COMPARATIVE ANALYSIS OF COMPRESSIVE STRENGTH IN CONCRETE CYLINDERS AND CUBES

By

Md. Ashraful Islam

Md. Shahidullah

Md. A M Mahin

Md. Zahidul Hasan Chowdhury

A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



Department of Civil Engineering

Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

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By

Md. Ashraful Islam	CE2002020026
Md. Shahidullah	CE2102023145
Md. A M Mahin	CE2102023163
Md. Zahidul Hasan Chowdhury	CE2102023009

Supervisor

M.A. Bashar Bhuiyan

Lecturer,

Department Of Civil Engineering (SU)

147/1, Green Road, Panthapath, Dhaka-1215, Bangladesh

A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



Department of Civil Engineering

Sonargaon University

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M.A. Bashar Bhuiyan — Chairman
Lecturer,
Sonargaon University

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STUDENT NAME	STUDENT ID.	SIGNATURE
Md. Ashraful Islam	CE2002020026	
Md. Shahidullah	CE2102023145	
Md. A M Mahin	CE2102023163	
Md. Zahidul Hasan Chowdhury	CE2102023009	

Dedicated

To

"Mother"

"Everyone in the world will love you, in that love hides any need. But the one person who will love you unconditionally .She is our mother"

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ABSTRACT

Concrete's compressive strength is vital for assessing its ability to withstand loads. This study compares the compressive strength of concrete using cube and cylindrical specimens to understand the reasons for observed variations.

Specimens were prepared with a target strength of 30 MPa at 28 days, using Ordinary Portland Cement (OPC), river sand, and crushed granite. Cube (100 mm x 100 mm) and cylinder (100 mm x 200 mm) specimens were cured for 7, 14, and 28 days, and tested for compressive strength. The strength variation is due to differences in specimen geometry, stress distribution, and failure modes. Cubes experience uniform stress distribution, while cylinders show concentrated stress at the ends, leading to lower strength.This study concludes that cubes provide higher compressive strength than cylinders, with implications for concrete testing standards and quality control. Further research on concrete grade, specimen size, and curing methods is recommended.

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CHAPTER 1
Introduction

1.1 Background and Motivations

Concrete, one of the most widely used construction materials, is essential for building the infrastructure that supports modern civilization. Its strength, durability, and versatility make it a popular choice for a variety of structures, from buildings and bridges to roads and dams. Compressive strength is one of the most important properties of concrete, as it determines the material's ability to withstand loads without failure. As such, testing the compressive strength of concrete is a fundamental part of quality control in the construction industry.

The compressive strength of concrete is typically evaluated by casting specimens in standard shapes, such as cubes or cylinders, and subjecting them to a controlled load in a compression testing machine. The results of these tests provide critical information on the concrete's capacity to resist compressive forces and are used to assess whether the concrete meets the required strength for a specific project.

However, it has been observed that the shape of the specimen used for testing can influence the measured compressive strength. Concrete specimens cast in cube form generally yield higher compressive strength values compared to those cast in cylindrical form. This variation in results is a subject of considerable interest in the field of civil engineering, as it may have implications for testing standards, material selection, and the interpretation of concrete strength in practice.

This thesis aims to explore and analyze the variation in compressive strength between cube and cylindrical specimens of concrete. The primary objective of the study is to compare the compressive strength of concrete cubes and cylinders, and to investigate the factors that contribute to any differences observed in the results. By conducting this study, we hope to provide a better understanding of how specimen shape influences compressive strength testing, which can, in turn, lead to improved testing procedures and more accurate predictions of concrete performance in real-world applications.

1.2 Problem Statement

Concrete is a fundamental material used in the construction industry, and its compressive strength is a key indicator of its quality and suitability for various applications. Standard tests for determining compressive strength typically involve using concrete specimens in the form of cubes or cylinders. However, a significant variation in compressive strength results has been observed between these two specimen shapes. Several studies have reported that cube specimens generally exhibit higher compressive strength compared to cylindrical specimens, which raises questions regarding the reliability and accuracy of results obtained from these different shapes. The discrepancy in results can affect the interpretation of concrete quality and may have implications for construction practices, particularly in regions where one specimen shape is favored over the other.

Despite the widespread use of both cubes and cylinders in strength testing, there is limited consensus on the reasons behind this variation and its practical significance. The variation in compressive strength results could be due to several factors, such as differences in specimen size, geometry, and stress distribution during testing. This research aims to address this knowledge gap by systematically comparing the compressive strength of concrete cubes and cylinders under controlled conditions, providing insights into the factors contributing to the observed differences.

1.3 Research Objectives

The primary objective of this research is to compare the compressive strength of concrete when tested using cube and cylindrical specimens. The specific objectives of this study are:

1. To determine and compare the compressive strength of concrete cubes and cylinders: Concrete specimens will be cast in both cube (100 mm) and cylinder (100 mm x 200 mm) forms, and their compressive strengths will be tested at various curing ages (e.g., 7 days,14 days, 28 days).

2. To investigate the influence of specimen shape on compressive strength results: The study will explore how the shape of the specimen (cube vs cylinder) affects the compressive strength measurements. This includes analyzing the differences in stress distribution and failure modes between cubes and cylinders.

3. To evaluate the effect of curing conditions and specimen dimensions: This objective involves examining how curing conditions (e.g., standard curing vs. water curing) and the size of the specimens impact the compressive strength for both cubes and cylinders.

4. To analyze the correlation between experimental results and established standards: The study will compare the obtained results with relevant international standards (such as ASTM and IS codes) to assess the consistency of the compressive strength values for both specimen shapes.

5. To provide recommendations for concrete testing: Based on the findings, recommendations will be made regarding the use of cubes or cylinders for specific applications, considering factors such as accuracy, practicality, and cost.

1.4 Scope of Study

This study focuses on the comparison of compressive strength between concrete specimens cast in the form of cubes and cylinders. The following scope defines the boundaries of this research:

1. Materials: Ordinary Portland cement (OPC) will be used as the binder, and fine and coarse aggregates will be sourced locally. The concrete mix design will be based on a target compressive strength of 30 MPa at 28 days.

2. Specimen Types: Concrete specimens will be prepared in two standard shapes:

- Cubes with dimensions of 100 mm x 100 mm x 100 mm.
- Cylinders with a diameter of 100 mm and a height of 200 mm.

3. Testing Age: The compressive strength tests will be conducted at two key ages: 7 days 14 days and 28 days of curing. These time intervals are commonly used in concrete testing to assess early-age and long-term strength development.

4. Curing Conditions: The concrete specimens will be cured under standard laboratory conditions (20 ± 2°C and 95% relative humidity) for the first 7 days, and the testing will be performed after curing for 7 and 28 days.

5. Testing Method: The compressive strength of the specimens will be measured using a calibrated compression testing machine. The load will be applied gradually until failure, and the peak load will be recorded to calculate the compressive strength.

6. Comparison with Standards: The research will adhere to relevant testing standards, such as ASTM C39 (for cylinders), IS 516:1959 (for cubes), and other applicable guidelines to ensure the validity and reliability of the results.

7. Limitations: This study will focus on a single grade of concrete (30 MPa) and will not consider variations in other types of concrete (e.g., high-strength concrete, self-compacting concrete). Additionally, the research will not explore the effects of varying aggregate types or admixtures on the compressive strength variation..

CHAPTER 2

Literature Review

The compressive strength of concrete is one of the most critical properties for evaluating its suitability for structural applications. Various standards and testing methods exist to assess this property, with cube and cylinder specimens being the most commonly used forms. Despite their widespread use, there is ongoing debate regarding the differences in compressive strength values obtained from cube and cylindrical specimens. This section reviews previous studies and literature on the factors influencing the variation in compressive strength results between cubes and cylinders, including specimen geometry, stress distribution, curing conditions, and material properties.

2.1 Compressive Strength of Concrete

Compressive strength is defined as the ability of a material to withstand axial loads without failure. For concrete, it is typically measured by applying a compressive load to a specimen of known dimensions until failure occurs. The strength is then calculated as the maximum load divided by the cross-sectional area. The test is usually carried out on concrete cubes (100 mm x 100 mm x 100 mm) or cylinders (100 mm diameter x 200 mm height) at various curing ages (e.g., 7 days, 14days, 28 days). The results are influenced by several factors, including the water-cement ratio, aggregate type, curing conditions, and the shape of the specimen.

2.2. Shape and Geometry of Concrete Specimens

The geometry of the specimen has a significant effect on the compressive strength results. Concrete cubes and cylinders differ in their aspect ratio (height-to-diameter ratio for cylinders) and failure mechanisms. While cubes have equal dimensions on all sides, cylinders are taller than their diameter, which leads to differences in how the stress is distributed during the test.

- Course Aggregates: These are larger particles, such as gravel or crushed stone that are retained on the 4.75 mm sieve. Coarse aggregates provide the bulk and structural strength to the concrete. The size, shape, and cleanliness of coarse aggregates are critical to achieving the desired properties of concrete. For instance, angular

aggregates tend to interlock better, providing higher strength compared to rounded aggregates.

- Cube Specimens: Cube specimens are typically easier to handle and test due to their uniform dimensions. They also provide a more isotropic stress distribution because the load is applied uniformly across all faces. This often results in higher compressive strength values compared to cylinders.

- Cylinder Specimens: Cylindrical specimens are more representative of concrete in real-world applications, such as beams, columns, and pavements, which are typically cylindrical or prismatic in shape. However, due to their geometry (height greater than diameter), cylinders tend to fail in a more brittle manner and experience localized stress concentrations near the ends, leading to lower compressive strength values.

2.3. Factors Affecting Compressive Strength Variation

Several studies have investigated the reasons behind the variation in compressive strength between cubes and cylinders. These factors include specimen size, stress distribution, and failure modes.

- Stress Distribution: According to Malhotra (1999), the stress distribution in a cube is more uniform than in a cylinder due to the isotropic nature of the cube's geometry. In contrast, a cylinder has a higher aspect ratio (height-to-diameter), which can result in more concentrated stress at the ends, causing earlier failure and lower measured strength.

- Failure Mechanisms: Mindess et al. (2003) noted that the failure mode of concrete cubes is more ductile compared to that of cylinders. Cubes tend to crush more evenly under load, whereas cylinders experience a more linear failure along the height, which may lead to different strength outcomes. The difference in failure modes is often cited as one of the primary reasons for the strength discrepancy between cubes and cylinders.

- Size Effect: The size of the specimen can also influence the compressive strength. Larger specimens generally exhibit lower compressive strength due to factors such as internal imperfections, aggregate distribution, and curing variability. Bazant and Pang (2007) found that the compressive strength of larger specimens, such as cylinders, may be lower than that of smaller specimens like cubes due to these inherent material heterogeneities.

2.4. Previous Studies on Compressive Strength Variation

A number of studies have explored the differences in compressive strength between cube and cylindrical specimens, and the findings have been mixed. Some studies report that cube specimens consistently show higher strength than cylinders, while others find minimal variation.

- Murdock (1994) compared the compressive strength of concrete cubes and cylinders and found that cubes exhibited an average strength increase of 10-15% compared to cylinders. This study attributed the difference to the more uniform stress distribution in cubes and the more ductile failure mechanism.

- Mollah and Shafiq (2010) conducted experiments on high-strength concrete and compared the results from cubes and cylinders. Their findings suggested that the compressive strength of cubes was consistently higher, but the difference decreased as the strength of concrete increased. They hypothesized that the difference in strength could be attributed to the increased brittleness of high-strength concrete and the reduced effect of specimen geometry at higher strengths.

- Gehm and Lauer (2006) explored the relationship between cube and cylinder strength across different concrete grades and curing methods. Their research confirmed that cubes generally provide higher compressive strength results, but the disparity was more significant for low-strength concretes. For high-strength concretes, the variation between cube and cylinder strength was relatively minor.

- Aitcin (2000) reviewed the factors influencing compressive strength and concluded that while cubes often yield higher results, cylinders are more representative of real-

world structural elements. The study emphasized that the choice of specimen shape should depend on the context in which the concrete is being used and the specific testing standards that apply.

2.5. Influence of Curing Conditions

Curing is one of the most critical factors affecting the compressive strength of concrete. Proper curing ensures that the concrete reaches its full strength potential by maintaining adequate moisture content and temperature. Several studies have indicated that curing conditions can impact the results obtained from cube and cylinder specimens differently.

- **Mineral Admixtures:** These include fly ash, slag, silica fume, and natural pozzolans. Mineral admixtures are often used to enhance the durability and performance of concrete. For example, fly ash can improve the workability and long-term strength of concrete, while silica fume increases the strength and reduces the permeability of concrete, making it more resistant to chemical attack.

- **Wet Curing vs. Air Curing:** Perrin and Fergani (2008) found that cube specimens are more sensitive to curing conditions than cylindrical specimens. Inadequate curing can result in significant strength reductions, particularly in cube specimens, which may lead to a larger difference in strength when compared to cylinders. Proper curing is essential for minimizing this effect.

- **Curing Temperature:** According to Neville (1995), curing temperature plays a role in the early strength development of concrete. While both cubes and cylinders are sensitive to temperature variations, cylinders tend to develop strength more slowly than cubes under higher curing temperatures.

2.6. Standards and Guidelines

Various international standards provide guidelines for testing the compressive strength of concrete using cube or cylindrical specimens. For example:

- ASTM C39/C39M provides the standard method for testing the compressive strength of cylindrical concrete specimens. It emphasizes the use of cylinders for assessing concrete strength in field applications.

- IS 516:1959 (Indian Standard) outlines the procedure for testing concrete cubes. It is widely used in India and many other countries for quality control in concrete testing.

- BS 1881-116:1983 (British Standard) also provides guidelines for testing concrete strength using both cube and cylinder specimens. It mentions that while cubes are typically used for testing, cylinders are more representative of structural elements like columns and beams.

The differences in testing standards and specimen types across various countries contribute to the variation in compressive strength results observed between cube and cylinder tests.

CHAPTER 3

Methodology

3.1 Introduction

The methodology for this research is designed to systematically compare the compressive strength of concrete specimens cast in the form of cubes and cylinders. The study will involve the preparation of concrete specimens, their curing under controlled conditions, and the subsequent testing to determine compressive strength. The methodology includes the materials used, the mix design, the specimen preparation process, testing procedures, and the equipment utilized. The following sections outline the detailed methodology followed in this research.

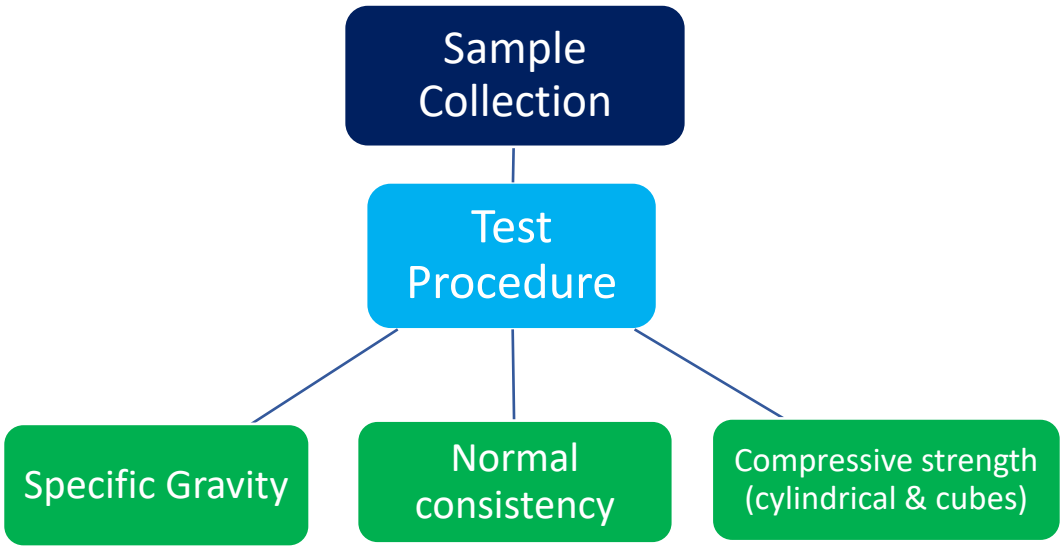


Fig. 3.1: Test Procedure

3.2 Methodology Overview

Laboratory work procedure is initiated after a good literary study on this similar work done previously. The following steps are followed for this research.

- Study of previous work.
- Collection of materials.
- Specimen making in laboratory.
- Slump test of concrete mix.
- Curing of specimen & Data collection.
- Calculation and result analysis.

During laboratory work, three separate mixes of concrete prepared for M10, M15 and M20 grade with stone chips, sand, cement and water. W/C ratio was fixed at 0.45 for all three mixes. Dimension of mound for cylinder specimen was 8"deep x 4" diameter [Fig. 1] and for cube specimen was four square inches (4"x4") [Fig. 2]. After making concrete mix, slump test of each grade has been performed. After 24 to 36 hours of casting, the molds were removed and the specimens were cured in water at room temperature.



Fig.3.2: Dimension of cylindrical specimen mold.



Fig.3.3: Dimension of cubical specimen mold

The standard allowable slump is needed to ensure the workability. However, the allowable slump data is shown in Table.1. It was much needed in this case because if the concrete is not workable the

Test results will be faulty and almost impossible to compare. Hence, the slump test results of different grades of concrete are given in Table.2.

Table 3.1: Allowable slump value chart

Allowable slump in Inch	Workability
0-1	Very Low
1-2	Low
2-4	Medium
More Then 4	High

Table 3.2: Slump test result of different grade of concrete

Grete Of Concrete	Water/Cement Ratio	Slump Test Result In Inches	Workability
M20 (1:1.5:3)	0.45	2.8	Medium
M15 (1:2:4)	0.45	3.4	Medium
M10 (1:3:6)	0.45	4.2	High



Fig.3.4: Universal Testing Machine

Each set of specimens contains 2 cylinders and 2 cubes of each ratio. Total 36 specimens were made. Compressive strength test of concrete using Universal Testing Machine [Fig. 3] was done at 7days, 14 days and 28 days' time interval of specimen casting date. 12 specimens for each M20, M15, and M10 grade of which, 2 cylinders and 2 cubes of each ratio were tested after 7 days of casting. Same procedure followed for 14 days and 28 days strength test. All results are noted to the following chart. Compressive strength test results of M20, M15 and M10 grade from the experiment are shown in Table.3, Table.4 and Table.5 respectively.

Table 3.3: M20 strength variation

Grade M20 (1:1.5:3)								
Cylinder				**Cube**				**Cylinder/Cube Ratio**
Days	**SL.**	**Strength (psi)**	**Avg. Strength**	**Days**	**SL.**	**Strength (psi)**	**Avg. Strength**	
7 Days	1	2500	2400	7 Days	1	2300	2600	0.92
	2	2300			2	3000		
14 Days	1	2700	2700	14 Days	1	3800	3200	0.84
	2	2800			2	2600		
28 Days	1	2600	2800	28 Days	1	3700	3400	0.82
	2	3100			2	3100		

Table 3.4: M15 strength variation

Grade M15 (1:2:4)								
Cylinder				**Cube**				**Cylinder/Cube Ratio**
Days	**SL.**	**Strength (psi)**	**Avg. Strength**	**Days**	**SL.**	**Strength (psi)**	**Avg. Strength**	
7 Days	1	1700	1700	7 Days	1	1900	1900	0.89
	2	1800			2	2000		
14 Days	1	2300	2100	14 Days	1	2900	2700	0.78
	2	2000			2	2600		
28 Days	1	2300	2400	28 Days	1	2700	2800	0.86
	2	2500			2	2900		

Table 3.5: M10 strength variation

Grade M10 (1:3:6)								
Cylinder				**Cube**				**Cylinder/Cube Ratio**
Days	**SL.**	**Strength (psi)**	**Avg. Strength**	**Days**	**SL.**	**Strength (psi)**	**Avg. Strength**	
7 Days	1	1000	900	7 Days	1	1300	1300	0.69
	2	900			2	1300		
14 Days	1	1100	1100	14 Days	1	1600	1600	0.68
	2	1200			2	1600		
28 Days	1	1300	1300	28 Days	1	1900	1800	0.72
	2	1400			2	1800		

3.3 Materials Used

The materials used for this study are standard components for making concrete, and they were selected based on their availability and relevance to typical concrete mixes used in construction.

Cement: Ordinary Portland Cement (OPC) conforming to IS 269:2015 (Indian Standard for Ordinary Portland Cement) was used in this study. It is a commonly used cement type for concrete preparation.

Aggregates: - Aggregates: The aggregates used included:

- **Fine Aggregate:** River sand passing through a 4.75 mm sieve (well-graded).

- **Coarse Aggregate:** Crushed granite with a nominal maximum size of 20 mm, conforming to IS 383:2016 (Indian Standard for Coarse and Fine Aggregates).

- **Water:** Potable water conforming to the requirements of IS 456:2000 (Indian Standard for Water for Concrete) was used for mixing and curing.

- **Admixtures:** No chemical admixtures were used in this study to maintain the simplicity and relevance to standard concrete mixes. The concrete mix was prepared without any retarders or accelerators.

- **Water:** Clean, potable water will be used in the concrete mixing process. The water-to-cement ratio will be varied in different mixes to examine its effect on the compressive strength of concrete.

3.4 Concrete Mix Design

The concrete mix design was based on a target compressive strength of 30 MPa at 28 days, using the IS 10262:2019 mix design method for ordinary concrete. The design mix was calculated based on the following parameters:

- **Target Compressive Strength:** 30 MPa at 28 days.

- Water-Cement Ratio: 0.45, based on the desired strength and the type of cement used.

- **Mix Ratio:** The mix ratio determined from the design was approximately 1:1.5:3 (Cement: Fine Aggregate: Coarse Aggregate) by weight.

The materials were proportioned accordingly to achieve the desired workability and strength of the concrete.

3.5 Specimen Preparation

Concrete specimens were cast in two different shapes: cubes and cylinders. The preparation of these specimens followed standard procedures as specified by relevant codes.

-Cube Specimens:

- Dimensions: 100 mm x 100 mm x 100 mm.

- Molds were oiled before pouring the concrete to ensure easy removal of the specimens after curing.

- The concrete mix was thoroughly mixed, ensuring uniform consistency and workability before being poured into the molds.

- After casting, the cubes were kept in the molds for 24 hours at room temperature (approximately 25°C) to allow initial setting.

- After 24 hours, the cubes were demolded and cured in a water tank at a temperature of 20 ± 2°C until the day of testing.

- Cylinder Specimens:

- Dimensions: 100 mm diameter x 200 mm height.

- Similar to the cube specimens, the cylinders were cast in oiled molds.

- Concrete was mixed, poured into the cylindrical molds, and compacted using a mechanical vibrator to ensure uniform compaction and to minimize air voids.

- After 24 hours, the cylinders were demolded and cured in a water tank under the same conditions as the cubes.

The concrete specimens were cured for two different time periods: 7 days and 28 days, with tests conducted at each of these curing ages. The specimens were kept under standard curing conditions (immersed in water at 20 ± 2°C) for the duration of the curing period.

3.6 Testing Procedures

The compressive strength of the concrete specimens was determined using a **Universal Compression Testing Machine (UTM)**, which conforms to international standards for concrete testing (e.g., IS 516:1959 for cubes and ASTM C39/C39M for cylinders).

- Test Age: The compressive strength tests were conducted curing ages: **7 days 14 days and 28 days.**

- Testing Procedure: 1. the specimens were removed from the curing tank and allowed to dry at room temperature for about 24 hours before testing.

2. Each specimen was placed centrally on the platen of the compression testing machine.

3. The load was applied gradually at a rate of 140 kg/cm²/minute (as per IS 516:1959), ensuring that the specimen was subjected to a uniform load.

4. The load was continuously increased until the specimen failed (i.e., cracks or complete crushing occurred).

5. The maximum load at failure was recorded.

CHAPTER 4

Results and Discussion

4.1 Introduction

This section presents the experimental results of the compressive strength tests conducted on concrete specimens in the shape of cubes and cylinders. The results are based on the compressive strength measured at two curing ages: 7 days 14 days and 28 days. The compressive strength values are compared for cube and cylinder specimens, and the variation between the two is analyzed.

Graphs were drawn to express the relationship of compressive strength of concrete and time which have been shown in [Fig. 4] for M20, [Fig. 5] for M15 and [Fig. 6] for M10 grade.

M20 Age vs Strength

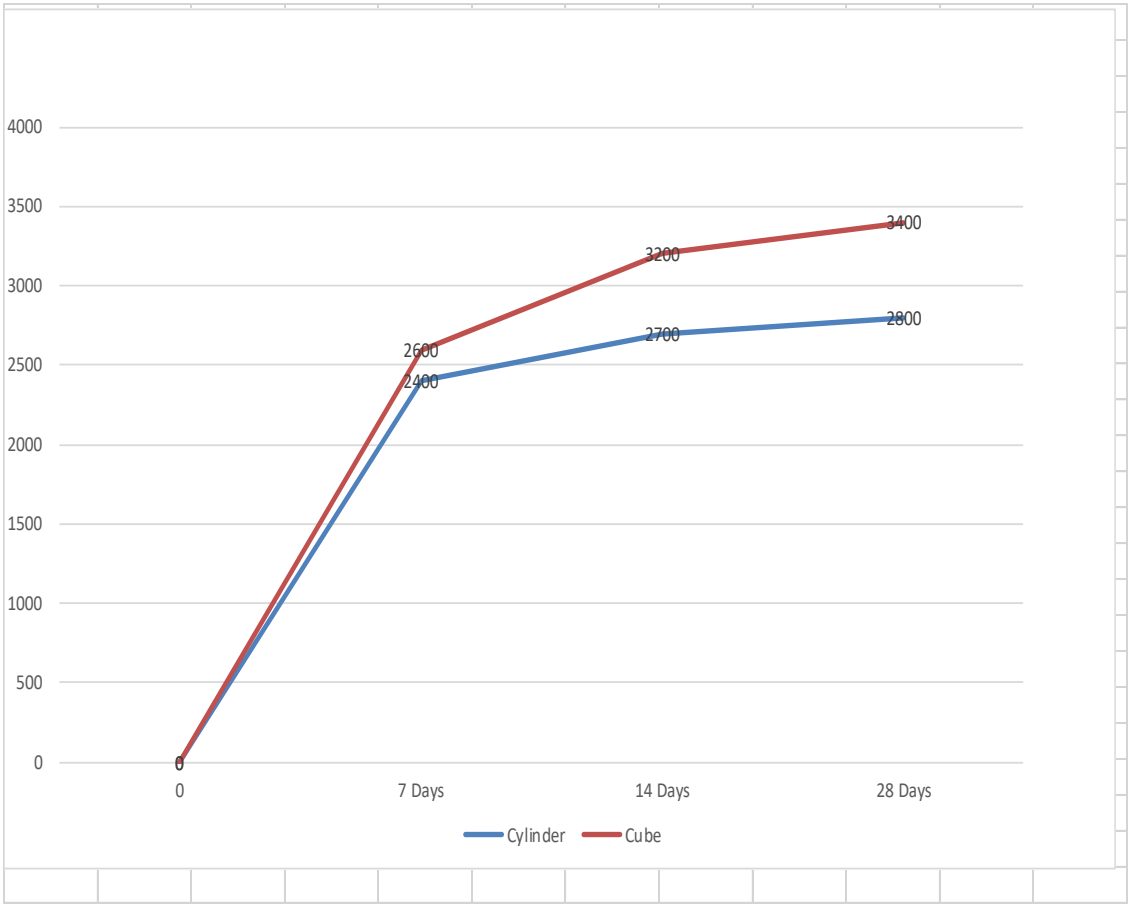


Fig. 4.1: M20 Age vs. Strength graph

Since, at first concrete sets, hardens and then gains strength with time, concrete strength has assumed zero for zero age. Strength variation of cylinder and cube is clearly notified from the following graphs. These graphs have also been shown that concrete strength is gradually increasing with time.

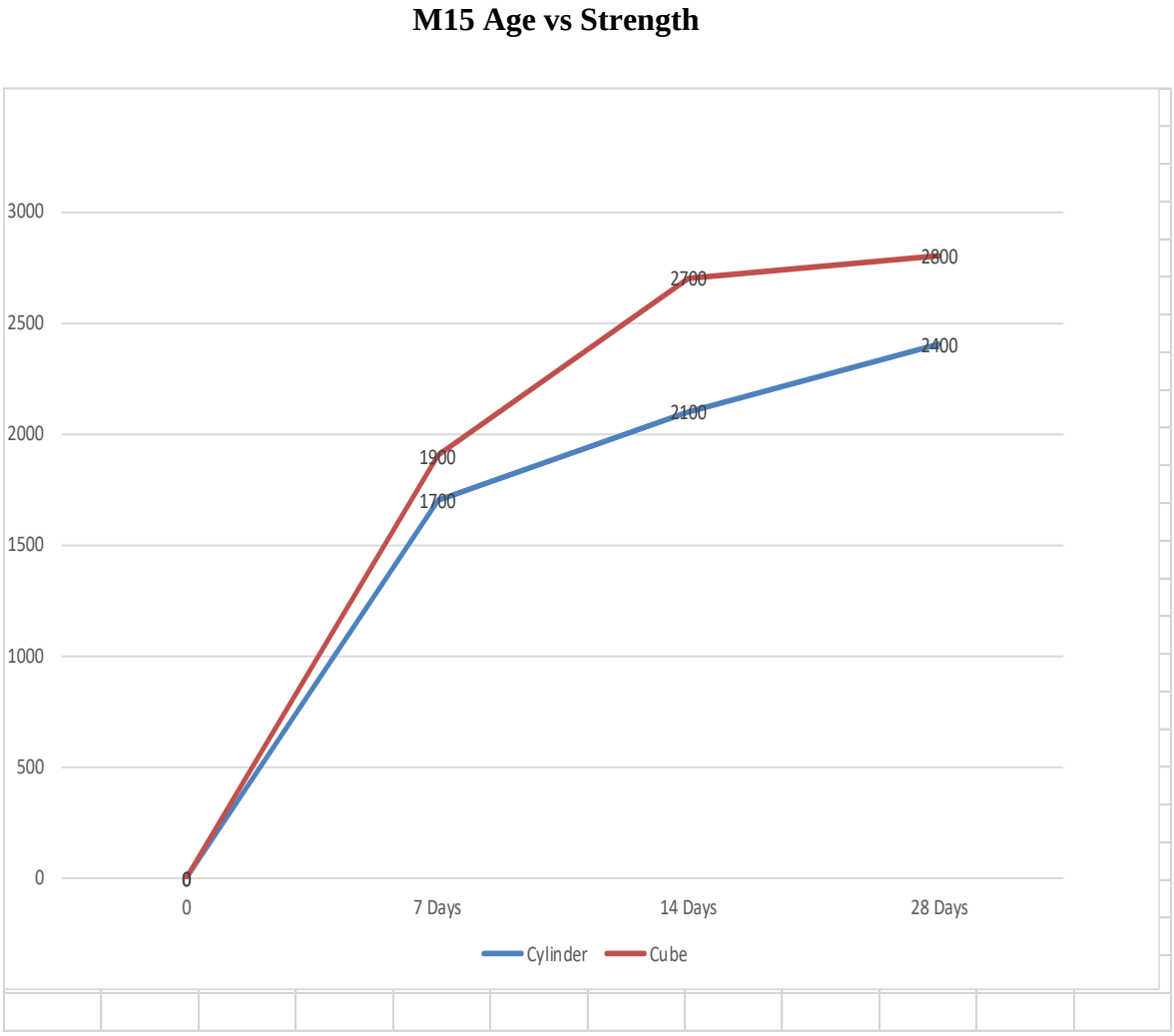


Fig. 4.2: M15 Age vs. Strength graph

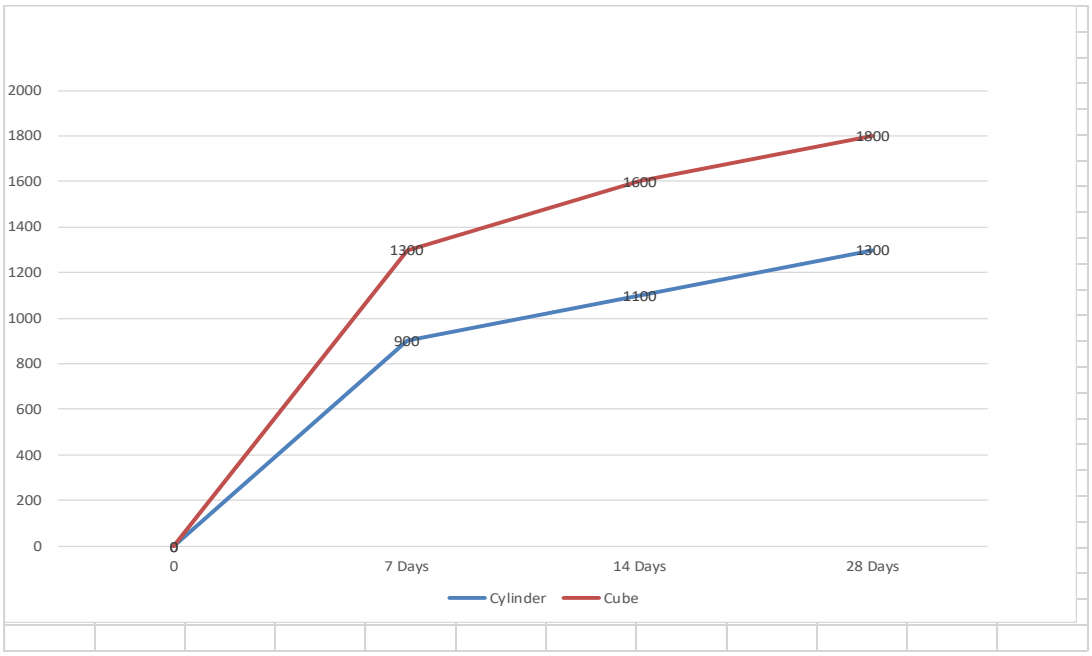


Fig. 4.3: M10 Age vs. Strength graph

From the strength test results, it was found that the Concrete Cube made of ratio 1:1.5:3 achieved the highest strength of 3400 psi by 28 days. It was also found that the Concrete Cylinder made of ratio

1:1.5:3 achieved the second highest strength of 2800 psi by 28 days. It is also found that, in average, the strength of Cube specimen is 1.25 times stronger than Cylinder specimen. Accepting the experimental variations and procedural errors from the standard, it may be assumed that achieving the design strength within 28 days, indicating its suitability of successful using in actual construction work. But it is also observed that, though M20 is good in strength, but all three grades are also good in strength according to non-workable strength category. Also, all of three are good in strength and workability from the point of view of where the concrete is to be used. In this study, only three most widely used grade of plain concrete i.e. M20, M10 and M15 were used. For better understanding of this study other grade of concrete should be used. In this study, w/c ratio was taken as a fixed value, it is recommended to use different w/c ratio for better understanding of the compressive strength of concrete.

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CHAPTER 5
Conclusions and Future Works

5.1 Conclusion

Compressive Strength: The study confirms that M20 concrete achieved maximum compressive strength among three mix proportions in both cube and cylinder tests. Cube specimens were found to be 9% stronger than cylinder specimens.

Geometry and Stress Distribution: Cube specimens, with isotropic geometry, experience more uniform stress distribution during compression, leading to higher strength. Cylindrical specimens, with a higher height-to-diameter ratio, experience concentrated stress at the ends, resulting in early failure and lower strength.

Failure Mechanism and Material Homogeneity: Cubes fail in a more ductile and evenly distributed manner, while cylinders fail more abruptly due to localized stress concentrations. Additionally, the uniformity of material in cubes contributes to more consistent strength measurements, while cylinders are more susceptible to material variations.

Curing Time: The study found that the compressive strength of both cubes and cylinders increases with curing time, with the greatest strength difference observed at 7 days. 14 days and 28 days, although the difference reduced, cubes still exhibited higher strength than cylinders.

5.2 Limitation and Recommendations

Limitations: Only standard cube (100 mm x 100 mm) and cylinder (100 mm x 200 mm) sizes were used, limiting the scope for varying specimen sizes.
The study did not investigate the impact of different curing methods (e.g., air curing, steam curing) on the compressive strength variation between cubes and cylinders.

Recommendations: Future studies should consider other concrete grades to assess the variation in compressive strength between cubes and cylinders for high-strength and low-strength concrete.

Different curing methods (e.g., steam curing, air curing) should be tested to understand how they impact the strength variation between different specimen shapes. Research should also explore the effect of specimen size (larger or smaller cubes/cylinders) and the impact of admixtures on the compressive strength results.

5.3 Future Work

Concrete Grade Variations: Future work could involve testing different grades of concrete (high-strength, low-strength) to determine if the difference in compressive strength between cubes and cylinders is more pronounced in certain concrete types.

Specimen Size and Shape: Investigating the impact of varying specimen sizes (e.g., smaller cubes, larger cylinders) and alternative shapes (e.g., prismatic specimens) could provide insights into how specimen geometry affects compressive strength.

Curing Methods and Environmental Conditions: Further research could explore various curing methods (wet curing, air curing, accelerated curing) and their effects on the strength variation between cubes and cylinders. Additionally, testing under different environmental conditions (e.g., exposure to high/low temperatures) may provide valuable data on how external factors influence compressive strength.

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APPENDIX











