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Seismic Analysis Comparison of G+11 Storey Conventional RC Frame Structure and Mivan Structure

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ABSTRACT

Earthquake is the important term that is considered while designing any multistorey structure. During earthquake large amount of energy is released in crust due to failure of rupture plane or tectonic plate movements. This energy reaches the surface of earth in form of waves. Due to this earthquake cause huge destruction on surface of earth and will cause damage to the structure. Hence earthquake is considered as one of the most disastrous of natural criteria. In this study G+11 storey building of rectangular plan is considered for the seismic analysis. The equivalent static method and response spectrum method is used for seismic evaluation of both conventional RC frame structure and mivan structure. ETABs 2017 software used for the analysis of the building, by considering seismic zone V and medium soil (Type II) as per IS 1893-2016. Storey displacement and storey shear are considered for checking the performances of the building. Objective of this study is to compare results obtained from static and response spectrum analysis in both longitudinal and transverse direction.

KEYWORDS: *Conventional RC frame structure, Mivan structural system, Seismic analysis, Response spectrum method, Equivalent static method, storey responses*

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1. INTRODUCTION

"Earthquake is the important term that is considered while designing any multi storey building. Earthquake is generated at epicentre due to failure in rupture plane or movement in tectonic plates/fault plane which produces lot of energy which reaches the surfaces of earth in form of waves in different patterns which causes severe destruction on surface of earth and damage in structures. Hence earthquakes are one of the most disastrous of natural criteria, there is a huge loss of life, property and many essential services. For this we have to take care while constructing the building, the0structure should be a earthquake resistant0sructure. The earthquake resistant structures are the structures which can resist the largest earthquake that can possibly occur in particular area as per the standard codes. The structure should be having a good building configuration than it is a earth quake resistant structure it should be having better lateral stiffness, ductility, lateral strength, stability and integrity. The structure to be made earthquake resistant many technologies are developed and different type of construction techniques are developed.

A. Mivan formwork system

Mivan formwork system or Aluminium formwork0system was0developed by Mivan Company Ltd from0Malaysia late 1990's as a system for constructing0mass housing project in developing countries .In this technique cast in place method is followed to cast load bearing walls using aluminium 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

- Wall components
- Beam components
- Deck components
- Other components

Formwork assembly can be done by Efficient- quick strip prop head and pin and wedge system.

Cost and time are the two important parameters which play a vital role in any construction activity. Hence it has become necessary to estimate cost and time required to complete the construction. At same time, progressive rise in construction industry in India and rapid growth of population and urbanization has led to shortage of space, accommodation and situation have become critical in urban and metropolitan areas. For construction of mass building works, it's far important to have progressive technology that are capable of fast construction and are able to construct best quality and durable construction in cost intended manner. One of such technology is Mivan Construction system.

B. Objectives

The following objectives are considered in the present studies,

- To know the seismic response of the Mivan0structural system and conventional0RC structural system with rectangular beam and column considered using ETABS-2017 software.
- Comparison is made for Mivan structural system v/s conventional RC structural system for both equivalent static method and response spectrum method.
- To check the storey response of the structures (storey displacements and storey shear).

2. METHODOLOGY

The structure with more than one storey level will be considered as multi degree freedom systems. Deformation of entire structure cannot be specified by a single displacement in MDOF; hence it requires more displacements co-ordinates to identify the structure how it is displayed. Multi storied buildings are the perfect examples for MDOF. In case of multi storied structure the total mass of building is centralized at the floor level. This assumption shows that these are having infinite number of degrees of freedom; structure with many degrees has a lumped mass at the floor levels.

A. Methods of analysis

Method of seismic analysis is done by many methods. Many methods are available for the seismic analysis of selected structure to get output results like forces that are developed due to seismic activity on the structure. This depends on the soil interaction, material of building, type of building, zone in which building is situated, height of structure and type of analysis.

I. **Equivalent0static method** is also known0as equivalent lateral force method. Seismic analysis on a building is done on assumption of the0horizontal force is similar to the dynamic loading, In the0method periods and shape0of higher mode of vibration are not required so the effort for the0analysis is less, except for the fundamental period. The base shear is calculated depends on the mass of structure, its fundamental periods of0vibration and shapes. Firstly, the base shear is calculated for an entire structure0then along the height of building distribution is done. At each floor level the lateral0force obtained are distributed to each structural element. This method is usually adopted0for a low to medium height building.

II. **Response spectrum method** is also called as a modal method or mode superposition method. This is a0linear dynamic analysis method. In0this method mode shapes of building are taken into consideration so it is called as model method/mode superposition method. Response0is read from design spectrum in each storey for the modal0frequency and modal mass. Other than fundamental one the mode affects the response of structure, this method used in buildings having asymmetrical plan and irregular in area for dynamic analysis. In case of multi storied buildings to find the forces and displacements caused due to medium range earthquake motion this method is used for analysis. In this method directly from the earthquake design spectrum the peak response of a building is obtained during an earthquake ground motion. Peak responses obtained in this method are quite precise with the structural design application. In this method multiple modes of response are considered. Based on modal frequency and modal mass the individual mode response is read from the response spectrum

3. MODELLING AND ANALYSIS

Type of structure	G+11-Conventinal RC structural system	G+11- Mivan structural system
Building dimension	(25 x 20) m	(25 x 20) m
No of bays0in x direction	5	5
No of bays0in y direction	4	4
Storey height	3m	3m
Height of structure	35 m	35 m
Each bay width	5m	5m

Beam size	450*600 mm	300*900 mm (at plinth level)
Column size	750*900 mm	-
Spandrel size	-	160*450 mm 160*900 mm 160*500 mm 160*450 mm
Pier size	-	1000*160 mm 600*160mm
Slab size	150 mm	150 mm
Wall size	Masonry walls 9''=150 mm	Concrete walls 160 mm,200mm and 300mm
Lift core wall size	200mm	200mm
Live load	40KN /m^2	4 KN /m^2
Roof and Floor finish	0.75 KN /m^2	0.75 KN /m^2
Roof load	2 KN /m^2	2 KN /m^2
Grade of concrete used	M30 for column M25 for all other members	M25
Grade of steel used	Fe500	Fe500
SEISMIC PARAMETERS as per IS1893:2000 (Part -I)		
Seismic Zone	V	
Type of Structure	SMRF(Special Moment Resisting Frame)	
Damping Ratio	5% (Table 2)	
Importance Factor (I)	1.5 (Table 6)	
Response Reduction Factor(R)	5 (Table 7)	

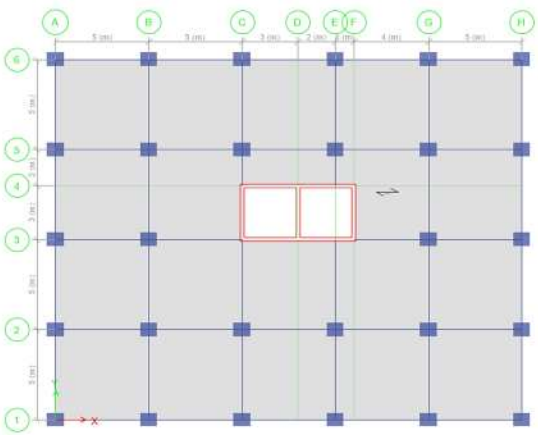


Fig 1: Conventional Structural Plan

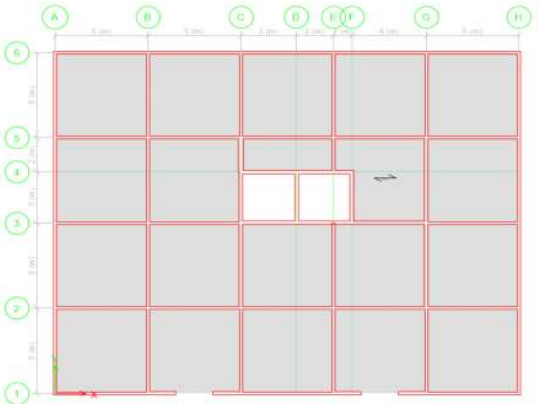


Fig 2: Mivan Structural Plan

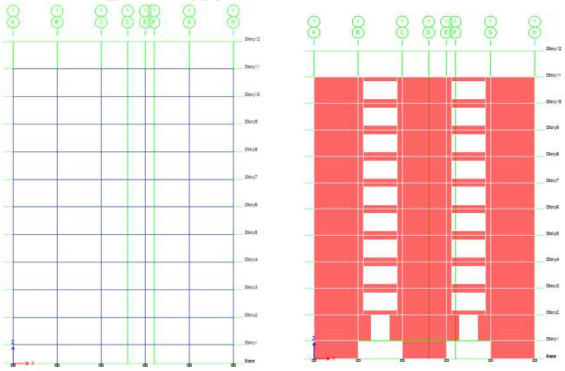


Fig 3: Conventional & Mivan Structural elevation.

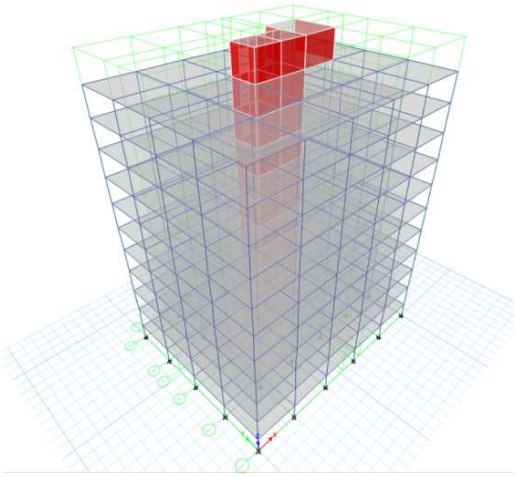


Fig 4: Isometric view of conventional RC structure system

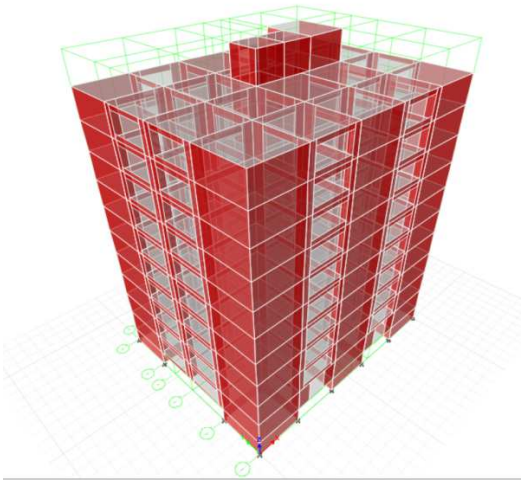


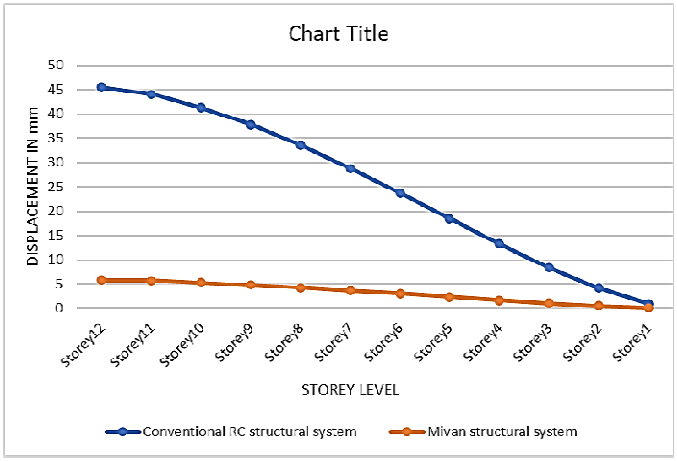
Fig 5: Isometric view of mivan structural system

4. RESULTS AND DISCUSSION

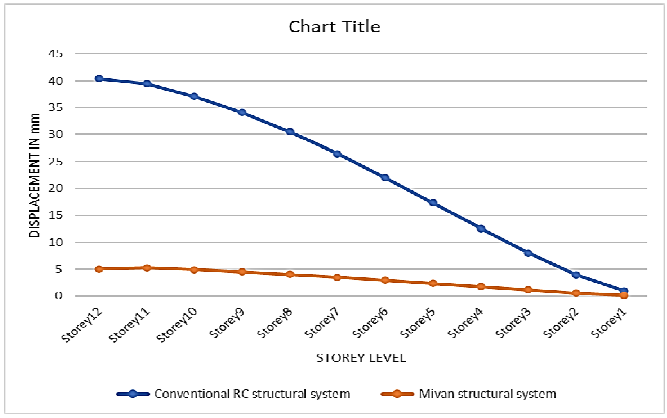
Both mivan and conventional structural model are done with all defined loads as mentioned in codal provisions. Then the structure is analysed in the ETABs software for both equivalent0static0method and response0spectrum0method. Storey responses are compared both in X and Y direction of respective method, in both analysis methods and also for the type of structure. Storey responses include storey displacement, storey shear

A. Storey displacement

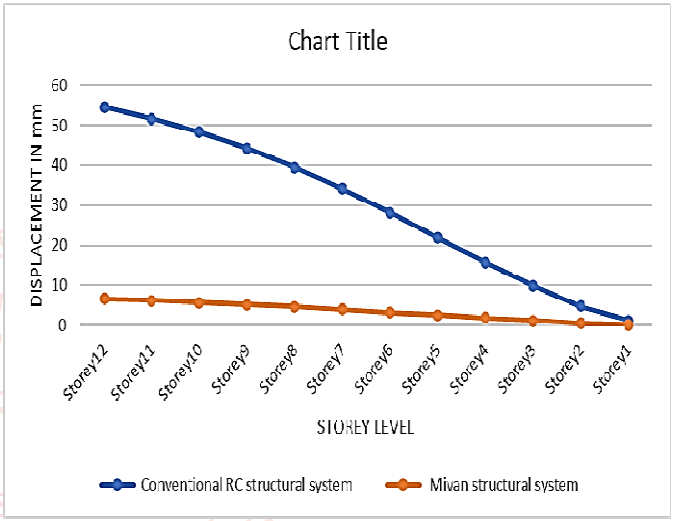
Displacement is said to be the total displacement occurred in the storey with respect to ground due to the static and dynamic loads. When the lateral loads like earthquake loads are acting on the building there occurs a displacement in the building. The parameter shows if displacement is less than the stiffness of building is high. When the height of building increases the loads coming on the floors also increases and that loads should be transferred to ground systematically but when the lateral loads act on structure if the building fails to transfer that loads then the displacement occurred in the building is more.



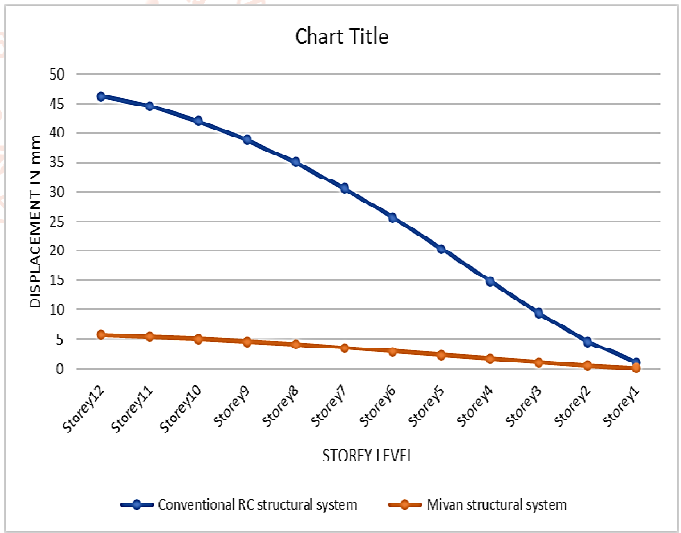
Graph 1: Storey displacement in x direction for equivalent static method



Graph 2: Storey displacement in x direction for response spectrum method



Graph 3: Storey displacement in y direction for equivalent static method



Graph 4: Storey displacement in y direction for response spectrum method

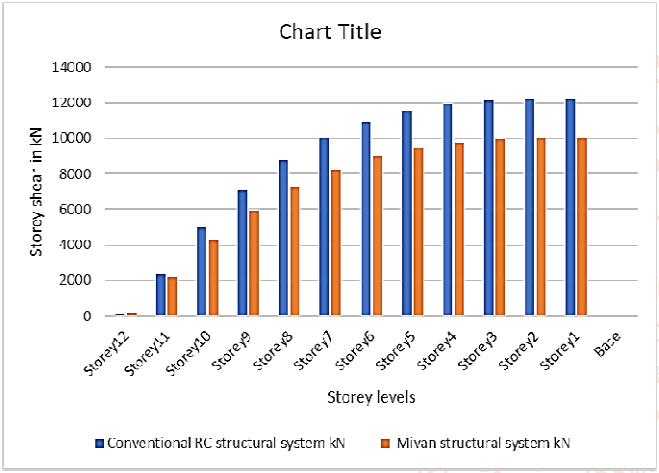
In this G+11 storey structure the maximum displacement in static method is y-direction of conventional RC structure i.e 54.637 mm and in x direction 45.515 mm. similarly for mivan structural system 5.826 mm is max displacement in x direction and 6.649mm is maximum displacement in0y direction.

For the same structure when response spectrum analysis is done then 40.466mm is max displacement in x-direction and 46.263mm in y0direction. For mivan system 5.056mm and 5.763 mm are the max value of displacements in x and y0direction respectively.

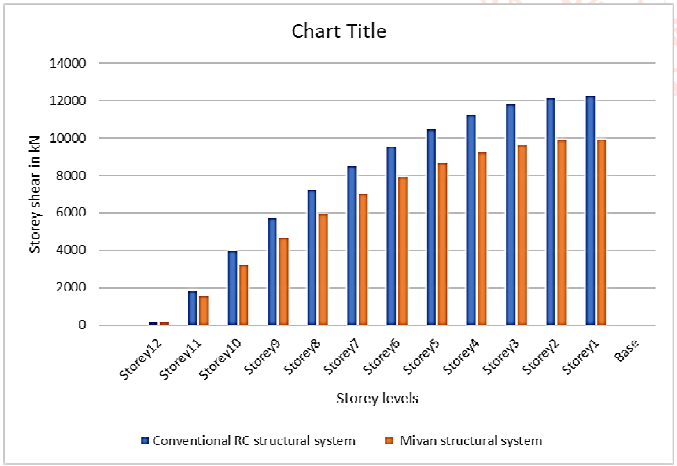
From the above observation we can say the displacement for mivan structure is has 90% less displacement than conventional RC frame, which indicates mivan can resisit lateral loads better than RC frame.

B. Storey shear

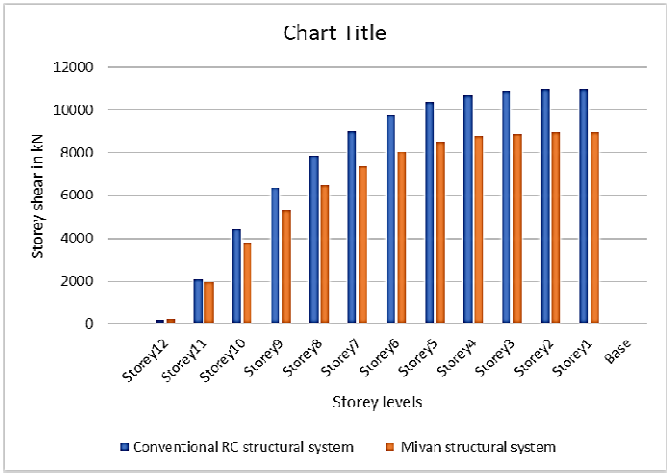
The computation of storey shear is done by adding of design0lateral forces at the levels above the storey0consideration of the structure. Usually, the storey shear value is maximum at the lower stories and minimum at the higher stories



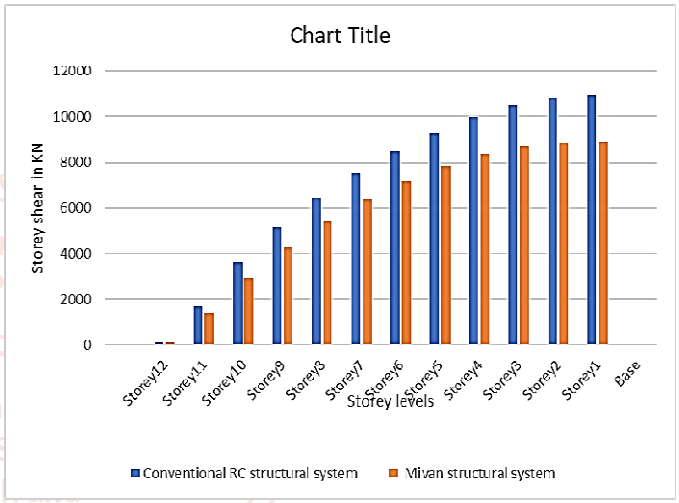
Graph 5: Storey0shear in x direction for equivalent static method



Graph 6: Storey0shear in x0direction for response spectrum0method



Graph 7: Storey shear in y direction for equivalent static method



Graph 8: Storey shear in y direction for response spectrum method

From above observation in static analysis for conventional RC structure the maximum storey0shear value in X and Y direction are 12232.8308 KN and 10946.994 KN respectively. For mivan structure the maximum storey Shear value in x and y0direction are 10946.994 KN and 8950.951 KN respectively.

In dynamic analysis for conventional RC frame the maximum base Shear value in x and y0direction are 12232.308 KN and 9939.638KN respectively. For mivan structure the maximum base shear value in x and y direction are 9939.638 kN and 8894.645 KN respectively. By this data it is observed that the value of storey shear is less for mivan structure.

5. CONCLUSIONS

The present study is focused on earthquake/seismic analysis of the G+11 structure of conventional RC structure system and G+11 mivan structure system. The seismic zone considered is zone 5 with medium soil and importance factor is taken 1.5. The dynamic analysis is done because the structure is considered in zone 5. Both static and dynamic analysis is done.

- Storey displacement for regular RC structure will have maximum value when compared to the mivan structure. In mivan the walls were designed as shear walls hence the displacement of building is less than normal conventional RC building.
- Storey Shear of mivan structure is 18.23% lesser than RC Structure in static analysis and in dynamic analysis the storey shear of mivan structure is 18.72% less than conventional RC structure.

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