A STUDY ON SEISMIC EVALUATION OF RC FRAMED STRUCTURES ON VARYING PERCENTAGE OF DIAPHRAGM DISCONTINUITY WITH & WITHOUT SHEAR WALLS

Sushmitha K B[1], Raghu M E[2]

[1]*Post Graduate in Structural Engineering, BIET College, Davanagere*
[2]*Asst. Professor, M. Tech Structural Engineering, BIET College, Davanagere-577004, India*

Abstract - *Earthquake are the reasons for the collapse of buildings by causing negative effect on the environment. Earthquakes occur at the location of weak structures, now a day the openings are common for buildings like lifts, lightings and also for architectural purposes. The aim of the project is to show the performance of the buildings with diaphragm openings using ETABS. The stability and supportability capacity can be enhanced by the proper location of openings in the buildings. Diaphragm discontinuities are done for the locations like, at the corners, Centre and in periphery, etc. The analysis is done for every case using ETABS software.*

In this present study, Seismic analysis of RC framed structures on varying percentage of Diaphragm openings as 0% (without opening), 8.33%, 16.66%, 33.32% by considering with and without shear walls for various cases have been discussed for the multistory building of G+10 story with an earthquake intensity of 0.16 (Zone III), and analysis is carryout for Equivalent static and Response spectrum analysis as per IS 1893-2002 (Part 1) using ETABS 2016. The obtained results which are discussed on seismic parameters for Base shear, Story Shear, Story Displacement, Story Drift ratios for both ESA & RSA.

Key Words: Diaphragm Discontinuity, Base Shear, Story Shear, Story Displacement, Story Drift and ETABS 2016.

1. INTRODUCTION

Earthquake is a wave like motion caused by vibrations and the forces below the apparent surface of the soil, moving across earth's crust. The Earthquakes are said to be impulsive because they occur frequently and unexpectedly by some activities like mining, nuclear tests and landslides. It results in the sudden release of huge amount of energy and acts as a seismic wave in all the possible directions which are also termed as low frequency sound waves, the explosive unleash of energy causes Earthquakes. The Earthquakes, Volcanic eruptions, Magma movement, Landslides and Underground explosions are the result of seismic waves. The buildings or structure may collapse by the earthquakes. The intensity differs which depends on the consequences of the Earthquake for the same magnitude. Seismometers are the instruments used to measure the seismic waves generated by Earthquakes.

1.1 DIAPHRAGM DISCONTINUITY

According to IS 1893-2002 if the effective width of the diaphragm opening is more than 50%, it should be designed as flexible nor less than 50% hence the opening is rigid. The degree of freedom can be reduced by the diaphragm openings. The numerical problems can be prevented by the usage of diaphragm openings for the building structures. Literally the openings in the slabs are given for different purposes of usage for lifts, shafts & architectural purpose. The construction of diaphragm openings undertaken by using plywood and concrete slab in the construction. The Diaphragm openings helps in protecting the life of human beings from the Earthquakes that occurs on the building structures. The figure represents various types of diaphragm discontinuity in building.

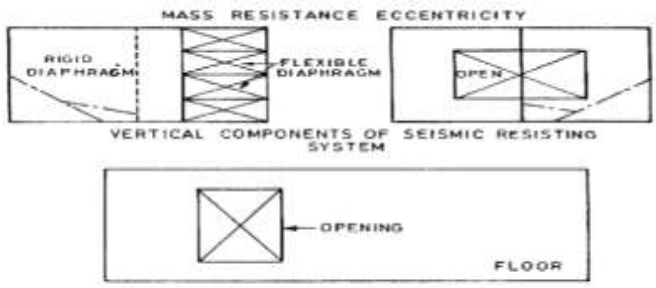

Fig -1: Diaphragm Discontinuity

1.2 OBJECTIVES OF THE PRESENT STUDY

The main objectives considered for seismic analysis of structure by considering with & without shear walls by Diaphragm discontinuity is as follows;

1. To develop the RC framed structure with varying percentage as 0%, 8.33%, 16.66%, 32.33% of slab opening having G+10 story has been modeled for seismic zone III.
2. To develop the RC framed structure with varying percentage of slab openings for without shear walls and with shear walls at corners (case 1) and shear walls at the slab opening periphery as well as corners (case 2).

3. The models have developed will be analyzed for both equivalent static and response spectrum analysis as per IS 1893-2002 Part 1.
4. The seismic parameters like time period, base shear, story shear, story displacement and story drift have been obtained for both Equivalent static analysis and Response spectrum analysis for all developed RC framed models.

2. PARAMETERS FOR DEVELOPING THE MODELS

For analysis of RC framed structure with varying percentage as 0%, 8.33%, 16.66%, 32.33% of slab opening with shear wall and without shear wall at corners and edge positions, can be studied by developing 12 models of G+10 story with a plan dimensions along X & Y axis, story heights and structural components which are beams, Columns, Slabs and Shear walls considered for the analysis of frame structures by the dimensions with the materials properties which are Grade of concrete and Grade of steel have been listed on Fallowing Table.

Table -1: Building Parameters for Analysis

SL. NO.	PARAMETERS	REMARKS
1	PLAN DIMENSIONS	24*32m
2	STORY HEIGHT	3.15m
3	PLINTH HEIGHT	1.75m
4	NUMNER OF STORIES	G+10
5	CONCRETE GRADE	M30
6	STEEL GRADE	Fe415,Fe500
7	DIMENSION OF COLUMN	500*500mm
8	DIMENSION OF BEAM	300*450mm
9	SLAB THICKNESS	150mm
10	NO OF MODELS	12
11	IMPORTANCE FACTOR	1
12	EXTERIOR WALL THICKNESS	200mm
13	INTERIOR WALL THICKNESS	100mm
14	SEIMIC ZONE	III
15	SOIL TYPE	type 2
16	RESPONSE REDUCTION FACTOR	3 (OMRF)

The fundamental natural period (T_a) for RC framed structure have been calculated as fallows,

For without shear wall

$T_a = 0.075xh^{0.75}$ (for RC framed building), Where

h = 36.4m.= $0.075x36.4^{0.75}$ = 1.11 sec.

For with shear wall

Along X direction, Ta= 0.09xh/ sqrt (d),

h = 36.4, d = 24m along X axis.

T_a = 0.09x36.4/sqrt (24) = 0.67 sec.

Along Y direction, Ta= 0.09xh/ sqrt (d),

h = 36.4, d = 32m along Y axis.

T_a = 0.09x36.4/sqrt (32) = 0.58 sec.

2.1 LOAD CALCULATIONS

a. Loads on slab:

Live load to be considered as 4 kN/m².

Floor finish,

For vitrified tiles of 12mm = 0.012 x 24 = 0.29kN/m².

Where 24 kN/m² is the density of plain concrete

Backing mortar of 20mm=0.02 x 20.4 =0.408 kN/m².

Where 20.424 kN/m² is the density of cement plaster

Ceiling of 12 mm thickness = 0.25 kN/m²

TOTAL = 0.948 kN/m².

Since, Total finish = 1.5 kN/m² for all the slabs.

Floor finish on for parking in GF = 2 kN/m².Floor finish on terrace, Water proof plaster = 0.150 kN/m²

Ceiling plaster of 12mm = 0.25 kN/m²

Total = 0.4 kN/m².

By taking extra load for water proofing = 2.6 kN/m².

Total floor finish on terrace to considered as 3kN/m².

b. Load on beam:

Loads considered on beam are self-weight and wall loads. Self-weight can be estimated directly through ETABS and wall loads have been calculated manually as fallows,

Brick density = 20N/mm² & Height of parapets wall on terrace=1.5m. Thickness of wall considered, for exterior walls = 200mm, for interior walls =100mm

For Exterior wall load,

= 0.200 x (3.2-0.450) x 20 + 0.04 x (3.2-0.450) x 20.4

= 13.244 kN/m.

For Interior wall load,

= 0.100 x (3.2-0.450) x 20 + 0.04 x (3.2-0.450) x 20.4

= 11.30 kN/m.

For Parapet wall load on terrace,

= 0.200 x 1.5 x 20 + 0.04 x 1.5 x 20.4 = 7.224kN/m.

2.2 MODELING USING ETABS 2016

For the study of the RC frame structures with varying % of Diaphragm openings with different position of slab opening have been done by using ETABS 2016 software for both ESA & RSA for considering 12 models which are shown in below figures.

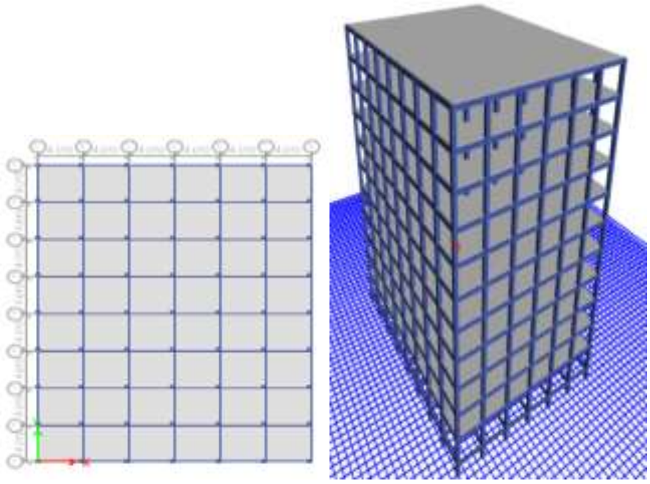

Fig -2: Plan elevation & 3D view for 0% slab opening without shear wall.

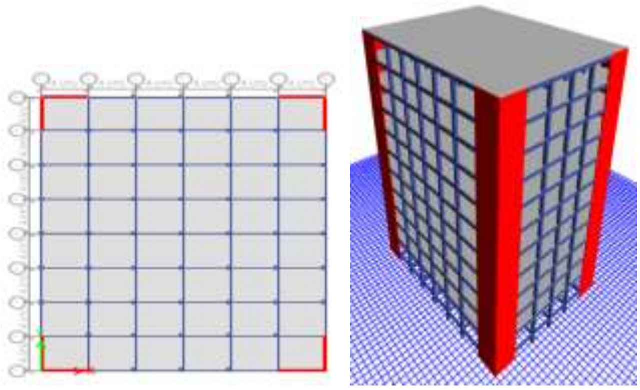

Fig -3: Plan elevation & 3D view for 0% slab opening with shear wall at corners.

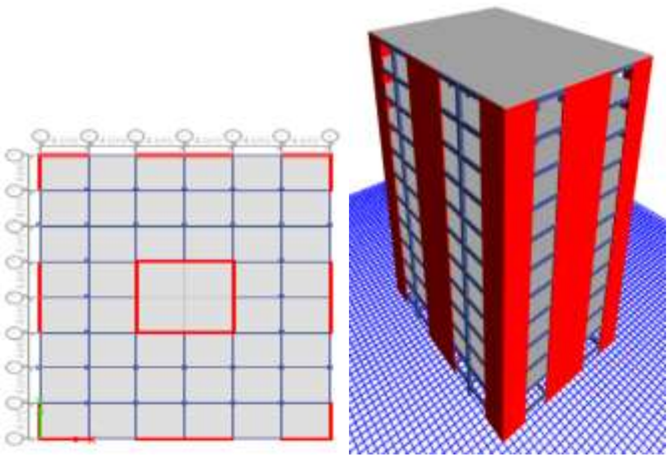

Fig -4: Plan elevation & 3D view for 0% opening with shear wall at center & periphery of the openings.

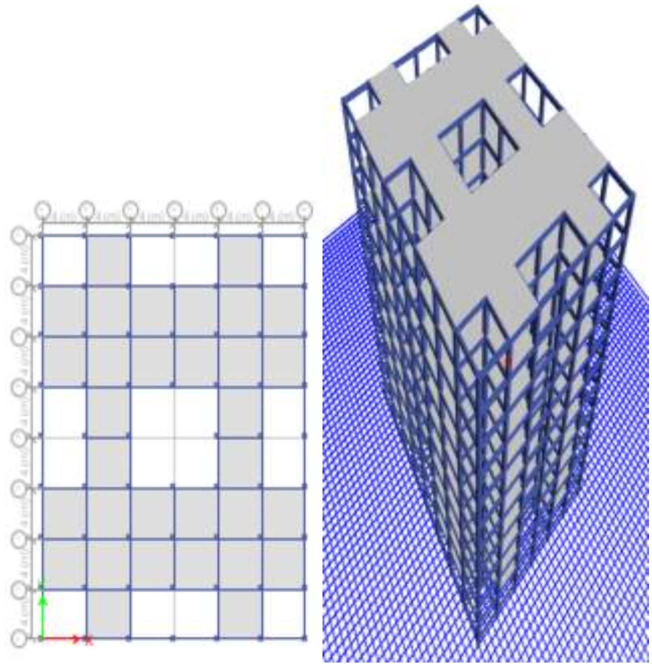

Fig -5: Plan elevation & 3D view for 33.32% slab opening without shear wall.

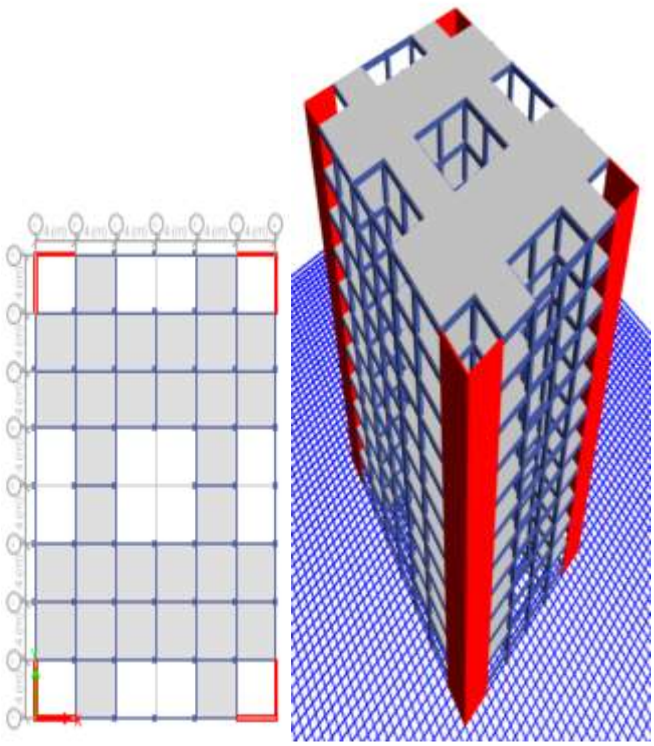

Fig -6: Plan elevation & 3D view for 33.32% slab opening with shear wall at corners.

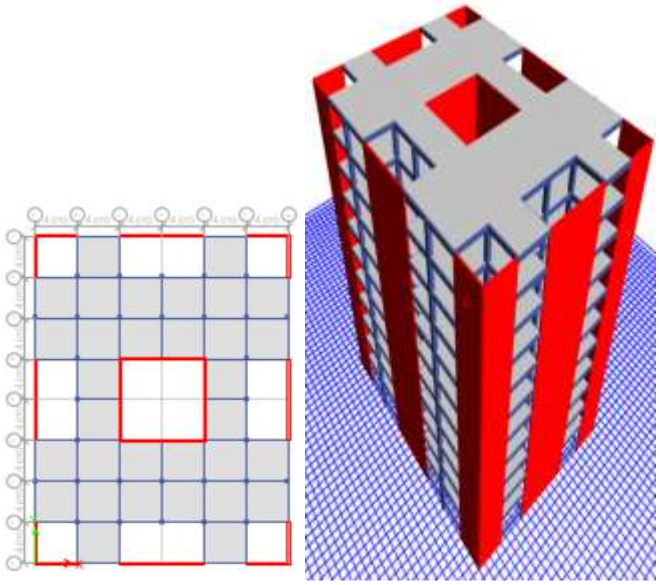

Fig -7: Plan elevation & 3D view for 33.32% opening with shear wall at center & periphery of the openings.

3 RESULTS & DISCUSSION

3.1 STORY SHEAR

Story shear is defined as the lateral forces acting on each story during earthquake and lateral force is maximum at the base and it is defined as the base shear. Story Shear results for the analysis have been listed below.

Table -2: Maximum Story Shear for ESA along X & Y Axis

Models	without shear wall	with shear walls	
		Case 1	Case 2
Model 1	4670.7225	8766.216	8418.6854
Model 2	4420.1879	8286.7445	8091.5838
Model 3	4249.2699	7959.6429	7764.4822
Model 4	3835.0695	7166.9491	6969.2597

Chart -1: Maximum Story Shear for ESA

Table -3: Maximum Story Shear for RSA along X & Y Axis

Models	without shear wall	with shear walls	
		Case 1	Case 2
Model 1	4670.7115	8766.2073	8418.666
Model 2	4420.1874	8286.7421	8091.5784
Model 3	4249.2618	7959.6391	7764.4685
Model 4	3835.0647	7166.9407	6969.2434

Chart -2: Maximum Story Shear for RSA

Chart 1 & 2 constitutes the variations of the obtained base shear and story forces for all the different developed models for both ESA & RSA. It has been observed that base shear & story shear for ESA are found to be more than the RSA and story shear is maximum along Y axis than the X axis.

3.2 STORY DISPLACEMENT

It is the variation of displacements along each story with respect to the base of the story when the lateral forces acting on each story during earthquake. Story displacement results from the analysis are listed below.

Table -4: Maximum Story Displacement for ESA along X & Y Axis

Models	without shear wall	with shear walls	
		Case 1	Case 2
Model 1	57.037	64.447	21.263
Model 2	56.056	62.492	20.405
Model 3	53.686	60.077	19.542
Model 4	50.622	55.697	17.588

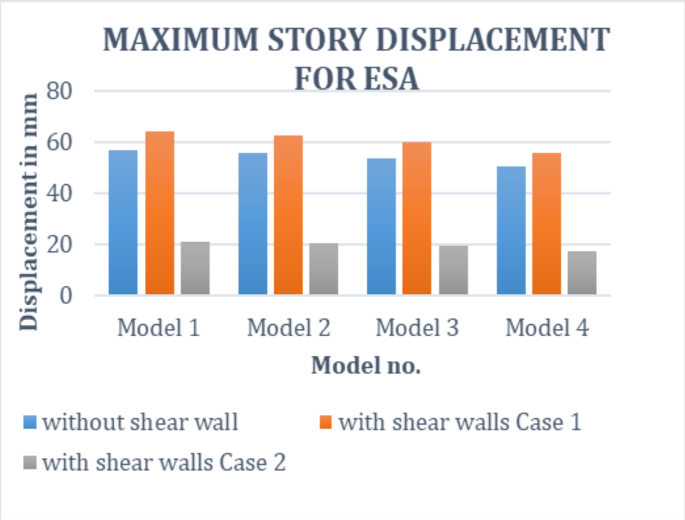

Chart -3: Maximum Story Displacement for ESA

Table -5: Maximum Story Displacement for RSA along X & Y Axis

Models	without shear wall	with shear walls	
		Case 1	Case 2
Model 1	45.769	50.905	18.195
Model 2	44.959	49.511	17.528
Model 3	43.089	47.787	16.841
Model 4	40.581	45.116	15.269

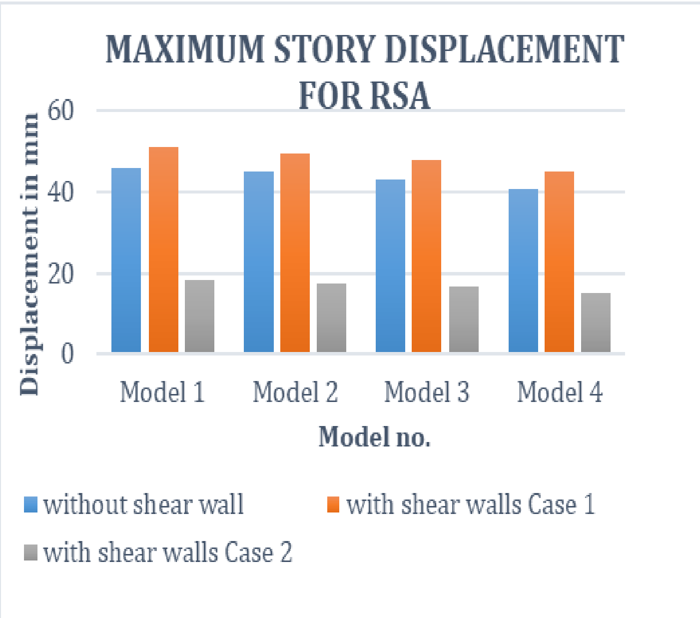

Chart -4: Maximum Story Displacement for RSA

Chart 3 & 4 constitutes the variations of resulted story displacement for the various cases of the developed models along the X & Y direction for ESA & RSA. The displacement is observed to be more along Y axis than the X axis and it has been observed to be the displacement in ESA is more than the RSA.

3.3 STORY DRIFT

The displacement of each story with respect to its consecutive story displacement during the action of lateral forces acting on every story. And the drift ratios are made with limitations as per IS 1893-2002 Clause 7.11.1. Story drift ratios result from the analysis have been listed below.

Table -6: Maximum Story Drift for ESA along X & Y Axis

Models	without shear wall	with shear walls	
		Case 1	Case 2
Model 1	0.002136	0.00221	0.000725
Model 2	0.002095	0.002142	0.000696
Model 3	0.002007	0.00205	0.000667
Model 4	0.001967	0.001932	0.000601

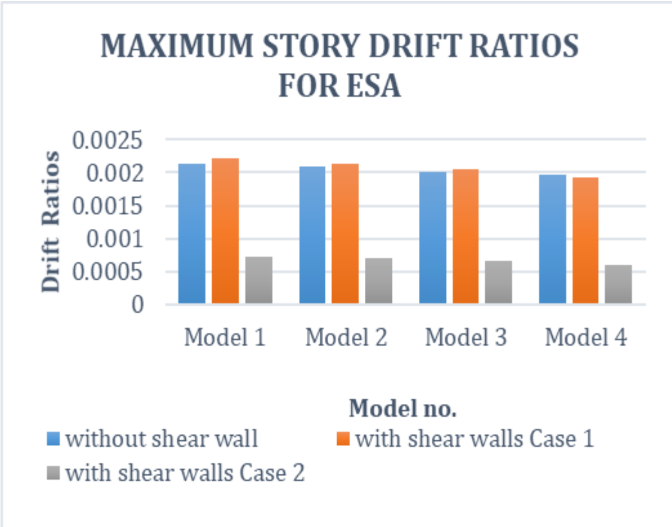

Chart -5: Maximum Story Drift Ratios for ESA

Table -7: Maximum Story Drift for ESA along X & Y Axis

Models	without shear wall	with shear walls	
		Case 1	Case 2
Model 1	0.001963	0.001759	0.000615
Model 2	0.00192	0.001707	0.000593
Model 3	0.001841	0.001645	0.000569
Model 4	0.001797	0.001633	0.000517

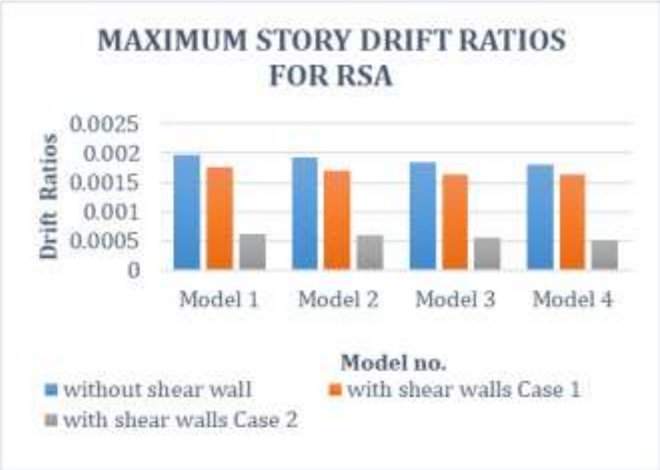

Chart -6: Maximum Story Drift Ratios for RSA

Chart 5 & 6 constitutes the variations of the resulted drift ratios for the various cases of the developed models for ESA & RSA along both X & Y directions. It has been observed that drift ratios are found to be more along Y axis than the X axis and drift ratios are found to be within the limitations made from the IS 1893-2002.

4. CONCLUSIONS

In the present study analysis of RC framed structures with varying percentage of diaphragm discontinuity with and without shear for various cases have been done by ESA & RSA using ETABS 2016 with the accordance of IS 1893-2002 (Part 1) guidelines.

i. If the % of slab opening rises story shear decreases for all the models of without shear walls and with shear walls for both the cases (Case 1 & Case 2). The story shear values are maximum for the models developed with shear walls when compared with the models of without shear walls and for the models with shear walls at corners have observed to be more in story forces than the models with shear walls at the center and periphery of the openings.

ii. The story displacement is greater in Y direction when compared with the X direction for all the models of both ESA & RSA for models developed without shear walls shows higher values of story displacement when compared with the models with shear walls (Case 1 & Case 2).

iii. The story drift ratio is greater in Y axis when compared with the X axis for all the models of both methods of analysis and drift ratios for the models developed without shear walls shows higher values than the models with shear walls (Case 1 & Case 2). Story drift ratios for all type models are observed to be within the limits of 0.004xH as per the codal provision of IS 1893-2002 (Part 1).

iv. From the present study it can be concluded that for RC framed structures with varying percentage diaphragm openings as 0%, 8.33%, 16.66% & 33.32%, since the diaphragm openings less than 50%, hence the RC framed structures are Rigid structures as per IS 1893-2002.

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BIOGRAPHIES

SUSHMITHA K B
Post Graduate Student
Dept. of Civil Engineering
BIET College, Davanagere.

RAGHU M.E
Asst. Professor
Dept. of Civil Engineering
BIET College, Davanagere.