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COMPARATIVE STUDY OF SEISMIC RESPONSE OF REGULAR AND IRREGULAR BUILDING WITH SHEAR WALL

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Abstract: This paper describes comparative study of seismic response of regular and irregular buildings with different positioning of shear wall by response spectrum method and time history analysis. Multistoried buildings are provided with shear wall at various positions. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Reinforced concrete framed buildings are adequate for resisting both vertical and horizontal loads acting on them. Extensive research has been done in the design and analysis of regular and irregular building. Present study includes seismic response of regular and irregular building with and without shear wall was carried out to understand the lateral loads, displacement and member end forces. An earthquake load is calculated by seismic coefficient method using IS 1893 (PART–I):2002. These analyses were performed using SAP 2000 15. Test results including base shear, displacement, and moment are presented and effect of seismic response by time history method and response spectrum method is studied.

Key words: RC Structure, SAP 2000 14, shear wall, seismic analysis, dynamic comparison

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INTRODUCTION

The dynamic loadings to be discussed are in the response spectrum method and the linear time-history analysis. The first one is widely used as it applies to the major part of a seismic analysis necessary for design purpose. The second method provides more detailed information regarding the seismic behaviour of a structure and is therefore used for more specific earthquake analyses. Both methods assume linear behaviour of the structure, i.e. proportionality between forces and deformation. This paper introduces the seismic response of regular and irregular buildings with shear wall. Generally shear wall can be defined as structural vertical member that is able to resist combination of shear, moment and axial load induced by lateral load and gravity load transfer to the wall from other structural member. Reinforced concrete walls, which include shear walls, are the usual requirements of Multi Storey Buildings. An introduction of shear wall represents a structurally efficient solution to stiffen a building structural system because the main function of a shear wall is to increase the rigidity for lateral load resistance. Now the dynamic loading on building is considered as El Centro ground motion, the north-south component of the recorded at a site, California during the Imperial Valley earthquake of May 18, 1940.

Literature

A study by Le Yee Mon (2014); In this paper present a fourteen storied Y-shaped high rise reinforced concrete building in seismic zone 4 is done by ETABS v 9.7.1 software using response spectrum analysis which is analyzed by changing various location of shear wall and found that When core shear wall placed at stair case & lift of building and planar shear walls placed at outer corner symmetrically X and Y direction gives better performance among the other models.

A study by R.Chittiprolu, R. Pradeep Kumar (2014) examines the significance of dynamic linear analysis using response spectrum method is performed and lateral load analysis is done for structure without shear wall and structure with shear wall. It is also observed that lateral forces are reducing when the shear walls are added at the appropriate locations of frames having minimum lateral forces.

A study by Himalee Rahangdale (2013) was conducted on G+ 5 stories symmetric building in Zone IV was presented with some preliminary investigation which was analyzed by changing various positions of shear wall with different shapes and found that a box type shear wall at centre is more safer than to other type of walls placed at different locations.

A study by P.S. Kumbhare (2012) was conducted to investigate the effectiveness of shear wall in a residential medium rise building considering frame system and duel system and found that frame type structural system becomes economical as compared to the dual type structural system and it can be used for medium rise residential buildings situated in high seismic zone.

Problem Statement

A residential building of G+10 regular structure having the base dimension of plan 16 m x 16 m with typical floor of height 3m is considered for the analysis. Spacing of frame is 4m.The structure is planned to be reinforced concrete with cement/fly ash brick infill wall. The structure is modeled using standard software SAP 2000 14. Geometry of the building for the column and beam has been considered as 350mm x 600mm. Material grades of M25 & Fe415 were used for the design

Structural properties of RC Building

Shear wall thickness =0.2 m, Total depth of slab=0.12 m, External wall thickness= 0.25 m, Internal wall thickness=0.15 m, Size of external column= 0.35 x 0.6 m, Size of internal column= 0.4 x 0.4 m, Size of beam in longitudinal and Transverse direction =0.35 x 0.6 m.

Following figures shows the plan of different models of regular and irregular building.

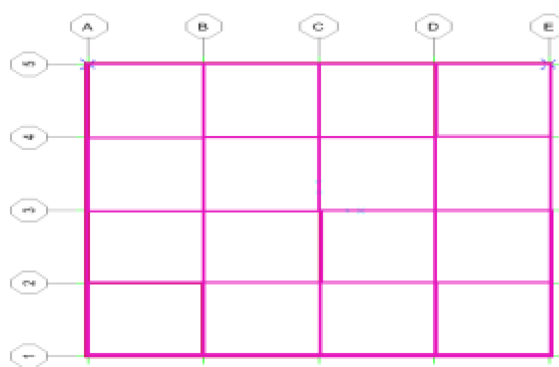

Fig. 1 Frame Type (Model of Building Without Shear Wall.)

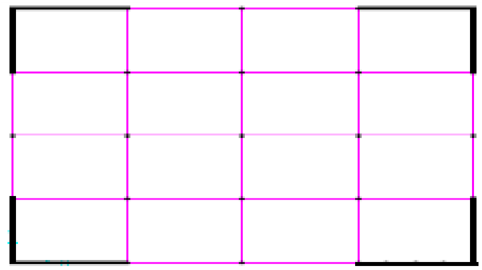

Fig. 2 MR TYPE 1 (Model of Building with Shear Wall type1 at corner)

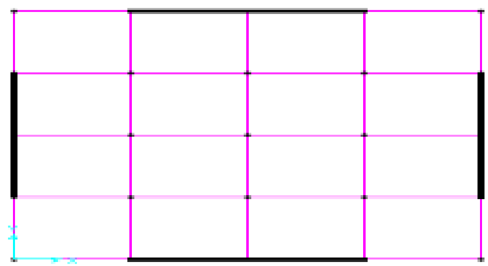

Fig. 3 MR TYPE 2 (Model of Building with Shear Wall type2 at middle)

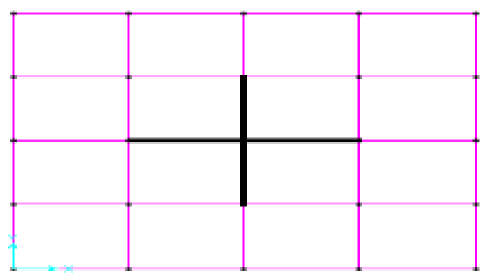

Fig. 4 MR TYPE 3 (Model of Building with Shear Wall type3 at centre)

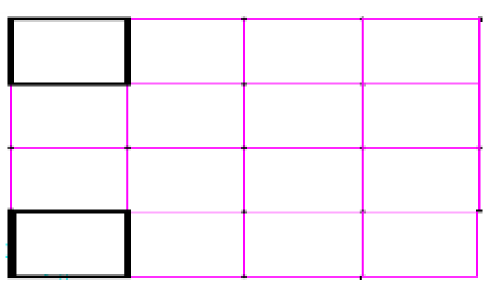

Fig. 5 MIR TYPE 4 (Model of Irregular Building with Shear Wall present irregularly)

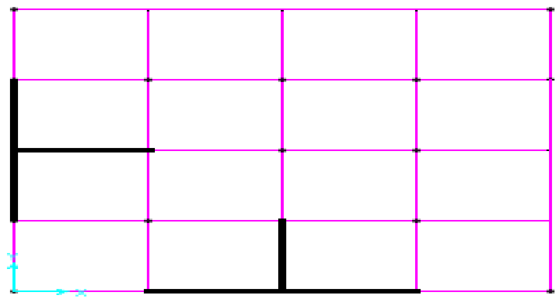

Fig. 6 MIR TYPE 5 (Model of Irregular Building with Shear Wall present irregularly)

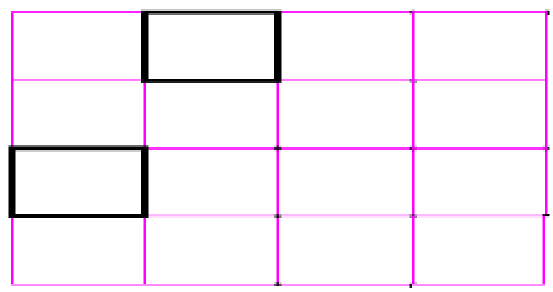

Fig. 7 MIR TYPE 6 (Model of Irregular Building with Shear Wall present irregularly)

RESULT SUMMERY

Asana Analysing the building of Regular and irregular model structure by using SAAP 2000 15 software, got the following result by response spectrum method and time history method, and compare the results of both the method

Table 1: Comparison of Max. base Shear in x dir. by RSM and THM of various model

MODEL TYPE	MAX. BASE SHEAR IN X- DIR (KN)	
	RSM	THM
FRAME TYPE	3302.247	3803.083
MR TYPE1	3023.031	3022.562
MR TYPE2	3023.948	3019.895
MR TYPE3	3225.068	3224.070
MIR TYPE4	3315.395	3966.213
MIR TYPE5	3163.891	3701.582
MIR TYPE6	3196.177	3256.820

Above table shows the maximum displacement in x direction and results shows the comparision between the response spectrum method and time histry method.

Table 2: Comparison of Max. Base Shear in y dir. by RSM and THM of various model

MODEL TYPE	MAX. BASE SHEAR IN Y- DIR (KN)	
	RSM	THM
FRAME TYPE	2888.412	3431.333
MR TYPE1	3023.031	3022.562
MR TYPE2	2962.925	2845.525
MR TYPE3	3224.620	3195.113
MIR TYPE4	2932.749	3387.436
MIR TYPE5	3146.364	3667.416
MIR TYPE6	2950.733	3283.787

Table 3: Comparison of Max. Moment by RSM and THM of various model

MODEL TYPE	MAX. MOMENT (KN-m)	
	RSM	THM
FRAME TYPE	26417.9827	30424.6685
MR TYPE1	24184.2513	23305.9861
MR TYPE2	24191.5884	24293.1734
MR TYPE3	25800.5424	25792.5708
MIR TYPE4	31603.0262	37680.4247
MIR TYPE5	43020.6358	50422.4873
MIR TYPE6	32997.9751	35556.1317

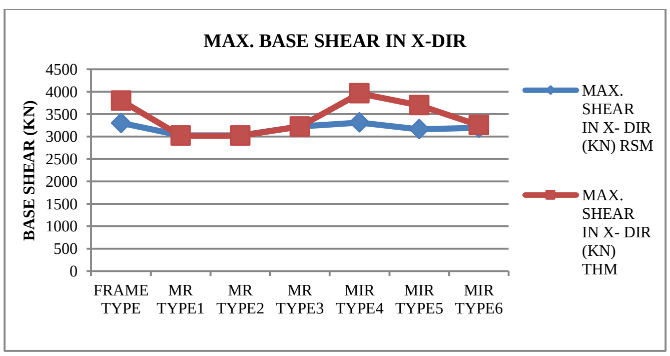

Fig 8: Comparison of Max. base shear in x (KN)

This graph shows maximum base shear in x- direction by RSM ahd THM, by comparing the maximum base shearin building is found in irregular type4. Hence the sesmics force at the base of building is maximum at MIR TYPE 4 comapre to all method

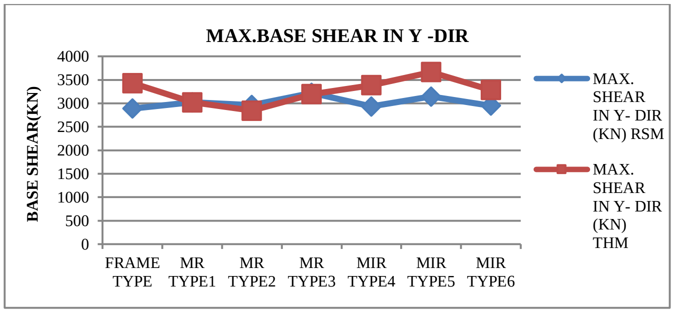

Fig 9: Comparison of Max. base Shear in y (KN)

This graph shows maximum base shear in y- direction by RSM ahd THM, observed that the base shear in y-direction is maximum in MIR TYPE 5 compare to all by time history method.

The maximum reducing moment is found in building MR TYPe 1 compare to all ,and reducion in boththe method is 5 to 15%

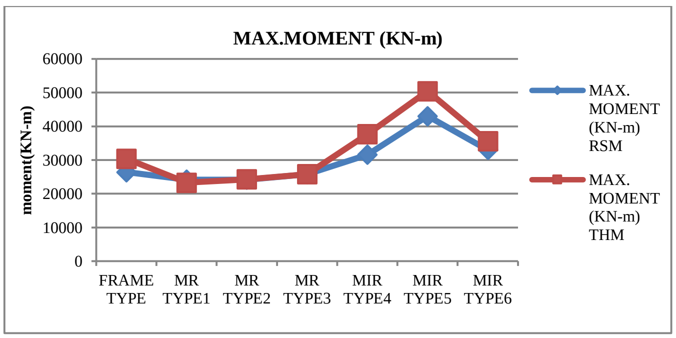

Fig 10: Comparison of Max. Moment (KN-m)

Table 4: Comparison of max. Displacement in x direction by RSM and THM

MODEL TYPE	MAX. DISPL. IN X- DIR (mm)	
	RSM	THM
FRAME TYPE	53.574	61.326
MR TYPE1	24.775	24.891
MR TYPE2	19.406	19.567
MR TYPE3	11.256	6.556
MIR TYPE4	32.835	34.154
MIR TYPE5	44.789	37.520
MIR TYPE6	30.476	32.568

Table 5: Comparison of max. Displacement in y direction by RSM and THM

MODEL TYPE	MAX. DISPL. IN Y- DIR (mm)	
	RSM	THM
FRAME TYPE	60.994	80.835
MR TYPE1	24.775	24.891
MR TYPE2	20.014	19.399
MR TYPE3	11.304	6.554
MIR TYPE4	30.382	31.207
MIR TYPE5	45.562	38.249
MIR TYPE6	30.133	32.955

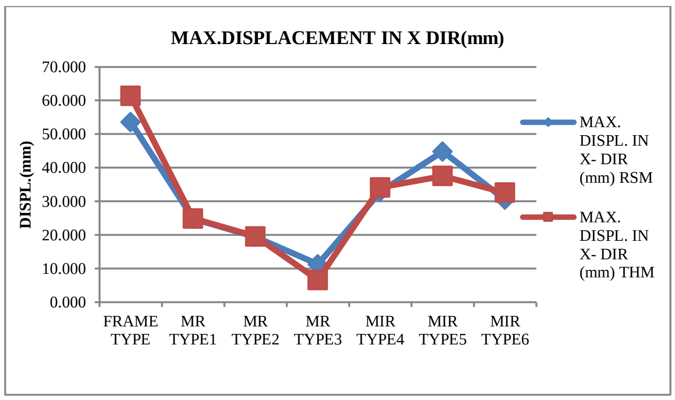

Fig 11: Comparison of max. Displacement in x direction by RSM and THM

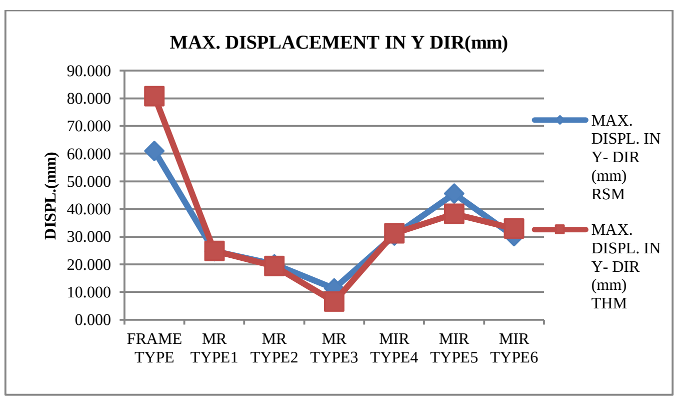

Fig 12: Comparison of max. Displacement in y direction by RSM and THM

Maximum displacement is minimum in MR TYPE 3 both in x and y direction. Comparison between all type of building observed that the MRTYPE 3 gives the better displacement than the others. This is the safe and effective.

Table 6: Comparison of max. Axial force in column by RSM and THM

MODEL TYPE	MAX. AXIAL FORCE IN COLUMN (KN)	
	RSM	THM
FRAME TYPE	4190.303	4483.671
MR TYPE1	2707.592	2717.592
MR TYPE2	2728.392	2756.24
MR TYPE3	271.99	171.36
MIR TYPE4	311.823	318.303
MIR TYPE5	788.81	804.145
MIR TYPE6	434.806	439.261

Table 7: Comparison of max. Shear force in column by RSM and THM

MODEL TYPE	MAX. SHEAR FORCE IN COLUMN (KN)	
	RSM	THM
FRAME TYPE	199.149	232.595
MR TYPE1	124.72	125.715
MR TYPE2	65.816	35.37
MR TYPE3	15.922	10.412
MIR TYPE4	62.716	73.398
MIR TYPE5	85.523	73.748
MIR TYPE6	51.818	58.519

Table 8: Comparison of max. Moment in column by RSM and THM

MODEL TYPE	MAX. MOMENT IN COLUMN (KN-m)	
	RSM	THM
FRAME TYPE	313.7838	361.8795
MR TYPE1	187.148	188.6199
MR TYPE2	102.9525	53.5871
MR TYPE3	24.2512	15.8235
MIR TYPE4	102.0924	100.6948
MIR TYPE5	128.749	110.9045
MIR TYPE6	77.7731	87.9691

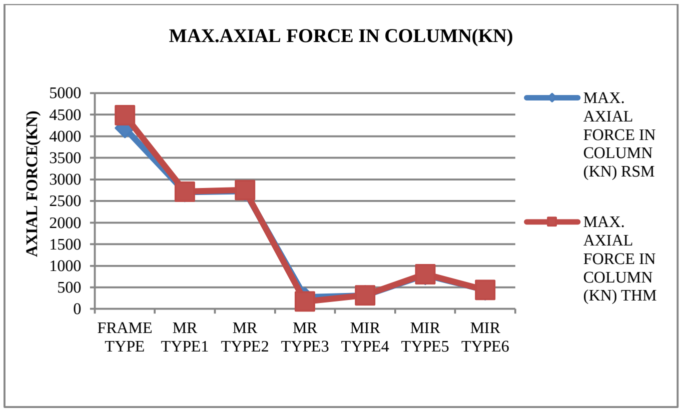

Fig 13: Comparison of max. Axial force in column by RSM and THM

The above graph found that the results are nearly same by both the methods. The maximum asial force is in frame type building and minimum in MR TYPE 3 while compare to that frame type structure to all models the reduction is coming 30 to 50% .

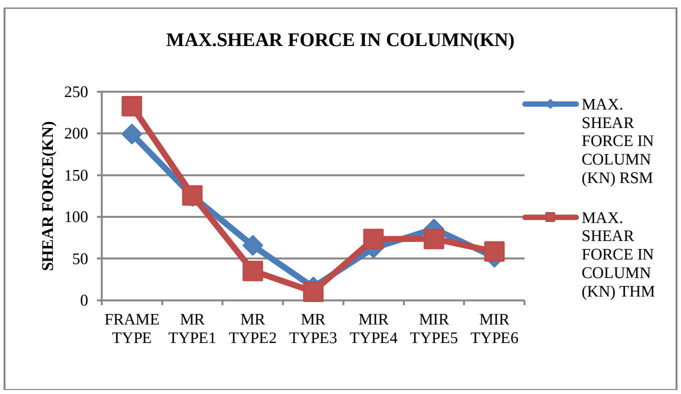

Fig 14: Comparison of max. shear force in column by RSM and THM

The graph shows the comparision of maximum shear force and building types it observed that MR TYPE 3 building column gives minimum shear force as compare to others. And compare to that frame type structure the reduction is coming 40 to 50%.

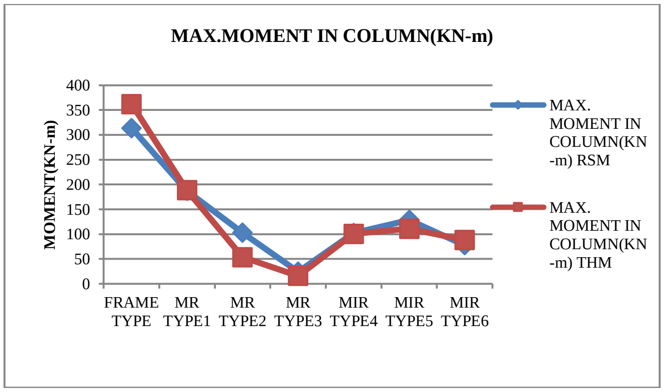

Fig 15: Comparison of max. Moment in column by RSM and THM

Above graph shows that moment is more effective in model of regular building type 3 in columns. Nd hence reduction observed by both the method is 10 to 20 %. Also observed that the result are found to be nearly same by both the methods.

CONCLUSION

In this study, the analysis of multistoried buildings was done by SAP 2000 14 software using response spectrum analysis and time history analysis. Based on the results of analysis , following conclusions were inferred.

A. By comparing the two methods, the displacement of the building has been reduce due to the presence of shear wall placed at the centre (MR TYPE 3) in x, y direction compare to all models

B. In THM, the maximum base shear observed in irregular model type 4 as compare to other models in x direction.

C. In y direction, the base shear is more in irregular model type 5 compare to other by THM.

D. The moment is minimum at regular model type 1 as compare to other models.

E. Different location of shear wall effect on axial load on the column. In absence of shear wall axial load and moments are maximum on column.

F. In the column, the axial force is found to be minimum in regular model type 3 as compare to other models.

G. The shear force in the column is observed minimum in regular model type 3 compare to other models by THM.

H. By the effect of dynamic loading, the maximum bending moment in column is minimum in regular model type 3 as compare to other models.

I. In Time History method, the maximum base shear is in shear wall type 3 as compare to others.

J. Comparing the all models, the base shear is near about same by both the methods in x, y direction.

K. In case of regular building, based on positioning of shear wall, no torsional effect on regular building is observed. But in case of irregular building, based on irregularly positioning of shear wall and the result analysis, the lateral forces on the building will create torsion effect around centre of rigidity of the building due to that eccentricity.

Hence, it can be said that the MR TYPE 3 regular buildings gives a better result as compare to others building models. So this building is more stable by applying dynamic loading where the shear wall placed at the centre. And the reduction between Response Spectrum Method and Time History Method is 5 to 10% is observed.

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