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Comparative Study of Mivan Technology and Conventional RCC Structures in High Seismic Zones

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Abstract- Conventional Reinforced Cement Concrete (RCC) framed structures are widely used in the construction industry; however, they require more time, labor, and materials, which leads to higher project duration and cost. To overcome these challenges, modern construction techniques such as MIVAN technology (aluminium formwork system) are being adopted in large-scale construction projects. The present study focuses on the comparative analysis of RCC structures designed using conventional framed construction and MIVAN structural system. The study involves planning, load calculation, structural modeling, analysis, and design of a multi-storey building using AutoCAD and STAAD.Pro software. All structural elements such as slab, beam, column, wall, and foundation are designed using the Limit State Method as per IS 456:2000 and other relevant Indian Standard codes. The structural analysis is carried out under various loading conditions including dead load, live load, and wind load, and the results such as bending moment, shear force, axial load, and deflection are obtained. Based on these results, the design of structural components is performed and compared for both systems. The study reveals that the MIVAN structural system provides higher stiffness, better load distribution, reduced deflection, and improved seismic performance due to monolithic construction and the presence of RCC shear walls. It also offers faster construction, better surface finish, and reduced labor requirement. However, the initial cost of MIVAN technology is higher compared to conventional construction, but it becomes economical for large-scale and repetitive projects such as mass housing. On the other hand, the conventional RCC framed structure provides flexibility in design and is more suitable for small-scale projects, but it involves more construction time and complexity due to the presence of beams and columns.

Keywords: *MIVAN Technology, RCC Framed Structure, Structural Analysis, STAAD.Pro, Aluminium Formwork.*

I. INTRODUCTION

The construction industry is one of the most significant contributors to the economic development of any country. In India, rapid urbanisation, population growth, and increasing demand for housing and infrastructure have placed immense pressure on the construction sector to adopt faster, safer, and more economical construction techniques. Traditional construction practices, particularly the conventional Reinforced Cement Concrete (RCC) framed structures, have been widely used for decades due to their flexibility, familiarity, and availability of materials. However, these methods are often associated with longer construction durations, higher dependency on skilled labour, and variations in quality control. In recent years, the need for mass housing and rapid urban development has led to the adoption of advanced construction technologies. One such modern and innovative system is Mivan Technology, also known as the Aluminium Formwork System. This technology enables the casting of walls and slabs together in a single operation, resulting in a monolithic structure with improved strength, durability, and uniformity. The use of aluminium formwork allows for rapid and repetitive construction cycles, making it highly suitable for large-scale residential projects. India is also highly vulnerable to seismic activities, with approximately 60% of its geographical area falling under seismic zones III, IV, and V.

Several major earthquakes in the past, such as the Latur earthquake (1993), Bhuj earthquake (2001), and Nepal earthquake (2015), have highlighted the deficiencies in conventional construction practices. Many buildings constructed using traditional RCC methods suffered severe damage or collapse due to inadequate structural detailing, poor workmanship, and lack of proper lateral load-resisting systems. These incidents emphasise the urgent need for adopting construction technologies that can provide better resistance to seismic forces. Conventional RCC structures are primarily based on a beam-column framing system, where loads are transferred through beams and columns to the foundation. The masonry infill walls are generally considered non-structural elements. However, during seismic events, these infill walls interact with the frame in a complex manner, often leading to irregular load distribution, increased stiffness variations, and potential failure mechanisms such as cracking, separation, or collapse of walls. Additionally, issues like soft storey formation, torsional irregularity, and weak beam-column joints further reduce the seismic performance of such structures.

On the other hand, Mivan Technology adopts a load-bearing wall system, where reinforced concrete walls act as the primary structural elements. The walls and slabs are cast together to form a box-type monolithic structure, which provides higher lateral stiffness and better load transfer mechanisms. This integrated structural system significantly enhances the building's ability to resist seismic forces by reducing displacement, storey drift, and stress concentrations. The monolithic action also ensures improved durability and minimizes the occurrence of cracks and leakages. Another important aspect driving the adoption of Mivan technology is the need for time efficiency in construction projects. Conventional construction methods involve multiple sequential activities such as shuttering, reinforcement placement, concreting, curing, and de-shuttering for each structural component separately. This process is time-consuming and often leads to project delays. In contrast, Mivan technology allows for a streamlined construction process where entire floors can be completed within a short cycle time, typically 4 to 7 days. This makes it highly advantageous for projects with strict timelines and large-scale repetitive units, such as affordable housing schemes and high-rise residential buildings.

II. RESEARCH METHODOLOGY

3.2 Planning

Planning is the first and one of the most important stages in structural design. Proper planning ensures efficient use of space, safety of structure, and economical design. In this study, the planning of the building is carried out using AutoCAD software, which is widely used for drafting and designing in civil engineering. AutoCAD helps in preparing accurate and detailed 2D drawings, which are essential for structural modeling and analysis.

The planning includes preparation of:

1. Architectural plan
2. Structural layout
3. Column positioning
4. Beam arrangement
5. Slab system
6. Sectional views

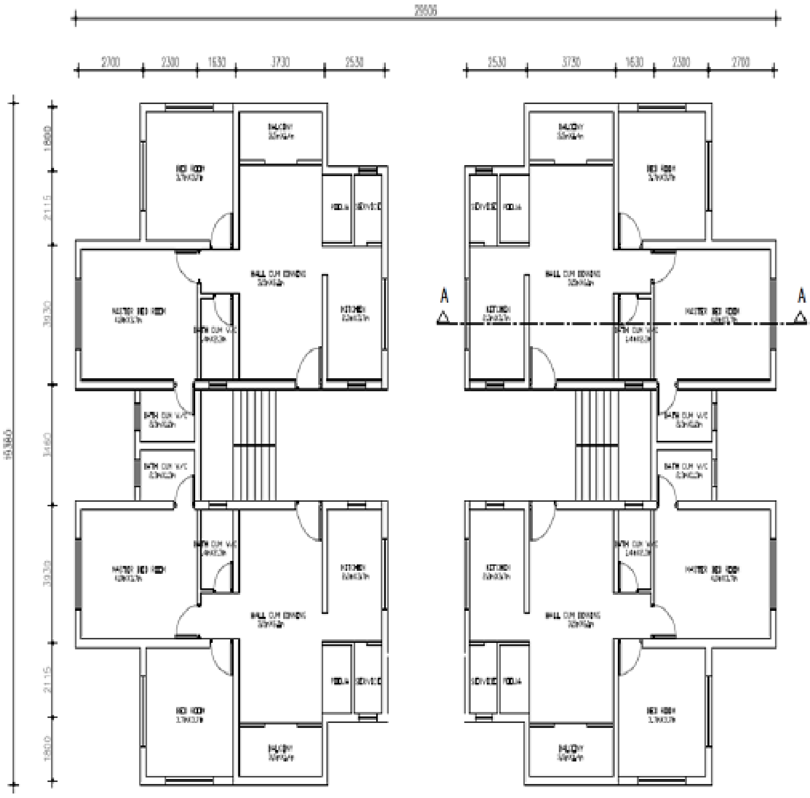

Fig.3.1: System of the Building

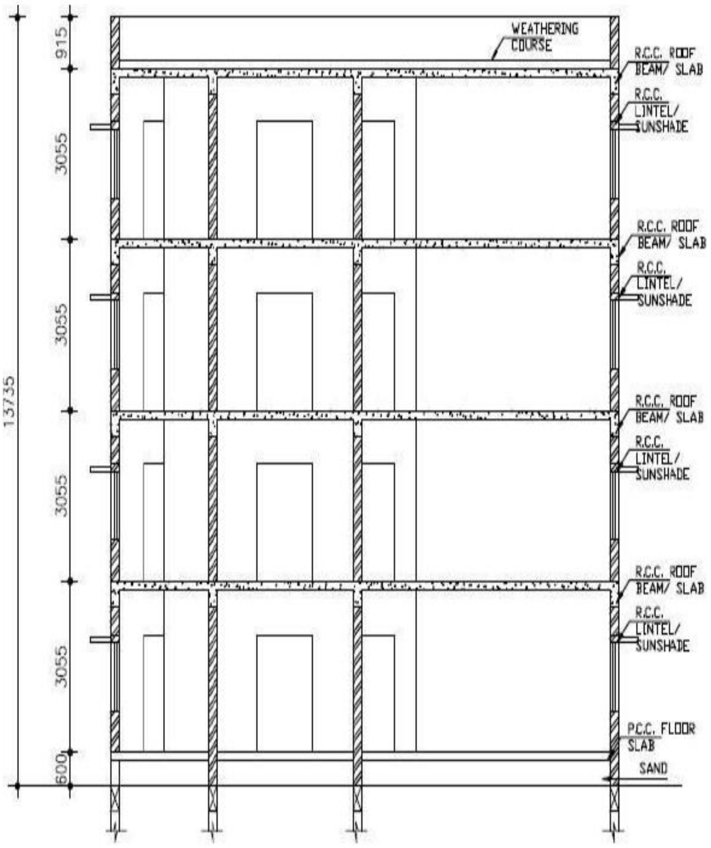

Fig.3.2: Sectional View of Framed Structure

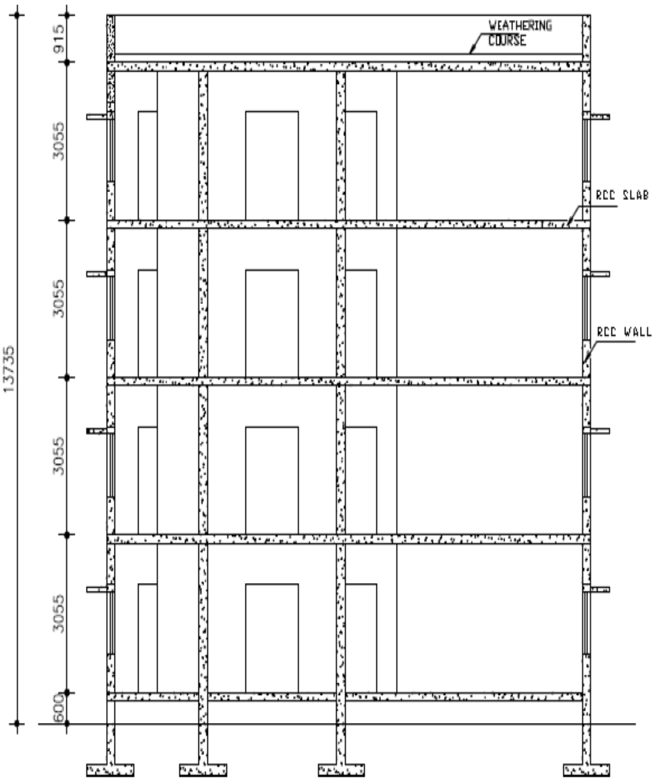

Fig. 3.3: Sectional View of MIVAN Structure.

Planning Considerations:
While planning the structure, the following important aspects are considered:

1. Proper column spacing and alignment for load transfer
2. Efficient beam layout to support slabs
3. Selection of suitable slab thickness
4. Proper positioning of doors, windows, and walls
5. Maintaining symmetry in the structure to reduce torsional effects
6. Ensuring functional requirements like ventilation and accessibility
7. Providing adequate structural stability and safety

In MIVAN technology, the planning is slightly different as load-bearing walls replace conventional beam-column system, and hence special attention is given to wall placement and thickness. Proper planning helps in reducing material wastage, improving structural efficiency, and achieving better performance.

3.3 Load Calculation

Load calculation is a very critical step in structural design. It involves determining all types of loads that act on the structure during its lifetime. All loads are calculated as per relevant provisions of Indian Standard Codes (IS 875 and IS 456).

3.3.1 Material Properties

The following materials are considered for the design:

1. **Grade of Concrete** = M25
2. **Grade of Reinforcement Steel** = Fe415
3. **Density of Concrete** = 25 kN/m³ (2500 kg/m³)

3.3.2 Types of Loads

1. Dead Load (DL)

Dead load includes the self-weight of all structural components such as slabs, beams, columns, and walls. It also includes permanent loads like floor finishes and fixed installations.

Calculation of Dead Load:

1. Slab Load
   = Thickness × Density
   = 0.15 × 25
   = 3.75 kN/m²
2. Partition Wall Load
   = 0.23 × 2.70 × 20
   = 12.42 kN/m
3. Terrace Wall Load
   = 0.23 × 0.90 × 20
   = 4.14 kN/m
4. Floor Finish Load
   = 1.00 kN/m² (assumed)

All dead loads are calculated as per IS 875 (Part I): 1987.

2. Live Load (LL)

Live load includes loads due to occupants, furniture, movable equipment, etc.

1. Live Load (Floors) = 2.00 kN/m²
2. Live Load (Terrace) = 1.50 kN/m²

As per IS 875 (Part II): 1987

3. Wind Load (WL)

Wind load is an important lateral load acting on the structure, especially for multi-storey buildings. The wind pressure is calculated using:

$$P_z = 0.6V_z^2$$

Where:

- P_z= Wind pressure
- V_z= Wind velocity at height z

Wind load depends on:

1. Basic wind speed
2. Height of building
3. Terrain category
4. Temperature and atmospheric conditions

Wind loads are calculated as per IS 875 (Part III): 1987.

3.3.3 Design Codes Used

The following codes are used in this study:

1. IS 456:2000 → Design of RCC structures
2. IS 875 (Part I, II, III) → Load calculations
3. SP-16 → Design aids for RCC
4. SP-34 → Detailing of reinforcement

3.3.4 Partial Safety Factors

As per IS 456:2000, the following load factors are used:

1. Dead Load Factor = 1.50
2. Live Load Factor = 1.50

3.4 Load Cases

The structure is analyzed under various load cases:
1. Dead Load (DL)
2. Live Load (LL)
3. Wind Load (WL)

Typical Floor Loads:
1. Slab Load = 3.75 kN/m²
2. Wall Load = 12.42 kN/m
3. Terrace Wall Load = 4.14 kN/m
4. Floor Finish = 1.00 kN/m²
5. Live Load = 2.00 kN/m²

These loads are applied in the structural model.

3.5 Load Combinations

The following load combinations are considered:
1. DL + LL
2. DL + WL (+X)
3. DL + WL (−X)
4. DL + WL (+Z)
5. DL + WL (−Z)
6. DL + LL + WL (+X)
7. DL + LL + WL (−X)
8. DL + LL + WL (+Z)
9. DL + LL + WL (−Z)

3.6 Structural Modeling

3.6.1 Softwares Used

1. AutoCAD
AutoCAD is used for preparing all **2D drawings**, including:
1. Floor plans
2. Structural layouts
3. Sections

2. STAAD.Pro
STAAD.Pro is used for:
1. Structural modeling
2. Load application
3. Analysis
4. Design

It can analyze:
1. Frame structures
2. Truss structures
3. Multi-storey buildings

Loads applied include:
1. Joint loads
2. Member loads
3. Area loads

The software automatically calculates:

1. Self-weight
2. Member forces
3. Deflections

3.6.2 Structural Analysis Output for Framed Structure from STAAD Pro

The results obtained include:

1. Bending Moment Diagram (BMD)
2. Shear Force Diagram (SFD)
3. Deflection values
4. Axial forces
5. Support reactions

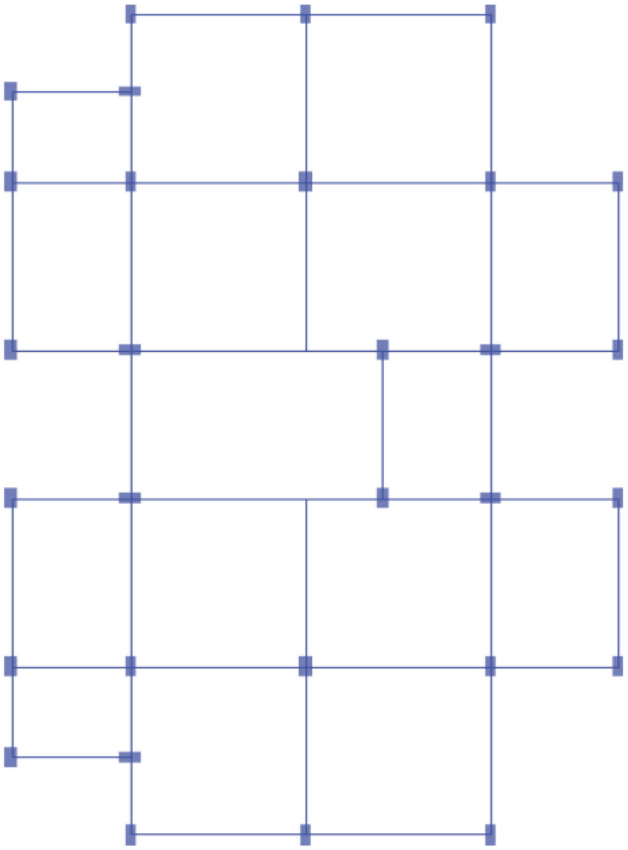

Fig.3.4: Plan view

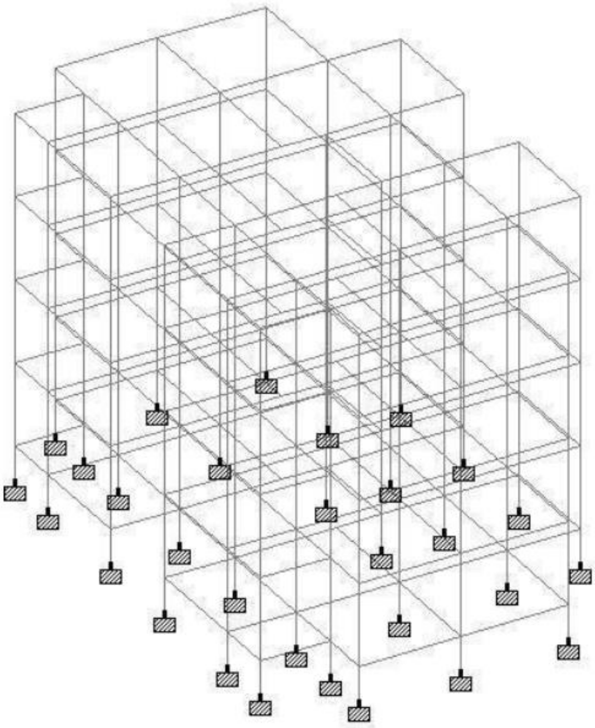

Fig.3.5: Isometric view

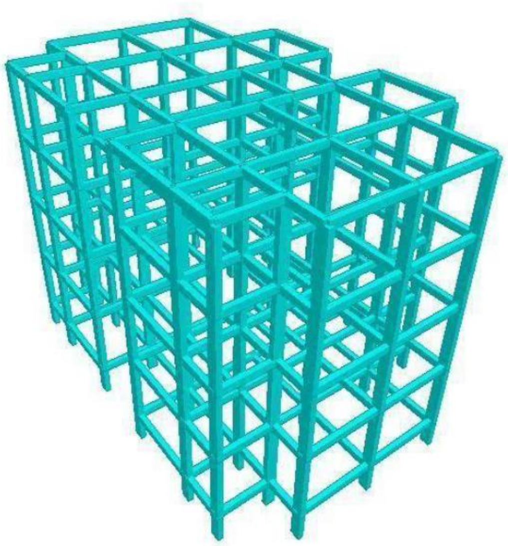

Fig.3.6: 3D Rendered view

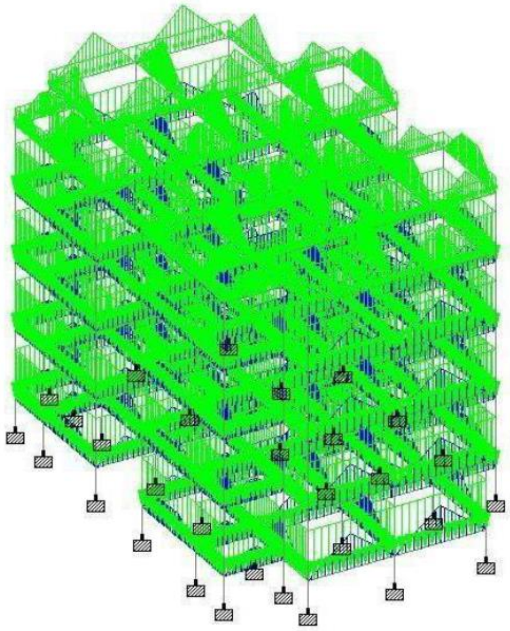

Fig.3.7: loading diagram

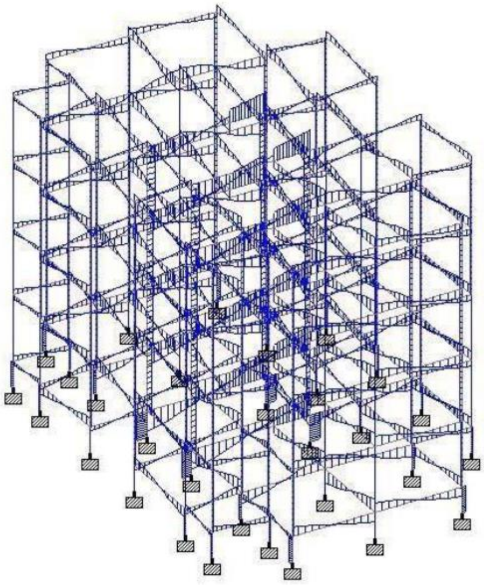

Fig.3.8: Shear force diagram

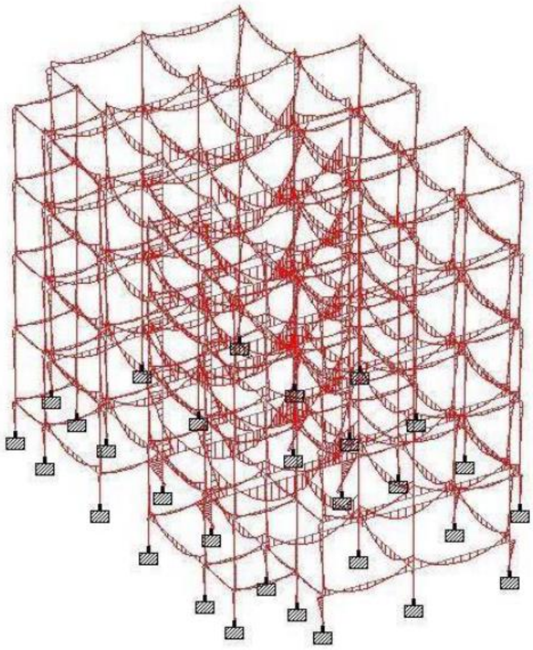

Fig.3.9: Bending moment diagram

3.6.3 Structural Analysis Output for Aluminium Formwork Structure (Mivan) From STAAD Pro

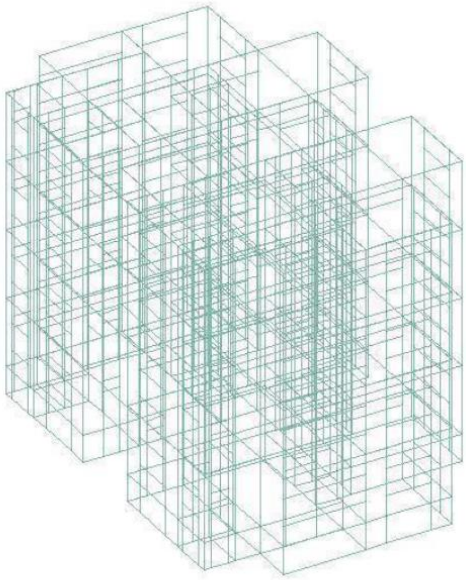

Fig.3.10: Isometric view

Fig.3.11: 3D rendered view

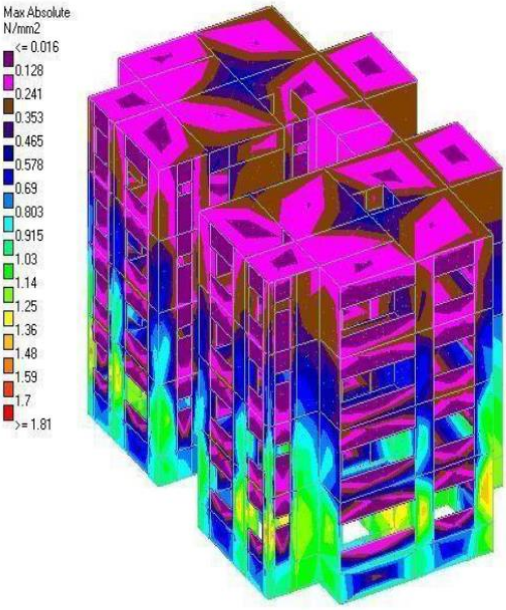

Fig.3.12: Plate stress diagrams (ABSOLUTE)

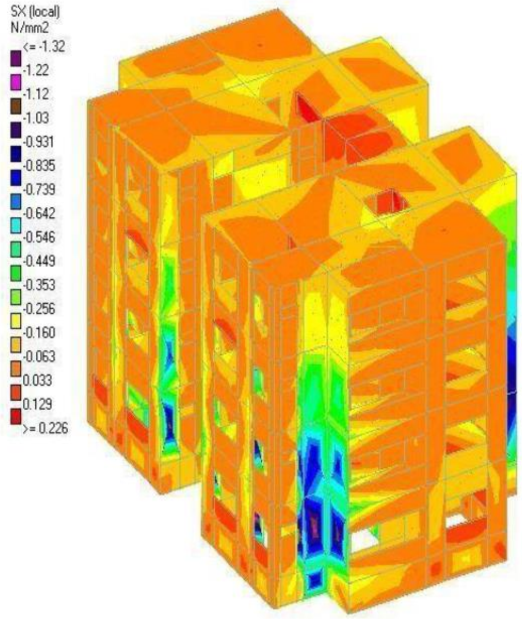

Fig.3.13: Plate stress diagrams (SX)

III. RESULTS

Table 4.1: Comparison of Framed Structure and MIVAN Structure

Sr. No.	Structural Component	Framed Structure (Conventional RCC)	MIVAN Structure (Aluminium Formwork System)
1	**Slab**	**Overall Depth:** 150 mm **Reinforcement:** • 10 mm dia bars @ 300 mm c/c in shorter span • 10 mm dia bars @ 300 mm c/c in longer span	**Overall Depth:** 150 mm **Reinforcement:** • 10 mm dia bars @ 300 mm c/c in shorter span • 10 mm dia bars @ 300 mm c/c in longer span
2	**Beam / Wall**	**Beam Size:** 230 × 375 mm **Reinforcement:** • 4 bars of 25 mm dia in tension zone • 4 bars of 25 mm dia in compression zone • 8 mm dia stirrups @ 180 mm c/c (2-legged)	**Wall Thickness:** 200 mm **Height:** 3000 mm **Length:** 4500 mm **Reinforcement:** • 10 mm dia bars @ 200 mm c/c (horizontal) • 12 mm dia bars @ 200 mm c/c (vertical)
3	**Column**	**Size:** 230 × 550 mm **Reinforcement:** • 8 bars of 20 mm dia • 8 mm dia lateral ties @ 230 mm c/c	**Not Required** (Load is carried by RCC shear walls instead of columns)
4	**Foundation**	**Type:** Isolated Footing **Size:** 2750 × 2750 mm **Depth:** 300 mm **Reinforcement:** • 11 bars of 20 mm dia in X-direction • 11 bars of 20 mm dia in Y-direction	**Type:** Wall Footing **Width:** 1200 mm **Depth:** 500 mm **Reinforcement:** • 12 mm dia bars @ 215 mm c/c in X-direction • 12 mm dia bars @ 215 mm c/c in Y-direction

4.2 Discussion

The above comparison clearly highlights the fundamental differences between the conventional RCC framed structure and the MIVAN structural system in terms of design philosophy, structural components, load transfer mechanism, construction efficiency, and overall performance. In the case of slab systems, although both structures adopt a similar slab thickness of about 150 mm with comparable reinforcement detailing, the behavior differs significantly due to the method of construction.

In conventional RCC framed structures, slabs are supported on beams, and the load is transferred from slab to beam and then to columns, which introduces additional bending moments, shear forces, and deflection. However, in the MIVAN system, slabs are cast monolithically along with walls using aluminium formwork, which results in a continuous and integrated structural system. This monolithic action increases the stiffness of the structure, ensures better load distribution, and significantly improves seismic performance by reducing weak joints. When comparing the beam and wall system, conventional RCC structures rely heavily on beams as primary load-transferring elements, requiring heavy reinforcement in tension and compression zones along with stirrups to resist shear forces, making the design and execution more complex and time-consuming. In contrast, the MIVAN system eliminates beams and replaces them with reinforced concrete shear walls, which act both as load-bearing and lateral load-resisting elements.

These walls distribute loads more uniformly across the structure and provide higher stiffness and strength, with reinforcement provided in both vertical and horizontal directions, leading to a more stable and durable structure. Similarly, in the case of column versus wall behavior, conventional RCC structures depend on columns as vertical load-carrying members that transfer loads from beams to the foundation, requiring heavy reinforcement and careful design due to their critical role in structural safety. On the other hand, MIVAN structures do not require separate columns, as the loads are directly transferred through continuous walls, which results in reduction of structural components, better load distribution, increased usable carpet area, and simplified construction process. Regarding the foundation system, RCC framed structures generally use isolated footings under each column, which involve larger excavation, higher reinforcement requirement, and potential stress concentration at specific points.
In contrast, MIVAN structures utilize continuous wall footings or raft foundations, which distribute the load along the entire wall length, thereby reducing stress concentration, minimizing differential settlement, and improving overall stability of the structure. From the perspective of overall structural behavior, the conventional framed structure behaves as a beam-column system with stepwise load transfer, making it relatively flexible and more prone to deflection under loading conditions, whereas the MIVAN system behaves like a monolithic box structure where loads are distributed uniformly throughout the system, resulting in higher stiffness, reduced deflection, and superior earthquake resistance due to better lateral load handling capacity. In terms of construction efficiency, RCC framed structures involve multiple sequential activities such as formwork erection, reinforcement placement, and concreting for each structural member separately, which increases construction time and labour requirement.

In contrast, the MIVAN system enables rapid construction through the use of reusable aluminium formwork, allowing casting of walls and slabs together in a single operation, which significantly reduces construction time (often achieving one floor cycle within 7–10 days) and ensures better quality control. Additionally, MIVAN construction provides smooth and uniform surface finish, eliminating or reducing the need for plastering, thereby saving both time and cost in finishing work. When considering cost aspects, RCC framed structures generally have lower initial construction cost due to conventional materials and methods, making them suitable for small-scale projects.

However, MIVAN construction involves higher initial investment due to the cost of aluminium formwork, but it becomes highly economical and cost-effective for large-scale and repetitive projects such as mass housing and high-rise buildings due to speed, reduced labour, and minimized maintenance requirements.

Overall, the discussion clearly indicates that while conventional RCC framed structures offer design flexibility and are suitable for smaller projects, the MIVAN structural system provides significant advantages in terms of speed, quality, durability, structural performance, and long-term economy, making it a modern and efficient construction technology for urban infrastructure development.

The above comparison clearly shows the fundamental difference between conventional RCC framed structure and MIVAN structural system in terms of design philosophy, structural components, and load transfer mechanism.
Slab Comparison:

In both systems, the slab thickness is kept as 150 mm, and reinforcement detailing is also similar. However, in MIVAN construction, slabs are cast monolithically along with walls, which increases the overall stiffness of the structure. This results in better load distribution and improved seismic performance. In conventional systems, slabs are supported by beams, which may introduce additional bending and deflection.

Beam vs Wall System:

In conventional framed structure, beams are essential structural members that transfer loads from slab to columns. The beams require heavy reinforcement, especially in tension and compression zones, along with stirrups for shear resistance. In contrast, MIVAN technology eliminates beams and replaces them with RCC shear walls, which act as both load-bearing and lateral load-resisting elements. These walls distribute loads more uniformly and provide higher stiffness. The reinforcement in walls is distributed in both horizontal and vertical directions, making the structure stronger and more stable.

Column vs Wall Behavior:

In conventional RCC structures, columns are vertical members that transfer loads from beams to the foundation. Columns require heavy reinforcement and are critical for structural safety.

In MIVAN structures, columns are not required, as the load is transferred directly through walls. This results in:

1. Reduction in structural components
2. Better load distribution
3. Increased usable space
4. Simplified construction

Foundation System:

In framed structures, isolated footings are provided under each column. These footings are larger in size and require more excavation and reinforcement.

In MIVAN structures, wall footings are used, which are continuous and distribute load along the length of the wall. This reduces stress concentration and improves stability.

Overall Structural Behavior:

1. Framed structure behaves as a beam-column system, where load transfer is stepwise
2. MIVAN structure behaves as a monolithic box system, where load is distributed uniformly

This results in:

1. Higher stiffness in MIVAN
2. Reduced deflection
3. Better earthquake resistance

Construction Efficiency:

1. Framed structure requires more time due to multiple activities (formwork, reinforcement, concreting)
2. MIVAN system allows fast construction using aluminium formwork
3. MIVAN provides better surface finish, reducing plastering work

Cost Consideration:

1. Framed structure has lower initial cost
2. MIVAN has higher initial cost but becomes economical for mass housing projects

CONCLUSION

Based on the detailed study, analysis, and comparison carried out between the conventional RCC framed structure and the MIVAN structural system, the following conclusions are drawn:

i. The study clearly shows that the conventional RCC framed structure follows a beam-column structural system, where the load is transferred from slab to beam, beam to column, and finally to the foundation, whereas the MIVAN structure follows a monolithic wall-slab system, which directly transfers load through RCC walls, resulting in a more uniform and efficient load distribution.
ii. It is observed that the MIVAN structure provides higher stiffness as compared to the framed structure due to the presence of continuous RCC walls, which act as shear walls and resist both vertical and lateral loads effectively.

iii. The analysis results indicate that the deflection and displacement values are comparatively lower in MIVAN structures, which improves the overall structural stability and serviceability of the building.
iv. The seismic performance of MIVAN structure is better, as the monolithic construction reduces weak joints and provides higher resistance against earthquake forces, making it more suitable for seismic zones.
v. In conventional structures, beams and columns require heavy reinforcement and careful detailing, whereas in MIVAN structures, reinforcement is distributed in walls, resulting in simplified structural design and detailing.
vi. The construction speed of MIVAN technology is significantly higher, as the use of aluminium formwork allows repetitive casting of walls and slabs in a single operation, thereby reducing overall project duration.
vii. The quality of construction in MIVAN system is superior, as it provides smooth surface finish, reduces plastering work, and ensures better dimensional accuracy.
viii. Although the initial cost of MIVAN construction is higher due to the use of aluminium formwork, it becomes economical for large-scale and repetitive construction projects, such as mass housing.
ix. The conventional RCC framed structure is more flexible in design and suitable for small-scale projects, where frequent design changes are required.
x. The foundation system in MIVAN structures provides better load distribution, as wall footings distribute loads continuously, whereas isolated footings in framed structures may lead to stress concentration.
xi. The study concludes that MIVAN technology is more suitable for modern construction, especially where speed, quality, and uniformity are important factors.

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