IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

AN EXPERIMENTAL STUDY ONPARTIAL REPLACEMENT OF CEMENT WITH GRANITE POWDER IN CONCRETE

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ABSTRACT

This project report entitled to “An Experimental study on partial replacement of cement with granite powder in concrete”. The main object of This experimental study is to analyse and investigates the feasibility of utilizing granite powder as a partial replacement for cement in concrete production. With the growing concerns over the environmental impact of cement manufacturing and the need for sustainable construction materials, granite powder—an industrial by-product from the granite cutting and polishing process—presents a promising alternative.

The study involved preparing concrete mixes with varying percentages of granite powder (ranging from 0% to 30%) as a partial replacement for cement. Tests were conducted to evaluate the workability, compressive strength, split tensile strength, and durability of the concrete at different curing periods. The results indicate that the inclusion of granite powder enhances the strength properties of concrete up to an optimal replacement level, beyond which the performance slightly declines. Additionally, granite powder contributed to improved sustainability and cost-effectiveness without compromising the structural integrity. This research supports the potential application of granite powder in green concrete technology and promotes the efficient management of industrial waste.

• **Keywords:**Granite powder,Cement replacement,Concrete properties,Mechanical proporties.

I. INTRODUCTION

1.1. GENERAL

In the recent construction industry, even though we are practicing with different composite materials concrete plays a major role in the construction sector. Concrete is a building material, consisting of cement, fine aggregate and coarse aggregate. Among the ingredients of concrete, coarse aggregate imparts greater volumetric stability and durability to concrete. It is cheaper than cement and hence directly helps in achieving economy in concrete. A good aggregate should produce the desired properties in both the fresh and hardened concrete.
Based on literature review, Granite Powder is selected as partial replacement cement in concrete.

Concrete is the most widely used construction material in the world, primarily composed of cement, fine aggregates, coarse aggregates, and water. Among these, cement acts as the main binding component, but its production is energy-intensive and contributes significantly to global CO_2 emissions. As the demand for concrete increases, so does the environmental impact of cement production. This has led researchers and engineers to explore alternative, more sustainable materials that can partially or fully replace cement without compromising the strength and durability of concrete.

Granite powder is a waste material generated during the cutting and polishing of granite stones in the construction and ornamental stone industries. This fine by-product is often discarded as waste, leading to environmental concerns related to its disposal. However, granite powder contains silica and other minerals that may possess pozzolanic properties, making it a potential supplementary cementitious material.

This study explores the potential of using granite powder as a partial replacement for cement in concrete. The objective is to evaluate the mechanical properties and workability of concrete mixes containing varying percentages of granite powder. By doing so, the study aims to reduce the consumption of cement, minimize environmental impact, and promote the reuse of industrial waste in construction. The results could offer a sustainable and cost- effective alternative to traditional concrete production, contributing to the development of green construction practices.

1.2 History of Granite Powder in Partial Replacement of Cement in Concrete

The concept of using industrial by-products in concrete is not new and has evolved significantly over the past few decades as a response to the growing demand for sustainable construction practices. Historically, materials such as fly ash, silica fume, ground granulated blast furnace slag (GGBS), and rice husk ash have been widely studied and utilized as supplementary cementitious materials (SCMs). These alternatives have proven effective in improving certain properties of concrete while also reducing environmental impacts.

Granite powder emerged as a potential SCM in the early 2000s when researchers began to investigate its physical and chemical properties. The granite industry, particularly in countries like India, Brazil, and China, generates substantial amounts of waste in the form of fine granite dust during the cutting, grinding, and polishing processes. Initially considered a disposal problem, this waste material started gaining attention for its pozzolanic behavior and mineral content—primarily silica, alumina, and calcium oxide—which are somewhat similar to the active components found in cement.

Early experimental studies focused on incorporating granite powder into concrete mixes to evaluate its impact on workability, setting time, and mechanical strength. Results from these initial investigations suggested that granite powder could partially replace cement (typically in the range of 5% to 30%) without significantly compromising strength, and in some cases, even enhancing it due to filler effects and improved particle packing.

Over time, research expanded to include long-term durability, resistance to chemical attacks, and economic and environmental benefits. The use of granite powder in concrete aligns with the principles of sustainable development by promoting resource conservation, waste management, and carbon footprint reduction.

Today, granite powder is increasingly recognized as a viable component in green concrete solutions, especially in regions with abundant granite processing industries. Its use represents a synergy between environmental responsibility and engineering innovation, contributing to the evolution of sustainable construction materials.

BEHAVIOR OF GRANITE POWDER IN CONCRETE

Granite powder, a byproduct of granite stone cutting and polishing, can be used as a partial replacement for cement or fine aggregates (sand) in concrete. Its inclusion influences concrete's properties in various ways depending on the dosage, mix design, and curing. Here's a breakdown of the behavior of granite powder in concrete:

1. Workability

- **Decreases slightly** with higher granite powder content because it's finer and increases water demand.
- Using **superplasticizers** can help maintain desired workability.

2. Strength

- **Compressive strength**:
  - **Increases** up to an optimal replacement level (typically 10–20%) due to the **filler effect** and **pozzolanic reaction** (when replacing cement).
  - Beyond optimal levels, strength may **decrease** due to excess fines or poor bonding.
- **Split tensile & flexural strength**:
  - Also tend to improve at lower replacement levels.

3. Durability

- **Improved resistance** to:
  - **Permeability** (denser microstructure).
  - **Chloride ingress** and **sulfate attack** (to a certain extent).
- **Reduced carbonation depth**, again due to reduced porosity.

4. Setting Time

- Slightly **increased** setting times when replacing cement, due to slower pozzolanic reaction compared to pure cement hydration.

5. Environmental and Economic Benefits

- Reduces reliance on cement and natural sand.

- Utilizes **industrial waste**, reducing environmental burden.
- May lower overall cost depending on availability.

MERITS OF USING GRANITE POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

Using granite powder as a partial replacement of cement in concrete offers several technical, environmental, and economic advantages. Here are the key merits:

Technical Merits

1. Improved Compressive Strength
   - Granite powder acts as a micro-filler, filling voids and making the concrete denser.
   - Up to ~10–15% replacement often results in higher compressive strength due to better particle packing and improved interfacial transition zones.
2. Enhanced Durability
   - Reduces permeability, which helps in protecting steel reinforcement from corrosion.
   - Can improve resistance to chemical attacks like chlorides and sulfates.
3. Better Microstructure
   - Finer particles help refine the pore structure, reducing the size and connectivity of capillary pores.
4. Pozzolanic Activity (in some cases)
   - If the granite powder has reactive silica or alumina, it may contribute to secondary hydration reactions, improving long-term strength.

Environmental Merits

1. Reduction in Cement Usage
   - Cement production is energy-intensive and emits a significant amount of CO_2.
   - Replacing a portion with granite powder reduces the environmental footprint of concrete.
2. Waste Utilization
   - Granite powder is an industrial byproduct; using it diverts waste from landfills and promotes sustainable construction practices.

Economic Merits

1. Cost Savings
   - Granite powder is often available at low or no cost compared to cement, leading to savings in large-scale construction.
2. Resource Conservation
   - Reduces the demand for raw materials used in cement production, such as limestone and clay.

APPLICATIONS OF GRANITE POWDER IN CONCRETE

Granite powder, when used in concrete, has a variety of practical applications, especially in sustainable and performance-driven construction. Here's a breakdown of its main applications in concrete:

1. **High-Performance Concrete (HPC)**

- Granite powder can enhance strength and durability, making it suitable for HPC used in:
  - High-rise buildings
  - Bridges
  - Industrial floors
  - Marine structures

2. Precast Concrete Products

- Improves surface finish and strength for:
  - Paving blocks
  - Tiles
  - Curbstones
  - Precast panels and beams

3. Architectural Concrete

- Finer particle size of granite powder helps achieve smooth finishes and aesthetic textures, ideal for:
  - Decorative facades
  - Cladding panels
  - Exposed concrete surfaces

- Used in concrete for:
  - Rigid pavements
  - Interlocking blocks
  - Median barriers
  - Sidewalks and curbs

5. Green/Sustainable Construction

- Supports eco-friendly practices in:
  - Green buildings
  - LEED-certified projects
  - Low-carbon construction initiatives

6. Mass Concrete Works

- In dams, foundations, and retaining walls where thermal cracking due to cement heat is a concern, replacing part of the cement with granite powder helps reduce the heat of hydration.

THE MAIN OBJECTIVE OF USING GRANITE POWDER IN CONCRTE

The main objective of using granite powder as a partial replacement of cement in concrete is to enhance the sustainability and performance of concrete by utilizing industrial waste**, thereby reducing the consumption of cement, lowering carbon emissions, and improving the mechanical and durability properties of concrete through the filler effect and potential pozzolanic activity of the granite powder.**

- "The primary objective of incorporating granite powder as a partial substitute for cement in concrete is to promote sustainable construction by reducing the environmental impact of cement production, utilizing industrial waste efficiently, and improving the physical and mechanical properties of concrete through enhanced packing density and potential secondary hydration reactions."

LITERATURE REVIEW

This chapter presents a review of recent research on using Granite powder as a partial replacement of cement in concrete.The key hardened properties of Granite powder in concrete in terms of strength and durability are also discussed in detail from the earlier published works.Some of them are presented here.

- 1. Sukesh et al. (2018): Replaced 0%, 10%, 20%, 30%, and 40% of cement with granite powder. Results showed that the compressive strength increased by 14.28% at 20% replacement level.
- 2. Kumar et al. (2019): Investigated the effect of replacing 0%, 10%, 20%, and 30% of cement with granite powder. The study found that the optimal replacement level was 20%, which resulted in a 10% reduction in cement consumption.
- 3. Rao et al. (2020): Examined the properties of concrete with 0%, 10%, 20%, and 30% granite powder replacement. The results showed that the workability and durability of concrete improved with the addition of granite powder.
- 4.Abukersh, S.,et al : He investigates the effects of using granite quarry dust as a partial replacement for cement on the compressive and tensile strength of concrete. The experimental results indicate that incorporating granite dust at levels of 20% to 50% significantly reduces compressive strength, with minimal negative effects on tensile strength.
- 5.Dandu, P., Gattu, R.R., Cheela, R.S : Their research assesses the mechanical properties and environmental impact of concrete mixtures where cement is partially replaced with granite powder. The study found that a mix containing 30% granite powder exhibited a 7% increase in compressive strength and an 11% increase in flexural strength compared to conventional mixes.
- 6.Asif, F., Ulmek, N : This review focuses on the use of waste granite powder as an admixture in concrete and its effects on the material's properties. The study concluded that incorporating granite fines improves compressive, tensile, and flexural characteristics of concrete while reducing overall costs.

MATERIALS & METHODS

3.1 GENERAL

The properties of ingredients of concrete are cement, sand and coarse aggregate were analysed based on the standard experimental procedures laid down in IS codes. The standard experimental procedure was adopted for the determination of normal consistency. initial and final setting times and compressive strength of cement.

These were conducted on coarse aggregate and fine aggregate to find the grain size distribution, the water absorption, specific gravity and bulk density Slump test is also conducted on fresh concrete.

3.1.1 MATERIALS

The materials used in experimental investigations are:

1. Cement {OPC}
2. Fine aggregates
3. Coarse aggregates
4. Granite powder
5. Water

3.1.2 CEMENT

The name "Portland cement" across in 1820s because of the early developers of modern calcium silicate cements, and Englishman named Joseph Aspdin, thought the most hardened paste before a resemblance to Portland limestone, a building material a name that contains the hardness & durability of stone was of course a marketing move. In general, cement is a common binding material, a substance which sets and hardens, and can bind with other materials together. Ordinary Portland cement of 43 grade conforming to IS 12269-1987 is used. The cement should be free from lumps and any foreign matters before it is used. The cement should be stored under the dry condition and used for this short duration. The properties of the cement were tested as per IS 4031.The properties are shown in Table 3.1.

S.no	Component	Content (%)
1.	Cao	64.64%

2.	SiO_2	21.28%
3.	Al_2O_3	5.6%
4.	MgO	2.06%
5.	SO_3	2.14%
6.	Fe_2O_3	3.36
7.	Total alkali	0.05
8.	Insoluble residue	0.22
9.	Loss in ignition	0.64

Table Chemical Composition Of Cement

FINENESS OF CEMENT:

The fineness of cement is a measure of the size of cement. It is necessary to check the best possible pounding of concrete; it has an impact on the conduct of bond.

Results Obtained:Fineness-95%

CONSISTENCY OF CEMENT:

Normal consistency is characterized as that rate of water required to create a concrete glue of standard consistency. Vicat device is utilized for discovering consistency of ceesument. The standard consistency of common Portland bond is to 35% by weight of concrete.

Results Obtained:Consistency-32%

Fig 3.1 Vicat apparatus

INITIAL & FINAL SETTING TIME OF CEMENT

When water is added to bond, the paste begins solidifying and picking up quality, at the same time losing its versatility. Two solidifying states are distinguished as initial and final setting circumstances separately.

Results Obtained:Initial setting Time-30 Min

Final Setting Time-570 Min

Fig 3.2 Vicat apparatus with mould

- Initial setting time is the interim between the expansion of water to concrete and the phase when needle stops to infiltrate totally.
- This time ought to be more 30 minutes for conventional bond.
- The final setting time of ordinary Portland cement is shall not over 600 minutes.
- 43 Grade of ordinary Portland cement {OPC} is used in casting the specimens for cube, cylinder and beam tests, the test comes about for physical properties of bond are exhibited.

SOUNDNESS OF CEMENT

Soundness refers to the ability of cement to retain its volume after setting without delayed expansion. Unsound cement can lead to cracking, distortion, or even failure in concrete structures due to expansion after hardening

Why is Soundness Important?

- Ensures **dimensional stability** of concrete.
- Prevents **cracks** or **disintegration** of concrete elements.
- Indicates **absence of excessive free lime (CaO)** or **magnesia (MgO)**, which cause **delayed hydration and expansion**.

Results Otained:Soundness-7mm

COMPRESSION STRENGTH TEST

Compressive strength of cement is the maximum compressive load that a hardened cement mortar cube can withstand without failure, per unit area. It is measured in megapascals (MPa) or N/mm² or It is a measure of how much **crushing force** the cement can resist **after hardening**.

Higher compressive strength = **stronger cement**. Results

Obtained:Compressive Strength-43 MPa

Fig 3.3 Compressive Strength test machine Table 3.1 -Properties of Cement

S. No	Properties	Test Results
1	Fineness	95%
2	Consistency	32%
3	Initial Setting Time	30 minutes
4	Final Setting Time	570 minutes
5	Soundness	7mm
6	Compressive strength	43 mpa

3.1.3 FINE AGGREGATES

The physical properties of a fine and coarse aggregates have much impact on quality of cement in new and solidified state. Tests physical properties like bulk density, specific gravity, water absorption, fineness modulus, grading of coarse aggregate is studied briefly for the purpose mix design and to determine the amounts of materials.

SPECIFIC GRAVITY OF FINE AGGREGATES:

Specific gravity of fine aggregate (sand) is defined as the ratio of the weight of a given volume of aggregates to the weight of equal volume of water. The specific gravity of fine aggregate (sand) is considered to be around 2.65 to 2.67.

Results Obtained:Specific Gravity-2.6

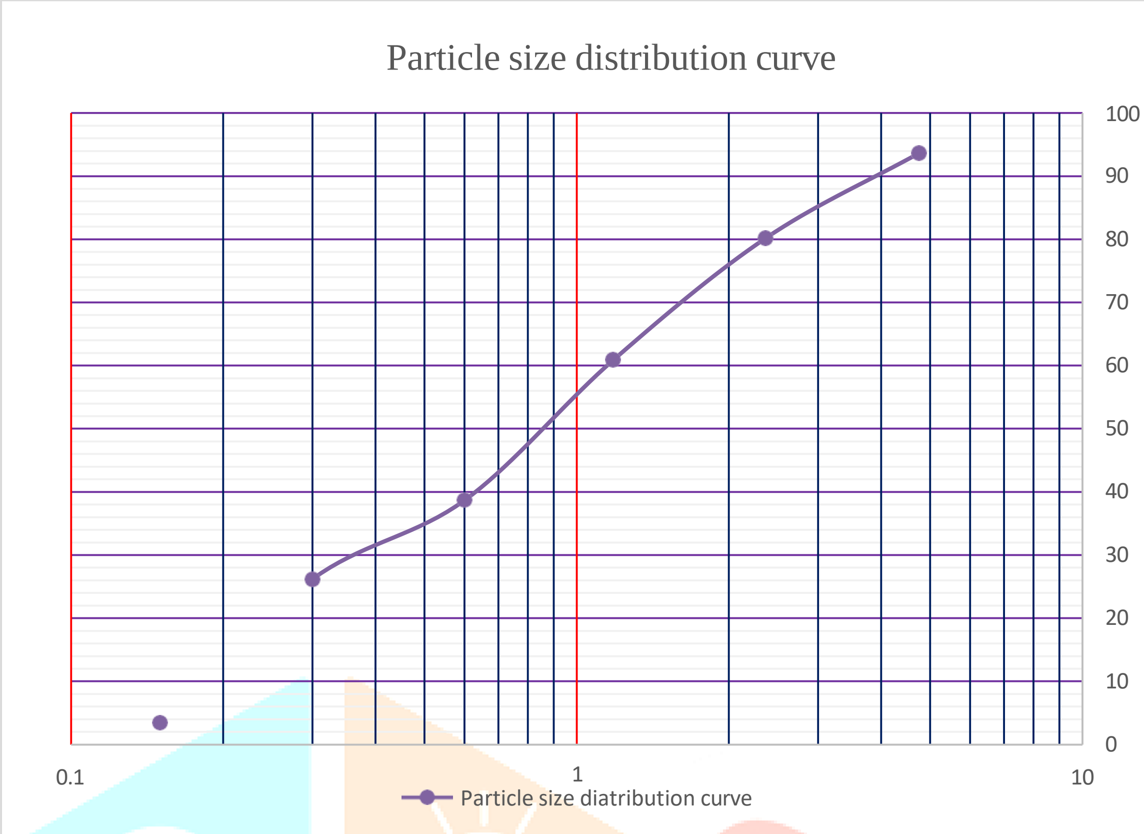
Fig 3.2: Pycnometer

GRADING CURVE OF FINE AGGREGATES:

- Grading of aggregate is the particle size distribution of a sample of aggregates on the basis of sieve analysis and sedimentation analysis.
- Sieve analysis is performed to find out the grading of the aggregates. Sieve analysis is a procedure in which aggregates are allowed to pass through a set of sieves arranged in descending order.
-

Results Obtained:Sieve analysis-2.9%

Sieve Analysis



GRAPH sieve analysis of fine aggregates

3.1.4. COARSE AGGREGATES

Coarse aggregate is defined as rock particles with diameter more than 4.75mm, usually called Commonly-used coarse aggregate in concrete are gravels and pebbles. Hard broken granite stones were used as a coarse aggregate in concrete. Size of the coarse aggregate used in investigation was 20mm.

Fig 3.4: Coarse aggregates

GRADING CURVE OF COARSE AGGREGATES:

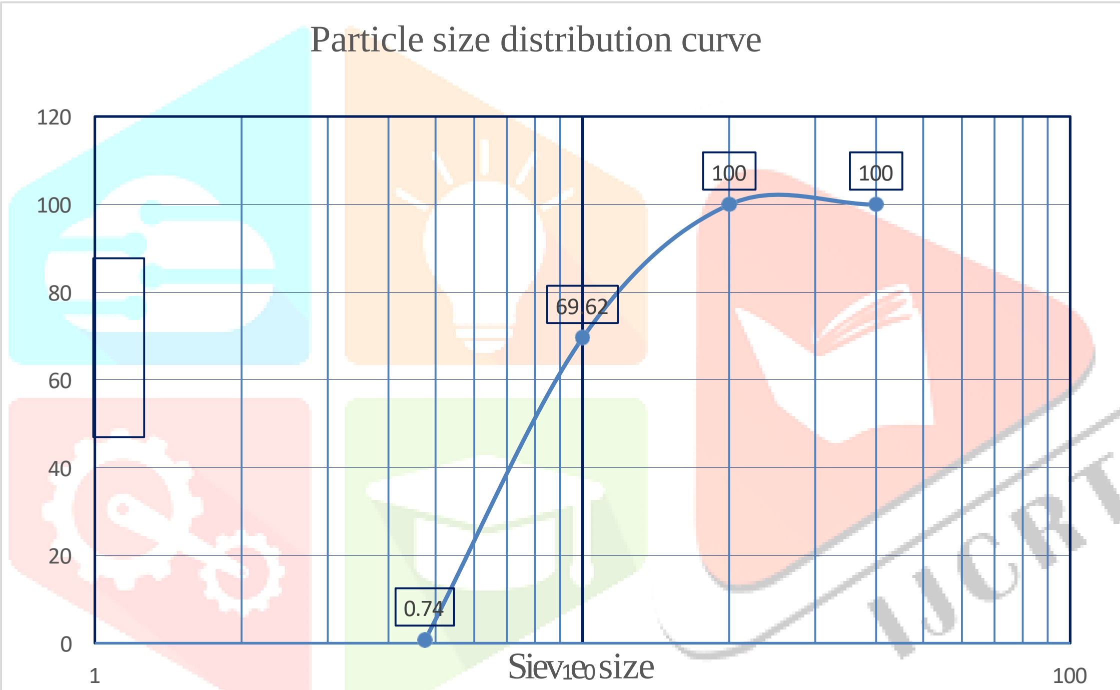
The grading curve of coarse aggregate refers to the distribution of particle sizes within the aggregate material. The grading curve is important because it can affect the workability, strength, and durability of concrete when the coarse aggregate is used as a component of concrete mix.

The grading of coarse aggregate is typically determined by performing a sieve analysis, in which the aggregate is separated into different size fractions by passing it.

Results Obtained:Fineness modulus-7.3%

% fineness

Fig 3.5: Grading curve of coarse aggregates



GRAPH sieve analysis of coarse aggregates

IMPACT TEST:

An impact test is a type of mechanical test that is used to measure the behaviour of materials under high-speed impact loading conditions. The purpose of an impact test is to evaluate a material's ability to absorb energy and resist fracture when it is subjected to sudden or dynamic loading.

Results Obtained:Impact value-18.5%

Fig 3.6: Impact test

WATER ABSORPTION

Water absorption test is a standard test performed on building materials, such as concrete, masonry, and natural stone, to determine the amount of water that can be absorbed by the material under specific conditions.

This test is typically performed to evaluate the durability and strength of the material.

The water absorption test involves soaking the test specimen in water for a specified period of time, usually 24 hours or more, and then measuring the weight of the specimen before and after soaking. The difference in weight is then used to calculate the percentage of water absorbed by the specimen.

Results Obtained:Obsorption value-1.25%

Fig 3.7: Water absorption

SPECIFIC GRAVITY OF COARSE AGGREGATES:

Specific Gravity is defined as the ratio of Weight of Aggregate to the Weight of equal Volume of water. The specific gravity of an aggregate is considered to be a measure of strength or quality of the material.

Results Obtained:Specific gravity-2.63

Fig 3.8: Specific gravity of coarse aggregates

CRUSHING TEST ON AGGREGATES:

The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load.

To achieve a high quality of pavement, aggregate possessing low aggregate crushing value should be preferred.

The aggregate crushing value for cement concrete pavement shall not exceed 30%. The aggregate crushing value for wearing surfaces shall not exceed 45%.

Results Obtained:Crushing value-12.26%

Fig 3.9: Crushing test

FLAKINESS INDEX TEST

Flakiness index test is conducted on coarse aggregates sample to estimate the shape of aggregates. It is defined as the percentage of mass of particles in it whose least dimension is less than three-fifth of their average dimension.

Results Obtained:Flakiness-14.5%

Fig 3.10: Flakiness index

ELONGATION INDEX TEST

The elongation index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the sample gauged. Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifth times.

Results Obtained:Elongation-13%

Fig 3.11: Elongation index

LOS ANGELES ABRASION TEST:

Los Angeles abrasion test on aggregates is the measure of aggregate toughness and abrasion resistance such as crushing, degradation and disintegration. The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value.

Fig 3.12:Los angeles abrasion test

3.1.4. GRANITE POWDER

Granite powder is a byproduct of the cutting and polishing processes of granite rocks, which are igneous rocks composed mainly of quartz, feldspar, and mica. Here's a detailed explanation

What is Granite Powder?

Granite powder is a fine, powdered form of granite produced during the sawing, grinding, and polishing of granite blocks and slabs. It's usually grayish in color, but the exact shade can vary depending on the mineral composition of the granite source.

Composition

Granite powder typically contains:

- **Silica (SiO_2)** – from quartz
- **Alumina (Al_2O_3)** – from feldspar
- **Iron oxides** – give color and some reactivity
- **Other trace minerals** – like mica, calcium, and magnesium compounds

Uses of Granite Powder

1. **Construction Material**:
   - Used as a partial replacement for **cement or sand** in concrete and mortar.
   - Helps in improving the strength and durability of concrete.
   - Can reduce overall construction costs and make use of industrial waste.
2. **Tiles and Bricks Manufacturing**:
   - Blended with clay or fly ash to produce eco-friendly building materials.
3. **Road Construction**:
   - Used in base layers or as a filler material.
4. **Soil Conditioner**:
   - Helps improve the mineral content of soil in agriculture.
5. **Paving and Landscaping**:
   - Acts as a base layer for pavements or used in decorative landscaping.

Advantages

- **Eco-friendly** – helps reduce industrial waste.
- **Cost-effective** – cheaper than cement or other binders.
- **Good filler material** – improves volume without compromising strength (when used appropriately).
- **Improves workability** – in some concrete mixes.

The idea is to **replace a portion of cement** in concrete with **granite powder**, which is a waste byproduct from granite processing. This helps:

- Utilize industrial waste effectively.
- Reduce the **carbon footprint** of cement production.
- Lower the overall **cost** of concrete.
- Improve some concrete properties (depending on the proportion used).

Fig 3.13 Granite powder

Table 3.2-Properties of Granite powder

S.NO	Properties	Test Results
1	Specific Gravity	2.56 – 2.68
2	Water Absorption	1% – 2%
3	Bulk Density	1450 – 1600 kg/m³
4	Fineness (Passing 75 µm)	85% – 95%
5	Moisture Content	<1%

Applications For Granite powder:

Granite powder, being a fine byproduct of granite stone processing, finds various applications due to its physical and chemical characteristics. It is especially valued for its fineness, strength-enhancing properties, and sustainability benefits.

1. Concrete Production (Cement or Sand Replacement)

- As a Partial Cement Replacement:
  - Used in concrete mixes (usually 5–15%) to reduce cement consumption.
  - Enhances strength and durability when properly proportioned.
- **As a Fine Aggregate (Sand) Replacement:**
  - Reduces natural sand usage.
  - Improves packing density and reduces porosity in concrete.

Application**:** Pavement blocks, flooring tiles, and precast elements.

2. Mortar and Plastering Works

- Used to replace a part of cement or sand in plaster or masonry mortars.
- Improves finish quality and reduces cracks.
- Cost-effective for large-scale plastering in non-load-bearing walls.

3. Bricks and Blocks Manufacturing

- Mixed with clay, fly ash, or cement to produce eco-friendly bricks or blocks.
- Increases compressive strength and reduces production cost.
- Useful in making interlocking pavers, fly ash bricks, and solid blocks.

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4. Road Construction

- **Acts as a filler material in:**
  - Sub-base layers
  - Bituminous mixes
  - Embankment stabilization

Helps increase pavement lifespan and reduce reliance on virgin materials.

5. Soil Stabilization and Improvement

- Used in soil stabilization to improve bearing capacity.
- Helps in land reclamation and landscape contouring.

Common in low-cost roadbeds, embankments, and construction on weak soils.

6. Ceramic and Tile Industries

- Granite powder mixed with other ceramic materials to produce:
  - Wall and floor tiles
  - Glazed ceramics Enhances

durability, reduces shrinkage.

7. Decorative and Landscaping Uses

- Used in:
  - Garden paths
  - Driveways
  - Decorative concrete finishes
- Gives a granular texture and natural color effect.

8. Environmental Applications

- Waste Management: Promotes reuse of industrial byproducts.
- Carbon Footprint Reduction: Replacing cement with granite powder helps reduce CO_2 emissions from concrete production

Summary of Granite Powder Applications

Application Area	Function of Granite Powder
Concrete & Mortar	Filler, strength enhancer, cost reducer

Bricks/Blocks	Additive for durability and shape retention
Roadworks	Base/filler for stability
Soil Works	Stabilizer and filler
Ceramics	Raw material for tiles
Landscaping	Decorative material
Sustainability	Eco-friendly waste utilization

3.1.5. WATER

Workability, compressive strengths, permeability and water tightness, durability and weathering, and drying shrinkage potential for cracking are all controlled by the precise amount of water in concrete. It makes the mixture workable and serves as a lubricant for the fine and coarse material. It joins cement chemically to create the binding paste. It is used to dampen the aggregate surface to stop it from absorbing the water that essential for chemical action.

Fig 3.15: Water

MIX DESIGN

Concrete is an extremely versatile building material because, it can be designed for great strength widely. In the present work, we carried out nominal mix design using the formulae & by performing calculations.

3.2 BASIC INGREDIENTS OF CONCRETE

1. Cement-It is the basic binding material in concrete.
2. Water-It hydrates cement and makes concrete workable.
3. Coarse aggregate -It is the basic building component of concrete.

4. Fine aggregate -Along with cement paste it forms mortar grout and fills the voids in the coarse aggregates.

5. Granite powder- It is a byproduct of the cutting and polishing processes of granite rocks used as a partial replacement material in concrete.

NOMINAL MIX DESIGN FOR M25 GRADE CONCRETE

Calculation of cement sand and aggregate for M25 grade concrete

M25Grade Concrete-1:1:2 Density of

Cement-1440 kg/m3

Density of fine Aggregate 1600 kg/m3 Density of

coarse Aggregate 1800 kg/m3 Dry volume of Cement:

1.54

Sum of the ratio:1+1+2=4

Cube Mould volume -3.75 10-0.003375

Cement-1/1+1+2* 0.003375*1440* 1.54=1.869kg Sand-

1/1+1+2*0.003375*1440* 1.54=2.076kg

Coarse aggregate -2/1+1+2*0.003375*1440* 1.54=4.672kg Water-

1869*40/100=748ml

TABLE 3.4: Mix proportion of M25 for 0.15 m^3

MIX	CEMENT (kg)	COARSE AGGREGATE (kg)	FINE AGGREGATE (kg)	GRANITE POWDER (gm)	WATER (ml)
0%	1.869	4.672	2.076	0	500
5%	1.776	4.472	2.076	0.0935	500
10%	1.682	4.672	2.076	0.187	500
15%	1.589	4.672	2.076	0.280	500
20%	1.496	4.672	2.076	0.373	500
25%	1.402	4.672	2.076	0.467	500
30%	1.309	4.672	2.076	0.560	500

3.3 TESTS FOR CONCRETE

There are many tests applied for fresh concrete and hardened concrete. In our project while preparing fresh concrete using pumice & ggbs in Workability tests are performed. To find workability slump cone test and compaction factor tests are to be conducted. For hardened concrete compressive strength is the main character for durability and tensile strength for cubes.

The various strength of concrete, the determination of compressive strength is so important because concrete is primarily means to withstand compressive stresses. Cubes are the type of test specimen for determination strength of concrete.

3.3.1 TEST ON FRESH CONCRETE:

1. Slump cone test
2. Compaction factor test
3. Vee bee consistometer

3.3.2 SLUMP CONE TEST:

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work it is not a suitable method for very wet or very dry concrete It does not measure all factors contributing to workability, nor is it always representative of gives an indication of the uniformity of concrete from batch to batch repeated batches of the same mis, brought to the same slump, will have the assume water content and water cement ratio, provided the weights of aggregates, cement and admixtures are uniform and aggregate grading is within acceptable limits. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slumps Quality of concrete can also be further assessed by giving a few tapping or blows by tapping rod to the hose plate The deformation shows the characteristics of concrete with respect to tendency for segregation.

The thickness of the metallic sheet for the mould should not be thinner than 1.6 sometimes the mould is providing with suitable guides for lifting vertically up. For tamping the concrete. a steel tamping rod 16 mm dia. 0.6 meter along with bullet and is used. The details of the slum cone apparatus. The internal surface of the moulds thoroughly cleaned and freed from superfluous moisture and adherence of any set concrete before commencing the test. The mould is placed on a smooth, horizontal, rigid and non-absorbent surface the mould is then filled in four layers. Each layer approximately of the height of the mould Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section After the top layer has been rodded, the concrete is struck off level with a tamping rod. The mould is removed from the concrete by immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subsidence is referred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. The difference in bright in mm intake as slump of concrete.

PROCEDURE:

1. Place the fresh concrete mix in the clean slump cone in three equal layers Tamping each layer with 25 times by the tamping rod in a uniform manner curved the cross section.

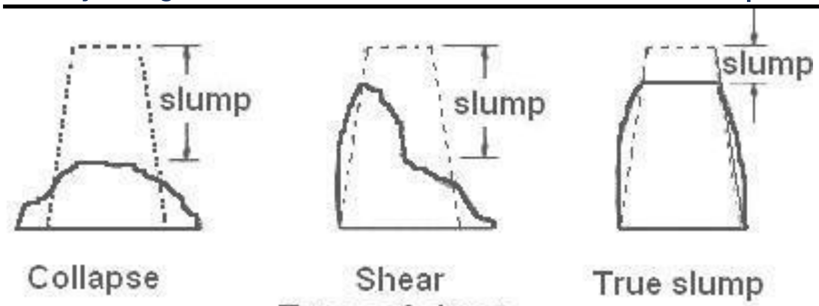
2. Stricken of the top of the concrete flush with trowel i.e., exactly levelled.

3 Remove the metal cone by raising It slowly and carefully in the vertical direction

4 As soon as the concrete settlement stop, measure the subsidence of the concrete.

Fig 3.15: Testing of Slump value

This is the most important test for workability of fresh concrete. The pattern of slump falling indicates the characteristics of concrete in addition to slump value. If the concrete slumps evenly it is called true slump. If one half of the cone slides down, it is called shear slump. In case of shear slump, the slump value is measured as the difference in height between the height of mould and the average value of the subsidence. Shear slump also indicates that the concrete is non-cohesive and shows the characteristics of segregation.



Types of slump

The apparatus for conducting the slum test essential consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under.

The dimensions of slump cone:

Top diameter=10cm Bottom

diameter=20cm

Height of slump cone=30cm

3.3.3. COMPACTION FACTOR TEST:

This is the most important tests for workability of fresh concrete.

PROCEEDURE: -

- Keep the compaction factor apparatus on the levelled ground and clean it thoroughly Weight the empty cylinder accurately (WI).
- Fix the cylinder on the base with fly nuts and bolts at the central axis of the hopper and cylinder lie on one vertical line.
- Fill the freshly mixed concrete in upper hoper gently and carefully without any compacting effort.
- After two minutes release the trapdoor so that the concrete may fall into the lower hopper.
- After 2 minutes opens the trap door of bottom hopper, so that the concrete fall into the cylinder. Remove the excess concrete above the top of cylinder by using trowel and weigh it(W2).
- Refill the cylinder with same sample of concrete in approximately 5cm thick layer by using the mechanical vibration so as to obtain the full compaction.
- Remove the excess concrete above the top of cylinder by using trowel and weigh it(W3)
- The value of compaction factor is obtained by the formulae -W2-W1/W3-W.

Fig 3.16: Compaction factor test

3.3.4 Vee Bee Consistometer

This test measures the relative effort required to change a mass of concrete from one definite shape to another (i.e., from conical to cylindrical) by means of vibration. The amount of effort (called remoulding effort) is taken as the time in seconds, required to complete the change. The results of this test are of value when studying the mobility of the masses of concrete made with varying amounts of water, cement and with various types of grading of aggregate.

Fig 3.17: vee bee consistometer

3.4 PREPARATION OF TEST SPECIMEN

The various details about the preparation of test specimen are presented in the sections.

Fig 3.18: Cubes

3.4.1 MIXING

Mix the concrete either by hand or in a laboratory hatch mixer

a) Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform colour.

b) Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate & add pumice & ggbs is uniformly distributed throughout the batch.

c) Add water and mix it until the concrete appears to be homogenous and of the desired consistency.

Fig 3.19: Mixing of concrete

3.4.2 SAMPLING

(a) Clean the moulds and apply oil.

(b) Fill the concrete in the moulds in layers approximately 5 cm thick.

(c) Compact each layer with not less than 20strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long bullet pointed at lower end).

(d) The level the top surface and smoothen it with a trowel.

3.4.3 CASTING

Specified number of cube samples and cylinder samples is cast in steel moulds with inner dimensions of 150mm x 150mm x 150mm and 300mm x 150mm. According to the design mix proportions, the ingredients of concrete are taken separately by weighing through electronic weigh balance. Present study has been carried in concrete technology laboratory, hence mix the dry sand and cement first and spread over the coarse aggregate. To maintain uniform water cement ratio in concrete production, clean the floor surface with sufficient water Mix the composition until to get the uniform colour Pour the concrete into a mould of one third layer and apply 25 blows uniformly on the surface of the concrete in mould.

After completion of pouring vibrate the moulds in table vibrator, meanwhile to study the workability of waste engine oil concrete composition tested the slump value and compaction factor tests Specimens are covered with plastic paper to maintain relative humidity After completion of 24 hrs, remove the specimens from moulds and placed into the curing pond. The details of fabrication and casting

Fig 3.20: Casting of cube

3.4.4 CURING

The cubes used for this test have a dimension of 150 x 150 x 150 mm as long as the largest aggregate does not exceed 20 mm

The casted specimen is removed from moulds after 24 hours and the specimens are kept immersed in a clear water tank. After cured the specimen in water removed at period of 7 days ,14 days and 28 days for testing. The specimen are taken out and allowed to dry under shade.

The results from the compressive strength test are used to determine the strength of the concrete.

EXPERIMENTAL WORK

4.1 INTRODUCTION

The purpose of experimental investigations is to obtain the compressive strength of M25 grade concrete by partial replacement of cement with Granite powder.

4.1.1 COMPRESSION TEST

Compression test of the concrete specimen is most widely used test to measure its compressive strength Compressive strength is the capacity of a material or structure to thousand loads tending to reduce size as opposed to tensile strength. Compressive strength of concrete is the most common performance measure used by the engineer in designing buildings other structures. Compression test is the most common test conducting on hardened concrete, because most of desirable characteristics properties of concrete are quantitatively elated to its compressive strength. The compression strength test is carried out on specimens cubical are cylindrical in shape. Prism is also sometimes used, but it is not common in our country.

Sometimes, the compressive strength of concrete is determined using parts of the beam tested in flexure. The end parts of the beam are left in fact after failure in flexure and because beam is usually of square cross section, thin part of the beam could be used to find out the compressive strength. The cubes specimen is of the size 150mmX150mmX150mm were used. The cubes of size 150mmx150mmx150mm were tested for compressive strength at different curing periods of 7,14,28 days. The average value of three specimens was taken as the compressive strength of the concrete. The quantities of cement, fine aggregate, coarse aggregate and water for each batch were measured by weighing balance of an accuracy of 1 gm.

The object of mixing is to coat the surface of all aggregate particles with cement paste and to blend all the ingredients of concrete in to a uniform mass. Though mixing of materials s essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency Two methods are adopted for mixing concrete, hand mixing and machine mixing, in the study the process of mixing the materials as been done by the machine. The test moulds are kept ready before preparing the mix. Moulds recleaned and oiled on all contacts surfaces then fixed on vibrating table firmly. The concrete filled into moulds in layers and then vibrated. The top surface of concrete is struck off level with a trowel. The number and date of casting are put on the top surface of the cubes.

When compacting by hand, the standard tampering bar is used and the strokes of the bar are distributed in a uniform manner over the cross section of the mould. The number of strokes per layer required to produce the specified conditions vary according to the type of concrete. In no case should the concrete be subjected to less than 35 strokes per layer for 15 cm or 25 strokes per layer for 10cm cubes. For cylindrical specimens, the number of strokes is not less than 30 per layer Glass powder replacement material of design mixes compaction of cubes, cylinders, beams and all regular mix for beams were hand compacted.

The test specimens were stored in a place free from vibration and covered with wet gunny bags for 24 hours from the time of addition of water to the dry ingredients After this period, specimens are removed from the moulds and immediately submerged in curing tank and kept there until taken out just period to rest. The water of curing tank was renewed or every seven days and maintained at temperature of 27+2/°c.

The cube compressive strength is calculated using Compressive Testing Machine as shown in fig. The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area calculated from mean dimensions of the section and shall be expressed to the nearest kg/cm², average of all values shall be taken as the representation of the batch provided and individual variation is not more than 15% of average.

Compressive strength= (Max load) / Area = P/A where,

P= Maximum applied load A=Cross sectional

area of specimen

Fig 3.21: Compressive strength test on concrete cube

4.2. RESULTS & DISCUSSION

4.2.1 RESULTS

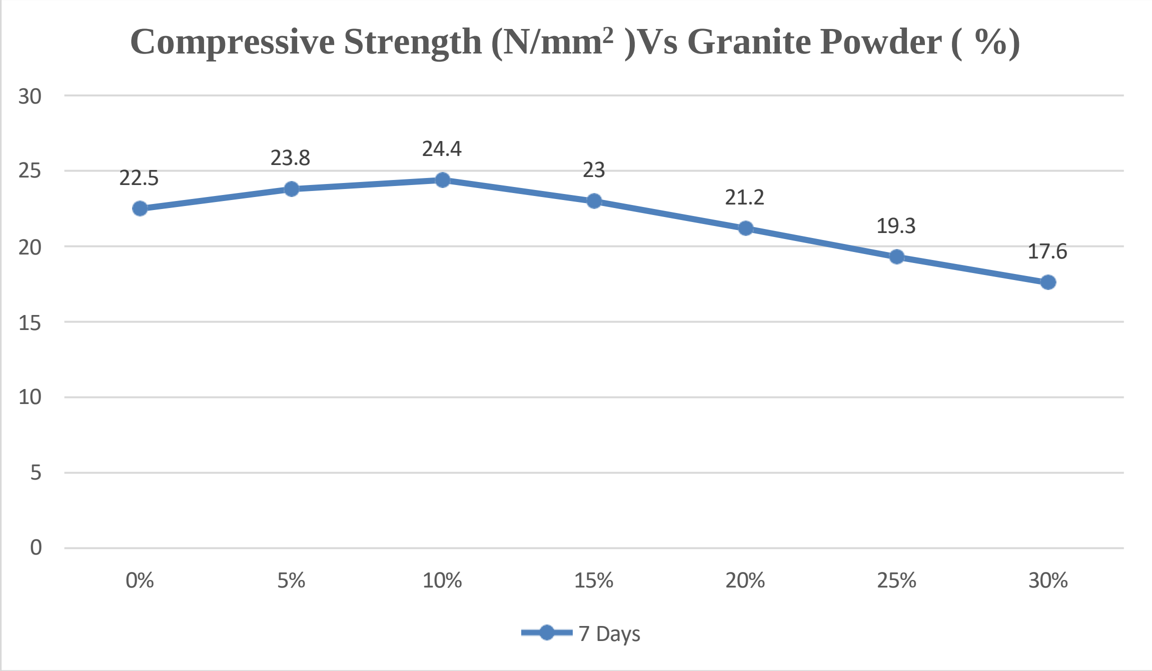
The result of the experimental investigation is presented in this chapter. The significance of the results was assessed with the reference to relevant IS codes.

4.2.1 Test results

4.2.2 Compressive strength of M25 grade of concrete

S. no	% Granite powder	Load (KN)	Compressive Strength (N/mm^2)
1	0%	506	22.5
2	5%+5%	536	23.8
3	10%+10%	549	24.4
4	15%+15%	517	23.0
5	20%+20%	477	21.2
6	25%+25%	375	19.3
7	30%+30%	347	17.6

TABLE 4.1 Compressive strength of M25 grade concrete for 7 days

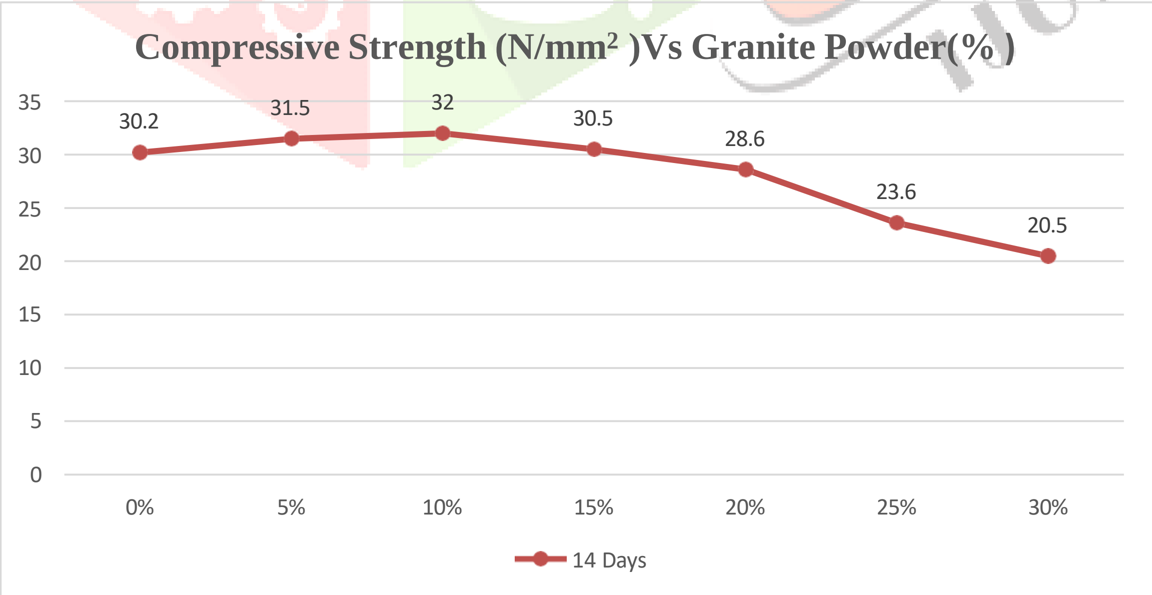


GRAPH Compressive Strength

4.2.3 Compressive strength of concrete for 14 days

s no	% of Granite powder	Load (KN)	Compressive strength(N/mm^2)
1	0%	680	30.2
2	5%+5%	709	31.5
3	10%+10%	720	32.0
4	15%+15%	686	30.5
5	20%+20%	643	28.6
6	25%+25%	615	23.6
7	30%+30%	564	20.5

Table 4.2: compressive strength of M25 grade concrete for 14 days

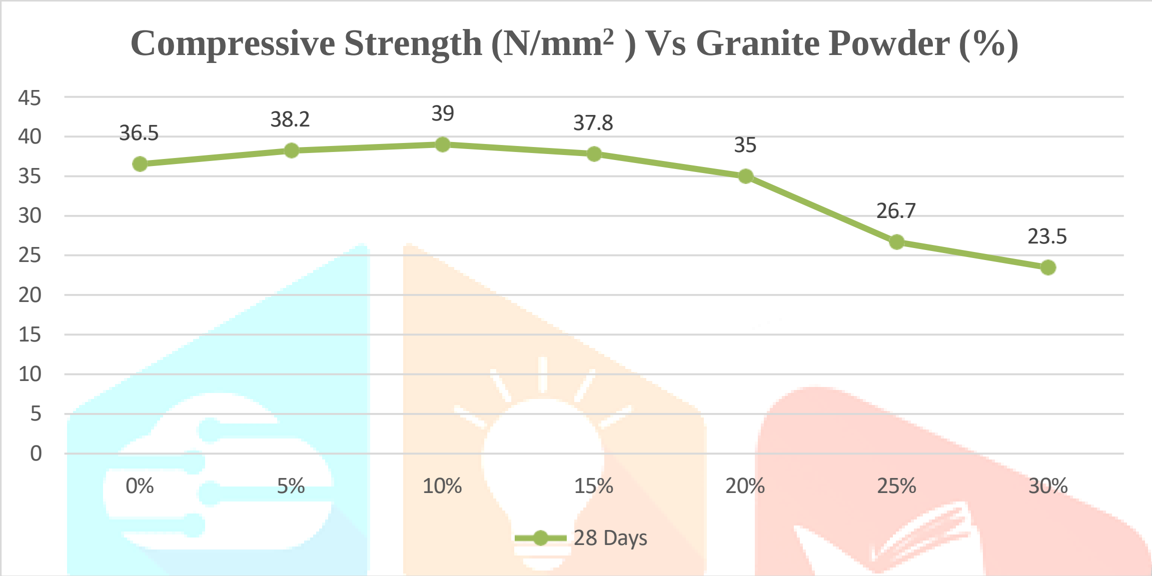


GRAPH Compressive Strength

4.2.4 Compressive strength of concrete for 28 days

S. no	% of Granite powder	Load (KN)	Compressive strength(N/mm^2)
1	0%	821	36.5
2	5%+5%	859	38.2
3	10%+10%	878	39.0
4	15%+15%	850	37.8
5	20%+20%	787	35.0
6	25%+25%	643	26.7
7	30%+30%	592	23.5

Table 4.3: Compressive strength of M25 grade concrete for 28 days



GRAPH Compressive Strength

TENSILE TEST

The Tensile testing Machine is highly recommended for evaluating the tensile strength of products and materials. The equipment is based on the Constant Rate of Traverse (CRT) principle. It is equipped with an upper jaw and a lower jaw. Universal Tensile Testing Machine is a reliable piece of equipment which is widely used for checking tensile strength of a product/sample. One of the most common mechanical testing techniques used to determine tensile strength, this is a method wherein controlled tension is applied to a sample until it fully fails.

Thus, the material properties of the sample can be easily determined by this test. It involves measuring the force required to elongate a sample under test to breaking point. Using this test, manufacturers and quality managers are able to determine the core strength of their products.

Test Specimen Preparation:

1. Shape: Common shapes include:
   - Cylindrical with metallic end caps
   - Dumbbell shape with a reduced middle cross-section to promote failure in the center
2. Curing: Standard 28-day curing in water
3. Surface: Ensure ends are smooth and parallel for proper gripping

Test Procedure:

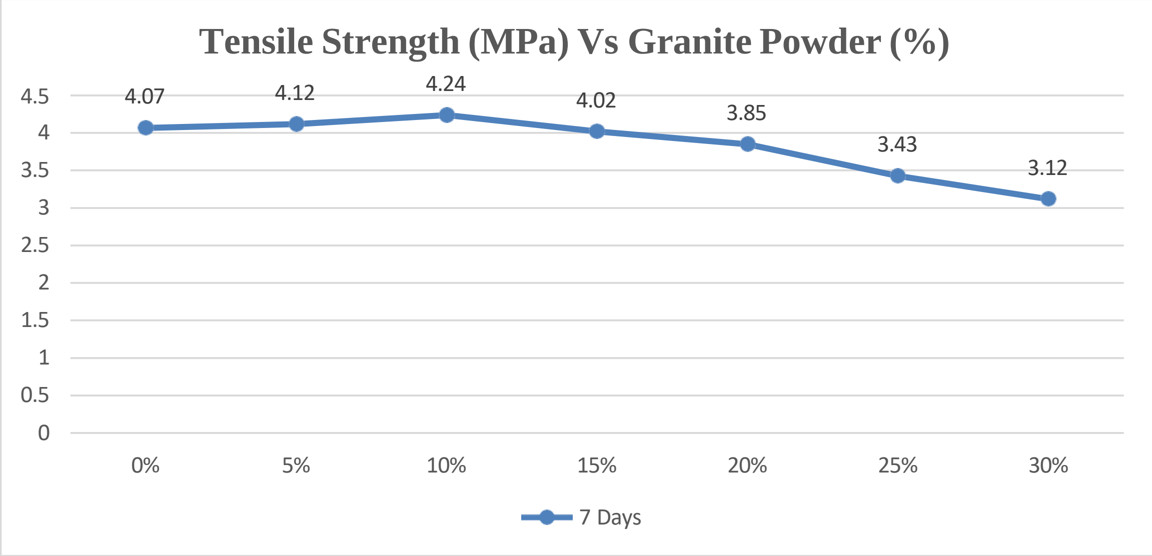
1. Mark the Gauge Length: Mark the central portion of the specimen for strain measurement (optional).
2. Grip Attachment:
   - Attach end fixtures/caps to the specimen using strong adhesive (like epoxy) or mechanical clamping.
   - Ensure perfect axial alignment to avoid bending.
3. Mounting:
   - Place the specimen vertically in the tensile testing machine.
   - Carefully align the specimen to prevent eccentric loading.
4. Loading:
   - Start applying tensile load gradually and uniformly.
   - Maintain a constant strain rate (as per the machine setting).
   - Observe the load and deformation until the specimen fails.
5. Record Failure Load:
   - Note the maximum load (P) just before the specimen fractures.

4.2.5 Test Results:

4.2.6 Tensile strength of M25 grade of concrete

S. no	% Granite powder	Load (KN)	Tensile Strength (MPa)
1	0%	72	4.07
2	5%+5%	73	4.12
3	10%+10%	75	4.24
4	15%+15%	71	4.02
5	20%+20%	70.5	3.85
6	25%+25%	64.3	3.43
7	30%+30%	61.8	3.12

TABLE 4.4 Tensile strength of M25 grade concrete for 7 days

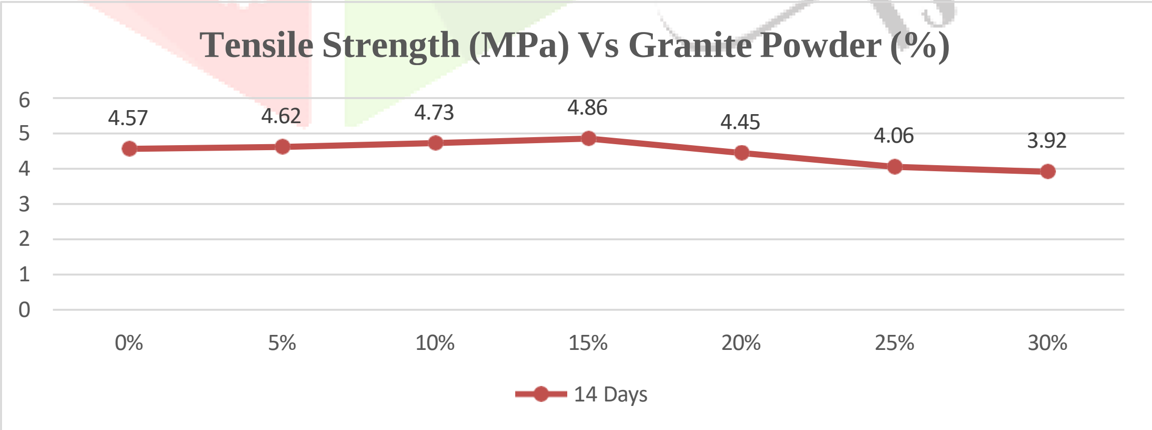


GRAPH Tensile Strength

4.2.7 Tensile Strength strength of concrete for 14 days

s no	% of Granite powder	Load (KN)	Tensile strength(MPa)
1	0%	80.5	4.57
2	5%+5%	82.0	4.62
3	10%+10%	84.2	4.73
4	15%+15%	86.4	4.86
5	20%+20%	78.4	4.45
6	25%+25%	71.6	4.06
7	30%+30%	69.5	3.92

Table 4.5: Tensile strength of M25 grade concrete for 14 days



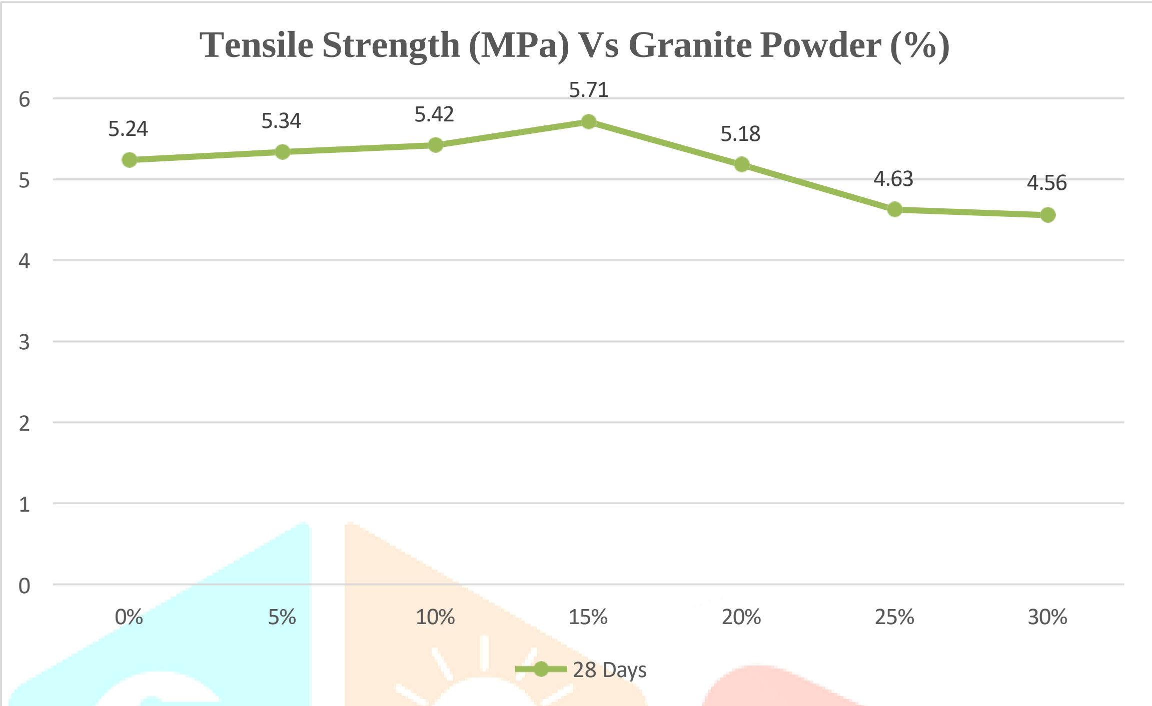
GRAPH Tensile Strength

4.2.8 Tensile strength of concrete for 28 days

S. no	% of Granite powder	Load (KN)	Tensile strength(n/mm^2)
1	0%	93	5.25
2	5%+5%	92.7	5.34
3	10%+10%	96	5.42
4	15%+15%	98.8	5.71

5	20%+20%	90	5.18
6	25%+25%	85.6	4.63
7	30%+30%	82	4.56

Table 4.6: Tensile strength of M25 grade concrete for 28 days



GRAPH Tensile Strength

CONCLUSION

The experimental study on the partial replacement of cement with granite powder in concrete has demonstrated that granite powder can be a viable alternative material in sustainable construction. The key findings include:

- **Strength Performance**: The compressive strength of concrete improves with moderate replacement levels (5%-15%) but decreases at higher levels (25%-30%) due to reduced cementitious content.
- **Workability**: Increasing granite powder content reduces workability, requiring adjustments in water-cement ratio or admixtures.
- **Durability**: Concrete with up to 20% replacement showed improved durability, indicating reduced porosity and better resistance to environmental effects.
- **Sustainability**: Utilizing granite powder as a partial cement replacement helps reduce industrial waste and supports eco-friendly construction practices.

Based on the test results the present investigation the following conclusion are drawn:

- For 7 days curing, the compressive strength is getting increased as we increase % of Granite powder. The compressive strength of concrete at 0% Granite powder is 22.5 N/mm² whereas for concrete with 5% of Granite powder is 23.8 N/mm²,10% of Granite powder is 28 N/mm^2 & 15% of Granite powder is 23.0 N/mm^2,20% Granite powder 21.2 N/mm^2,25% of Granite powder 19.3 N/mm^2,30% Granite powder 17.6 N/mm^2
- For 14 days curing, the compressive strength is getting increased as we increase % of Granite powder. The compressive strength of concrete at 0% Granite powder is 30.2N/mm² whereas for concrete with 5% of Granite powder is 31.5 N/mm²,10% of Granite powder is 32.0 N/mm2 & 15% of Granite powder is 30.5 N/mm2, 20% Granite powder 28.6 N/mm^2,25% of Granite powder 23.6 N/mm^2,30% Granite

powder 20.5N/mm

- For 28 days curing, the compressive strength is getting increased as we increase % of Granite powder. The compressive strength of concrete at 0% Granite powder is 36.5 N/mm² whereas for concrete with 5% of Granite powder is 38.2 N/mm²,10% of Granite powder is 39.0 N/mm2 & 15% of Granite powder is 37.8 N/mm2, 20% Granite powder 35.0 N/mm^2,25% of Granite powder 26.7 N/mm^2,30% Granite powder 23.5 N/mm^2

Optimal Replacement Level: Based on the results, 10%-20% granite powder replacement is recommended for achieving a balance between strength, workability, and durability.

This study highlights the potential of granite powder as a sustainable construction material, encouraging further research and practical implementation in real-world applications.

- We can save nearly ₹ **11,25,000-45,00,000** for 5000-10000 m³ of concrete.

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