A STUDY ON PROPERTIES OF CONCRETE USING POLY URETHANE BY CORPORATING LIGHT WEIGHT AGGREGATE

Mohammed Aleem Pasha[1], Mirza Mubashir Ahmed Baig[2]
[1]M.Tech Scholar, [2]Assistant Professor
Department of Civil Engineering, Vaagdevi College of Engineering
Bollikunta, Warangal-506002, Telangana
Corresponding email id: aleempasha10911@gmail.com

ABSTRACT

High fluidity, low self-weight, and low thermal conductivity are just a few of the beneficial qualities of foamed concrete that are making it more and more popular in civil construction and building projects. But it has major downsides as well, such as increasing shrinkage over time and poor strength. The curing conditions have a significant impact on how the strength of foamed concrete develops. The hydration process, which is essential for the strength and durability of concrete, can only take place during curing. By testing foamed concrete at various ages and with different curing techniques, this study aims to discover its sustainability as a structural material by measuring its compressive strength, modulus of elasticity, and drying shrinkage.

Polyurethane foamed concrete was used to create cubes, cylinders, and prisms as study samples. Water, moisture, air, and a curing substance that forms a membrane were the four different curing regimes that these samples underwent. In order to assess how each curing procedure affected the mechanical properties of the concrete, we tested the compressive strength, modulus of elasticity, and drying shrinkage at various intervals. Based on the study's findings, moisture curing outperformed all other curing methods in terms of compressive strength for foamed concrete samples across all age groups. This indicates that increasing the strength and longevity of foamed concrete requires keeping the curing mixture very moist. Polyurethane foamed concrete has certain limitations, like shrinkage and low early strength, but it can be employed in structural applications with the right curing techniques, according to the results.High fluidity, low self-weight, and low thermal conductivity are just a few of the beneficial qualities of foamed concrete that are making it more and

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INTRODUCTION

Structural lightweight concrete is perfect for uses that call for lighter materials without compromising strength, thanks to its lower density (1440-1840 kg/m³) compared to regular weight concrete. In contrast, the density of normal weight concrete is usually between 2240 and 2400 kg/m³. Lightweight concrete with a compressive strength of 17 MPa or above is not appropriate for use in structural applications. One form of lightweight concrete that does this is foamed concrete, which contains air in an aerated structure that accounts for at least 20% of its volume. One way to accomplish this is by employing stable foam in a pre-prepared cement slurry (the "pre-foaming" method), and the other is by creating foam while mixing (the "mixed foaming" method). Foamed concrete is adaptable for a wide range of uses due to its compressive strengths ranging from 1 to 25 MPa and dry densities ranging from 400 to 1600 kg/m³. The compressive strength of foamed concrete can be enhanced to 20-25 MPa by adding supplementary elements such as fly ash, ground granulated blast-furnace slag (GGBS), micro silica, and SiO_2 powder. This makes the material acceptable for structural or load-bearing applications. It is worth noting that, as long as the curing process is followed correctly, the strength of foamed concrete remains relatively unaffected by using a large percentage of GGBS to replace cement. For strength development, a content of 20% to 30% crushed fly ash is usually ideal.

The ultimate characteristics of foamed concrete are highly dependent on the curing process. The curing process improves the material's resilience to climatic variables like freezing and thawing, as well as its strength, volume stability, and longevity. Researchers found that air curing, as opposed to water curing, produced greater early strength for foamed concrete that had ground bone instead of cement for 10% of the cement. After the first sixty to ninety days, however, there was no discernible difference in strength between the two curing techniques. Regardless, water curing is still the way to go if you want your material to keep its strength over time. To guarantee the material's structural performance, it is important to use the right curing procedures. Specimens that were air-cured in natural weathering settings had a compressive strength that was 28.2% lower than those that were water-cured

OBJECTIVE OF POLY URETHANE CONCRET

- **Find out how sand's density and compressive strength affect foamed concrete.**
- Find out how foam concrete stacks up against regular concrete in terms of density and compressive strength.
- Evaluate the percentage increase in strength between regular weight concrete & foam concrete.

Polyurethane concrete's fluidity makes it an excellent choice for building and repair tasks that require the filling of gaps and voids, as the material is particularly effective at doing so, Polyurethane concrete, when cured, creates a robust and stiff framework that can handle loads of varying densities and improve the overall structural integrity of structures

In applications that necessitate a solid and stable base, polyurethane concrete's resistance to bending under moderate load situations guarantees dimensional stability and longevity. Structure with Low Density: Roof insulation, lightweight partitions, and specific structural components are just a few examples of when polyurethane concrete's lightweight properties come in handy.

LITERATUREREVIEW

A binder, water, and foam are the main components of foam concrete. However, depending on the practical needs of the application, other elements including sand, fiber, fillers, and additives (such as agents that reduce water content or control setting) can be included. Foam concrete binder options include magnesite powder (Vinogradov et al., 1998), ground granulated blast furnace slag (GGBS) mixed with low-value liquid glass (Beljakova et al., 1998), and Narayanan and Ramamurthy (2000) suggest that cement is not always necessary. In addition, works by researchers such as Fujiwara et al. (1995), Johansson et al. (1999), and Hashimoto et al. (1976) have documented the utilization of finely-ground cement, high-early-strength Portland cement, and rapid-setting hydraulic cement.

The invention of non-shrinking foam concrete by Spinnery (1993) was a breakthrough in the field of foam concrete. This type of foam substitutes cement with an equal quantity of cementitious fines, such as fly ash, slag cement, kiln dust, or non-cementitious fines, such as silica and limestone. In their study, Fujiwara et al. (1995) found that high-strength foam concrete could be made with a binder mixture of high-early-strength Portland cement, silica fume, and ultra-fine silica stone powder. This concrete had a wet density of 1500 kg/m³ and a compressive strength of about 50 MPa after 28 days.

The optimal supplementary materials for producing high-strength foam concrete, according to Kamaya et al. (1996), are non-organic materials with a specific surface area more than 7500 g/cm². Middle Eastern coastal sand, for example, has poor grading and a high concentration of chloride and sulfate ions, which can have a negative impact on the quality of concrete, resulting in reduced strength and durability. But foam concrete has been made with inland dune sand, which is more spherical and has smaller particles. For the correct workability and to prevent foam degeneration, the quantity of water in foam concrete mixes is critical. When making high-strength foam concrete, Fujiwara et al. (1995) discovered that a water-to-binder ratio of 0.19 was ideal. In 1954, Valore's initial research highlighted the necessity for larger water/cement ratios in low-density foam concretes; nevertheless, for mixes with the same density, adding more sand

inincreases the water/cement ratio. When mixing concrete, consistency is usually more important than sticking to a specific water-to-cement ratio.

In order to successfully introduce foam to foam concrete mixes that do not contain water-reducing agents, it is essential to add enough water to the premixed paste or mortar to keep it workable. Overdosing on the water-to-binder ratio can cause the foam bubbles to separate, which could lead to an uneven distribution of density in the finished product, as stated by the British Cement Association (1991) for each density range of foam concrete. Although most foam concretes are best made with a water-to-cement ratio of 0.5 to 0.6, some with a high strength have reported using ratios as low as 0.19 to 0.17 (Fujiwara et al., 1995; Kamaya et al., 1996).

METHODOLOGY

MATERIALS

CEMENT (ORDINARYPORTLAND):

Cement, a binding agent that sets and hardens to cling to building components like stones, bricks, tiles, etc., is a crucial component of every construction project. Limestone (calcium), sand or clay (silicon), bauxite (aluminum), and iron ore are the main components of cement, which is a fine powdered material that can also contain shells, chalk, marl, shale, clay, blast furnace slag, slate, and other similar materials. In cement factories, the raw materials are heated until they become a solid, which is subsequently pulverized into a fine powder for sale. The chemical reaction between water and cement produces a paste that, when dried, binds the structural elements of various building materials together.

Ordinary Portland Cement of grade 53, made by RAMCO Cement, was utilized in this experimental study.

PROPERTIES OF CEMENT

- **FINENESS OFCEMENT:**

Cement fineness is defined as the size of cement particles, sometimes expressed as the specific surface area of the particles. The surface area, which affects the rate of hydration and, by extension, the strength and setting time of the cement, increases as the particle size decreases. The particle size analysis, air permeability, and sedimentation procedures are among several that can be used to measure fineness.

The cement utilized in the project has a fineness of 90 microns. To achieve the required workability, strength, and performance in the mix, the cement particles must be tiny enough to pass through a sieve with holes of 90 microns, as shown by this measurement. Cement particle size is a critical factor in concrete production since it affects how quickly the material hydrates and how strong it becomes.

NORMALCONSISTENCYOFCEMENT

- In order to evaluate the amount of water needed to create a cement paste with the appropriate workability for different tests, it is necessary to conduct the cement normal consistency test. Standards IS: 4031 (Part 4) - 1988 and IS: 5513-1976 detail this process.
- The typical consistency of cement paste is that which permits a 10-millimeter-diameter and fifty-millimeter-long Vicat plunger to reach a depth of 33–35 millimeters from the mold's top. This test is conducted using the Vicat equipment in accordance with IS: 5513-1976. Ensuring the correct amount of water is added to the cement paste effects the strength and setting time of the concrete, hence the normal consistency test is vital.

Procedure

The Vicat apparatus is used to determine the standard consistency of cement paste, which is necessary to ensure that the cement has the correct water content for hydration and setting. The consistency is determined by the amount of water needed for the Vicat plunger to reach a depth of 5 to 7 mm into the cement paste, measured from the bottom of the Vicat mould. Starting with 26% water to 300 grams of cement (by weight of cement), the test continues by adding 2% increments of water until the required consistency is reached. To make the paste, combine the cement and water and stir for three to five minutes. Stir constantly so the mixture does not start to harden before the mold is filled. Following this, a non-porous plate is used to set the Vicat mould on top of the paste. Once the mold is filled and the paste is level, the Vicat plunger is lowered and released gently so it can sink into the paste. This procedure is carried out multiple times with different amounts of water until the desired consistency is achieved. The typical consistency of the provided cement sample was found to be 32 mm of penetration in this experiment.

- **SETTING TIME OF CEMENT**

In the case of cement, the first setting time is the amount of time that passes from the addition of water until the paste begins to lose its plasticity; in contrast, the final setting time is the amount of time that passes from the addition of water until the paste completely loses its plasticity and becomes firm enough to resist pressure. The Vicat apparatus is used to conduct these tests in accordance with standards such as IS: 5513-1976 and IS: 4031 (Part 4)–1988 and IS: 4031 (Part 5)–1988.

Step one is to make a cement paste by mixing 300 grams of cement with 0.85 times the amount of water needed to achieve a standard consistency. The water used must be drinkable or distilled. Once the water has been poured to the cement, a Vicat mould put on a non-porous plate will hold the paste while a stopwatch is begun. After leveling the surface, the mold is filled to the top. The next step is to keep the test block in a damp closet so that the conditions stay humid.

The needle from the Vicat device is dropped onto the test block to determine the first setting time. The procedure is carried out at regular intervals until the needle is unable to pass through the block at a depth greater than 5 ± 0.5 mm from the base. We note the initial setting time as soon as this happens. To find the final setting time, just swap out the needle with an annular attachment and gently press it onto the test block. When the needle makes a mark on the block, but the annular attachment doesn't, we know the cement is entirely set.

Cement Reliability

To ensure that structures are sturdy and long-lasting, cement must be able to keep its volume after setting without experiencing excessive expansion. The hardened mass is susceptible to cracking and disruption caused by cement that is not structurally sound and which expands too much after setting. This happens when the cement has too much lime and doesn't mix well with the acidic oxides in the kiln. Therefore, it is vital to ensure the cement is sound in order to prevent concrete constructions from potentially suffering damage over time

To determine whether cement is stable, one can follow the guidelines provided in IS: 4031 (Part 3) - 1988, which include the Le-Chatelier method. The steps to perform the Le-Chatelier test are as follows:

Before setting the Le-Chatelier mold on a glass sheet that has been lightly oiled, give it a quick oiling. Pour cement paste into the mold, using the recipe in IS: 4031 (Part 4) - 1988, which calls for 0.78 times as much water as is needed to make a paste of standard consistency. While following the standard's instructions, measure the paste while keeping the mould's edges together. Set a tiny weight on top, cover the mold with an additional lightly oiled glass sheet, and then immerse the whole thing in water at 27 ± 2°C for a day. After a day, take a precise measurement (to the nearest 0.5 mm) of the distance between the mould's indicator points. Immerse the mold in water once more, this time maintaining the identical temperature.

Bring the water to a boil over a 25- to 30-minute period, then maintain the boil for three hours. Once the mixture has boiled, take the mold out and let it cool before taking another measurement of the distance between the indication spots.

As the cement expands, the disparity between the two readings reflects this change. The maximum allowable expansion for regular, quick-setting, and low-heat Portland cements is 10 mm. The cement is considered unsafe for building purposes if its growth goes over this threshold. Cement used in building projects must pass this test to guarantee it will not crack or otherwise fail structurally as a result of excessive expansion.

FINE AGGREGATES

Local resources are used to choose fine aggregates for this project, which are defined as those that pass through a 4.75 mm sieve. For this purpose, sand and crushed stone are the main fine aggregates. An important factor in the workability and strength of concrete is the proportion of fine particles, which typically range from 35 to 45 percent by volume or mass of the total aggregate composition.

The Fine Aggregate's Specific Gravity

- An essential quality that aids in deciding the aggregate's appropriateness for different uses is the specific gravity of fine aggregate. To find it, take the mass of one volume of distilled water and divide it by the mass of one volume of fine aggregate. Because it impacts both the volume calculations and the total density of the concrete, knowing the specific gravity of fine aggregate is critical for mix design. To find the specific gravity of fine aggregate, one uses the following gequipment. The specific gravity of aggregates can be measured using a pyrometer, a specialized container.
- A balance is a kind of weighing scale that measures the water and fine aggregate by comparing their respective weights.
- In order to guarantee that the chosen fine aggregate will add to the concrete mix's quality and stability, this test checks its density and weight

Specific gravity of fine aggregates

Procedure for the determination of specific gravity of fine aggregate

Here is how to use a pycnometer to find the specific gravity of coarse aggregate. Before using the pycnometer to measure moisture or other impurities, make sure it is completely dry. Once the pycnometer is dry, weigh it empty and mark the reading as W1. All subsequent measurements are based on this.

Then, fill the pycnometer with around 200 grams of coarse material. It is important that the coarse aggregate matches the sample you are testing. Put the pycnometer and coarse aggregate through their paces and record the combined weight as W2. This procedure is useful for calculating the aggregate's weight in comparison to the pycnometer's empty weight. Fill up the rest of the pycnometer with distilled water once you've weighed it with the coarse aggregate. This makes sure the aggregate is completely immersed in water and for precise volume displacement measurement. When the pycnometer is full, add the water and aggregate and note the resulting weight as W3. The specific gravity of the coarse aggregate is computed from these reported weights in future computations.

1.Empty the pycnometer and clean it and fill it with distilled water. Note the weight W4

Specific Gravity =G=2.462 g/cm3

- **Fineness modulus of fine aggregates:**

Get the sample ready first if you want to know the fineness modulus of fine aggregate. Before drying the fine aggregate sample in an oven set to 100–110°C, transfer it to a pan. Take the sample out of the oven and weigh it once it has dried thoroughly. That way, you can be guaranteed that the fineness modulus calculation is based on correct results, free of moisture content.

The next step is to get the sieves ready by stacking them from largest to smallest, starting with the largest. After positioning the sieves in the desired configuration, pour the dried sample onto the top sieve if using a mechanical shaker. Put the top sieve cover on and use the sieve plate to secure the setup. Set the mechanical shaker to shake the sieves for a minimum of five minutes after turning it on. The fine aggregate will be evenly dispersed throughout all of the sieve sizes if this is done.

Place the dried sample into the upper sieve, seal it, and start shaking the sieves by hand. Shake the top two sieves in a vertical, horizontal, inward, and outward motion to separate the particles. To shake the sieves completely, start with the first two and work your way up to the fourth. Keep shaking until all of the sieves have been shaken.

After the sieving process is finished, make a note of how much material was retained on each sieve. Add together the weights from all of the sieves to get the total weight retained. To calculate the cumulative percentage retained, take the total weight of the sample and divide it by 100. Then, add up all the weights retained. Lastly, to find the fineness modulus, add all the percentages retained by each filter and divide the total by 100. An important factor in concrete mix design, this number indicates how fine the aggregate

Fineness modulus of aggregate= (cumulative% retained)/100

=(275/100)=**2.75**

Fineness modulus of fine aggregates

LIQUID POLYURETHANE FOAM:

Chemzest Enterprises of Chennai supplied the liquid polyurethane foam (PUF) used in this undertaking. Two halves, PUF40-A (1 kilogram) and PUF40-B (1.2 kg), make up the PUF-40 grade of polyurethane foam that is employed. It is common practice to react di- or tri-isocyanates with polyols to create polyurethane polymers, such as PUF. The polyurethane structure can be formed by combining isocyanates and polyols, both of which contain two or more functional groups per molecule. When combined at room temperature, the two components of PUF's rigid foam system—Part A and Part B—expand to create a closed-cell, light-density foam. There is a wide range of densities available for PUF, from 38 to 300 kg/m^3 for pack core densities and 23 to 130 kg/m^3 for free-rise densities. The foam made from liquid PUF has great thermal qualities, therefore it may be used for a lot of different kinds of performance requirements.

Systems that rely on thermal integrity, like cold storage facilities, benefit greatly from this foam's ability to control and sustain an interior temperature. Polyurethane foam's high thermal efficiency makes it a popular choice for insulation projects that require precise temperature regulation.

The properties of Polypropylene foam are given below

Properties of polyurethane foam

GROUND GRANULATED BLASTFURNACESLAG

Ground Granulated Blast Furnace Slag (GGBS) powder was purchased from Astrra Chemicals in Chennai for this undertaking. When mixed with regular Portland cement and other pozzolanic ingredients, GGBS forms long-lasting concrete. The capacity to greatly increase the durability of concrete has led to its widespread use in regions like

Asia (especially India, Japan, and Singapore), the United States, and Europe. This has resulted in building lifespan extensions of fifty to one hundred years. Portland Blast Furnace Cement (PBFC) and High-Slag Blast Furnace Cement (HSBFC) are two main uses of GGBS, with GGBS contents ranging from 30% to 70% in both cements. Durable concrete, whether ready-mixed or site-batched, also makes heavy use of it. The amount of GGBS used determines how much longer it takes for concrete built with GGBS to set compared to regular Portland cement. A slower setting time means less heat of hydration and less temperature rise, which means cold joints are less likely to occur. Where quick setting is required, however, building dates may be affected by this delayed setting.

Incorporating GGBS into concrete has several advantages, such as making it more resistant to chloride, decreasing the probability of reinforcing corrosion, increasing resistance to sulfate and other chemical attacks, and decreasing the danger of damage from alkali-silica reactions (ASR). For this reason, GGBS is a great material to use when trying to improve the performance and longevity of concrete buildings.GGBS Powder

WATER

It is critical to use clean water that is devoid of any hazardous compounds, including oils, acids, alkalies, salts, organic matter, and other undesirable elements, while mixing water for concrete. The strength and longevity of the concrete can be diminished by these compounds. The water used to make foamed concrete must be drinkable so that the chemical reactions of the foam don't harm the finished product. Keep the water temperature below 25°C for best results.

Because these things might alter the surface tension of the water and hence the foaming process, it is essential that the foaming agent not come into touch with any oil, fat, or chemicals. But mold oils and waxes won't be an issue because the foam will be embedded in the mortar when it contacts them. To guarantee the desired qualities and performance of the finished product, the water used to make the concrete mix must meet the regulatory standards for concrete mixing water

EXPERIMENTAL WORK.

MIX PROPORTION

Standardized procedures for proportioning the mixture of foamed concrete do not exist; instead, general guidelines like free water content, water-to-cement (w/c) ratio, and retaining unit volume are utilized. The desired plastic density, however, takes center stage in the design of foamed concrete. Foamed concrete can desorb water from the whole mix ranging from 50 to 200 kg/m³, depending on plastic density, curing regime, and exposure conditions; thus, it is difficult to design for a certain dry density. Consequently, getting the necessary qualities usually involves a process of trial and error (Nehdi, 2001).

By calculating the solid volume for a given mixture proportion and density, McCormick (1967) offered a logical proportioning approach to aid in guiding proportioning. With a known weight-to-cement ratio and desired density, the volume of foam required to create cement slurry can be determined according to the procedure laid out in ASTM C 796-97. Mixture components including foam volume, water content, cement content, and the % of GGBS replacement can be determined using formulae derived by Nambiar and Ramamurthy (2006b) for a given fresh density, filler-cement ratio, and 28-day compressive strength.

Mix proportion=1: 4.32 (cement: fine aggregates)

Water cement ratio=0.5(IS CODE 456-2000 Table no.5)

Target mean strength= 26.5 KN/mm²

Target density=1650Kg/mm³

MIXING PROCEDURE

Cement, GGBS, and sand were the main ingredients, and their weights were measured out first. To make sure all of the dry ingredients were evenly distributed, they were combined in a concrete mixer. Once the mixture had been dry-mixed, water was gradually added until a pourable consistency was reached. To avoid oversaturating the mixture, the components were mixed for one minute to make sure they were well combined.

Then, the foam was added to the wet mixture in the specified amount. At this point, we were careful not to overmix after adding the foam, since that could cause it to disintegrate and provide unpredictable effects. To disperse the foam uniformly without weakening it, the mixing was prolonged for a short time. Cube molds measuring 150 x 150 x 150 mm were used to pour the mixture once it was ready. The compressive strength and additional characteristics of the foamed concrete were then evaluated using these cubes.

Workability Test on New Concrete

Freshly mixed concrete is considered workable if it retains most of its original consistency when handled, transported, and poured into shapes. A concrete's workability determines its compaction and strength in a direct correlation. On the other hand, the necessary workability differs from one concrete type and one application to another. Two tests were carried out to determine the feasibility:

Testing for Compaction Factors

Evaluation of Slump Cone and Compaction Factor

For freshly mixed concrete mixes that aren't very workable, the Compaction Factor Test can tell you how consistent the mixture is. Both IS:1199-1959 and SP:23-1982 served as inspiration for this test. Particularly helpful for vibration-compacted concrete, it outperforms the slump test in terms of sensitivity and precision. You can use lightweight, normal weight, or heavy aggregates with a nominal maximum size of 40 mm or less in the test, and it works for both plain and air-entrained concrete.

- Method Compaction Ratio Tool Scoop (about 150 mm in length)
- Stability (sensitive to 10 g) for loads up to 25 kg
- Measures 16 mm in diameter and 600 mm in length; tamaker
- Ruler Mixing implements and vessels, or a concrete mixer

➢ **SLUMPCONETEST**

When checking the consistency of newly mixed concrete, the Slump Test is commonly employed. It finds the amount of slump in concrete, which is a measure of its workability because it shows how fluid and mobile the material is. Standard IS: 7320-1974, IS: 1199-1959, and SP: 23-1982 specify the slump test, which is widely used in laboratories and on construction sites. Nevertheless, keep in mind that the slump test could miss some of the elements that affect concrete's workability and isn't appropriate for very dry or highly wet concrete. True slump happens when the concrete slumps uniformly, whereas shear slump happens when half of the cone slides down; the pattern of the slump also gives more information about the concrete's properties.

TESTS ON HARDENED CONCRETE:

For hardened concrete we performed three tests they are:

- Density of Concrete
- Compression Test
- Flexural Strength Test
- Stress Strain behavior of Cylinder

DENSITY

Data on Concrete Density and Samples

Polyurethane samples containing10%,20%, and 50% GGBS, as well as control concrete and polyurethane control concrete, are all part of the research. A 10% solution of liquid polyurethane was mixed with the water in each of these samples. Cement, fine and coarse aggregates, water, and occasionally additional components like fly ash, slag, and admixtures make up a concrete mixture, and the combination's compactness is reflected in its density, which is a measure of its unit weight.

The sample cubes used in this investigation had the following dimensions: 150 mm x 150 mm x 150 mm. During manufacturing, the initial density is measured and compared to the specified or goal density; this is called the casting density. Specimens were demoulded within 24 hours of casting and then cured for7,14, or 28 days in a controlled environment.

Stress Analysis

Cubic concrete specimens can have their compressive strengths measured using the compression test. Molded cubes are subjected to a compressive axial load at a predetermined pace until failure is achieved in this test. The method is based on recommendations made in SP: 23-1982, IS: 10086-1982, IS: 516-1959, and IS: 1199-1959 The testing machine is a dependable apparatus that can apply the specified load within ±2% of the maximum load.

Moulds for Cubes: Moulds for cubes measuring 150 mm that adhere to IS: 10086-1982.

Conforming to IS: 10086-1982, cylindrical molds are available in dimensions of 150
mm in diameter and 300 mm in height.

Methodology Examples: Various samples were evaluated, including control concrete, polyurethane control concrete, and polyurethane samples with varying concentrations of GGBS (10%, 20%, and 50%), as well as 10% liquid polyurethane added to the water concentration.

Materials Sampling: Before using them in any concrete batch, the aggregates must have air-dried to the appropriate grade.

To prepare the cement, it is mixed thoroughly, either by hand or with a mixer, so that the mixture is homogenous.

The amounts of all ingredients, including water, should match those actually used in the project.

Weighing: The water, aggregate, and cement amounts are measured to within 0.1 percent of the whole batch weight.

You can mix concrete by hand or use a batch mixer, but either way, you want to make sure none of the water or other ingredients go to waste. In order to fill the test molds, each batch should yield around 10% more than what is needed

For the molding process, standard cube-shaped test specimens measure 150 mm x 150 mm x 150 mm; however, 100 mm cubes can be utilized if the aggregate's biggest nominal size is less than 2 cm. The length of a cylindrical specimen is twice its diameter.

Avoid segregation and undue laitance by compacting specimens shortly after mixing.

Curing: After water is added, the test specimens must be kept in a vibration-free area with a relative humidity of at least 90% at a temperature of 27° ± 2°C for a period of 24 hours ± half an hour. Be sure to clean the bearing surfaces of the testing machine and remove any loose debris from the specimen's contact surfaces before placing it in the machine. Instead of putting the strain on the top and bottom of the cubes, position the specimen such that it is pressing down on the opposing side. Check that the specimen's axis is perpendicular to the platen's center of rotation for proper alignment. Keep packing material away from the test specimen faces as they contact the steel platen.

FLEXURAL STRENGTH TEST

The sample cubes used in this investigation had the following dimensions: 150 mm x 150 mm x 150 mm. During manufacturing, the initial density is measured and compared to the specified or goal density; this is called the casting density. Specimens were demoulded within 24 hours of casting and then cured for7,14, or 28 days in a controlled environment.

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Testing Era

It is usual practice to do compressive strength tests at 7 and 28 days, but if needed, early strengths can be assessed at 24 hours ± ½ hour and 72 hours £ 2 hours. The time at which the dry ingredients are mixed with water is used to determine the age of the test specimens.

The testing machine is a dependable apparatus that can apply the specified load within ±2% of the maximum load.

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2. Materials Sampling: Before using them in any concrete batch, the aggregates must have air-dried to the appropriate grade.
3. To prepare the cement, it is mixed thoroughly, either by hand or with a mixer, so that the mixture is homogenous.
4. The amounts of all ingredients, including water, should match those actually used in the project.
5. Weighing: The water, aggregate, and cement amounts are measured to within 0.1 percent of the whole batch weight.
6. You can mix concrete by hand or use a batch mixer, but either way, you want to make sure none of the water or other ingredients go to waste. In order to fill the test molds, each batch should yield around 10% more than what is needed.

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8. Avoid segregation and undue laitance by compacting specimens shortly after mixing.
9. Curing: After water is added, the test specimens must be kept in a vibration-free area with a relative humidity of at least 90% at a temperature of 27° ± 2°C for a period of 24 hours ± half an hour.
10. Be sure to clean the bearing surfaces of the testing machine and remove any loose debris from the specimen's contact surfaces before placing it in the machine. Instead of putting the strain on the top and bottom of the cubes, position the specimen such that it is pressing down on the opposing side.
11. Check that the specimen's axis is perpendicular to the platen's center of rotation for proper alignment.
12. Keep packing material away from the test specimen faces as they contact the steel platen.
13. Applying the Load: Without causing any shock, gradually raise the load to around 140 kg/sq. cm/min until the specimen breaks.
14. Results Recording: Take note of the concrete's appearance and any peculiar failure characteristics, and record the highest load that was applied to the specimen.

In order to determine if the concrete specimens are suitable for use in a variety of structural applications, this compression test gives important information about their strength and durability.

RESULTS

The experiment results which are conducted on both fresh and hardened concrete are discussed in this chapter.

TESTONFRESH CONCRETE

WORKABILITYTEST

Five distinct mix proportions were tested for workability in freshly mixed concrete; some of the mixes included

GGBS and polyurethane foam, while others did not. The workability was assessed using the Compaction Factor Test and the Slump Cone Test, among other tests. The tests determine how easy it is to mix, transport, and pour the concrete. The workability of each mix fraction under varied situations was revealed by recording and tabulating the outcomes of these experiments for comparison.

Workability test result on fresh concrete

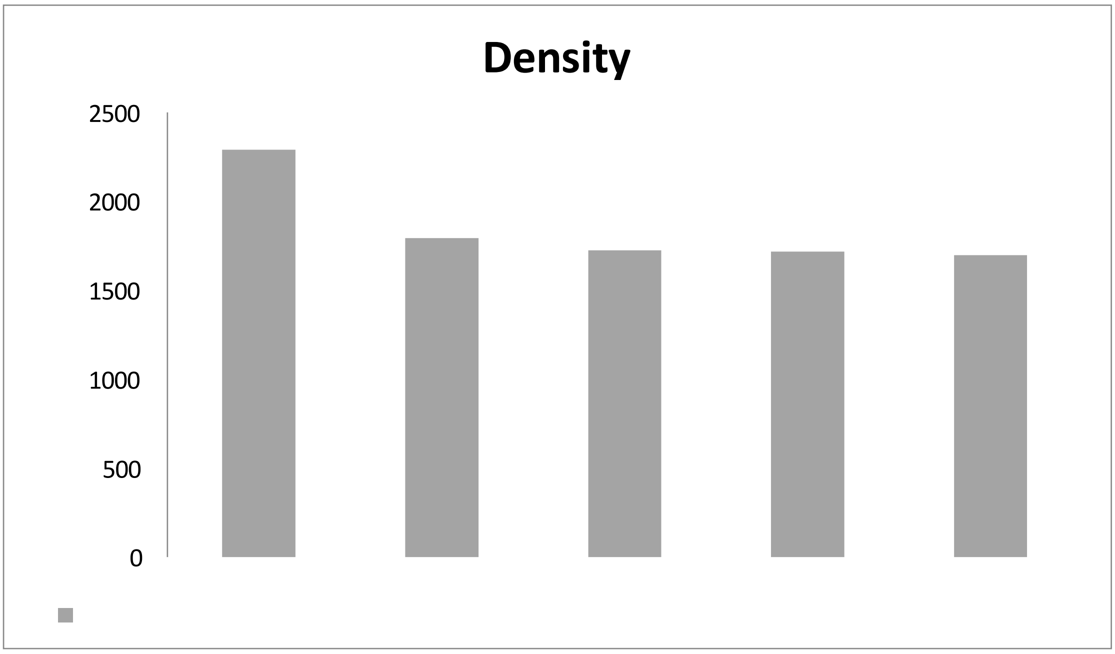
Mix Designation	Workability	
	Compaction Factor	Slump in mm
CC	0.89	74
PUCC	0.96	96
PUG1	0.93	87
PUG2	0.93	82
PUG3	0.925	79

Polyutherane foam increases the workability of concrete and maximum compaction factor value can be observed as 0.96 and slump of 96 mm for the mix containing 10% of polyutherane foam

TEST ON HARDENED COCRETE

DENSITY OF CONCRETE

It was found that the control concrete had the highest density out of all the samples once the density calculations were completed. Consistent with this pattern, the densities of the other samples were lower than those of the control concrete. The mixture with the lowest density was PUG3, which consisted of 50% GGBS for sand replacement and 10% polyurethane for water. The control concrete had a higher density than all of the other mixes.

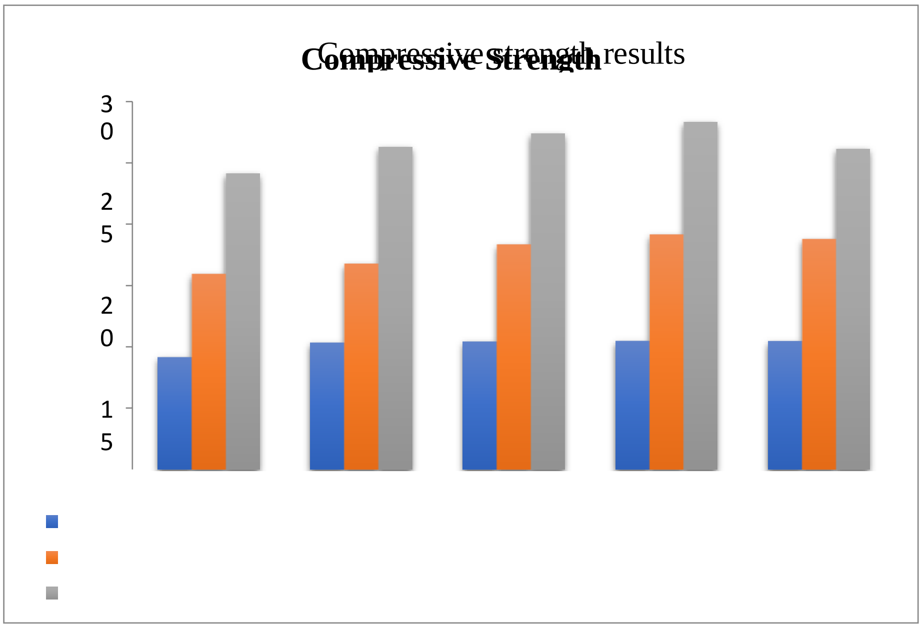


	CC	PUCC	PUG1	PUG2	PUG3
Density	2290	1794	1724	1718	1698

Density of different Samples

COMPRESSIVESTRENGTH

Figure analysis shows that after 28 days, the concrete mix with the maximum compressive strength (28.31 MPa) was the one that had 20% GGBS in the liquid polyurethane foam. After that came the mixture with 10% GGBS, which reached 27.37 MPa in terms of compressive strengthThere was no combination that outperformed PUG2 in terms of compressive strength when compared to the control concrete prepared with fine particles; nevertheless, all of the mixes did better than the control.

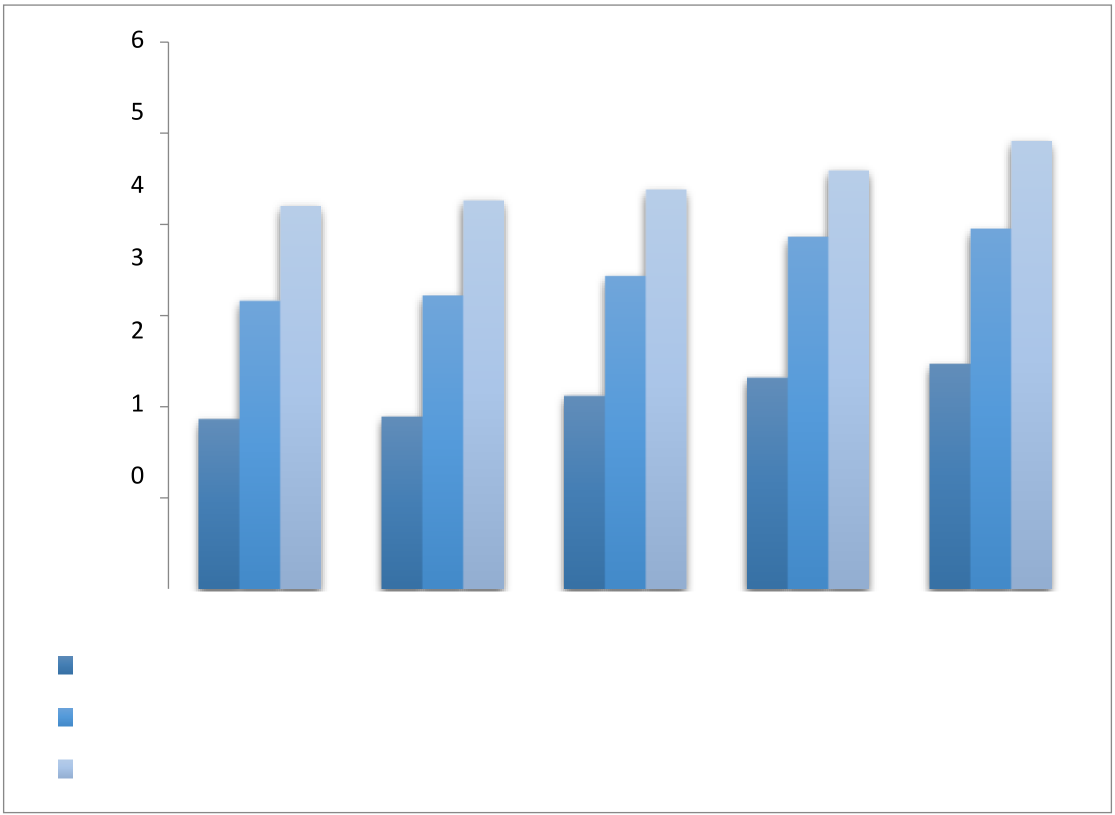


	CC	PUCC	PUG1	PUG2	PUG3
3days	9.14	10.28	10.42	10.48	10.42
7days	15.92	16.74	18.31	19.12	18.76
28 days	24.12	26.28	27.37	28.31	26.14

F

LEXURALSTRENGTH RESULTS

The sample containing liquid polyurethane with 50% GGBS had the maximum flexural strength after 28 days of testing. The flexural strength of the control concrete was the lowest, on the other hand. Both the 20% and 50% GGBS liquid polyurethane samples had comparable flexural strength values. Flexural strength was 4.2 MPa for the liquid polyurethane control concrete. The control concrete has a poor flexural strength in general. When a 10% polyurethane mix was added to water, the flexural strength of all



the samples decreased except for PUG3, which showed the greatest strength among them.

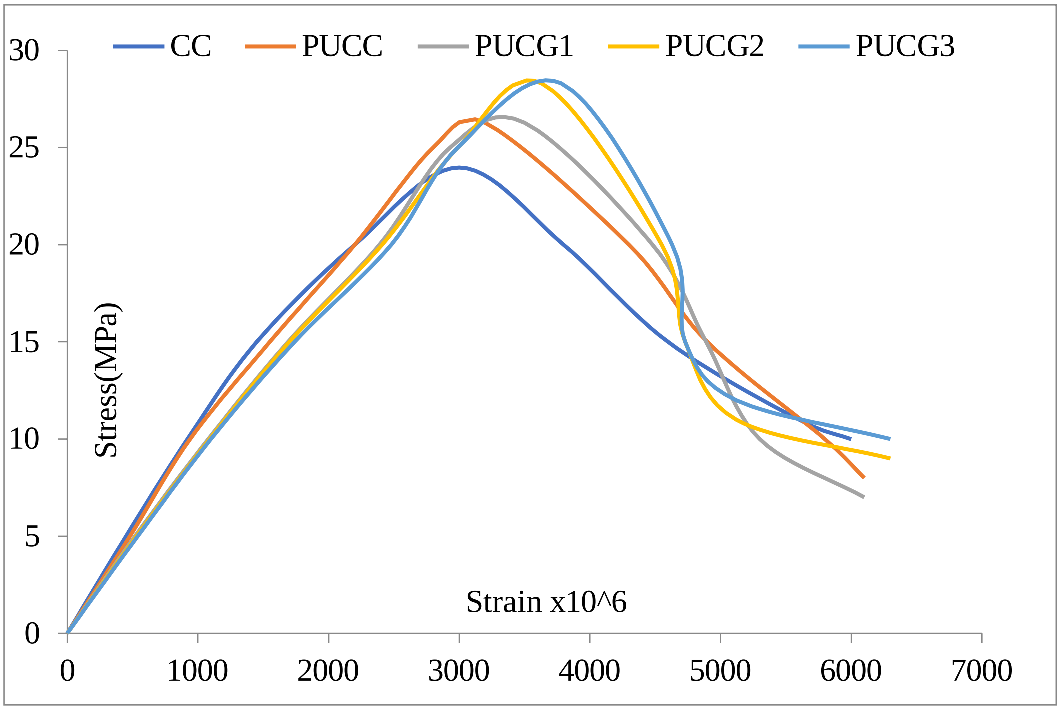
	CC	PUCC	PUG1	PUG2	PUG3
3days	1.86	1.89	2.12	2.32	2.46
7days	3.16	3.21	3.42	3.86	3.94
28 days	4.2	4.26	4.38	4.59	4.91

Flexural strength results

STRESS STRAIN BEHAVIOUR RESULTS:

The relationship between stress and strain under load can be visually represented by a stress-strain curve. The Y-axis shows the stress, and the X-axis shows the strain. With a reported stress of 0 MPa, the control concrete sample showed the lowest stress in this investigation. Mixed with 10% GGBS, the mixture comprising polyurethane concrete showed the greatest stress at 29 MPa.

The control concrete exhibited less stress-strain behavior as compared to the other samples. All of the test mixes, with the exception of PUGG1, showed reduced stress-strain values when compared to the control concrete. PUGG1 performed the best in this regard.

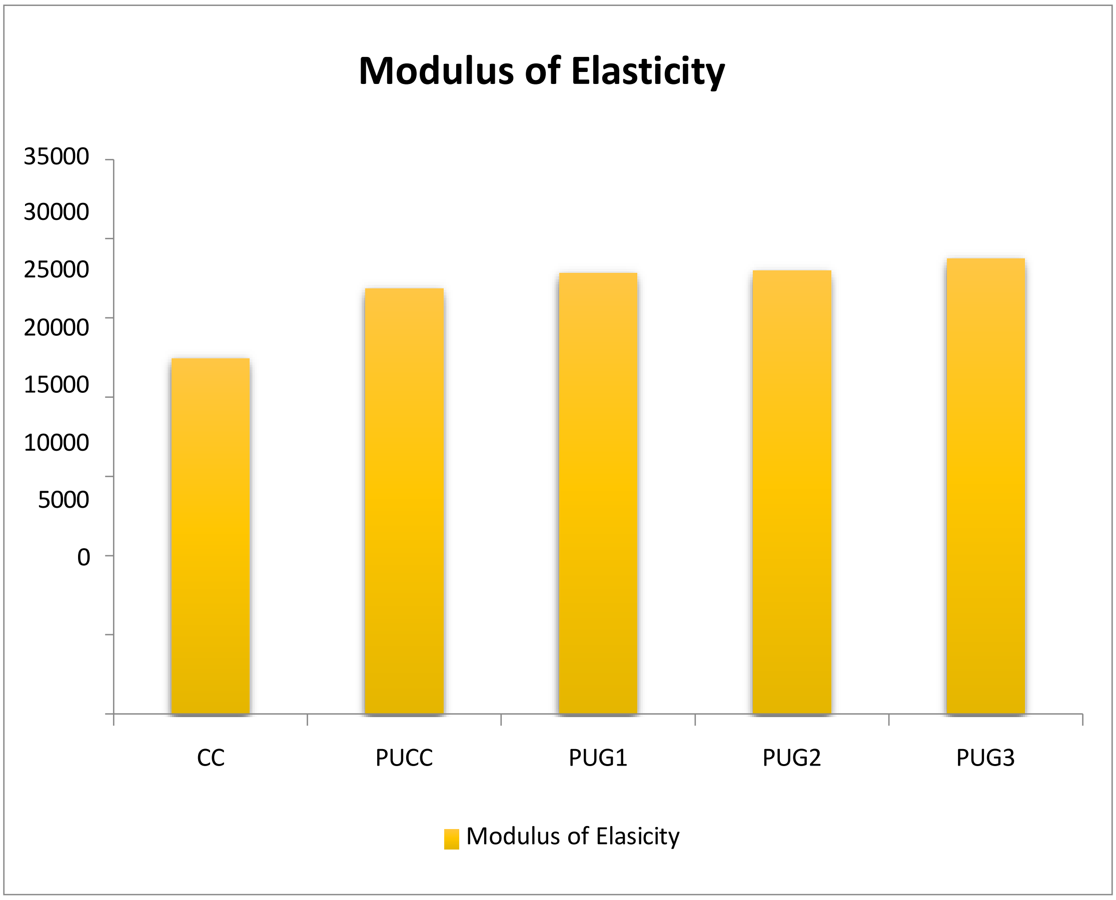


Stress-strain Curve for Concrete Cylinders

Strain softening with low ductility is observed in all samples according to the stress-strain curve, suggesting that there is limited deformation before failure. A higher degree of deformation was seen in the specimen that included polyurethane foam, indicating that it was more flexible. Furthermore, there was a clear peak in the strain curve of the specimens that had GGBS added to them, suggesting that the addition of GGBS improved their performance.

Modulus of Elasticity

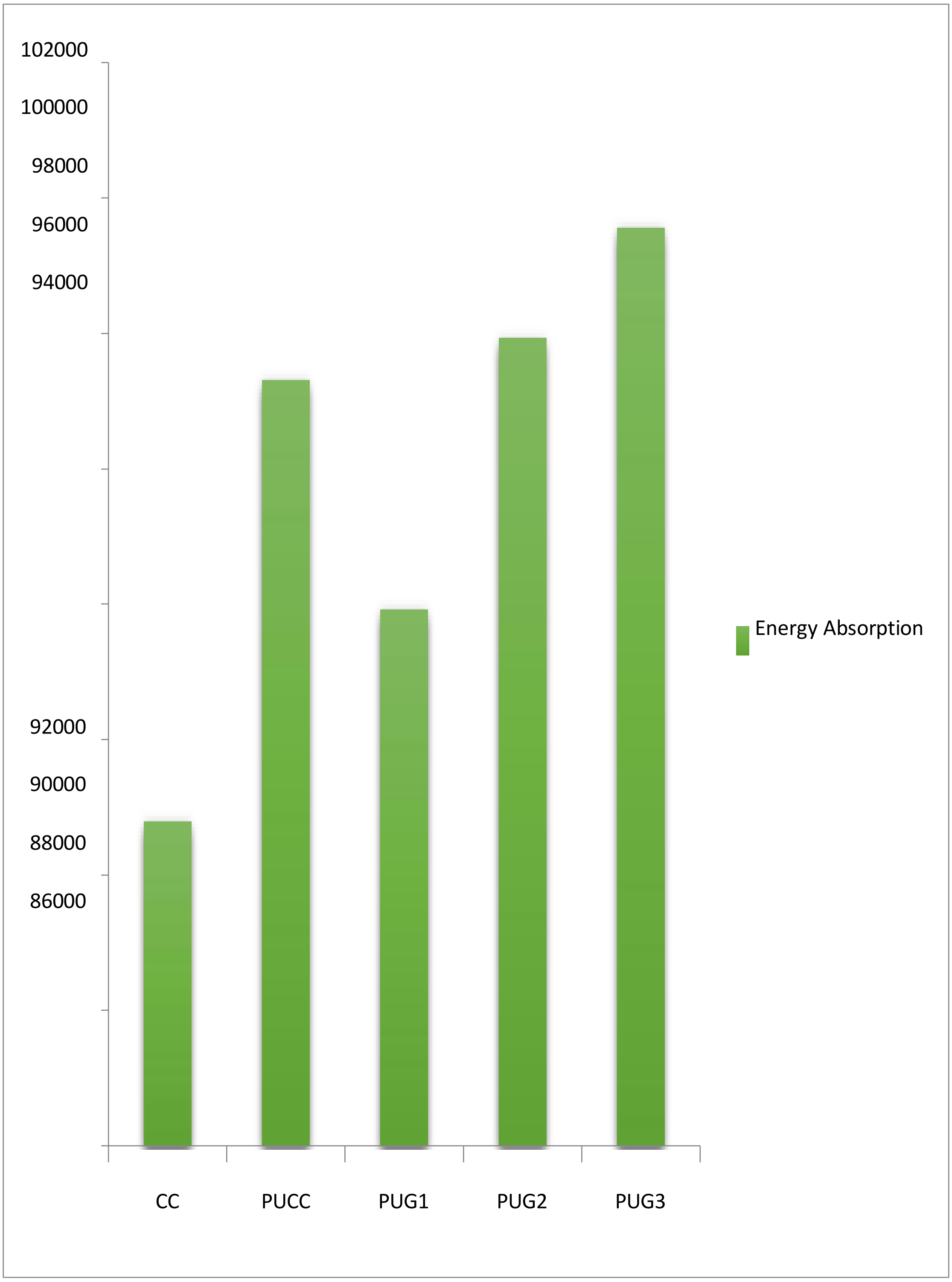
At a proof stress of 0.2 percent, the modulus of elasticity can be calculated by analyzing the stress-strain curve's slope. The liquid polyurethane concrete that was tested had the highest modulus of elasticity, measuring 28,748.7 MPa, when 50% GGBS was substituted with it. The modulus of 22,462.7 MPa was the lowest recorded for the control concrete. The modulus of elasticity was decreased in all mixes compared to PUG3 when 50% GGBS was used in place of sand and 10% polyurethane was added to the water content. The similarity in the modulus values between PUG1 and PUG2 indicates that their stiffness performance was



Modulus of elasticity

STRAIN ENERGY

The area under the stress-strain curve is used to compute the strain energy, which is the amount of energy absorbed by a concrete specimen. One essential way to evaluate the toughness of concrete is by measuring its energy absorption. This provides a consistent means to compare the material's performance. Experimental results showed that the control concrete absorbed the least amount of energy, but the mixture of 50% GGBS and 10% polyurethane absorbed the most. Compared to the PUG3 mix, which exhibited the best performance in terms of energy absorption, all of the samples that were made with GGBS at 50% sand and 10% polyurethane in the water content absorbed less energy.



Energy absorption results

CONCLUSIONS

The effects of GGBS and polyurethane (PU) polymer on concrete characteristics were the subject of numerous noteworthy discoveries in the research.

The PUGG2 mix significantly increased concrete's compressive strength by substituting 10% PU polymer for water and 20% GGBS for fine aggregate by weight. In comparison to the control concrete mix, the compressive strength increased by 17.3% as a consequence of this.

Compressive strength was not significantly different between the PUGG2 and PUGG3 mixtures, suggesting that additional modifications to the composition did not produce notable variations in this attribute.

Because of its void-filling capabilities, GGBS is found to increase concrete's flexural strength when added to the mix. With 50% GGBS in place of fine aggregate, the PUCG3 mix had the highest flexural strength.

Observations of the stress-strain relationship revealed that the strain in concrete increased with increasing GGBS content, peaking at 0.00385 compared to 0.00305 for regular concrete.

There was a possible decrease in self-weight because the concrete's density was discovered to be lower than that of normal concrete

Compared to regular concrete, the concrete's modulus of elasticity increased by around 18-27%, albeit this increase was not statistically significant.

Substituting GGBS for 10% of the fine aggregate reduced the energy absorption index at first, but the absorption capacity improved with increasing GGBS content.

The application of polyurethane alone greatly enhanced the concrete's characteristics. But adding GGBS improved the concrete's overall qualities much more.

Finally, adding GGBS to polyurethane concrete improved its strength and other qualities while decreasing its density. It is possible to reduce the size of structural components and, consequently, construction costs by using this combination to make lightweight concrete that is well-suited for structural applications.

SCOPE FOR FUTURE STUDY

Because of its special qualities, foam concrete finds many uses in the building trade. Its typical applications include making building blocks and insulating floors and roofs from heat and sound.

For applications requiring a higher density of foam concrete, such as floors and basements, as well as for the construction of collapsible blocks and divider panels in structures, foam concrete is utilized. It is also used as pipe insulation.

Foam concrete is advantageous because of its low cost. No considerable ground preparation is necessary for its direct application on marginal ground, including peat and poor soils. Because of this, earth-retaining structures can be built at a cheaper cost by reducing lateral loading.

In addition, building with foam concrete blocks is significantly quicker because they are lightweight and available in big, precisely sized pieces. Not only are these blocks simple to work with, but they also make it straightforward to cut channels and holes for electrical wiring and sockets.

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