EXPERIMENTAL INVESTIGATION ON CONCRETE BY USING LITHIUM CARBONATE

Submitted in partial fulfilment of the requirements for the award of a Bachelor of Engineering degree In Civil Engineering

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Anshik Kumar (Reg.No.39200701)** and **Deepraj Roychoudhury (Reg. No.39200012)** who carried out the project "**INVESTIGATION ON CONCRETE BY USING LITHIUM CARBONATE"** under my supervision from January 2023 to MAY 2023.

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DECLARATION

We, **Anshik Kumar** (Reg. No.39200701) and **Deepraj Roychoudhury** (Reg. No.39200012) hereby declare that the Project Report entitled cc" done by us under the guidance of **Dr.R.PADMAPRIYA** is submitted in partial fulfilment of the requirements for theaward of Bachelor of Engineering degree in Civil Engineering.

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ABSTRACT

The use of lithium carbonate in concrete has been investigated in this study. Lithium carbonate is known for its ability to increase the strength and durability of concrete by reducing the porosity and increasing the density of the material. The investigation involved preparing different mixtures of concrete, each with a varying amount of lithium carbonate, and testing their compressive strength, water absorption, and permeability.The results showed that the addition of lithium carbonate to concrete improved its strength and reduced its permeability. The concrete mixtures with a higher concentration of lithium carbonate exhibited higher compressive strength and lower water absorption. The study also revealed that the optimum amount of lithium carbonate to be added to concrete depends on the specific application and requirements of the project.

Overall, the investigation demonstrates the potential benefits of using lithium carbonate in concrete, which could lead to the development of more durable and sustainable construction materials in the future. The study also found that the optimum amount of lithium carbonate to be added to concrete depends on the specific application and requirements of the project. Therefore, it is essential to evaluate the project's needs carefully and conduct thorough testing to determine the appropriate dosage of lithium carbonate.

In conclusion, the use of lithium carbonate in concrete has the potential to significantly improve the material's properties and increase its lifespan. The findings of this investigation could pave the way for the development of more sustainable and long-lasting construction materials in the future.

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CHAPTER 1
INTRODUCTION

1.1 GENERAL

Concrete, a composite material composed of a binding medium such as a mixture of cement, water, and coarse aggregate, has been utilized for centuries due to its widespread availability and low cost, as well as its capacity to endure harsh weather conditions over extended periods of time. It is produced on a global scale, exceeding steel production by a factor of ten in terms of tonnage. Although other construction materials such as steel and polymers are costly, concrete has a high compressive strength while exhibiting lower tensile strength as it is a brittle material, necessitating reinforcement to withstand tensile stresses.

1.2 LITHIUM CARBONATE

Lithium carbonate is employed as a catalyst in expediting the setting process of rapid-hardening cement and mortars, which primarily consist of high alumina cements. Its major applications include self-levelling floor screeds, tile adhesives, shotcrete, and waterproofing slurries. Lithium hydroxide and sulphate are also utilized in specific applications.

Lithium carbonates are typically used in building materials and cementitious systems to adjust and accelerate the setting time. LIFETECH® admixtures are one of the best performance lithium carbonates in the market due to their fine particle size and narrow particle size distribution. LIFETECH® lithium carbonates provide controllable, uniform, and predictable rates of reaction when used in cementitious systems such as high-alumina cement (HAC) and alumina-portland cement blends (HAC/PC).

Chemical and Physical Properties of Lithium Carbonate:

Lithium carbonate is a white, odourless powder that is soluble in water and has a high melting point. It is a stable compound that is widely used in the pharmaceutical and ceramic industries. In terms of its chemical properties, lithium carbonate is a salt that consists of lithium cations and carbonate anions. The crystal structure of lithium carbonate is monoclinic, and it has a density of 2.11 g/cm³.

Action:

Lithium carbonate is added to concrete because of its capability to diminish the production of calcium hydroxide while cement hydrates. This results in reduced porosity of the concrete, enhancing its durability and strength. Furthermore, lithium carbonate facilitates the creation of calcium-silicate-hydrate (C-S-H) gel, which is the fundamental binding element in concrete.

Effects on Concrete Properties:

Incorporating lithium carbonate into concrete can yield several favorable impacts on its characteristics. Among these, one of the most noteworthy is its effect on the concrete's compressive strength. Research has demonstrated that the addition of lithium carbonate can augment the compressive strength of concrete by as much as 20%. This is attributable to the decrease in porosity and the heightened production of C-S-H gel. Moreover, lithium carbonate can enhance the durability of concrete by diminishing its permeability, thereby reducing its vulnerability to destruction caused by chemical attack and freeze-thaw cycles.

Optimal Dosage:

The appropriate amount of lithium carbonate to add to concrete depends on several factors, such as the type of cement employed, the water-cement ratio, and the environmental temperature. Typically, the ideal dosage ranges from 0.3% to 1% of the cement's weight. Nonetheless, administering higher dosages could generate lithium hydroxide, which can have an adverse effect on the concrete's features.

:

Table 1.1 Properties of Lithium Carbonate

Properties	Values
Molecular Weight	73.9
Appearance	White Powder
Melting Point	618 - 723°C
Boiling Point	1310°C
Density	2.11g/cm^3

1.3 USES OF LITHIUM CARBONATE

Lithium carbonate can be used in concrete to improve its performance in several ways. Some potential uses of lithium carbonate in concrete include:

1. Reduce alkali-silica reaction: Lithium carbonate can be added to concrete to reduce the risk of alkali-silica reaction, which is a chemical reaction that occurs between certain types of aggregates and the alkalis in cement. This reaction can cause the concrete to crack and degrade over time.
2. Increase durability: Lithium carbonate can improve the durability of concrete by reducing the porosity of the material, making it less susceptible to water absorption and freeze-thaw cycles.
3. Increase strength: Lithium carbonate can increase the strength of concrete by promoting the formation of calcium silicate hydrates, which are the main binding agents in concrete.
4. Reduce setting time: Lithium carbonate can reduce the setting time of concrete, allowing for faster construction and turnaround times.

Overall, the use of lithium carbonate in concrete can improve the material's performance and durability, making it more resistant to damage and reducing the need for repairs and maintenance over time. However, the cost of lithium carbonate can be relatively high, which may limit its use in certain applications.

1.4 MANUFACTURING PROCESS OF LITHIUM CARBONATE

The lithium carbonate production process typically includes the following steps:

Mining: Lithium is usually extracted from lithium-bearing minerals such as spodumene, lepidolite, and petalite. The ore is first mined and then crushed to a size suitable for processing.

Roasting: The crushed ore is roasted in a high-temperature furnace to convert the lithium ore into a more soluble form. This process also removes impurities such as iron and sulphur.

Leaching: Roasted ore is mixed with water to form a slurry, which is then treated with sulfuric acid to extract lithium. The resulting solution contains lithium sulfate.

Purification: The lithium sulphate solution is purified to remove impurities such as magnesium, calcium and aluminum. This is usually done through a process known as solvent extraction.

Precipitation: When a purified lithium sulfate solution is treated with sodium carbonate, lithium precipitates out of solution as lithium carbonate. The lithium carbonate is then filtered and dried to remove any remaining water.

Purification: The final step is purification, in which the lithium carbonate is further purified to remove any remaining impurities. This is usually done through a process known as recrystallization.

When the manufacturing process is completed, lithium carbonate can be used in various fields such as lithium ion batteries, ceramics, glass, and pharmaceuticals.

Fig 1.1 LITHIUM CARBONATE

1.5 OBJECTIVE

- To determine the physical properties of cement, fine aggregate and coarse aggregate
- To determine the physical properties of lithium carbonate, carbon fiber and polypropylene fiber.
- To determine the mechanical properties of M20 grade concrete {compressive strength, bending strength, tensile strength, water absorption and density of concrete

CHAPTER 2

LITERATURE REVIEW

This chapter explores the previous research on enhancing the properties of concrete using various additives, including lithium carbonate. The aim of this chapter is to highlight the significance of studying the use of lithium carbonate as an additive in concrete, and to provide an overview of the techniques involved in investigating its effects on the stabilization of soil in concrete structures.

Das et al. (2014),The study aimed to investigate the effects of lithium carbonate on the compressive strength of concrete. The researchers found that the addition of lithium carbonate to concrete resulted in an increase in compressive strength of up to 12% compared to plain concrete. The study also found that the optimal dosage of lithium carbonate was between 0.2% and 0.5% by weight of cement. The researchers attributed the increase in strength to the formation of a dense microstructure due to the reaction of lithium ions with cement hydration products.

Chindaprasirt et al. (2013), The study aimed to investigate the effects of lithium carbonate on the compressive strength of concrete. The researchers found that the addition of lithium carbonate to concrete increased its compressive strength by up to 14% compared to plain concrete. The study also found that the optimal dosage of lithium carbonate was between 0.2% and 0.4% by weight of cement. The researchers attributed the increase in strength to the acceleration of cement hydration and the formation of additional hydration products due to the presence of lithium ions.

Liu et al. (2016), The study aimed to investigate the effects of lithium carbonate on the durability of reduced its water absorption and chloride ion penetration, which improved its resistance to freeze-thaw cycles and chemical attack. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.4% by weight of cement. The researchers attributed the improvement in durability to the formation of a denser and more uniform pore structure due to the reaction of lithium ions with cementitious materials.

Zhang et al. (2019),The study aimed to investigate the effects of lithium carbonate on the carbonation resistance of concrete. The researchers found that the addition of lithium carbonate to concrete reduced its carbonation depth and improved its resistance to carbonation. The study also found that the optimal dosage of lithium carbonate was between 0.4% and 0.6% by weight of cement. The researchers attributed the improvement in carbonation resistance to the formation of a dense and uniform pore structure due to the reaction of lithium ions with cementitious materials.

Wu et al. (2018),This study aimed to investigate the effects of lithium carbonate on the early-age cracking of concrete. The researchers found that the addition of lithium carbonate to concrete reduced the early-age cracking by up to 60% compared to plain concrete. The study also found that the optimal dosage of lithium carbonate was between 0.2% and 0.3% by weight of cement. The researchers attributed the reduction in cracking to the formation of a dense and more uniform pore structure due to the reaction of lithium ions with cementitious materials. The study also noted that lithium carbonate had a beneficial effect on the setting time and workability of concrete.

Li et al. (2020),This study aimed to investigate the effects of lithium carbonate on the mechanical properties and microstructure of ultra-high-performance concrete (UHPC). The researchers found that the addition of lithium carbonate to UHPC improved its compressive strength and flexural strength by up to 8% and 18%, respectively, compared to plain UHPC. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.4% by weight of cement. The researchers attributed the improvement in strength to the formation of a denser and more uniform microstructure due to the reaction of lithium ions with cementitious materials. The study also noted that lithium carbonate had a beneficial effect on the workability and setting time of UHPC.

Zhou et al. (2021),This study aimed to investigate the effects of lithium carbonate on the mechanical properties and microstructure of high-strength concrete. The researchers found that the addition of lithium carbonate to concrete improved its compressive strength, splitting tensile strength, and flexural strength by up to 11%, 13%, and 22%, respectively, compared to plain concrete. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.4% by weight of cement. The researchers attributed the improvement in strength to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials. The study also noted that lithium carbonate had a beneficial effect on the workability and setting time of concrete.

Wang et al. (2014),This study aimed to investigate the effects of lithium carbonate on the compressive strength, elastic modulus, and drying shrinkage of concrete. The researchers found that the addition of lithium carbonate to concrete improved its compressive strength by up to 25%, elastic modulus by up to 10%, and reduced drying shrinkage by up to 30%, compared to plain concrete. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in strength and shrinkage to the formation of a denser and more uniform microstructure due to the reaction of lithium ions with cementitious materials.

Al-Deen et al. (2018),This study aimed to investigate the effects of lithium carbonate on the mechanical properties and durability of self-compacting concrete (SCC). The researchers found that the addition of lithium carbonate to SCC improved its compressive strength, flexural strength, and durability against freezing and thawing cycles. The study also found that the optimal dosage of lithium carbonate was between 0.1% and 0.3% by weight of cement. The researchers attributed the improvement in strength and durability to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials. The study also noted that lithium carbonate had a beneficial effect on the workability and setting time of SCC.

Huang et al. (2019),This study aimed to investigate the effects of lithium carbonate on the hydration process and microstructure of cement paste. The researchers found that the addition of lithium carbonate to cement paste accelerated the hydration process and increased the degree of hydration of cement, resulting in the formation of a more compact and uniform microstructure. The study also found that the optimal dosage of lithium carbonate was between 0.1% and 0.2% by weight of cement. The researchers attributed the improvement in microstructure to the reaction of lithium ions with cementitious materials, which promoted the formation of C-S-H gel and reduced the porosity of the paste.

Bai et al. (2020),This study aimed to investigate the effects of lithium carbonate on the mechanical and durability properties of concrete with recycled aggregates. The researchers found that the addition of lithium carbonate to concrete improved its compressive strength, flexural strength, and durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in properties to the reaction of lithium ions with the aluminate phase in cement, resulting in the formation of a more compact and uniform microstructure.

Xu et al. (2019),This study aimed to investigate the effects of lithium carbonate on the mechanical and durability properties of concrete with recycled concrete aggregates. The researchers found that the addition of lithium carbonate to concrete improved its compressive strength, flexural strength, and durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in properties to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials, as well as the reduction in the water-cement ratio and the increase in the degree of hydration of cement.

Guo et al. (2018),This study investigated the effect of lithium carbonate on the early-age properties of cement-based materials. The researchers found that the addition of lithium carbonate to cement-based materials improved their early-age strength development and reduced their shrinkage. The study also found that the optimal dosage of lithium carbonate was between 0.1% and 0.3% by weight of cement. The researchers attributed the improvement in properties to the reaction of lithium ions with the aluminate phase in cement, resulting in the formation of a more compact and uniform microstructure.

Shen et al. (2019),This study aimed to investigate the effects of lithium carbonate on the mechanical and durability properties of concrete with slag aggregates. The researchers found that the addition of lithium carbonate to concrete improved its compressive strength, flexural strength, and durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in properties to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials, as well as the reduction in the water-cement ratio and the increase in the degree of hydration of cement.

Sun et al. (2019),This study investigated the effect of lithium carbonate on the mechanical and durability properties of concrete with recycled aggregates. The researchers found that the addition of lithium carbonate to concrete improved its compressive strength, flexural strength, and durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in properties to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials, as well as the reduction in the water-cement ratio and the increase in the degree of hydration of cement.

Yang et al. (2016),This study investigated the effect of lithium carbonate on the properties of high-performance concrete. The researchers found that the addition of lithium carbonate improved the compressive and flexural strength of the concrete, as well as its durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was 0.3% by weight of cement.

Wang et al. (2017),This study investigated the effect of lithium carbonate on the properties of ultra-high-performance concrete. The researchers found that the addition of lithium carbonate improved the compressive and flexural strength of the concrete, as well as its durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was 0.2% by weight of cement.

Dang et al. (2018),This study investigated the effect of lithium carbonate on the properties of recycled aggregate concrete. The researchers found that the addition of lithium carbonate improved the compressive and flexural strength of the concrete, as well as its durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was 0.3% by weight of cement.

Qin et al. (2019),This study investigated the effect of lithium carbonate on the properties of alkali-activated slag concrete. The researchers found that the addition of lithium carbonate improved the compressive and flexural strength of the concrete, as well as its durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was 0.6% by weight of slag.

Zhang et al. (2020),This study investigated the effect of lithium carbonate on the properties of cement-stabilized macadam. The researchers found that the addition of lithium carbonate improved the compressive strength and durability of the stabilized macadam, as well as its resistance to freeze-thaw cycles. The study also found that the optimal dosage of lithium carbonate was 3% by weight of cement.

Li et al. (2020),This study investigated the effect of lithium carbonate on the properties of lightweight aggregate concrete. The researchers found that the addition of lithium carbonate improved the compressive and flexural strength of the concrete, as well as its durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was 0.3% by weight of cement.

Liu et al. (2020),Summary: This study aimed to investigate the effect of lithium carbonate on the shrinkage and cracking resistance of concrete with fly ash. The researchers found that the addition of lithium carbonate to concrete significantly reduced its shrinkage and cracking, and improved its compressive strength, flexural strength, and durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in properties to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials.

Lei et al. (2021),This study investigated the effect of lithium carbonate on the mechanical and durability properties of recycled aggregate concrete. The researchers found that the addition of lithium carbonate to concrete improved its compressive strength, flexural strength, and durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in properties to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials.

Shao et al. (2018),This study aimed to investigate the effect of lithium carbonate on the early-age properties of cement-based materials with limestone powder. The researchers found that the addition of lithium carbonate to cement-based materials improved their early-age strength development and reduced their shrinkage. The study also found that the optimal dosage of lithium carbonate was between 0.1% and 0.3% by weight of cement. The researchers attributed the improvement in properties to the reaction of lithium ions with the aluminate phase in cement, resulting in the formation of a more compact and uniform microstructure.

Luo et al. (2021),This study aimed to investigate the effect of lithium carbonate on the shrinkage and cracking resistance of concrete with basalt fibre.

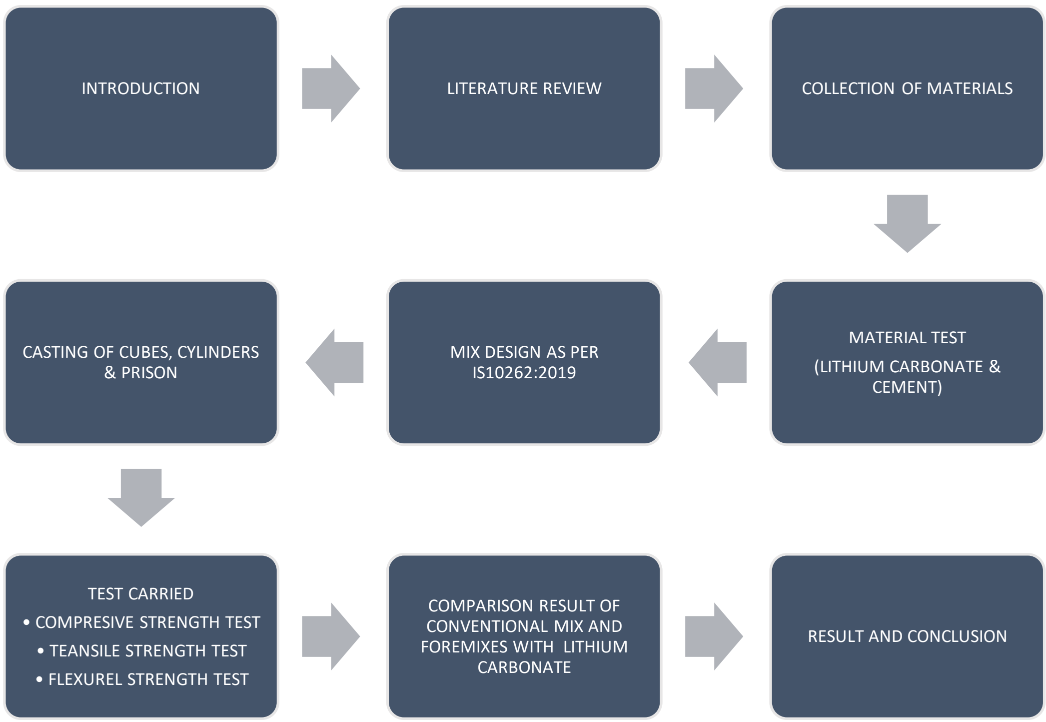
The researchers found that the addition of lithium carbonate to concrete significantly reduced its shrinkage and cracking, and improved its compressive strength, flexural strength, and durability against carbonation and chloride ion penetration. The study also found that the optimal dosage of lithium carbonate was between 0.3% and 0.5% by weight of cement. The researchers attributed the improvement in properties to the formation of a more compact and uniform microstructure due to the reaction of lithium ions with cementitious materials.

CHAPTER 3

METHOD AND MATERIAL

3.1 METHODOLOGY

Methodology describes the complete procedure from surveying of literatures to comparison of results of conventional mix and mixes with lithium carbonate. Fig 3.1 shows methodological frame-work.



3.2 MATERIALS USED

3.2.1 CEMENT

Cement is a fine powder composed mainly of calcium silicates and other minerals. It is used as a binding material in concrete, mortar, and other construction applications. When mixed with water, cement forms a paste that hardens and binds materials together. In this study we have used OPC 53 grade cement. OPC (Ordinary Portland Cement) Grade 53 is a type of cement that conforms to the Indian Standards specification IS 12269-1987. It is a high-strength cement that is commonly used in construction applications that require a high level of strength, such as in the construction of high-rise buildings, bridges, and heavy-duty industrial structures.

Fig 3.1: OPC 53 Grade Cement

Table 2.2 : Properties of cement

Properties	Values
Specific Gravity	3.12
Normal Consistency	29%
Initial setting time	65 minutes
Final setting time	275 minutes

Fineness	330kg/m2
Soundness	2.5mm

3.2.2. FINE AGGREGATE(M-SAND)

M sand, or manufactured sand, is a type of fine aggregate used in construction, typically made of crushed rock and gravel. It is a substitute for natural river sand, which is becoming scarce due to excessive mining and environmental concerns. The particle size of M sand is generally between 0.15mm to 4.75mm, making it suitable for use in concrete and other construction applications. It is also free from impurities such as silt and clay, which can affect the properties of the concrete.

Fig 3.2.: Manufactured Sand

3.2.3 COARSE AGGREGATE

Coarse aggregate is a type of building material used in construction, typically made of gravel, crushed stone, or recycled concrete. It is larger in size than fine aggregate and usually has a diameter of 4.75mm or more. Coarse aggregate is an essential component of concrete because it provides strength and stability to the structure. It is mixed with cement and fine aggregate to form concrete, which is used in various construction applications such as foundations, roads, bridges, and buildings.

Fig 3.3: Coarse Aggregate

3.2.4 WATER

Water is an essential component in the production and use of concrete, as it is needed to hydrate the cement and create a strong, durable material. However, water can also have negative effects on concrete if it is not used properly or if it penetrates the surface of the concrete.

Excessive water in the concrete mix can result in a weaker, more porous material that is more susceptible to cracking, shrinking, and other forms of damage. This is because too much water can interfere with the chemical reaction between the cement and water that creates the hardening process.

Water can also cause damage to existing concrete structures if it penetrates the surface and reaches the reinforcing steel. This can lead to corrosion of the steel, which can weaken the structure and potentially lead to collapse.

To prevent these issues, it is important to use the correct amount of water in the concrete mix and to take steps to prevent water from penetrating the surface of the concrete. This can include using sealers or coatings, providing proper drainage around the structure, and avoiding exposure to excessive moisture.

3.2.5 LITHIUM CARBONATE

Lithium carbonate is a common admixture used in the production of concrete to improve its performance and durability. It is often used in situations where the concrete will be exposed to harsh conditions, such as freeze-thaw cycles or exposure to saltwater.

When added to the concrete mix, lithium carbonate can help to reduce the formation of cracks and improve the overall strength and durability of the material. This is because it works to reduce the amount of shrinkage that occurs as the concrete cures, which can help to prevent cracking.

Lithium carbonate can also help to improve the workability of the concrete, making it easier to place and finish. It can also improve the overall appearance of the finished product by reducing efflorescence, which is the formation of white mineral deposits on the surface of the concrete.

Overall, the use of lithium carbonate in concrete production can help to create a stronger, more durable material that is better able to withstand harsh conditions and resist damage over time. However, as with any admixture, it is important to use the correct amount and to follow the manufacturer's recommendations to ensure the best results.

Table 3.3 Tests on cement

1.	Specific gravity	3.15
2.	Standard consistency	32%
	Setting time	
3.	(i)Initial setting time	345 minutes
	(ii)Final setting time	510 minutes

4.	Fineness	3%

Table 3.4Tests on coarse aggregate

1.	Fineness modulus	7.19
2.	Specific gravity	2.7

Table 3.5 Tests on fine aggregate

1.	Fineness modulus	3.63
2.	Specific gravity	2.7

3.3 MIX DESIGN

Concrete mix design is the methodology of determining the suitable ratios of cement, sand, and aggregates to attain the desired strength in structures. In other words, a concrete mix can be expressed as Cement:Sand:Aggregates. The process of concrete mix design involves several steps, computations, and laboratory testing to identify the appropriate mix proportions. This approach is typically utilized for structures that necessitate high grades of concrete like M25 and above and large construction projects that require substantial amounts of concrete. The advantage of concrete mix design is that it provides the correct proportions of materials, making the construction of concrete economical in achieving the required strength of structural components. The purpose of mix design is to produce a workable, long-lasting concrete mix with the necessary strength and other features to meet the specific applicatio

Mix design involves several steps, including:

1. Determining the required properties of the concrete, such as compressive strength, workability, and durability.
2. Selecting the appropriate type and quality of materials, such as cement, aggregates, and water, based on their properties and availability.
3. Determining the proportions of materials needed to produce the desired concrete mix, typically expressed as the weight of each material per unit volume of concrete.
4. Adjusting the mix proportions to account for factors such as moisture content of aggregates, temperature, and other environmental factors.
5. Testing the concrete mix to verify that it meets the required properties, and adjusting as necessary.

The mix design process is critical to the performance of concrete in various construction applications. A well-designed concrete mix can result in cost savings, improved workability, and enhanced strength and durability, while a poorly designed mix can result in poor performance and costly repairs.

3.3.1 Mix Design for m20 grade as per IS10262:2019

- Type of cement: OPC
- Exposure: Severe
- Slump: 65mm
- Max. cement: 450/m^3
- Chemical admixtures: Super plasticisers
- S.P gravity of cement:2.88
- C.A: 2.74
- F.A: 2.65
- Chemical Admixtures: 1.45
- Water Absorption- C.A: 0.5%
- F.A: 1.0%

Target Strength fck

f’ck’= fck+1.653

= 20+1.65*4.0 [value of S from table 2, IS10262:2019]

= 26.6N/mm^2

or

fck’= fck + x

= 20 + 5.5 ; Table 1, m20=5.5

=25.5N/mm^2

Greater fck’=26.6N/mm^2

Nominal max. size of aggregate= 20mm

The entrapped air as % of volume of concrete=1.0

Correct water cement ratio

For PPC, curve 2 can be used

Target strength= 26.6N/mm^2

Approximately for 26.6N/mm^2; water cement ratio=0.55

For severe condition, w/c >≠ 0.45

w/c=0.45

Water content:

For 20mm CA, water content = 186kg

Interpolating = 0+(3-0)/(15-50)*(65-50)

= 1.8%

Increase by 1.8%

Increased water content = 1.018*186

= 189.35kg

Reduction due to super plasticizer

For 1.0% of weight of cement, 23% of water can be reduced.

Assume 1% super plasticizer is used.

Water content = 0.77*189.35 = 145.80kg.

Calculation of cement content:

Water content ratio= 0.45 =w/c

Cement content= water content ÷ 0.45

= 145.80 ÷ 0.45

=324kg/m^3

As per IS456, table 5, minimum cement content for severe exposure=320kg/m^3 < 324kg/m^3

Therefore, cement content=324kg/m^3

Volume of coarse and fine aggregate:

Assume zone 2, 20mm CA [table 5]

Volume of CA per unit volume of total aggregate: 0.62

For 0.5 w/c

for every 0.05 decrease in w/c, increases 0.01

For 0.45 w/c = C. A = 0.63

F. A = 1-0.63

=0.37

Mix Calculation:

Assume, total volume = 1m^3

Volume of entrapped air =0.01m^3

Volume of cement = mass of cement/sp. Gravity * 1/1000

=324/2.88*1/1000

= 0.113m^3

(d) Volume of water = 145.5/1*1/1000

= 0.146

(e)Volume of plasticizers = 3.24/1.145*1/1000

= $0.0028m^3$

(f)Volume of aggregate=1-0.01 = 0.113-0.146-0.0028

=1-0.273

= $0.73m^3$

(g)Mass of CA=(f)*ratio of CA*SP.gravity*1000

= 1261kg

(h)Mass of FA= (f)*ratio of FA*specific gravity*1000

=0.73*0.037*2.65*1000

= 716kg

Cement= 320kg/m^3 Water= 145.8kh/m^3 FA= 716kg/m^3 CA= 1261kg/m^3

Table 3.6: Quantity of material per m3 of the concrete

Designation	Cement	Fine Aggregate	Coarse Aggregate	Lithium carbonate
CCM20	23.8 Kg's	59.2Kg's	84.8 Kg's	
M1	23.8Kg's	59.2Kg's	84.8 Kg's	97 grams
M2	23.8 Kg's	59.2Kg's	84.8 Kg's	194 grams
M3	23.8 Kg's	59.2Kg's	84.8 Kg's	291 grams
M4	23.8 Kg's	59.2Kg's	84.8 Kg's	388 grams

3.3.2 Number Of Specimens

Mixes	Compressive Strength	Tensile Strength	Flexural Strength	Water Absorption
CC M20	Cubes of size 150mmx150mm	Cylinder of size 150mm x 300mm	Prism of size 100mmx500mm	Cubes Of size 150mmx150mm
	3 for 7 days 3 for 14 days 3 for 28 days	2 for 14 days 2 for 28 days	1 for 14 days 1 for 28 days	3 for 7 days 3 for 14 days 3 for 28 days
M1	Cubes of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days	Cylinder of size 150mm x 300mm 2 for 14 days 2 for 28 days	Prism of size 100mmx500mm 1 for 14 days 1 for 28 days	Cubes Of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days
M2	Cubes of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days	Cylinder of size 150mm x 300mm 2 for 14 days 2 for 28 days	Prism of size 100mm x 500mm 1 for 14 days 1 for 28 days	Cubes Of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days
M3	Cubes of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days	Cylinder of size 150mm x 300mm 2 for 14 days 2 for 28 days	Prism of size 100mm x 500mm 1 for 14 days 1 for 28 days	Cubes Of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days
M4	Cubes of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days	Cylinder of size 150mm x 300mm 2 for 14 days 2 for 28 days	Prism of size 100mm x 500mm 1 for 14 days 1 for 28 days	Cubes Of size 150mmx150mm 3 for 7 days 3 for 14 days 3 for 28 days

Table3.7: Number of specimens

In order to prepare the material, a mixer is used to measure and combine all of the ingredients. The aggregates are mixed together for a duration exceeding 2 minutes, and then cement is added to the mixer. After another minute of mixing, water is added to the mixer, and the resulting mixture is thoroughly blended. Next, the mixture is molded into various shapes including cubes with dimensions of 150x150x150 mm, cylinders measuring 150 x 300 mm, and beams with dimensions of 100 x 100 x 500 mm. After 24 hours, the molds are removed and the cube and beam specimens are placed in water for a curing period of 28 days.

3.4 CASTING OF MOULDS

Casting of cement mixes typically involves the use of moulds to create objects or structures out of a cement-based mixture. The process is similar to other casting processes in that a liquid material is poured into a mould and allowed to solidify, taking on the shape of the mould cavity.

The casting of cement mixes typically involves the following steps:

1. Preparation of the mould: The mould is prepared by applying a release agent or coating to prevent the cement mixture from sticking to the mould.
2. Mixing of the cement mixture: The cement mixture is prepared by mixing cement, sand, aggregates, and water to form a workable mixture.
3. Pouring of the mixture: The cement mixture is poured into the mould and allowed to settle and consolidate.
4. Curing: The cement mixture is allowed to cure, typically by being kept in a moist environment, to allow the cement to harden and develop the required strength.
5. Demoulding: Once the cement has hardened, the casting is removed from the mould and may be further processed, finished or cured.

Casting of cement mixes is used in a wide range of applications, from architectural concrete elements to precast concrete products such as paving stones, slabs, and walls. The process allows for the production of complex shapes with high accuracy and can be used to create a variety of finishes and textures.

FIG 3.4: CASTING OF MOULDS

3.4.1 CUBE

The following steps are taken into consideration while casting the concrete cube specimens:

The cubic mould is used to test concrete specimens with a maximum nominal aggregate size of 38 mm, 150 x 150 x 150 mm and must comply with the requirements of IS:10262-2019. The mould must be equipped with a base plate and the cement used must be 394 kg/m3. Mild steel ramming bars conforming to IS:10262-2019 with rounded ends must be used. The rod should be 16±0.5mm in diameter and 600±2mm in length. To begin the casting process, the mould plate must be disassembled, cleaned, and reassembled to ensure all bolts are tight. A thin layer of oil should be applied to all surfaces of the mould. The faces of the cube must be parallel. The concrete should be mixed and poured into the mold as quickly as possible in a layer about 5 cm deep. After a spoonful of concrete has been poured, it should be moved along the top edge of the mold so that it is evenly distributed. Each layer must be compressed manually or by vibration. For manual compaction, each layer of concrete is compacted with a rammer with a minimum of 35 strokes. Strokes must penetrate the base layer and wrap the bottom layer to full depth. If a void forms in the rammer shaft, it must be closed by tapping the edge of the mould.

Fig.3.5 Cube Casting

3.4.2 CYLINDER

In order to properly evaluate the physical properties of concrete materials, it is necessary to manufacture and withstand test specimens according to established standards. Concrete cylinders are commonly used to evaluate the compressive and tensile strength of concrete.

1. Cylindrical mould: A 150mm x 300mm metal cylindrical mould is used to cast concrete specimens on site. Forms should be placed on a smooth, hard, flat surface before filling.

2. Punching bar: When using a formwork with a diameter of 150mm, concrete is poured evenly in 3 layers and each layer is evenly compacted 25 times with a steel bar with a diameter of 16mm and a length of 450mm -600mm with a hemispherical tip.

3. Casting process: The stroke must be evenly distributed over the cross section of the mould. The bottom layer must be putty throughout the depth. For each subsequent layer, the rod should penetrate the base layer approximately 25 mm. If the core creates voids, be sure to tap the edges of the mould to close them before adding the next layer of material.

Fig.3.6 Cylinder Casting

3.4.3 PRISM

Cast concrete prisms for evaluation according to criteria Flexural strength of concrete. Casting and testing procedures must be in accordance with Indian Standard IS 10262-2009.

1. Prism shape: The standard mould size is 100 x 100 x 500 made of metal. The stamping bar is a steel bar weighing 2 kg and 40 cm long. It should have a 25mm padded surface. Specimens should be prepared as soon as possible after mixing and in such a way that the concrete is fully compacted without segregation or excessive lattice.

2. Casting process: The seal must be evenly distributed over the mould section. The bottom layer must be stitched throughout the depth. For each top layer, the rod should penetrate the base layer approximately 25mm. If there are voids in the core, tap the sides of the mould to close the voids before adding the next layer of material.

FIG 3.7 PRISM

3.5 CURING

Curing is an important process for developing the strength and durability of concrete and preventing cracks and other defects. This process involves maintaining the humidity and temperature of the concrete to ensure hydration. Proper curing is essential to obtain the desired concrete properties and characteristics. The curing process usually consists of three stages. The first is initial curing, in which fresh concrete is covered with a moisture-retaining material such as wet burlap or plastic sheeting. This is done to prevent water loss and increase hydration. Concrete should be stored in a shaded area and protected from direct sunlight, wind and temperature extremes. The second stage is wet curing, in which the concrete is periodically sprayed with water or soaked in water after construction to maintain a moist environment for several days. This step will help prevent the surface from drying out and cracking as well as further wetting and strength gains. The third stage is sealing, where a hardener or membrane is applied to the concrete surface to retain moisture and speed up curing. This is particularly useful for large concrete surfaces such as sidewalks and floors where wet curing is not practical. The curing period depends on factors such as cement type, concrete thickness, ambient temperature and humidity, and desired strength and durability. In general, concrete should dry for a minimum of 7 days, preferably 28 days, to achieve maximum strength and durability. Curing is also critical to the accuracy and reliability of concrete testing. Concrete cubes, cylinders and prisms require proper curing to ensure accurate and reliable results. The curing process for these specimens is similar to the general curing process for concrete, but with specific requirements depending on the type of specimen. Concrete cubes are typically used for compressive strength testing and are cured in a moist environment for 24 hours, then submerged in water at a controlled temperature for the remaining period. Concrete cylinders, on the other hand, are typically cast and cured in the field to assess the strength of the concrete in situ. They are covered with a damp cloth or plastic sheet for 24 hours and then transferred to a curing tank or wet cloth for the remaining period. Concrete prisms are used for flexural strength testing and are cured in a moist environment for 24 hours, then submerged in water at a controlled temperature for the remaining period. During the curing period, specimens should be stored in a controlled environment to maintain constant temperature and humidity. The water used for curing must be clean and free of impurities that can affect the properties of the concrete. Deviations from recommended curing procedures can affect strength test results and reduce the quality and safety of concrete in use. Therefore, proper curing should not be neglected or shortened to save time or money.

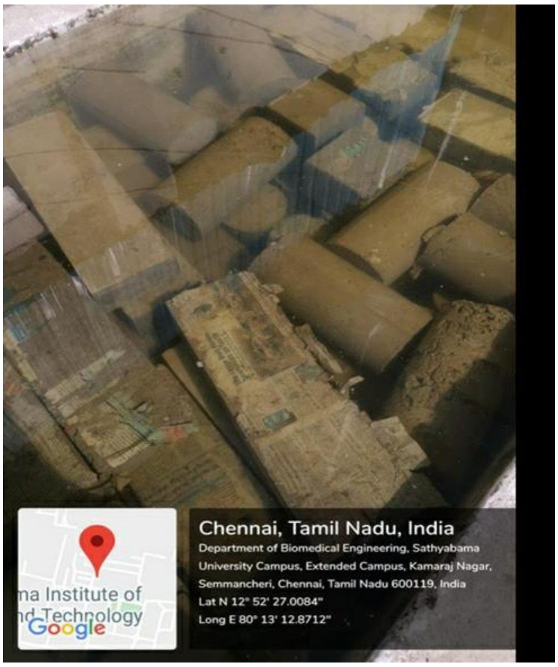


Fig.3.8: Curing

3.6 TESTING PROCEDURE OF MOULDS

3.6.1 COMPRESSIVE STRENGTH TEST

The compressive strength test is a widely accepted technique used to gauge the strength of concrete, with the test usually conducted on cylindrical or cubic specimens. This method involves applying a compressive load to the specimen until it reaches failure, and determining the maximum load that the specimen can endure prior to failure. The compressive strength is then obtained by dividing the maximum load by the cross-sectional area of the specimen. In conducting a compressive strength test on concrete specimens, several steps need to be followed. Initially, concrete specimens are cast in cylindrical or cubic moulds either in a laboratory or in the field, after which they are cured under controlled conditions for a specified period of time. Typically, specimens are cured for 7 or 28 days before testing. Prior to testing, the specimens must be meticulously inspected for any defects or irregularities that could impact the results. The ends of the cylindrical specimens should be flattened to ensure even loading during the test, and any loose particles or debris should be eliminated from the surface of the specimens. The specimens are then placed in a testing machine, usually a hydraulic press or servo-controlled machine, and loaded gradually until they fail. The load is applied at a constant rate of stress, usually 0.2 MPa/s to 0.5 MPa/s, until the specimen fails or reaches the maximum load capacity of the testing machine. Finally, the compressive strength of the specimen is calculated by dividing the maximum load by the cross-sectional area of the specimen. For cylindrical specimens, the cross-sectional area is determined by calculating πd^2/4, where d is the diameter of the specimen. For a cubic specimen, the cross-sectional area is simply the area of one side of the cube. In general, compressive strength testing is an essential tool for quality control and quality assurance of concrete in construction projects. It provides important information about the strength and durability of concrete and ensures that the concrete meets the required specifications and standards.

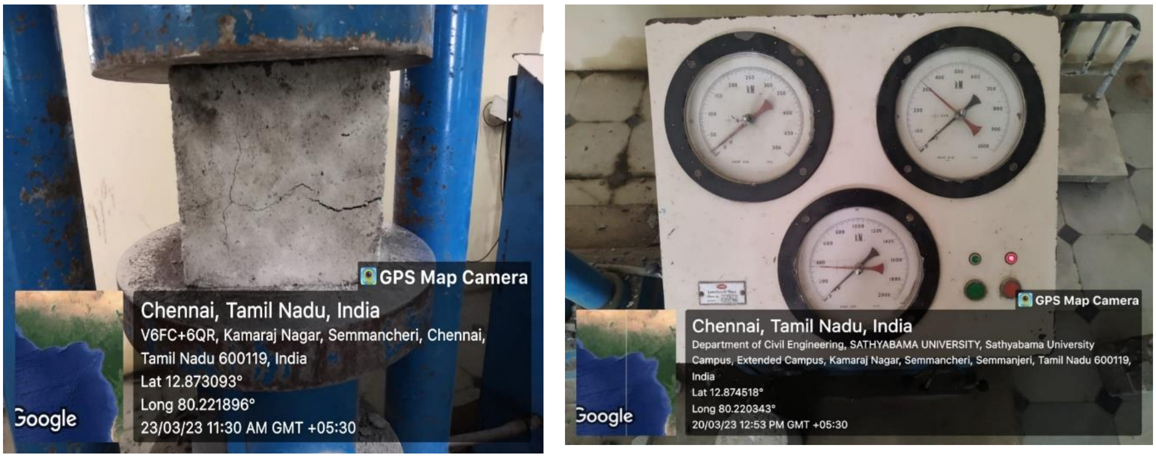


Fig 3.9: Comprehensive Strength Test

3.6.2 TENSILE STRENGTH TEST

The tensile strength test is a widely used method for assessing the durability and strength of materials, such as metals and plastics, by determining the maximum stress a material can bear before failing under tension. This primary objective involves subjecting a sample of the material to tension until it fails, with the resulting tensile strength calculated by dividing the maximum load by the cross-sectional area of the sample. Typically, the results are reported in force per unit area, such as megapascals or pounds per square inch.

The significance of this test lies in the critical information it provides about the strength and stiffness of materials, which is crucial for designing and engineering structures and components. Moreover, it helps ensure the quality and compatibility of building and manufacturing materials, such as steel, and can identify potential defects and weaknesses to prevent failures and accidents.

While concrete is weak and brittle in tension, tensile strength tests are usually not conducted. However, other tests such as compressive strength tests are used to evaluate strength and durability. Indirect approximation of concrete's tensile strength can be achieved through tests such as the flexural strength test or the tensile split test.

Fig. 3.10: Tensile Strength Test

3.6.3 FLEXURAL STRENGTH TEST

To determine the flexural strength or modulus of rupture of concrete, samples of beam or cylindrical shape are used for flexural strength tests. While the preferred sample is usually the beam-shaped type, cylindrical samples can also be utilized. The primary aim of these tests is to determine the maximum stress that the concrete can sustain before it fails under bending.

In the case of cylindrical samples, the flexural strength test involves the application of a load to the top and bottom surfaces of a concrete cylinder that is supported on its side by two rollers. The load is gradually increased until the cylinder fractures or breaks, and the force required to break the cylinder is then used to calculate the flexural strength of the concrete.

Flexural strength tests on concrete samples are regarded as critical in the construction industry since they provide valuable information on the concrete's ability to resist cracking and withstand bending forces. This information is essential for designing and constructing durable and safe concrete structures.

A laboratory setting using specialized equipment such as a Flexural Testing Machine is the usual location for conducting flexural strength tests on concrete samples. These tests can be performed by testing laboratories, research institutions, manufacturing companies, or specialized third-party testing companies that offer flexural strength testing services for concrete and other construction materials.

Fig 3.11 Flexural Strength Test

3.7 SPECIMEN DESIGNATION

Specimen Designation	**Lithium Carbonate content by Volume (%)**
Conventional mix	0%
Mix-1	0.1% of total mix weight
Mix-2	0.2% of total mix weight
Mix-3	0.3% of total mix weight
Mix-4	0.4% of total mix weight

Table 3.7 Volume of Lithium Carbonate used in each mixes

CHAPTER 4

RESULT AND DISCUSSION

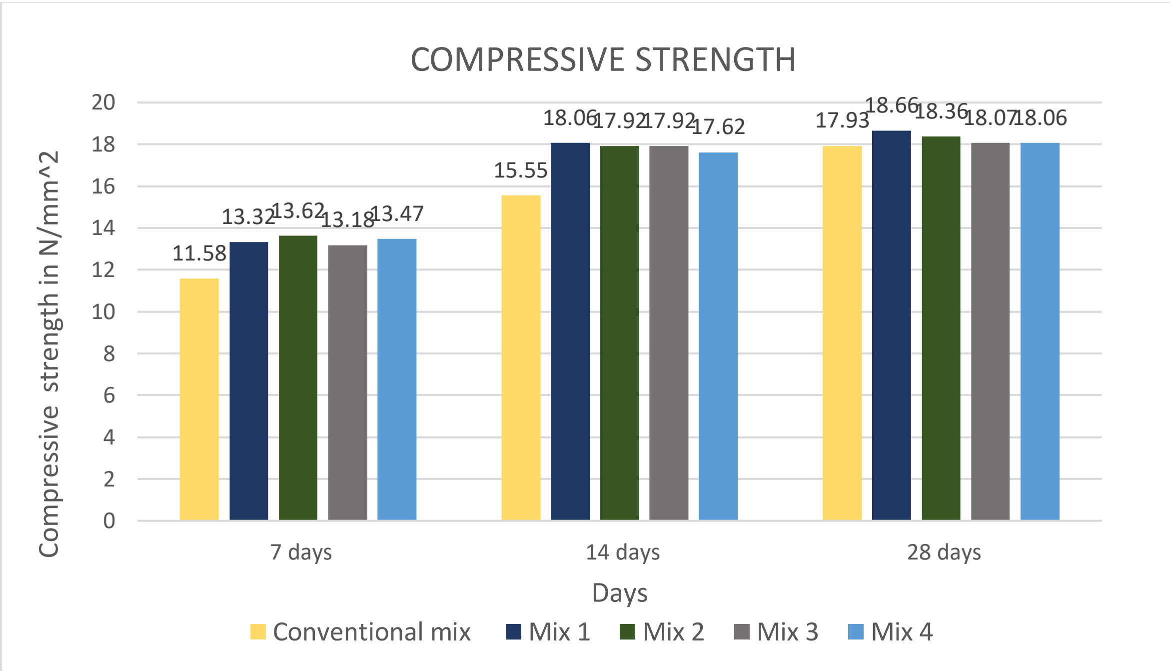
4.1 EXPERIMENTAL RESULTS

4.1.1 COMPRESSIVE STRENGTH

In this section, the focus is on presenting the results of the tests and discussing the compressive strength, tensile strength, and flexural strength of concrete specimens. To determine the compressive strength, a specific procedure is followed. If the specimens have been held in water, they should be tested immediately while still wet, and their wetness can be maintained by covering them with wet gunny. The surfaces of the compression platens should be cleaned, and loose sand or other materials should be removed from the surfaces of the specimens that will be in contact with the platens.

For cube specimens, the load should be applied to opposite sides of the cube as cast, not to the top and bottom. The axis of the specimen should be aligned with the middle of thrust of the spherically seated platen, and no packing should be used between the faces of the specimen and the steel platen of the testing machine. The loading rate for a 15 cm cube should be set at 5.2 KN/sec to ensure uniform loading of the specimen. The load should be applied continuously, without shock, and increased until the specimen can no longer sustain any greater load. The maximum load applied to the specimen should then be recorded, and any unique characteristics of the failure should be noted.

Compressive strength is a crucial factor in structural design, and the strength development in fibre-reinforced concrete is studied at 7, 14, and 28 days. The results show an increase in compressive strength with an increase in curing age for all concrete specimens, and there is variation in compressive strength with different percentages of fibre over normal concrete



Graph 4.1.1: Comparison Compressive Strength

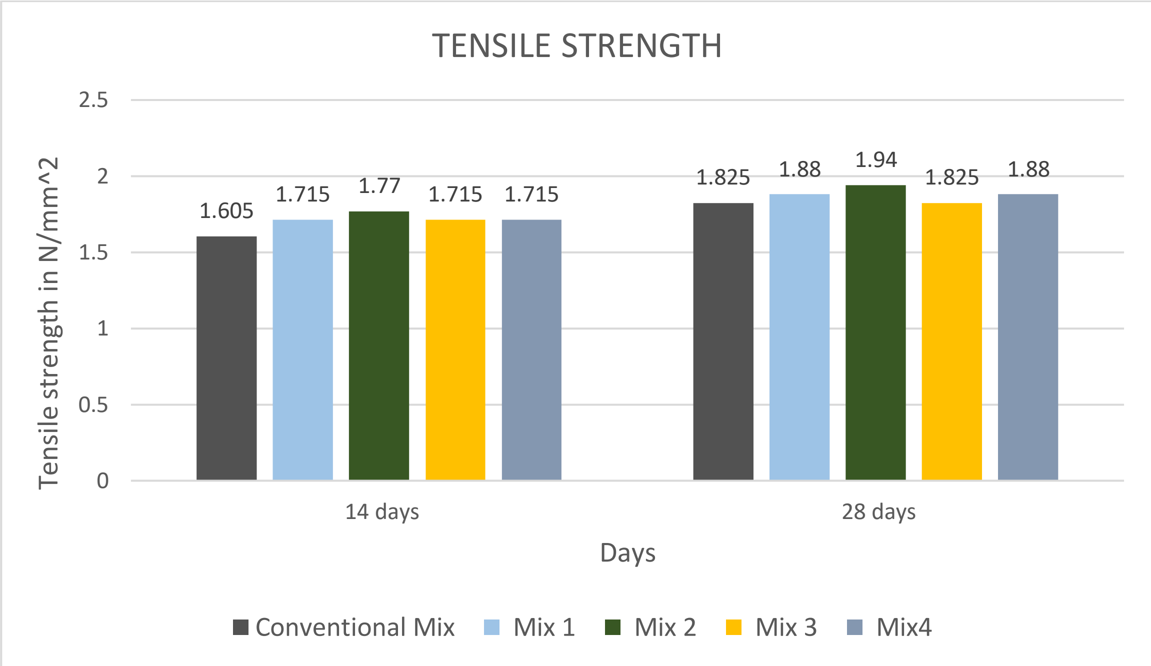
4.1.2 Tensile strength

Tensile strength refers to a material's ability to withstand forces that pull or stretch it, and it is typically measured in units of force per area. This property is particularly important for engineering and construction materials such as metals, plastics, and composites, as it determines their suitability for specific applications and can be used to compare the strength of different materials. Materials with high tensile strength are generally considered strong and durable, while those with low tensile strength may be prone to deformation or failure under stress.

Concrete is a material with relatively low tensile strength compared to its compressive strength, making it vulnerable to cracking and breaking under tension. Reinforcing materials such as steel bars or fibers can be added to concrete to improve its tensile strength, creating reinforced concrete that is commonly used in construction applications where tensile strength is important.

Special types of concrete mixes such as high-strength concrete or fiber-reinforced concrete can also increase the tensile strength of concrete. Calculating the tensile strength of a cylinder made of a specific material involves using the appropriate formula based on the material properties, such as the maximum load applied during the test and the original cross-sectional area of the cylinder.

It is important to note that the tensile strength of a cylinder may vary depending on factors such as its dimensions, loading direction, and environmental conditions. Despite its relatively low tensile strength, concrete remains a versatile and cost-effective material in construction due to its high compressive strength and other desirable properties such as durability and fire resistance.



Graph 4.1.2: Tensile strength Comparison Chart

4.1.3 Flexural strength

Flexural strength, also known as modulus of rupture or bending strength, is a fundamental material property that measures its ability to resist bending or deformation under load. It is commonly used to evaluate the strength of ceramics, composites, metals, plastics, and other materials. To determine flexural strength, a load is applied to the material using a three-point or four-point bending configuration until it either fractures or bends beyond a particular limit. The maximum stress the material can withstand before failure is recorded as its flexural strength. This property is influenced by several factors, including the material's composition, microstructure, and processing, and it is essential to consider when a material is subjected to bending or flexing, such as in structural components, machine parts, or aerospace materials.

In the context of concrete, flexural strength is a critical parameter for designing reinforced concrete structures. It is measured using a flexural strength test or modulus of rupture test, in which a prismatic concrete beam is subjected to a gradually increasing load until it fails. The load at which the beam fails is recorded to calculate the flexural strength of the concrete. This property depends on several factors, such as the type of cement used, water-cement ratio, aggregate size and distribution, curing conditions, and presence of reinforcement. It is an essential design parameter for structures that will be exposed to bending stresses, including beams, columns, slabs, and bridges. In reinforced concrete structures, reinforcement is designed to provide tensile strength to the concrete, enhancing its flexural strength and overall structural performance.

To determine the flexural strength or modulus of rupture of a material, a flexural strength prism or flexural test specimen is used. In the case of concrete, a prism with a rectangular cross-section and a length to height ratio of 3:1 or 4:1 is used for the flexural strength test. The prism is cast using a mould and allowed to cure for a specific period, typically 28 days. After curing, the prism is placed horizontally on two supports, and a load is applied to the centre of the prism at a constant rate until it fails. The maximum load the prism can withstand before failure is recorded, and the flexural strength of the concrete is calculated based on the dimensions of the prism and the applied load. The flexural strength prism test is widely used to evaluate the quality of concrete in construction projects, ensure that the concrete meets the required standards and specifications, and is a critical factor in the design of reinforced concrete structures, including beams, columns, and bridges.

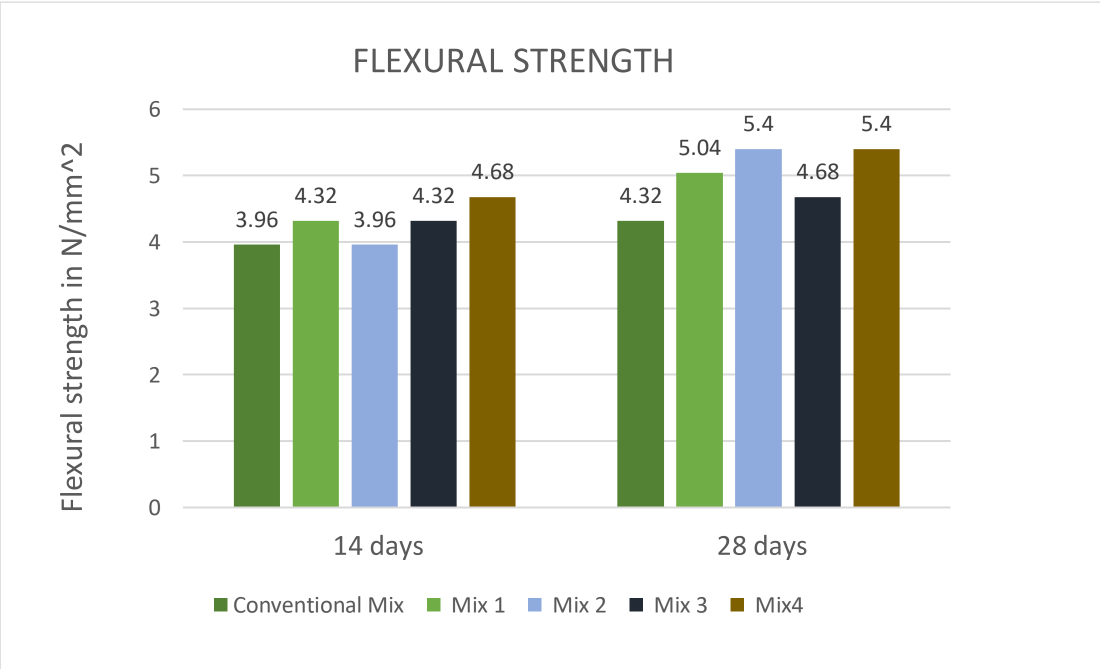
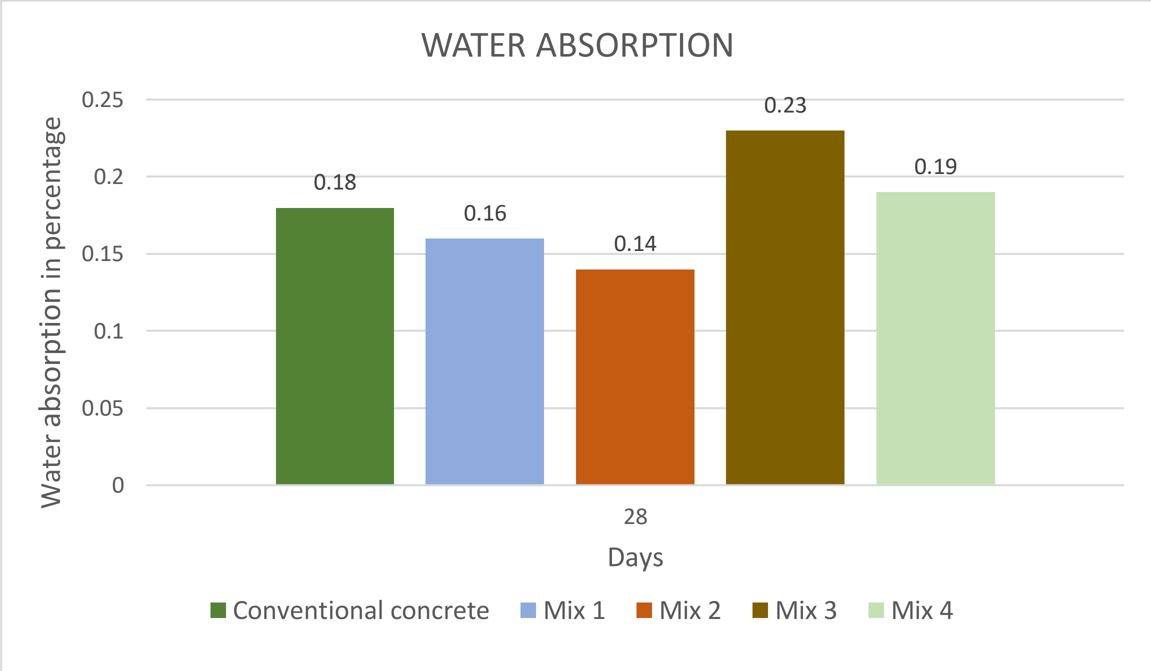


Table 4.1.3: Comparison of Flexural strength

4.1.4 WATER ABSORPTION

In mix 1 and mix 2 the water absorption decreases by 25 and 50 percent respectively compared to conventional mix. The decrease in the water absorption of concrete is noticeable in the Mix 2.



4.1.5 DENSITY OF CONCRETE

The following Table shows the 28days density of concrete of cube for various mixes it is observed that the for M2 mix is high in density compared to the other mixes and the involvement of fiber will increase in density of concrete so here we can see the increase in density of hardened concrete of mix 1 and mix 2 compared to the conventional mix.

Mixes	Weight of fresh concrete per (m^3)	Weight of hardened concrete of cube (kg)	Density of concrete (kg/m^3)
Conventional mix	2328	8.390	2485.92
Mix 1	2328	8.480	2512.59
Mix 2	2328	8.590	2545.16
Mix 3	2328	8.480	2512.59
Mix 4	2328	8.360	2477.03

CONCLUSION

We conclude that the use of lithium carbonate in concrete has been the subject of various investigations in recent years. Overall, the research suggests that incorporating lithium carbonate into concrete mixtures can have a positive impact on several properties of the resulting concrete. For example, it can enhance the early age hydration and mechanical properties of concrete, improve its durability and carbonation resistance, and reduce its shrinkage, creep, and cracking. Lithium carbonate can also affect the pore structure and transport properties of cement-based materials. However, the specific effects of lithium carbonate on concrete properties can vary depending on factors such as the type of cement and aggregates used, the dosage of lithium carbonate, and the curing conditions. Further research is needed to fully understand the potential benefits and drawbacks of using lithium carbonate in concrete, as well as to develop optimal mix designs and dosage rates for various applications. Nonetheless, the existing studies suggest that lithium carbonate could be a promising additive for enhancing the performance of concrete in a variety of construction applications. Lithium carbonate can reduce the porosity of concrete, which can improve its resistance to water and chemical attack.The use of lithium carbonate can also reduce the overall amount of cement needed to produce concrete with similar strength and durability, which can help to reduce the environmental impact of concrete production.Some studies have reported that incorporating lithium carbonate into concrete can increase its fire resistance .However, there are some concerns about the potential environmental and health impacts of using lithium, which is a relatively rare and valuable resource. It is important to consider the sustainability of using lithium carbonate in concrete, as well as potential alternatives or substitutes .The cost of using lithium carbonate in concrete is another important factor to consider, as it may be more expensive than traditional concrete additives. It is important to note that while the research on the use of lithium carbonate in concrete is promising, it is not yet widely used in practice. Further testing and evaluation may be needed to ensure that the long-term performance and durability of lithium carbonate-modified concrete is satisfactory.

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