

# Concrete Mix Design For M40 Grade

Aniket Thakur<sup>1</sup>, Prathamesh Shinde<sup>2</sup>, Chetan Wadile<sup>3</sup>, Rohit Patil<sup>4</sup>, Dr. HemrajKumavat<sup>5</sup>

**Abstract-** This project focuses on designing an M40 grade concrete mix used in high-strength structures like bridges and high-rise buildings. The aim is to achieve a compressive strength of 40 MPa with good workability, durability, and cost efficiency. The mix design was carried out as per IS 10262:2019 and IS 456:2000. Material tests were conducted to determine key properties required for accurate mix proportions. Trial mixes were prepared and evaluated, and the final mix met the required strength and workability. Compared to M20 and M30, M40 showed better performance for heavy-load structures. Overall, the study highlights the importance of proper testing and quality control in concrete mix design.

**Keywords:** M40 Grade Concrete, Concrete Mix Design, Compressive Strength, Workability, Durability, Trial Mix, Material Testing, Quality Control, High-Strength Concrete, IS 10262:2019, IS 456:2000, Structural Concrete.

## I. INTRODUCTION

Concrete is widely used due to its strength, durability, and cost-effectiveness. Its performance depends on proper mix design, which determines the correct proportions of materials to achieve desired strength and workability.

M40 grade concrete, with a compressive strength of 40 MPa, is suitable for heavy-load structures like high-rise buildings and bridges. This study develops an optimum mix using IS 10262:2019, with material testing and comparison to M20 and M30 grades to evaluate performance and applications.

### Aim of the Study :

Identify the constructs of a Journal – Essentially a journal consists of five major sections. The number of pages may vary depending upon the topic of research work but generally comprises up to 5 to 7 pages. These are: multi-label learning, more than one class can be assigned to an instance. With the increase in the number of data

## II. IDENTIFY, RESEARCH AND COLLECT IDEA

A detailed review of previous studies on M40 grade high-strength concrete was carried out with reference to key Indian Standard (IS) codes and established textbooks. According to IS 456:2000, M40 concrete is designed to achieve a specified characteristic strength, requiring a

minimum cement content of 320 kg/m<sup>3</sup> and a maximum water-cement ratio of 0.45. As per IS 10262:2019, the target mean compressive strength is considered as 48.25 MPa, assuming a standard deviation of 5 MPa under good quality control conditions. Aggregates were evaluated in accordance with IS 383:2016 to ensure compliance with grading, size, and cleanliness requirements. Standard references by M.S. Shetty and A.M. Neville provided additional insights into the role of low water-cement ratio, admixtures, and proper curing practices in achieving durable and high-strength concrete.

All construction materials were carefully tested to confirm compliance with relevant standards. Ordinary Portland Cement of grades 43 and 53 was verified as per IS 8112:2013 and IS 12269:2013, respectively. Fine aggregate used in the study was Zone II sand, as specified in IS 383:2016. Coarse aggregates of 20 mm nominal size were selected based on recommendations from IS 10262:2019. The mixing water satisfied the requirements of IS 456:2000 to avoid any adverse effects on durability and strength. The evaluation confirmed that all materials met the prescribed standards, providing a reliable basis for the development of M40 grade concrete.

## III. METHODOLOGY

### 1. Concrete Mix Design as per ACI 211.1-1991, IS 10262:2019 & IS 456:2000

Concrete mix design is the systematic procedure used to determine the appropriate proportions of cement, water, fine aggregates, coarse aggregates, and admixtures to achieve the required strength, workability, and durability. The ACI 211.1-1991 method provides a practical approach based on empirical relationships, considering factors such as slump, maximum aggregate size, and exposure conditions.

Material	Quantity (kg/m <sup>3</sup> )
Cement	421
Water	160
Fine aggregate	229
Coarse aggregate	1674

In contrast, IS 10262:2019 offers a detailed step-by-step methodology tailored to Indian construction practices, including target mean strength calculations, water-cement

ratio selection, and adjustments for workability and durability requirements. IS 456:2000 complements this by specifying durability criteria, minimum cement content, and maximum permissible water–cement ratio based on environmental exposure conditions.

Material	Quantity (kg/m <sup>3</sup> )
Cement	465
Water	186
Fine Aggregate (FA)	651
Coarse Aggregate (CA)	1083

**2.Material Selection**

All materials were examined to confirm compliance with the relevant standards before use. Ordinary Portland Cement of grades 43 and 53 was tested in accordance with IS 8112:2013 and IS 12269:2013, respectively. Fine aggregate consisted of Zone II sand as specified in IS 383:2016. Coarse aggregate of 20 mm nominal size was selected following the recommendations of IS 10262:2019. The water used for mixing satisfied the requirements of IS 456:2000, ensuring no adverse effects on strength and durability. The evaluation showed that all materials met the prescribed standards, providing a reliable basis for producing high-strength M40 grade concrete.

**3.Concrete Mixing and Cube Casting**

Concrete was prepared manually in accordance with the finalized mix proportions. Water was added in a controlled manner to maintain the specified water–cement ratio of 0.40 throughout the mixing process.

A total of twelve cube specimens of size 150 mm × 150 mm × 150 mm were cast using standard methods. The concrete was placed in layers, compacted by rodding and vibration to eliminate air voids, and the top surface was properly finished using a trowel.

After 24 hours of casting, the specimens were carefully removed from the molds and placed in a curing tank filled with clean water maintained at room temperature.

Compressive strength tests are planned to be conducted at intervals of 7, 14, 21, and 28 days in order to evaluate both early-age and long-term strength development of the concrete.



**Fig.1 Casting of M40 Grade Cubes**



**Fig.2 Curing of M40 Grade Cubes**

**4.Testing of Cubes**

After completing the casting and curing process of M40 grade concrete cubes, experimental tests were performed to evaluate their compressive strength and surface hardness. These tests were conducted at curing ages of 7, 14, and 21 days to study the pattern of strength development and to assess the overall quality of the concrete.

**Procedure**

1. The cured specimens were taken out from the curing tank, and any surface moisture was removed using a dry cloth.
2. The dimensions of each cube were measured precisely to ensure accurate calculation of strength.
3. Each specimen was then positioned in the Compression Testing Machine (CTM) with the load applied uniformly on the cast faces.
4. The load was applied gradually at a constant rate of 140 kg/cm<sup>2</sup> per minute until the specimen failed.
5. The maximum load at failure was recorded, and the compressive strength was determined.

$$\text{Compressive Strength (MPa)} = \frac{\text{Load (N)}}{\text{Area (mm}^2\text{)}}$$

**A. Compressive Strength**

Age of Concrete	Avg Compressive Strength (MPa)	IS 456 Expected Strength (MPa)	Peak Load (kN)	Remarks
7 Days	21.89 MPa	~26 MPa (65% of 40 MPa)	~ 492 kN	Slightly lower than expected
14 Days	36.40 MPa	~36 MPa (90% of 40 MPa)	~ 819 kN	Matches IS expectations
21 Days	38 MPa	90–95% of 40 MPa	~ 855 kN	Almost at full strength
28 Days	43.9 MPa	≥ 40 MPa	987.76 kN	Exceeds characteristic strength

The compressive strength results at different curing ages show a steady increase, indicating proper strength development of the M40 concrete. At 7 days, the strength (21.89 MPa) was slightly lower than expected, likely due to early curing conditions. By 14 days, it reached 36.40 MPa, showing significant improvement, and at 21 days, it increased to 38 MPa, nearing full strength.

At 28 days, the concrete achieved 43.9 MPa, exceeding the required 40 MPa for M40 grade. This confirms that the mix design, material quality, and curing process were effective, making the concrete suitable for high-strength structural applications.

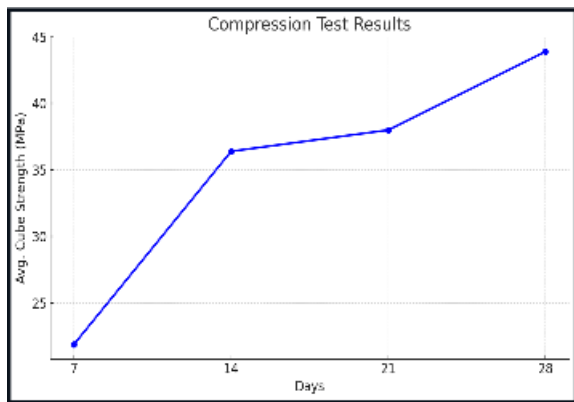


Fig.3 Graphical Representation of Compressive Strength

**B. Non-Destructive test**

Age of Concrete	Average Rebound Number	Equivalent Compressive Strength (MPa)	% of 28-Day Strength (40 MPa)	Remarks
7 Days	-	21.89 MPa	55 %	gaining good strength
14 Days	38	36 MPa	90 %	Concrete gaining good strength
21 Days	39	38 MPa	95 %	Nearly reached full strength
28 Days	39.5	39.2	99 %	Almost reached full strength

The rebound hammer test was conducted on three concrete samples to assess surface hardness and indirectly estimate compressive strength. The rebound values were nearly identical, indicating uniform surface quality and proper curing.

The estimated compressive strength ranged from 40.2 MPa to 41.0 MPa, showing very little variation. This consistency reflects good compaction and sound construction practices. Since the values fall within the expected range for M40 grade concrete, the material is considered reliable and suitable for structural applications.

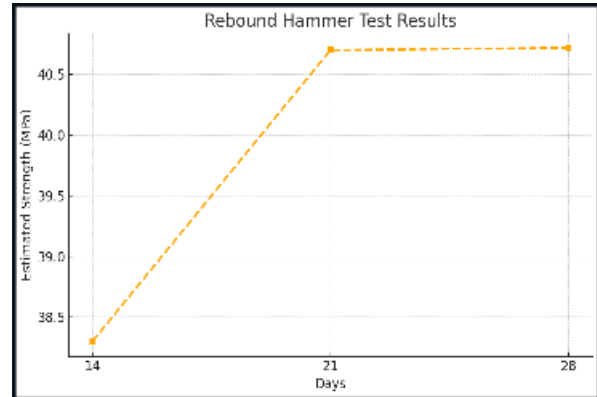
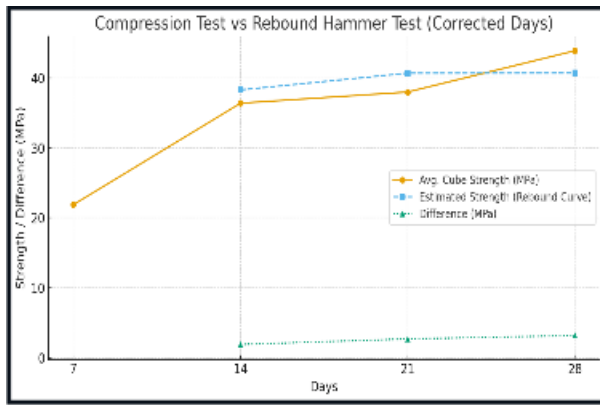


Fig.4 Graphical Representation of Rebound Hammer Test

**5. Result**

Day	Avg. Cube Strength (MPa)	Avg. Rebound Number	Estimated Strength (from rebound curve)	Difference
7	21.89 MPa	-	-	0
14	36.4 MPa	37.29	38.3	1.90
21	38 MPa	39.4	40.7	2.70
28	43.9 MPa	39.8	40.72	3.18



**Fig.5 Comparison of CTM and Rebound Hammer Test**

The comparison chart shows a clear relationship between cube test results and rebound hammer values at 14, 21, and 28 days. The cube strength increases steadily from 36.5 MPa to 44 MPa, indicating normal strength development of M40 concrete.

The rebound hammer values also follow a similar trend, ranging from about 38.3 MPa to 40.8 MPa, though slightly lower as it measures surface hardness. The difference between the two methods remains small (around 1.9 to 3.4 MPa), showing good consistency between surface and internal strength.

Overall, the close agreement between both results confirms uniform quality, proper curing, and suitability of the concrete for structural use.

#### IV. CONCLUSION

The study confirms that the designed concrete mix satisfies the required strength, workability, and durability criteria. The 28-day compressive strength exceeded the target value, indicating proper selection of water-cement ratio, aggregate proportions, and mixing process.

The concrete showed good workability during placement and compaction, ensuring uniformity and minimal voids. This reflects effective construction and curing practices.

Overall, the results demonstrate that the mix design is reliable, durable, and suitable for load-bearing structural applications.

#### REFERENCES

[1] **IS 10262:2019** – Concrete Mix Proportioning, Bureau of Indian Standards, New Delhi.

- [2] **IS 456:2000** – Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi.
- [3] Shetty, M. S., & Jain, A. K. *Concrete Technology: Theory and Practice*, S. Chand Publications.
- [4] Rajasekaran, S., & Ramesh, S. (2020). *Concrete Mix Design of M40 Grade*.
- [5] Banerjee, T. K., Banerjee, A. N., & Sinha, S. P. (2019). *Influence of Mix Proportions on M40 Concrete Strength*.
- [6] Gupta, R. K., Mishra, S. S., & Singh, V. (2021). *Experimental Investigation on M40 Concrete with Different Types of Admixtures*.
- [7] Shankar, M. K. S., Swamy, S. R., & Kiran, K. S. R. (2018). *Optimization of M40 Concrete Mix Design for High Strength*.
- [8] Kumar, S. B., & Singh, P. R. (2017). *Durability of M40 Grade Concrete with Mineral Admixtures*.
- [9] *A Design Mix Procedure and Durability Evaluation of GGBFS & Fly Ash Based Geopolymer Concrete*. Available at: <https://doi.org/10.14445/22315381/IJETT-V70I11P219>
- [10] *A Review of Concrete Mix Designs*. Available at: <https://www.researchgate.net/publication/342261416>
- [11] *An Experimental Study on Strength Characteristics of M40 Grade Concrete by Partial Replacement of OPC by Red Mud and Hydrated Lime*. IJRES, Volume 10, Issue 10, October 2022, pp. 200–211.
- [12] *Mathematical Model for the Compressive Strength and Elastic Properties of Triple-Blended Steel Fiber Self-Compacting Concrete Based on Experimental Investigation*. Available at: <https://www.researchgate.net/publication/341367762>
- [13] *Evaluation of M35 and M40 Grades of Concrete by ACI, DOE, USBR and BIS Methods of Mix Design*.
- [14] *Experimental Study on Partial Replacement of Coarse Aggregate by Bamboo and Fine Aggregate by Quarry Dust in Concrete*. Available at: <https://www.researchgate.net/publication/322653128>
- [15] *Effect on Workability and Compressive Strength of M40 Grade Concrete by Partial Replacement of Cement*. IJIREM (2022), Article ID: IJIR-1303, pp. 130–136. Available