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influence of the positioning of shear wall on the stability analysis of diaphragm discontinuous structure

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ABSTRACT :*In today's context, many buildings are designed in irregular configuration both in plan and elevation. In future these buildings may subject to highly intensity lateral loads. This study is to investigate the proportional distribution of forces due to the lateral loads on all stories. Irregular G+21 story structures of reinforced concrete (RC) are modeled with diaphragm discontinuity and are analyzed by STAAD Pro. In this project diaphragm discontinuities are considered in the slab portion. This diaphragm is considered as rigid and Semi-rigid. The building is analyzed by Pseudo-static method of seismic analysis. The Response quantities like; maximum moment, support reaction, story displacement and base shear are estimated and are compared for irregular building with diaphragm discontinuity. It has been observed that the structural parameter like story shear, displacement, base shear and time period are depends on the lateral story stiffness distribution.*

KEYWORDS: *Seismic performance, Irregular structures, Pseudo-static method, type of diaphragm, diaphragm discontinuity, Seismic zones, Staad-pro*

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I. INTRODUCTION

In multi-storied framed building, damages from earthquake generally initiate at locations of structural weaknesses present in the lateral load resisting frames. This behaviour of multi-story framed buildings during strong earthquake motions depends on the distribution of mass, stiffness, strength in both the horizontal and vertical planes of buildings. In some of the cases, these weaknesses may be enhanced by discontinuities in stiffness, strength or mass along the diaphragm. Such discontinuities between diaphragms are often associated with sudden variations in the frame geometry along the length of the building. Structural engineers have developed confidence in the design of structure in which the distributions of mass, stiffness and strength are more or less uniform. There is a less confidence about the design of structures having irregular geometrical configurations and diaphragm discontinuities (J. Sreenath and Dr. H. SudharsanaRao, 2018).

The recent earthquake including the last Nepal earthquake (2015) in which many reinforced concrete structures have been severely damaged or collapsed, have indicated the need for evaluating the seismic adequacy of existing buildings. The main function of the diaphragm is to transfer the torsion and shear from lateral members and distributing it to vertical resisting members. Stiffness diaphragm determines how stiffness diaphragmtransfers torsional moment and shear from lateral member to vertical member. In frequent cases revealed that structural weakness tends to form discontinuities in mass, stiffness and strength along the sides of diaphragm. These discontinuities in the diaphragm are equal to the sudden change in geometry along the length of building. According to IS 1893:2000 building with discontinuities gives lesser deformation and it is more used in earthquake affected areas (V. Vinod 2017).

DIAPHRAGM

Roof, floor or other membrane or horizontal bracing belongs to horizontal systems, were help to transfer the lateral system of loads from horizontal resisting to vertical-resisting elements.

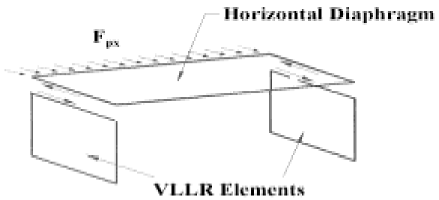

Figure1: Introduction to diaphragm

TYPES OF DIAPHRAGM

The rigidity of the diaphragms is divided into mainly 2 groups based on relative flexibility: rigid and flexible diaphragm.

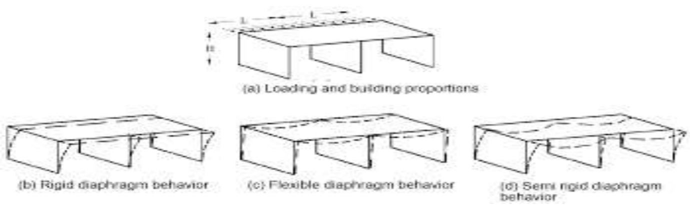

Figure2: Types of diaphragm and their behavior against structural loading

II. METHODOLOGY

In present work, Pseudo-static method is considered for the Seismic analysis of high rise structure. This method is used to investigate the influence on the seismic performance of high rise structures with the presence of Diaphragm discontinuity. For this work, we had considered that the structure will fall under the Seismic Zone IV and V and analysis is being carried out as per the codal provisions of IS 1893: 2002/05.

Structural Investigation:

I had considered a high rise structure of G+ 21 stories Residential Tower having floor dimensions of 90 m x 50 m, fall under Seismic zone IV and V. Such structure is being analyzed by analysis and design software, made by Bentley solutions.

Table 1: Structural specifications

Specifications	Data
Typical Story Height	3.5 m
Base Story Height	1.5 m
No. of Bays along X-Direction	19
No. of Bays along Y-Direction	11
Bay Length along X-Direction	5 m
Bay Length along Y-Direction	5 m
Concrete Grade	M-25
Density of R.C.C.	25 KN/m3
Density of Masonry	20 KN/m3
Columns	450_mm_x 450_mm
Beams	350 mm x 350 mm
Slab Thickness	120 mm
Bottom Support Conditions	Fixed
Floor Diaphragm Rigidity	Rigid and Semi-Rigid
Live Load- Roof Rest of the structure	1 KN/m2 2 KN/m2
Soil Conditions	Type 2(Medium Soil)
Damping Ratio	0.05(asper IS-1893: 2002)
Poisson Ratio	0.2
Response Reduction Factor	3(OMRF)
Importance Factor	1
Zone Factor	0.24 and 0.36 (as per IS1893)

Building Configurations:

These are the cases which has being considered for the analysis of tower with diaphragm discontinuity as well as with the presence of shear wall, as explained below:

[A] Tower with diaphragm discontinuity:

1. Model A 2. Model B 3. Model C

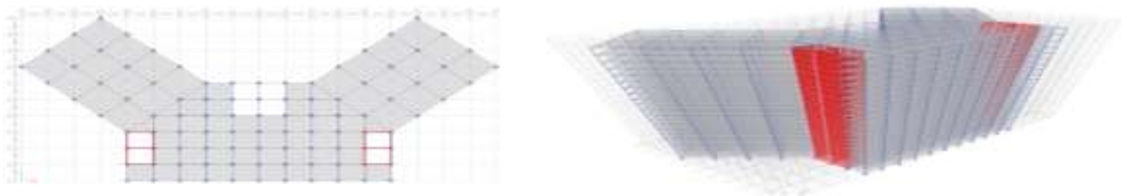

Figure3: Plan and 3-Dimensional view of Model A

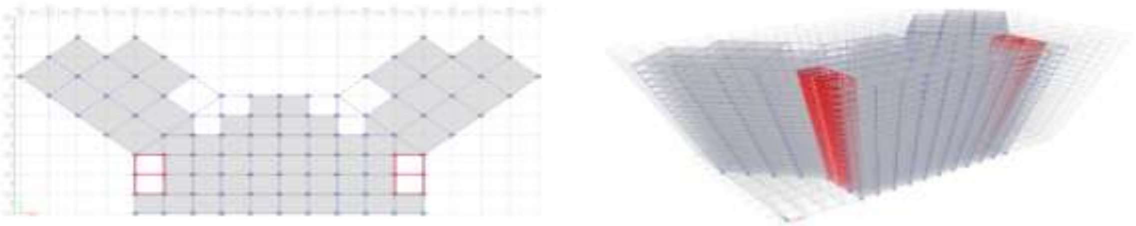

Figure 4: Plan and 3-Dimensional view of Model B

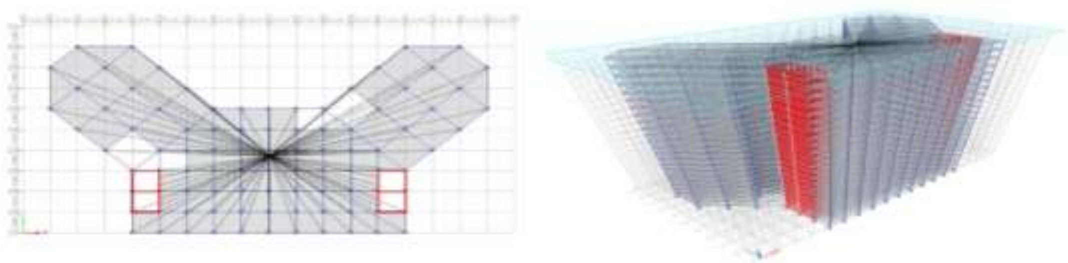

Figure5: Plan and 3-Dimensional view of Model C

[B] Tower with Shear wall and diaphragm discontinuity:

1. Model A 2. Model B 3. Model C

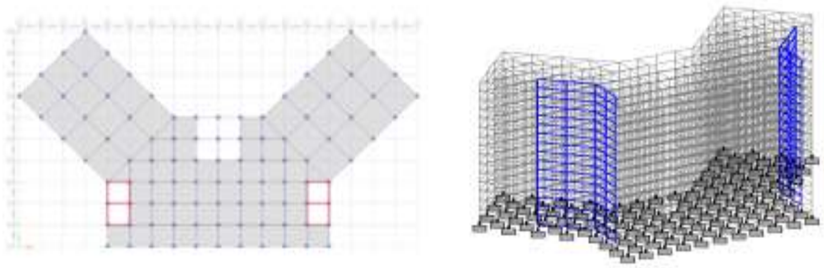

Figure6: Plan and 3-Dimensional view of Model A with the presence of Shear wall

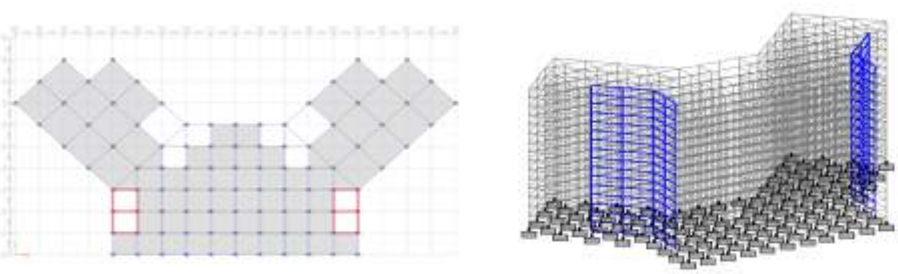

Figure7: Plan and 3-Dimensional view of Model B with the presence of Shear wall

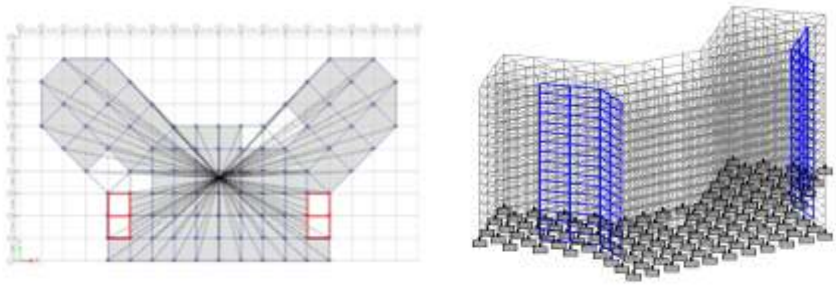

Figure8: Plan and 3-Dimensional view of Model C with the presence of Shear wall

III. STRUCTURAL INVESTIGATION

Selection of Geometry

These are the cases which are going to be seismically analyzed using STAAD Pro software:

A: Normal Structural Configurations:

1. Model A
   a. 22 story structure with Rigid Diaphragm under Zone IV : M1ZIVR
   b. 22 story structure with Semi-Rigid Diaphragm under Zone IV : M1ZIVSR
   c. 22 story structure with Rigid Diaphragm under Zone V : M1ZVR
   d. 22 story structure with Semi-Rigid Diaphragm under Zone V :M1ZVSR
2. Model B
   a. 22 story structure with Rigid Diaphragm under Zone IV : M2ZIVR
   b. 22 story structure with Semi-Rigid Diaphragm under Zone IV : M2ZIVSR
   c. 22 story structure with Rigid Diaphragm under Zone V : M2ZVR
   d. 22 story structure with Semi-Rigid Diaphragm under Zone V : M2ZVSR
3. Model C
   a. 22 story structure with Rigid Diaphragm under Zone IV : M3ZIVR
   b. 22 story structure with Semi-Rigid Diaphragm under Zone IV : M3ZIVSR
   c. 22 story structure with Rigid Diaphragm under Zone V : M3ZVR
   d. 22 story structure with Semi-Rigid Diaphragm under Zone V : M3ZVSR

B: Structural Configurations with Shear Wall

1. Model A
   1) 22 story structure with Rigid Diaphragm under Zone IV : M1ZIVR-SHW
   2) 22 story structure with Semi-Rigid Diaphragm under Zone IV : M1ZIVSR-SHW
   3) 22 story structure with Rigid Diaphragm under Zone V : M1ZVR-SHW
   4) 22 story structure with Semi-Rigid Diaphragm under Zone V :M1ZVSR-SHW
2. Model B
   1) 22 story structure with Rigid Diaphragm under Zone IV : M2ZIVR-SHW
   2) 22 story structure with Semi-Rigid Diaphragm under Zone IV : M2ZIVSR-SHW
   3) 22 story structure with Rigid Diaphragm under Zone V : M2ZVR-SHW
   4) 22 story structure with Semi-Rigid Diaphragm under Zone V : M2ZVSR-SHW
3. Model C
   1) 22 story structure with Rigid Diaphragm under Zone IV : M3ZIVR-SHW
   2) 22 story structure with Semi-Rigid Diaphragm under Zone IV : M3ZIVSR-SHW
   3) 22 story structure with Rigid Diaphragm under Zone V : M3ZVR-SHW
   4) 22 story structure with Semi-Rigid Diaphragm under Zone V : M3ZVSR-SHW

So, all the above cases are considered for the structural analysis. Above 12 cases is for normal and next 12 cases with the presence of shear wall is for seismic analysis of building. Hence, overall 24 cases are studied under STAAD Pro software and their comparative results have been evaluated.

IV. RESULTS AND DISCUSSIONS

[A]. Residential tower with diaphragm discontinuity:

The result below shows the seismic performance of tower with diaphragm discontinuity against severe loadings as per IS: 1893: 2002/05. These are:

1. For Base Shear

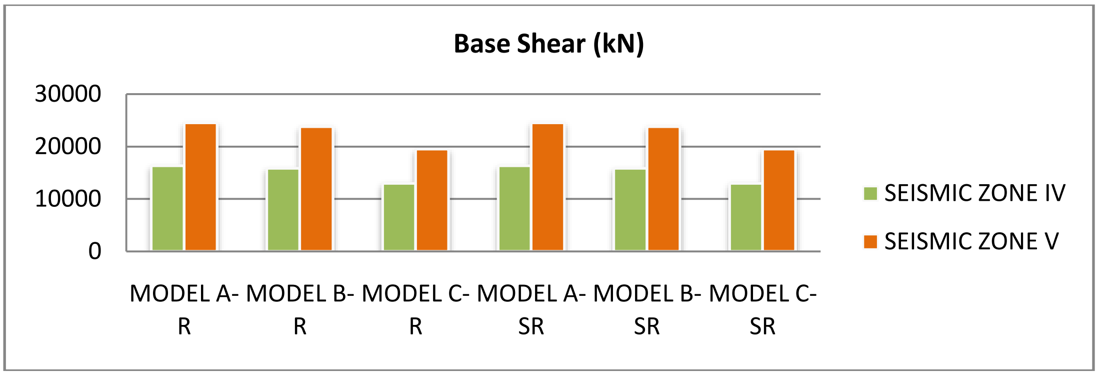

Figure9:Values of Base Shear (kN)

It is clear that the value of Base Shear goes on decreasing from 3.07% to 20.56% as we change the diaphragm discontinuity from Model A to B, followed by A to C and the value remains same as we change the seismic values as well as the diaphragm conditions because the structural weight of the building is constant.

2. For Shear Force

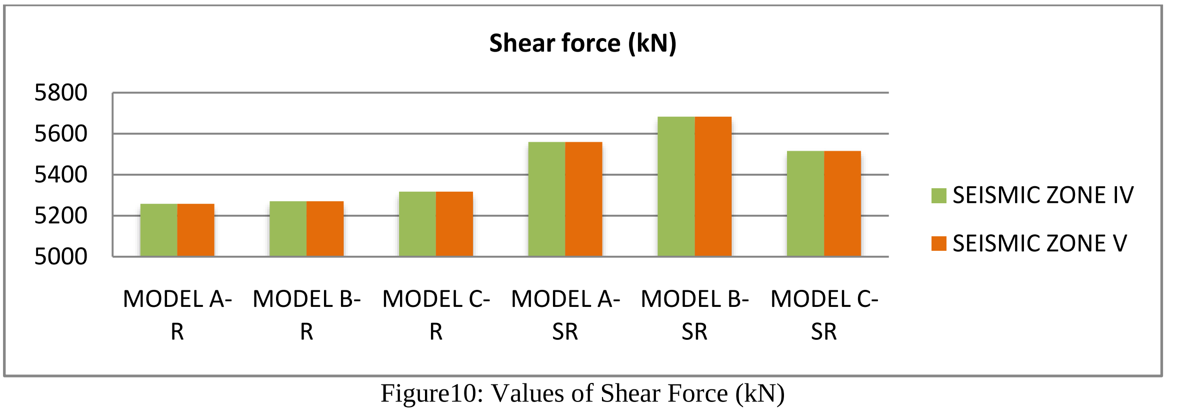

Figure10: Values of Shear Force (kN)

It is clear that the value of Shear Force goes on increasing from 0.24% to 1.12% as we change the rigid diaphragm discontinuity from Model A to B, followed by A to C and increasing from 2.204% from Model A to B and decreasing from 0.784% from Model A to C as we change the semi-rigid diaphragm discontinuity and the value remains same as we change the seismic values. This result shows higher shear force in flexible diaphragm as compared to rigid diaphragm.

3. For Bending Moments

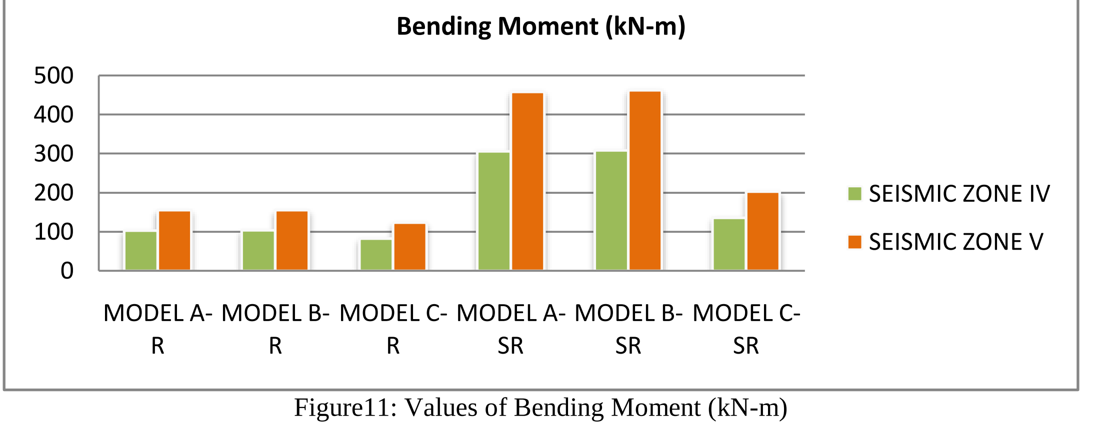

Figure11: Values of Bending Moment (kN-m)

It is clear that the value of Moment goes on increasing from 0.296% and decreasing 20.27% as we change the rigid diaphragm discontinuity from Model A to B, followed by A to C respectively and increasing from 0.786% and decreasing 55.47% as we change the semi-rigid diaphragm discontinuity from Model A to B, followed by A to C respectively and the value increased by 50% equal as we change the seismic zones IV to V.

4. For Displacements

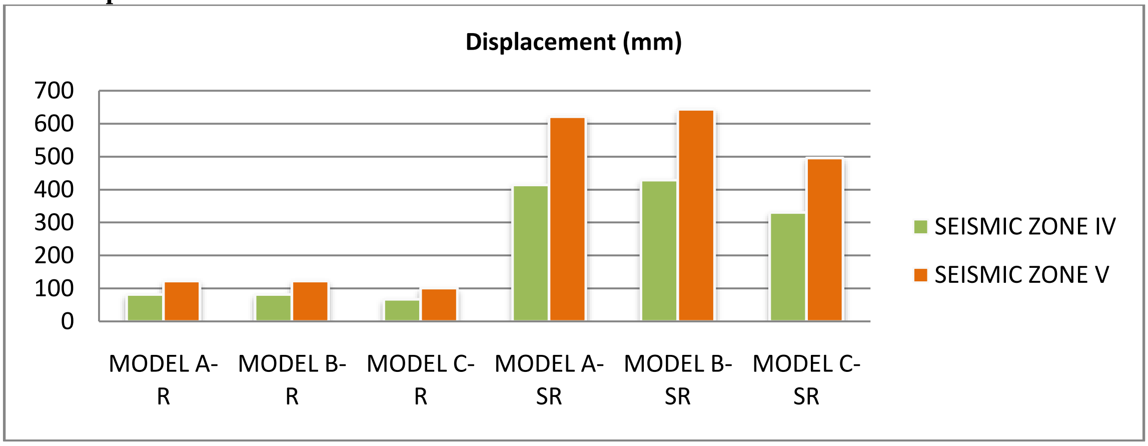

Figure12: Values of Displacement (mm)

We found that as we change the model type with increasing the discontinuity in structural diaphragm, the value of displacements (mm) goes on decreasing as we move from model A to B and then up-to C by 0.13% followed by 17.40% in case of Rigid diaphragm and the value of displacements (mm) goes on increasing as we move from model A to B and then up-to C by 3.49% and then decreased by 20.24% in case of Semi-rigid diaphragm.

[B]: RESIDENTIAL TOWER IN PRESENCE OF SHEAR WALL WITH DIAPHRAGM DISCONTINUITY

The result below shows the seismic performance of tower in presence of Shear wall with diaphragm discontinuity against severe loadings as per IS: 1893: 2002/05. These are:

1. For Base Shear

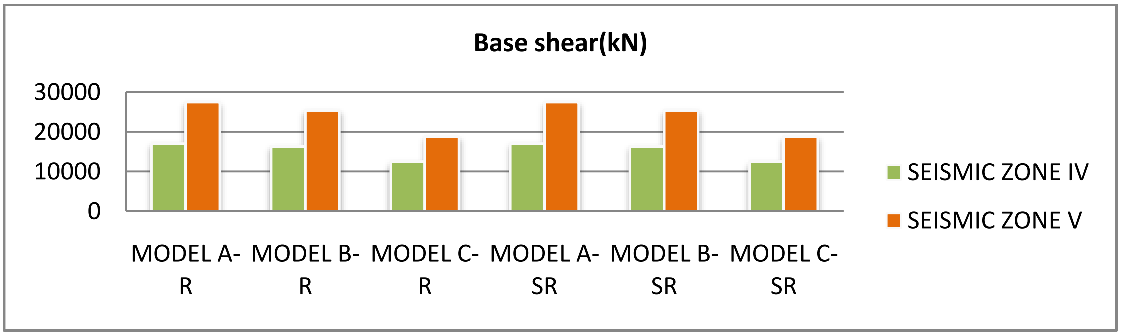

Figure13:Values of Base Shear (kN)

It is clear that the value of Base Shear goes on decreasing from 4.59% to 26.48% as we change the diaphragm discontinuity from Model A to B, followed by A to C and the value remains same as we change the seismic zones.

2. For Shear Force

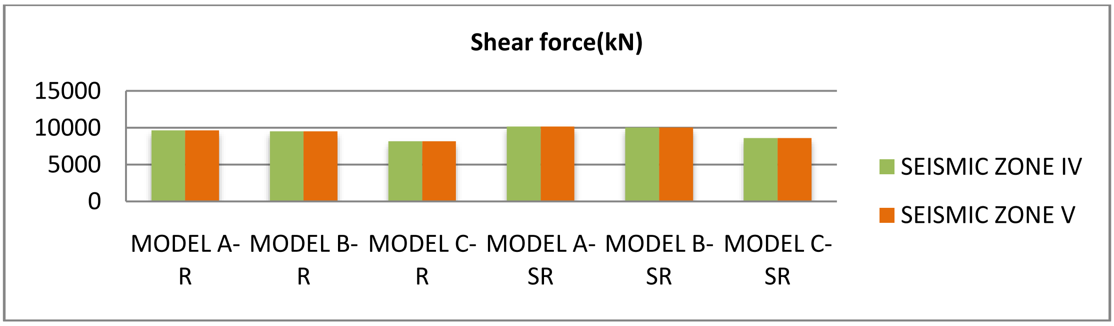

Figure14: Values of Shear Force (kN)

It is clear that the value of Shear Force goes on decreasing from 1.579% to 15.34% as we change the diaphragm discontinuity from Model A to B, followed by A to C and the value remains same as we change the seismic zones.

3. For Bending Moments

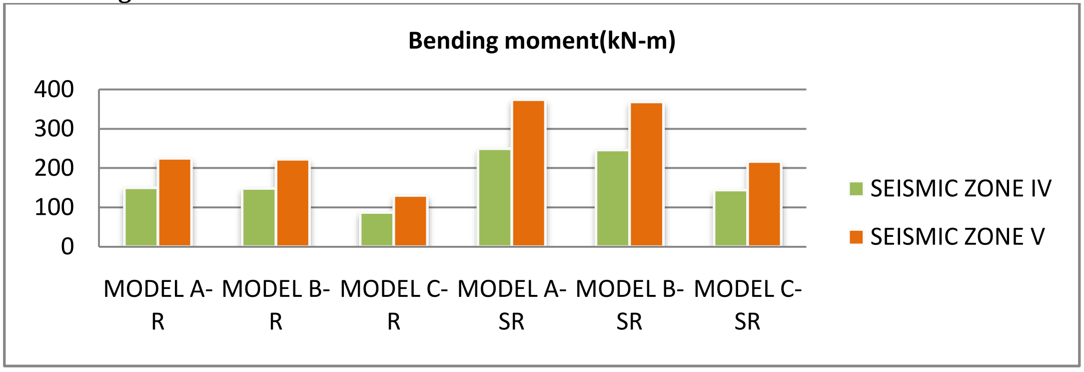

Figure15: Values of Bending Moment (kN-m)

We found that as we change the model type with increasing the discontinuity in structural diaphragm, the value of moment goes on increasing as we move from model A to B by 1.38% and then decreasing as we move from model A to C by 1.38% in case of Rigid diaphragm discontinuity.

And the value of moment goes on increasing as we move from model A to B and then up-to C by 42.1% and then decreased by 42.1% in case of Semi-rigid diaphragm discontinuity and the value of Moments are increased by 50.12% equal as we change the seismic zones IV to V.

4. For Displacements

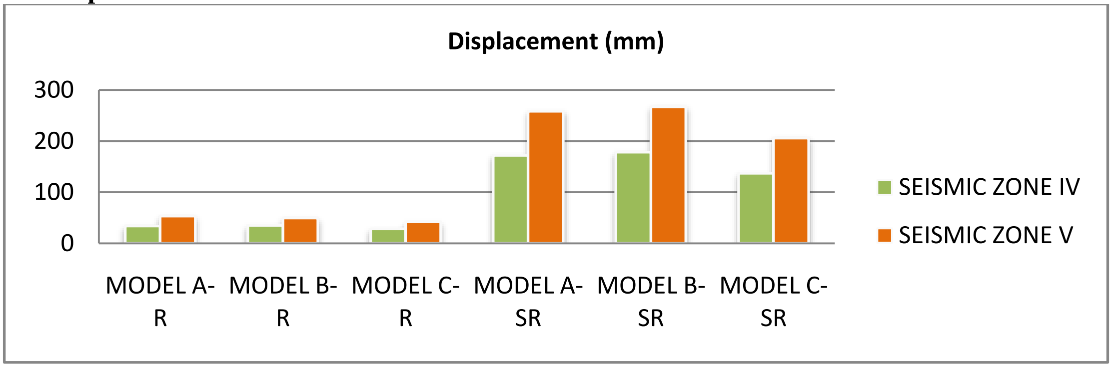

Figure16: Values of Displacements (mm)

We found that as we change the model type with increasing the discontinuity in structural diaphragm, the value of displacement (mm) goes on decreasing as we move from model A to B and then up-to C by 2.40% followed by 17.48% in case of Rigid diaphragm.

And the value of displacement (mm) goes on increasing as we move from model A to B by 3.49% and then decreased by 23.07% as we move from Modal A to C in case of Semi-rigid diaphragm.

And the values of displacement are increased by 55.6% equal as we change the seismic zones IV to V.

V. CONCLUSION

Above analysis results are elaborated and discussed here on the basis of various sub-heads:

1.1 Base Shear:

We found that the structure having rigid and semi-rigid diaphragm with increasing the discontinuity in structural diaphragm from Modal A to B and to C are discussed below:

[A]. Tower with diaphragm discontinuity under Seismic loading condition:

(a) The value of Base shear is goes on decreasing by 3.07% as we move from model A to B.

(b) The value of Base shear is goes on decreasing by 20.56% as we move from model A to C.

(c) Values of Base shear are approximately equal as we move from seismic zones IV to V.

[B]. Tower with diaphragm discontinuity in presence of Shear wall under Seismic loading condition:

(a) The value of Base shear is goes on decreasing by 4.59% as we move from model A to B.
(b) The value of Base shear is goes on decreasing by 26.48% as we move from model A to C due to increasing weight of shear walls.
(c) Values of Base shear are approximately equal as we move from seismic zones IV to V.

1.2 Shear Force:

We found that the structure having rigid and semi-rigid diaphragm with increasing the discontinuity in structural diaphragm from Modal A to B and to C are discussed below:

[A]. Tower with diaphragm discontinuity under Seismic loading condition:
(a) The value of Base reactions is goes on increased by 0.24% (in case of rigid) and 2.204% (in case of semi-rigid) as we move from model A to B.
(b) The value of Base reactions is goes on increased by 1.120%(in case of rigid) and decreased by 0.784% (in case of semi-rigid) as we move from model A to C.
(c) Values of Base reactions are approximately equal as we move from seismic zones IV to V.

[B]. Tower with diaphragm discontinuity in presence of Shear wall under Seismic loading condition:
(a) The value of Base reactions is goes on decreased by 1.579% as we move from model A to B.
(b) The value of Base reactions is goes on decreased by 15.34% as we move from model A to C due to increasing weight of shear walls. It increases the strength capability of the structure.
(c) Values of Base reactions are approximately equal as we move from seismic zones IV to V.

1.3 Maximum Moments:

We found that the structure having rigid and semi-rigid diaphragm with increasing the discontinuity in structural diaphragm from Modal A to B and to C are discussed below:

[A]. Tower with diaphragm discontinuity under Seismic loading condition:
(a) The value of moment goes on increasing by 0.296% (in case of rigid) and 0.786% (in case of semi-rigid) as we move from model A to B.
(b) The value of moment is goes on decreased by 20.27% (in case of rigid) and 55.47% (in case of semi-rigid)as we move from model A to C due to increasing weight of shear walls.
(c) Values of moment are increased by 50% equal as we move from seismic zones IV to V.

[B]. Tower with diaphragm discontinuity in presence of Shear wall under Seismic loading condition:
(a) The value of moment goes on increasing by 1.38% (in case of rigid) and 42.1 % (in case of semi-rigid) as we move from model A to B.
(b) The value of moment is goes on decreased by 1.38% (in case of rigid) and 42.1% (in case of semi-rigid)as we move from model A to C due to increasing weight of shear walls.
(c) Values of moment are increased by 50.12% equal as we move from seismic zones IV to V.

1.4 Maximum Displacements:

We found that the structure having rigid and semi-rigid diaphragm with increasing the discontinuity in structural diaphragm from Modal A to B and to C are discussed below:

[A]. Tower with diaphragm discontinuity under Seismic loading condition:
(a) The value of displacement is goes on decreased by 0.13% (in case of rigid) and increased by 3.49% (in case of semi-rigid) as we move from model A to B.
(b) The value of displacement is goes on decreased by 17.4% (in case of rigid) and 20.24% (in case of semi-rigid)as we move from model A to C due to increasing weight of shear walls. It increases the strength capability of the structure.
(c) Values of displacement are increased by 48.2% equal as we move from seismic zones IV to V.

[B]. Tower with diaphragm discontinuity in presence of Shear wall under Seismic loading condition:
(a) The value of displacement is goes on decreased by 2.4% (in case of rigid) and 3.49% (in case of semi-rigid) as we move from model A to B.
(b) The value of displacement is goes on decreased by 17.48% (in case of rigid) and 20.24% (in case of semi-rigid)as we move from model A to C due to increasing weight of shear walls. It increases the strength capability of the structure.
(c) Values of displacement are increased by 55.6% equal as we move from seismic zones IV to V.

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