

# **EXPERIMENTAL STUDY ON LIGHT WEIGHT CONCRETE USING PUMICE AS A REPLACEMENT OF COARSE AGGREGATE**

Submitted in partial fulfillment of the requirements  
for the award of Bachelor of Engineering degree in  
Civil Engineering

By

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## **SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A++" by NAAC**

**JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

**APRIL – 2024**



# **SATHYABAMA**

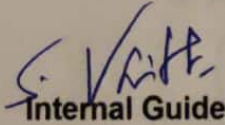


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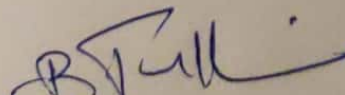
This is to certify that this Project Report is the bonafide work of **ABHIRAM PRADEEP (Reg. No. 40200001)** and **THIRUMAL VARNAN (Reg. No. 40200013)** who carried out the project entitled "**EXPERIMENTAL STUDY ON LIGHT WEIGHT CONCRETE USING PUMICE AS A REPLACEMENT OF COARSE AGGREGATE**" under our supervision from December 2023 to April 2024

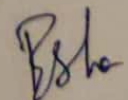
  
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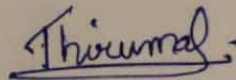
  
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## DECLARATION

We, ABHIRAM PRADEEP (Reg.No. 40200001) and THIRUMAL VARNAN (Reg.No. 40200013) hereby declare that the Project Report entitled "EXPERIMENTAL STUDY ON LIGHT WEIGHT CONCRETE USING PUMICE AS A REPLACEMENT OF COARSE AGGREGATE." done by us under the guidance of Dr. S Vanitha, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

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## ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. Devyani Gangopadhyay, B.Arch., M.T.P., Ph.D.**, Dean, School of Building and Environment and **Dr. S. Packialakshmi, M.E., Ph.D.**, and **Dr. R. Padmapriya, M.E., Ph.D.**, Head of the Department, Dept. of Civil Engineering for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr.S. VANITHA.**, for her valuable guidance, suggestions and constant encouragement paved way for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Civil Engineering who were helpful in many ways for the completion of the project

## **ABSTRACT**

The construction industry's increasing demand for concrete has led to a rise in environmental concerns due to the extensive use of traditional coarse aggregates such as crushed stone and gravel. This study explores the feasibility of substituting conventional coarse aggregates with pumice, a lightweight and naturally occurring volcanic material. Pumice is known for its low density and abundance, making it an attractive alternative with potential benefits for sustainability in construction.

This research investigates the mechanical properties, durability, and environmental impact of pumice concrete. Through a comprehensive experimental program, we evaluate the compressive strength, flexural strength, and workability of pumice concrete mixtures in comparison to traditional concrete. Additionally, durability tests such as freeze-thaw resistance, alkali-silica reaction, and sulfate attack are conducted to assess the long-term performance of pumice-based concrete.

Preliminary findings indicate that pumice concrete exhibits promising mechanical properties and satisfactory durability, with the added advantage of reduced weight. The environmental impact of pumice concrete is also analyzed, focusing on its potential to reduce carbon emissions in the construction industry.

This research aims to contribute to sustainable construction practices by offering an environmentally friendly alternative to conventional coarse aggregates. The results from this study provide valuable insights for engineers, architects, and construction professionals seeking to reduce the environmental footprint of concrete production while maintaining structural integrity.

## TABLE OF CONTENTS

| Chapter No. | Title                                                | Page No.  |
|-------------|------------------------------------------------------|-----------|
|             | <b>Abstract</b>                                      | v         |
|             | <b>List of Figures</b>                               |           |
|             | <b>List of Tables</b>                                |           |
|             | <b>List of Symbols and Abbreviations</b>             |           |
| <b>1</b>    | <b>INTRODUCTION</b>                                  |           |
|             | 1.1 General                                          | 1         |
|             | 1.2 Materials and Methods                            | 2         |
|             | 1.2.1 Cement                                         | 2         |
|             | 1.2.2 Fine Aggregate                                 | 3         |
|             | 1.2.3 Coarse aggregate                               | 3         |
|             | 1.2.4 Water                                          | 4         |
|             | 1.2.5 Batching, Mixing and Casting of concrete cubes | 4         |
|             | 1.3 Pumice as a Replacement of Coarse Aggregate      | 5         |
| <b>2</b>    | <b>LITERATURE SURVEY</b>                             | <b>7</b>  |
|             | 2.1 General                                          | 7         |
|             | 2.2 Review of the literature                         | 7         |
|             | 2.3 Inference from the literature                    | 10        |
| <b>3</b>    | <b>AIM AND SCOPE OF THE STUDY</b>                    | <b>11</b> |
|             | 3.1 Aim and objectives                               | 11        |
|             | 3.2 Scope of the project                             | 11        |
| <b>4</b>    | <b>MATERIALS AND EXPERIMENTAL WORKS</b>              | <b>12</b> |
|             | 4.1 Materials                                        | 15        |
|             | 4.1.1 Cement                                         | 15        |

|          |                                                    |           |
|----------|----------------------------------------------------|-----------|
|          | 4.1.2 Fine aggregate                               | 15        |
|          | 4.1.2 Coarse aggregate                             | 16        |
|          | 4.1.4 Pumice Light Weight Aggregate                | 17        |
|          | 4.1.5 Water                                        | 18        |
|          | 4.2 Experimental works                             | 18        |
|          | 4.2.1 Mix proportion                               | 18        |
|          | 4.3 Procedure for casting of cubes and<br>cylinder | 23<br>25  |
|          | 4.3.1 Concrete strength according to days          | 26        |
|          | 4.3.2 Curing of concrete                           | 28        |
|          | 4.4 Testing of concrete                            | 28        |
|          | 4.4.1 Compressive strength test                    | 30        |
|          | 4.4.2 Split tensile strength test                  |           |
| <b>5</b> | <b>RESULTS AND DISCUSSION</b>                      | <b>33</b> |
| <b>6</b> | <b>SUMMARY AND CONCLUSION</b>                      | <b>35</b> |
|          | <b>REFERENCE</b>                                   | <b>36</b> |

## LIST OF FIGURES

| FIGURE | TITLE                                      | PAGE |
|--------|--------------------------------------------|------|
| No     |                                            | No   |
| 1.2    | CEMENT                                     | 2    |
| 1.3    | M-SAND                                     | 3    |
| 1.4    | COARSE AGGREGATE                           | 3    |
| 1.5    | MEASURING CYLINDER WITH WATER              | 4    |
| 1.6    | PUMICE STONE                               | 6    |
| 1.7    | TYPES OF PUMICE                            | 6    |
| 4.1    | COMPRESSIVE STRENGTH TESTING MACHINE       | 13   |
| 4.2    | SPLIT TENSILE TESTING MACHINE              | 13   |
| 4.3    | CASTING OF CUBES AND CYLINDER              | 24   |
| 4.4    | PREPARATION OF CONCRETE                    | 25   |
| 4.5    | CURING OF CONCRETE                         | 26   |
| 4.6    | COMPRESSIVE STRENGTH TEST OF CUBE SPECIMEN | 28   |
| 4.7    | CRACK PATTERN OF CUBE SPECIMEN             | 29   |
| 4.8    | SPLIT TENSILE TEST OF CYLINDRICAL SPECIMEN |      |
| 4.9    | CRACK PATTERN OF CYLINDRICAL SPECIMEN      | 30   |

## LIST OF TABLES

| TABLE No | TITLE                                             | PAGE No |
|----------|---------------------------------------------------|---------|
| 4.1      | PROPERTIES OF<br>CEMENT                           | 14      |
| 4.2      | PROPERTIES OF<br>CONVENTIONAL<br>COARSE AGGREGATE | 16      |
| 4.3      | PROPERTIES OF PUMICE<br>LIGHTWEIGHT AGGREGATE     | 17      |
| 5.1      | COMPRESSIVE STRENGTH TEST<br>ON CONCRETE          | 32      |
| 5.2      | SPLIT TENSILE STRENGTH TEST<br>ON CONCRETE        | 33      |

# CHAPTER 1

## INTRODUCTION

### 1.1 GENERAL

**Concrete** is a composite material composed of aggregate bonded together with a fluid cement that cures over time. Concrete is the second-most-used substance in the world after water, and is the most widely used building material. Its usage worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminium combined.

When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and moulded into shape. The cement reacts with the water through a process called concrete hydration that hardens it over several hours to form a hard matrix that binds the materials together into a durable stone-like material that has many uses.<sup>[5]</sup> This time allows concrete to not only be cast in forms, but also to have a variety of tooled processes performed. The hydration process is exothermic, which means ambient temperature plays a significant role in how long it takes concrete to set. Often, additives (such as pozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix, delay or accelerate the curing time, or otherwise change the finished material. Most concrete is poured with reinforcing materials (such as steel rebar) embedded to provide tensile strength, yielding reinforced concrete.

In the past, lime based cement binders, such as lime putty, were often used but sometimes with other hydraulic cements, (water resistant) such as a calcium aluminate cement or with Portland cement to form Portland cement concrete (named for its visual resemblance to Portland stone).

Lightweight concrete is a useful alternative to ordinary concrete in the production of lightweight building units because of its comparatively high strength to unit weight ratio. Light concrete, which contains less cement, is gaining popularity as a building material, due to the release of less pollution to the environment. Additionally, lower-density concrete can be used for smaller cross-section load-bearing elements and subsequent

smaller foundations. Furthermore, lighter concrete requires less concrete in the foundation to resist less pressure than ordinary concrete, and the overall mass of the materials to be carried is reduced, resulting in enhanced productivity. Low-density concrete is also better at insulating against heat than ordinary concrete. Ordinary concrete, on the other hand, contains more cement than lightweight concrete. However, a relevant cost comparison should be based on the structure's design employing lightweight concrete, rather than just the cost of materials. Pumice is a volcanic sponge-like material made from molten lava that cools quickly and traps millions of tiny air bubbles.

## **1.2 MATERIALS AND METHODS**

### **1.2.1 CEMENT**

A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is behind only water as the planet's most-consumed resource. Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as hydraulic or the less common non-hydraulic, depending on the ability of the cement to set in the presence of water.



**Fig 1.2: Cement**

### **1.2.2 FINE AGGREGATE**

The size of fine aggregate is defined as equal to or less than 4.75 mm. This means that the aggregates that can pass through a number 4 sieve with a mesh size of 4.75 mm are referred to as fine aggregates. These include clay, silt, and sand. Crushed gravel and crushed stone can also fall under this category.



**Fig 1.3: M-sand**

### **1.2.3 COARSE AGGREGATE**

A coarse aggregate is a granular material or particle that have a diameter greater than 0.19 inch. These coarse aggregates generally fall in the range of 3/8 inch and less than two inches in diameter. If you compare these diameters to that of an average rock diameter, you would see that the coarse aggregates are much smaller in size.



**Fig 1.4: Coarse aggregate**

#### **1.2.4 WATER**

The water used was clean tap water free from any deleterious substances and impurities and was collected from the tap in the Concrete Laboratory of Department of Civil Engineering, Ahmadu Bello University, Zaria. The water is portable; it therefore satisfies the specification requirement for water according to BS 3148.



**Fig 1.5: Measuring cylinder with water**

#### **1.2.5 BATCHING, MIXING AND CASTING OF CONCRETE CUBES**

Batching by volume approach was adopted in this research work. A mix ratio of 1:2:3 (by weight of cement: fines: coarse) with a water cement ratio of 0.5 and a targeted strength of 30N/mm<sup>2</sup> was used. The percentage replacements of fine aggregate (sand) with groundnut shells were 0, 5, 15, 25, 50 and 75% by volume of the fine aggregate to determine the effects of different proportions of the groundnut shell on some properties of concrete. Table 1 presents the calculated masses of constituent materials for all mixes. The 0% replacement served as control for other mixes. Workability tests using the slump and compacting factor were carried out. Concrete cubes were cast

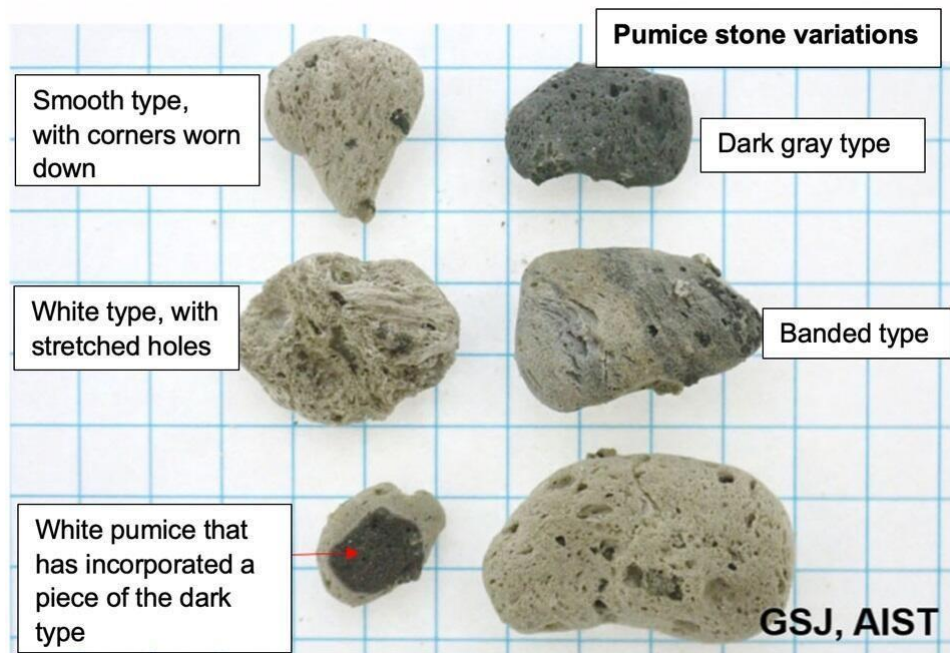
using steel moulds of sizes 150mm × 150mm × 150mm. The moulds were assembled and lubricated prior to casting for easy removal of cubes. Machine vibration was used during the casting. The concrete cubes were demolded 24 hours after casting and were cured for 28 days in water at room temperature. The cubes were surface dried and weighted to obtain their densities prior to testing and the compressive strength of the cubes was obtained by crushing with the universal testing machine located in the Concrete Laboratory, Department of Civil Engineering

### **1.3 PUMICE AS A REPLACEMENT OF COARSE AGGREGATE**

Due to depletion of natural granite stone, pumice can be used as an alternative material for coarse aggregate. Pumice is a porous rounded and irregular sponge like nature formed by the action of weathering with a volcanic origin source. The suitability of pumice and volcanic materials for a particular end-use is dependent on their physical properties such as toughness, grain-size, grain-shape, density and friability. However, the porous nature of the aggregate enhances interlocking sites for the cement paste to infiltrate and to form dense uniform interfacial zones between aggregate. Pumice is excessively cellular, glassy lava and has the same basic composition of rhyolite. Scoria is irregular in form and generally very vesicular and has the basic composition of basalt. Scoria is usually heavier, darker and more crystalline than pumice. Pumice is an extremely light, porous raw material. It can be found in many parts of the world including various developing countries with areas of past or present volcanic activities. Because of their lightweight nature and insulation properties, both pumice and scoria are used as lightweight aggregate in concrete products for structural concrete, plaster aggregate and loose fill aggregate. The use of light weight aggregates to produce light weight concrete has the advantage of reducing the dead weight in building structures. Lightweight Aggregate Concrete (LWAC) is vital and flexible material in modern construction.



**Fig 1.6: PUMICE STONE**



**Fig 1.7: TYPES OF PUMICE**

## CHAPTER 2

### LITERATURE SURVEY

#### 2.1 GENERAL

The following major research project has been taken from international journals as a reference to analyze the concepts for the project.

#### 2.2 REVIEW OF THE LITERATURE

**R. S. Muralitharan and V. Ramasamy** investigated the mechanical properties of pumice light weight aggregate concrete. In this investigation, pumice stone are proposed to be utilized as the coarse aggregate. It is possible to develop lightweight concrete using pumice with a dry density of 1200 kg/m<sup>3</sup> up to 1450 kg/m<sup>3</sup>. At present, the amount of work has been undertaken to investigate the mechanical properties of lightweight aggregate concrete. Compressive strength, splitting tensile strength, acid resistance, and thermal resistance were investigated for pumice lightweight aggregate concrete and at various ages of curing. The objective is to develop lightweight concrete using Indian pumice coarse aggregate and to study the behaviour of pumice lightweight concrete under cyclic loading. At the end of the investigation, the following conclusions were made: Structural compressive strength of pumice almost reached normal coarse aggregate compressive strength. Reduction in density confirms that lightweight concrete can be used for lightweight structures. Experimental Investigation on Lightweight Concrete using Pumice Aggregate

**A. Suba Lakshmi, S. Karthick, Gasper Helden, M. Dinesh Boopathi and V. Balaji Pandian** carried out the study on lightweight concrete by using pumice aggregate. Replacing pumice stone with coarse aggregate is said to be structural lightweight concrete solves to reduce the self-weight of building. The main objective is to determine whether pumice stone lightweight concrete can be used as structural concrete, to determine the compressive strength and split tensile strength of

lightweight concrete having density below  $1800\text{kg/m}^3$  and to study the effect of various types replacements (20%, 50%, 80%, 100%) of natural aggregate by lightweight aggregate (pumice) and conventional concrete on 7, 28 days. From the study, it is found that 50% replacement of pumice lightweight aggregate with conventional coarse aggregate is the optimum replacement level and the increasing percentage of pumice aggregate decreases the strength of concrete. The Study on Strength Properties of Lightweight Concrete using Lightweight Aggregate

**B. Devi Pravallika and K. Venkateswara Rao** carried out an experimental study on strength and durability properties of M40 concrete by partial replacement of coarse aggregate with a natural lightweight aggregate pumice stone. Pumice stone which is of natural lightweight aggregate is being chosen as the best material for the partial replacement to coarse aggregate. It gives good strength when compared to the other materials. The method of the study will be conducted on by replacing the usual aggregate by natural lightweight aggregate by 0%, 10%, 20%, 30%, 40% and 50%. The physical and mechanical properties of natural aggregate are evaluated and found that 20% replacement of pumice lightweight aggregate gives optimum value and beyond 20% the strength of concrete decreases. It gives good strength when compared to the other materials. The method of the study will be conducted on by replacing the usual aggregate by natural lightweight aggregate by 30%, 40% and 50%

The physical and mechanical properties of natural aggregate are evaluated and found that 20% replacement of pumice lightweight aggregate gives optimum value and beyond 20% the strength of concrete decreases.

Two quality zones of lightweight concrete using pumice aggregate, namely the brittle zone and the ductile zone. The maximum percentage of pumice aggregate in concrete is 50 % so that it enters the ductile zone and has good performance. The model new equations for the modulus of elasticity and the modulus of rupture of lightweight concrete Two quality zones of lightweight concrete using pumice aggregate, namely the brittle zone and the ductile zone. The maximum percentage of pumice aggregate in concrete is 50 % so that it enters the ductile zone and has good performance. The model new equations for the modulus of elasticity and the modulus of rupture of

lightweight concrete Two quality zones of lightweight concrete using pumice aggregate, namely the brittle zone and the ductile zone. The maximum percentage of pumice aggregate in concrete is 50 % so that it enters the ductile zone and has good performance. The model new equations for the modulus of elasticity and the modulus of rupture of lightweight concrete One-third of the weight of paddy is made up of rice husk, an agricultural waste product created during the grinding of paddy. In developing and undeveloped nations, rice husks are frequently used as fuel for industrial applications because they have a high calorific value. Rice Husk Ash (RHA), obtained by the combustion of Rice husk contains amorphous silica and has shown excellent performance when used as a pozzolanic material in concrete.

Growing activities in the construction sector have resulted in a rapid depletion of natural resources for building material production. Several current studies have presented the potential application of agricultural wastes in building material production owing to good physical and mechanical properties. Utilisation of such waste materials can contribute to reducing environmental impacts by proving alternative waste management strategies worldwide. The inclusion of Recycled Waste Glass (RWG) in concrete can be an alternative to ensure construction and environmental sustainability. RWG can be an excellent option to substitute natural aggregate, despite adding glass to concrete may result in an expansion in concrete through Alkali-Silica Reaction (ASR).

**V Manoj, R Sridhar and V .G Ajey Kumar** investigated that pumice is a rock particle that was used in this experiment's concrete, and light weight aggregate is a type of aggregate that is lighter than natural aggregate. The major purpose of the suggested methodology is to use optimization techniques to frame a mathematical model. Structural lightweight concrete is used extensively in the construction sector, particularly in high-rise buildings. Only lightweight aggregates can be used to make it. Pumice is a solid component and a highly porous rock light in nature that can be used as an alternative to coarse aggregate (CA) in concrete and Nano Silica an alternative for cement. This lightweight aggregate, on the other hand, has a higher density than other natural and artificial lightweight aggregates. As a result, the density of concrete made with this lightweight aggregate is relatively high, falling into the semi-lightweight

concrete category. According to the latest analysis, to further at the density of an lightweight concrete with high strength, Pumice was partially replaced with a coarse aggregate. In this study, pumice was substituted for CA in percentages of 0%, 20% and 30% by quantity and Nano Silica replaced in 1-3% for different mixes to predict three output parameters such as compressive strength (Mpa), split tensile strength (Mpa), flexural strength (Mpa). The addition of pumice to CA concrete decreases density while also lowering all mechanical properties, according to test results. This is because pumice has a smooth surface texture and has a lower density than CA. On the other hand, lightweight concrete containing more than 20% pumice changes into structural lightweight concrete with excellent strength. Several studies demonstrated an overall gain in strength as well as weight loss. As a result, light-weight concrete is equal to heavy-weight concrete in terms of strength.

**Alaa M. Rashad :** Pumice stone is a natural sponge-like lightweight aggregate formed during the rapid cooling and solidification of molten lava. After suitable preparation, it can be used as an aggregate to produce lightweight concrete or as a cementitious material to produce blended cement or geopolymer. This article focused on the influence of pumice powder (PP) on fresh properties and hardened properties of conventional cementitious materials and geopolymers. Additionally, different modification methods carried out to modify some properties of conventional cementitious materials containing PP have been included. This review showed that the incorporation of PP in the traditional cement matrix has some benefits such as increasing thermal and acoustic insulation, increasing fire resistance, increasing abrasion resistance, decreasing unit weight, decreasing hydration heat, decreasing drying shrinkage, decreasing autoclave expansion, increasing sulfate resistance, increasing seawater resistance, increasing acid resistance, increasing electrical resistivity, decreasing alkali silica reaction (ASR) expansion, decreasing porosity, water absorption and permeability. On the other hand, it has a negative effect on workability, mechanical strength and increasing carbonation rate. This review also confirmed that PP has a promising future in the field of alkali-activated and geopolymer materials.

## **2.3 INFERENCE FROM THE LITERATURES**

1. The reduction in percentage loss in weight recorded in the treated samples shows that concrete produced with GSA are more durable when compare to natural concrete
2. this review would assist the development of code of practices pertaining to the use of agro-wastes, and thus persuade the concerned personnel to switch to sustainable construction practices

## **CHAPTER 3**

### **AIM AND SCOPE OF THE STUDY**

#### **3.1 AIM AND OBJECTIVE**

- ▶ To produce lightweight concrete by using pumice aggregate.
- ▶ To know the characteristics of conventional concrete and pumice aggregate concrete.
- ▶ To study the effect of various types of replacements (30%, 40% & 50%) of natural aggregate by pumice lightweight aggregate and conventional concrete.

#### **3.2 SCOPE OF THE PROJECT**

The main scope of the project is to find the feasibility of replacing the conventional coarse aggregate with pumice aggregate by 30%, 40% & 50% in M30 concrete.

## **CHAPTER 4**

### **MATERIALS AND EXPERIMENTAL WORK**

Literature reviews were studied to collect the data regarding pumice aggregate and based on the data collected preliminary works were performed. Materials like pumice aggregate, coarse

aggregate, fine aggregate, cement were collected. Basic tests on materials were done to make sure that they are suitable for making concrete. The mix design for control concrete of grade M30 and pumice aggregate concrete had determined as per IS 10262–2009. Moulds were prepared to cast the specimen. Moulds of size 150 mm x 150 mm x 150 mm and cylinder moulds of size 150 mm x 300 mm were used to cast the specimen with partial replacement of 30%, 40% & 50% of coarse aggregate with pumice aggregate. Casted specimens were tested after 7, 14 & 28 days of curing. Destructive tests like Compressive strength test, Split tensile strength test. Test results were compared and conclusions have arrived.

Pumice concrete is a lightweight concrete made by incorporating pumice aggregate into the mix. Pumice is a volcanic rock with a porous and lightweight structure, making it an ideal candidate for lightweight concrete applications. Experimental work on pumice concrete has focused on its mechanical properties, durability, and sustainability.

In terms of mechanical properties, studies have investigated the compressive strength, tensile strength, and flexural strength of pumice concrete mixes with varying proportions of pumice aggregate, cement, and other additives. These experiments aim to optimize the mix design to achieve desired strength while maintaining the lightweight nature of the concrete.

Durability studies have examined the resistance of pumice concrete to factors such as freeze-thaw cycles, sulphate attack, and chemical corrosion. Pumice concrete's porous structure can enhance its resistance to freeze-thaw damage by allowing water to drain quickly, reducing the risk of internal pressure buildup and cracking.

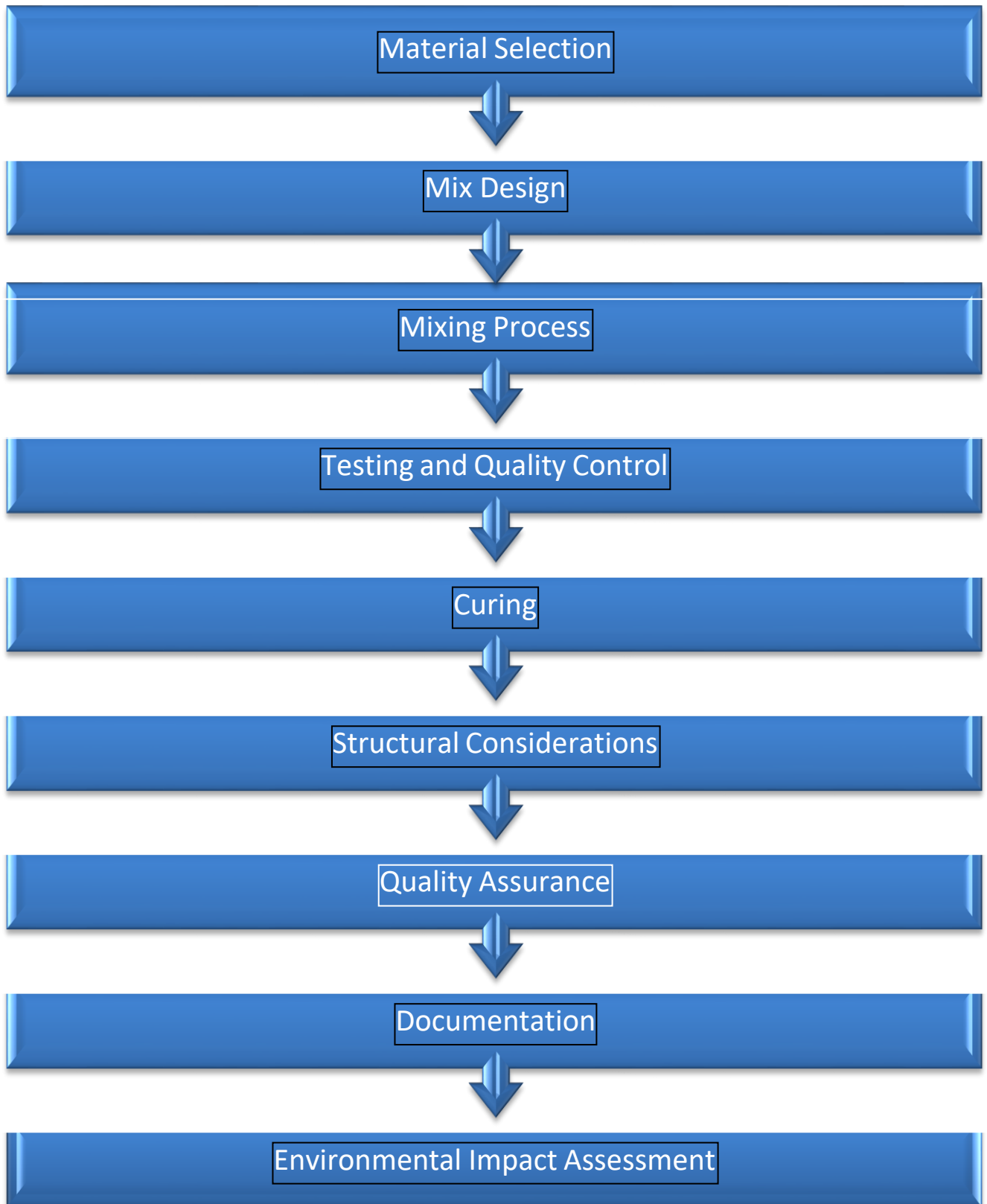
Additionally, researchers have explored the environmental sustainability of pumice concrete compared to traditional concrete. Pumice is a naturally occurring material that requires minimal processing, making it a more eco-friendly alternative. Its lightweight properties also contribute to reduced transportation costs and emissions during construction.



**Fig 4.1: Compressive strength testing machine**



**Fig 4.2: Split tensile testing machine**



## 4.1 MATERIALS

The testing of the ingredient materials of concrete such as cement, fine aggregate and coarse aggregate are carried out and results are presented below.

### 4.1.1 CEMENT

Cement is a material, generally in powder form, that can be made into a paste usually by the addition of water and, when moulded or poured, will set into a solid mass. Numerous organic compounds used for adhering, or fastening materials, are called cements, but these are classified as adhesives, and the term cement alone means a construction material.

The most widely used of the construction cements is Portland cement. It is a bluish-gray powder obtained by finely grinding the clinker made by strongly heating an intimate mixture of calcareous and argillaceous minerals. The chief raw material is a mixture of high-calcium limestone, known as cement rock, and clay or shale. Blast-furnace slag may also be used in some cements and the cement is called Portland slag cement (PSC). The colour of the cement is due chiefly to iron oxide. In the absence of impurities, the colour would be white, but neither the colour nor the specific gravity is a test of quality.

Ordinary Portland cement of 53 grades conforming to IS 8112-1989 was used. Tests were carried out on various physical properties of cement and the results are shown in table

| Physical properties  | Values of OPC used |
|----------------------|--------------------|
| Standard consistency | 29.2%              |
| Initial setting time | 45 Minutes         |
| Final setting time   | 265 Minutes        |
| Specific gravity     | 3.15               |

**TABLE 4.1 Properties of cement**

#### **4.1.2 FINE AGGREGATE**

Fine aggregate / sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic materials. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. Much of the earth's surface is sandy, and these sands are usually quartz and other siliceous materials. The most useful commercially are silica sands, often above 98% pure. Beach sands usually have smooth, spherical to ovaloid particles from the abrasive action of waves and tides and are free of organic matter. The white beach sands are largely silica but may also be of zircon, monazite, garnet, and other minerals, and are used for extracting various elements.

Sand is used for making mortar and concrete and for polishing and sandblasting. Sands containing a little clay are used for making moulds in foundries. Clear sands are employed for filtering water. Sand is sold by the cubic yard (0.76 m<sup>3</sup>) or ton (0.91 metric ton) but is always shipped by weight. The weight varies from 1,538 to 1,842 kg/m<sup>3</sup>, depending on the composition and size of grain. Construction sand is not shipped great distances, and the quality of sands used for this purpose varies according to local supply. Standard sand is silica sand used in making concrete and cement tests. The fine aggregate is passing through 4.75 mm sieve and had a specific gravity of 2.6. The grading zone of fine aggregate is zone II as per Indian Standard specifications.

Specific  
gravity = 2.66  
Water  
absorption = 1%

#### **4.1.3 COARSE AGGREGATE**

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is

granite, limestone, and trap rock. The last is a term used to designate basalt, gabbros, diorite, and other dark coloured, fine-grained igneous rocks. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. The sizes are from 20mm to 4.75mm in although larger sizes may be used for massive concrete aggregate. Machine crushed granite broken stone angular in shape is use as coarse aggregate.

| S.No | PROPERTIES             |                     | TEST RESULTS          |
|------|------------------------|---------------------|-----------------------|
| 1    | Specific Gravity       |                     | 2.70                  |
| 2    | Sieve Analysis         |                     | 4.68                  |
| 3    | Water Absorption       |                     | 0.67%                 |
| 4    | Bulk Density           | Loose bulk density  | 1.54g/cm <sup>3</sup> |
|      |                        | Rodded bulk density | 1.53g/cm <sup>3</sup> |
| 5    | Impact Test            |                     | 25.16%                |
| 6    | Crushing strength test |                     | 24.75%                |

**Table 4.2 - Properties of conventional coarse aggregate**

#### **4.1.4 PUMICE LIGHTWEIGHT AGGREGATE**

Pumice stone, typically sized between 20 to 40mm, is a lightweight volcanic rock widely used in concrete production. Its porous nature and low density make it an ideal aggregate for creating lightweight concrete, which offers benefits such as improved insulation, reduced dead load on structures, and ease of handling during construction. In concrete mixtures, pumice stone acts as an aggregate, providing bulk and contributing to the overall strength and durability of the concrete. Due to its lightweight properties, concrete made with pumice stone can achieve desired structural

performance while using less material compared to traditional concrete mixes.

One of the significant advantages of incorporating pumice stone into concrete is its thermal insulation properties. The porous structure of pumice traps air, creating pockets of insulation within the concrete mixture. This characteristic makes it particularly suitable for applications where thermal efficiency is important, such as in construction projects requiring energy-efficient buildings or structures.

Moreover, concrete containing pumice stone exhibits good workability, allowing for ease of placement and finishing during construction. This contributes to increased productivity and cost-effectiveness on construction sites.

Overall, pumice stone of size 20 to 40mm plays a valuable role in the construction industry by offering a lightweight, thermal insulating, and workable aggregate option for producing concrete with enhanced properties and performance.

| S.No | PROPERTIES             |                     | TEST RESULTS          |
|------|------------------------|---------------------|-----------------------|
| 1    | Specific Gravity       |                     | 1.05                  |
| 2    | Sieve Analysis         |                     | 2.75                  |
| 3    | Water Absorption       |                     | 50%                   |
| 4    | Bulk Density           | Loose bulk density  | 0.48g/cm <sup>3</sup> |
|      |                        | Rodded bulk density | 0.47g/cm <sup>3</sup> |
| 5    | Impact Test            |                     | 20%                   |
| 6    | Crushing strength test |                     | 81.1%                 |

**Table 4.3: Properties of Pumice Lightweight Aggregate**

#### 4.1.5 WATER

Water is an important ingredient of concrete as it plays an important role in mixing, laying, and compaction, setting and hardening of concrete. It influences the strength

development and durability of concrete. The quantity and quality of water is required to be looked into very carefully. Fresh potable water confirming IS- 456–2000 was used for the preparation of the concrete. Portable water free from salts was used for casting and curing of concrete as per IS: 456-2000 recommendations.

## **4.2 EXPERIMENTAL WORK**

### **4.2.1 MIX PROPORTION**

Design mix for M30 grade as per IS10262-2009 recommendations are used. The mix proportion for normal concrete and various percentage of replacement of pumice aggregate concrete is given

- |                               |                         |
|-------------------------------|-------------------------|
| a) Grade designation          | : M <sub>30</sub>       |
| b) Type of cement             | : OPC- 53 grade         |
| c) Max. size of aggregate     | : 20mm to 40mm          |
| d) Minimum W/C ratio          | : 0.5                   |
| e) Workability                | : 400 kg/m <sup>3</sup> |
| f) Exposure condition         | : Good                  |
| g) Method of concrete placing | : moderate              |
| h) Degree of supervision      | : Good                  |

### **Test data for materials\_**

- |                               |                |
|-------------------------------|----------------|
| a) Cement used                | : OPC-53 grade |
| b) Specific gravity of cement | : 3.15         |
| c) Specific gravity of        |                |
| Coarse aggregate              | : 2.66         |
| Fine aggregate                | : 2.67         |
| d) Water absorption           |                |
| Coarse aggregate              | : 0.5%         |
| Fine aggregate                | : 1.0%         |

### STEPS INVOLVED IN MIX DESIGN:

- Determination of target strength
- Selection of water/cement ratio
- Selection of water content
- Calculation of cement content
- Calculation of coarse aggregate content
- Calculation of fine aggregate content
- Calculation of water content
- Calculation of the mix proportion

#### Target Strength

$f_{ck} = f_{ck} + 1.65 s / f_{ck} + x$ , whichever is higher      where,

$f_{ck}$  = target average compressive strength at 28 days,  $f_{ck}$  = characteristics compressive strength at 28 days,

$s$  = standard deviation.

$x$  = factor based on grade of concrete as per table-1

$s = 5.0 \text{ N/mm}^2$  (IS-10262:2019, Table-2)       $x = 6.5$

$\text{N/mm}^2$  (IS-10262:2019, Table-1)       $f_{ck} = 30 + 1.65x$

$5 = 38.25 \text{ N/mm}^2$        $f_{ck} = 30 + 6.5 = 36.5$

$\text{N/mm}^2$       hence,  $f_{ck} = 38.25 \text{ N/mm}^2$

#### Water – Cement Ratio

Exposure – Severe

IS-456-2000, Table-3&5,

Water cement ratio – 0.45

### Water content

IS-10262, Table- 4

20mm aggregate – 186kg (for 50mm slump)

for every 25mm- add 3% (IS-10262-Cl.5.3)

for 125mm,  $186 + 9\% \text{ of } 186 = 203\text{lit}$

**Water content = 203lit**

### Aggregate Proportion Between C.A & F.A

I S- 10262, Table-5, Cl.5.5.1

zone – 2 – 0.62 [ w/c ratio – 0.5]

every 0.05 decrease, increase 0.01 [w/c ratio – 0.45]

$$0.45 - 0.4 = -0.05$$

$$0.62 + 0.01 = 0.63$$

For concrete Cl5.5.2(10% reduction)

$$0.63 \times 0.9 = 0.567 \text{ m}^3$$

For 1  $\text{m}^3$  volume, Coarse aggregate =  $0.567 \text{ m}^3$

Volume of Coarse Aggregate = 0.567  $m^3$

**Volume of Fine Aggregate = 1- 0.567 =0.433  $m^3$**

#### Mix Calculation

Volume of concrete = 1 $m^3$

volume of cement = (mass / s.g) x (1/1000) = 452 / (3.15x1000) =0.145  $m^3$

Volume of Cement = 0.145  $m^3$

Volume of Water (c)= (Mass/Sp. gravity) X (1/1000)= 203 / (1x1000)

Volume of water = 0.203  $m^3$

#### Volume Of All in Aggregates

1 - (b + c) = 1- (0.145 + 0.203) = 0.652  $m^3$

#### Mass Of Coarse Aggregate:

(Vol. of all in Aggregate) X (Vol. of C.A) x (Sp. Gravity of C.A) x (1000)

= 0.652 x 0.567 x 2.8 x 1000

= 1036

Mass of Coarse Aggregate = 1036 kg

Mass of Fine Aggregate:

(Vol. of all in Aggregate) x (Vol of F. A) x (Sp. gravity of F.A) x (1000)

$0.652 \times 0.433 \times 2.7 \times 1000 = 762.25 \text{ kg}$

Mass of fine aggregate = 762.25kg

### **SUMMARY:**

Cement = 452 kg/  $m^3$

Water = 203 kg/  $m^3$

Fine Aggregate = 762 kg/  $m^3$

Coarse Aggregate = 1036 kg/  $m^3$

Pumice Aggregate = 310.8 Kg/  $m^3$

Water Cement Ratio = 0.45

### **Proportion:**

1: 1.5: 2.5

Therefore, the mix proportions for casting = **1: 1.5: 2.5**

FORMULAS:

**COMPRESSIVE STRENGTH OF CONCRETE =**

$$\frac{\text{LOAD TAKEN BY SPECIMEN}}{\text{CROSS SECTIONAL AREA OF CUBE}}$$

$$C = \frac{P}{A} \times 1000$$

**SPLIT TENSILE STRENGTH OF CONCRETE =**

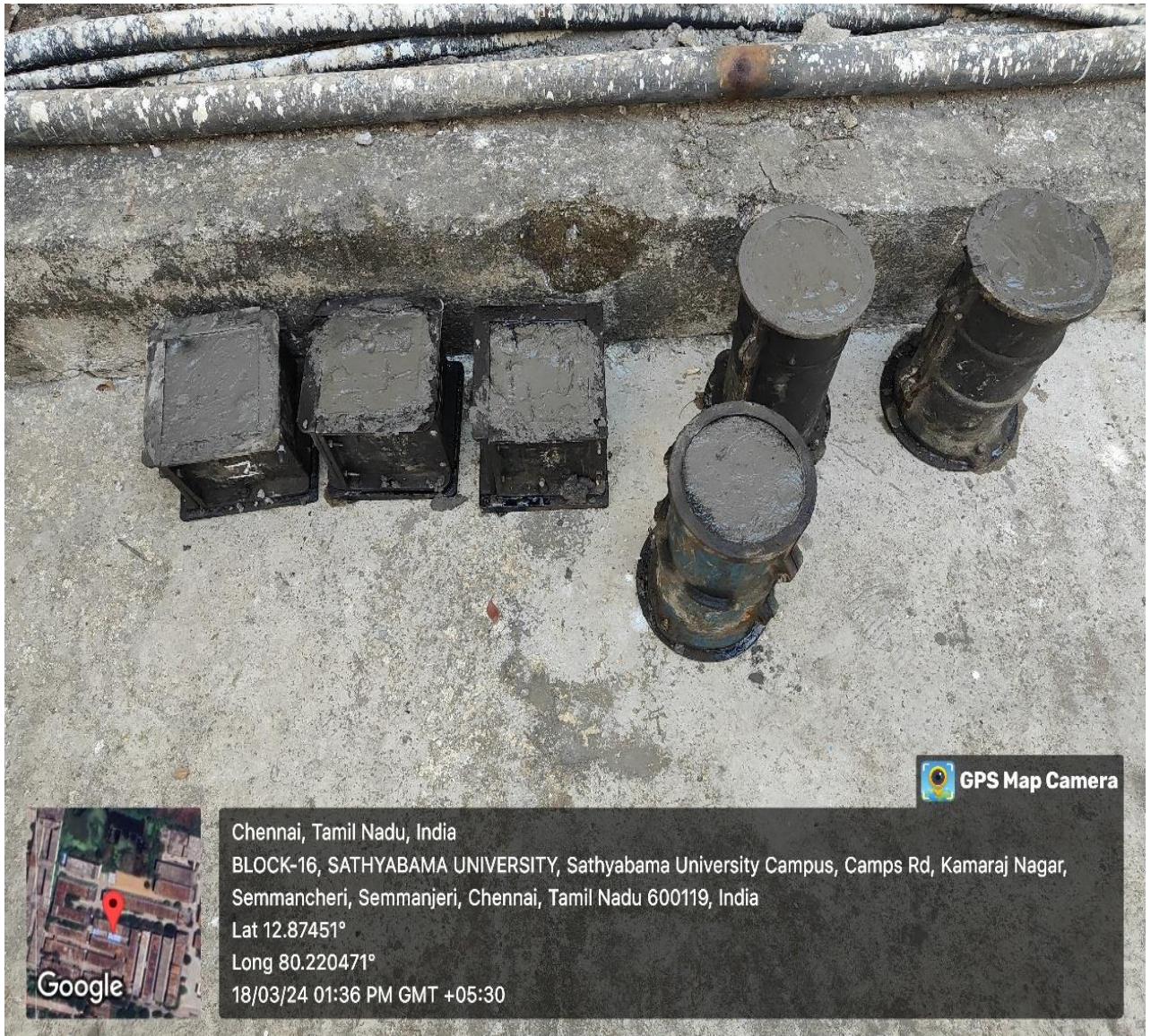
$$\frac{2 \times \text{Max load applied}}{\text{Length} \times \text{diameter}}$$

$$T = \frac{2 \times p}{\pi d L}$$

#### **4.3 PROCEDURE FOR CASTING OF CUBES AND CYLINDERS**

The size of cube mould is 150x150x150mm, pour concrete in the cubes in three layers. Compact each layer with 35 NOS of strokes with the tamping rod. Finish the top surface by trowel after compaction of the last layer. After 24 hours, remove the specimen from the mould. After that submerge the specimen in clean, fresh water until the time of testing. Place the cube in testing machine and record the maximum load applied to the conventional & concrete cubes. Take average strength of specimen cubes.

The size of cylinder mould is 150x300mm, pour concrete in the cylinders in three layers. Compact each layer with 35 NOS of strokes with the tamping rod. Finish the top surface by trowel after compaction of the last layer. After 24 hours, remove the specimen from the mould. After that submerge the specimen in clean, fresh water until the time of testing. Place the cylinder in testing machine and record the maximum load applied to the conventional & concrete cubes. Take average strength of specimen cylinders.



**Fig 4.3: casting of cubes and cylinder**

#### 4.3.1 Concrete strength according to days

- 7 days - 65%
- 14 days - 90%
- 28 days - 100%



**Fig 4.4: Preparation of concrete**

#### **4.3.2 CURING OF CONCRETE**

Curing of concrete is a crucial process that ensures optimal strength, durability, and performance of the material. It involves maintaining adequate moisture and temperature conditions for the concrete to properly hydrate and gain strength. Proper curing helps prevent cracking, shrinkage, and surface defects.

There are several methods for curing concrete, including ponding, sprinkling, moist curing, and using curing compounds or membranes. Ponding involves creating a water reservoir around the concrete surface to keep it continuously moist. Sprinkling involves regularly wetting the surface with water. Moist curing involves covering the concrete with wet burlap, sand, or other materials to retain moisture. Curing compounds and membranes form a barrier on the surface to prevent moisture loss.



#### **Fig 4.5: Curing of concrete**

The duration of curing depends on factors such as the type of cement used, ambient temperature, humidity, and project requirements. Generally, concrete should be cured for at least seven days, but longer durations may be necessary for optimal strength development.

Proper curing is essential for achieving the desired properties of concrete and ensuring its long-term performance. Neglecting curing can lead to reduced strength, increased permeability, and premature deterioration of the concrete structure. Therefore, it's critical to follow appropriate curing practices to maximize the lifespan and durability of concrete structures.

## **4.4 TESTING OF CONCRETE**

### **4.4.1 COMPRESSIVE STRENGTH TEST**

The compressive strength of M30 grade concrete typically ranges between 20 to 30 megapascals (MPa), or approximately 2900 to 4400 pounds per square inch (psi). M30 grade concrete is a mix design where the characteristic compressive strength is attained after 28 days of curing. It consists of a blend of cement, sand, coarse aggregates, and water in specific proportions.

The specific mix proportions for M30 concrete vary depending on factors such as the quality of materials, desired workability, and environmental conditions. However, a typical mix may include one part cement, 1.5 parts sand, and three parts coarse aggregates by volume, with a water-cement ratio of around 0.45 to 0.5.



**Fig 4.6: Compressive strength test of cube specimen**



**Fig 4.7: Crack pattern of cube specimen**

Achieving the desired compressive strength requires proper mixing, placing, and curing procedures. During curing, the concrete gains strength as the cementitious materials hydrate, forming a dense matrix. Adequate curing duration and conditions, such as maintaining moisture and appropriate temperatures, are crucial for optimal strength development.

M30 grade concrete is commonly used in various structural applications, including residential and commercial buildings, bridges, and pavements, where moderate to high strength is required. It offers a balance between cost and performance, making it a popular choice for many construction projects.

#### 4.2.2 SPLIT TENSILE TEST



**Fig 4.8: Split tensile test of cylindrical specimen**

The split tensile strength of M30 concrete refers to its ability to resist tensile forces when subjected to splitting or tension along its axis. M30 concrete is a mix design that indicates the concrete's compressive strength of 30 megapascals (MPa) after 28 days of curing. While split tensile strength is not directly measured in the mix design, it's often evaluated to assess the concrete's overall performance and durability.

To determine the split tensile strength of M30 concrete, cylindrical specimens are typically cast and cured following standard procedures. After the curing period, these specimens are subjected to a splitting tensile test, where a compressive force is applied diametrically to the specimen until it fractures. The force required to cause splitting is measured, and the split tensile strength is calculated using a formula based on the dimensions of the specimen.

Several factors influence the split tensile strength of M30 concrete, including the water-cement ratio, aggregate type and size, curing conditions, and the presence of admixtures. A lower water-cement ratio generally leads to higher tensile strength due to better cement hydration and reduced porosity. Proper curing is also crucial for achieving optimal strength development.

Additionally, the quality and gradation of aggregates play a significant role in determining concrete strength. Well-graded aggregates with proper bonding characteristics enhance the overall cohesion and resistance to cracking under tensile loading.



**Fig 4.9: Crack pattern of cylindrical specimen**

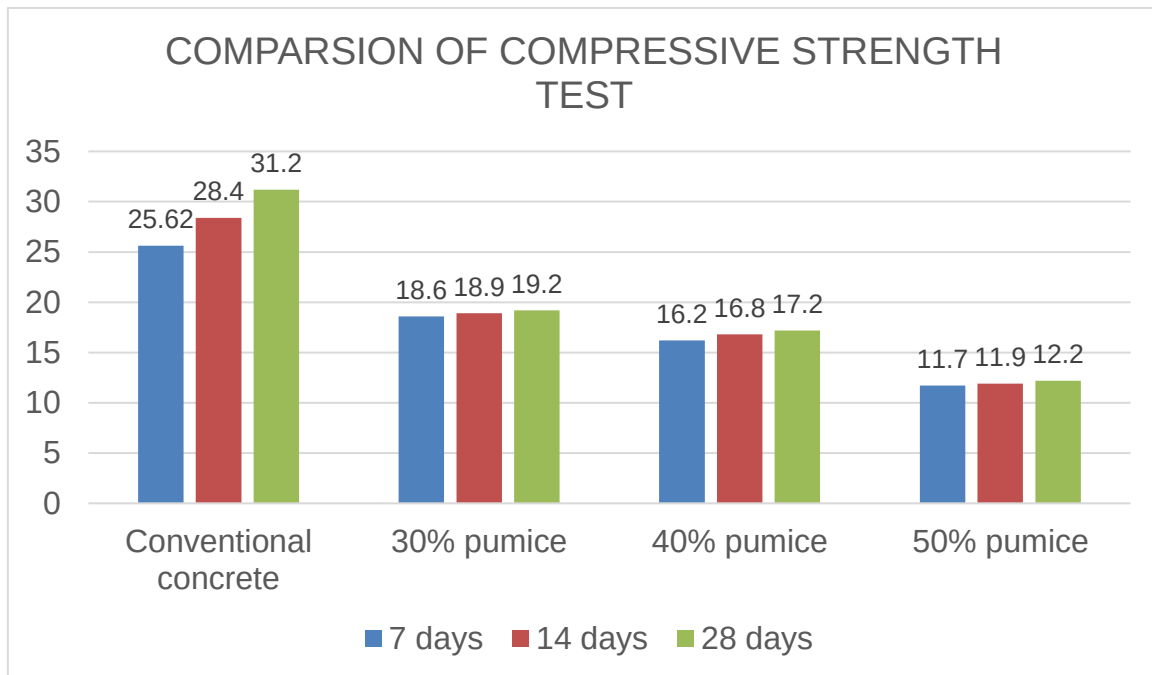
Overall, understanding and optimizing the factors that influence split tensile strength are essential for ensuring the durability and structural integrity of M30 concrete in various applications, ranging from buildings and bridges to pavements and dams.

## CHAPTER 5

### RESULTS AND DISCUSSION

| <b>No. OF<br/>DAYS</b> | <b>CONVENTIONAL<br/>CONCRETE<br/>(N/mm<sup>2</sup>)</b> | <b>30% PUMICE<br/>AGGREGATE<br/>(N/mm<sup>2</sup>)</b> | <b>40% PUMICE<br/>AGGREGATE<br/>(N/mm<sup>2</sup>)</b> | <b>50% PUMICE<br/>AGGREGATE<br/>(N/mm<sup>2</sup>)</b> |
|------------------------|---------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|
| <b>7 DAYS</b>          | <b>25.62</b>                                            | <b>18.6</b>                                            | <b>16.2</b>                                            | <b>11.7</b>                                            |
| <b>14DAYS</b>          | <b>28.4</b>                                             | <b>18.9</b>                                            | <b>16.8</b>                                            | <b>11.9</b>                                            |
| <b>28 DAYS</b>         | <b>31.2</b>                                             | <b>19.2</b>                                            | <b>17.2</b>                                            | <b>12.2</b>                                            |

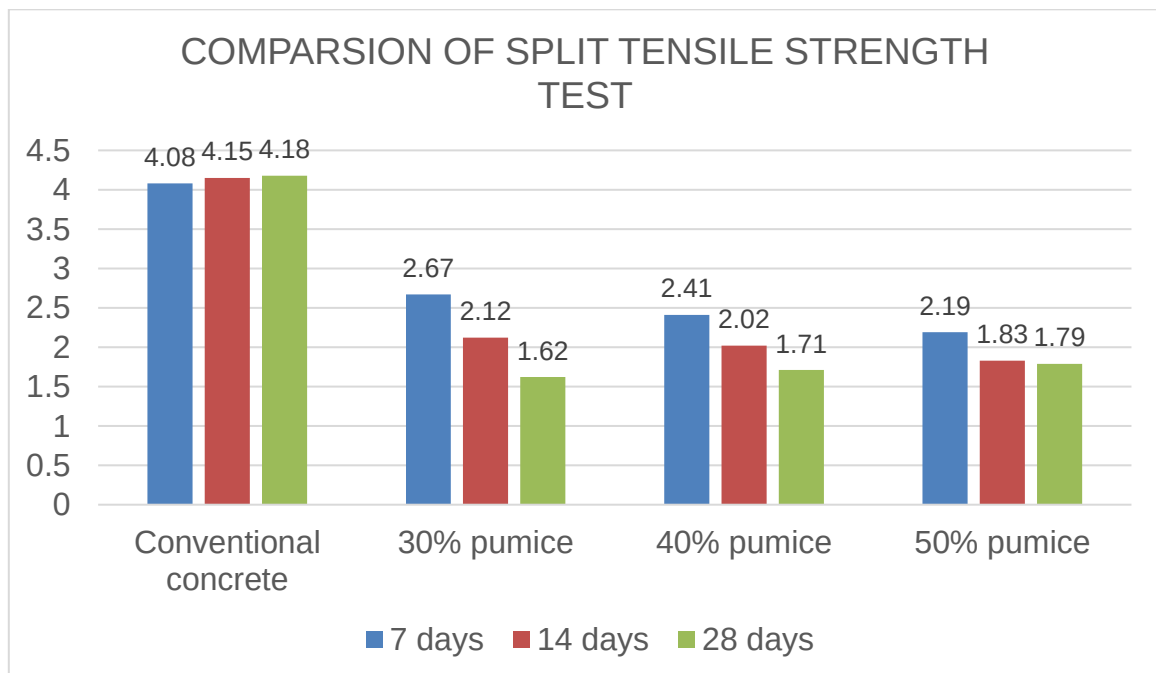
**Table 5.1: Compressive strength test on concrete**



**Graph 5.1: comparison of compressive strength test**

| No. OF DAYS | CONVENTIONAL CONCRETE (N/mm <sup>2</sup> ) | 30% PUMICE AGGREGATE (N/mm <sup>2</sup> ) | 40% PUMICE AGGREGATE (N/mm <sup>2</sup> ) | 50% PUMICE AGGREGATE (N/mm <sup>2</sup> ) |
|-------------|--------------------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------------|
| 7 DAYS      | 4.08                                       | 2.67                                      | 2.41                                      | 2.19                                      |
| 14DAYS      | 4.15                                       | 2.12                                      | 2.02                                      | 1.83                                      |
| 28 DAYS     | 4.18                                       | 1.62                                      | 1.71                                      | 1.79                                      |

**Table 5.2: Split tensile strength test on concrete**



**Graph 5.2: comparison of split tensile strength test**

## **CHAPTER 6**

### **SUMMARY AND CONCLUSION**

Based on the experimental investigations carried out, the following conclusions are made:

- It shows that increasing percentages of pumice aggregate will decrease the density of the concrete which results in lightweight aggregate concrete.
- Pumice aggregate can be replaced for natural aggregate to decrease the self-weight of concrete.
- Pumice aggregate absorbs more water as compared to normal coarse aggregate because pumice aggregate contains more pores hence strength will be reduced. Hence superplasticizers are used.
- The compressive strength, split tensile strength and flexural strength of Pumice LWAC with 30%, 40% and 50% replacement shows that only 30% replacement has optimum value. After 30% the compressive strength and split tensile strength value for 40% and 50% decreases.
- It shows that increasing percentages of pumice aggregate decreases the strength of concrete.
- This type of concrete can be used in wall panels of non-load bearing type for use in precast buildings and can be used in lintels, sunshades and partition walls.
- Pumice aggregate concrete can be used in earthquake-resistant structures.

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