

# International Journal of Innovative Research in Science, Engineering and Technology

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## Time History Analysis of Residential Building with & Without Expansion Joints: A Case Study by ETABS

Shubhangi Singla<sup>1</sup>, Ravikant Kumar<sup>2</sup>

P.G. Student, Department of Civil Engineering, RPIIT Engineering College, Karnal, Haryana, India<sup>1</sup>

Associate Professor, Department of Civil Engineering, RPIIT Engineering College, Karnal, Haryana, India<sup>2</sup>

**ABSTRACT:** Expansion joints are frequently required between adjacent buildings and are often introduced to separate two or more parts of the same building. Parameters of each individual tower and the tower as a whole were analyzed using time history analysis using past earthquake data. Time history analysis was carried out using ETABS2013 software. The study of storey deflection and storey drift experienced by various storeys in all the cases analyzed in this dissertation work show that there is less variation. Therefore, while designing a structure with span more than 45m (without expansion joints), it was observed that consideration of thermal effects lead to satisfactory result.

**KEYWORDS:** Storey Drift, Max Storey Displacement and Time Period.

### I. INTRODUCTION

An expansion joint or movement joint is an assembly designed to safely absorb the heat-induced expansion and contraction of construction materials, to absorb vibration, to hold parts together, or to allow movement due to ground settlement or earthquakes. They are commonly found between sections of building, bridges, sidewalks, railway tracks and other structures.

As per IS 456, normally structures exceeding 45m length are designed with one or more expansion joints. In case the client **doesn't want to incorporate an expansion joint** keeping in view the aesthetic value of the structure. A thermal analysis must be done to safe guard the design

#### Expansion joint Limit for various structures:-

- RCC structures - **45m** (IS 456)
- Load bearing structures - **30m** (SP-62)
- Sunshades, Balconies and Parapets - **6m to 23m** (SP-62)

### ARCHITECTURAL AND FIRE ISSUES INVOLVED IN EXPANSION JOINTS

□

Architects have a strong dislike for expansion joints, with good reason. The joints require very significant design effort by the architect end, ultimately, no matter how well they are done, they are expensive and unattractive. In low to mid-rise buildings, architects will frequently ask that the joints be made the same width over the full height of the building, in order to simplify the design. This is, of course, acceptable from a structural engineering perspective, but can add to the expense of the project because of the larger-than-needed joint covers that will be employed at the lower floors of the building. Fire rating is typically accomplished through use of fire blankets that are hung slack across the joint. Reportedly, inadequate fire protection for expansion joints was a major contributor to the 85 deaths in the 1980 MGM Grand fire.

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## LOCATION OF EXPANSION JOINTS

1. The joints shall be so arranged as to avoid acute angles and re-entrant angles. The angles at the corner of slabs should preferably be not less than 90 degree and not more than 180 degree.
2. The transverse joints in adjacent lanes may be kept in one line in order to avoid sympathetic cracking which is likely to develop if the joints are staggered.
3. Skew joints shall be avoided as they may lead to cracking at the acute angled corners and may tend to make the slab move sideways.

## NEED FOR EXPANSION JOINTS

Expansion joints or building separations between adjacent buildings that are constructed at different times, have different ownership, or are otherwise not compatible with each other are clearly necessary and generally unavoidable. Within a single building, however, it is desirable to avoid expansion joints if possible. Whenever expansion joints have been routinely inserted in the past, modern analysis methods can often provide the engineer with sufficient information and confidence to eliminate the joints. Where a sufficiently detailed and sophisticated analysis is performed, the required forces at re-entrant corners, narrow and weak diaphragm areas, etc. can be determined with a fairly high degree of confidence, and appropriate resistance can be provided. Sometimes it is even possible and desirable to avoid joints between wings of a building that are to be constructed in two or more phases. Generally the agency having jurisdiction would require that the complete building, at each level of completion, meet the code applicable to the most recent stage of construction. In the case of significant changes in seismic codes, this could lead to a requirement to seismically retrofit the previously constructed phases of the building, or to introduce the previously avoided joint.

## ECONOMICS OF EXPANSION JOINTS

In major urban areas, the largest cost of expansion joints may well be the cost of the land (or lost building area) needed to accommodate the joint. For example, in Gurgaon, even in the current poor office economy, office buildings sell for more than Rs 12000 per square foot. If an owner wants to construct a 40 storey building on a site with a 100 ft. long side Adjacent to another building, and a 4 inch. Wide building separation (seismic joint) is needed, the lost square footage would be worth Rs  $12000 \times 100 \times 40 \times .34 = \text{Rs}16320000$ . For joints within a building, the cost is in the additional structure, the added cost of joint wall and floor covers, additional flashing and sealing, fire blankets, and piping and ductwork expansion devices.

## OBJECTIVE OF PRESENT STUDY

Expansion joints are generally not referred by architects because they involve high cost of construction and also require complicated detailing to achieve water tightness. Even from aesthetic point of view expansion joints are generally avoided but its structural purpose can be achieved by designing the structure for thermal stresses which are accounted.

The main objectives of this dissertation work are:-

- a. To know the displacement pattern in various types of frames.
- b. To analyse the drift pattern in various types of frames.
- c. To compare the effect of drift and displacement in different models prepared.
- d. To compare the variation of drift and displacement with storey height.
- e. To discuss the seismic response of structure and compare it with other frames of
- f. Different lengths (with and without expansion joint).

In this study time history method of analysis was used in commercial structural analysis software ETABS 2013.

## II. LITERATURE REVIEW

Earthquake induced structural pounding frequently causes damage to buildings particularly at the expansion joint between adjacent buildings because usually the expansion joint width is very small typically about 5cm. Collision avoidance cannot be achieved by seismic retrofitting. Experimental investigation was done to find an effective method

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for reducing severe damage due to pounding at expansion joint between narrowly separated buildings. This method involves inserting a shock absorbing material such as rubber into the expansion joint gap. Takabatake.H (2014).

The characteristics ( intensity, duration, etc. ) of seismic ground vibrations expected at any location depends upon the magnitude of earthquake, its depth of focus, distance from the epicentre, characteristics of the path through which the seismic waves travel, and the soil strata on which the structure stands. The random earthquake ground motions, which cause the structure to vibrate, can be resolved in any three mutually perpendicular directions. The predominant direction of ground vibration is usually horizontal. (G.G.Penelis 1997).

The earliest provisions for seismic resistance were the requirement to design for a lateral force equal to a proportion of the building weight (applied at each floor level). This approach was adopted in the appendix of the 1927 Uniform Building Code (UBC), which was used on the west coast of the USA. It later became clear that the dynamic properties of the structure affected the loads generated during an earthquake. In the Los Angeles County Building Code of 1943 a provision to vary the load based on the number of floor levels was adopted (based on research carried out at Caltech in collaboration with Stanford University and the U.S. Coast and Geodetic Survey, which started in 1937). The concept of "response spectra" was developed in the 1930s, but it wasn't until 1952 that a joint committee of the San Francisco Section of the ASCE and the Structural Engineers Association of Northern California (SEAONC) proposed using the building period (the inverse of the frequency) to determine lateral forces.

The University of California, Berkeley was an early base for computer-based seismic analysis of structures, led by Professor Ray Clough (who coined the term finite element). Students included Ed Wilson, who went on to write the program SAP in 1970, an early "Finite Element Analysis" program.

Earthquake engineering has developed a lot since the early days, and some of the more complex designs now use special earthquake protective elements either just in the foundation (base isolation) or distributed throughout the structure. Analysing these types of structures requires specialized explicit finite element computer code, which divides time into very small slices and models the actual physics, much like common video often have "physics engines". Very large and complex buildings can be modeled in this way. (Wikipedia 2013)

Nonlinear time history analysis is adopted when a high degree of accuracy is required in the analysis of structure. Incremental dynamic forces acting on the structure must be remain in equilibrium is the basic analysis requirement in this analysis. The characteristics of the displacement dependent lateral resisting forces within the structure define the basic difference between the linear and nonlinear time history analysis. Lateral resisting forces in the elastic systems are represented as a single valued function of the displacement whereas lateral resisting forces in inelastic systems are dependent on the prior history of the motion. To solve the differential equation a numerical integration method is used, results of which gives the time history of the response. The advantages of the nonlinear dynamic time-history analysis include the ability to describe nonlinear inelastic response, and to represent the time-history of the seismic response of the structure. (Wikipedia 2013)

## General

AS per IS 456, normally structures exceeding 45m length are designed with one or more expansion joints. However in view of large number of factors involved in deciding the location, spacing and nature of expansion joints, the provision of expansion joint in RCC structures shall be left to the discretion of the designer. Codal provisions indicate that expansion joints are desirable for spans beyond 45 m.

Code (IS 456-2000) clearly mentions about the thermal effects to be taken care of, **but doesn't** indicate the difference in structural behavior of building with expansion joint (length less than 45m) and without expansion joint (length more than 45m) under seismic load. To study structural behavior under seismic loading, a plan of a residential G+5 building with approximate covered area of 2700 sq. m having 6 expansion joints, dividing the building into six different towers was used and time history analysis (Elcentro earthquake data) was done using ETABS 2013 software.

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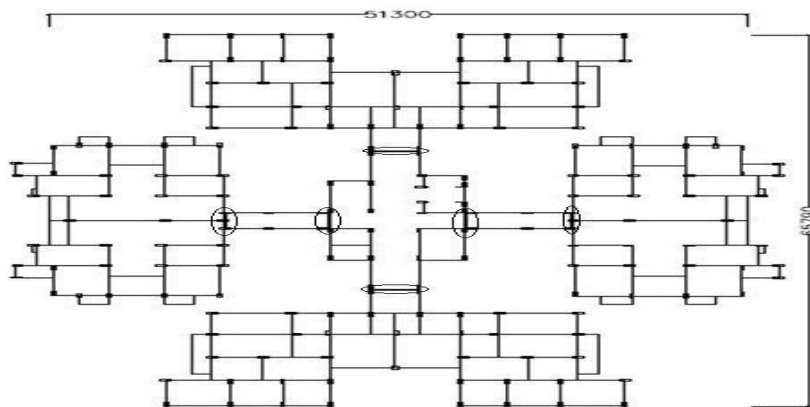
## Details of the Models

In order to study the seismic response of structure with and without expansion joints, a plan of G+5 existing residential building was used, which has 6 expansion joints that divides the building into seven towers as shown in fig.

The highlighted areas in the below fig. show the location of expansion joints which divides the building into seven towers.

- Four Residential Towers
- Two Lobby Towers
- One Staircase Tower

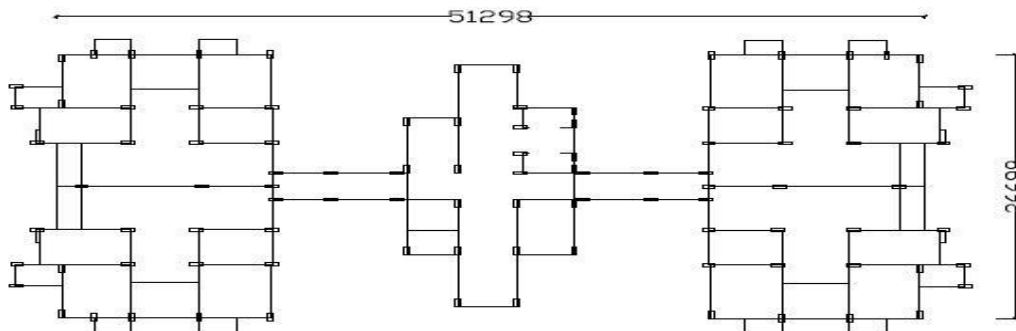
Column of size 300mm\*700mm, 700mm\*300mm and 500mm\*800mm, beam of size 300mm\*500mm as per plan layout were modeled, the height of the ground storey column and other typical storey is kept equal to 3.2m



PLAN OF RESIDENTIAL G+5 BUILDING WITH EXPANSION JOINTS

## ASSUMED MODELS (Without Expansion Joints)

The highlighted areas indicate the presence of expansion joint in fig 3.2 by removing those expansion joints two towers have been modeled and analyzed under the time history of Elcentro earthquake data. The length of the two assumed towers is 51.3 m and 67.8 m respectively (which is more than 45 m). While modeling the two towers all the factors such as column size, beam size, dead load, live load, rigid diaphragm etc. are kept same as per plan layout .The plan of two assumed models are shown below.



Assumed tower (a) with length 51.3 m aprox. (Without expansion joints)

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## III EXPERIMENTAL RESULTS

### Storey Drift of structures with expansion joint

The storey drift is the relative displacement between two consecutive floors. Sway of the models structures with expansion joint is studied i.e. (different length of buildings) obtained from linear time history analysis. Displacement profiles have insignificant difference in storey displacement as compared with length of building, similarly in the case of storey drift also the variation is insignificant as compared with buildings of different length at each floor.

Storey Level	Height of Storey in meter	7.8m L. Tower (mm)	25m S.Tower (mm)	26mR.Tower (mm)	33mR.Tower (mm)
Foundation	0	0	0	0	0
First Floor	3.2	21	19.8	18.8	21.54
Second Floor	6.4	29.7	29.94	28.896	32.11
Third Floor	9.6	28.8	25.49	26.8	24.231
Fourth Floor	12.8	24.7	21.91	19.677	18.88
Fifth Floor	16	15.8	8.368	12.672	12.48

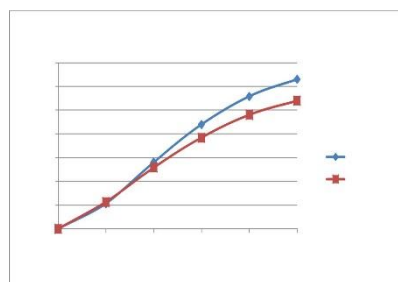
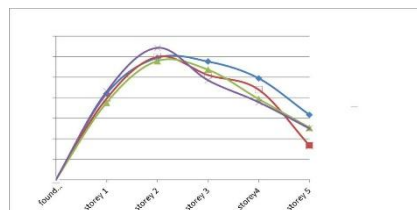
### STOREY NO.V/S DRIFT

### Deterministic Response of models without Expansion Joints

#### Storey Displacement

The displacement profiles in x and y direction are studied for models without expansion joints by plotting height of building v/s displacement.

### STOREY NO.V/S DRIFT



Comparative graph showing the sway of storeys

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Storey Level	Height of Storey in meter	51m A. Tower(a) (mm)	65m A.Tower(b) (mm)
Foundation	0	0	0
First Floor	3.2	21.2	22.496
Second Floor	6.4	56.1	51.584
Third Floor	9.6	88	76.768
Fourth Floor	12.8	111.6	96.064
Fifth Floor	16	126.1	107.904

## IV. CONCLUSIONS

1. Storey drift for the models with and without expansion joints under the seismic load was maximum at second storey however with increase in length of building, the variation in storey drift is insignificant. Similarly the variation in storey displacement is also insignificant with respect to length.
2. From the linear time history analysis it has been observed that for various models, the time period value decreases with the increase in length of the building.
3. It has been observed that seismic response of a building with span greater than 45m is nearly similar to that of building with span less than 45m but in accordance to codal provisions, thermal effects have to be included during the analysis for satisfactory result.
4. When the model is subjected to lateral load, mass of each floor acts independently resulting in each floor to drift with reference to adjacent floors. With the increase in the length of building, **the relative drift between adjacent floors isn't affected.**

## REFERENCES

- [1] Berkeley, Computers and Structures, Inc. 2005. CSI analysis reference manual. Computers and Structures, Inc., Calif
- [2] Berkeley, Computers and Structures, Inc. 2005. SAP2000 advanced [computer program]. Version 10.0.1. Computers and Structures, Inc., Calif.
- [3] Berkeley, Computers and Structures, Inc. 2005. Section Designer [computer program]. Version 10.0.0. Computers and Structures, Inc., Calif.
- [4] Berkeley, Computers and Structures, Inc. 2008. ETABS nonlinear [computer program]. Version 9.2.0. Computers and Structures, Inc., Calif.
- [5] Berkeley, ETABS 2013 Integrated software for structural analysis and design. Computers and structure .Inc, California.