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Praveen Kumar 2K22/STE/11 May 2025

# EFFECT OF COCONUT SHELL ASH AS A PARTIAL REPLACEMENT FOR PORTLAND CEMENT IN COMPRESSIVE STRENGTH AND WORKABILITY OF CONCRETE

**A Dissertation**

**Submitted In Partial Fulfilment of the Requirements for the Degree**

**of**

**MASTER OF TECHNOLOGY**
in

**Structural Engineering**

**Submitted by**

**Praveen Kumar**

**(2K22/STE/11)**

**Under the Supervision of**

**Dr. Rajeev Kumar Garg**

**Professor**

**Delhi Technological University**

**Department of Civil Engineering**
**DELHI TECHNOLOGICAL UNIVERSITY**
**(Formerly Delhi College of Engineering) Shahbad Daulatpur, Main Bawana Road, Delhi-110042, India**

**MAY 2025**

**DELHI TECHNOLOGICAL UNIVERSITY**

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Shahbad Daulatpur, Main Bawana Road, Delhi-42

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I **Praveen Kumar** hereby certify that the work which is being presented in this thesis entitled **EFFECT OF COCONUT SHELL ASH AS A PARTIAL REPLACEMENT FOR PORTLAND CEMENT IN COMPRESSIVE STRENGTH AND WORKABILITY OF CONCRETE** in fulfilment of the requirements for the award of the Degree of Master in Technology, submitted in the Department of **Civil Engineering**, Delhi Technological University is an genuine record of my own work carried out during the period from **August,2024 to May,2025** under the supervision of **Dr. Rajeev Kumar Garg**

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# ABSTRACT

The price of cement used in concrete construction has been steadily increasing, making it less affordable, even though the demand for housing and other construction projects continues to rise with population growth. The production of cement has a major environmental impact because it releases large amounts of $CO_2$ into the atmosphere. To address these issues, use of industrial waste and alternative materials to cement and concrete has been encouraged. This not only lowers the demand for natural raw materials but also helps reduce environmental damage. As population and industrial activities increase, so does the amount of waste produce worldwide. The most effective ways to manage this growing waste problem is through waste reduction and reuse. Agricultural waste, such as coconut shells, is one example. Usually burned in the open to dispose, which harms the environment, these shells can be processed into ash and used as a pozzolanic material to partially replace Cement at levels of 0%, 20%, 25%, and 30%. In to present study, 32 concrete cubes are made and cured in water for 7 and 28 days. The compressive strength and water absorption characterstics were tested. The results showed that adding coconut shell ash improved both properties after 28 days, but only up to a certain percentage. Beyond that point, the benefits started to decline, indicating there's an ideal limit to how much ash should be used.

# ACKNOWLEDGEMENTS

Completing the research thesis, **"EFFECT OF COCONUT SHELL ASH AS A PARTIAL REPLACEMENT FOR PORTLAND CEMENT IN COMPRESSIVE STRENGTH**," has been a journey filled with challenges, growth and invaluable support. As i reflect on this endeavour, I am deeply grateful to all those who have played a role in its realization.

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(Praveen Kumar)

## List of Abbreviations

CCSA- Crushed coconut shell ash

NBC- National Building code

IS- Indian standards

76 CBR- California bearing ratio

OMC- Optimum moisture content

CSA- Coconut shell ash

CSAC- Coconut shell ash concrete

RHS- Rice husk ash

EP- Environment protection

# CHAPTER ONE
# INTRODUCTION

The increasing demand for construction materials, alongside the environmental problems caused by agricultural waste, has inspired researchers to explore sustainable alternatives like green concrete. Doing so can not only reduce production costs but also support environmental protection efforts and even generate foreign income. Coconut shells, a common form of agricultural waste, are widely available in tropical regions. As the importance of coconut as a crop grows—especially as a source of biofuel—so does the need to manage its byproducts effectively. However, with the rising and unreliable costs of fuel, coconut shells have begun to be used as an alternative energy source. In Nigeria, for example, they are used to power boilers, maintain plantation roads, and serve as fuel for blacksmiths. Despite this, a large portion—up to 90%—of coconut waste is still discarded or openly burned, significantly contributing to greenhouse gas emissions (Madakson et al., 2021). Given these environmental and economic challenges, there is a pressing need for better coconut waste management practices, including improved use, storage, and disposal methods. While several possible uses for coconut shell have been proposed, most are not yet cost-effective or practical on a large scale. Allowing this type of waste to decompose naturally can take a long time and release pollutants harmful to nearby communities. Incorporating CSA into concrete could help address these concerns and promote environmental sustainability. Using CSA could also help lower the amount of agricultural waste that ends up in landfills. The study involved in which cement replaced by ash (CCSA) to observe the impact on concrete properties such as density, compressive strength, and water absorption. Many waste materials, especially those that do not decompose easily, pose long-term disposal challenges and contribute to environmental pollution. One way to address this is through the "waste hierarchy" approach, which prioritizes reducing, reusing, and recycling waste—with recycling being the most preferred option (Zhang et al., 1996). To ensure quality construction, the concrete must be workable—meaning it can be easily mixed, shaped, and placed—while still achieving the required strength to support structural loads (Hannant, 2001). However, if the mix is too workable, it may lose strength over time. Over the years, many studies have looked into improving concrete by introducing new materials—whether recycled, natural, or synthetic—into the mix. Concrete, although man-made, resembles natural rock in appearance and performance. Its strength develops over time through the hydration. While the use of coconut shell in concrete is not common—especially for lightweight, non-load bearing applications—it holds great promise as a sustainable building material.

1

## 1.1 STATEMENT OF PROBLEM

The increasing need for traditional construction materials such as concrete, bricks, blocks and tiles increase to overexploitation of natural resources like river sand, granite and gravel. This overexploitation has resulted in environmental degradation and imbalance. At the same time, the rising cost of building materials—particularly cement and steel reinforcement—has significantly driven up overall construction costs. Additionally, the environmental damage caused by cement manufacturing has highlighted the need for alternative binding materials that can either partially or entirely replace cement in concrete production. Finding ways to recycle and utilize these waste materials can reduce their negative environmental impact. Studies have shown that many agricultural byproducts rich in amorphous silica are suitable for replacing a portion of cement in concrete. Amorphous silica reacts more efficiently with lime than its crystalline counterpart. Indian Standards (IS) define pozzolanic materials as siliceous or aluminous substances that, though not cementitious by themselves. In India, the demand for coconuts continues to grow due to their widespread use in food, oil extraction, and beverages. However, this also leads to a large volume of coconut shell waste being generated daily and discarded around coconut-processing industries, restaurants, and street vendors. These discarded shells often accumulate around factory areas, causing waste management and storage issues, as well as environmental concerns. Moreover, with inflation and global economic challenges driving up material costs, there is an urgent need to find cost-effective alternatives for construction. Utilizing coconut shell waste in concrete production not only offers a solution to waste disposal problems but also reduces the overall cost of producing environmentally friendly or "green" concrete.

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## 1.2 OBJECTIVES OF STUDY

The objective and the present study are:

50

- To find the effect of CCSA as partial replacement of cement.
- To find the effect of CCSA as partial replacement cement on workability of concrete.
- To find the effect of CCSA as partial replacement of cement on water absorption.

1

## 1.2 SCOPE OF STUDY

30 42 63

In the research, compressive strength and water absorption tests are conducted in the Concrete Laboratory in the Civil Engineering Department of Delhi Technological University. The concrete is prepared using a mix ratio of 1:2:4, with a target density of 2400 kg/m³ and a compressive strength of 30 N/mm². Compressive strength will be tested on concrete cubes after curing for 7 and 28 days. Each cube has dimensions of 150 mm by 150 mm by 150 mm. A total of 24 concrete cubes is cast, with cement partially replaced by CCSA at varying composition of 0%, 20%, 25%, and 30%.

1

## 1.3 SIGNIFICANCE OF STUDY

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The rising prices of construction material, particularly cement and bars, have significantly increased overall building costs. In addition, the environmental pollution caused by cement manufacturing has driven the need to find alternative binding materials that can either fully or partially replace cement in concrete production. Using CCSA as a partial substitute for cement can help reduce the volume of coconut shells disposed of in landfills. Moreover, if concrete made with coconut shell ash proves effective, it could offer a sustainable, eco-friendly alternative material for local builders and contractors.

1 CHAPTER TWO

# LITERATURE REVIEW

## 2.0 INTRODUCTION

This chapter discusses about the effect of coconut shell ash in concrete about their engineering properties of concrete such as compressive strength and water absorption.

## 2.1 CONCRETE

Concrete is a mixture of cement, fine and coarse aggregates, and water, combined in specific ratios to achieve desired strength. Understanding the properties of each component—cement, aggregates, and water—is essential to predicting and controlling
61 concrete behaviour (Olufemi et al., 2002). Today concrete is the most commonly used man-made construction material across nearly all fields of engineering and architecture worldwide. According to Simmons H.L. (2007), the use of concrete dates back to the third century B.C. when the Romans used a mixture of lime, crushed stones, and sand to build structures like temples. Following the fall largely forgotten and remained dormant until the Renaissance period. Interest in ancient Roman construction methods resurfaced in the 15th century with the study of *De Architectura*. However, it wasn't until the late 18th century that systematic research into concrete resumed. The breakthrough came in 1824 with the discovery of the key ingredient used in modern concrete: Portland cement.

1

## 2.3 CLASSIFICATION OF CONCRETE

### 2.3.1 Based on unit weight;

| | |
|---|---|
| Ultra light concrete | < 1,200 kg/m |
| Light weight concrete | 1200-1800 kg/m |
| Normal weight concrete | 2,400 kg/m |
| Heavy weight concrete | >3,200 kg/m |

### 2.3.2 Based on strength;

| | |
|---|---|
| Low strength concrete | <20 MPa |
| Moderate strength concrete | 20-50 MPa |
| High strength concrete | 50-200 MPa |
| Ultra high strength concrete | >200 MPa |

## 2.4 PROPERTIES OF CONCRETE

- Workability
- Segregation
- Bleeding
- Hardness

47 ## 2.5 STRENGTH OF CONCRETE

The strength of concrete is the ability to withstand loads under compression, flexure,
1 or shear. It is primarily influenced by the water-cement ratio (w/cm), the proportions of the mix ingredients, and the methods used for mixing, placing, and curing the
5 concrete. A lower water-cement ratio results in stronger concrete, as it reduces the amount of water in the mix. Adding too much water, however, thins the paste, making it easier to coat the particles but weakening the concrete by diluting the paste and reducing its strength.

1 ### 2.5.1 COMPRESSIVE STRENGTH

The compressive strength of concrete refers to the maximum load it can withstand per unit area without failing. To determine compressive strength, concrete cubes. The
19 strength is calculated by dividing the failure load by the cross-sectional area that resists the load, with the result typically expressed in Megapascals (MPa) in SI units. For example, residential structures may require a compressive strength of 17 MPa, while commercial buildings often require 28 MPa or higher, according to the International Building Code (IBC). Some specialized applications may require strengths exceeding
31 70 MPa. They are also used for quality control, accepting concrete, or estimating the strength of concrete in a structure, which can guide decisions about construction activities such as form removal or curing methods. "Standard Practice for Making and Curing Concrete Test Specimens in the Field." For estimating the strength of in-place

concrete, procedures for field-cured specimens are also outlined in IS 516: 1959. Typically, strength requirements are evaluated at the ages of 7 and 28 days.

### 2.5.2 FACTORS AFFECTING STRENGTH OF CONCRETE

- Water/cement ratio
- Coarse/fine aggregate ratio
- Age of concrete
- Compaction
- Curing

### 2.5.3 DURABILITY OF CONCRETE

Concrete durability is its capacity to resist factors such as weathering, chemical reactions, and wear, while preserving its intended mechanical properties. In other words, it measures how long concrete can serve its purpose without experiencing substantial degradation. Durability is vital for ensuring the long-term stability and cost-efficiency of concrete structures, as it directly influences their lifespan and maintenance needs.

### 2.5.4 TENSILE STRENGTH OF CONCRETE

Concrete's tensile strength is generally much lower than its compressive strength. It is often represented as a percentage of the compressive strength, with values around 10% being typical. For instance, M20 grade concrete, which has a compressive strength of 20 $N/mm^2$, typically has a tensile strength between 2 and 3 $N/mm^2$.

### QUALITY OF RAW MATERIALS:

A) **Cement:** when stored properly in dry conditions and meeting the relevant standards, is suitable for use in concrete Hydraulic cements can harden underwater due to chemical reactions that form water-insoluble hydrates, making them resistant to water and chemical attacks. Cement with a high content of tricalcium silicate ($Ca_3S$) typically gains strength much faster than cement rich in dicalcium silicate ($Ca_2S$). To improve the resistance of concrete to sulphates, sulphate-resisting cement, which contains low amounts of tricalcium aluminate ($Ca_3A$), can be used. Ordinary Portland cement (OPC), a low-heat cement, is the most commonly used type in construction, and its specifications are outlined in IS 516: 1959.

**B) AGGREGATE**: The quality, size, shape, texture, and strength of aggregates play a significant role in determining the strength of concrete. The presence of contaminants such as salts (chlorides and sulphates), silt, and clay can weaken concrete. Aggregates are a crucial component of concrete, typically considered an inert material that is distributed within cement paste to form a solid mass, which can be moulded or cast into different shapes. They act as the structural framework of the concrete. When concrete is subjected to stress, failure can occur within the aggregate, the cement matrix, or at the interface between them, or a combination of these factors. The bond between the aggregate and the matrix is a key factor influencing concrete strength. The strength cleanliness of the aggregate. Surface texture is particularly important for flexural strength, with smoother particles generally leading to reduced strength. Where cracking is more likely to initiate. Larger aggregates can result in bigger cracks at the interface, which are more likely to interact with cracks in the paste and other interfacial cracks. As a result, similar strength can be achieved with both smooth and rough aggregates by adjusting the w/c ratio slightly.

**C) Water**: Water is crucial in determining the strength of concrete, with the amount used being particularly important. Concrete strength improves when less water is used in the mix. However, this is not a rigid rule, and it is important to refer to the relevant standards for testing water intended for construction use. A concrete mix that contains just enough water for complete hydration of the cement.

**WATER / CEMENT RATIO:**The water-cement (w/c) ratio is a key factor that influences the strength of concrete. The density of hardened cement, in terms of the gel/space ratio, is determined by the w/c ratio. A higher w/c ratio results in a more porous paste, which lowers the concrete's strength. The strength continues to improve with a decreasing w/c ratio, but only if the concrete is properly compacted. If the w/c ratio is very low then no water-reducing agent is used, the workability can be so poor that air voids are trapped in the hardened concrete, which can result in a lower strength compared to concrete with a higher w/c ratio

**D) AGE OF CONCRETE:** The degree of hydration in concrete is directly related to its age, as long as the concrete is not allowed to dry out or exposed to very low temperatures. In theory, as long as the concrete stays hydrated, the hydration process will continue, though at a progressively slower rate. For most practical purposes, it is generally assumed that most of the concrete's strength is achieved within 28 days. On the 7th day, the strength is typically between

60% and 80% of the strength at 28 days, with the percentage being higher for mixtures. However, relying on this continued strength development for structural design should be done cautiously, as the rate of cement hydration can vary significantly under different real-world conditions.

1 E) **COMPACTION OF CONCRETE:**Once the concrete is placed, it must be compacted to eliminate any air voids trapped in the mix. These air voids can significantly reduce the concrete's strength. For instance, every 1% of trapped air can cause a decrease in strength by about 5% to 7% (Gambhir ML, 1999). This means that concrete with just 5% air voids due to improper compaction could lose up to one-third of its strength. Additionally, air voids increase the permeability of the concrete, which in turn affects its durability. Without sufficient density and impermeability, concrete will not be watertight, making it more vulnerable to aggressive liquids and more likely to deteriorate. It’s important to distinguish between entrained air bubbles and entrapped air at this point. Entrained air bubbles are small and spherical, which can enhance frost resistance.

F) **CURING OF CONCRETE:** Curing is a process that protects fresh concrete from evaporation. which can negatively affect the hydration of cement. It helps to ensure that cement hydration continues, thereby promoting the strength development of the concrete. Concrete surfaces are typically cured by sprinkling water on them. Most of the strength development and hydration occur during the first month of the concrete. As a result, concrete continues to gain strength as it ages.

## 2.6 WORKABILITY OF CONCRETE

Workability refers to how easily concrete can be transported, placed. It is also the internal work done which is required to overcome the frictional forces between the concrete to achieve full compaction. Since no single test can find all these factors, various methods are used. Consistency is sometimes used to refer to the degree of wetness—generally, wetter concrete is more workable than dry concrete.

### 2.6.1 SLUMP TEST ( IS 1199 )

There are four different possible slump: true slump, zero slump, shear slump, collapse slump.

Factors affecting concrete workability:

- Water-cement ratio
- Admixtures.
- 5 Sand to aggregate ratio

A) **WATER-CEMENT RATIO:** The higher the water-cement ratio, the greater the workability of concrete. This is because adding more water increases inter-particle
22 lubrication, making the concrete easier to mix and place. However, while higher water content improves workability, it reduces the strength of the concrete. This
2 happens because increasing the water-to-cement ratio leads to higher porosity in
7 the concrete, weakening its structure. A lower water-cement ratio results in fewer voids and a stronger hardened cement paste.

4 B) **ADMIXTURES:** Chemical admixtures will be used to improve the workability of concrete. The addition of air-entraining agents creates tiny air bubbles that
68 act like ball bearings between particles, enhancing mobility and workability while reducing bleeding and segregation. Additionally, the inclusion of fine pozzolanic materials has a positive effect on workability by improving lubrication in concrete.

33 C) **SAND TO AGGREGATE RATIO:** If the amount of sand in the mix increases,
1 the workability of the concrete tends to decrease. This is because sand has a larger surface area and more contact points, which causes increased friction and
1 resistance during mixing. To create stronger concrete, a low water-cement ratio is typically used. It might seem that by keeping the cement content high, sufficient workability can be achieved while still maintaining a low water-cement ratio. However, this approach must be carefully balanced to ensure the right mix for both strength and ease of handling.

## 2.7 ADVANTAGES OF CONCRETE

39 • **Economical**: Concrete is one of the most affordable and widely accessible construction materials. Its production cost is significantly lower compared to other engineered materials. Concrete primarily consists of three major components—cement, aggregates, and water—all of which are relatively inexpensive and commonly available across the globe. In comparison to materials like steel, plastic, or polymers,

concrete components are more economical and easier to source locally. This widespread availability allows concrete to be produced near construction sites, minimizing the transportation costs often associated with other building materials used.

1

## 2.8 FRESH CONCRETE

Fresh concrete is that stage of concrete will be in plastic stage and can be mould in any specific shape. After it sets it will lose its plasticity nature.

1

### 2.8.1 PROPERTIES OF FRESH CONCRETE

- Setting time
- Workability
- Segregation
- Hydration in cement

### SETTING OF CONCRETE

The setting of concrete refers to the process in which it changes from a plastic state to solid stage, hardened form before it begins to develop significant strength. This early stage of hardening is closely linked to the setting behavior of the cement paste,
59 meaning the properties of cement play a crucial role in determining the setting time.
4 Several factors influence the setting time of concrete, including the water-cement ratio temperature, cement and fineness of cement, relative humidity, admixtures used, and the type and quantity of aggregates. Proper control of these variables is essential to ensure desirable setting

### CONCRETE BLEEDING

44 Bleeding in concrete, also known as water gain, is a specific type of segregation where excess water in the mix rises to the surface. This phenomenon is most common in overly wet mixes, poorly proportioned or inadequately mixed concrete, and is particularly noticeable in thin elements like slabs or when concrete is placed under hot, sunny conditions.

As the water rises, it can accumulate on the surface, sometimes carrying fine cement particles with it. When the surface is trowelled, heavier aggregates sink while water and cement rise, forming a weak layer of cement paste on top called laitance. This laitance negatively affects the surface durability of slabs and pavements, leading to dust formation in dry conditions and muddy surfaces in wet weather. During bleeding, water travels upward through the mix.

**SEGREGATION IN CONCRETE:**

The separation of concrete's constituent materials, leading to an uneven distribution of its components. Ideally, concrete should be a uniform, homogenous mix where all ingredients cement, aggregates, and water are evenly blended. Because the materials used in concrete differ in size, shape, and specific gravity, there's a natural tendency for them to separate. However, when concrete is properly designed factoring in aspects like aggregate grading, size, shape, surface texture, and the right amount of water it becomes cohesive and resistant to segregation. In such a well-prepared mix, the cement paste holds the aggregates together and prevents them from settling or separating. The paste is also thick enough to retain water, limiting its movement and ensuring uniformity throughout the mixture. Thus, a properly proportioned and mixed concrete will not show signs of segregation.

4

**HYDRATION IN CONCRETE:**

Concrete gains its strength through the hydration of cement particles—a process that is gradual and extends over a long period. Although hydration begins rapidly, its rate decreases over time. On construction sites, higher water-cement ratios are often used, but since concrete is exposed to the atmosphere, much of this water evaporates. As a result, the remaining water in the concrete may not be sufficient to ensure complete and effective hydration, especially in the upper layers. To support continuous hydration, additional moisture must be provided to compensate for water lost due to evaporation and absorption. This is where curing plays a crucial role. The goal is to create a favourable environment to ensure strength development and durability. Hydration also produces which can be problematic, particularly with respect to volume stability. If not managed, this heat can lead to shrinkage and cracking. One effective way to control this is through proper water curing, which helps dissipate heat and minimizes its adverse effects on the concrete structure.

## 2.9 HARDENED CONCRETE

Strength refers to a material's capacity to withstand stress without failing. In concrete, failure typically occurs through cracking. When subjected to direct tension, concrete tends to fail as numerous small cracks develop and expand, ultimately causing the material to break apart—a process commonly referred to as "crushing." Concrete performance is primarily assessed based on its mechanical properties, such as shrinkage, creep, and especially compressive strength, which is considered the most critical property. While higher compressive strength often implies better overall performance, this assumption doesn't always hold true when mineral admixtures are used to partially replace cement. In such cases, improvements may not directly correlate with enhancements in other mechanical properties.

## 2.10 ADMIXTURES IN CONCRETE

Admixtures, also known as additives, are materials other than Portland cement, water, and aggregates that are added to concrete either just before or during the mixing process. Instead of relying solely on specialized cements, it is often possible to modify the properties of standard cement by incorporating appropriate admixtures. Today, concrete is used for a wide variety of applications and in diverse environmental conditions. In some of these situations, conventional concrete may not provide the necessary performance or durability. Admixtures are used in such cases to enhance the characteristics of ordinary concrete, tailoring it to specific needs (Liu, 2004). Before using any admixture in a project, it should be tested in trial mixes using actual job materials and under expected site conditions (including temperature and humidity

### 2.10.1 The major reasons for using admixtures:

According to IS 9103:1999, admixtures are categorized based on their intended function and the specific performance characteristics they impart to concrete. These categories include retarders, plasticizers, water-reducing agents, air-entraining admixtures, bonding agents, accelerators, colouring agents, waterproofing agents, and various other specialized additives. These widely used types are generally easy to find at most local concrete supply outlets.

**ADMIXTURES AND THEIR PROPERTIES**

| TYPE OF ADMIXTURE | MATERIAL | DESIRED EFFECT |
|---|---|---|
| Air entraining | Salts of wood resins, synthetic detergents, sulphonated lignin, fatty acids | Improve durability |
| Plasticizers | Hydroxylated carboxylic acids | Reduces water required for giving consistency |
| Accelerators | Calcium chloride | Accelerated settling and early strength development |

| | | |
|---|---|---|
| Pozzolonas | Fly ash, natural pozzolona (class n) | Improve workability and plasticity |
| Water repellant | Sterate of calcium, aluminium, ammonium and soluble chlorides | Decrease permeability |

TABLE: 2.1 TYPES OF ADMIXTURE AND ITS PROPERTIES

3 **2.10.2 Air-entraining admixtures:**

Air-entraining admixtures are used to intentionally create and stabilize tiny air bubbles within concrete. This process significantly enhances the durability of concrete, especially when exposed to freezing and thawing cycles. Additionally, it helps in reducing or eliminating issues like segregation and bleeding. The entrained air can be
1 introduced by using air-entraining cement, which is Portland cement mixed with air-entraining agents during its production. Specifications and testing methods for air-entraining admixtures are provided in IS 9103:1999. For the manufacture of air-entraining cements, the additions must also comply with the requirements outlined in this standard.

3 **2.10.3 Water-reducing admixtures:**

Water-reducing admixtures are used to decrease the amount of mixing water needed to achieve a concrete mix with a specific slump. These admixtures can help lower the
29 water-cement ratio, reduce the amount of cement needed, or increase the slump. Typically, water reducers can reduce water content by about 5% to 12%. When used without reducing the water content, they can increase the slump of the mix. However, this might lead to a quicker loss of slump, which in turn reduces workability.

12 **2.10.4 Retarding admixtures:**

Retarding admixtures are used to slow down the setting rate of concrete. High temperatures in fresh concrete (around 30°C or 86°F) often accelerate the hardening process, making placing and finishing the concrete more challenging. They are useful
6 for various purposes, such as: Counteracting the effect of hot weather on the setting time. Delaying the initial setting of concrete or grout in challenging placement conditions, like when placing concrete in large foundations or piers, cementing oil wells, or pumping grout over long distances. Allowing extra time for special finishing
54 techniques, like exposing aggregate surfaces. However, the use of retarders can lead to a slight reduction in strength during the early stages. The impact of retarders on other properties, like shrinkage, may be unpredictable. Therefore, it's recommended to

conduct acceptance tests with actual job materials under the expected conditions before using retarders.

### 2.10.5 Accelerating Admixtures:

Accelerating admixtures are used to speed up the rate of hydration (setting) and early strength development in concrete. The most commonly used chemical for this purpose is calcium chloride ($CaCl_2$), particularly in non-reinforced concrete. It should meet the standards specified in IS 9103: 1999. Calcium chloride has been widely used and studied, providing valuable data on its impact on concrete properties. While it accelerates strength gain, calcium chloride also has some drawbacks. It doesn't significantly lower the freezing point of concrete, and using it to prevent freezing is not recommended. Reliable methods to protect concrete during cold weather should be employed instead.

### 2.10.6 Colouring Admixtures:

Concrete can be colour using both natural and synthetic materials for aesthetic purposes and safety reasons. To counteract this, most carbon black pigments contain additives that offset this effect. Before using any colouring admixture in a project, it's important to test its colour fastness under sunlight and autoclaving conditions. Additionally, calcium chloride should not be used with pigments, as it can cause distortions in colour.

## 2.11 MODIFIED CONCRETE USING WASTE

The ongoing depletion of natural resources and environmental concerns in many countries have led to increased research into the effective use of various types of waste like agricultural, industrial, mining, and domestic waste.. By using these types of waste as a replacement in concrete in fixed proportion, thus the result of concrete will be improved.

### 2.11.1 Waste as Partial Cement Replacement Material

Various types of waste have been used as ingredients in the production of regular concrete. The high cost of cement, which serves as the binder in mortar and concrete, has driven the search for alternatives. Beyond cost, cement production has drawbacks such as high energy consumption, $CO_2$ emissions contributing to global warming, and the depletion of limestone deposits. In advanced countries, fly ash—produced from cement, typically ranging from 10% to 30% by weight. These cements offer advantages such as better chemical resistance, lower heat of hydration, cost savings, improved workability, reduced bleeding, and greater impermeability. However, they come with disadvantages, including slower strength development and increased shrinkage.

1

## 2.12 COCONUT SHELL FROM VARIOUS PARTS OF INDIA

Generally coconut is produced in southern India at various places. Most of the coconut when they were ripen produced shells into it. Annually coconut shells are produced in tonnes in India. In 2023-24, 3.11 billion tonnes of coconut shells are produced in India. This will be a major problem to handle these coconut shells as they require 3 to 4 years to decompose. This will be a major problem in India to handle at a very high scale. So, if we convert these coconut shells into ash then this will solve our major environmental problems

1

### 2.12.1 Coconut shell

Cocos Nucifera trees, commonly known as coconut palm trees, grow abundantly along
11 coastal areas of tropical countries. These trees thrive in sandy, saline soil and warm climates. A healthy coconut tree can produce around 120 large husks and shells annually, each containing a coconut inside. These husks are typically discarded as waste. Consumers buy coconuts with the shells, which are then broken open to remove the meat. To repurpose the shells, they are burned at high temperatures in a furnace to produce coconut shell ash (Walter et al., 2006).

## 2.13 Incinerator

Incinerators, are used to burn waste materials like coconut shells, reducing them to ash. This process, known as incineration, involves burning waste at high temperatures to convert it into gas and ash. Rotary kiln incinerators are particularly effective for large-scale incineration and are commonly used by municipalities and industrial plants.

### 2.13.1 Incineration Process:

Incinerators are designed to burn waste material at a very high temperature, range between 850°C and 1200°C, to reduce the coconut shell to ash and gas.

### 2.13.2 cost of burning:

Cost of burning of coconut shell will directly depend on the quantity of material used for burning of material. Burning coconut shells cost is negligible.

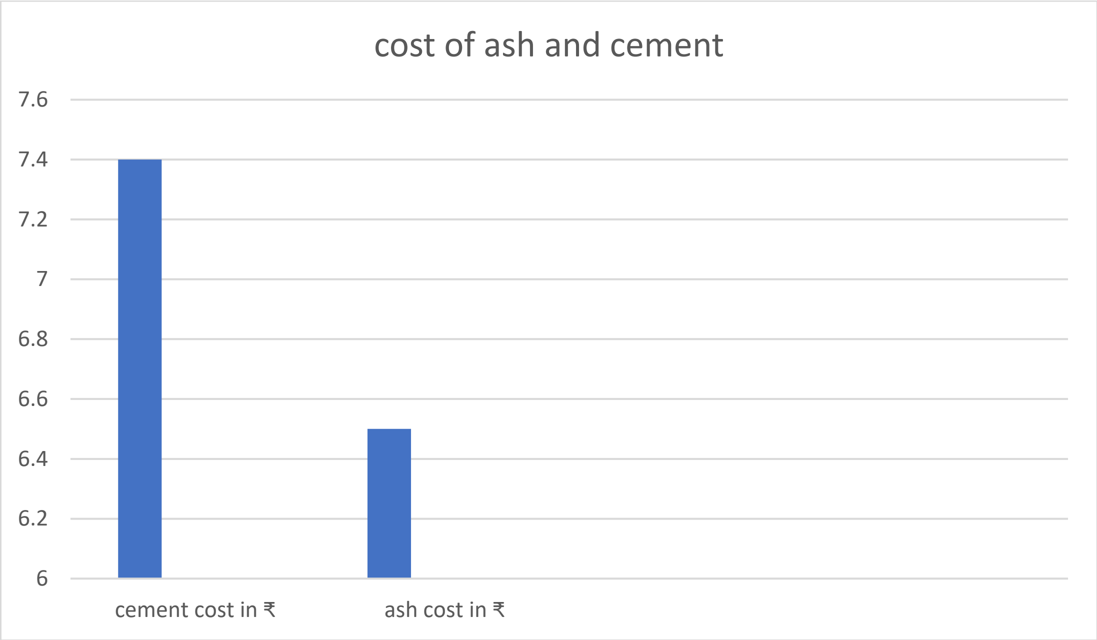
Material used for burning coconut shells:

- Plane ground surface or low height material
- Dry coconut shell
- Oil used in burning

## 2.14 COMPARING COST OF CEMENT AND COCONUT SHELL ASH

- **Cement cost:** Cost of manufacturing cement in India per kilogram varies for different companies. While single cost calculation is hard to pinpoint but estimate suggest that the cost per bag is around ₹340 to ₹400 for a 50 kg bag. This translates to roughly ₹6.80 to ₹8 per kg. The average cost is around ₹ 7.4

- **Coconut shell ash cost:** The cost of dry coconut broken shells in southern India varies between ₹ 1.5 to 2. The ash content in coconut charcoal is about 0.5 to 0.6 kg. hence the rough cost of coconut shell charcoal will be around ₹ 3 to 3.3. Now we will burn coconut charcoal which have approx. 40 to 50% ash content into it. So, the rough cost of coconut shell ash will be around ₹ 6 to 7. The average cost is around ₹ 6.5




GRAPH:1 COMPARING COST OF ASH AND CEMENT MANUFACTURING

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The above graph shows us about the comparison between the cost of ash and cement. As it as understood that the difference between the costs are not to big and the properties of concrete is improved with the use of coconut shell ash. Hence it will be feasible to use it for commercial purposes in the future.

**2.14.1 COST REDUCTION USING COCONUT SHELL ASH IN CONCRETE**

The cost difference between CSA and cement will be negligible ( the cost of coconut shell ash will be reduced further as we will purchase the coconut shells in bulk and increase the efficiency of burning)

**2.14.2 CONCRETE ABSORB CARBON DIOXIDE**

concrete does absorb CO2 through a process called carbonation. This natural process involves the reaction between CO2 from the atmosphere and calcium compounds in concrete, forming calcium carbonate and effectively locking away the CO2. While the amount absorbed it contributes to concrete's overall sustainability.

**Carbonation:**

Concrete, especially exposed concrete, naturally absorbs CO2 from the surroundings.

**Mechanism:**

This process involves the reaction between CO2, water, and calcium compounds (like calcium hydroxide) within the concrete structure.

**Result:**

This reaction forms calcium carbonate, which is a stable, solid compound that effectively traps the CO2.

### 2.14.3 COCONUT SHELL ASH CONCRETE ABSORB CARBON DIOXIDE

concrete incorporating coconut shell ash can contribute to carbon dioxide absorption, although it's primarily through the cement's natural carbonation process, not specifically through the ash itself. Its primary mechanism for carbon dioxide absorption is the same as regular concrete: a natural process called re carbonation where concrete reacts with CO2 in the air.

**Coconut Shell Ash and Carbon Absorption:**

56 While coconut shell ash may have some impact on the overall carbon footprint of the concrete due to its use as a cement replacement, its direct contribution to carbon dioxide absorption is the same as that of regular concrete: through the cement's natural carbonation process.

## 2.15 REVIEW OF PAST WORKS

Industrialization in developing countries has led to increased agricultural production and the accumulation of unmanageable agro-wastes. Coconut shells, as a by-product of the coconut palm industry, are considered agricultural and industrial waste and can become a health and environmental nuisance if not disposed of properly. The resulting waste products require transportation and disposal in landfills, contributing to pollution, which is a significant issue in countries like Nigeria (Mahmood et al., 2002). Recycling these waste materials into new construction materials could be a practical solution to reduce the high cost of construction materials in developing nations (Abdulfatai et al., 2013). Common construction materials include Ordinary Portland Cement (OPC) and mineral admixtures, which are materials added to the concrete mix (along with cement, aggregates, and water) to modify specific properties of concrete in both its fresh and hardened states (Gupta, 2004). However, many of these admixtures are imported and are often expensive, making durable concrete less affordable for many people (Aboshio et al., 2009). In countries like Nigeria and other African nations, the demand for construction materials is continually increasing, driven by the need for infrastructure. However, the production of materials. Several studies have focused on utilizing local agricultural and industrial by-products as

1 substitutes for OPC and aggregates, thus reducing the overall cost of construction (Elinwa et al., 2005; Wazumtu and Ogork, 2015). Research on the use of waste materials, including coconut shell ash (CSA), has shown promising results. A study by Utsev and Taku (2012) revealed that CSA could replace 10-15% of OPC in concrete, making it a cost-effective alternative to current disposal methods. Although the strength of concrete with CSA may be slightly lower (7.1% weaker than control), it provides a viable alternative (Nagarajan et al., 2014). Other studies have also investigated coconut shell and husk ash as replacement materials. For example, Olugbenga et al. (2011) found that the addition of coconut shell and husk ash (CSHA) reduced the plastic index of paste samples, which decreased swelling potential and increased strength. Oluremi et al. (2012) demonstrated that coconut husk ash could improve the California bearing ratio (CBR) of low-quality soils, while Popoola et al. (2019) encouraged using coconut waste ash to lower the cost of lime in construction. Additionally, Amarnath and Rama Chandrudu (2012) found that replacing coarse aggregates with coconut shells did not negatively affect the properties of concrete when compared to fly ash replacements. Despite these positive findings, concrete produced with coconut shell ash, coconut shells, or coconut husk ash still generally falls short of the properties of conventional concrete.

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

This chapter outlines the systematic approach followed for conducting the research. It provides a thorough explanation of all the necessary calculations involved. Additionally, this chapter tell us about in detailed about the materials used and the specimens tested. Testing will be carried out in the Concrete Laboratory at Delhi Technological University.

## 3.2 EXPERIMENTAL PROGRAM

The aim of this experiment is to study the impact of incorporating coconut shell ash (CSA) as a partial substitute for ordinary Portland cement. Cubes measuring 150 x 150 x 150 mm were used for mixing, curing, and other processes. The coarse aggregate used in the mix consisted of 20mm single-sized granite, while the fine aggregate was local river sand. The mixture was prepared using a constant water-cement ratio of 0.5, with the aggregate content (both coarse and fine) remaining consistent across all mixes, except for the variation in the percentage of ordinary Portland cement and coconut shell ash. A designed mix was created, with CSA incorporated at different volumes (0%, 20%, 25%, and 30%). The other mixes included varying amounts of CSA by volume. After mixing, the workability is checked. The strength is then compared to which did not contain coconut shell ash.

## 3.3 INSTRUMENTATION AND LABORATORY WORK

### 3.3.1 MATERIALS

These materials listed below are used in the preparation of the concrete specimen so that we will achieve our design objectives;

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Ash
- Admixture

#### 3.3.1.1 CEMENT

The cement used in this research work was the Ordinary Portland cement and it conformed to the requirement ( IS 269, 1989). Grade 3 type of cement as per the Indian Standards.

#### 3.3.1.2 FINE AGGREGATE

Fine aggregate typically includes natural, crushed, or manufactured sand. For this study, locally available natural sand was used, ensuring it met the required grading standards for coarse, medium, and fine sizes. I made sure the sand was free from clayey materials and other impurities that could lead to expansion or contraction as the water evaporates from the mortar.

#### 3.3.1.3 COARSE AGGREGATE

Coarse aggregate makes up 60-70% of the volume in a concrete mix. This study is crushed granite with a 20mm diameter, exhibiting a normal weight and irregular shape. I ensured that the coarse aggregate was air-dried to achieve a saturated surface dry condition, thereby preventing any impact on the water-cement ratio.

#### 3.3.1.4 WATER

Water plays a crucial role in concrete mixing. Both insufficient and excessive water can significantly impact the mix and the concrete's overall strength. Using the correct amount of water, either by weight or volume, is essential. It is important that the water fills the spaces between the particles in the mix. Adding extra water helps lubricate the particles, making it easier to compact the concrete.

#### 3.3.1.5 COCONUT SHELL ASH

The fibrous outer layers of the coconut shells were carefully removed. After collection, the shells were left to sun-dry before being burnt. Once burnt, the shells were ground into a fine powder and then air-dried as shown in figure 1 to 3.

71 **FIG: 1 COCONUT SHELL ASH**

**FIG 2: BURNING OF COCONUT SHELL**

Present study Ranatunga.k.s.et al.2023

**FIG 3: FORMATION OF COCNUT SHELL ASH**

### 3.3.1.6 Oxide composition of different materials

Here we compare the properties of CCSA with other materials

**Table 3.1: Oxide composition of different materials**

| **Oxide** | **Percentage composition (%)** | | | |
|---|---|---|---|---|
| | CSA | OPC | RHA | BAGASSE ASH |
| SiO2 | 37.98 | 21.78 | 82.20% | 73% |
| Al2O3 | 24.17 | 5.79 | 0.15% | 6.7% |
| Fe2O3 | 15.48 | 2.5 | 0.16% | 6.3% |
| CaO | 4.98 | 64.0 | 0.55% | 2.8% |
| MgO | 1.89 | 1.00 | 0.35% | 3.2% |
| MnO | 0.8 | 0.21 | ------ | ------ |
| Na2O | 0.96 | 0.61 | ------ | 1.1% |
| K2O | 0.84 | 0.16 | ------ | 2.4% |

| | | | | |
|---|---|---|---|---|
| P2O5 | 0.31 | 0.06 | ------ | 4.0% |
| SO3 | 0.70 | 2.76 | 0.24% | 0.04% |
| LOI | 11.94 | 2.31 | 5.44% | 0.9% |

## 3.4 MIX DESIGN

Our design that we have considered is given below:

**TABLE 3.2 WEIGHT MATERIALS OF 6 CONCRETE CUBES**

| CEMENT | SAND | COURSE AGGREGATE (20MM) | FINE AGGREGATE (10MM) | WATER | ADMIXTURE |
|---|---|---|---|---|---|
| 11.400KG | 25.02KG | 14.656KG | 18.209KG | 4.988L | 68ML |

**TABLE 3.3 PERCENTAGE REPLACEMENT OF ASH IN CEMENT**

| SAMPLE | CONTENT | CEMENT (kg) | COCONUT SHELL ASH (kg) |
|---|---|---|---|
| CSA-1 | 0% | 11.400 | 0 |
| CSA-2 | 20% | 9.12 | 2.28 |
| CSA-3 | 25% | 8.55 | 2.85 |
| CSA-4 | 30% | 7.98 | 3.42 |

## 3.5 PREPARATION OF TEST SPECIMENS

For the compressive strength test, cube moulds measuring 150 x 150 x 150mm were used. For the slump test, a frustum of a cone with a height of 300mm and a base diameter of 200mm was employed, with the smaller opening measuring 100mm. It was crucial to prepare the test specimens prior to mixing the concrete. A total of 24 specimens were utilized in this study. To prevent leakage during vibration. Next, I cleaned the internal surfaces of the metallic moulds, crude oil, to ensure the concrete wouldn't be damaged during mould removal. Finally, I positioned the moulds under a sheltered area, ensuring it was free from any vibrations.

**FIGURE: 3 CONCRETE MOULD OF CONCRETE**

### 3.5.1 MIXING PROCESS

The mixing was performed using the mixer. The components were weighed using a balance to ensure they adhered to the proportions specified in the mix. The ash is added in the mix. The coarse aggregate was then added, followed by the water.


**FIGURE: 4 CONCRTE MIXING**

**FIGURE: 5 WEIGHT OF AGGREGATE**

1 **3.6 TESTS ON CONCRETE**

Test on both state of concrete is considered.

- Tests on fresh concrete
- Tests on hardened concrete

Fresh concrete refers to the mixture of all its components before it has gained strength, which corresponds to the initial stages of cement hydration. The properties of fresh concrete significantly impact how it is handled, placed, and consolidated.

37 **SLUMP TEST**

1 The concrete slump test is an empirical method used to assess the workability. This test is conducted to evaluate the consistency of freshly mixed concrete and follows the guidelines set by Indian standards. It is widely used due to the simplicity of the equipment involved and the straightforward testing.

**APPARATUS**

- Frustum cone size of 300mm high and base of 200mm and 100mm on top.
- A 600mm metal rod.

### A) INTERPRETATION OF RESULTS

1 The slumped concrete can take on different shapes, and based on its appearance, the slump is classified as true slump, zero slump, shear slump, or collapse slump. A
16 collapse slump typically indicates that the mix is too wet. Only a true slump provides
16 useful results for this test. A collapse slump usually suggests that the mix has high workability or excessive moisture, making the slump test unsuitable for assessing its consistency.

### B) TEST ON HARDENED CONCRETE

Test are done on concrete cubes are: compressive strength and water absorption test.
32 The cubes are tested for 7 and 28 days.

### C) COMPRESSIVE STRENGTH TEST

Among the various tests performed on concrete, the compression test is the most
1 crucial as it provides insights into all the essential characteristics of concrete. Through this single test, one can determine whether the concreting process has been carried out correctly.

### D) APPARATUS

- Universal testing machine
- Cubes

### E) MIXING

The mixing is done in concrete mixer. First course, fine aggregates are mix in drum then we add ash and water and admixtures and mix them well.

## F) SAMPLING

Concrete is put in greased mould. These moulds put on vibration table for 2 minutes so that no voids will be left inside and then put them for 24 hours in a clean place.

**Figure: 6 Concrete moulds filled with fresh concrete**

**Figure: 7 Casted concrete specimens**

## G) CURING

The test specimens put in the water tank till the test date. The curing water should be tested and replaced every 7 days, ensuring that the water temperature is maintained at 27±2°C.

**Figure: 8 Concrete cubes in a concrete water tank**

1 **PROCEDURE FOR COMPRESSION TESTING**

- Remove the specimen from tank and keep it dry.
- Place the cubes in UTM machine.
- 1 Load applied gradually at the rate of $140kg/cm^2$/min till the cube fail.
- Record the values.

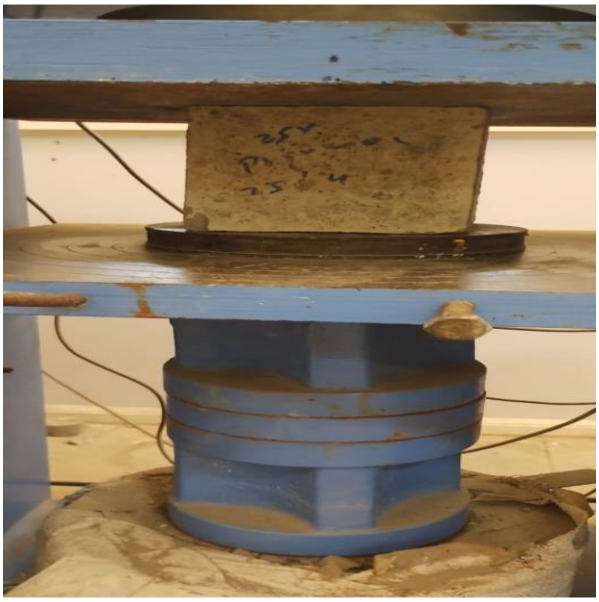

**Figure: 9 Crushing of concrete beam specimen using the compression testing machine**

## 3.7 PRECAUTIONARY MEASURES

The following precautionary measures were observed during the course of this research:

- Proper personal protective equipment was worn at all times.
- A release agent (used oil) was applied to all internal surfaces of the metal moulds to prevent damage to the concrete during demoulding.
- Concrete was adequately compacted during casting to eliminate air pockets and avoid the formation of voids.
- Care was taken during the slump test to avoid parallax errors and the slumped concrete.
- The slump cone (frustum) was securely fixed to its base to prevent movement while tamping the concrete.
- The curing water was periodically changed if contamination was observed, to protect the concrete from potential chemical attack.
- During the compression test, it was ensured that the machine pointer moved accurately from zero to the peak load value, reflecting the concrete’s maximum strength.
- Concrete cubes were correctly positioned in the compression testing machine, with flat surfaces aligned against the platens for uniform loading.

## 3.8 ECONOMIC COST RELATED TO COCONUT SHELL ASH

Using coconut shell ash can lead to economic benefits by reducing cement consumption, a major cost factor in cement concrete production. This cost reduction is achieved by partially replacing cement with CSA, which is a readily available waste product. However, the initial cost of collecting, burning, and processing the coconut shells to produce CSA may need to be factored in.

**Reduced Cement Usage:**

CSA can act as a supplementary cementitious material (SCM), allowing for a
22
reduction in the amount of cement needed in the concrete mix. This directly translates to lower cement costs.

**Waste Utilization:**

Using CSA is a form of waste recycling, reducing disposal costs and environmental impact.

**Potential for Lower Production Costs:**

By reducing cement consumption and potentially lowering production costs associated with waste management, the overall cost of concrete production can be reduced.

24
## 3.9 ENVIRONMENTAL COST RELATED TO COCONUT SHELL ASH CONCRETE

Using coconut shell ash (CSA) in concrete can offer significant environmental benefits, mainly by reducing reliability on cement, which is a major source of CARBON DIOXIDE emission (green house gas), and by using cheap agricultural waste coconut shells. By replacing cement with CSA can reduce embodied carbon and also reduce the overall environment impact of concrete on atmosphere. However, the environment impact of coconut shell as burning also need to be carefully considered and monitored, which also includes the energy required for its collection, transportation, burning and any potential emissions during the combustion of coconut shells.

**<u>Benefits:</u>**

**A) Reduced CO2 emissions:**

Cement production is a significant impact on atmosphere which will influence the
13
environment impact. Using CSA, a pozzolanic material, as a partial replacement of cement can reduce the amount of cement needed, thus decreasing CO2 emissions

associated with cement manufacturing as while manufacturing cement there is tremendous amount of gases will be released in the atmosphere.

**B) Waste reduction:**

Coconut shells is an agricultural byproduct that would be produced in tonnes in all over the world otherwise it will be discarded, which will influence the disposal problems and potential environmental pollution as it require 3 to 5 years to decompose the coconut shells. By utilizing CSA transforms this waste into a valuable resource and also contributing to our economy also.

**C) Reduced reliability on non-renewable resources:**

Cement is a non-renewable material, while coconut shells is a renewable resource. Using CSA helps in reducing the demand of cement which require lots of non renewable resources for its manufacturing processes whereas CSA is a finite resource.

**D) Potential for improved durability:**

Some studies suggest that partially using CSA in concrete can improve its durability and resistance to chemical attack which will increase the lifespan of concrete structures.

**Reduced material costs:**

Using coconut shell ash will use inexpensive agricultural waste like coconut shells can potentially lower the cost of concrete production and also a cheap source.

## 3.10 OXYGEN SUPPLY INFLUENCE THE QUALITY OF CSA

9 Oxygen supply directly impact the quality of coconut shell ash. It mainly depends on the type of container and process used which will be open from sides so that proper supply of oxygen will be there while burning CSA. Supplemental oxygen can also be provided by different process for adequate supply of oxygen. This can lead to improved the quality and overall well-being. In CSA, if central nervous system fails to send adequate oxygen supply to the breathing purpose leading to reduce the oxygen consumption. Supplemental oxygen can help in by reducing the body respond to low oxygen levels. By increasing oxygen levels, the need for increased breathing effort is reduced, potentially elevate the CSA quality.

## 3.11 LIFE CYCLE ASSESMENT

A Life Cycle Assessment (LCA) for coconut shell ash focuses mainly on evaluating the environment impact of the production of coconut shell ash and use from its entire lifespan, from raw material to discarded to reuse as coconut shell ash. This will involve the all stages of the cycle which include cultivation, processing and its application in construction industries as a cementitious material.

- **Coconut Cultivation:**
  This stage includes assessment of the environmental impact by growing a coconut tree which includes fertilizer, pesticide, land management, raw materials and energy consumption.
- **Coconut Shell Ash Processing:**
  This stage will involve analyse the energy consumption and pollution associated with burning of coconut shell to produce ash. With the help of controlled burning of coconut shells will minimize environmental impact.
- **Application as a Cementitious Material:**
  14 When coconut shell ash is ready then it will be used as a partial replacement in cement, its impact is assessed by considering the reduce in cement production, which cause high pollution and has a high carbon footprint.

# CHAPTER FOUR

# RESULT AND DISCUSSION

## 4.0 INTRODUCTION

We try to address how the property of coconut shells ash alters the concrete property. Majorly Amorphous silica present in ash influence the property. Below we are discussing our findings.

This chapter presents the various tests conducted on the concrete specimens and discusses the results obtained. A total of 24 concrete specimens were prepared and cured. The tests were performed at 7 and 28 days, with three cubes crushed on each testing day, and the average of the three results recorded for analysis. The concrete mix used followed a 1:2:4 ratio, utilizing coarse aggregates of 20mm and 10mm sizes.

## 4.1 COMPRESSIVE STRENGTH TEST

| PERCENTAGE OF CSA | TIME | COMPRESSIVE STRENGTH | | | CROSS SECTION AREA (mm2) (150*150 mm2) | AVERAGE COMPRESSIVE STRENGTH (N/mm2) |
|---|---|---|---|---|---|---|
| 0% OF CSAC | 7 DAYS | 25.98 | 24.15 | 24.73 | 22500 | 24.95 |
| | 28 DAYS | 39.17 | 36.97 | 38.19 | 22500 | 38.11 |
| 20% OF CSAC | 7 DAYS | 27.91 | 29.19 | 27.41 | 22500 | 27.97 |
| | 28 DAYS | 41.49 | 43.77 | 41.78 | 22500 | 42.34 |
| 25% OF CSAC | 7 DAYS | 21.89 | 21.34 | 21.59 | 22500 | 22.606 |
| | 28 DAYS | 32.42 | 31.86 | 31.82 | 22500 | 32.03 |
| 30% OF CSAC | 7 DAYS | 27.57 | 29.17 | 25.69 | 22500 | 27.47 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 28 DAYS | 41.17 | 44.22 | 38.79 | 22500 | 41.39 |

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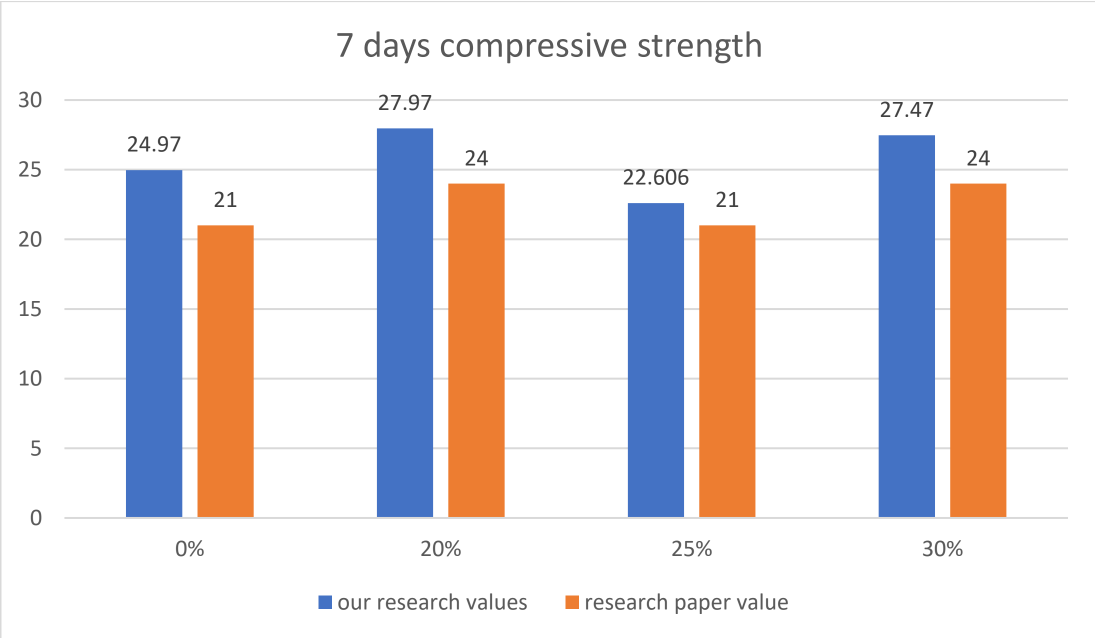
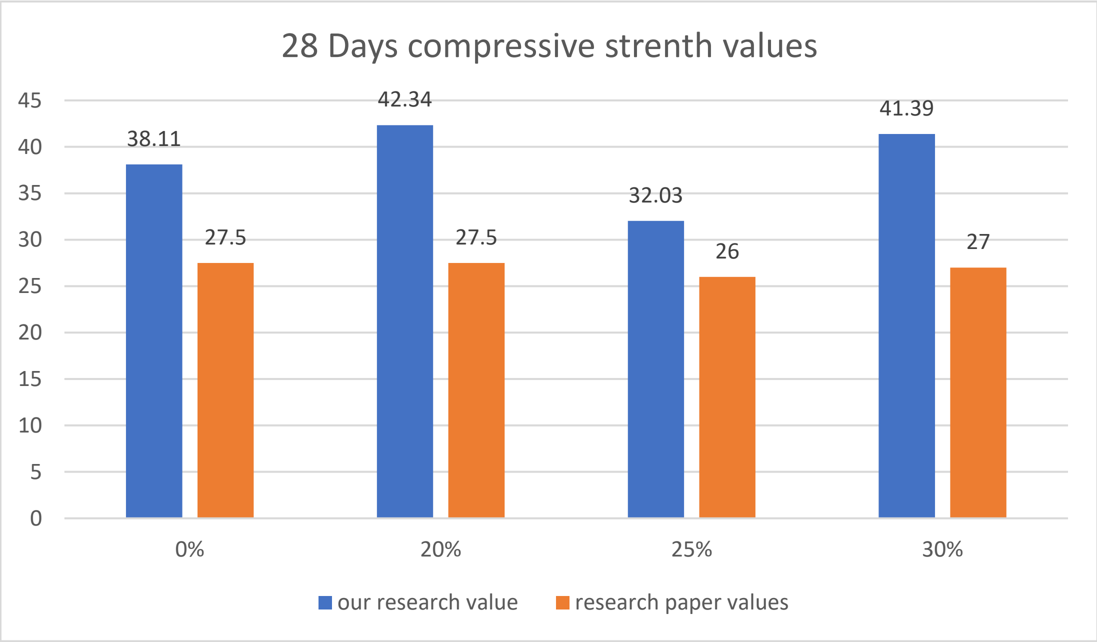
**Table 4.1 compressive strength of cubes**

### 4.1.1 COMPARING OUR RESULTS WILL OTHER RESEARCH PAPER



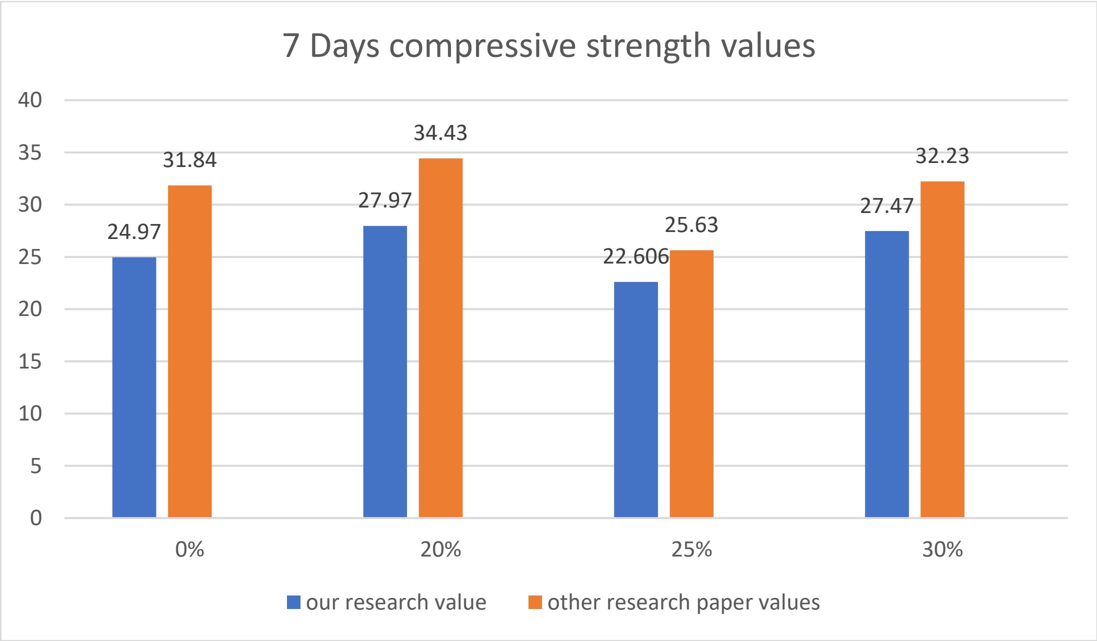

Present study Ranatunga.k.s.etal.2023

**Graph 1: Representing 7 days compressive strength comparison with other research paper.**



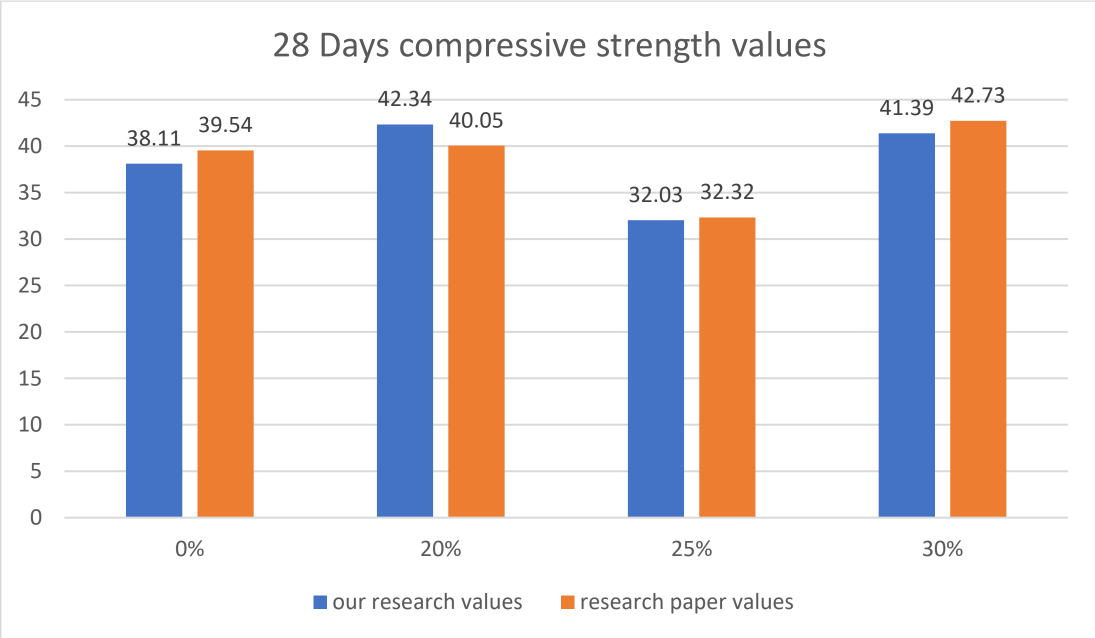

Present study Ranatunga.k.s.etal.2023

**Graph 2: Representing 28 days compressive strength comparison with other research paper.**




Present study sajjad .et al.2021

**Graph:3 Representing 7 days compressive strength comparison with other research paper.**




Present study sajjad .et al.2021

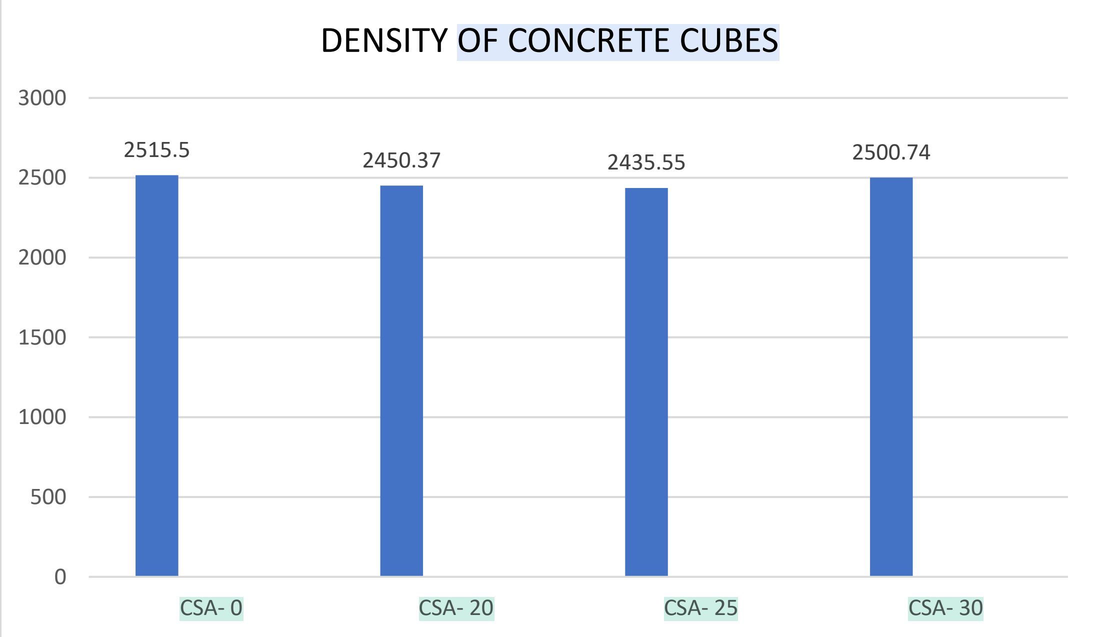
**Graph:4 Representing 28 days compressive strength comparison with other research paper.**

### 4.1.2 HOW THE STRENGTH OF OUR CONCRETE IS IMPROVED WITH OTHER RESEARCH

The strength of cement concrete is influenced by several factors, such as mix design, properties of the materials used, water-cement ratio, and workability. Additionally, the colour of the coconut shell ash is an indicator of its quality whiter ash typically have amorphous silica and is therefore more effective. The quality of the ash is also affected by the amount of oxygen consumed during the burning process; higher oxygen levels generally result in better-quality ash.

The use of CSA not only enhances strength making it a more environmentally sustainable alternative to traditional cement. Proper curing is essential as well submerging the samples in water for at least 14 days positively impacts the overall strength development of the concrete.

## 4.2 DENSITY OF CONCRETE CUBES




**GRAPH: 5 Represents the density of cubes**

The density of concrete is around 2400 kg/m³. Our results show that the density of our mix is around 2435 to 2515 kg/m³ Which is mostly same as compared to normal concrete.

## 4.3 WATER ABSORPTION TEST

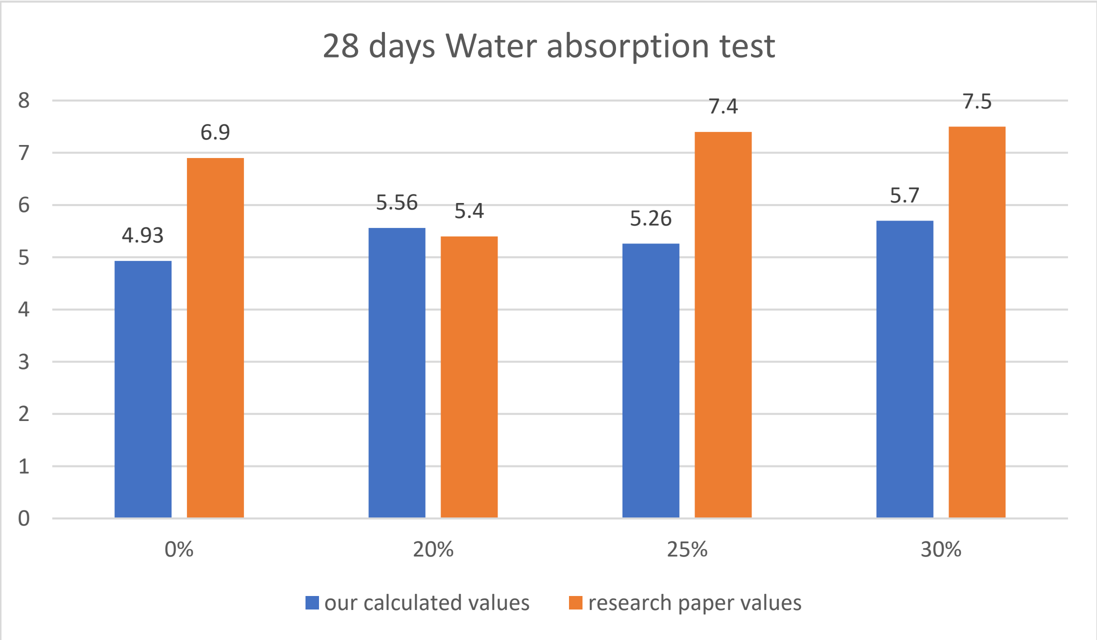
The test specimens were first prepared, and the initial weights of all concrete cubes were recorded. After each curing period, the cubes were again weighed to obtain their final weights. The amount of water reabsorbed was then determined by comparing the final weights with the air-dried weights. This process was done for both air-dried cubes and self-cured cubes, and the differences in water absorption were calculated and compared between the two conditions.

| % OF CSA | INITIAL WEIGHT OF CONCRETE CUBE(KG) | FINAL WEIGHT OF CONCRETE CUBE(KG) | WATER ABSORPTION (PERCENTAGE) | AVERAGE WATER ABSORPTION (PERCENTAGE) |
|---|---|---|---|---|
| | 8.81 | 9.19 | 4.31 | |
| | 8.61 | 9.03 | 4.9 | 4.93 |
| 0% | 8.05 | 8.50 | 5.6 | |

| | | | | |
|---|---|---|---|---|
| | 8.20 | 8.6 | 4.9 | 5.56 |
| | 8.04 | 8.56 | 6.1 | |
| 20% | 8.59 | 9.07 | 5.7 | |
| | 7.95 | 8.41 | 5.9 | 5.26 |
| | 8.01 | 8.44 | 5.1 | |
| 25% | 8.70 | 9.14 | 4.8 | |
| | 8.29 | 8.76 | 5.4 | 5.7 |
| | 8.56 | 8.97 | 6.1 | |
| 30% | 8.49 | 8.97 | 5.6 | |

**TABLE 4.2: WATER ABSORPTION IN CONCRETE CUBES AFTER 28 DAYS**

### 4.3.2 Comparing our results of water absorption with research papers

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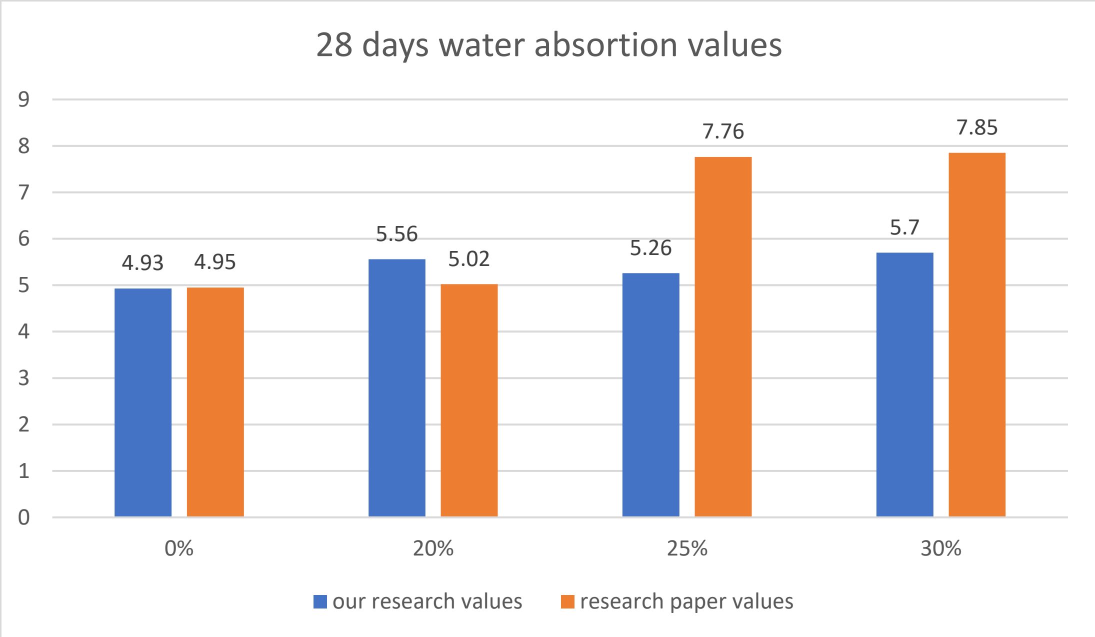
**Graph 6: Representing 28 days water absorption values comparison with other research paper.**




Presented by J.S.Lumbab. et al 2024

**Graph 7: Representing 28 days water absorption values comparison with other research paper.**

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# CHAPTER 5

## CONCLUSION AND RECOMMENDATIONS

Based on the experimental study the important conclusion are given below

## 5.0 CONCLUSIONS

70 In this research, cement was partially replaced with coconut shell ash (CSA) by weight, and concrete specimens were cast using 20%, 25%, and 30% CSA for M25 grade concrete. 52 As per IS code specifications, the cast specimens underwent compressive strength tests and water absorption tests after 7 and 28 days of curing. The results showed that CSA concrete demonstrated improved workability, attributed to the smooth texture of the coconut shell ash. Notably, concrete mixes containing CSA achieved higher compressive strength, making them potentially suitable for applications where M30 grade strength is required, even when designed as M25. With proper control of emissions during the production of CSA.

20 At the end of this research, the following key conclusions were drawn:

- The test results confirmed uniform dispersion of coconut shell ash (CSA).
- The inclusion of CSA led to improved workability and contributed to a reduction in external cracking and permeability, enhancing the durability of the concrete.
- CSA proved to be a cost-effective and readily available cement components.
- Its use also reduced bleeding, adsorption, and segregation, thereby improving the overall consistency and quality.
- Importantly, the compressive strength of concrete increased.

**s**

These results show the property of concrete will be improved like compressive strength, durability, workability and water absorption. If there will be higher replacements then this will be suitable for less critical application.

- **Optimizing Cement Replacement:**

  Research suggest that we can start replacing with 20% of Ordinary Portland Cement with CSA. This will improve the strength, water absorption, workability and durability.

- **Potential Benefits:**

CSA, when used in moderate quantity, can reduce the environmental impact of concrete by reducing gases.

- **Workability and Durability:**

  CSA improves the workability, making it a better option for different applications in concrete.

- **More Research:**

  36 For different research papers, consider the effects of CSA on different types of concrete, such as lightweight concrete or high-strength concrete.

- **Combined Use:**
  Combining CSA with other materials having cementitious properties (like silica fume, fly ash and bagasse) might offer even more benefits with them.

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