Performance of Flat Slabs & Flat Plates in High Seismic Zone with Varying Stiffness

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Abstract – *Flat slabs and flat plate system of construction is one in which the beams used in the conventional methods of constructions are done away with. The slab directly rests on the column and load from the slab is directly transferred to the columns and then to the foundation. To support heavy loads the thickness of slab near the support with the column is increased and these are called drops, or columns are generally provided with enlarged heads called column heads or capitals. In present era, conventional RC Frame buildings are commonly used for the construction. The structural efficiency of the flat-slab construction is hindered by its poor performance under earthquake loading. In the present work Flat Plate and Flat Slab buildings of G+10 story building model is considered. In the present study a parametric investigation is carried out in order to identify the seismic response of systems a) flat plate/slab building b) flat plate/slab with steel bracings c) flat plate/slab with shear walls are studied and analyzed by using ETABS version 9.7.2. Present work provides a good source of information on the parameters such as maximum displacement, story drift, story shear, base shear, time period performance of shear walls v/s steel bracings are carried out.*

Key Words: Flat slab, flat plate, bracing, shear wall, storey displacement, storey drift, base shear, time period.

1. INTRODUCTION

Flat Slab building structures have main advantages in excess of conventional slab-beam-column structure since of gratis design of breathing space, shorter structure occasion, architectural-functional and economic aspects, thus making the choice for contractors and architects. Because of the absence of deep beams, flat-slab structural scheme is considerably extra flexible for side loads after that usual RC frame organization and so as to makes the system more vulnerable for lateral loads. The flat plate system has been adopted in many buildings construction taking advantage of the reduced floor height to meet the economical and architectural demands. Flat slab RC buildings exhibit several advantages over conventional beam column building. However, the structural effectiveness of flat-slab construction is hindered by its alleged inferior performance under earthquake loading. Although flat-slab systems are widely used in earthquake prone regions of the world, unfortunately, earthquake experience has proved that this form of construction is vulnerable to more damage and failure, when not designed and detailed properly. Therefore careful analysis of flat slab building is important(6)

2. LITERATURE REVIEW

Dakshayani S and Chaithra N (2016) [1], Analysed a G+9 storey building for seismic zone IV as per IS 1893: 2002 using ETABS software. The effectiveness of various types of steel bracing (ISMB 450) i.e., X, V, inverted V, diagonal bracing are examined. Flat slab is also used by providing drop panels and peripheral beam. For all models parameters are kept constant. The effect of the distribution of the steel bracing along the flat slab to RC frame on the seismic performance of the building is studied. The performance of the building is evaluated in terms of storey displacement, storey shear, story drifts and slab stresses. The percentage reduction in lateral displacement along X direction is tabulated. As compared to V and diagonal braced frame, the inverted V and X braced frame reduces the displacements and storey drift of the structure when combined with flat slab. The storey shear is significantly more for V and inverted V bracing. Providing the steel bracings and Flat slab with drop panels gives less slab stress on structure compared to RC bare frame. Hence it is concluded that the use of steel bracing with flat slab in construction resists the lateral forces for many vulnerable conditions.

Mohana H.S, Kavan M.R (2015)(2) , Analysed a G+5 commercial multistoried building having flat slab and conventional slab has been analyzed for the parameters like base shear, storey drift, axial force, and displacement. The performance and behavior of both the structures in all seismic zones of India has been studied. In the present work the storey shear of flat slab is 5% more than conventional slab structure, the axial forces on flats lab building is nearly 6% more than conventional building, the difference in storey displacement of flat and conventional building are approximately 4mm in each floor. The present work provides reasonable information about the suitability of flat slab for various seismic zones without compromising the performance over the conventional slab structures

Durgesh Neve1, R. P.Patil (2016)(3) , Analysed G+8 storey hospital building in Zone III is presented with some investigation which is analyzed by replacing complete columns by shear walls for determining parameters like storey drift, storey shear and displacement and is done by using Etabs software. Due to high seismic zone the column sizes of structure increases which decreases carpet area and also the aesthetic look from inside. Shear Walls are specially designed structural walls included in the buildings to resist horizontal forces that are induced in the plane of the wall due to wind, earthquake and other forces. They are mainly flexural members and usually provided in high rise buildings to avoid the the total collapse of the high rise buildings under seismic forces.

Navyashree K and Sahana T S (2014) [4], carried out six number of conventional RC frame and Flat Slab buildings of G+3, G+8, and G+12 storey building models for analysis. The performance of flat slab and the vulnerability of purely frame and purely flat slab models under different load conditions were studied and for the analysis, seismic zone IV is considered. The analysis is done with using E-Tabs software. It is necessary to analyse seismic behaviour of building for different heights to see what changes are going to occur if the height of conventional RC Frame building and flat slab building changes. Therefore, the characteristics of the seismic behaviour of flat slab and conventional RC Frame buildings suggest that additional measures for guiding the conception and design of these structures in seismic regions are needed and to improve the performance of building having conventional RC building and flat slabs under seismic loading, The object of the present work is to compare the behaviour of multi-storey commercial buildings having flat slabs and conventional RC frame with that of having two way slabs with beams and to study the effect of height of the building on the performance of these two types of buildings under seismic forces. Present work provides a good source of information on the parameters lateral displacement, storey drift, storey shear, column moments and axial forces, time period.

Pradip S. Lande and Aniket B. Raut (2015) [5], carried out a parametric investigation to identify the seismic response of system considering Zone V. They have considered the following elements for their works- (a) building with flat slab, (b) flat slab with parametric beam, (c) flat slab with shear walls, (d) flat slab with drop and (e) conventional building. Analyses were carried out using ETABS nonlinear version 9.7.3 for determining the seismic performance of the structure. They considered G+6 and G+12 storied building. Column size 450mm x 450mm and beam size 230mm x 400mm were considered for G+6 and column size of 650mm x 650mm and beam size 230mm x 500 mm were considered. On the basis of the work carried out, the author concluded that the storey displacement is found to be maximum for flat slab building as compared to conventional RCC building. The maximum storey drift found for G+6 building was 0.04 % of height.

Bindu N Byadgi, Vijayalaksmi R, Dr.Jagadish Kori (2017)(6), Flat block structures area unit a lot of advantageous than standard beam column structures. However, throughout the earthquake loading its performance is hindered due to the reduced stiffness. sadly, earthquake expertise has well-tried that this kind of construction is prone to a lot of harm and failure, once not designed and elaborated properly. so careful analysis of flat block building is vital. during this work, the stiffness of flat plate and flat block structures for various level height like G+10, G+15, G+20 level in high unstable zone (zone V) area unit thought-about and analyzed mistreatment Etabs software package version nine.7.2. during this work, the investigation is meted out to check the performance of flat plate and flat block structures with variable stiffness mistreatment shear wall and steel bracing at varied locations and for various level height area unit studied and additionally the variation in level displacement, bury level drift, base shear, period of time and performance of shear wall v/s steel bracings for flat plate and flat block structures area unit studied and results area unit compared.

Sanjay P N et al (2014) [7], carried out to check the performance of building having flat slabs underneath unstable loading, provision of flat block with drop and while not drop is planned within the gift work. the item of this work is to match the behaviour of multi-storey buildings having flat slabs with drops and while not drop on the performance of those 2 forms of buildings underneath unstable forces. And differing kinds of zones and completely different form of soils condition as per IS code Provision of work provides an honest supply of knowledge on the parameters structure shear, base shear, structure drift, and most bending moment at column

2.2 OBJECTIVES:

1. Analyzing the flat plate and flat slabs by Equivalent static analysis & response spectrum analysis method with the help of E-TABS

2. Performance of Flat plate and flat slabs with shear wall and bracing are analysed .

3. The Seismic load are applied to the all four models as per the IS code conditions.

4. Comparsion of parameters like story drift, story displacement, base shear & natural time period.

5. Finally it should be identified that which structure gives the better results for design purpose.

3. MODELLING AND ANALYSIS(6)

The RC frames comprises of columns, beams and slabs. Analysis of the frames is done using ETABS. Dead load, imposed load, and earthquake load are considered for analysis.

3.1 Material property

- Grade of concrete = M25 and M30
- Grade of steel = Fe 500

- Young's modulus of concrete = 25000 and 30000Mpa
- Young's modulus of steel = 200000MPa
- Unit weight of steel = 78.0 kN/m^3
- Unit weight of concrete = 25 kN/m^3

3.1.2 Geometry of model[6]

- Size of Beam = (0.4x0.60) m
- Size of Column (BxD) = (0.40x0.40) m
- Thickness of Flat Plate = 0.25 m
- Thickness of Flat Slab = 0.25 m
- Thickness of Drop = 0.25 m
- Thickness of Shear wall = 0.23 m
- Typical floor height =3.5m
- Total height of building = 35m
- Response reduction factor = 5
- Damping Ratio = 5%
- Importance factor = 1
- Soil condition = Medium soil

3.1.3 Consideration of loads[6]

The dead load is considered as per IS 875-1987 (Part I-Dead loads)[10] . The imposed load is considered as per IS 875-1987 (Part II-Imposed loads)[11].

3.1.4 Earthquake Load (EL)[6]

The earthquake load is considered as per the IS 1893-2002(Part 1)[9] .The factors considered are

- Zone factors = 0.36 (zone V)
- Importance factor = 1.0
- Response reduction factor = 1.0
- Soil condition = Medium soil
- Damping = 5%

3.2 About the Models

1. Model-1 Flat Plate with Shear wall
2. Model-2 Flat Plate with bracing
3. Model-3 Flat slab with Shear wall.
4. Model-4 Flat slab with bracing

3.2.1 Model-1: Flat plate with shear wall

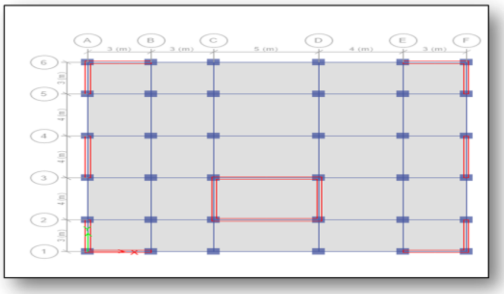

Fig 1-Plan view of flat plates with shear wall

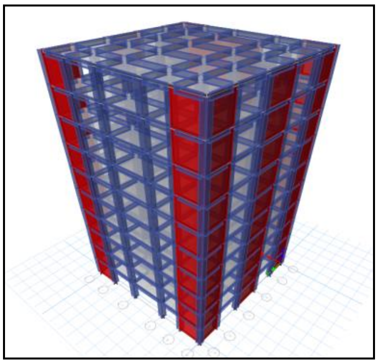

Fig 2- 3D view of flate plate with shear wall

3.2.2 Model-3: Flat slab with shear wall

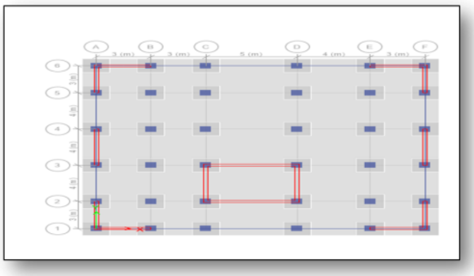

Fig 3-Plan view of flat slab with shear wall

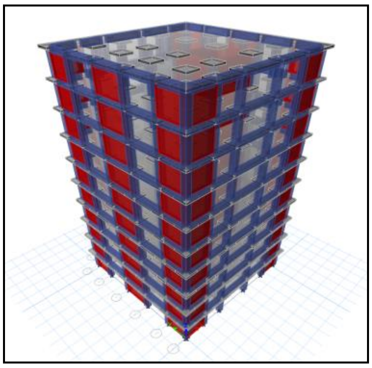

Fig 4- 3D View of flat slab with shear wall

4. RESULTS AND DISCUSSION

4.1 Analysis by Equivalent static analysis

4.1.1 Maximum displacement

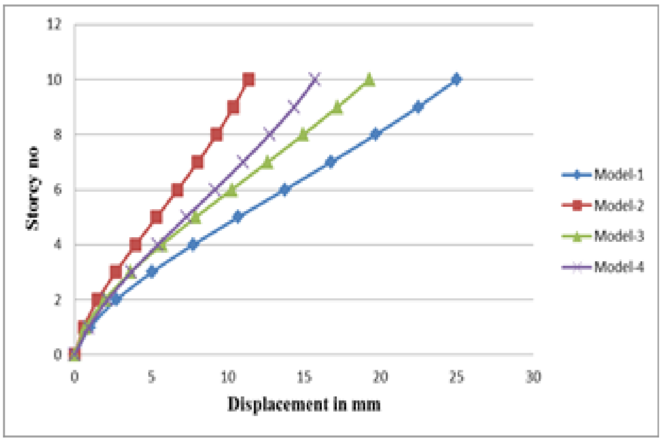

Fig 4.1: Story Displacement by ESA along X- Direction

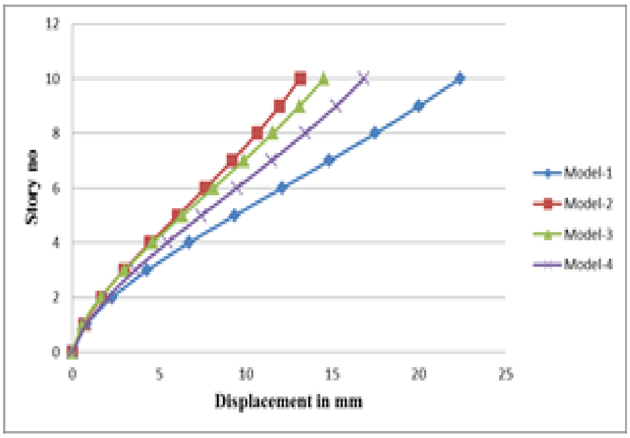

Fig 4.2: Story Displacement by ESA along Y- Direction

4.1.2. Maximum Story Drift

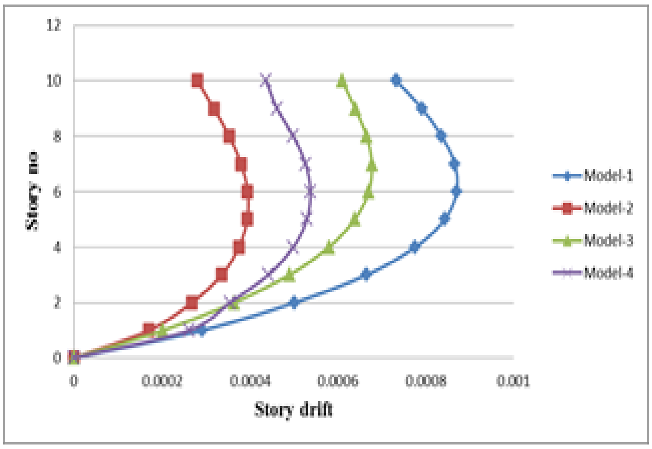

Fig 4.3: Story Drift by ESA along X-Direction

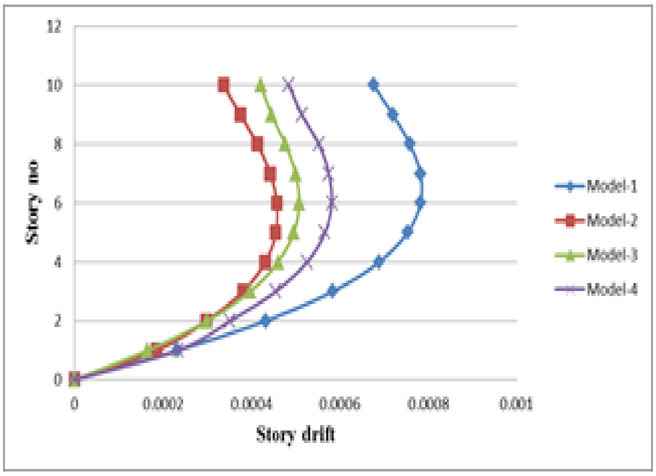

Fig 4.4: Story Drift by ESA along Y-Direction

4.1.3 Base Shear

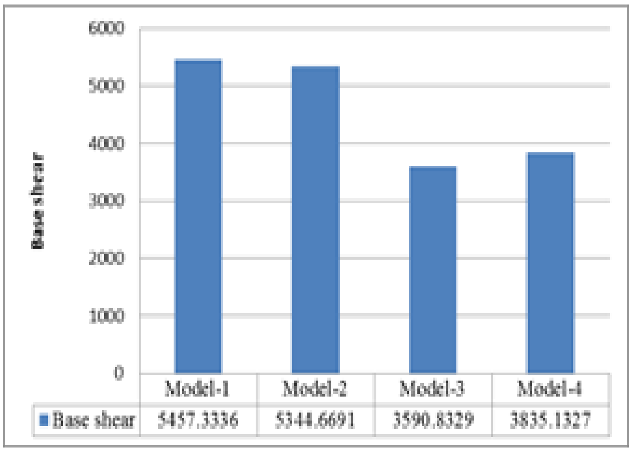

Fig 4.5: Base Shear by ESA along X-Direction

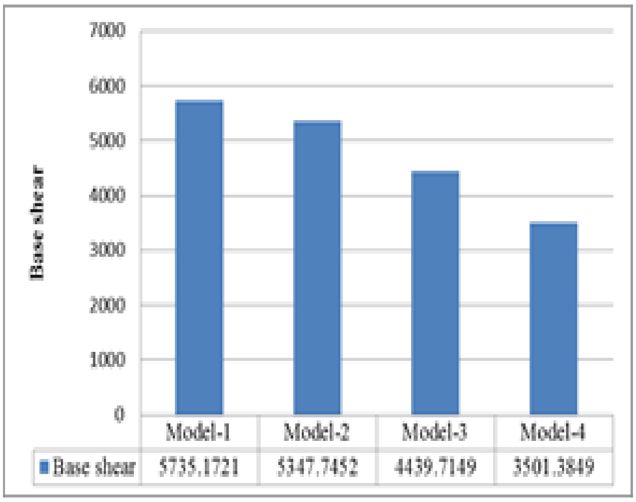

Fig 4.6: Base Shear by ESA along Y-Direction

4.2 Analysis by Response Spectrum Analysis

4.2.1 Maximum displacement

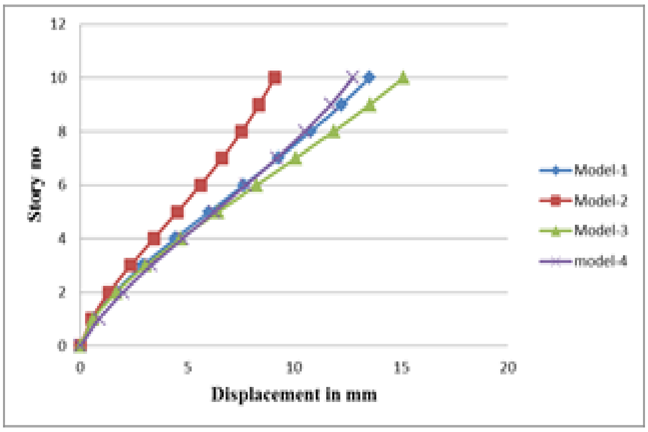

Fig 4.7: Story Displacement by RSA along X- Direction

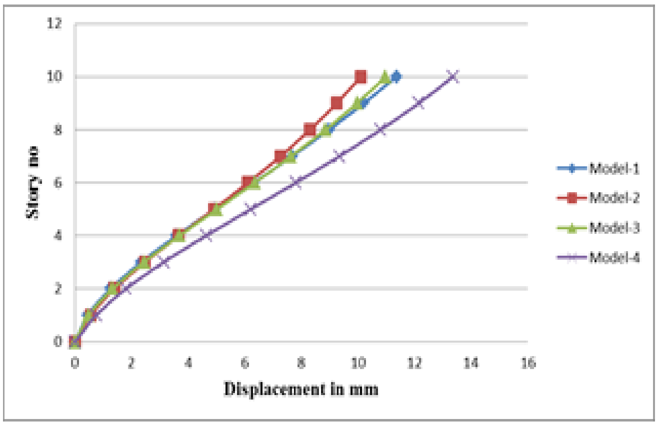

Fig 4.8: Story Displacement by RSA along Y- Direction

4.2.2. Maximum Story Drift

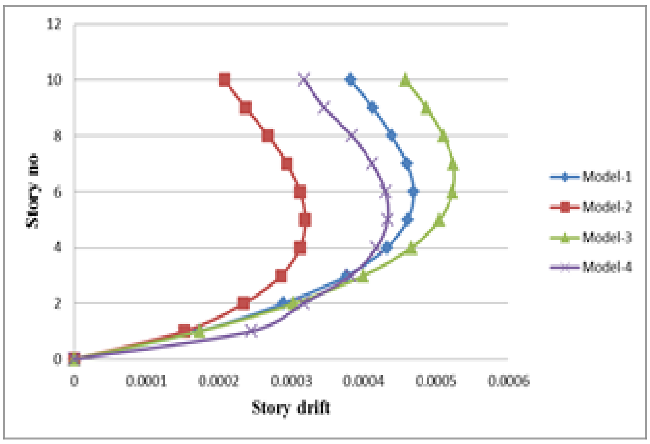

Fig 4.9: Story Drift by RSA along X-Direction

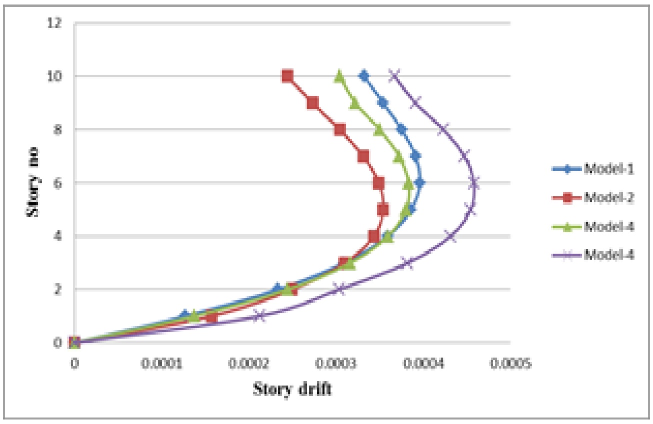

Fig 4.10: Story Drift by RSA along Y-Direction

4.2.3 Base Shear

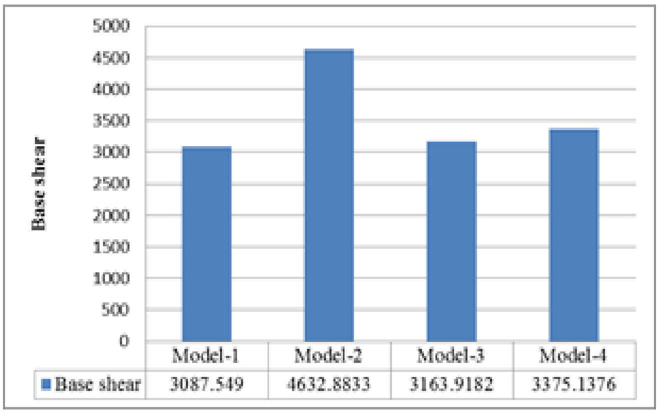

Fig 4.11: Base Shear by RSA along X-Direction

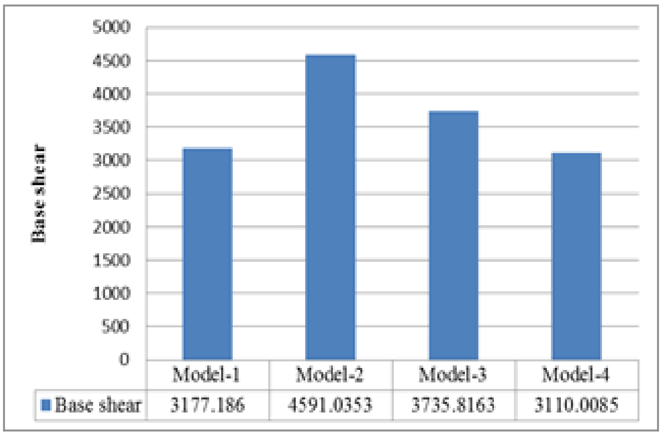

Fig 4.12: Base Shear by RSA along Y-Direction

4. CONCLUSIONS

1. From the study it is concluded the flat slab with shear wall gives better results in Equivalent static analysis and Response Spectrum Analysis than flat plate with shear wall.

2. The story displacement is minimum in flat slab as compared to flat plate.

3. Story drift is also less in flat plate, where it is maximum in flat plate

4. Natural time period is minimum for flat slab as compared to the flat plate.

5. The base shear in response spectrum load cases observed more forces in shear wall systems when compared to bracing system.

6. It is concluded that the flat slab has the maximum lateral load resistance as compared to flat plate.

7. Flat slab system time period is less when it is compared to flat plate structure. This is because flat slab is less Stiffer than flat plate system.

8. In different Equivalent static analysis and Response Spectrum Analysis the model 2.0 gives the better results, in story displacement, story drift, base shear and time period.

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