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Comparative Study on Design of RCC Structure Using Mivan Technology

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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, Aluminium Formwork System, Conventional RCC Construction, Monolithic RCC Structures, Seismic Performance, Structural Analysis, ETABS

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.

Despite its advantages, Mivan technology also presents certain challenges. The initial cost of aluminium formwork is relatively high, and it requires careful planning and standardisation of design to achieve maximum efficiency. Additionally, architectural flexibility is limited, as modifications after formwork fabrication are difficult. Therefore, it becomes essential to evaluate whether the benefits of Mivan technology outweigh its limitations when compared to conventional RCC construction, especially in the Indian context. The comparative study between conventional RCC structures and Mivan technology-based structures is therefore of great importance. Such a study helps in understanding the differences in structural behaviour, construction methodology, cost implications, and overall performance under various loading conditions, including seismic loads. It also provides valuable insights for engineers, designers, and policymakers in selecting the most appropriate construction technique based on project requirements. Furthermore, with the increasing emphasis on sustainable construction practices, it is necessary to consider factors such as material efficiency, reduction in construction waste, energy consumption, and environmental impact. Mivan technology, by reducing material wastage and improving construction efficiency, has the potential to contribute towards sustainable development goals. In the Indian scenario, government initiatives such as Pradhan Mantri Awas Yojana (PMAY) and other mass housing schemes have accelerated the adoption of modern construction technologies. Mivan technology has been widely used in such projects due to its ability to deliver large numbers of housing units within a short period while maintaining consistent quality. In this context, the present study focuses on a comparative analysis of RCC structures designed using conventional methods and Mivan technology. The study aims to evaluate their performance based on key parameters such as structural behaviour, construction speed, cost-effectiveness, and seismic resistance. The findings of this study will help in identifying the most suitable construction technique for modern infrastructure development, particularly in earthquake-prone regions.

II. MODELING AND RESULTS

2.6 Structural Modeling

2.6.1 Softwares Used

1. AutoCAD

AutoCAD is used for preparing all **2D drawings**, including:

- Floor plans
- Structural layouts
- Sections

It is easy to use, accurate, and widely accepted in industry.

2. STAAD.Pro

STAAD.Pro is used for:

- Structural modeling
- Load application
- Analysis
- Design

It can analyze:

- Frame structures
- Truss structures
- Multi-storey buildings

Loads applied include:

- Joint loads
- Member loads
- Area loads

The software automatically calculates:

- Self-weight
- Member forces
- Deflections

2.6.2 Structural Analysis Output for Framed Structure from STAAD Pro

The results obtained include:

- Bending Moment Diagram (BMD)
- Shear Force Diagram (SFD)
- Deflection values
- Axial forces
- Support reactions

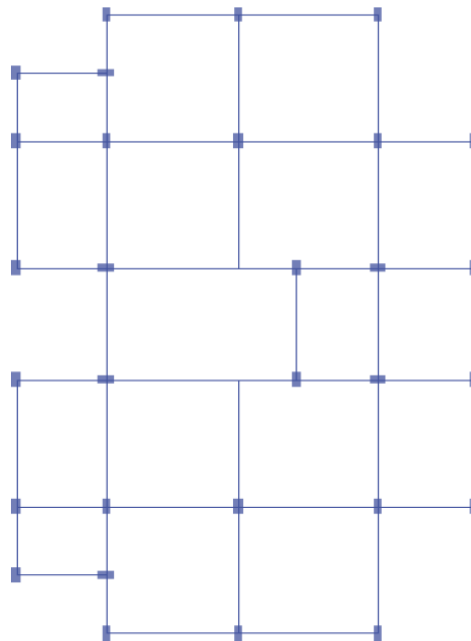


Fig.2.4: Plan view

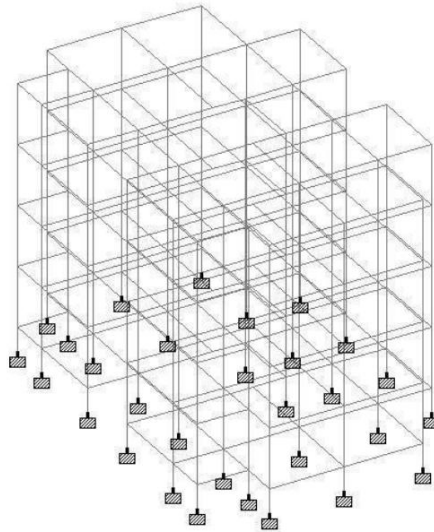


Fig.2.5: Isometric view

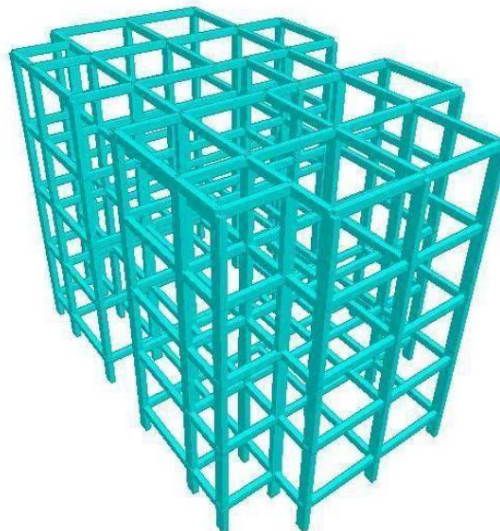


Fig.2.6: 3D Rendered view

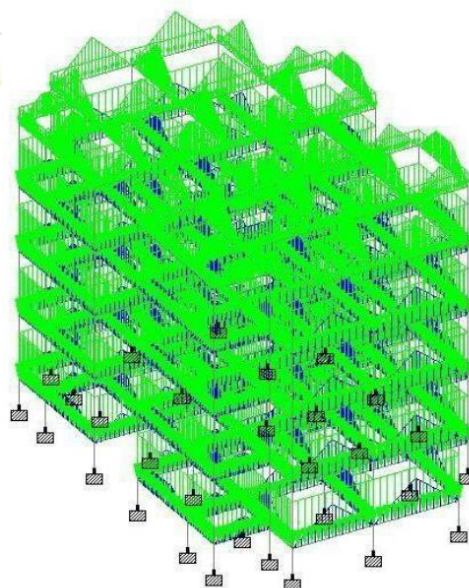


Fig.2.7: loading diagram

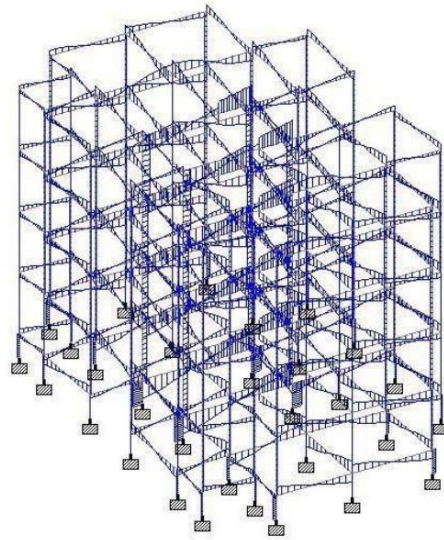


Fig.2.8: Shear force diagram

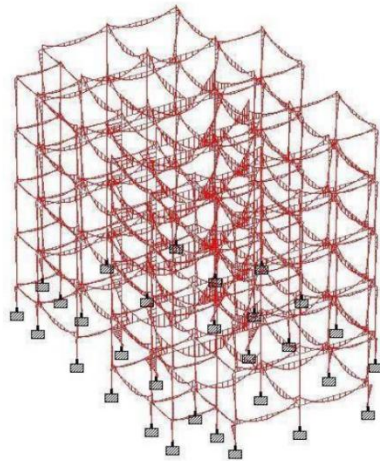


Fig.2.9: Bending moment diagram

2.6.3 Structural Analysis Output for Aluminum Formwork Structure (Mivan) From STAAD Pro

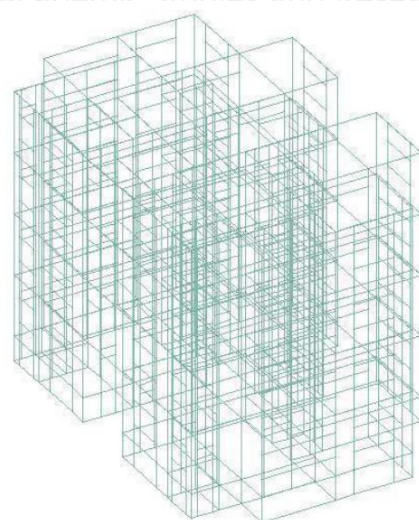


Fig.2.10: Isometric view

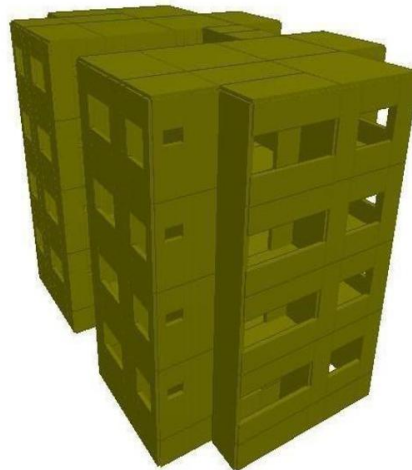


Fig.2.11: 3D rendered view

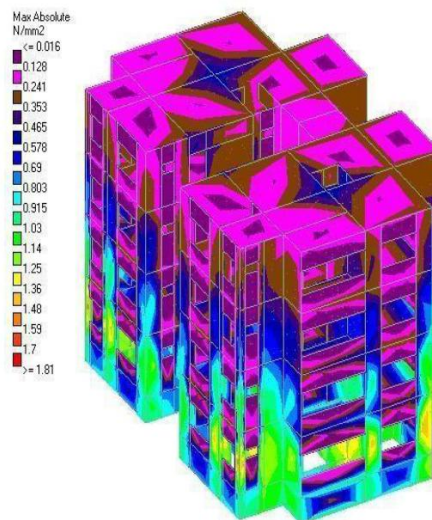


Fig.2.12: Plate stress diagrams (ABSOLUTE)

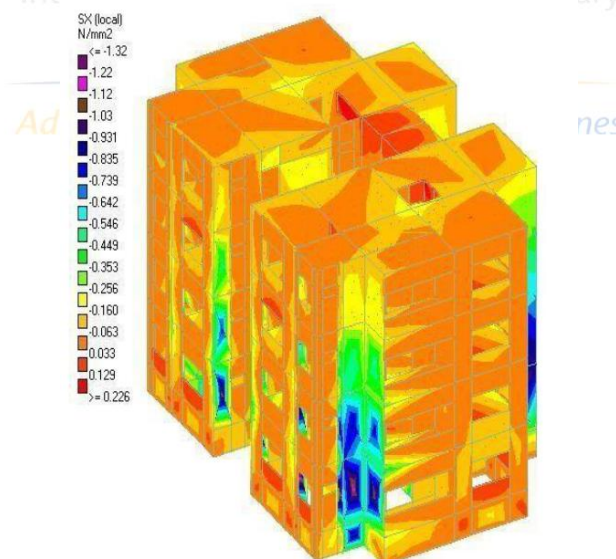


Fig.2.13: Plate stress diagrams (SX)

2.7 R.C.C Roof Slab Design for Framed Structure

Given Data:

- Size of slab = 3.70 m × 3.70 m
- Grade of concrete = M25
- Grade of steel = Fe415

Step 1: Type of Slab

Aspect ratio:

$$L_y/L_x = 3.70 / 3.70 = 1.0$$

Since the ratio is less than 2, the slab is designed as a two-way slab.

Step 2: Thickness of Slab

$$d = \text{Span} / (0.8 \times 40)$$

$$= 3700 / (0.8 \times 40)$$

$$= 119.08 \text{ mm}$$

Provide effective depth = 130 mm

Overall depth D = 150 mm

Step 3: Effective Span

Effective span = Minimum of:

- C/C distance = 3.70 + 0.23 = 3.93 m
- Clear span + d = 3.70 + 0.13 = 3.83 m

Effective span = 3.83 m

Step 4: Load Calculation

- Self weight = 0.15 × 25 = 3.75 kN/m²
- Floor finish = 2.00 kN/m²
- Live load = 3.00 kN/m²

Total load = 8.75 kN/m²

Design load:

$$W_u = 1.5 \times 8.75 = 13.125 \text{ kN/m}^2$$

Step 5: Bending Moment Calculation

$$M_u = \alpha w_u l^2$$

- Positive moment = 6.74 kNm
- Negative moment = 9.05 kNm

Step 6: Check for Depth

$$M_R = 0.138 f_{ck} b d^2$$

Required depth = 51.22 mm < 130 mm

Hence safe.

Step 7: Reinforcement Calculation

- Ast (positive) = 141.06 mm²
- Ast (negative) = 188.3 mm²

Provide:

- 10 mm bars @ 300 mm c/c

Step 8: Shear Check

Shear stress = 0.193 N/mm²

Permissible = 0.29 N/mm²

Hence safe.

Step 9: Deflection Check

Provided depth > required depth

Hence deflection is safe.

Step 10: Torsion Reinforcement

- $A_{st} = 141.22 \text{ mm}^2$
- Provide 6 mm bars @ 200 mm c/c

2.8 R.C.C Beam Design

Given Data:

- Size = $230 \times 375 \text{ mm}$
- Concrete = M25
- Steel = Fe415

Bending Moment:

- Negative moment = 165.36 kNm
- Positive moment = 142.36 kNm

Since $\mu > \mu_{\text{limit}} \rightarrow$ Doubly reinforced section

Reinforcement:

- Bottom bars = 4 nos 25 mm
- Top bars = 4 nos 25 mm

Shear Reinforcement:

- Provide 8 mm stirrups @ 180 mm c/c

Deflection Check:

L/d ratio safe \rightarrow No problem

2.9 R.C.C Column Design

Given Data:

- Size = $230 \times 550 \text{ mm}$
- Load = 1880.43 kN

Steel Calculation:

Asc = 2500 mm^2

Provide:

- 8 bars of 20 mm dia

Ties:

- 8 mm dia @ 230 mm c/c

2.10 Foundation Design

Given Data:

- Load = 1500 kN
- SBC = 200 kN/m^2

Size of Footing:

- $2.75 \text{ m} \times 2.75 \text{ m}$

Check for Bearing Capacity:

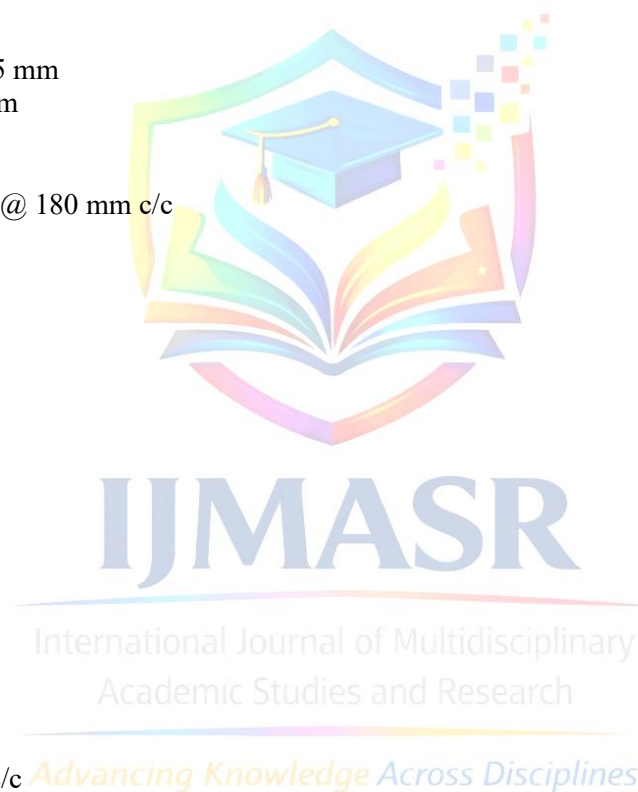
$P_{\text{max}} < \text{SBC} \rightarrow$ Safe

Depth:

Provide 450 mm

Reinforcement:

- 20 mm bars in both directions



2.11 MIVAN SLAB DESIGN

Same as framed slab:

- Thickness = 150 mm
- Reinforcement = 10 mm @ 300 mm c/c
- Safe in bending, shear, deflection

2.12 RCC Wall Design (Mivan)

Given Data:

- Wall thickness = 200 mm
- Height = 3 m

Reinforcement (from STAAD output table):

- Horizontal: 8 mm @ 250 mm
- Vertical: 20 mm @ 450 mm

Edge reinforcement provided

Walls act as shear walls, improving seismic performance.

3.13 Wall Footing Design (Mivan)

Dimensions:

- 3.0 m × 1.2 m
- Depth = 0.5 m

Loads:

- Total load = 597.32 kN

Bearing Pressure:

= 169.92 kN/m² < SBC → Safe

Stability:

- FOS against overturning = 124.44 → Safe

Reinforcement:

- Bottom: 20 mm bars
- Spacing:
 - X-direction = 210 mm
 - Y-direction = 215 mm

RESULT & DISCUSSION:

2.1 Comparison of Framed Structure and Mivan Structure

In this section, a detailed comparison is carried out between the conventional RCC framed structure and the MIVAN structural system based on structural components such as slab, beam/wall, column, and foundation. The comparison helps in understanding the differences in design approach, reinforcement detailing, structural behavior, and overall efficiency of both systems.

Table 2.1: 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 12 mm dia bars @ 215 mm c/c in X-direction • 12 mm dia bars @ 215 mm c/c in Y-direction

2.2 Discussion

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:

- Reduction in structural components
- Better load distribution
- Increased usable space
- 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:

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

This results in:

- Higher stiffness in MIVAN
- Reduced deflection
- Better earthquake resistance

Construction Efficiency:

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

Cost Consideration:

- Framed structure has lower initial cost
- 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:

1. 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.
2. 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.
3. 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.
4. 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.
5. 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.
6. 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.

7. The quality of construction in MIVAN system is superior, as it provides smooth surface finish, reduces plastering work, and ensures better dimensional accuracy.
8. 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.
9. The conventional RCC framed structure is more flexible in design and suitable for small-scale projects, where frequent design changes are required.
10. 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.
11. 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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