Experimental Investigation on the Compressive Strength of Microconcrete and Conventional Concrete

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***Abstract*—As a cornerstone of civil engineering, concrete remains the most extensively utilized construction material globally. The advent of specialized cement-based formulations has catalysed the integration of micro concrete into critical domains such as structural reinforcement, rehabilitation, and repair. This research endeavours to empirically assess and juxtapose the compressive strength profiles of micro concrete against conventional concrete. Specimens were fabricated using meticulously selected mix designs and subjected to testing across various curing intervals. Compressive strength was quantified via a Universal Testing Machine (UTM), with subsequent analysis comparing the data to delineate the distinct strength evolution trajectories of both material types. Furthermore, the study scrutinizes the pivotal roles played by material composition, water-cement ratio, and curing duration in governing compressive strength. This investigation aims to establish a comparative framework for evaluating the mechanical properties and prospective applications of micro concrete alongside conventional concrete.**

I. INTRODUCTION

Concrete is an essential construction material used in buildings, bridges, foundations and other infrastructure. Conventional concrete consists mainly of cement, fine aggregate, coarse aggregate and water. Its strength and durability depend on material properties, mix proportions, compaction and curing conditions. Microconcrete is a specialised cement-based material generally formulated with fine aggregates and, depending on the product, mineral or chemical admixtures. Some commercial microconcrete products are flowable and non-shrink materials used for repairing damaged concrete members, grouting and structural rehabilitation. The compressive strength of concrete is an important parameter for evaluating its ability to resist compressive loads. Therefore, comparing the compressive strength of microconcrete and conventional concrete can help understand their mechanical performance and suitability for different construction applications. By 2050, the global population is projected to reach approximately 9.7 billion—an increase of 1.5 billion from current levels—with an estimated 68 % living in urban areas, a considerable rise from the current 55 % [1]. This rapid urbanization will drive significant demand for housing, pavements, pedestrian zones, local road networks, highways, rail infrastructure, power supply systems, cycling facilities, and other essential infrastructure. According to the United Nations, approximately 1.6 billion people, i.e. 20 % of the current population, lack adequate housing and essential services, with some sources projecting that this number could rise to 3 billion by 2030. Regardless of the underlying causes, the UN estimates that around 96,000 new homes will need to be built worldwide each day to meet demand [2]. Although economic crises may temporarily or locally affect this growth rate, achieving sustainable development will become increasingly challenging if the current exploitation, consumption, and waste generation patterns are maintained, leading to rapid depletion of natural resources [3]. Meeting this demand using current civil construction practices would require a substantial increase in Portland cement consumption, a material with significant environmental impacts [4], [5]. For every ton of Portland cement produced, approximately

600 kg of CO_2 is emitted into the atmosphere [6], an environmental cost that scales proportionally with global demand for cementitious materials and is no longer acceptable in the context of sustainability. In 2020 alone, global concrete production reached around 14×10^9 m^3 , approximately 40 % destined for the residential market, and Portland cement production totalled 4.2×10^9 tons [1]. The Cement Technology Roadmap [7] proposes strategies to mitigate CO_2 emissions in cement production, including improving thermal and electrical efficiency, adopting alternative fuels, and implementing CO_2 capture and storage. However, the partial replacement of clinker with potentially reactive materials capable of forming hydraulic compounds (supplementary cementitious materials – SCM), is recognized as the most cost-effective strategy for reducing the carbon footprint of cement and concrete

II. CLASSIFICATION OF MICROCONCRETE

Microconcrete is a specialised cement-based construction material used mainly for repair, rehabilitation and strengthening of reinforced concrete structures. It is generally prepared using cement, fine aggregates, water and suitable chemical or mineral admixtures. Depending on the product or mix design, it may contain specially graded small aggregates and may be designed to provide high flowability and reduced shrinkage. One of the main advantages of microconcrete is its ability to fill narrow gaps and congested reinforcement areas with proper placement. It is commonly used in column jacketing, beam and slab repairs, structural strengthening and filling damaged concrete sections. Its properties, such as compressive strength, workability, bonding and durability, depend on its composition and curing conditions. In structural engineering, microconcrete is an important material for rehabilitation because it can help restore the strength and serviceability of damaged concrete members. Key characteristics - High flowability in suitable formulations. - Good compressive strength. - Suitable for congested reinforcement. - Used in repair and rehabilitation work. - Can be formulated for low shrinkage. - Useful for filling restricted or inaccessible sections.

2.4 Research Gap

Previous studies have investigated the mechanical behaviour of microconcrete, including the influence of water-cement ratio, aggregate grading, cement content and loading conditions.

However, a controlled comparative experimental investigation of the compressive strength of a selected microconcrete product or mix and conventional concrete under the same curing ages and testing conditions can provide useful additional information.

This study therefore focuses on comparing the compressive strength of both materials using consistent specimen preparation, curing and testing procedures.

III. AIM

To experimentally investigate and compare the compressive strength of microconcrete and conventional concrete.

IV. OBJECTIVE

1. To study the properties and composition of microconcrete and conventional concrete.
2. To prepare specimens of both materials using selected mix proportions.
3. To determine compressive strength at 7, 14 and 28 days.
4. To compare the strength development of both materials.
5. To identify their potential applications in construction and structural rehabilitation.

V. MATERIALS REQUIRED

1. Cement

Used as the primary binding material in conventional concrete and in cement-based microconcrete formulations.



2. Fine aggregate

Sand or suitably graded fine aggregate used in the concrete mix.



3. Coarse aggregate

Used in conventional concrete according to the selected mix design. Its use in microconcrete depends on the product formulation.



4. Microconcrete material

Commercial prepacked microconcrete or a specifically designed laboratory microconcrete mix.



5. Water

Clean water suitable for concrete mixing and curing.



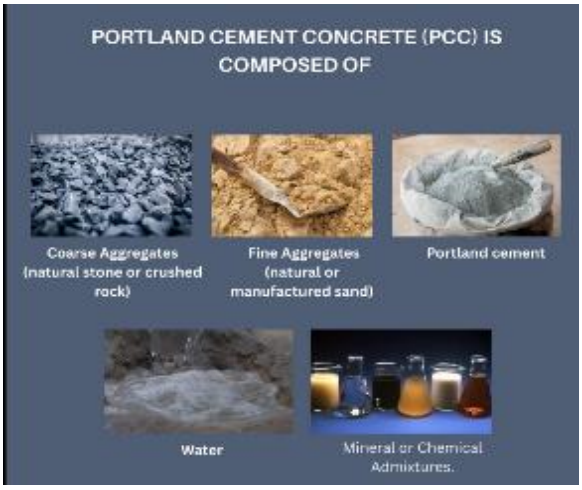
6. Chemical admixture

Used where required by the selected mix design or microconcrete manufacturer's instructions.



7. Experimental methodology

Step 1: Material collection



The purpose of material collection is to obtain all the required materials for preparing conventional concrete and microconcrete specimens. The quality and properties of the materials directly influence the workability and compressive strength of concrete.

5.2 Materials required

Material Purpose

Cement Binding material in conventional concrete

Fine aggregate Fills voids and contributes to the concrete matrix

Coarse aggregate Provides the aggregate skeleton in conventional concrete

Water Required for hydration and workability

Microconcrete Specialised material selected for comparison

Admixture Improves flowability or other properties when required

5.3 Detailed procedure

1. Collect cement from a reliable manufacturer and record its type and grade.
2. Collect fine aggregate and coarse aggregate from a suitable source.
3. Ensure that aggregates are reasonably clean and free from unwanted organic impurities.
4. Collect clean water suitable for concrete preparation.
5. Select the microconcrete material. If it is a commercial product, obtain its technical data sheet.
6. Record the brand, product name, batch number, manufacturing date and expiry date, where applicable.
7. Store all materials in suitable conditions to prevent moisture contamination.

5.4 Equipment required

- Weighing balance.
- Measuring containers.
- Material storage containers.
- Sample trays.
- Laboratory record book.

5.5 Observations to record

Material Details to record

Cement Type, grade, brand and manufacturing date

Fine aggregate Source, grading and moisture condition

Coarse aggregate Source, nominal maximum size and grading

Water Source and suitability

Microconcrete Brand, product specifications and recommended water dosage

Step 2: Material testing



VI. PURPOSE

Material testing is carried out to understand the physical properties of the constituent materials. These properties are useful for selecting suitable materials and determining the concrete mix proportions.

6.1 Specific gravity test

Purpose: To determine the ratio of the density of a material to the density of water at a specified temperature.

Equipment:

- Pycnometer or suitable specific gravity apparatus.
- Weighing balance.
- Water.
- Sample of aggregate.

Procedure:

1. Take a clean and dry sample of aggregate.
2. Weigh the empty apparatus.
3. Add the aggregate sample and record its mass.
4. Add water according to the selected test procedure.
5. Remove trapped air and record the required masses.
6. Calculate specific gravity using the appropriate formula for the selected apparatus and aggregate condition. Pavement.

Purpose: To determine the particle-size distribution of fine and coarse aggregates.

Equipment:

- Standard test sieves.
- Sieve shaker.
- Weighing balance.
- Sample trays.
- Brush.

Procedure:

1. Take a representative aggregate sample.
2. Dry the sample to the required condition.
3. Weigh the total sample.
4. Arrange the standard sieves in descending order of opening size.
5. Place the sample on the top sieve.
6. Shake the sieve stack manually or mechanically for the specified duration.
7. Weigh the material retained on each sieve.
8. Calculate percentage retained, cumulative percentage retained and percentage passing.
9. Prepare a particle-size distribution curve if required.

Calculations:

\[\%\text{ Retained}= \frac{\text{Mass retained on sieve}}{\text{Total sample mass}}\times100 \]

\[\%\text{ Passing}=100-\%\text{ Cumulative retained} \]

laboratory. These tests are based on fatigue loading simulating traffic loads and movements ≥ 0.2 mm/h due to thermal expansion or/and ≥ 0.6 mm/s due to traffic loads. There are two load models with contact pressure of

0.8 N/mm² and 1.0 N/mm². The number of cycles depends on desired durability category: 10, 15, 25 or 50 years.

6.2 Water absorption test



Purpose: To determine the amount of water absorbed by aggregate.

Procedure:

1. Take a representative aggregate sample.
2. Wash it if required by the test procedure.
3. Immerse the sample in water for the specified period.
4. Remove the sample from water.
5. Bring it to the saturated surface-dry (SSD) condition using the appropriate method.
6. Record the SSD mass.
7. Oven-dry the sample to constant mass.
8. Record the oven-dry mass.
9. Calculate the water absorption.

\[\%\text{ Water absorption}= \frac{W_{SSD}-W_{dry}}{W_{dry}}\times100 \]

Where:

- \(W_{SSD}\) = saturated surface-dry mass.
- \(W_{dry}\) = oven-dry mass.

Result: Water absorption percentage of aggregates.

6.3 Summary of material tests

Test	Material	Main output
Specific gravity	Fine and coarse aggregates	Specific gravity
Sieve analysis	Fine and coarse aggregates	Particle-size distribution
Water absorption	Fine and coarse aggregates	Absorption percentage
Bulk density	Fine and coarse aggregates	kg/m³

Important: For commercial prepacked microconcrete, its internal aggregate grading and proportions may be proprietary. Do not claim to have tested its separate ingredients unless the manufacturer supplies them and they can be sampled properly.

Step 3: Mix selection

6.4 Purpose

The purpose of mix selection is to decide the concrete grade and material proportions for preparing the test specimens.

6.5 Conventional concrete mix selection

For conventional concrete, select the required grade, such as M20, M25 or M30, depending on the project objectives.

For example, if M30 concrete is selected, its target mean strength must be considered during mix design.

The mix design should account for:

- Grade of concrete.
- Required workability.

- Water-cement ratio.
- Cement content.
- Fine aggregate content.
- Coarse aggregate content.
- Admixture dosage, if required.
- Moisture condition and water absorption of aggregates.

The mix proportions should be established using the applicable concrete mix-design procedure, not simply by assuming a nominal ratio.

6.6 Microconcrete mix selection

If commercial prepacked microconcrete is selected:

1. Identify the product and its intended application.
2. Read the manufacturer's technical data sheet.
3. Note the recommended water-to-product dosage.
4. Record the recommended mixing time and equipment.
5. Note the specified layer thickness, placement and curing requirements.
6. Check the specified strength-testing procedure and specimen dimensions.

If laboratory-made microconcrete is selected, establish and document its constituent proportions and aggregate grading.

6.7 Mix design record

Parameter	Conventional concrete	Microconcrete
Grade/product	Selected grade	Product name/formulation
Cement	As per mix design	As per formulation, if known
Fine aggregate	As per mix design	As per formulation, if known
Coarse aggregate	As per mix design	Depends on formulation
Water	As per mix design	Manufacturer's dosage or designed quantity
Admixture	As required	As specified or designed

Step 4: Mixing

4.1 Purpose

Mixing ensures uniform distribution of cement, aggregates, water and admixtures to obtain a consistent concrete mixture.

6.8 Equipment required

- Concrete mixer or pan mixer.
- Mixing tray.
- Weighing balance.
- Measuring cylinder.
- Shovel or trowel.
- Stopwatch.
- Personal protective equipment.

6.9 Conventional concrete mixing procedure

1. Clean the mixer or mixing tray.
2. Weigh the required quantity of cement.
3. Measure the required fine and coarse aggregates.
4. Mix the dry aggregates and cement until reasonably uniform.
5. Add the calculated water gradually.
6. Add admixture, if specified, using the approved dosage and procedure.
7. Continue mixing until a uniform mixture is obtained.
8. Check the fresh concrete workability using the appropriate test.
9. Record the mixing time and any unusual observations.

6.10 Microconcrete mixing procedure

1. Clean the mixing container and mixing equipment.
2. Measure the exact quantity of prepacked microconcrete.
3. Measure the water specified by the manufacturer.
4. Add the material and water in the recommended sequence.
5. Mix using a suitable mechanical mixer.
6. Avoid adding extra water to improve flowability unless the manufacturer's instructions permit it.
7. Continue mixing for the specified duration.
8. Check the consistency and flow characteristics using the product-recommended method.

6.11 Fresh concrete observations

Record the following:

- Appearance and uniformity.
- Workability or flowability.
- Mixing time.
- Water quantity.
- Admixture dosage.
- Any segregation or bleeding.

Expected output: Two separately prepared, uniform mixtures ready for casting.

VII. CASTING OF SPECIMENS

7.1 Purpose

Casting is carried out to prepare standardised specimens for determining the compressive strength of the selected materials.

7.2 Equipment required

- Cube moulds of the specified size.
- Mould oil/release agent.
- Tamping rod or suitable compaction equipment.
- Trowel.
- Concrete tray.
- Identification labels.

7.3 Specimen selection

A 150 mm cube is a commonly used concrete compression-test specimen in Indian laboratories, subject to the applicable standard and material requirements.

A proposed specimen plan is:

Material	7 days	14 days	28 days	Total
Conventional concrete	3	3	3	9
Microconcrete	3	3	3	9
Total	6	6	6	18

Confirm that the microconcrete manufacturer's procedure allows this specimen size and testing method before using the same cube dimensions for both materials.

7.4 Casting procedure

For conventional concrete:

1. Clean the cube moulds.
2. Apply a thin layer of mould-release oil to the internal surfaces.
3. Assemble the mould properly and check for leakage.
4. Fill the mould in the required number of layers according to the applicable test procedure.
5. Compact each layer using the prescribed method.
6. Avoid excessive compaction, segregation and air voids.
7. Level the top surface using a trowel.
8. Mark the specimen identification number.

For microconcrete:

1. Prepare the mould according to the specified product procedure.
2. Apply suitable mould-release agent if permitted.
3. Place the mixed material into the mould.
4. Allow it to flow and fill the mould.
5. Use only the compaction or vibration procedure recommended by the manufacturer.
6. Avoid excessive vibration, which may cause segregation in some formulations.
7. Finish the surface and identify the specimen.

7.5 Specimen identification

For example:

- CC-7-1: Conventional concrete, 7 days, cube 1.
- CC-28-2: Conventional concrete, 28 days, cube 2.
- MC-7-1: Microconcrete, 7 days, cube 1.
- MC-28-3: Microconcrete, 28 days, cube 3.

Step 6: Curing

1 Purpose



Curing provides suitable moisture and temperature conditions for the development of concrete strength. Inadequate curing can affect the measured compressive strength.

2 Equipment required

- Curing tank.
- Clean water.
- Thermometer, if required.
- Specimen identification tags.
- Laboratory record sheet.

3 Procedure

1. Keep the specimens undisturbed for the initial setting period specified by the applicable procedure.
2. Demould the specimens carefully.

3. Check each specimen for visible damage.
4. Record the specimen identification and demoulding date.
5. Place specimens in the specified curing environment.
6. Maintain the required curing conditions.
7. Keep the specimens identified and separated by testing age.
8. Remove the specimens at their designated testing age.

4 Curing ages

- 7 days.
- 14 days.
- 28 days.

These ages provide information about strength development over time. Follow the applicable product instructions if the microconcrete requires a different curing method or test age.

5 Precautions

- Do not damage cube edges during demoulding.
- Do not mix up specimen identification numbers.
- Avoid drying of specimens during the curing period.
- Maintain comparable and documented conditions wherever the two materials' specifications allow.

Step 7: Compressive strength testing using CTM

7.1 Purpose

The purpose of the compressive strength test is to determine the maximum compressive load that the specimen can withstand before failure.

7.2 Equipment required

- Calibrated Compression Testing Machine.
- Concrete cube specimens.
- Measuring scale or vernier caliper.
- Cleaning brush.
- Laboratory observation sheet.

7.3 Testing procedure

1. Remove the specimen from the curing environment at the selected testing age.
2. Clean the surface of the specimen.
3. Measure and record its dimensions.
4. Check the specimen for visible defects.
5. Clean the CTM bearing surfaces.
6. Place the cube centrally on the lower platen.
7. Ensure that the load is applied to the appropriate faces according to the test method.
8. Apply the load continuously at the prescribed rate.
9. Continue loading until the specimen fails.
10. Record the maximum failure load.
11. Remove the failed specimen carefully.
12. Repeat the procedure for all specimens.
13. Calculate the compressive strength for each specimen.

7.4 Calculation

\[f_c=\frac{P}{A} \]

Where:

- \(f_c\) = Compressive strength in N/mm².
- \(P\) = Maximum failure load in N.
- \(A\) = Loaded area in mm².

Illustrative calculation

Assume:

- Cube dimensions = 150 × 150 × 150 mm.
- Maximum failure load = 675 kN.

VIII. CONCLUSION

“The experimental investigation was carried out to compare the compressive strength of microconcrete and conventional concrete. Specimens were prepared and tested at selected curing ages. The obtained results were analysed to evaluate the strength development of both materials. Based on the experimental observations, the relative compressive-strength performance of the selected microconcrete and conventional concrete was determined. The study provides information regarding the potential application of the tested materials in construction and structural rehabilitation.”

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