. natural fibers as sisal demonstrates stronger defense against sulphate assault. After trials, they reasoned that e-plastic can be disintegrated by utilizing it as development material which can, at last, diminish ecological contamination just as landfill load.

[8]. T. Subramani et al. (2015) they have studied on partial substitute of sisal as a rough mixture. The substitute became fabricated from 3 one of-a-kind ratios i.e., 5%, 10%, and 15%. The 7 days, 14 days and 28 days of Compressive power check, break up tensile power check and Flexural power check became conducted. The Compressive power and Split tensile power of concrete containing plastic mixture are retained greater or much less in assessment with managed concrete specimens. Anyway, pleasant discernibly faded whilst the plastic substance became over 20%. It has been inferred that 20% of sisal general may be joined as coarse general substitution in cement without a long-haul poor influence and with worth pleasant development properties.

[9]. Vivek S. Damal et al. (2015) An experimental observe is made at the usage of sisal with a percent substitute starting from 0 % to 21.5% i.e. (7.5%, 15%, and 21.5%) at the power standards of M30 Concrete. By evaluating above outcomes with traditional concrete at 28 days the compressive power of concrete it's far discovered that the compressive power of concrete is decreased via way of means of 52.98% whilst the pleasant combination is changed via way of means of 21.5% of sisal. This proved that the compressive power of concrete receives decreased whilst pleasant combination is changed via way of means of sisal. Compressive power takes a look at is used to calculate the power of concrete containing numerous sisal contents on the age of 7, 14, 28 days respectively. Cube specimens are forged for locating the compressive power of specimens on 7, 14, 28 days for every blend specification following the same old take a look at strategies with the assist of dice trying out machine. It is discovered that the compressive power of concrete is discovered to be most excellent whilst the pleasant combination is changed via way of means of 7.5% with digital waste. Past it, the compressive power of cement keeps diminishing. The compressive power of concrete will regularly lower whilst pleasant combination is changed past 15% with digital waste. From this observe, we are able to use digital waste into the concrete via way of means of by replacing the fine aggregate.

[10]. Salman Siddique, et al. (2015) They made an experimental examine to explain the power improvement sample of natural fibers concrete is much like that of traditional concrete however there's a lower in power at all of the curing ages. The usage of mineral admixtures may be used to boom compressive power. They concluded that natural fibers is the doubtlessly possible cloth for use as first-class combination to supply long lasting concrete. Its use as first class combination in concrete will assist in assuaging the ability hassle of dwindling herbal resources. Its use may also assist International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06 Issue: 04 | Apr 2019 www.irjet.internet p-ISSN: 2395-0072 © 2019, IRJET | Impact Factor value: 7.211 | ISO 9001:2008 Certified Journal | Page 2764 in shielding environmental surroundings. They additionally stated that until date a completely restricted studies painting natural fibers as combination in concrete has been carried out. Therefore, in addition investigations to examine the methods wherein natural fibers as a combination alternative in concrete influences the rheological residences of sparkling concrete, mechanical and sturdiness residences of hardened mass are needed.

[11] Abdul Rahuman1 , Saikumar Yeshika2 et al. present research was designed to check the workability and strength properties of sisal fiber reinforced concrete with different mix proportions and different percentage of fiber addition. The materials were chosen to improve the various strength properties of the structure to obtain sustainability and better quality structure. Short discrete vegetable fiber (sisal) was examined for its suitability for incorporation in cement concrete. The physical property of this fiber has shown no deterioration in a concrete medium. Fibers were brushed, lined up and cut to obtain 4cm length. Degree of workability of concrete mix with 0.2% super plasticizer and water cement ratio 0.45 had good workability with slump value 53mm and compaction factor 0.88, which is effective, was obtained. Materials were hand mixed with 0.5%, 1% and 1.5% addition of fiber in M20 and M25 mix design and casted in cubes and cylinders. The obtained specimens were subjected to tests aimed to check the compressive, tensile and flexural strength. An increase in compressive strength by 50.53% and tensile strength by 3.416% was observed for 1.5% addition of fiber in M20 mix design respectively. An increase in compressive strength by 52.51% and tensile strength by 3.904% was observed for 1.5% addition of fiber in M25 mix design respectively.

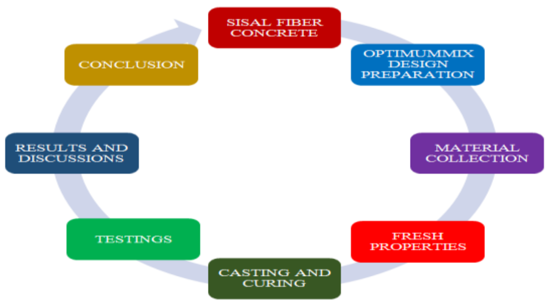
III.PROJECT OVER VIEW

3.1 OBJECTIVE OF THE STUDY

This study is conducted to accomplish some predefined objectives.

1. To investigate the effect of partial replacement of cement with ceramic waste on the 7-day compressive strength of concrete. The study evaluates different mix proportions, where cement is replaced by ceramic waste in varying percentages (0%, 10%, 15%, 20%, and 25%). The goal is to determine the optimum replacement percentage that enhances compressive strength while maintaining structural integrity.
2. To determine effect of different proportion of Sisal fibre in the mix.
3. To determine the strength of cubes and cylinders at 7 and 28 days and comparing with conventional concrete.
4. To determine the percentage variation in strength in cubes and cylinders at 7days and 28 days.
5. Comparison of mechanical properties results of sisal fibre concretes with best percentage of ceramic waste cube.

3.2 METHODOLOGY:



Methodology

3.3 MATERIALS USED FOR THIS EXPERIMENT

The experimental investigation aims to evaluate the mechanical, physical, and durability properties of concrete when cement is partially replaced with ceramic waste and reinforced with sisal fiber. This section outlines the materials, mix design, testing procedures, and analysis methods used in the study.

1. **CEMENT** – Ordinary Portland Cement (OPC) used as the primary binder.
2. **CERAMIC WASTE** – Finely ground ceramic waste used as a partial replacement for cement.
3. **FINE AGGREGATE** – River sand or crushed stone sand, used for workability and strength.
4. **COARSE AGGREGATE** – Crushed granite or similar aggregates to provide structural strength.
5. **WATER** – Potable water for hydration and workability of the concrete mix.
6. **SISAL FIBER** – Any chemical admixtures used to enhance performance.

IV.PREPARATION OF MATERIALS

Proper preparation of materials is essential to ensure uniformity, consistency, and accuracy in concrete mix design and testing. All materials used in construction must be brought to room temperature before the commencement of tests.

Figure 2 Preparation of materials

CEMENT PREPARATION

i. Cement should be thoroughly mixed by hand or using a mechanical mixer to achieve uniformity and blending.
ii. Proper care must be taken to prevent lump formation and eliminate the risk of contamination with foreign substances.

STORAGE REQUIREMENTS:

i. Cement should be stored in a dry, moisture-free environment.
ii. Containers or storage bags should be airtight to prevent exposure to air and humidity.

AGGREGATE PREPARATION

i. Fine and coarse aggregates should be properly graded to ensure consistency in the concrete mix.
ii. Aggregates must be stored in a dry condition to prevent excess moisture absorption, which may alter the water-cement ratio.
iii. Sieve analysis should be performed before mixing to verify that aggregates meet the required grading standards.

WATER PREPARATION

i. Clean, potable water should be used for mixing and curing (as per IS: 456-2000).
ii. Water must be free from impurities, chemicals, and suspended particles to avoid adverse effects on concrete strength.

CONCRETE MIXING AND HANDLING

i. All materials should be accurately weighed before mixing to maintain proper proportioning.
ii. Mixing should be carried out using a mechanical mixer to achieve uniform consistency.
iii. The concrete mix must be homogeneous, free from segregation, and have proper workability before casting.

PROPORTIONING

Proportioning step includes employing correct proportions of materials used in the concrete mix. The required quantities of cement, aggregates and water which are used to provide a good mix must be calculated properly. Depending up on the grade of the mix the proportions of the materials can be calculated. No material must be added more than the proportional limit because it may not give the good mix for the proposed work.

BATCHING:

Batching is the process of measuring and combining the required quantities of cement, aggregates, water, and admixtures to prepare the concrete mix. Proper batching ensures consistency, strength, and durability of concrete.

METHODS OF BATCHING

Batching can be done using two primary methods:

1) VOLUME BATCHING

i. Materials are measured based on volume (e.g., using measuring boxes or containers).
ii. Less accurate than weight batching and not suitable for high-strength concrete.
iii. Prone to inconsistencies due to moisture variations in aggregates.

2) WEIGHT BATCHING

i. Materials are measured by weight using weighing scales or automated batching plants.

ii. Ensures high precision and uniformity in the mix.

iii. Eliminates errors caused by moisture content variations in aggregates.

iv. In this study, weight batching is used to ensure accurate proportioning of cement, aggregates, water, ceramic waste, and sisal fiber.

STEPS IN BATCHING

CEMENT BATCHING

- Weighed using digital weighing machines.
- Stored properly to avoid lumps and moisture absorption.

FINE AGGREGATE (SAND) BATCHING

- Checked for moisture content before weighing.
- Proper sieve analysis ensures grading consistency.

COARSE AGGREGATE BATCHING

- Measured accurately to maintain proper aggregate-cement ratio.
- Ensured clean and dry before use.

WATER BATCHING

- Measured using graduated tanks.
- Proper water-cement ratio (W/C = 0.45-0.50) maintained for workability.

1. CERAMIC WASTE & SISAL FIBER BATCHING

- Ceramic waste powder is pre-weighed and mixed with cement.
- Sisal fibers are cut to required lengths (20-30 mm) and pre-mixed to prevent clumping

MEASUREMENT OF WATER

Water plays a **critical role** in concrete mix preparation, influencing its **workability, strength, and durability.** The correct **water-cement ratio (W/C)** must be maintained to ensure proper **hydration, setting, and hardening** of concrete.

WATER-CEMENT RATIO (W/C RATIO)

The W/C ratio is the proportion of water to cement by weight. It directly affects:

- Lower W/C ratio (0.40 - 0.50) → Higher strength, but less workability.
- Higher W/C ratio (>0.60) → More workability, but lower strength.
- For this study, the optimal W/C ratio is maintained at 0.45 to achieve good workability and strength.

MEASUREMENT METHOD

1. USE OF GRADUATED MEASURING TANKS:

- Water is measured in liters using calibrated containers or digital meters.
- Ensures precision and consistency in the mix.

ADJUSTMENT FOR MOISTURE CONTENT:

- Fine and coarse aggregates contain moisture, which affects the actual W/C ratio.
- Moisture correction is applied to avoid excess water in the mix.

ADDITION PROCESS:

- Water is added gradually during mixing to ensure uniform hydration.
- Avoids over-watering, which can cause bleeding and reduced strength.

MIXING OF CONCRETE

Concrete mixing is a crucial step in ensuring uniformity, strength, and durability. While hand mixing is possible, batch mixing using a concrete mixer is preferred for better consistency and efficiency. To compensate for material losses due to sticking to the mixer surfaces, an extra 10% of materials is included in each batch.

MIXING PLATFORM & EQUIPMENT

Concrete should be mixed on a non-absorbent, water-resistant surface to prevent material loss.

Mixing tools include batch mixers, trowels, shovels, and measuring containers.

STEP-BY-STEP MIXING PROCEDURE

DRY MIXING OF CEMENT AND FINE AGGREGATE

- Cement and fine aggregate (sand) are mixed thoroughly.
- Mixing continues until a uniform color and texture are achieved.

ADDITION OF COARSE AGGREGATE

- Coarse aggregate is added to the cement-sand mixture.
- The mix is blended until the coarse aggregate is evenly distributed.

WATER ADDITION & FINAL MIXING

- The pre-measured quantity of water is added gradually.
- Mixing continues until the concrete mix becomes homogeneous and reaches the desired consistency.

ADJUSTMENTS IN WATER CONTENT

- If the mix becomes too diluted, the batch must be discarded, and a fresh mix prepared.
- If adjustments are required, mixing should be repeated with proper water-cement ratio control.

SPECIFICATIONS OF CUBE MOULDS

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- Standard Size: 150 mm × 150 mm × 150 mm (as per IS: 516-1959).
- Material: Made of cast iron or steel for durability and precision.
- Tolerances: Each mould must have a flat and smooth inner surface to ensure correct dimensions.

PREPARATION OF CUBE MOULDS

- Cleaning & Assembly:
- The inner surfaces of the mould should be cleaned and free from dust, rust, or hardened concrete.
- Moulds should be properly assembled and tightened to prevent leakage.
- Application of Mould Release Oil:
- A thin layer of oil or grease is applied to the inner surfaces to facilitate easy removal of hardened concrete specimens.
- Placing on a Level Surface:
- The moulds are kept on a rigid, level, and vibration-free platform to prevent uneven concrete settlement.

FILLING & COMPACTING THE CONCRETE IN CUBE MOULDS

- Concrete is poured in three layers, each layer being one-third of the mould height.
- Each layer is compacted with a tamping rod (16 mm diameter, 25 strokes per layer) to eliminate voids and air gaps.
- The top surface is leveled with a trowel to ensure a smooth and even finish.

CURING OF CONCRETE CUBES

- The moulds are kept undisturbed for 24 hours at room temperature.
- After 24 hours, the cubes are carefully demoulded and placed in a curing tank with clean water for 7, 14, or 28 days, ensuring proper hydration and strength development.

CURING OF SPECIMENS:

After proper compaction of moulds the specimens are kept aside in that moulds without causing any disturbance to the moulds and are placed at room temperature for 24 hours. And then they are removed from the moulds by losing the screws and by slowing tamping the sides of the moulds and they are transferred into other curing tanks. The casted number of cubes, beams and cylinders are now kept in fresh water for curing.

Curing of specimens

IV. TESTING OF SPECIMENS

After achieving the required curing period, concrete specimens are removed from the curing tanks. The surfaces are then cleaned to remove excess water, ensuring accurate test results. The specimens undergo compressive, flexural, and split tensile strength tests following IS: 516-1959 standards.

COMPRESSIVE STRENGTH TEST ON CONCRETE SPECIMENS

The compressive strength test is one of the most important tests conducted on concrete specimens. It provides critical information about the mechanical properties, quality, and durability of the concrete mix. By conducting this test, civil engineers can verify whether the concrete has been properly mixed, placed, and cured, ensuring that the structural design requirements are met.

Concrete mixes can be designed to achieve a wide range of strength and durability characteristics, depending on the specific requirements of the structure. Therefore, compressive strength testing is a standard practice in construction projects to confirm that the concrete mix meets design specifications.

COMPRESSION TESTING MACHINE (CTM)

- Used to determine the compressive strength of concrete cubes.
- Maximum load capacity:2000 kN (200 tons).
- Equipped with a control valve to regulate the loading rate.
- Consists of upper and lower bearing plates where test specimens are placed.
- Requires regular oil level checks for smooth operation.

TESTING PROCEDURE FOR COMPRESSIVE STRENGTH

PREPARATION OF SPECIMEN

- Concrete cubes of 150 mm × 150 mm × 150 mm are cast and properly compacted.
- The cubes are cured in water for 7 and 28 days before testing.
- After curing for 7, or 28 days, the specimens are

removed from the curing tank.

- The specimens are removed from the curing tank and surface water is cleaned off before testing.

PLACING THE SPECIMEN

- The cube is placed centrally on the lower bearing plate of the compression testing machine.
- The smooth surface of the cube is positioned in contact with the loading plate.
- The upper plate is adjusted to ensure proper contact with the cube.

APPLYING THE LOAD

- The control handle is rotated until the upper plate touches the surface of the cube.
- The oil pressure valve is closed, and the machine is started.
- Load is applied at a uniform rate of 140 kg/cm² per minute.
- The load is increased continuously until visible cracks appear, and the cube fails.
- The maximum load at failure is recorded

CALCULATION

- The maximum load at failure is recorded.
- Compressive strength is calculated using the formula:

$$\text{Compressive Strength} = \frac{\text{Load at Failure (kN)}}{\text{Cross-sectional Area of Specimen (mm}^2\text{)}}$$

OBSERVATIONS AND ANALYSIS

The type of failure (crack pattern, crushing, or splitting) is noted. Results are compared with the standard values to evaluate concrete quality and compared with the design mix strength values to verify compliance.The compressive strength values at 7 days and 28 days are noted.

Standard Compressive Strength Values for Different Grades of Concrete

V.RESULTS AND DISCUSSIONS

To Investigate the effect of partial replacement of cement with ceramic waste powder and the concurrent addition of sisal fiber in different proportions on the mechanical properties of concrete. A series of tests are conducted on concrete samples to evaluate their compressive strength, flexural strength, and split tensile strength.The investigational analysis results are presented in tables and graphically represented to illustrate the variations in strength characteristics due to the combined influence of ceramic waste powder and sisal fiber. The study aims to determine the optimal mix proportion that enhances concrete performance while maintaining structural integrity.

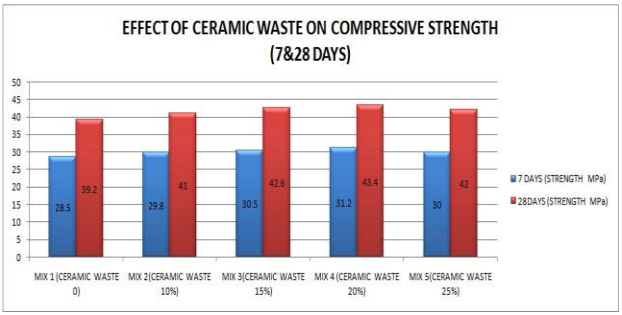
COMPRESSIVE STRENGTH:

The compressive strength values are determined by conducting tests using a compression testing machine. These tests are carried out at two different curing periods, namely 7 days and 28 days, and the results are tabulated accordingly.

The compressive strength values are assessed for cement that has been partially replaced with ceramic waste while incorporating sisal fiber at varying percentages. The tests are conducted for different mix proportions, and the results are recorded at curing periods of 7 and 28 days.

COMPRESSIVE STRENGTH RESULTS

EFFECT CERAMIC WASTE ON COMPRESSIVE STRENGTH



Graph.1 Effect ceramic waste on compressive strength

DISCUSSION ON CERAMIC WASTE REPLACEMENT

Up to 20% replacement (M4): The compressive strength increased due to the pozzolanic activity of ceramic waste.

- Beyond 20% (M5): The strength decreased as excessive ceramic waste reduced cementitious material, weakening the concrete matrix.
- M4 (20% ceramic waste) had the highest strength at 28 days (43.4 MPa),indicatingthe best balance between sustainability and mechanical properties.

EFFECT OF SISAL FIBER ON COMPRESSIVE STRENGTH (7 & 28 DAYS)

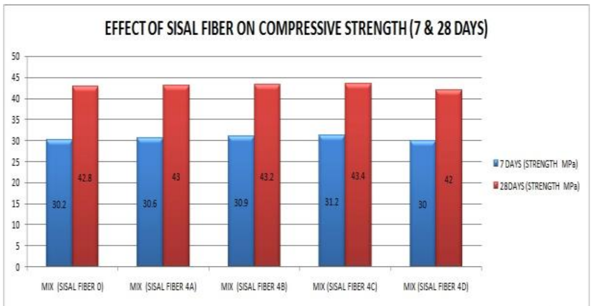
(This table examines the effect of different sisal fiber percentages, while keeping ceramic waste replacement constant at 20%.)

Mix ID	Cement (%)	Ceramic Waste (%)	Sisal Fiber %	7 Days Strength (MPa)	28 Days Strength (MPa)
M40	80	20	0.0	30.2	42.8
M4a	80	20	0.5	30.6	43.0
M4b	80	20	1.0	30.9	43.2
M4c (Optimum)	80	20	1.5	**31.2**	**43.4**
M4d	80	20	2.0	30.0	42.0

EFFECT OF SISAL FIBRE ON COMPRESSIVE STRENGTH

The below Graph shows the compressive strength of all mixes improved significantly from 7 days to 28 days, indicating proper curing and hydration of the concrete mix.

The addition of sisal fiber has a positive impact on compressive strength.The strength increased slightly as the fiber content varied from 4A to 4C, with the highest 28-day strength (43.4 MPa) in Mix (Sisal Fiber 4C).However, for Mix (Sisal Fiber 4D), a slight decrease (42 MPa) was observed, suggesting an optimal limit beyond which excessive fiber might negatively impact strength. Optimal Sisal Fiber Mix: Mix (Sisal Fiber 4C) achieved the highest strength, indicating an optimal fiber content that enhances compressive properties.Comparison with Control Mix (Sisal Fiber 0):Compared to the control mix (Sisal Fiber 0), all fiber-reinforced mixes exhibited higher compressive strength, confirming the reinforcing benefits of sisal fibers.



Graph.2 Effect of sisal fibre on compressive strength

DISCUSSION ON SISAL FIBER ADDITION

- Up to 1.5% fiber (M4c): Strength increased due to crack resistance and improved load transfer.
- Beyond 1.5% fiber (M4d): Strength decreased due to fiber clumping and poor workability.
- M4c (1.5% fiber) had the highest 28-day strength (43.4 MPa), proving the optimal balance of fibers.

FINDINGS

20% ceramic waste is the best replacement level for strength-improvement.
1.5% sisal fiber gives the highest compressive strength due to better reinforcement.
Excessive ceramic waste (>20%) or fibers (>1.5%) reduces strength due to weak bonding and workability issues.

EFFECT OF CERAMIC WASTE REPLACEMENT ON COMPRESSIVE STRENGTH

The results indicate that replacing cement with ceramic waste up to 20% (M4) led to an increase in strength, while higher replacement levels caused a gradual decrease in strength.

- The increase in strength for M2–M4 is attributed to pozzolanic activity in ceramic waste, which helps in additional hydration and improves the density of the concrete matrix.
- Beyond 20% replacement (M5), a strength reduction was observed due to the excessive reduction of cement content, which weakens the binding property of concrete.

EFFECT OF SISAL FIBER ADDITION ON STRENGTH

- The addition of sisal fiber up to 1.5% (M4) increased the strength due to better crack resistance, fiber bridging effect, and improved ductility.
- Beyond 1.5% fiber content (M5), the strength started to decline, mainly due to poor workability, increased void formation, and improper bonding between fibers and cement matrix.
- M4 (1.5% fiber) recorded the highest 28-day strength (43.4 MPa), which is 10.7% higher than M1 (control, 39.2 MPa).
- Excessive fiber content (2.0% in M5) caused fiber clumping and reduced compaction efficiency, leading to voids and a decrease in strength.

COMPARISON OF 7-DAY AND 28-DAY STRENGTH

- All mixes showed a significant increase in strength from 7 days to 28 days, indicating the normal hydration process.
- M1 (Control) exhibited a strength gain of 37.5% from 7 to 28 days (28.5 MPa → 39.2 MPa).
- M4 (Optimum Mix, 20% ceramic waste + 1.5% fiber) showed a 39% increase in strength (31.2 MPa → 43.4 MPa), confirming the positive influence of pozzolanic reaction and fiber reinforcement.

KEY OBSERVATIONS FROM RESULTS

Optimum Performance (M4: 20% Ceramic Waste + 1.5% Sisal Fiber)

- Highest 28-day strength (43.4 MPa), a 10.7% increase over the control mix.
- Balanced pozzolanic reaction and fiber reinforcement, leading to denser concrete.
- Recommended for sustainable and high-strength applications.

EFFECT OF SISAL FIBER ON STRENGTH DEVELOPMENT

- 1.5% fiber (M4) improved strength due to crack resistance and better load distribution.
- Excess fiber (2.0% in M5,) caused workability issues, fiber balling, and internal voids, leading to strength reduction.

STRENGTH GAIN OVER TIME

- The strength increased by approximately 35-

40% from 7 days to 28 days across all mixes.

- M4 had the highest strength gain of 39%, proving the positive effect of ceramic waste and fiber reinforcement.

PRACTICAL IMPLICATIONS OF THE STUDY

1.SUSTAINABLE CEMENT REPLACEMENT

- Up to 20% ceramic waste can be effectively used as a cement substitute, reducing cement consumption and environmental impact.

OPTIMIZED FIBER CONTENT

- 1.5% sisal fiber improves strength and toughness, but excess fiber (>1.5%) reduces workability and strength.
- The balance between workability and mechanical properties is essential for effective fiber-reinforced concrete.

APPLICATIONS OF THE OPTIMUM MIX (M4)

- Recommended for structural concrete applications, especially where higher crack resistance and durability are needed.
- Can be used in pavements, slabs, and precast elements for enhanced performance and sustainability.

VI CONCLUSION

- The experimental study concluded that 20% ceramic waste replacement in cement provides the highest compressive strength of 43.4 MPa at 28 days, enhancing concrete performance through pozzolanic activity.
- From above graph.1 consisting the effect of ceramic waste it shows that this study evaluates the effect of incorporating ceramic waste into concrete on its compressive strength over 7 and 28 days.
- The analysis includes five different mixes with varying percentages of ceramic waste replacement. The highest 28-day strength (43.4 MPa) is observed at 20% replacement. Beyond 20% ceramic waste, the compressive strength declines slightly.
- From above graph.2 consisting the effect of sisal fiber it shows that the compressive strength of all mixes improved significantly from 7 days to 28 days, indicating proper curing and hydration of the concrete mix.The addition of sisal fiber has a positive impact on compressive strength.
- The strength increased slightly as the fiber content varied from 4A to 4C, with the highest 28-day strength (43.4 MPa) in Mix (Sisal Fiber 4C).However, for Mix (Sisal Fiber 4D), a slight decrease (42 MPa) was observed, suggesting an optimal limit beyond which excessive fiber might negatively impact strength.Optimal Sisal Fiber Mix:Mix (Sisal Fiber 4C) achieved the highest strength, indicating an optimal fiber content that enhances compressive properties.Comparison with Control Mix (Sisal Fiber 0):Compared to the control mix (Sisal Fiber 0), all fiber-reinforced mixes exhibited higher compressive strength, confirming the reinforcing benefits of sisal fibers.
- However, strength declines beyond 20% due to reduced cementitious properties. The optimal sisal fiber content of 1.5% improves crack resistance and tensile strength, but exceeding this leads to poor workability and air voids. The combination of 20% ceramic waste and 1.5% sisal fiber produced the best results, making it a sustainable and high-performance alternative to conventional concrete. This study promotes eco-friendly construction by utilizing industrial waste and natural fibers without compromising strength. Future research should focus on durability aspects, fiber optimization, and real-world applications to validate long-term performance.

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