IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Design And Operational Study Of India's First Semiconductor Manufacturing Facility

Prof. Hari Aiwale 1. Kale Nikhil Sharad

Faculty Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology, Lonavala

1Student Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology, Lonavala

ABSTRACT

This study presents an evaluation of the structural performance and construction practices adopted in the Micron Semiconductor Plant, a key infrastructure project located in Ahmedabad's rapidly expanding industrial and technological landscape. Developed as part of India's semiconductor mission, the facility plays a significant role in strengthening the nation's electronics manufacturing capabilities and enhancing its position within global supply chains. The project comprises advanced industrial infrastructure, including cleanroom facilities, production units, and utility systems designed to meet stringent operational and environmental requirements.

High-strength concrete grades, namely M45 and M55, are utilized in critical structural components such as foundations, columns, and slabs to ensure superior strength, durability, and resistance to dynamic and environmental loads. Experimental evaluation of concrete properties—particularly workability and compressive strength—demonstrates the suitability of these grades for heavy-duty and precision-based industrial applications. Special consideration is given to vibration-resistant foundation systems and controlled construction methodologies to support sensitive semiconductor manufacturing equipment.

The findings indicate that the integration of high-performance materials, advanced construction techniques, and strict quality control measures is essential for achieving structural stability and operational efficiency in such high-tech facilities. The project is expected to significantly enhance semiconductor production capacity, promote technological self-reliance, and contribute to the development of a robust electronics manufacturing ecosystem in India.

Keywords - Semiconductor Manufacturing Facility, Industrial Infrastructure, High-Strength Concrete (M45 & M55), Compressive Strength, Workability, Structural Stability, Vibration-Resistant Foundations, Quality Control, Construction Safety

INTRODUCTION

Ahmedabad's rapid industrial expansion has created a strong demand for advanced and resilient infrastructure systems. The Micron Semiconductor Plant in Ahmedabad represents a significant milestone in India's semiconductor mission, supporting the nation's vision of emerging as a global hub for electronics manufacturing. As a state-of-the-art high-tech facility, the project plays a crucial role in semiconductor Assembly, Testing, Marking, and Packaging (ATMP), strengthening the integration between global supply chains and domestic production capabilities.

The structural framework of the plant is designed to meet stringent performance and durability requirements. High-strength concrete grades, such as M45 and M55, are utilized to ensure superior compressive strength, durability, and long-term structural reliability. The key structural components include RCC bored cast-in-situ pile foundations, pile caps, pedestals, grade slabs, industrial flooring systems, heavy-duty structural columns, steel roof structures, cleanroom facilities, and auxiliary utility buildings. These elements are engineered to withstand dynamic loads, equipment-induced vibrations, and varying environmental stresses.

In addition, the project incorporates advanced construction technologies and materials tailored for high-precision industrial applications. These include high-performance industrial flooring systems, vibration-resistant foundation solutions for sensitive equipment, epoxy-coated reinforcement (where required), and specialized waterproofing systems for substructure protection. Such measures are essential to maintain structural integrity and operational efficiency in a semiconductor manufacturing environment.

A key design focus of the facility is the creation of highly controlled internal conditions, rather than conventional transport or speed-based parameters. The plant is engineered to maintain strict control over temperature, humidity, and airborne contaminants, ensuring a clean and stable environment necessary for precision manufacturing processes.

Overall, the Micron Semiconductor Plant exemplifies the integration of advanced structural engineering practices with specialized industrial requirements, contributing significantly to India's technological growth and infrastructure development.

Key Project Features:
Location: Ahmedabad, Gujarat
Type: Semiconductor ATMP Facility
Purpose: Strengthens India's semiconductor ecosystem and supports global electronics manufacturing supply chains
Infrastructure: Cleanrooms, utility buildings, production blocks, and support facilities
Contractor: Tata Projects Ltd

Financials

- Total Project Cost: ₹22,500 Cr (approx.) Phase-1
- Construction Cost: ₹13,000 Cr (approx.)
- Infrastructure & Utilities Cost: ₹4,000 Cr (approx.)

Engineering Highlights

Concrete Grades: M45 and M55 for high strength and enhanced durability

Structural Components:

Foundations: RCC bored cast-in-situ piles, isolated/combined footings, and raft foundations designed to support heavy industrial and equipment loads

Substructure: Pedestals columns, beam and footings engineered for stability and load distribution

Superstructure: RCC and structural steel frameworks, industrial roofing systems, and high-load- bearing floor slabs, Precast columns, Beams and slab

Special Structures: Cleanroom facilities, vibration-resistant machine foundations, and utility blocks designed for precision manufacturing requirements

Flooring Systems: Heavy-duty industrial flooring with epoxy/anti-static finishes suitable for semiconductor operations

Safety Features: Fire-resistant materials, safety-compliant structural design, and provisions aligned with industrial safety standards

Reinforcement: HYSD Fe500 with FBE coating for foundation and substructure works
Bearings & Joints: POT-PTFE bearings and Strip Seal/Modular expansion joints

Urban Impact

Strengthens Ahmedabad's position as a major semiconductor and industrial hub, enhancing connectivity with national and global supply chains.

Expected to boost employment opportunities, reduce dependency on imports, and support the growth of allied industries in the region.

Supports India's rapid technological and industrial development by establishing advanced manufacturing infrastructure and promoting economic growth in Gujarat.

1. METHODOLOGY

1.1 Materials Used

- **Concrete**: M45 & M55 grade are high-strength concrete grades used for heavy structural Elements; M45 ≈ 45 MPa characteristic compressive strength at 28 days and M55 ≈ 55 MPa. Typical mix limits: maximum w/c ≈ 0.40**,** minimum cement ≈ 360–380 kg/m³, and use of OPC 53 + superplasticiser are standard to achieve workability and strength.

- **Cement type:** OPC 53 (IS 8112/IS 269) is commonly specified for M45–M55 mixes in India.

- **Aggregate:** Use well-graded crushed aggregates (max 20 mm) and control fines to achieve target workability.

- **Admixture dosage:** Superplasticizer per manufacturer to reach required slump (M45: 50– 100 mm slump typical; M55: 100–150 mm depending on placement).

- Curing**:** Minimum 7 days (preferably 14–28 days) for high-strength mixes to develop design strength.

- **Steel: Fe-500D for reinforcement**

HYSD (High Yield Strength Deformed) bars of Grade Fe500 are widely used in modern reinforced concrete construction, especially when paired with high-strength concrete grades like M45 for foundations and M55 for superstructures.

- **Structural Elements**:

➢ Piles: 1.0 M & 1.2 m diameter, 20–30 m depth
➢ Pile Caps: RCC caps distributing load
➢ Piers: Circular RCC piers, 8–12 m height

1.2 Testing

- **Workability**: Slump test
- **Compressive Strength**: Cubes tested at 7 and 28 days
- **Traffic Simulation**: VISSIM software
- **Cost Analysis**: Compared with cement road widening

2. WORK DONE

2.1 Sieve Test (75-micron): -

The presence of material finer than 75 microns (No. 200 sieve) is a critical factor in the construction of durable concrete roads. These ultra-fine particles, primarily consisting of silt and clay, tend to coat the surface of aggregates such as sand and coarse particles. This coating interferes with the proper bonding between cement paste and aggregates, ultimately reducing the strength and durability of the concrete.

To control this issue, established standards such as ASTM, AASHTO, and the Indian Roads Congress (IRC) specify permissible limits for fine particles. For fine aggregates (sand), the allowable percentage typically ranges between 3% and 5%, while for coarse aggregates, it is generally restricted to about 1% or less.

Exceeding these limits can adversely affect the properties of concrete. The mix becomes excessively cohesive and difficult to handle, requiring additional water to maintain workability. This increase in water content weakens the concrete matrix, leading to reduced strength, higher shrinkage, and the development of cracks over time. Consequently, the long-term performance and service life of concrete pavements are significantly compromised.

Fig.01 - Material finer than 75-micron silt contact (Sand)

2.2 Moisture content in Aggregate Test: -

Moisture content in aggregates is a critical parameter that must be monitored regularly in concrete production. Both fine and coarse aggregates contain moisture, which may exist as absorbed water within the pores or as free surface moisture. If not properly accounted for, this additional water alters the effective water-cement ratio, directly affecting the quality and performance of concrete.

Excess moisture in aggregates increases the water content of the mix, leading to reduced strength, higher shrinkage, and a greater tendency for cracking. Conversely, when aggregates are too dry, they absorb water from the mix, resulting in reduced workability and difficulty in placement and compaction.

In practice, aggregates are classified into four moisture conditions: oven-dry, air-dry, saturated surface dry (SSD), and wet. Among these, the SSD condition is considered ideal, as the aggregate pores are fully saturated while no free water is present on the surface. This ensures that the water added during mixing accurately represents the intended water-cement ratio.

Therefore, it is essential to determine the moisture content of aggregates on-site and adjust the mixing water accordingly. For instance, if sand exhibits a higher moisture content than expected, the added water must be reduced to maintain the desired mix proportions. Proper control of aggregate moisture is crucial for achieving consistent strength, durability, and long-term performance of concrete, particularly in pavement construction.

Fig.02 - Moisture content in Aggregate

Fig.03 - Sieve analysis coarse aggregate and fine aggregate

Fig.04. Flakiness and Elongation

Fig.05. Slump checking

Fig.06. Slump test at site

Fig.07. Concrete cube marking at site

Fig.08. Cube testing machine

Fig.09. Cube Testing at Knack Laboratory at Vadala

Fig.10. Cube test readings

Fig.11. Cast in situ slab 700mm thk

Fig.12.Above Precast slab 150 mm thk

Fig.13. Strucutral FAB Building

Fig.14. FWT Final lift Casting

Fig.15. Final View before & After

3. RESULTS AND DISCUSSION

4.1 Workability Test – Slump Test Results

The slump test was conducted to evaluate the workability and consistency of fresh concrete mixes used in the study. Workability is an important property of concrete that indicates the ease with which concrete can be mixed, transported, placed, compacted, and finished without segregation or bleeding. The test was performed in accordance with IS 1199:2018 using a standard slump cone apparatus.

The observed slump values for different concrete mixes are presented below:

Mix	Slump Value (mm)	Workability
Mix 1	75	Medium
Mix 2	90	Good
Mix 3	100	Excellent

4.2 Compressive Strength Test Results

The compressive strength test was conducted to determine the load-carrying capacity and strength development of hardened concrete. Concrete cube specimens of standard size **150 mm × 150 mm × 150 mm** were cast, cured, and tested using a Compression Testing Machine (CTM) in accordance with IS 516:2021.

The average compressive strength values obtained are shown below:

Age of Concrete	Average Compressive Strength (N/mm²)
7 Days	32
28 Days	47

4. CONCLUSIONS

- The use of **M45 and M55 grade concrete** provides high compressive strength, enhanced durability, and extended service life, making it highly suitable for demanding industrial structures.
- Experimental evaluation of **workability and compressive strength** confirms the effectiveness of these concrete grades for critical structural components such as foundations, columns, and heavy-load-bearing elements.
- The project successfully supports **high-precision semiconductor manufacturing** by incorporating vibration-resistant foundations and structurally stable infrastructure, ensuring reliable operation of sensitive equipment.
- Although the initial cost may be relatively higher, the system proves to be **economical in the long term** due to improved durability, reduced maintenance requirements, and efficient construction practices.
- Environmental considerations are addressed through **optimized material utilization, energy-efficient systems, and minimized environmental impact**, contributing to sustainable construction practices.

5. The Micron Semiconductor Plant plays a pivotal role in **strengthening India's semiconductor ecosystem**, promoting technological self-reliance and supporting industrial and economic growth.

6. REFERENCES

1. IS 2386 (Part I) - Indian Standard for sieve analysis.
2. ASTM C136, AASHTO T27, or IS 2386 (Part I) Standard test methods
3. M45 Mix Design Example (IS 10262:2019)
4. IS 516 (Part 1/Sec 1):1959 – Methods of Tests for Strength of Concrete
5. IS 456:2000 – Code of Practice for Plain and Reinforced Concrete
6. IS 1199:1959 – Methods of Sampling and Analysis of Concrete
7. IS 10086:1982 – Specification for Moulds for Test Specimens of Concrete
8. IS 14858:2000 – Compression Testing Machine Requirements
9. Concrete Cube Sampling as per IS 456
10. Concrete Cube Casting Procedure Explained (IS 516 + IS 456)
11. ISO 45001 — Occupational Health and Safety Management Systems
12. Concrete Technology by Nirali Prakashan (Dr. Dinesh Kumar Gupta/Dr. M.N. Bajad)
13. SP: 16(S&T): 1980 Design for reinforced concrete to IS 456: 1978 132 SP: 23(S&T): 1982
14. Handbook on concrete mixes

15. IS 10080 :1982 Specification for vibration machine for casting standard cement mortar cubes
16. IS 10079 :1982 Specification for cylindrical metal measures for use in tests of aggregates and concrete
17. IS 10070 :1982 Specification for machine for abrasion testing of coarse aggregates
18. IS 516: 1959 Method of test for strength of concrete