“STUDY ON SEPARATION DISTANCE BETWEEN ADJACENT BUILDINGS FOR PREVENTION OF SEISMIC POUNDING”

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Abstract- Structures are built close to each other in various cities and urban areas where cost of land is high and availability of land is difficult. Due to this closeness, the structures may collide with each other when subjected to any vibration or earthquake. This collision of buildings or its different parts during the vibration is called pounding which result in architectural and structural damages or collapse of the entire structure. The among the possible structural damages, seismic induced pounding has been commonly observed in several earthquakes. As a result, a parametric study on buildings pounding response as well as proper seismic hazard mitigation practice for adjacent buildings is carried out. Therefore, the needs to improve seismic performance of the built environment through the development of performance-oriented procedures have been developed. To estimate the seismic demands, nonlinearities in the structure are to be considered when the structure enters into inelastic range during devastating earthquakes. Despite the increase in the accuracy and efficiency of the computational tools related to dynamic inelastic analysis, engineers tend to adopt simplified non-linear static procedures instead of rigorous non-linear dynamic analysis when evaluating seismic demands. This is due to the problems related to its complexities and suitability for practical design applications. The push over analysis is a static, nonlinear procedure that can be used to estimate the dynamic needs imposed on a structure by earthquake ground motions. Project aims at studying seismic gap between adjacent buildings by dynamic and pushover analysis in software. A parametric study is conducted to investigate the minimum seismic pounding gap between two adjacent structures by response Spectrum analysis for medium soil. Pounding produces acceleration and shear at various story levels that are greater than those obtained from the no pounding case, while the peak drift depends on the input excitation characteristics. Also, increasing gap width is likely to be effective when the separation is sufficiently wide practically to eliminate contact.

Kyewords:Structural pounding, Building collision, Adjacent buildings, Seismic separation distance, Pounding analysis

1. INTRODUCTION

The Seismic Pounding can be defined as the collision of adjacent buildings during the earthquakes. The principle reason for the pounding effect is the insufficient gap in between the adjacent buildings. It is one of the main causes of severe building damages in earthquake. The non-structural damage involves pounding or movement across separation joints between adjacent structures. Seismic pounding between two adjacent buildings occur during an earthquake when adjacent buildings of different dynamic characteristics vibrate out of phase at-rest separation is insufficient. A separation joint is the distance between two different building structures – often two wings of the same facility that allows the structures to move independently of one another. Also, Poundings may occur because of structural irregularities. For example eccentricity between mass rigidity centers cause torsion in the structure. Pounding is very complex phenomenon. It could lead to infill wall damage, plastic deformation, column shear failure, local crushing and possible collapse of the structure. Adjacent structures with different floor levels are more vulnerable when subjected to seismic pounding due to additional shear forces on the columns causing more damage and instability to the building. The patterns of the damage vary from minor and architectural damages to major structural damages to even total loss of the building function and its stability. In other words, pounding phenomena in adjacent buildings can be catastrophic and more dangerous than the effect of earthquake on a single building. Pounding is the phenomena of collision between adjacent building or different parts of the same building during strong vibrations. It may cause either architectural or structural damage and may lead to partial or even complete collapse of the structure. Jointly separated building structures can be a severe risk in seismically active areas. Earth quake convey on pounding between closely spaced structure is one of the highest cause of seismic susceptibility as it can cause severe disturbance to non structural and structural members and even assigned to structural collapse The difference in the dynamic characteristics of adjacent building structures leads to an out-of-phase vibration of the structures when subjected to earthquake.

II. LITERATURE REVIEW

Jeng Hsiang Lin et al Presented herein is a spectral approach to evaluate the seismic pounding probability of two adjacent buildings simulated by multi degree- of-freedom systems and separated by a minimum code-specified separation during a period of time. The analytical approach is based on random vibration theory and total probability theory. Numerical simulations of 36 cases are presented in this study. Results of this investigation reveal that the period ratio of the adjacent buildings plays a major role that affects the pounding risk of adjacent buildings. Also noted is that the effect of period ratio on pounding risk has not yet been taken into account in the seismic pounding related provisions of the Uniform Building Code.

Mizam Dogan et al studied the pounding of adjacent RC Buildings for seismic loads concluded that constructing adjacent buildings with equal floor heights and separation distances reduces the effect of pounding considerably. Existing adjacent buildings which are not properly separated from each other can be protected from effects of pounding
by placing elastic materials between them. Also limiting lateral displacement of existing adjacent buildings with cast in- place RC walls is an effective method for preventing structural pounding. These precautions cannot always isolate adjacent buildings completely from pounding but it can help in damping of pounding energy.

Valles et al introduced the Pseudo Energy Radius concept to study, (i) the minimum gap size to avoid pounding, (ii) the amplifications due to pounding, and (iii) the evaluation of different pounding mitigation techniques, including the use of supplemental damping devices and shock absorbers. A simple formulation, based on the Pseudo Energy Radius and statistical linearization, was developed to calculate the minimum gap to avoid pounding. Pounding effects in the response of structures were studied, and a simple methodology based on the Pseudo Energy Radius was developed to estimate these effects. Possible pounding mitigation techniques using energy dissipation devices, such as damper links, shock absorbers, or supplemental damping in the structure are described. The use of the Pseudo Energy Radius is suggested to estimate mitigation effectiveness. The formulations presented are then summarized to provide structural engineers with simple design/evaluation procedures to solve pounding problems. Building code considerations for pounding are reviewed. Critical gap to avoid pounding is usually specified in terms of the sum of the maximum displacements, or as a percentage of the height, or as a fixed quantity, or as a SRSS combination of the response. Making use of the improved correlation coefficient based on the above mentioned Pseudo Energy Radius, the Double Difference Combination rule may be used to calculated the critical gap to avoid pounding. The formulation can be extended to determine more rational critical gap formulations in seismic codes.

III. Structural Modeling

1 Details of the Models

The models which have been adopted for study are 4 bay of Four storied (G+4), Eight Storied (G+8) buildings with storey height of 3.2m and 3.4m. The frame systems are consisting of square columns and rectangular beams. The floor slabs are taken 125mm thick. The foundation height is 1.6m. All the models are considered in Seismic zones V.

The configurations of models have been considered for the purposes of the study are as follows:

Seismic zone: V: PLAN A

1 Four storied (Gr+4) of 3.2m storey height

2 Eight storied (Gr+8) of 3.2m storey height

3 Four storied (Gr+4) of 3.4m storey height

4 Eight storied (Gr+8) of 3.4m storey height

Seismic zone: V: PLAN B

1. Four storied (Gr+4) of 3.2m storey height
2. Eight storied (Gr+8) of 3.2m storey height
3. Four storied (Gr+4) of 3.4m storey height
4. Eight storied (Gr+8) of 3.4m storey height

2. SECTION PROPERTIES

- **MODEL (A1 , A3, B1, B3)**

MODELA1-G4-3.2-Z5		
STORY	MEMBER	SECTION
GR TO TERRACE	C1 TO C22	C400X400M20
1FL - TERRACE	B1 TO B35	B230X600M20
GROUND	B1 TO B35	PB230X450M20

- **MODEL (A2 , A4, B2, B4)**

MODELA2-G8-3.2-Z5		
STORY	MEMBER	SECTION
TERRACE	C1 TO C22	C400X400M20
8FL		
7FL		
6FL		
5FL	C1 TO C22	C500X500M20
4FL		
3FL		
2FL		
1FL	C1 TO C22	C550X550M20
GROUND		
1FL - TERRACE	B1 TO B35	B230X600M20
GROUND	B1 TO B35	PB230X450M20

THE PLAN OF THE BUILDINGS ARE AS SHOWN BELOW:

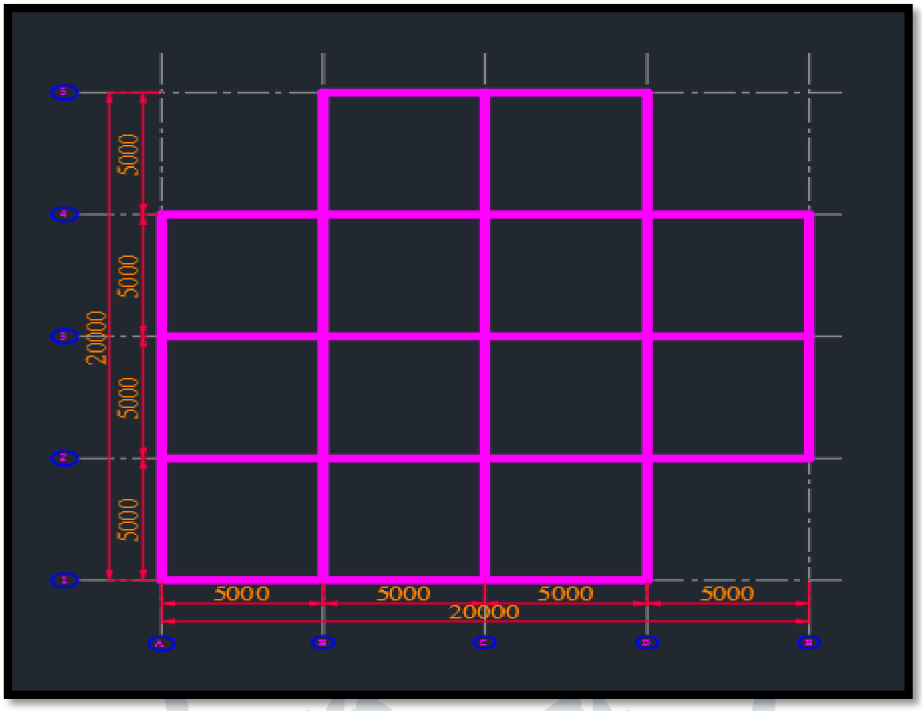

Fig..1: Column Beam Layout for Analysis for Plan A with A1, A2, A3, A4 Models

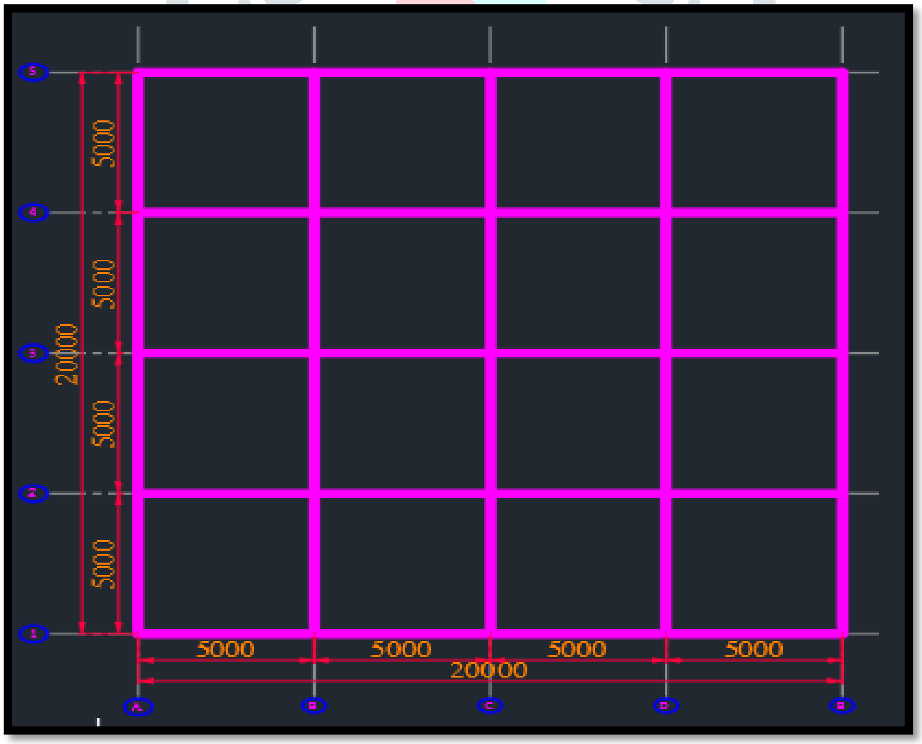

Fig. .2: Column Beam Layout for Analysis for Plan B with B1, B2, B3, B4 Model

V. ANALYSIS RESULT FOR SQUARE MODEL

4.2.1 For PLAN A model with different model A1 , A2 , A3, A4

1) for model A1

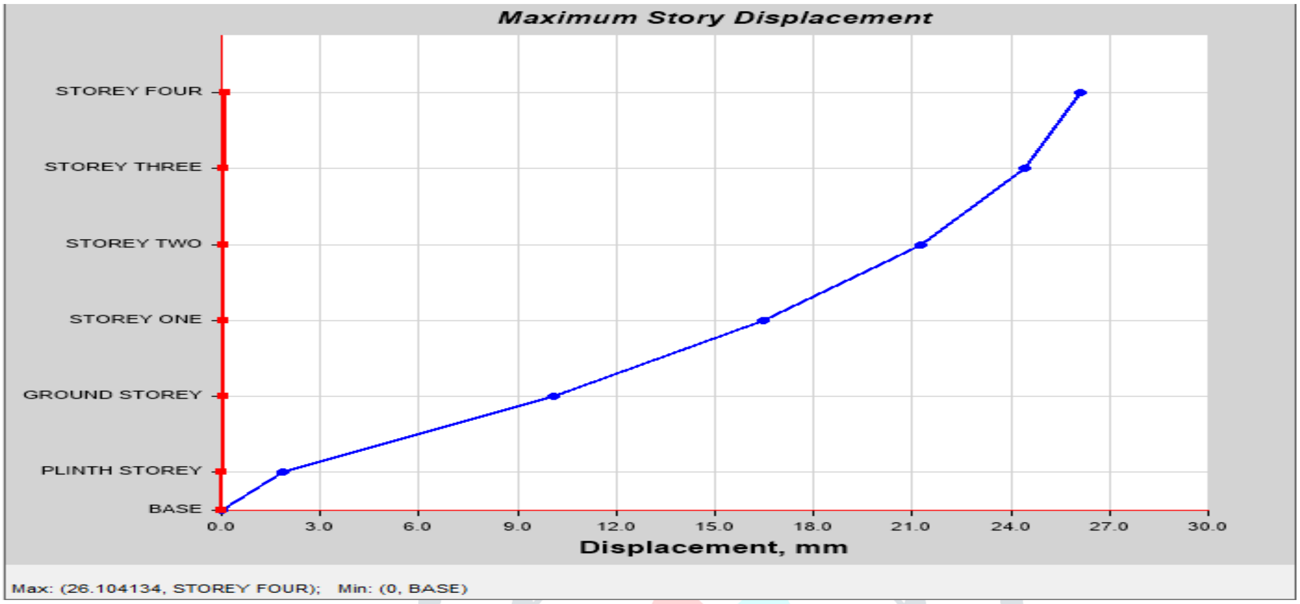

Figure 3: Maximum displacement of model A1

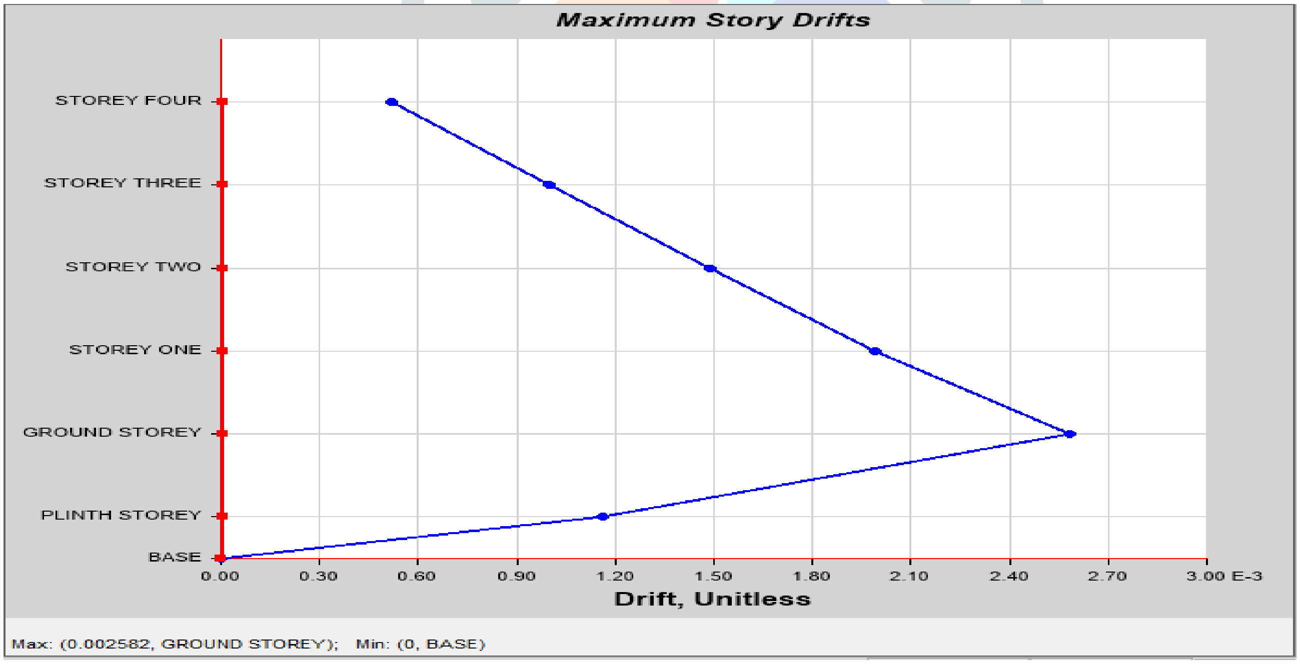

Figure 4: Inter-story of model A1

2) For model A2

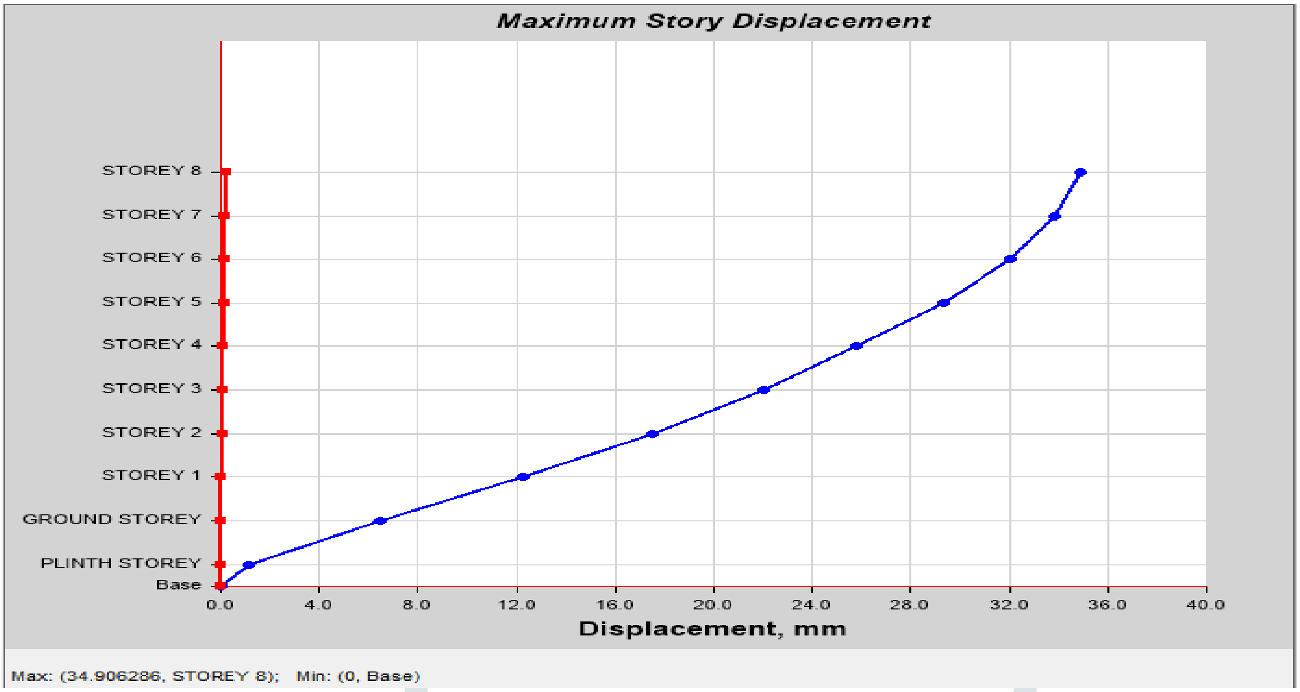

Figure 5: Maximum displacement of model A2

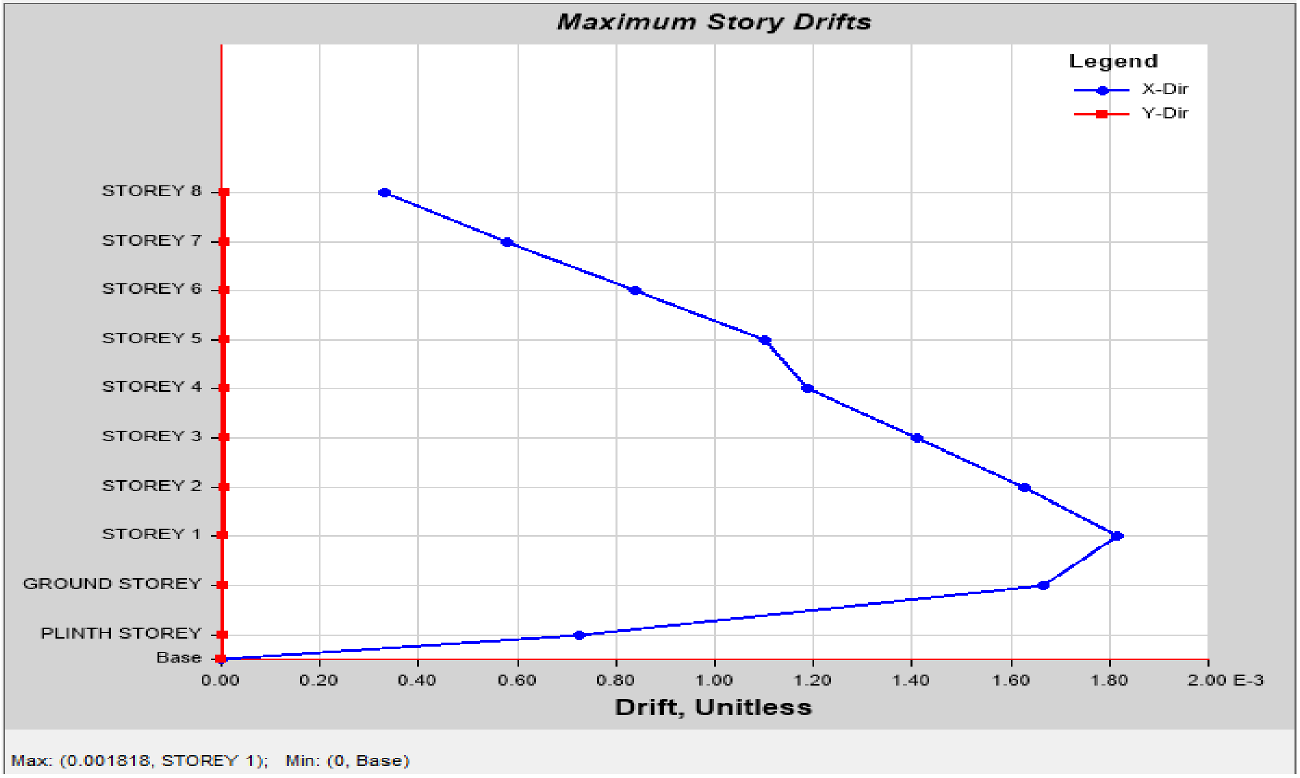

Figure 6: Inter-story of model A2

3) For model A3

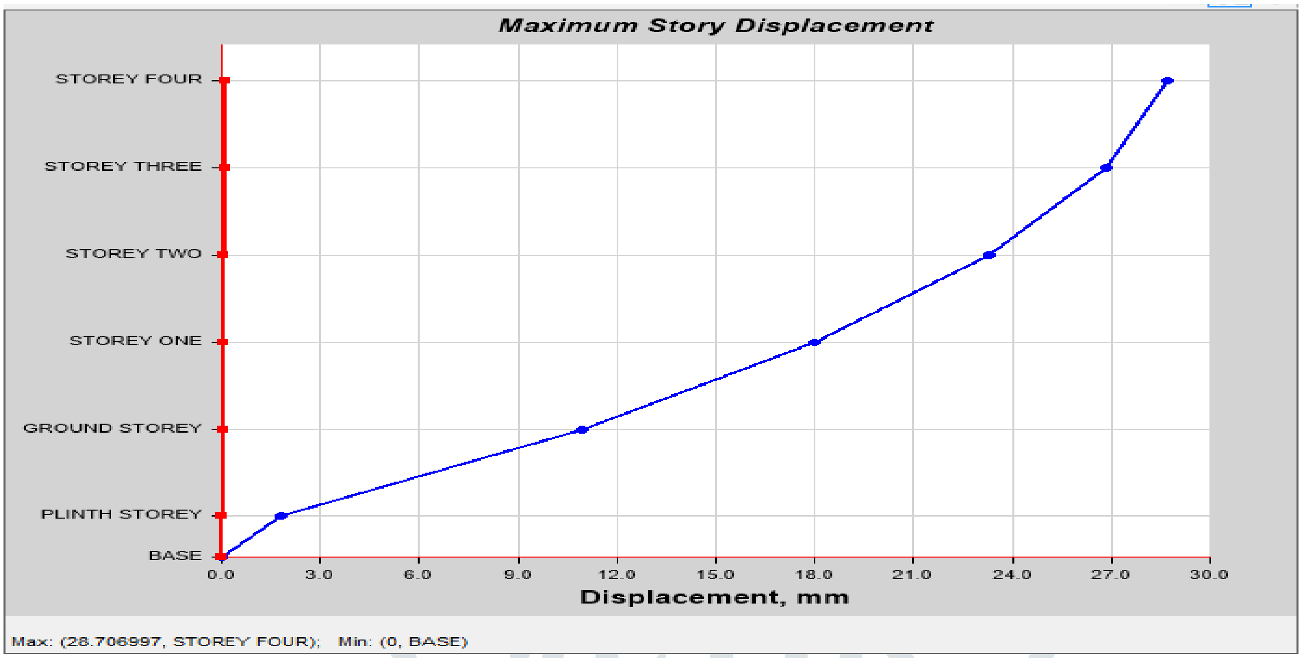

Figure 7: Maximum displacement of model A3

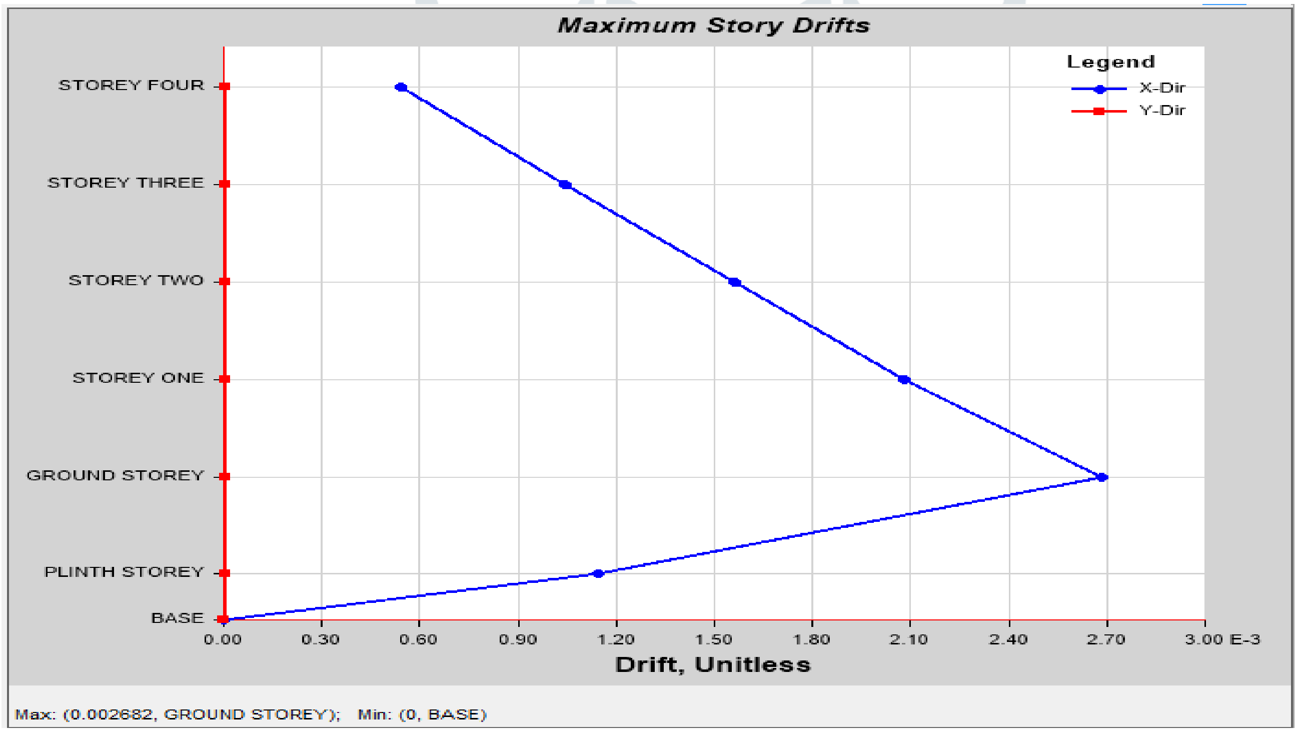

Figure 8: Inter-story of model A3

4) For model A4

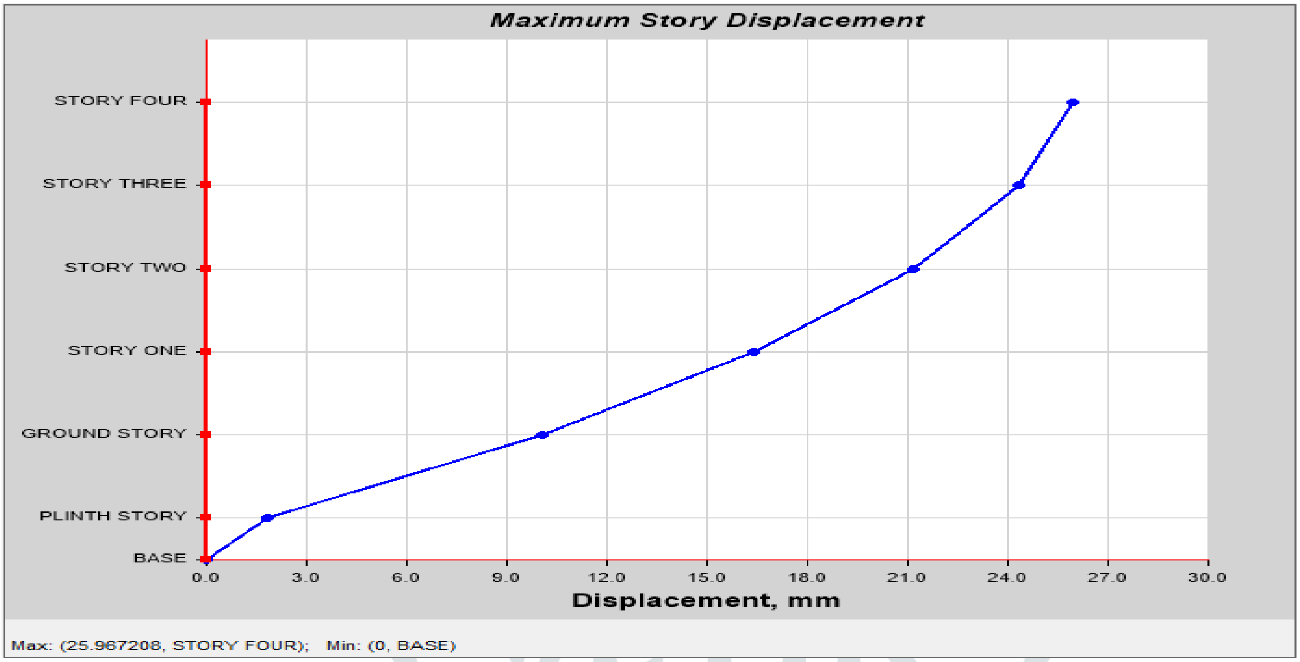

Figure 9: Maximum displacement of model A4

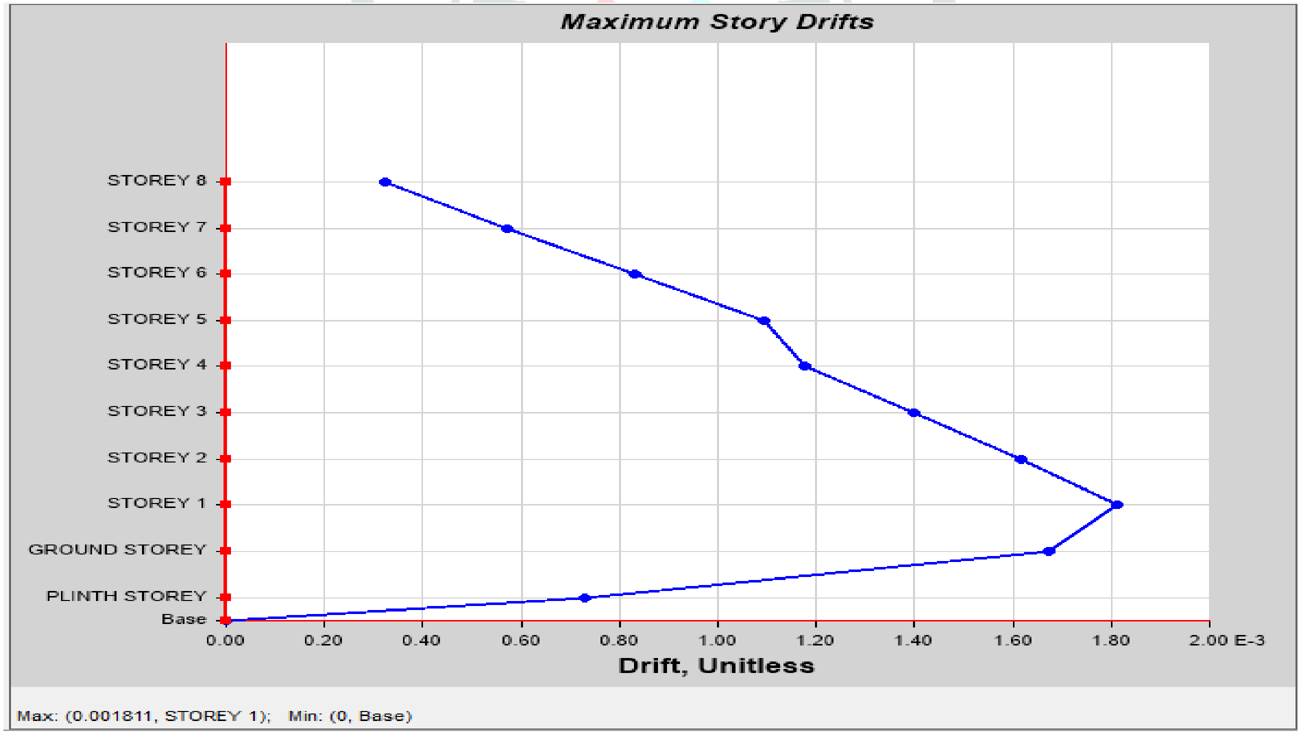

Figure 10: Inter-story of model A4

4.2.2 For PLAN B model with different model B1, B2, B3, B4

5) For model B1

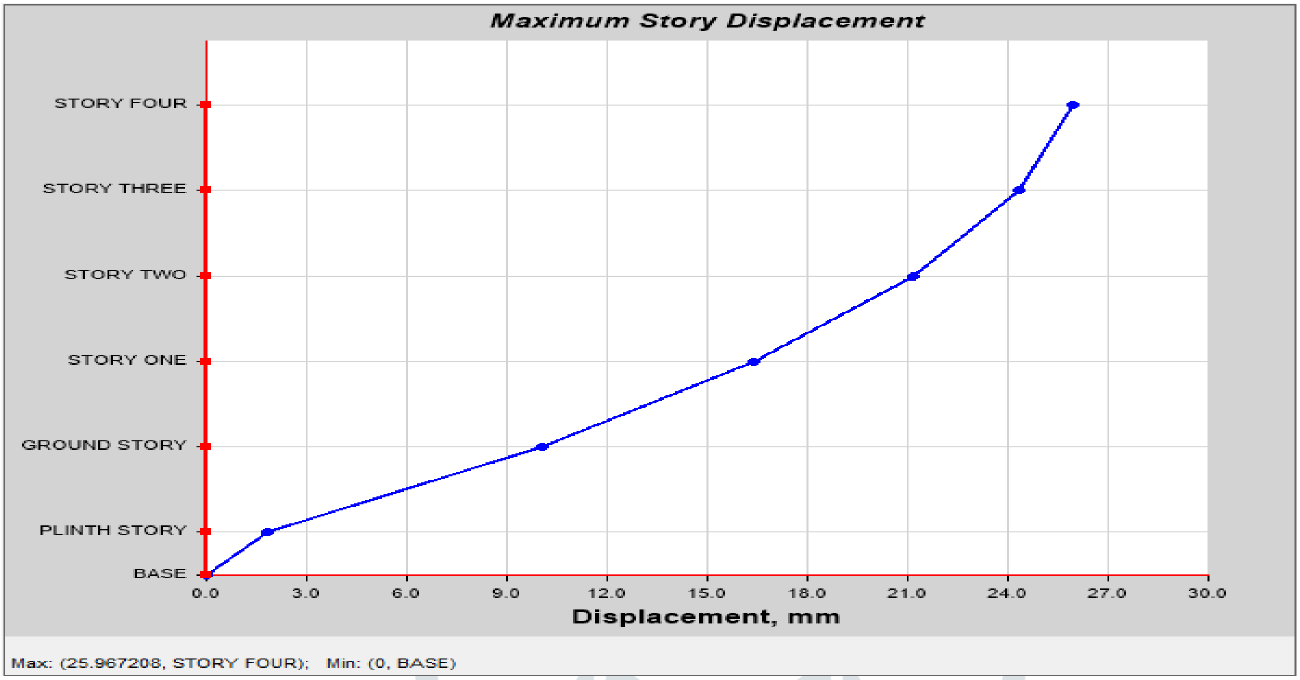

Figure 11: Maximum displacement of model B1

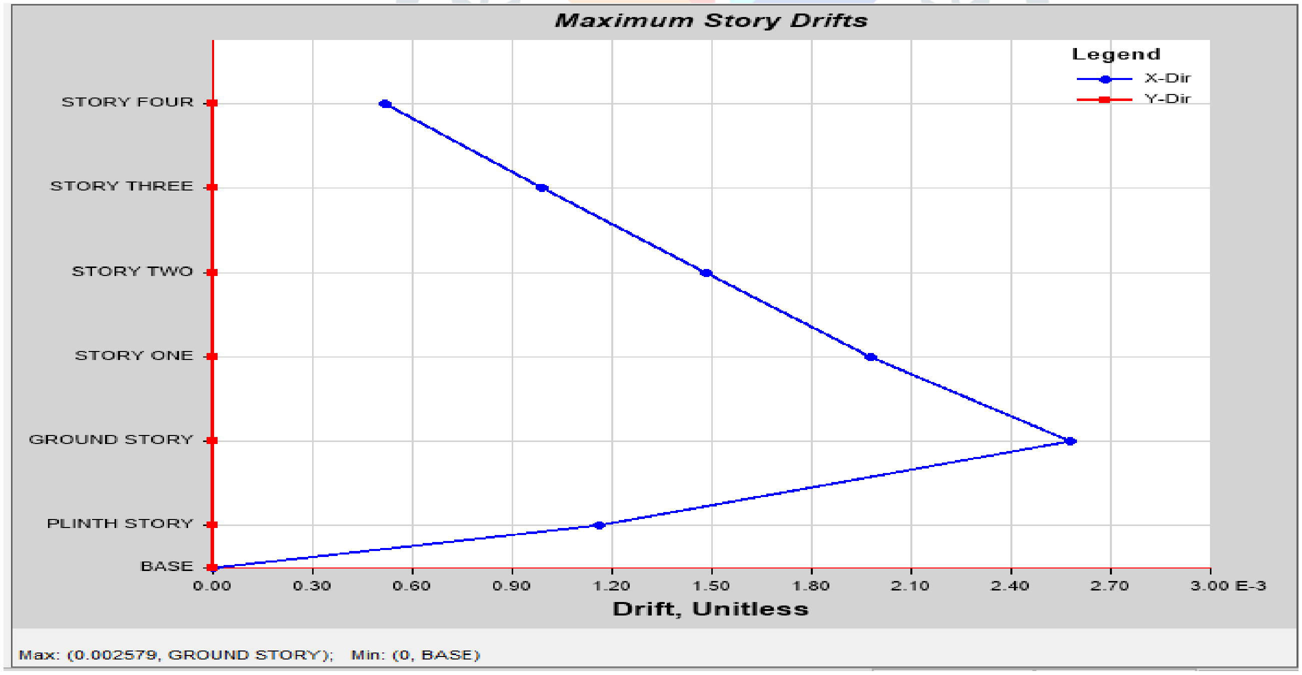

Figure 12: Inter-story of model B1

6) For model B2

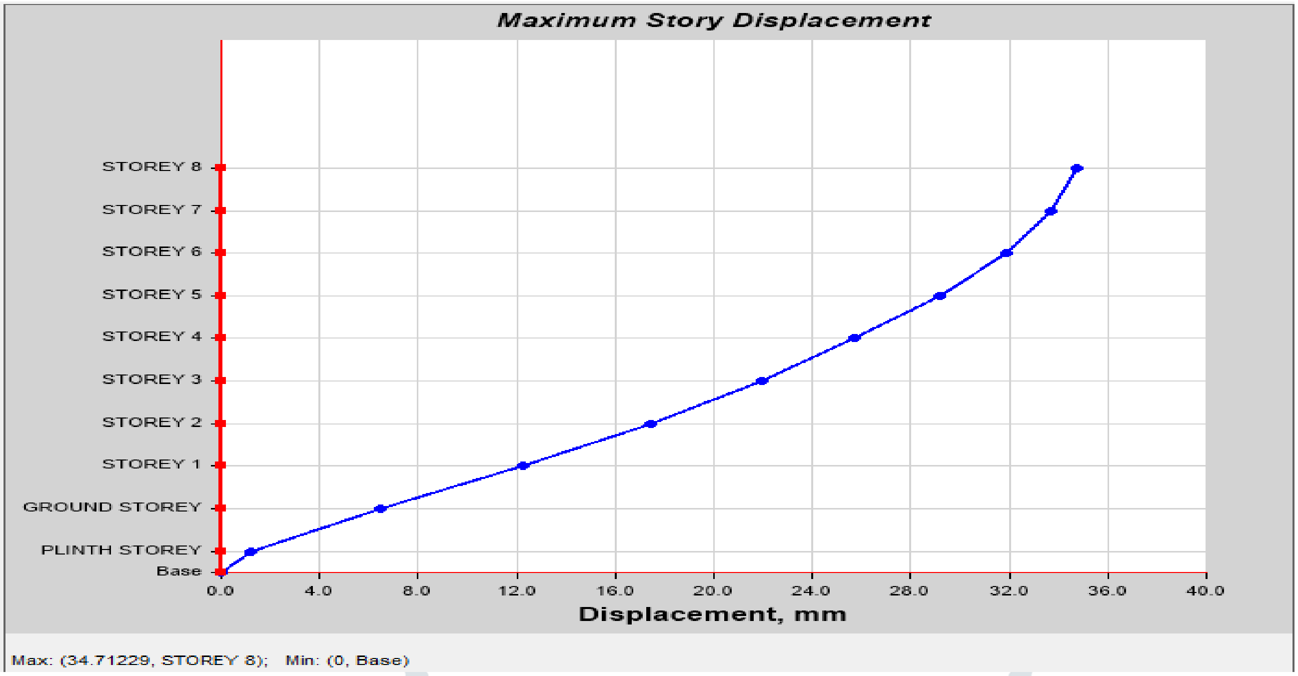

Figure 13: Maximum displacement of model B2

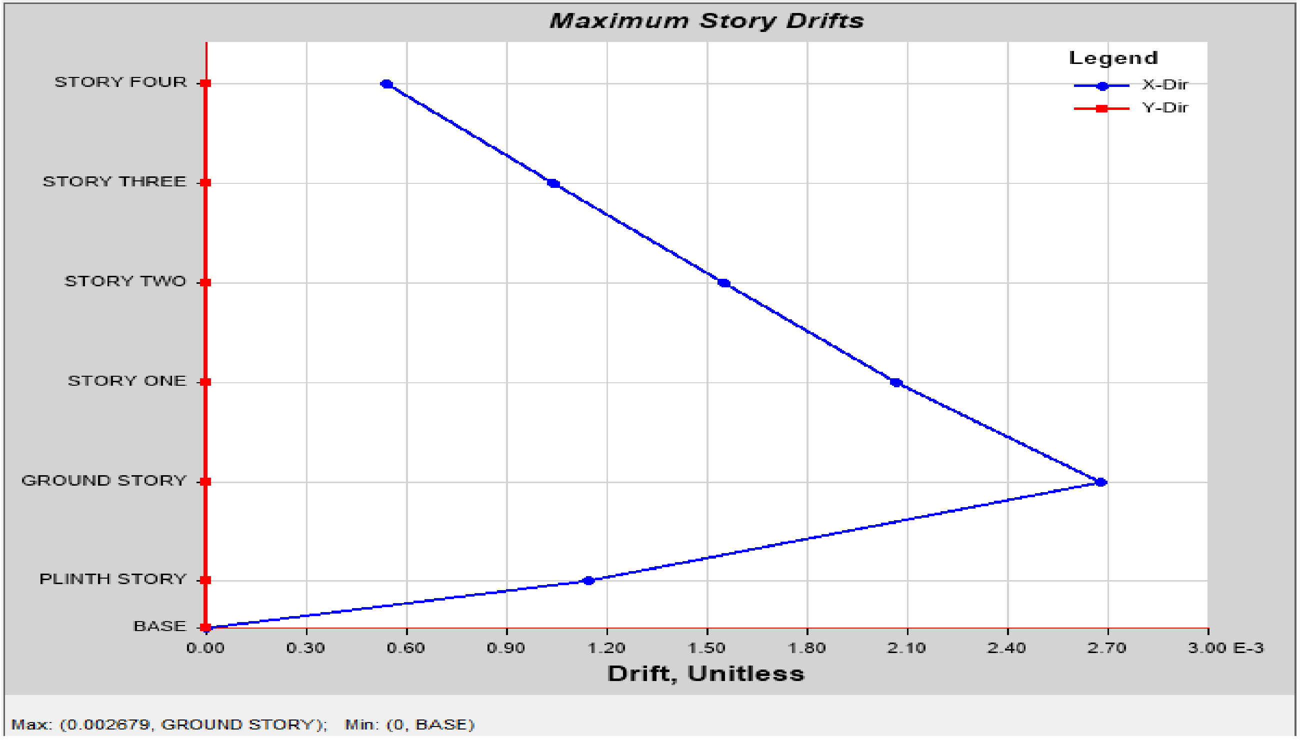

Figure 14: Inter-story of model B2

7) For model B3

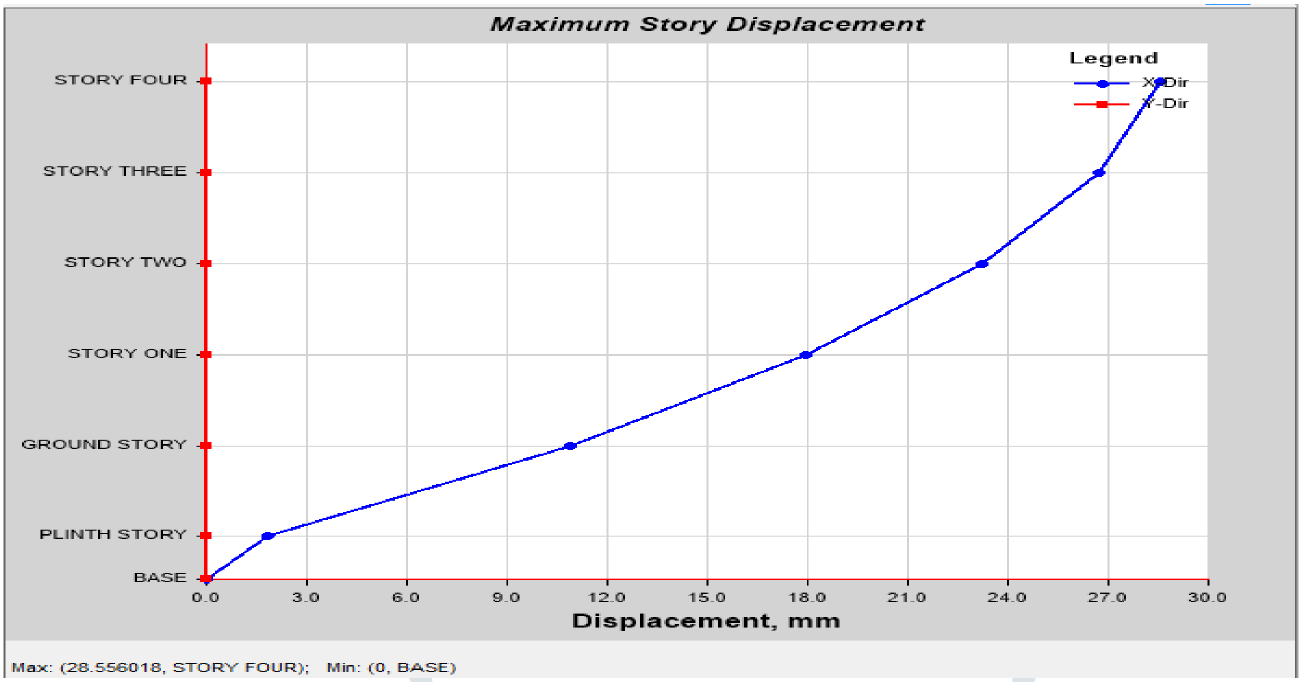

Figure 15: Maximum displacement of model B3

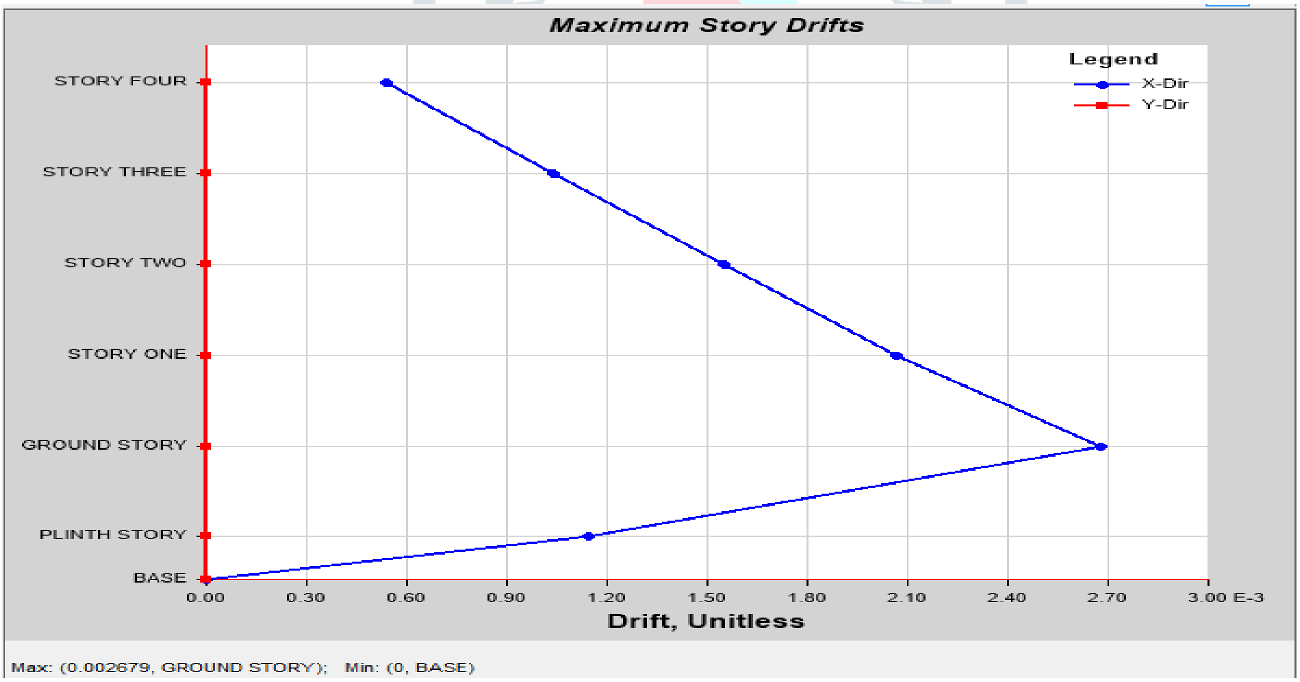

Figure 16: Inter-story of model B3

8) For model B4

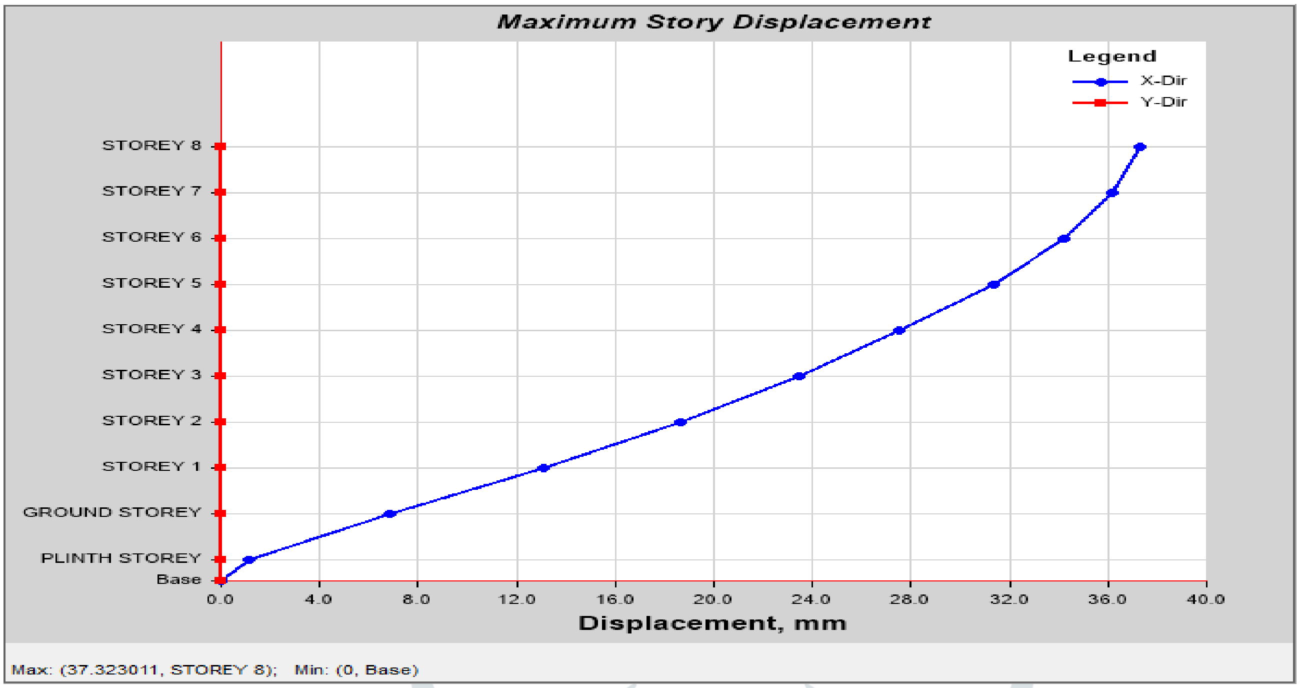

Figure 17: Maximum displacement of model B4

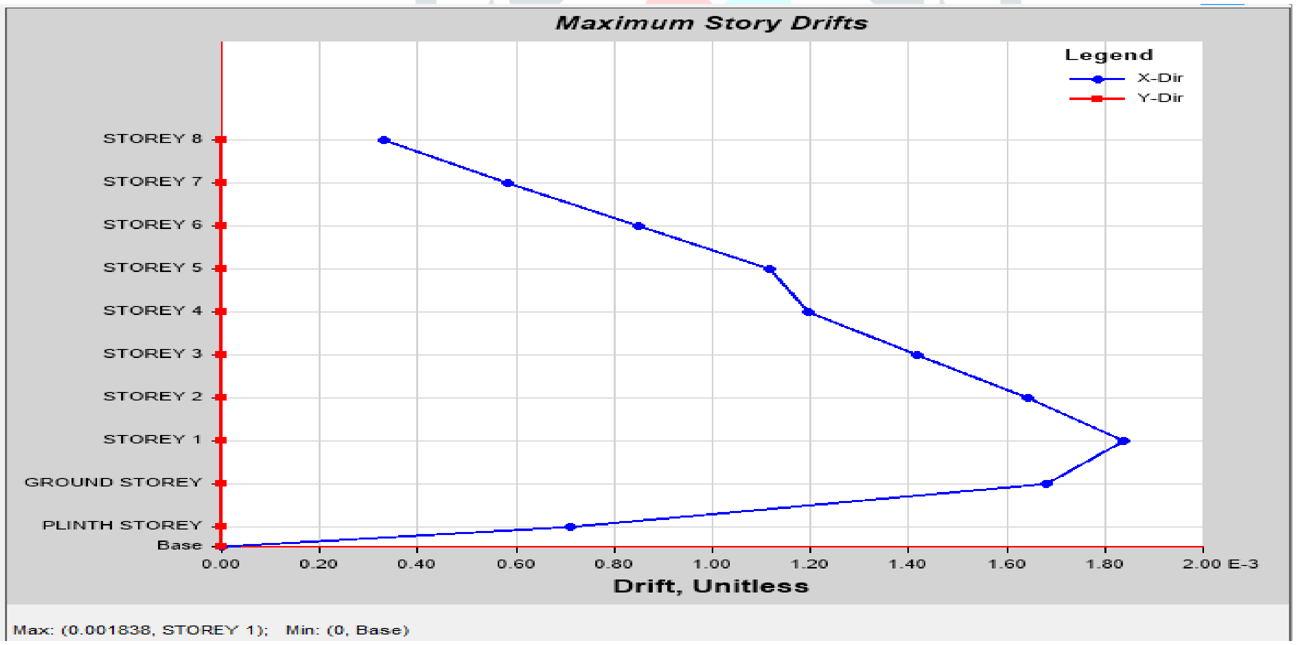

Figure 18: Inter-story of model B4

VII. COMPARISONS OF RESULTS

The Lateral story displacement obtained from Pushover analysis for the G+4, G+8buildings

MODEL	MAXIMUM BUILDING DISPLACEMENT
A1	26.10 mm
A2	34.90 mm
A3	28.70 mm
A4	37.53 mm
B1	25.96 mm
B2	34.71 mm
B3	28.55 mm
B4	37.32 mm

.1: Displacement in mm for G+4,G+8 models

The above Table shows the lateral displacement of G+4, G+8 (PLAN A & PLAN B) storey buildings. Maximum displacement is observed at top story of the buildings

5.3 Minimum separation distance between the adjacent buildings (ABS rule).

The minimum separation distance between the adjacent building of same story height is calculated by considering the buildings are in different property, and applying ABS rule (adding maximum lateral displacement of top floor of adjacent buildings

5.3.1 RESULT FOR PLAN A

G+4 with adjacent building G+4				
Building	STOREY HEIGHT (M)	ADJACENT BUILDING	STOREY HEIGHT (M)	MINIMUM SEPARATION DISTANCE BY ABS RULE (MM)
G+4	3.2	G+4	3.2	**52.2**
	3.2	G+4	3.4	**54.8**

.2: Displacement in mm for plan A (G+4 with adjacent building G+4)

G+4 with adjacent building G+8				
Building	STOREY HEIGHT (M)	ADJACENT BUILDING	STOREY HEIGHT (M)	MINIMUM SEPARATION DISTANCE BY ABS RULE (MM)
G+4	3.2	G+8	3.2	**61**
	3.2	G+8	3.4	**63.63**
	3.4	G+8	3.2	**63.60**
	3.4	G+8	3.4	**66.23**

Table 3: Displacement in mm for plan A (**G+4** with adjacent building G+8)

5.3.2 RESULT FOR PLAN B

G+4 with adjacent building G+4				
Building	STOREY HEIGHT (M)	ADJACENT BUILDING	STOREY HEIGHT (M)	MINIMUM SEPARATION DISTANCE BY ABS RULE (MM)
G+4	3.2	G+4	3.2	**51.92**
	3.2	G+4	3.4	**54.51**

Table 4: Displacement in mm for plan B (G+4 with adjacent building G+4)

G+4 with adjacent building G+8				
Building	STOREY HEIGHT (M)	ADJACENT BUILDING	STOREY HEIGHT (M)	MINIMUM SEPARATION DISTANCE BY ABS RULE (MM)
G+4	3.2	G+8	3.2	**60.67**
	3.2	G+8	3.4	**63.28**
	3.4	G+8	3.2	**63.26**
	3.4	G+8	3.4	**65.87**

Table 5: Displacement in mm for Plan B (G+4 with adjacent building G+8)

VIII. conclusion

The obtained minimum separation distance between the adjacent buildings is has to be provided to avoid the seismic pounding during earthquake.

1) for PLAN A

- From the above results for seismic zone V, the minimum separation gap varies from 52.20 mm to 66.23 mm for considered pair of adjacent buildings of same story height.

- From the above results for seismic zone V, the minimum separation gap varies from 54.80 mm to 63.63 mm for considered pair of adjacent buildings of different story height

2) For PLAN B

- For seismic zone V, the minimum separation gap varies from 51.92 mm to 65.87 mm for considered pair of adjacent buildings of same story height.
- For seismic zone V, the minimum separation gap varies from 54.51 mm to 63.28 mm for considered pair of adjacent buildings of different story height.

From the above results it is conclude that the required minimum separation gap between adjacent buildings of different story height is more than the required minimum separation gap of adjacent buildings of same story height.

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