iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: VI Month of publication: June 2024

DOI: https://doi.org/10.22214/ijraset.2024.63306

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

Comparative Study of Conventional Structure and Mivan Structure Using ETABS

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***Abstract:** With rapid urbanization and industrialization, the demand for construction has surged to accommodate this expanding population. However, limited land availability has necessitated vertical construction over horizontal expansion. MIVAN technology has emerged as a viable solution, employing concrete instead of traditional masonry walls, particularly suitable for high-rise buildings. In this study, conventional and MIVAN structures with varying wall thicknesses is analyzed and compared using ETABS software with Response Spectrum analysis. Results show significant decreases in displacements, story drifts and time period in MIVAN structures, particularly with a wall thickness of 300mm for I-shaped structures. Additionally, MIVAN structures with 300mm walls exhibit higher story shear and stiffness, indicating better performance under seismic conditions compared to other shapes. Thus, MIVAN technology with 300mm walls in I-shaped structures offers superior seismic resilience in tall buildings.*

***Keywords:** MIVAN technology, Aluminum Formwork, Response Spectrum Method, Story displacements, Story drift, Time period, Story shear, Story Stiffness.*

I. INTRODUCTION

Given the limited availability of land, vertical construction is now favored over horizontal expansion. For large-scale building projects, it is crucial to utilize advanced technologies that enable rapid construction while ensuring high quality. The use of aluminium has also emerged as a significant technique for efficient formwork, potentially accounting for up-to 25% of a building's structure, and even more in bridge construction. Therefore, it is vital that the forms are meticulously designed to achieve cost-effectiveness without compromising on strength and efficiency. MIVAN technology is one such method employed for expedited construction.

A. MIVAN Technology

Mivan formwork system Mivan formwork system or Aluminium formwork system was developed by Mivan Company Ltd from Malaysia late 1990's as a system for constructing mass housing project in developing countries. Compared with repetitive design, the system is built multiple times by structural elements, ensuring a fast and economical construction method. In this technique cast in place method is followed to cast load bearing walls using aluminum panels as formwork. Mivan is a pre-engineered aluminium formwork system where the precision is high because the beams, columns, walls, staircase and slabs formworks

The components of formwork are

1) Wall components
2) Beam components
3) Deck components
4) Other components

Fig 1: MIVAN Form work

In MIVAN formwork system, walls and slabs are cast simultaneously at the site by using easy-going lightweight aluminum shuttering formwork. MIVAN system is much faster than the traditional beam, column, and brick construction. MIVAN comes out on top as being faster. The MIVAN buildings resistance when subjected to lateral loads such as earthquake, wind loads etc. Design of such lateral load resisting structures preserve the lives of people during earthquakes. It also safeguards the structures during earthquakes from the performance requirements.

II. LITERATURE REVIEW

Nitesh Baban Patekar et:al [2023][4]. The ultimate aim of this study is to provide guidance to construction professionals in making informed decisions regarding the selection of formwork systems, taking into account factors such as cost, time, labor requirements, and quality.

Mansi Rangari et: al [2022][7] This paper describes about comparative analysis of MIVAN formwork over conventional methods in terms of cost, quality, time, and strength parameters.

Sunny Gorivale et:at [2022][5]. The present study is to analysis of regular RCC structure, Braced structure and mivan structure and compare seismic performance of these analyses are carried out G+40 story structures positioned in earthquake zones III & using soft, medium and hard soil. Storey Displacement, time period and Storey forces results are also computed and compared for all the cases.

Ms. Shivani et: al [2022][9] This study aims to discuss and assess various formwork systems, examining their impact on project duration, cost, quality, cycle time, repetitions and labor requirements.

Kambale et: al [2022][10] This paper describes about cost-effective analysis. It is highly effective for repetitive building layouts and above- the-plinth work.

Mr. Nikhil S. Thote et:at [2022][6] In the present work, A residential of G+9 Framed and Mivan building is analysis statically (Linear method) for this work design software ETABS 2016 is used for design and analysis. Here the results for Time period, Maximum displacement and Story drift are compared static results for Zone-3 with medium soil type.

Darshankumar Patel et:al [2022][11] In this paper, we make comparisons MIVAN advanced technologies to traditional prefabrication innovation in terms of both cost and time.

Deep Jayesh Mistry et: al [2021][13] This paper delves into the analysis of on-site shape technology, demonstrating its superiority over traditional shaping methods.

Anuj choubey et:al [2020][18] This paper aims to highlight the potential of MIVAN technology in constructing super high-rise buildings. Specifically, it investigates the seismic response of high-rise building with different shapes, such as rectangle shape, C shape L shape and I Shape. The analysis employs the Response Spectrum Method using ETABS software to assess the seismic performances of these structures. Through such technologically innovative, there is a hope to overcome housing challenges and provide sustainable housing solutions for the growing population.

A. Aim and Objective of Work

1) To study seismic response of conventional G+30 building using response spectrum analysis
2) To study of seismic behavior of regular and irregular G+30 building using MIVAN technology
3) To compare the seismic responses story drift, displacement, time period, storey shear and storey stiffness of conventional building rectangle, L, I, C and + shapes using MIVAN technology and determine the best building.

B. Need Of Present Work

MIVAN system is much faster than the traditional beam, column, and brick construction, thus MIVAN comes out on top as being faster. This innovative form of work is actually suitable for constructing houses in large quantities at a faster speed. The speed of construction needs to be given greater importance, especially for large housing projects or township projects. The need of MIVAN structure is to increase the durability and serviceability of structures.

III. METHODODLOGY

Using ETAB software, G+30 building models are created. We have considered following shapes for both conventional & MIVAN structure.

1) Rectangle
2) L shape

3) I Shape
4) C Shape
5) + shape

A. Description Of Building

Software used for analysis: ETABS
Code provisions: IS 456: 2000
IS 16700: 2023
Type of analysis: Response spectrum analysis
Building details:
Structure Type: Regular structure and irregular
Height of Building: G+30 (93.2 m)
Total No. of Story: 31
Height of Each Story: 3m
Height of Bottom Story: 3.2m
Beam Size: Varying beam sizes
Upto storey 10 = 600 x 450mm
From storey 11 to storey 20 = 550x400mm
From storey 21 to storey 30 = 450x300mm
Column Size: Varying column sizes
Upto storey 10 =750 x 600mm
From storey 11 to storey 20 = 700x550mm
From storey 21 to storey 30 = 600x450mm
Slab Thickness: 150mm.
Wall thickness: Varying wall thickness (200mm, 250mm, 300mm)
Material properties
Grade of Concrete: M50 (for Beams, Column and Slabs)
Grade of Steel: HYSD 500
Load consideration
Dead Load:
Beam1: 6.75 kN/m
Beam 2: 5.5 kN/m
Beam 3:3.375 kN/m
Column 1: 11.25 kN/m
Column 2:10.3125 kN/m
Column 3:6.75 kN/m
Slab: 3.75 kN/m2
Live Load: 3 kN/m2
Floor Finish: 2 kN/m2
Seismic load factors and its considerations
Codal provision: IS 1893:2016
Seismic Zone - V
Zone Factor - 0.36
Soil Category - III
Importance Factor - 1.2
Response Reduction Factor R - 5
Damping (βeff) – 5%
Wind Load factor and its considerations
Codal provision: IS 875: 2015 (part-3)
Risk co-efficient(k1): 1

Terrain category(k2): 4
Topograghy (k3): 1
Important factor: 1
Wind speed (vb): 50m/s
Windward co-efficient: 0.8
Leeward co-efficient: 0.5
Where: vb is the basic wind speed m/s
k1 is probabaility factor (risk co-effiecient)
k2 is the terrain roughness and height factor
k3 is topography factor
k4 is importance factor
vb, k1, k2, k3, k4 values based on the IS 875: 2015 (part-3)

B. Method Of Analysis: Response Spectrum Method

Response spectrum method may be performed for any building using the design accelerations or by a site-speciic design acceleration spectrum. The response spectrum proves to be valuable in earthquake engineering as they aid in the analysis of a building's and equipment's performance during seismic events.

C. Modelling Of Building

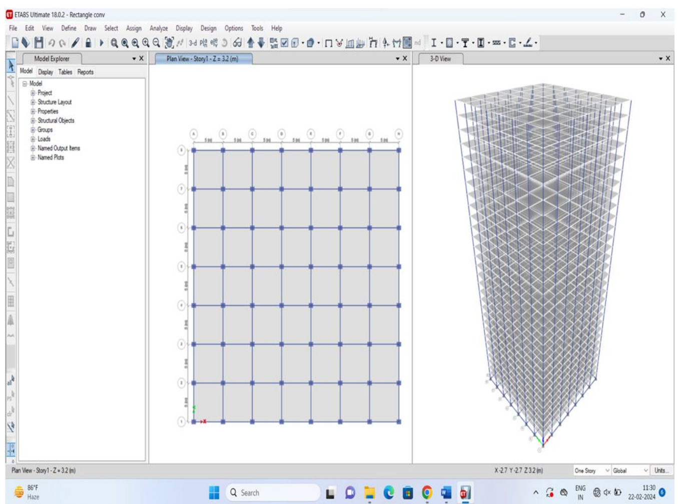

Figure 2: Plan and 3D view of rectangular shape conventional structure

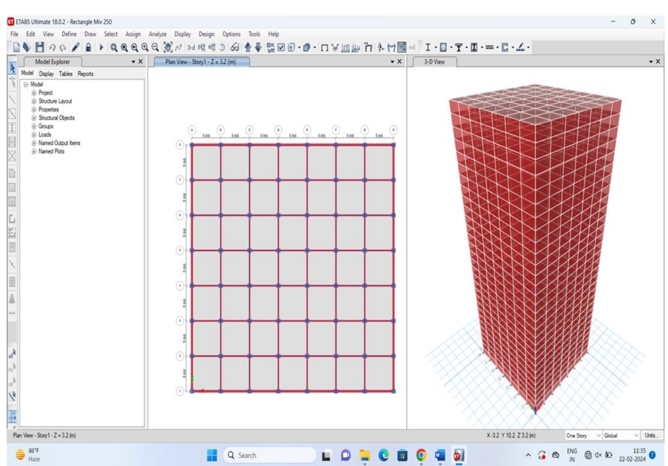

Figure 3: Plan and 3D view of rectangular shape MIVAN structure

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

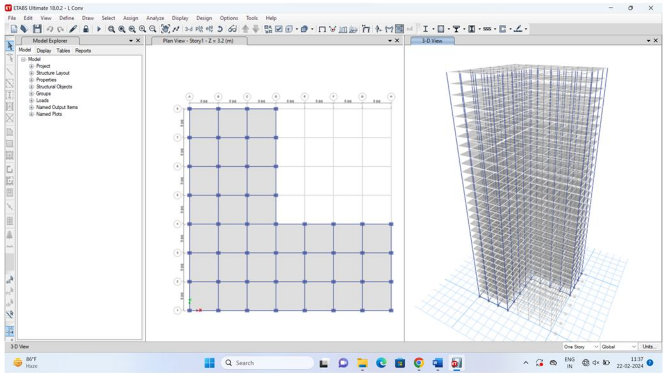

Figure 4: Plan and 3D view of L shape conventional structure

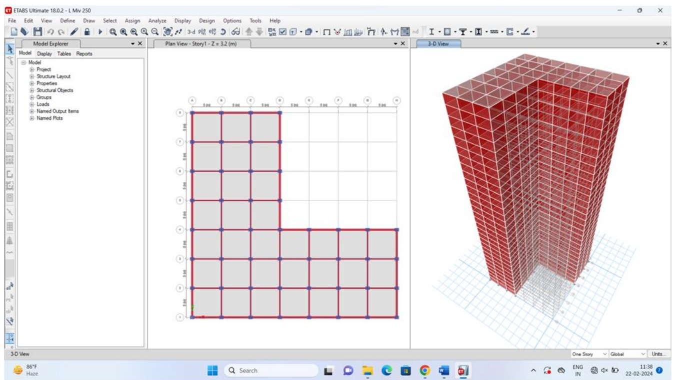

Figure 5: Plan and 3D view of L shape MIVAN structure

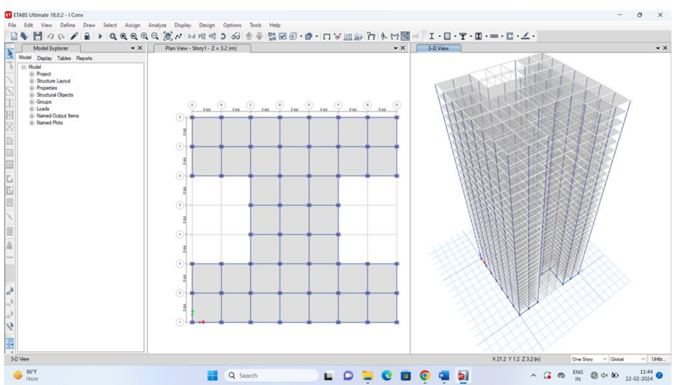

Figure 6: Plan and 3D view of I shape conventional structure

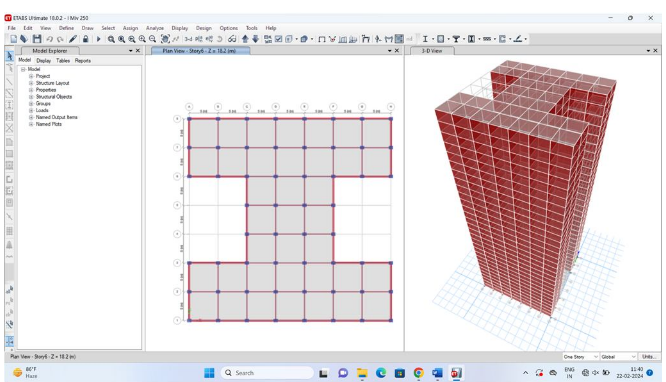

Figure 7: Plan and 3D view of I shape MIVAN structure

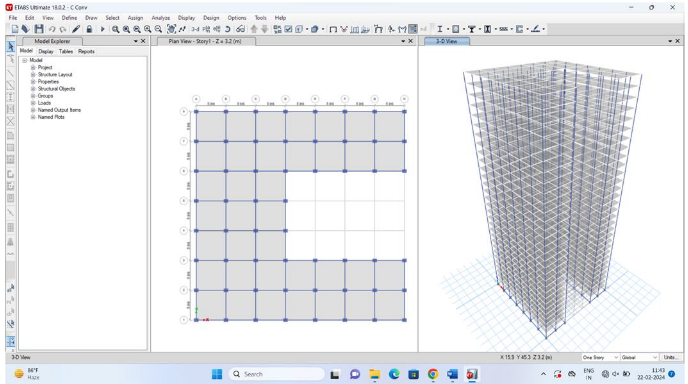

Figure 8: Plan and 3D view of C shape conventional structure

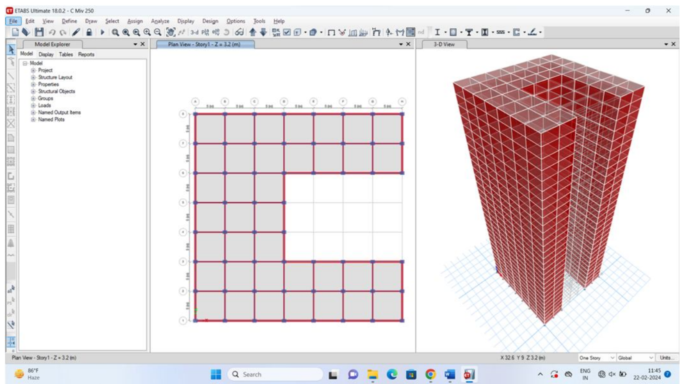

Figure 9: Plan and 3D view of C shape MIVAN structure

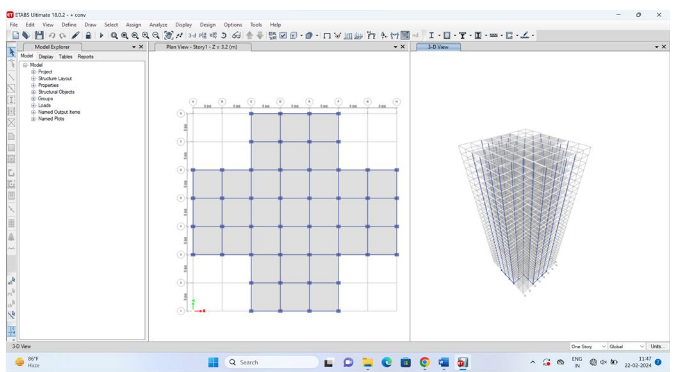

Figure 10: Plan and 3D view of + shape conventional structure

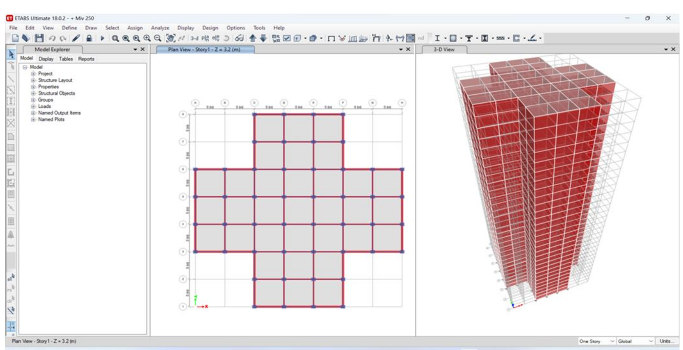

Figure 11: Plan and 3D view of shape MIVAN structure

IV. RESULTS AND DISCUSSIONS

Results estimated from the study of conventional high-rise structure and mivan high rise structure with different shapes by using computer software ETABS under earthquake loading. The Details of Different prepared software model which include total height, wall type and thickness and shape of building considered for the analysis

A. *Maximum Displacement(mm)*

Shapes	Conventional Structure (mm)	MIVAN structure with wall thickness 200mm (mm)	MIVAN structure with wall thickness 250mm (mm)	MIVAN structure with wall thickness 300mm (mm)
Rectangle	995	55	47	44
L Shape	886	72	67	62
I Shape	738	53	46	42
C Shape	993	82	71	33
+ Shape	841	58	54	53

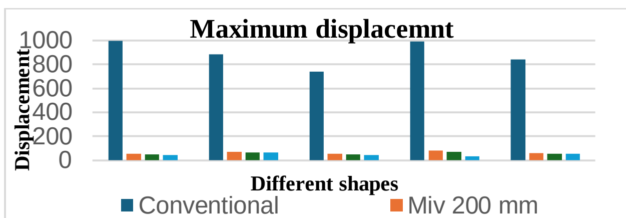

Fig 12: Maximum Displacement of Conventional and MIVAN structure

Maximum storey displacement means the displacement which occurred at each storey level because of various loading pattern. Figure shows maximum at top storey then goes on reduction up to first storey for conventional and MIVAN structure. The decreases in displacements of MIVAN structures with wall thickness of 250mm for rectangle, L shape, I shape, C shape and + shape is 95.27 %, 92.43 %, 93.7 %, 92.8 %, and 93.5 % respectively. When compared to the conventional structure with wall thickness of 250mm. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 250mm of rectangle, L shape, I shape, C shape and + shape displacement is reduced by 14.55%, 6.94%, 13.21%, 13.41%, 6.90%. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 300mm of rectangle, L shape, I shape, C shape and + shape displacement is reduced by 20%, 13.89%, 20.75%, 59.76%, 8.62%.

B. *Storey drift (Unitless)*

Shapes	Conventional Structure	MIVAN structure with wall thickness 200mm	MIVAN structure with wall thickness 250mm	MIVAN structure with wall thickness 300mm
Rectangle	0.014326	0.00069	0.00060	0.00057
L Shape	0.012544	0.00091	0.00085	0.00080
I Shape	0.01367	0.00066	0.00057	0.00052
C Shape	0.017648	0.00103	0.00089	0.00042
+ Shape	0.012079	0.00076	0.00072	0.00071

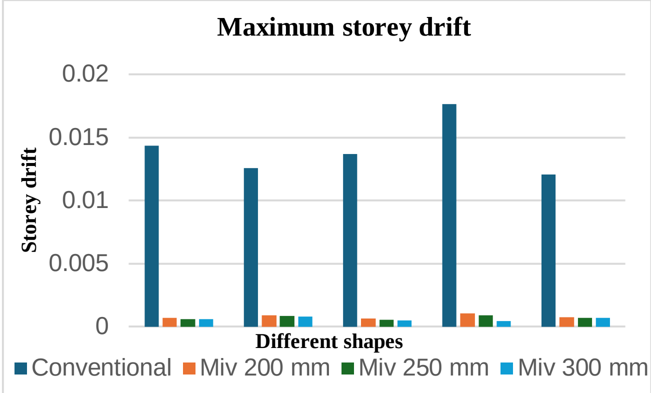

Fig 13: Maximum story drift of Conventional and MIVAN structure

Storey drift is relative displacement between any two levels of storey between the floor above and below the under consideration. As per the IS1893-2002 storey drift is 0.004 times the storey height. Figure shows maximum at top storey then goes on reduction The decreases in story drift of MIVAN structures with wall thickness of 250mm for rectangle, L shape, I shape, C shape and + shape is 95.76 %, 93.22 %, 95.82 %, 97.60 %, 94.06 % respectively. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 250mm of rectangle, L shape, I shape, C shape and + shape storey drift is reduced by 12.91%, 6.49%, 13.62%, 13.76%, 5.28%. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 300mm of rectangle, L shape, I shape, C shape and + shape reduced by 17.65%, 11.88%, 21.18%, 59.11%, 5.55%.

C. Time period (sec)

Shapes	Conventional structure	MIVAN structure with wall thickness of 200mm	MIVAN structure with wall thickness of 250mm	MIVAN structure with wall thickness of 300mm
Rectangle	3.373	0.648	0.627	0.605
L Shape	3.398	0.773	0.749	0.729
I Shape	3.468	0.656	0.635	0.614
C Shape	3.507	0.734	0.71	0.687
+ Shape	3.374	0.71	0.689	0.668

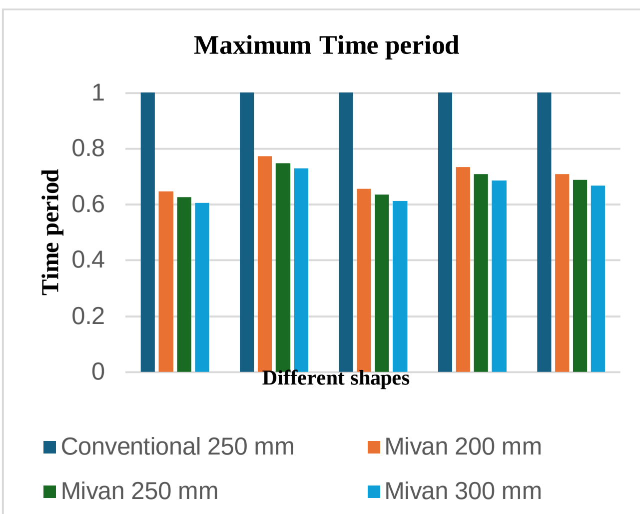

Fig 14: Maximum time period of Conventional and MIVAN structure

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

As thickness wall of structure is increases the time period of the structure decreases. The decreases in time period of MIVAN structures with wall thickness of 250mm for rectangle, L shape, I shape, C shape and + shape is 81 %, 78 %, 82 %, 80 %, 80 % respectively when compared to the conventional structure with wall thickness of 250mm. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 250mm of rectangle, L shape, I shape, C shape and + shape of time period reduced by 3.24%, 3.10%, 3.20%, 3.27%, 2.96%. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 300mm of rectangle, L shape, I shape, C shape and + shape reduced by 6.64%, 5.69%, 6.40%, 6.40%, 5.92%.

D. Storey shear(kN)

Shapes	Conventional Structure (kN)	MIVAN structure with wall thickness 200mm (kN)	MIVAN structure with wall thickness 250mm (kN)	MIVAN structure with wall thickness 300mm (kN)
Rectangle	57775	99024	106591	107611
L Shape	25613	77712	83138	89290
I Shape	30429	84242	89652	93324
C Shape	28923	91412	98090	104992
+ Shape	30739	64455	68365	85034

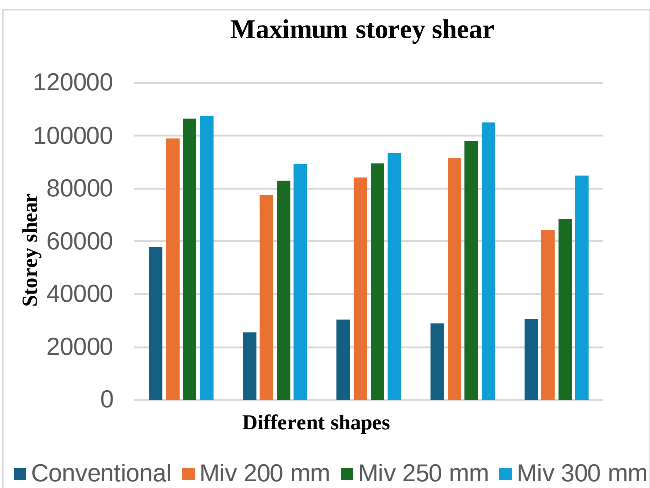

Fig 15: Maximum storey shear of Conventional and MIVAN structure

The design seismic force to be applied at each floor level is called story shear as the height is decreasing the storey shear will have maximum value. From output it is observed that maximum storey shear is occur for MIVAN structure. The increase in story shear of MIVAN structures with wall thickness of 250mm for rectangle, L shape, I shape, C shape and + shape is 45.79 %, 69.19 %, 66.05 %, 70.5 %, and 55.03 % respectively. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 250mm of rectangle, L shape, I shape, C shape and + shape of storey shear increased by 7.10%, 6.53%, 6.03%, 6.81%, 5.72%. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 300mm of rectangle, L shape, I shape, C shape and + shape increased by 7.98%, 12.97%, 9.73%, 12.93%, 24.20%.

E. Storey stiffness(kN/m)

Shapes	Conventional Structure (kN/m)	MIVAN structure with wall thickness 200mm (kN/m)	MIVAN structure with wall thickness 250mm (kN/m)	MIVAN structure with wall thickness 300mm (kN/m)
Rectangle	3088213	119808076	136810710	166119445
L Shape	2156229	94748292	94748292	114543156
I Shape	2691541	113214148	132696005	159664293
C Shape	2691149	113034854	134617380	162058260
+ Shape	2274561	87135934	100586237	121412430

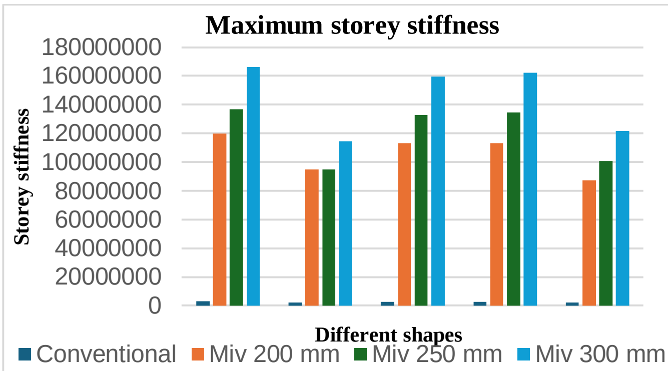

Fig 16: Maximum stiffness of Conventional and MIVAN structure

Stiffness is the extent to which an object resists deformation in response to an applied force. As the height is decreasing the storey stiffness will have maximum value. From output it is observed that maximum storey stiffness is occur for MIVAN structure. The increase in story stiffness of MIVAN structures with wall thickness of 250mm for rectangle, L shape, I shape, C shape and + shape is 97.74 %, 97.72 %, 97.97 %, 98.0%, and 97.73 % respectively. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 250mm of rectangle, L shape, I shape, C shape and + shape of storey stiffness increased by 12.43%, 14.03%, 14.68%, 16.03%, 13.37%. When MIVAN structure wall thickness 200mm is compare with MIVAN structure with wall thickness is 300mm of rectangle, L shape, I shape, C shape and + shape increased by 27.88%, 28.89%, 29.09%, 30.25%,28.23%.

V. CONCLUSION

The following conclusions are made based on the results obtained from the analysis of G+30 storied regular and irregular tall structure with and without MIVAN technology by using ETABS software responses in the form of maximum story displacement, maximum story drift, story shear, and story stiffness are noted:

1) MIVAN structural system is rigid and has better resistance to lateral loads. Hence MIVAN structures wall thickness of 300 mm has less displacement compared to other wall thickness of MIVAN structure.
2) Storey drift values more for MIVAN structure compared to conventional structure.
3) As the time period(sec) values for the mivan structure lower than the conventional structure. So, the mivan structure is more flexible and more mass.
4) As the height is decreasing the storey shear will have maximum value. This is due to increase in structural stiffness of shear wall as the shear wall increases the rigidity of structure leading to higher storey shear values.
5) As the height is decreasing the storey stiffness maximum value increasing. Mivan Structure with 300mm wall thickness has more storey stiffness compared to the conventional structure.

From above results, conclude that MIVAN technology with wall thickness of 300mm of I shape structure will give better performance to seismic conditions in regular and irregular tall building compared to the other shapes of structures.

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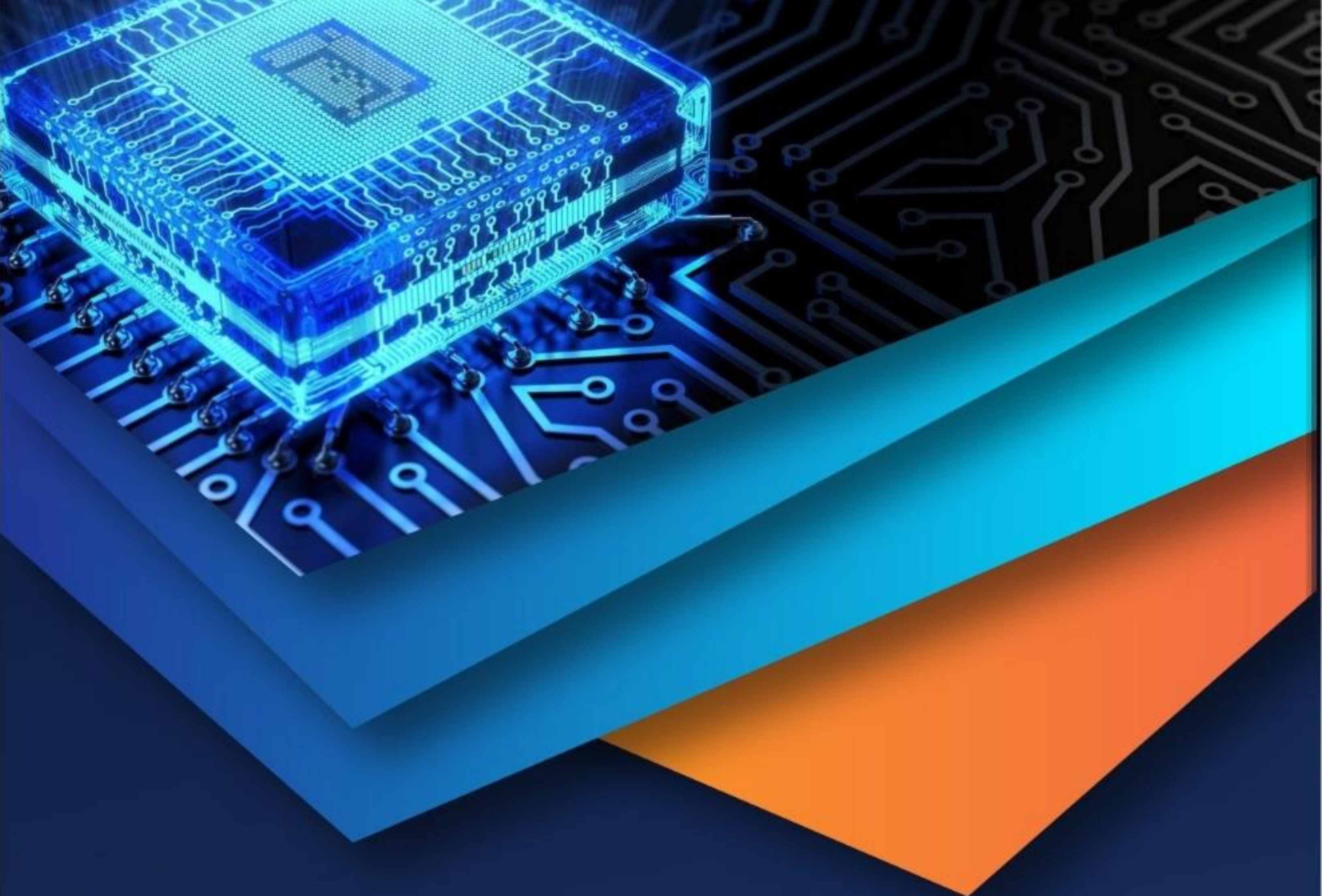

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