BEHAVIOUR OF ASYMMETRIC BUILDING DURING EARTHQUAKE

A Project Submitted
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF TECHNOLOGY

In

Structural Engineering

By

Ratnesh Pathak

(University roll No. 1170444012)

Under the Guidance of

Mr. Shubhranshu Jaiswal
(Assistant Prof.)

BABU BANARASI DAS UNIVERSITY
LUCKNOW
2018-19

CERTIFICATE

This is to certify that the thesis entitled titled "**Behaviour of asymmetric building during earthquake**" by **Ratnesh Pathak** Under the guidance of Assistant Professor **Mr**. **Shubhranshu Jaiswal** to the Babu Banarasi Das University, Lucknow for the award of the degree of Master of Technology from Structural Engineering is a bonafide record of research work carried out by him under our supervision. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

Researcher's Guide

Mr. Shubhranshu Jaiswal
(Assistant Prof.)
Department of Structural Engineering
Babu banarasi das university
Lucknow

Date

DECLARATION

I hereby declare that, I am the sole author of this thesis. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Ratnesh pathak
(1170444012)
Department of Structural Engineering
Babu banarasi das university
Lucknow

ACKNOWLEDGEMENT

I would like to express my special appreciation and thanks to my researcher guide Assistant Professor **Mr. Shubhranshu Jaiswal**, you have been a tremendous mentor for me. I would like to thank you for encouraging my research. Your advice on both research as well as on my career have been valuable. I would also like to thank my all faculty member of the Civil Engineering of BABU BANARASI DAS UNIVERSITY, Lucknow **Mr. Mohammad Afaque Khan**, **Mr. Faheem Ahmed Khan**, **Mr. Bilal Siddiqui**, **Mr Shubhranshu Jaiswal** and also to the head of department (HOD) **Mr. Anupam Mehrotra**. I also want to thank you for letting my defense be an enjoyable moment, and for your brilliant comments and suggestions, thanks to all faculty member. A special thanks to my family member and also to my all friends. Words cannot express how grateful I am to my all faculty member of BBDU, Lucknow. Thank you for supporting me for everything, and especially I can't thank all of you enough for encouraging me throughout this experience. Finally I thank my God, my best Father, for letting me through all the difficulties

ABSTRACT

In this paper we study about the seismic analysis of the asymmetrical building, in which building have three different shape such as T, L and plus shape. At every re-entrant corner provided curved beam with slab. The main purpose of providing curve beam in every model to reduce the mainly torsion at corner because storey overturning moment is maximum at the base and if the torsion is also maximum at the base then maximum chances to produce the crack at the re-entrant corner of the building. There are six models in this paper and taking zone five for seismic analysis. All the analysis of the models are done with the help of the ETABS software by using two different IS Code such as IS CODE 1893 part1: 2016 for the earthquake resistant design of the structure and IS CODE 456:2000 for design and analysis of the reinforced concrete structure. The height of the every model is 27m and considering that frame is special moment resisting frame. The main purpose of this paper to study the variation of torsion of frame at corner, storey overturning moment, base shear, etc due to provide the curved beam and without curved beam.

Key words:- Time History Analysis, ETABS, Asymmetrical Building, L shape, T shape, Plus shape, Seismic Analysis.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND SYMBOL

CM	Centre of Mass
CS	Centre of Stiffness
R	Response factor
IS	Indian Standard
LL	Live Load
DL	Dead Load
V_B	Base shear
A_h	Design horizontal seismic coefficient for a structure
W	Seismic weight of building
Z	Zone factor
I	Importance factor
R	Response reduction factor
S_a/g	Average response acceleration coefficient

CHAPTER-1
INTRODUCTION

1.1General

Earthquake resistant design of reinforced concrete building is continuing area of research because structures have been prone to earthquake since the first structure was built. The utilization of space in urban cities has caused many changes in the structure of building we want more functionality in less space which makes building asymmetric. In the past the Seismic damage surveys analyzed and concluded that asymmetric building more prone to damage during earthquake hence the seismic behavior of an asymmetric structure has become important. Basic aspect of seismic design the mass of the building being designed controls seismic design in addition to the building stiffness, because earthquake induces inertia forces that are proportional to the building mass. Designing buildings to behave elastically during earthquakes without damage may render the project economically unviable. As a consequence, it may be necessary for the structure to undergo damage and thereby dissipate the energy input to it during the earthquake. Therefore, the traditional earthquake-resistant design philosophy requires that normal buildings should be able to resist.

(a) Minor (and frequent) shaking with no damage to structural and non-structural elements;

(b) Moderate shaking with minor damage to structural elements, and some damage to non- structural elements; and

(c) Severe (and infrequent) shaking with damage to structural elements, but with NO collapse (to save life and property inside/adjoining the building).

Therefore, buildings are designed only for a fraction (~8-14%) of the force that they would experience, if they were designed to remain elastic during the expected strong ground shaking and thereby permitting damage. But sufficient initial stiffness is required to be ensured to avoid structural damage under minor shaking. Thus, seismic design balances reduced cost and acceptable damage, to make the project viable. This careful balance is arrived based on extensive research and detailed post-earthquake damage assessment studies. A wealth of this information is translated into precise seismic design provisions.

In contrast, structural damage is not acceptable under design wind forces. For this reason, design against earthquake effects is called as earthquake-resistant designand not earthquake-proof design.

1.2 The four virtues of Earthquake Resistant Building

For a building to perform satisfactorily during earthquakes, it must meet the philosophy of earthquake-resistant.

1.2.1 Characteristics of Buildings

There are four aspects of buildings that architects and design engineers work with to create the earthquake-resistant design of a building, namely seismic structural conFigure uration, lateral stiffness, lateral strength and ductility, in addition to other aspects like form, aesthetics, functionality and comfort of building. Lateral stiffness, lateral strength and ductility of buildings can be ensured by strictly following most seismic design codes. But good seismic structural conFigure uration can be ensured by following coherent architectural features that result in good structural behavior. All buildings are vertical cantilevers projecting out from the earth's surface. Hence, when the earth shakes, these cantilevers experience whiplash effects, especially when the shaking is violent. Hence, special care is required to protect them from this jerky movement. Buildings intended to be earthquake-resistant have competing demands. Firstly, buildings become expensive, if designed not to sustain any damage during strong earthquake shaking. Secondly, they should be strong enough to not sustain any damage during weak earthquake shaking. Thirdly, they should be stiff enough to not swing too much, even during weak earthquakes. And, fourthly, they should not collapse during the expected strong earthquake shaking to be sustained by them even with significant structural damage. These competing demands are accommodated in buildings intended to be earthquake-resistant by incorporating four desirable characteristics in them. These characteristics, called the four virtues of earthquake-resistant buildings, are:

1. Good seismic conFigure uration, with no choices of architectural form of the building that is detrimental to good earthquake performance and that does not

introduce newer complexities in the building behavior than what the earthquake is already imposing;

2. At least a minimum lateral stiffness in each of its plan directions (uniformly distributed in both plan directions of the building), so that there is no discomfort to occupants of the building and no damage to contents of the building;
3. At least a minimum lateral strength in each of its plan directions (uniformly distributed in both plan directions of the building), to resist low intensity ground shaking with no damage, and not too strong to keep the cost of construction in check, along with a minimum vertical strength to be able to continue to support the gravity load and thereby prevent collapse under strong earthquake shaking; and
4. Good overall ductility in it to accommodate the imposed lateral deformation between the base and the roof of the building, along with the desired mechanism of behavior at ultimate stage.

Behavior of buildings during earthquakes depend critically on these four virtues. Even if any one of these is not ensured, the performance of the building is expected to be poor.

1.3 Regular and Irregular configuration of building

The component of the building, which resists the seismic forces, is known as lateral force resisting system (L.F.R.S). The L.F.R.S of the building may be of different types. The most common forms of these systems in a structure are special moment resisting frames, shear walls and frame-shear wall dual systems. The damage in a structure generally initiates at location of the structural weak planes present in the building systems. These weaknesses trigger further structural deterioration which leads to the structural collapse. These weaknesses often occur due to presence of the structural irregularities in stiffness, strength and mass in a building system. The structural irregularity can be broadly classified as plan and vertical irregularities. A structure can be classified as vertically irregular if it contains irregular distribution of mass, strength and stiffness along the building height. In reality, many existing buildings contain irregularity, and some of them have been designed initially to be irregular to fulfill different functions e.g. basements for commercial purposes created by eliminating central columns. Also, reduction of size of beams and columns in the upper stores to fulfill functional requirements and for other commercial purposes like storing heavy mechanical appliances etc. This difference in usage of a specific floor with respect to the adjacent floors results in irregular distributions of mass, stiffness and strength along the building height. In addition, many other buildings are accidentally rendered irregular due to variety of reasons like non- uniformity in construction practices and material used. The building can have irregular distributions of mass, strength and stiffness along plan also in such a case it can be that the building has a horizontal irregularity Different type of Irregularity of building presented in Figure 1.1

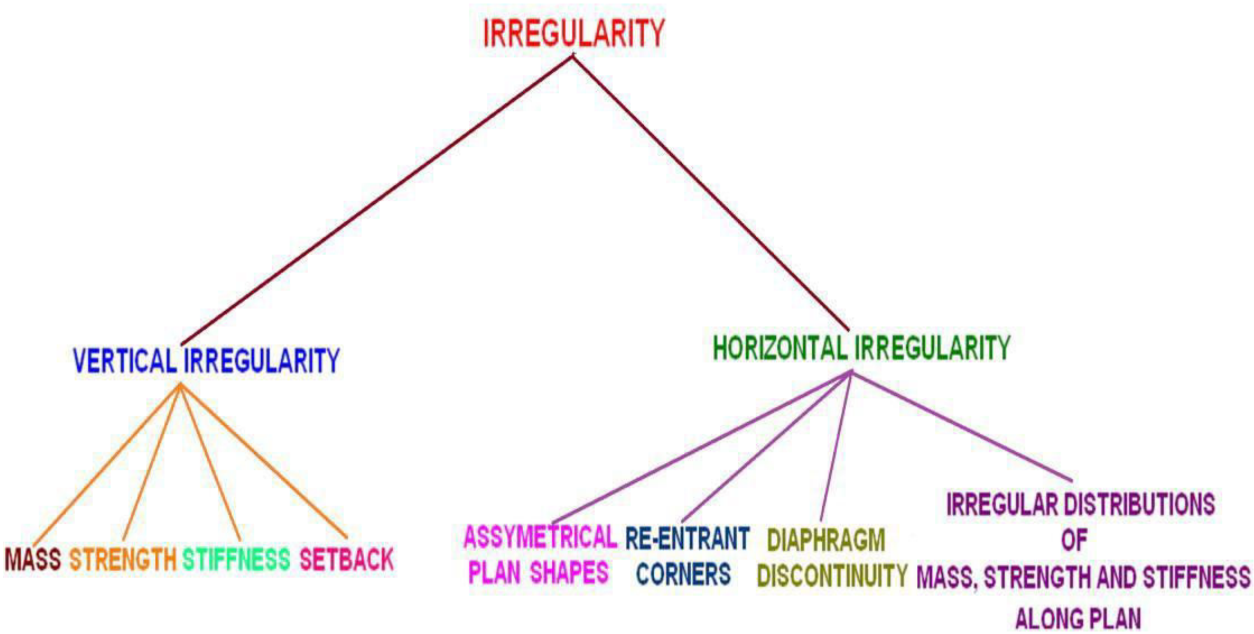

Figure 1.1: Irregularity

1.3.1 Definitions of Irregular Buildings – Plan Irregularities

(i) **Torsion Irregularity**: To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure

(ii) **Re-entrant Corners**: Plan conFigure urations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction.

(iii) **Diaphragm Discontinuity**: Diaphragms with abrupt discontinuities or variations in stiffness, including those having cut-out or open areas greater than 50 percent of the

gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next.

(iv) **Out-of-Plane Offsets**: Discontinuities in a lateral force resistance path, such as out- of-plane offsets of vertical elements

(v) **Non-parallel Systems:** The vertical elements resisting the lateral force are not parallel to or symmetric about the major orthogonal axes or the lateral force resisting elements.

1.3.2 Definition of Irregular Buildings – Vertical Irregularities

(i) Stiffness Irregularity – (a) Soft Storey: A soft storey is one in which the lateral stiffness is less than 70 percent of that in the story above or less than 80 percent of the than 80 percent of the average lateral stiffness of the three storeys above.

(b) Extreme Soft Storey: A extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above. For example, buildings on STILTS will fall under this category.

(ii) Mass *Irregularity*: Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200percent of that of its adjacent storeys. The irregularity need not be considered in case of roofs.

(iii) Vertical Geometric Irregularity: Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than150 percent of that in its adjacent storey.

(iv) In-Plane Discontinuity in Vertical Elements Resisting Lateral Force: A in-plane offset of the lateral force resisting elements greater than the length of those elements.

(v) strength irregularity (weak story): A weak story is a storey whose lateral strength is less than of the storey above.

(vi) floating or stub columns: such columns are likely to cause concentrated damage in the structure. This feature is undesirable and hence should be prohibited, if it is part or supporting the primary lateral load of resisting system.

Irregular modes of oscillation in two principal plan directions: stiffness of beam, columns, braces and structural wall determine the lateral stiffness of a building in each principal plan direction if

(a) the first three modes contribute less than 65 percent mass participation factor in each principal plan direction, and

(b) the fundamental lateral natural period of the building in two principal plan direction are closer to each other by 10 percent of larger value.

1.4 Re-entrant corner

The re-entrant, lack of continuity or "Inside" corner is the common characteristic of building conFigure urations that, in plan, as the shape of an L T.H +. or combination of shapes occurs due to lack of tensile capacity and force concentration. According to IS 1893 (Part 1: 2016. plan conFigure urations of a structure and its lateral resisting system contain re-entrant corner where both projections of the structure beyond the re-entrant corner are greater than 15% of its plan dimension in the given direction re-entrant corners of the buildings are subjected to two types of problems The first is resulting in a local stress concentration at the notch of the re-entrant corner and the second problem is torsion.

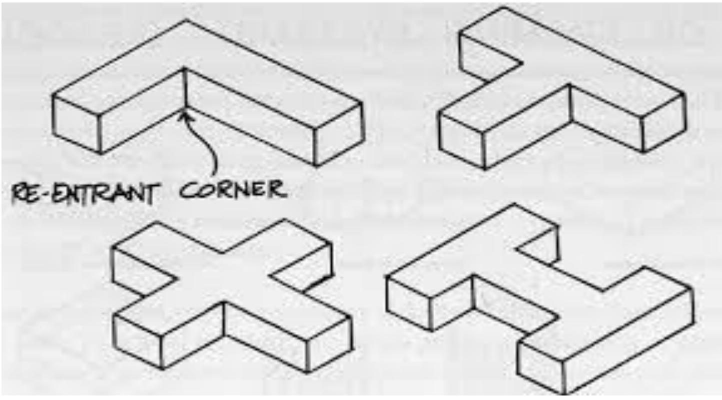

Figure 1.2 reentrant corner building shape

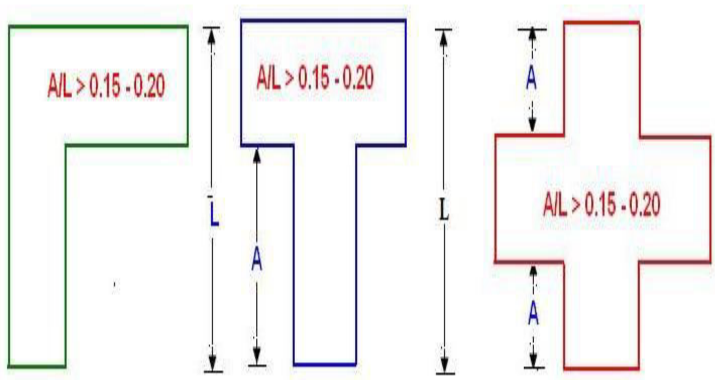

Figure 1.3 Re-entrant corner irregularity

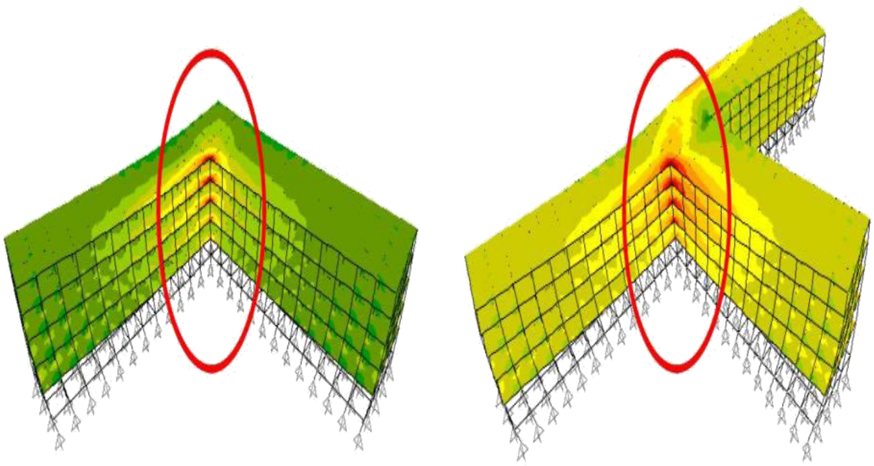

Figure 1.4: Stress concentration at re-entrant

CHAPTER-2
Literature survey

B K Raghuprasad, Vinay S, Amarnath.k (2.1) represented seismic analysis of buildings symmetric and asymmetric in plan. In this paper effort to check torsional effect in asymmetric plan building. They modeled the frame in two ways fist one is spring model and second one is column model in spring model column replaced by spring. By dynamic analysis of structure, they concluded that

- The natural frequencies of an asymmetric spring model are greater than those of symmetric spring model while the rotations about the vertical axis through the mass Centre of an asymmetric model are lesser than those of symmetric model.
- Maximum displacement of asymmetric column model due to an earthquake ground motion (eccentricity 17%) is greater than that of symmetric column model.
- Similarly, maximum displacement of an asymmetric spring model due to an earthquake is greater than that of symmetric spring model.
- The base shear of an asymmetric 11 story building (eccentricity 11%) is larger than that of a symmetrical 11 story building.

Chaithra S, Anue marry Mathew (2.2) presented paper on "Behavioral analysis of asymmetric building with solid coupled and shear wall with staggered openings". In this they modeled 3 building in seismic zone V the number of storey height was 10, 20, 40 and floor height of each storey is taken as 3m, varying depth of coupling beam and staggered opening shear walls. The first building analyzed without shear wall and second one analyzed with shear wall the building modeled and analyzed in ETABS software. They concluded that

- A large and extensive study conducted with regard to shear wall and their modification revealed findings which are really useful with regard to future research in the field of study. Based on all those experimental and analytical studies conducted the most appropriate location was at the outer edges of the building parallel to the X and Y direction. In the present project shear wall is provided at the outer edge

- Buildings with shear walls with regular openings, a brittle failure is observed whereas in case of buildings with shear walls with staggered openings, a ductile failure was analyzed from studies.

- The maximum displacement, time period of shear wall with staggered and coupled shear walls reveals their superiority over solid shear walls.
- Base shear is comparatively more in case of asymmetric buildings compared to symmetric buildings.
- The main conclusion of the study is that solid shear wall are the most stable forms of shear walls, if functional flexibility needs to be provided it shall be in the form of coupled shear walls or by the provision of staggered openings.

Sharath Irappa Kammar, Tejas D. Doshi (2.3) presented "Nonlinear static analysis of asymmetric building with and without shear wall". In this paper effort is made to study the behavior of structure with re-entrant corners under gravity and seismic loading. They modeled T shape building with and without shear wall in SAP2000 commercial software and also analyzed in this and concluded that

- The base shear of the building increase with the addition of the shear wall as the load resisting capacity increases.

- The addition of shear wall significantly reduces the displacement in the structures when compared with the structures without shear wall.

- The performance point of the models without shear wall will have base shear less compared to model with shear wall as the shear wall resists the earthquake forces to greater extent.

- From results, it is observed that the buildings with re-entrant corners are more prone to earthquake damage causing Torsional effect.

M.D. Bensalah, M. Bensaibi (2.4) presented paper on "assessment of the torsion Effect in asymmetric Building under seismic Load". The main objective of the paper is to estimate the influence of torsion effects induced on the behavior of an asymmetrical structure. The dynamic analysis is done with finite element software GEFDYN by making asymmetrical and symmetrical modeled. They concluded that

- This work demonstrates that the torsional response in structures subjected to earthquake may be influenced by many parameters. Some of these effects as the ultimate top displacement, ductility, reduction factor and the dynamic eccentricity are presented.
- In terms of capacity the lateral yielding strength of the asymmetrical structure is higher than the one of the symmetrical structures in both directions.

- The ductility increases with increasing input motion (Arias intensity) and decrease with Increasing predominant period with significant variation in asymmetrical structure than those Symmetrical structures.

- The reduction factor decreases when the dominant period of the earthquake increases. Unlike the reduction factor increase with decreasing input motions.
- The normalized eccentricity increases when Arias intensity is low on the elastic and inelastic domain and decrease when it is high. To generalize the obtained results, and study the existence of correlations between the structural characteristics and the input motion parameters, the parametric study has to be pursued for other cases such as multistory models with bi-directionality of input motions.

Desai RM, Khurd V.G, Patil SP, Bavane N.U (2.5) presented paper on" Behavior of symmetric and asymmetric structure in high seismic zone". In this paper they modeled three building G+3, G+6 and G+9 and effort is made to study the effect of eccentricity between Centre of mass and Centre of rigidity. By sap 2000 commercial software they analyzed as low rise midrise and high-rise building, they concluded that

- Performance of Asymmetrical building is better than Symmetrical building for given loading and soil condition.
- The column sizes behavior changes differently for Asymmetrical and

Symmetrical structure, as height of building increases.

- Structural parameters such as storey drift, lateral displacement, time period is higher into Asymmetrical structure.
- Base shear of Symmetrical structure is more as compare to Asymmetrical structure. • Torsional moment in asymmetrical structure is more than symmetrical structure.

Bindunathi, K.Rajasekhar (2.6) Presented paper on "comparison of percentage of steel quantities and cost of asymmetric commercial building under gravity loads and seismic loads". In this paper asymmetric commercial building modeled in E-tabs software. As per IS 456:2000 gravity loads and live load estimated. Seismic analysis of the structures is carried out on the basis of lateral force assumed to act along with the gravity loads. Building is type of G+4 and main objective of analysis is to study the different forces like moments, Shear forces and axial forces acting on building. They concluded that

- The variation of percentage of steel of seismic loading when compared to gravity loading is 21.93%
- The variation of estimated cost for those structural members analyzed and designed under seismic loading is 23.99% greater than gravity loaded building.
- Hence it is concluded that with a variation of around 25 % seismic design can be included in the design office.

Shreyasvi C, B. Shivakumaraswamy (2.7) In the present study, an attempt has been made to compare an irregular building consisting of re-entrant corner with a regular building of rectangular conFigure uration. Mainly the difference in their response to ground motion was studied and also the response of the re-entrant building located in different seismic zones was compared and the conclusion about various aspects has been listed below.

The ground acceleration to which the structure is subjected to is higher in zone V when compared to zone II. The peak acceleration increases from zone II to zone V.

- The displacement undergone by the joint with reentrant of 42.85% is highest when compared to other two joints. Also, the joint displacement is highest in zone .

- The drifts and maximum storey displacement undergone by a re – entrant building is highest when located in zone V and least in zone II.
- As re-entrant buildings have lesser time periods; they are more susceptible to ground motions and the probability of undergoing damage due to high frequency ground motions is high.
- The columns located near the re-entrant corners experience more seismic loads as compared to other interior columns. Hence, they require higher ductile detailing when compared to other columns.
- Also, longer the cantilever projection of the building from the re-entrant corner greater the force experienced by the column located near to it.

Neha P. Modakwar, Sangita S. Meshram, Dinesh W. Gawatre (2.8) presented paper on "Seismic Analysis of Structures with Irregularities. In this paper they study behavior of structure with re-entrant corner as whole as well as in parts it was through initially of choosing a realistic structure wherein opening and staircases. they concluded that

- The Re-entrant corner columns are needed to be stiffened for shear force in the horizontal direction perpendicular to it as significant variation is seen in these forces From the torsion point of view the re-entrant corner columns must be strengthen at lower floor levels and top two floor levels and from the analysis it is observed that behavior of torsion is same for all zones.
- Equation generated from the graph shall be used for calculating values of shear forces, moments and displacements in various zones. Effect of torsion is much more when diaphragms at some level are removed, so in re-entrant corner building it is better to avoid irregularity in diaphragm.

Vaishnavi Vishnu Battul1, Mithun Sawant, Tejashri Gulve, Rohit Deshmukh (2.9) presented paper on "Study of Seismic Effect on Re-entrant Corner Column" in this paper five storied residential building located in zone V area. The soil is hard. For comparison, a regular building is considered, by pushover analysis they concluded that

- Irregularity in plan is unavoidable. It is because of many reasons like requirement of client, functional requirements, etc. Due care is needed while designing such structures. It is observed from above study that for re-entrant corner columns need more attention than the other columns. These columns should be designed properly
- After proper modifications the bending moment capacity of re-entrant corner column is increased by 1.5 and twice in case of IS456 and IS13920 respectively.Base Shear for regular Structures is more than that of irregular structures.
- Base shear for modified structures is more than the original structures.
- Irregularity level is almost about 25% for both the irregular structures.

Divyashree M, Gopi Siddappa (2.10) presented paper on "Seismic Behavior of RC Buildings with Re-entrant Corners and Strengthening". in this paper a typical 4-storey building of regular and irregular (with re-entrant corner) have been chosen for the comparison of their seismic performance in order to evaluate the retrofitting strategies, two type of retrofitting strategies namely, use of shear walls and bracings are considered by pushover analysis they concluded that

- Results of both Pushover and response spectrum analysis confirmed the poor performance of frames with re-entrant corners. In the present study, building with re- entrant corners experienced about 12% more lateral drift and 22% reduction in base shear capacity compared to regular building. Also, results have confirmed their susceptibility to stress concentration at notch and torsion due to asymmetry.

- Buildings retrofitted with shear wall and bracing at notches of all storey (model S2 & B2) showed an improvement in base shear carrying capacity of 75% and 110% respectively while those retrofitted at ground level only (model S1 & B1) showed an improvement in base shear carrying capacity of 31% and 22% respectively.

- Response spectrum analysis have shown that retrofitted models S2 and B2 showed a reduction in maximum storey drifts in X-direction by 17% and 29% respectively.

`

CHAPTER-3

Methodology

3.1 codal provision for asymmetric building

The basic approach of design codes is application of linear static or dynamic load methods for design based on Earthquake Loading. Some of the codal provisions are studied in the following. As per [IS 1893 (Part 1) a building said to have re-entrant corner in any plan direction when structural configuration in plan has projection size greater than 15% of its overall plan dimension in that direction. The Static Eccentricity (e) is defined in the design codes as the distance between the Center of Mass (CM) and Center of Rigidity (CR) of the structure. The Center of Rigidity is defined as “The point through which the resultant of the restoring forces of a system acts.”. The Center of Mass is defined as “The point through which the resultant of the masses of a system acts. This point corresponds to the center of gravity of masses of system.” The Design Eccentricities (edi, esi) are obtained based on the values of the static eccentricity after accounting for the dynamic amplification of torsion and allowance for accidental torsion induced by rotational component of ground motion. Most design eccentricities are based on the formula

$$edi = \alpha e + \beta b$$

$$esi = \gamma e - \beta b:$$

Seismic force depends on the seismic hazard at the site of the building represented by the Seismic Zone Factor Z. Also, in keeping with the philosophy of increasing design forces to increase the elastic range of the building and thereby reduce the damage in it, codes tend to adopt the Importance Factor I for effecting such decisions (Figure 1.12). Further, the net shaking of a building is a combined effect of the energy carried by the earthquake at different frequencies and the natural periods of the building. Codes reflect this by the introduction of a Structural Flexibility Factor Sa/g.As per the Indian Seismic Code IS:1893 (Part 1) - 2016, Design Base Shear V_B is given by

$V_B = A_h W$

$A_h = (ZI/2R) * (Sa/g)$

where Z is the Seismic Zone Factor, I the Importance Factor, R the Response Reduction Factor and and Sa/g the Design Acceleration Spectrum Value.

Seismic Zone	**II**	**III**	**IV**	**V**
Seismic Intensity	low	moderate	severe	Very severe
Zone Factor, Z	0.10	0.16	0.24	0.36

Table 3.1 : Zone Factor, Z [IS 1893 (Part 1): 2016]

I = Importance Factor

Value of importance factor depends upon the functional use of the structures, characterized by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance (as given in Table – 3.2).

Building	**Importance Factor I**
Normal building	1.5
Residential building	1.2
All other building	1.0

Table 3.2: Importance Factor, I [IS 1893 (Part 1): 2016]

Lateral Load Resisting System	R
Building Frame Systems	
Ordinary RC moment resisting frame (OMRF)	3.0
Special RC moment-resisting frame (SMRF)	5.0
Steel frame with	4.0
(a) Concentric braces	
(b) Eccentric braces	5.0
Steel moment resisting frame designed as per SP 6 (6)	5.0
Buildings with Shear Walls	
Ordinary reinforced concrete shear walls	3.0
Ductile shear walls	4.0
Buildings with Dual Systems	
Ordinary shear wall with OMRF	3.0

Table 3.3 : Response reduction factor Factor, R [IS 1893 (Part 1): 2016

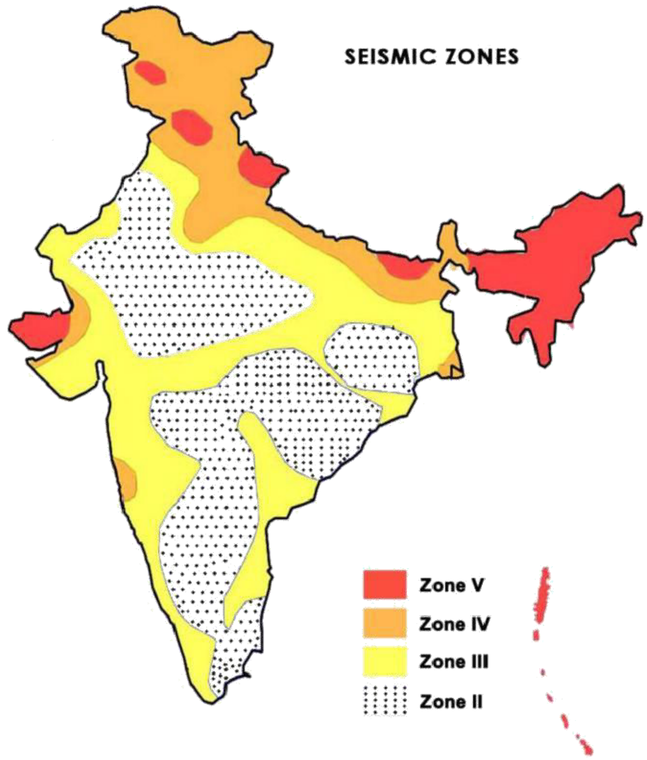

Figure 3.1: Sketch of Seismic Zone Map of India: sketch based on the seismic zone of India map given in IS:1893 (Part 1) - 2016

3.2 Software

ETABS is extended three-Dimensional analysis of building system. ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object- based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

From the start of design conception through the production of schematic drawings, ETABS integrates every aspect of the engineering design process. Creation of models has never been easier - intuitive drawing commands allow for the rapid generation of floor and elevation framing. CAD drawings can be converted directly into ETABS models or used as templates onto which ETABS objects may be overlaid. The state-of-the-art SAP Fire 64-bit solver allows extremely large and complex models to be rapidly analyzed, and supports nonlinear modeling techniques such as construction sequencing and time effects (e.g., creep and shrinkage).

Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls are included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures.

ETABS provides an unequaled suite of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the tallest commercial high-rises. Immensely capable, yet easy-to-use, has been the hallmark of ETABS since its introduction decades ago, and this latest release continues that tradition by providing engineers with the technologically-advanced, yet intuitive, software they require to be their most productive.

3.3 Equivalent lateral force method

Building and their element should be design and constructed to resist the effect of design lateral force. The design lateral force is first computed for the building as whole and then distributed to various floor levels.

This method of finding design lateral forces also known as the static method or equivalent static method or the seismic coefficient method. This procedure does not require dynamic analysis, however, it accounts for the dynamics of building in an appropriate manner. The static method is the simplest one it requires less computational effort and is based on formulae given in the code of practice. First the design base shear is computed for the whole building, and it is then distributed along the height of building. The lateral force at each floor level thus obtained are distributed to individual lateral load resisting elements.

$$Q_i = V_B \frac{W_i}{\sum_{i=1}^{n} W_i} \frac{h_i^2}{h_i^2}$$

Where Q_i is the design lateral fore at floor i, W_i is the seismic weight of the floor i, h_i is the height of floor i measured from the base, and n is the number of storeys in the building, i.e., the number of levels at which the mass are located.

3.4 Dynamic analysis method

Dynamic analysis may be performed either by response spectrum method or by the time-history method. In the response spectrum method,

3.4.1 Response spectrum method

The peak response of a structure during an earthquake is obtained directly from the earthquake response (or design) spectrum. It is the representation of maximum responses of a spectrum of idealized single degree freedom system of different natural periods but having same damping, under the action of the same earthquake ground motion at their bases. Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure. Response-spectrum analysis provides insight into dynamic behavior by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. It is practical to envelope response spectra such that a smooth curve represents the peak response for each realization of structural period. Response-spectrum analysis is useful for design decision-making because it relates structural type-selection to dynamic performance. Structures of shorter period experience greater acceleration, whereas those of longer period experience greater displacement.

Structural performance objectives should be taken into account during preliminary design and response-spectrum analysis.

3.4.2 Time History Analysis

The time history analysis technique represents the most sophisticated method of dynamic analysis for building. In this method the mathematical model of building is subjected to accelerations from earthquake records that present the expected earthquake at the base of structure. The method consist of step by step direct integration over a time interval. The time history method is applicable for both elastic and inelastic analyses. In elastic analyses the stiffness characteristics of the structure is assumed to be constant for the whole duration of earthquake. In the inelastic analyses however, the stiffness is assumed to be constant through incremental time only. In this method the earthquake motions are applied directly to the base of model of a given structure. Instantaneous stresses throughout the structure are calculated at small interval of time for the duration of Earthquake or a significant portion of it.

The model is analyzed by Time History Method. The data of the time history is taken from the time history function which name is “ALTADENA-1”.

3.5 Modelling Detailing

In this we prepared six model in which model shape is L, T and Plus (+) and providing the curved beam at every re-entrant corner to increase the value storey stiffness, to reduce the mode of time period as well as effect of the torsion at the frame member. Taking bay to bay distance 3m and storey height is also 3m. Details data are provided in the given table

S. No	Parameter	Value
1.	Concrete	M25
2.	Rebar	Mild250, HYSD415

3.	Beam	450mmX350mm
4.	Column	500mmX350mm
5.	Slab	160mm
6.	Angle of Curved Beam	3 degree
7.	Height of Building	27m (9 storey)

Table-3.4: Section Parameter

3.5.1. Load on Model

According to the IS CODE 1893 part- 2016, for earthquake we consider some data such as importance factor (I) =1.5, Response reduction factor (R)=5, Zone=0.36 and soil type is II type.

S. No	Load Name	Values
1.	Dead Load	Auto defined
2.	Live load at slab	3KN/m2
3.	Roof load	2KN/m2
4.	Live load at curved slab	1KN/m2
5.	Parapet wall	7.5KN/m
6.	EX	IS 1893 Part 1 2016
7.	EY	IS 1893 Part 1 2016
8.	Wall load	14KN/m

Table 3.5: Load on Model

3.6 Different view of model

3.6.1 L shape without curved beam at the re-entrant corner (M1)

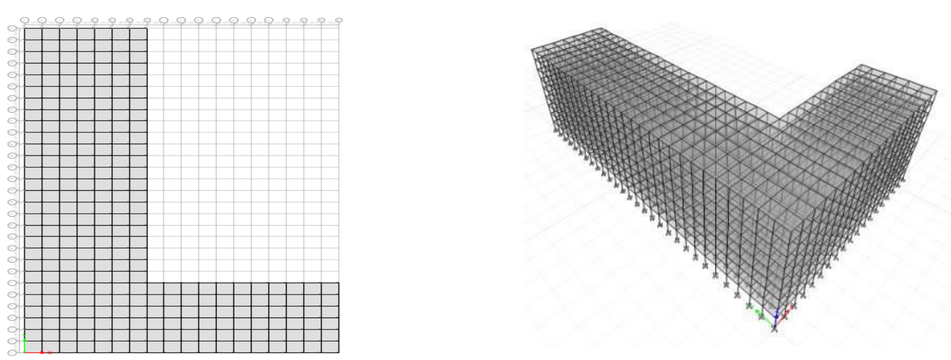

Figure 3.2: Plan and 3D View of Model 1

3.6.2 L shape without curved beam at the re-entrant corner (M2)

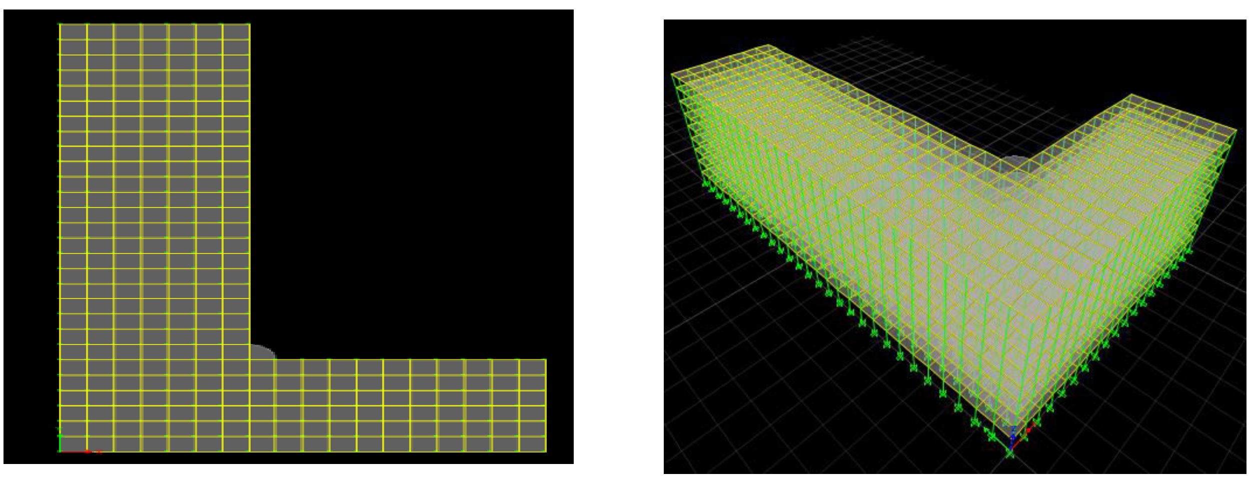

Figure 3.3: Plan and 3D view of Model2

3.6.3 T shape without curved beam at re-entrant corner (M3)

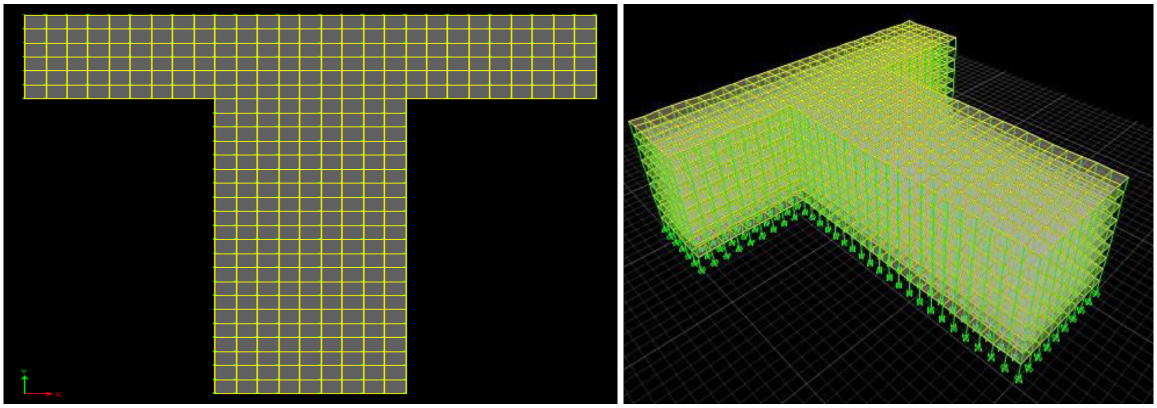

Figure 3.4: Plan and 3D view of Model3

3.6.4 T shape with curved beam at re-entrant corner (M4)

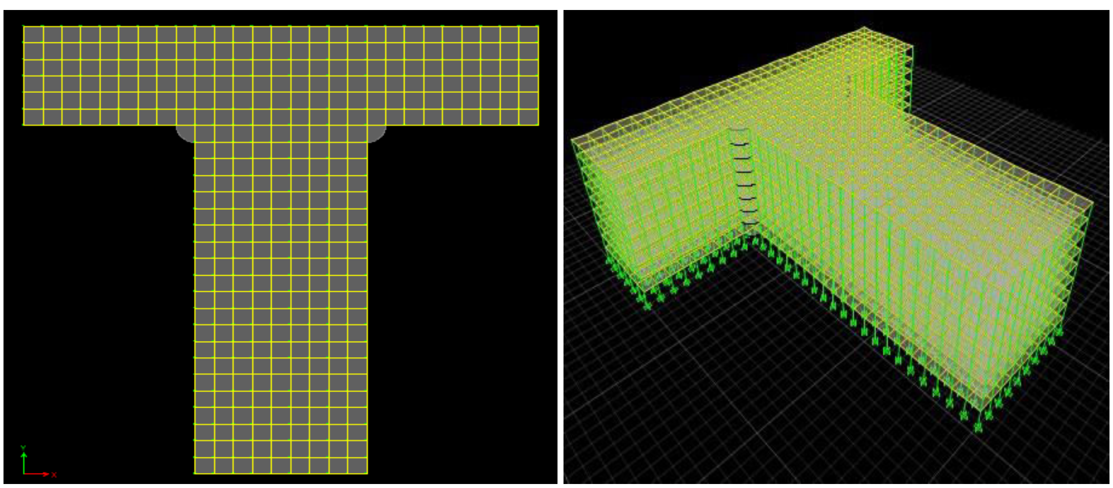

Figure 3.5: Plan and 3D view of Model4

3.6.5 Plus (+) shape without curved beam at re-entrant corner (M5)

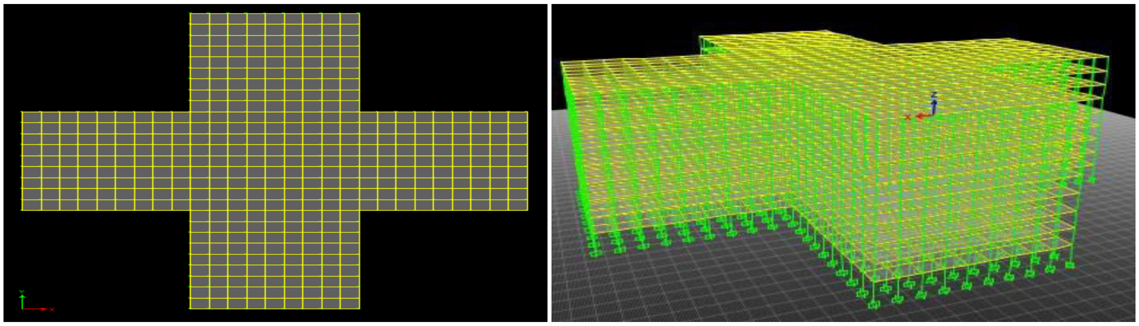

Figure 3.6: Plan and 3D view of Model5

3.6.6. Plus (+) shape with curved beam at re-entrant corner (M6)

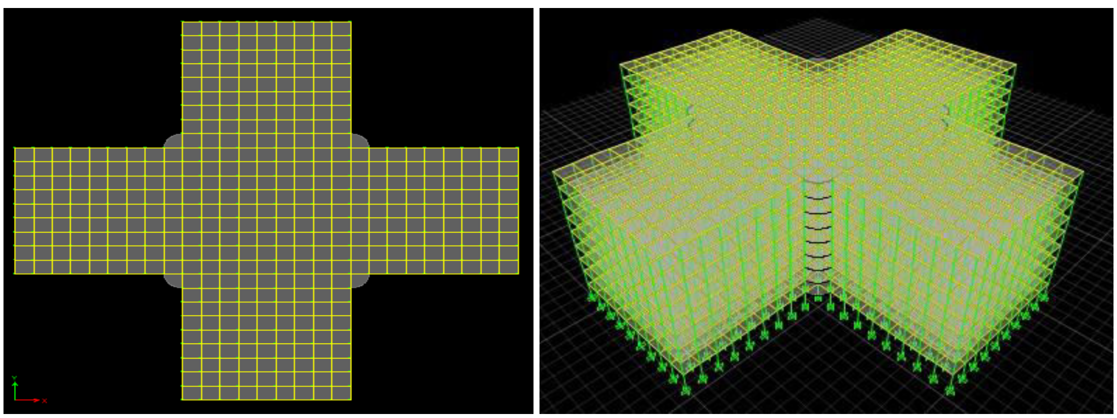

Figure 3.7: Plan and 3D view of Model6

3.7 Load Combination

According to the IS CODE 1893 part1 2016, we use the mainly 13 load combination which is given below in table: -

A.1.5(DL+LL)	**B.**1.2(DL+LL+EX)	**C.**1.2(DL+LL-EX)
D.1.2(DL+LL+EY)	**E.**1.2(DL+LL-EY)	**F.**1.5(DL+EX)
G.1.5(DL-EX)	**H.**1.5(DL+EY)	**I.**1.5(DL-EY)
J.0.9DL+1.5EX	**K.**0.9DL-1.5EX	**L.**0.9DL+1.5EY
M.0.9DL-1.5EY		

Table-3.6: Load Combination

CHAPTER-4
Result and Discussion

4.1 General

In this CHAPTER we will study all the analysis of the models which we analyzed in the Etabs software. This chapter mainly includes the base shear, maximum storey displacement, story stiffness, modal period and frequency with graph,torsion values at reentrant corner, response spectrum curve of every model.

4.2 Base Shear

Base shear is an estimate of the maximum expected lateral forces on the base of the structure due to seismic activity

4.2.1 Base Shear of Model-1(L shape without curved beam) due to EX and EY

Storey	Elevation (m)	X Direction (KN)	Y Direction (KN)
Story9	27	4534.3237	3762.9115
Story8	24	4371.6097	3627.8795
Story7	21	3347.0137	2777.5953
Story6	18	2459.0304	2040.6822
Story5	15	1707.66	1417.1404
Story4	12	1092.9024	906.9699
Story3	9	614.7576	510.1706
Story2	6	273.2256	226.7425
Story1	3	68.3064	56.6856
Base	0	0	0

Table-4.1: Base Shear of Model-1 due EX and EY

4.2.2 Base Shear of Model-2(L shape with curved beam) due to EX and EY

Story	Elevation (m)	X Direction (KN)	Y Direction (KN)
Story9	27	4538.6253	3766.869
Story8	24	4374.3844	3630.5559
Story7	21	3349.138	2779.6444
Story6	18	2460.5912	2042.1877
Story5	15	1708.7439	1418.1859
Story4	12	1093.5961	907.639
Story3	9	615.1478	510.5469
Story2	6	273.399	226.9097
Story1	3	68.3498	56.7274
Base	0	0	0

Table-4.2: Base Shear of Model-3 due EX and EY

4.2.3 Base Shear of Model-3(Tshape without curved beam)due to EX & EY

Storey	Elevation (m)	X Direction (KN)	Y Direction (KN)
Story9	27	6065.5206	4968.543
Story8	24	5843.0879	4786.339
Story7	21	4473.6142	3664.541
Story6	18	3286.737	2692.316
Story5	15	2282.4562	1869.664
Story4	12	1460.772	1196.585
Story3	9	821.6842	673.0789
Story2	6	365.193	299.1462
Story1	3	91.2982	74.7865
Base	0	0	0

Table-4.3: Base Shear of Model-3due to EX and EY

4.2.4. Base Shear of Model-4 (T shape with curved beam)

Storey	Elevation (m)	X Direction (KN)	Y Direction (KN)
Story9	27	822.503	4976.3386
Story8	24	365.5569	4791.5995
Story7	21	91.3892	3668.5684
Story6	18	0	2695.2747
Story5	15	6074.4134	1871.7186
Story4	12	5848.91	1197.8999
Story3	9	4478.0717	673.8187
Story2	6	3290.0118	299.475
Story1	3	2284.7305	74.8687
Base	0	1462.2275	0

Table-4.4: Base Shear of Model-4due to EX and EY

4.2.5 Base Shear of Model-5 (plus shape without curved beam)

Storey	Elevation (m)	X Direction (KN)	Y Direction (KN)
Story9	27	6931.8655	5689.7084
Story8	24	6672.4905	5476.8121
Story7	21	5108.6255	4193.1843
Story6	18	3753.2759	3080.7068
Story5	15	2606.4416	2139.3797
Story4	12	1668.1226	1369.203
Story3	9	938.319	770.1767
Story2	6	417.0307	342.3008
Story1	3	104.2577	85.5752

Base	0	0	0

Table-4.5: Base Shear of Model-5due to EX and EY

4.2.6 Base Shear of Model-6 (plus shape with curved beam)

Storey	Elevation (m)	X Direction (KN)	Y Direction (KN)
Story9	27	6951.3116	5705.3303
Story8	24	6685.7289	5487.3517
Story7	21	5118.7612	4201.2537
Story6	18	3760.7225	3086.6353
Story5	15	2611.6128	2143.4968
Story4	12	1671.4322	1371.8379
Story3	9	940.1806	771.6588
Story2	6	417.8581	342.9595
Story1	3	104.4645	85.7399
Base	0	0	0

Table-4.6: Base Shear of Model-6due to EX and EY

4.3 Modal Time Period

According to IS CODE 1893 part1:2016, the modal time period is defined as the modal natural period of mode k is the time period of vibration in mode k. where k= 1, 2…. defined mode.

4.3.1 Modal Time Period for L shape with and without Curved Beam (M1, M2)

Mode	Time Period of L shape without curved beam	Time Period of L shape with curved beam
1	0.889	0.889
2	0.763	0.763
3	0.738	0.738
4	0.296	0.296
5	0.289	0.278
6	0.254	0.253
7	0.244	0.244
8	0.202	0.198
9	0.176	0.176
10	0.154	0.153
11	0.142	0.142
12	0.136	0.135

Table-4.7: Time Period for Model1 and Model2

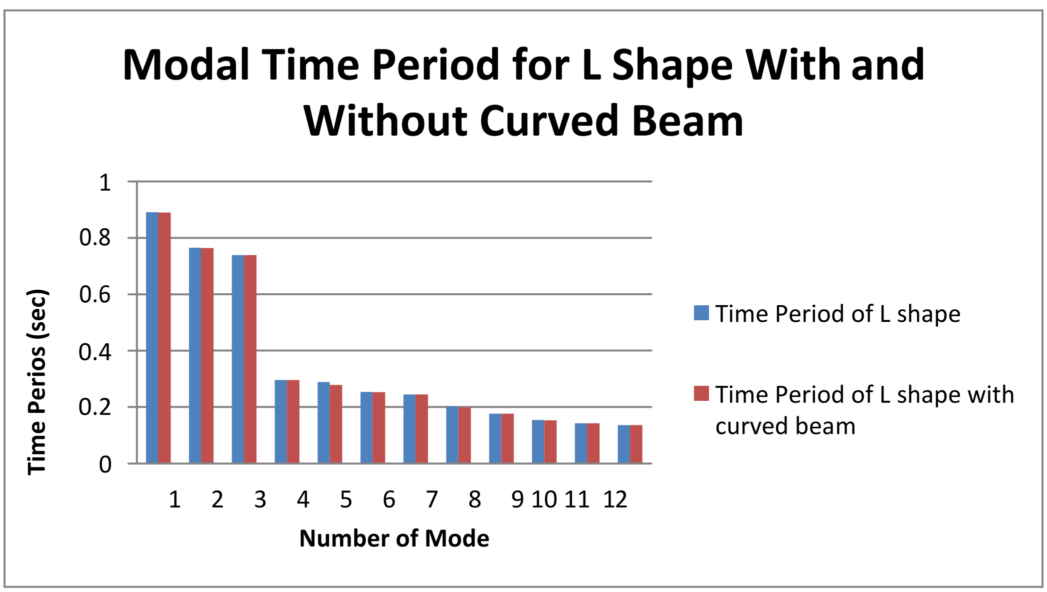

Figure .-4.1: Model time period of L shape model M1 and M2

4.3.2 Modal Time Period for T shape with and without Curved Beam (M3, M4)

Mode	Time Period of T shape	Time Period of T shape with curved beam
1	0.896	0.897
2	0.773	0.773
3	0.734	0.735
4	0.298	0.298
5	0.257	0.257
6	0.248	0.243
7	0.242	0.237
8	0.186	0.181
9	0.177	0.177
10	0.171	0.161
11	0.155	0.154
12	0.148	0.142

Table-4.8: Time Period for Model5 and Model6

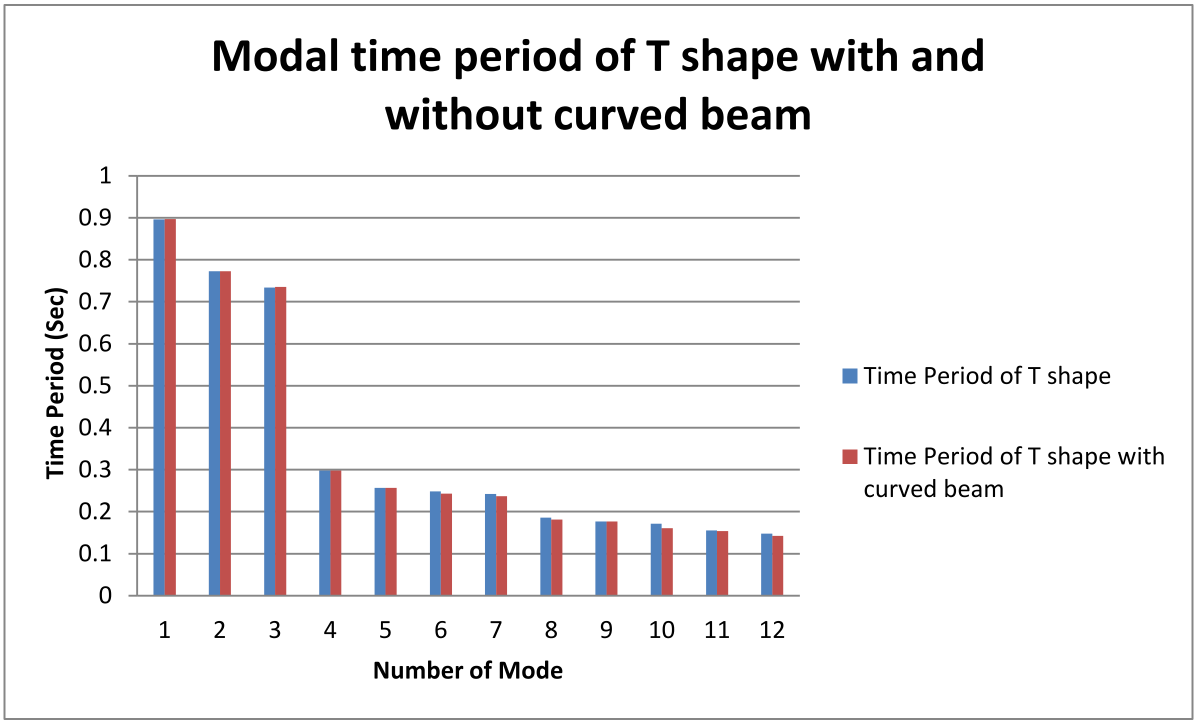

Figure .-4.2: Model time period of T shape model M3 and M4

4.3.3 Modal Time Period for Plus (+) shape with and without Curved Beam (M5, M6)

Mode	Time Period of Plus shape	Time Period of Plus shape with curved beam
1	0.898	0.9
2	0.794	0.795
3	0.737	0.739
4	0.299	0.299
5	0.263	0.263
6	0.243	0.244
7	0.178	0.178
8	0.156	0.156
9	0.143	0.143
10	0.129	0.127
11	0.127	0.118
12	0.122	0.114

Table-4.9: Time Period for Model5 and Model6

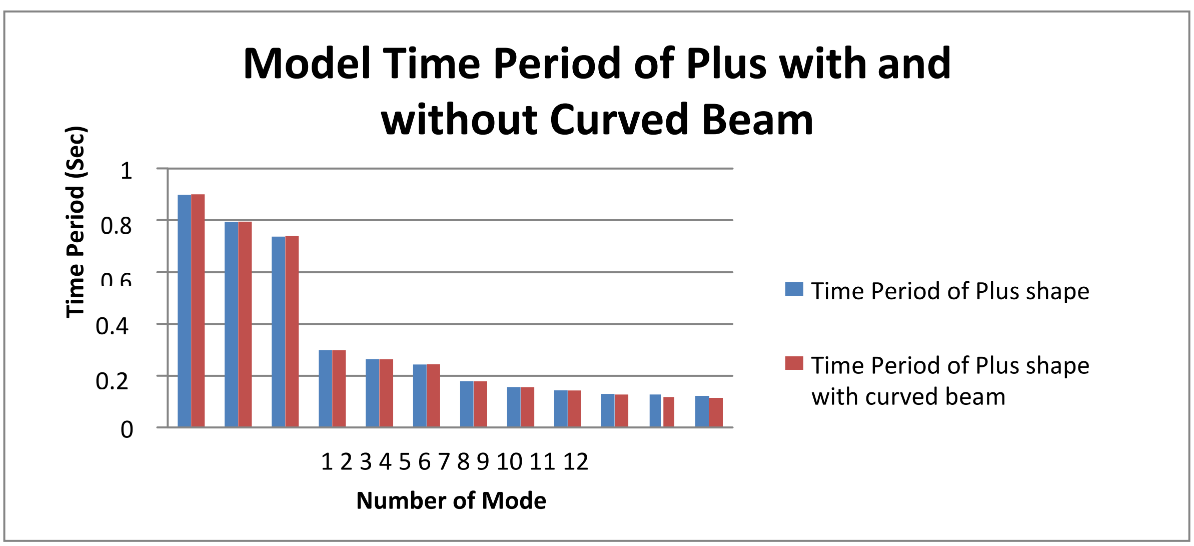

Figure 4.3: Model time period of T shape model M5 and M6

4.4 Response Spectrum Curve

A response spectrum is a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency that are forced into motion by the same base vibration or shock. ... For transient input (such as seismic ground motion), the peak response is reported.

4.4.1 Response Spectrum Curve for Spectral Acceleration vs. Time for L Shape Without Curved beam (M1)

The Chart of the response spectrum curve of the model-1 at story 9 due to applied time history data is given below: -

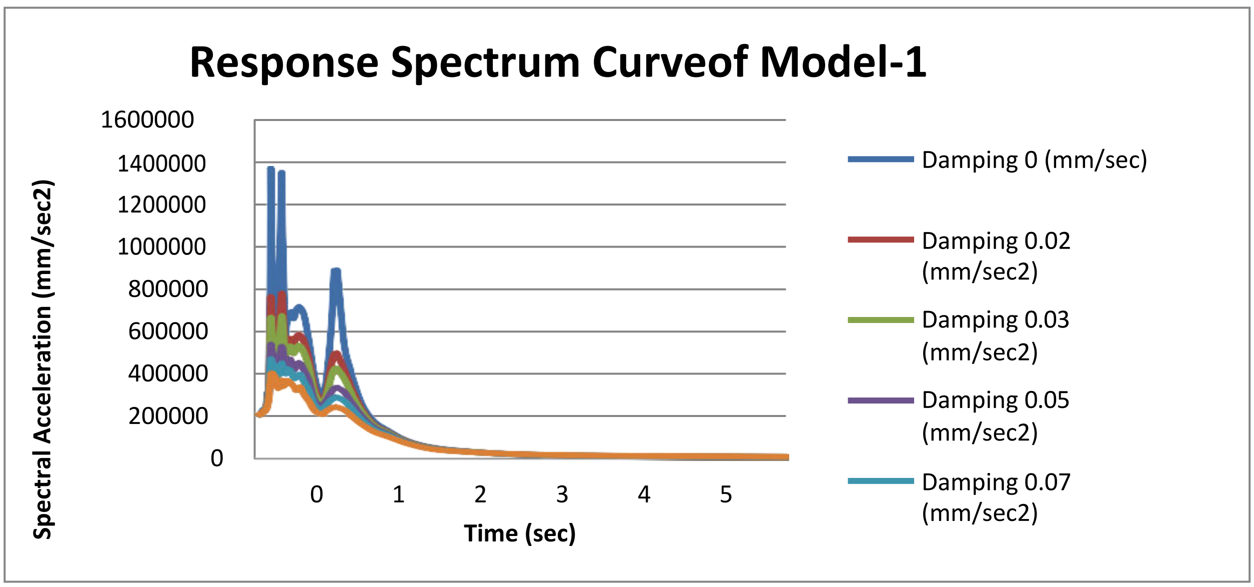

Figure 4.4: Response Spectrum Curve for Model-1

Period (sec)	Damping 0 (mm/sec2)	Damping 0.02 (mm/sec2)	Damping 0.03 (mm/sec2)	Damping 0.05 (mm/sec2)	Damping 0.07 (mm/sec2)	Damping 0.1 (mm/sec2)
0.03	201999.7	202397.2	202278.3	202165.8	202163.9	202266.9
0.036	203539.6	203371.7	203366.9	203425.1	203493.7	203584.6
0.04	204661.3	204592.2	204594.5	204601.4	204612.9	204637.8
0.045	206083.7	206127.7	206160.6	206148.5	206102.9	206046.8
0.05	203237.7	206514.8	206787.5	207012.2	207090.9	207117.3
0.056	208164.6	208912.8	208812	208646	208572.4	208547.9
0.061	207741.9	208925.7	209190.2	209549.3	209800.2	210030.2
0.067	224989.9	214597.5	213759.6	213304.8	213188.8	213068.1
0.071	217659.7	217656.2	217370	216947.7	216589.4	216064
0.077	224561.7	223750.8	223007.5	221774.3	220791.1	219582.4
0.083	223100.8	225606.7	226105.8	225507.9	224367.4	222700.6
0.091	233539.9	226230.6	226188.8	226153.4	225412.4	223930.8
0.1	248282.6	240476.6	237968.5	234124.4	231257.6	228099
0.111	307183.1	276148.3	268924.8	259686	253291.9	245540.8
0.118	293948.3	286002.1	283431	277734.2	270785.7	259683.1
0.125	413421.9	351851.8	335442.2	310682.2	292822.7	282400.9
0.133	697416.3	528318.7	478939.5	425793.4	384035.1	336368.8
0.136	785612.8	588043.4	541373.1	462106.8	403222	345685
0.142	1361997	755210.2	657455.2	526041.4	460236.5	392208.3
0.143	1316745	747740.3	649417.9	532372.4	464857.5	395260.2
0.154	876442.8	638620.8	578355.1	489170.6	448446	397692.6
0.154	863941.9	634313.7	576143.6	489326	445388.2	396240.2
0.167	450262.3	455305.1	455480.1	444508.4	423303.5	384394.9
0.176	644593.5	555611.1	523995.9	473602.4	433565.1	384725
0.182	723035.1	586266.3	539837.2	470586	424288.7	372837.1
0.2	539398.3	492253.9	469063.4	424177.5	393810.4	347675.9
0.202	472060.8	473293.3	459518.4	422047.4	384696.6	341016.1

0.213	595566.6	518638.1	488913.1	435750.4	388473.3	327969.2
0.227	921747.6	639362	560781.4	461117.2	398870.6	347030.6
0.244	1345631	772975.4	666314.7	521560.8	444875.9	364965.1
0.25	1137263	733597.4	643011.7	518755.5	429872.1	339809.2
0.254	1030528	697884.7	621702.7	504939.7	420511.2	336264.2
0.278	573539.9	501708.5	477311.1	435377.4	396310.1	345130
0.289	620418	530194.4	504252	457266.5	415429.7	361398.5
0.296	641366.7	540012.4	511897.3	461919.7	418615.7	363686.7
0.303	659625.8	554110.7	521866.9	464693.4	415598.7	359509.5
0.333	687923.7	559857	520897.4	458291.3	405089	350400.2
0.357	655842.3	535759.9	490509.9	413393.7	376953.4	336215.5
0.385	700211.9	571914.3	518417.8	433506.2	378462.8	318353.7
0.417	709539.3	578010.8	524919.2	444646.6	393198.5	333498.2
0.455	673910.8	544348.8	491613.4	410828.5	356188.8	296946
0.5	554228.8	462075.3	424727.2	361464.5	315832.3	265816.9
0.556	379001.8	323725.1	299683.3	264990.9	245300	220308.6
0.625	273908.4	262693.8	257537.6	244401.2	229321.1	206128.9
0.667	377019.4	309158.3	294145.9	270339.4	248584.8	219557.8
0.714	632209.1	440510.5	383870.8	309336.1	273761.9	234568
0.738	877660.8	485448.8	414958.3	325158.3	281308.7	238039
0.763	870248.4	493972.7	421615.3	331217.9	285419.3	237937.6
0.769	880392.6	490428.4	418883.5	330966.1	285441.2	237936.2
0.833	533276.9	412551.4	372141.1	309371.2	267039.6	225421.5
0.889	419635.2	341705.3	313566.5	268246.8	238912.5	202962.6
0.909	380787.5	316057.2	290217	254940.7	226540.4	192761.3
1	251864.5	224841.5	213995.9	193964.4	177568.7	156816.3
1.111	172375	156476.3	151432.7	142088.1	133296.5	122450.9
1.25	126397.2	118647.4	115489.6	109269.7	104418.6	97767.07
1.429	79093.57	75105.93	73410.28	70446.31	68272.87	66112.27
1.667	47810.39	45704.59	44738.3	43012.08	41536.66	39465.19

2	29909.82	29012.46	28573.17	27901.04	27361.27	26773.16
2.5	14951.75	14858.19	14911.8	15206.94	15615.9	16431.56
3.333	7817.91	7915.44	8048.6	8493.19	8972.45	9915.44
5	3121.46	3266.29	3420.64	3804.47	4281.36	4992.56

Table 4.10: response spectrum curve data model 1

4.4.2.) Response Spectrum Curve for Spectral Acceleration vs. Time for L Shape with Curved Beam (M1)

The Chart of the response spectrum curve of the model-2 due to applied time history data is given below: -

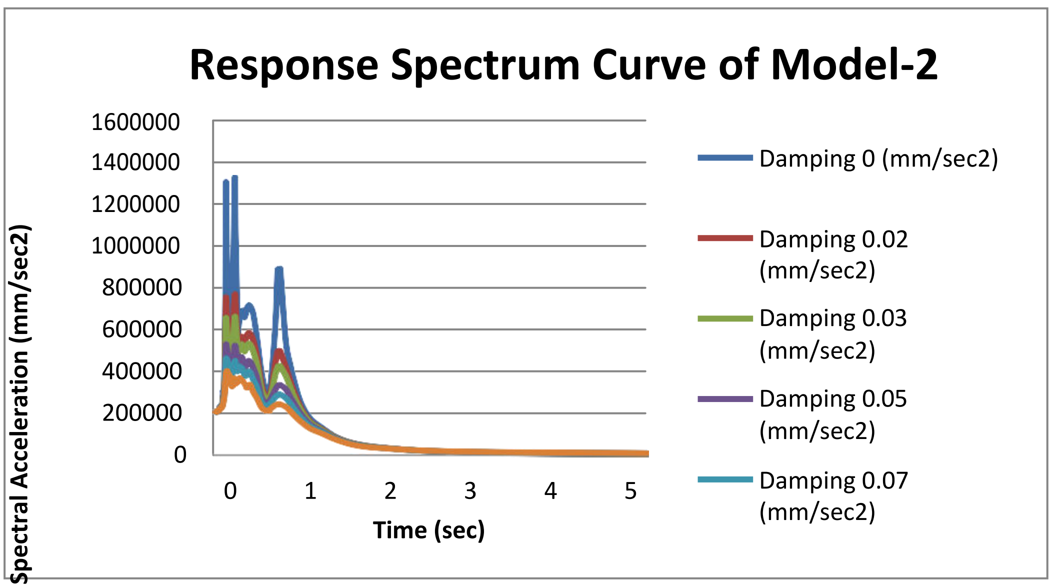

Figure 4.5: Response Spectrum Curve for Model-2

Period (sec)	Damping 0 (mm/sec2)	Damping 0.02 (mm/sec2)	Damping 0.03 (mm/sec2)	Damping 0.05 (mm/sec2)	Damping 0.07 (mm/sec2)	Damping 0.1 (mm/sec2)
0.03	201498.5	201897.6	201777.9	201664.2	201661.7	201764.3
0.036	203035.6	202866.9	202861.9	202920.2	202989	203080
0.04	204155.7	204086.3	204088.6	204095.5	204107	204131.8
0.045	205576.2	205620.5	205653.5	205641.5	205595.7	205539.3
0.05	202708.6	206001.8	206275.8	206501.8	206581	206607.6
0.056	207649.2	208401.3	208300.1	208133.5	208059.8	208035.5
0.061	207213.3	208403.8	208669.9	209031.3	209284	209515.6
0.067	224544.5	214093.1	213250.7	212794	212677.9	212557.1
0.071	217162.7	217158.4	216870.8	216446.9	216087.1	215559.2
0.077	224092.9	223278.2	222530.5	221290	220300.9	219084.9
0.083	222571.9	225131	225634	225031.9	223882.8	222203.8
0.091	233831.3	225703.6	225661.9	225655.9	224906.6	223410.8
0.1	247961.9	240068.9	237532.6	233643.8	230742.6	227545.5
0.111	306436.1	275110.4	267871.3	258680.4	252370.5	244749.3
0.118	292398.7	284697.7	282259.1	276813.7	270063.4	259161.5
0.125	412157.9	351360.4	335149.3	310613.9	291829.6	278468.7
0.133	687735.1	520025.5	472491.8	420438.2	379566.1	332855.3
0.135	753341.7	543340.7	505015	441681.5	392995.7	339596.3
0.142	1297787	744935.5	648087.6	518436.1	453516.4	386491.6
0.143	1266238	735788.7	641369.5	524088.1	457639	389214.2
0.153	891658.3	638787.5	571702.5	497303.6	451917.7	397095.8
0.154	849747.5	624220.1	566514	480594.6	441133.3	392176
0.167	443615.2	448800.9	449098.6	438401.2	417484.6	379010.3
0.176	644214.5	552874.4	520710.4	469727	429437.3	380514.9
0.182	716019.2	579610.7	533382.1	467704.3	421160.3	369506.8
0.198	604370.4	508898.5	475206.4	434946.9	399736.9	350097.7

0.2	538670.1	489162.7	465389.7	420684.1	389991.8	343736.5
0.213	587922.9	512480.3	483138.1	430475.9	383558.7	323514.8
0.227	898317.1	628182.5	553550.3	454896.1	396749.7	344948.8
0.244	1324318	761377.7	655892.8	517227.4	441030.2	361680.2
0.25	1130726	725235.4	639076.7	515554.6	427196.7	338498.4
0.253	1037833	697393.4	620765.1	503598.5	419048.2	336016.7
0.278	572636	501255.8	476009.1	434346.7	395508	344601.8
0.278	573179.9	501699.2	476320.6	434643.8	395789.7	344852
0.296	642000.6	540704.1	510717.1	460879.2	417726.2	363017.8
0.303	659303.7	553570	520956.5	463977	415052.9	358858.5
0.333	686863.2	559664.6	520312.7	457850	404773.3	349628.7
0.357	653411.2	535042.2	489832.4	412781.3	376339.3	335531.2
0.385	698414.7	570398.5	517030.1	432707.3	377724.1	317905.8
0.417	709094	577792.8	524797.4	443647.5	392255.1	332622.9
0.455	672945.3	543613.4	490979.7	410728.5	356132.4	297043.1
0.5	553696.2	461756.7	424439.1	361224.5	315758.2	265503.3
0.556	378700	323474.4	299454.1	264840.3	245142.3	220168.8
0.625	273861.1	262620.3	257459.2	244318	229237.4	206048.8
0.667	376823.7	309053.6	294043.9	270228.9	248468.2	219434.9
0.714	632219.4	440520.5	383900.2	309372.9	273601.4	234412
0.738	883229.4	486318	415397.3	325618.8	281554.1	237942.4
0.763	871535.1	494323	421879.5	331350.4	285529.3	238091.3
0.769	881867.5	490767.5	419156.3	331131.8	285547.7	238085.8
0.833	533631.9	412685.5	372277.2	309448.7	267111.8	225614.8
0.889	418549	341022.3	313023.6	267821.2	238580.4	202706.2
0.909	380883.8	316162.5	290181.1	254897.3	226487	192721.9
1	251941.2	224800.1	213949.7	193939.6	177525.7	156823.3
1.111	172416.4	156483.2	151473.7	142117.7	133366.2	122515.5
1.25	126364.2	118621.8	115459.5	109250.7	104387.3	97757.38
1.429	79075.86	75084.31	73382.64	70411.58	68230.33	66065.22

1.667	47796.56	45690.44	44727.37	42995.44	41524.67	39464.2
2	29904.75	29006.12	28563.42	27891.42	27344.22	26747.59
2.5	14944.35	14850.58	14903.66	15198.22	15605.63	16420.74
3.333	7813.78	7910.98	8043.74	8487.58	8965.67	9907.87
5	3119.64	3264.14	3418.28	3801.33	4277.86	4987.86

Table-4.11: Response Spectrum Curve Data for Model-2

4.4.3.) Response Spectrum Curve for Spectral Acceleration vs. Time for T Shape Without Curved Beam (M3)

The Chart of the response spectrum curve of the model-3 due to applied time history data is given below: -

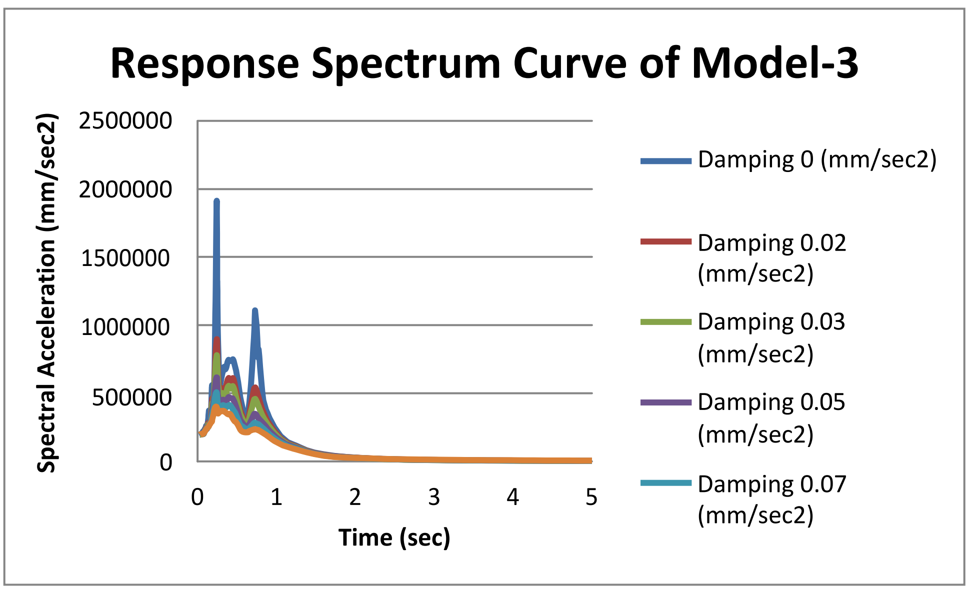

Figure 4.6: Response Spectrum Curve for Model-3

Period (sec)	Damping 0 (mm/sec2)	Damping 0.02 (mm/sec2)	Damping 0.03 (mm/sec2)	Damping 0.05 (mm/sec2)	Damping 0.07 (mm/sec2)	Damping 0.1 (mm/sec2)
0.03	196271.5	195604.1	195849.4	196162.5	196331.9	196476.1
0.036	197487.6	197706	197727	197663.9	197600.1	197554.9
0.04	197990.2	198125.1	198127	198133.5	198141	198154.7
0.045	198639.4	198692.7	198636.6	198662.9	198750.7	198866.7
0.05	206830.7	200969.3	200467.4	200045.9	199892.5	199831.6
0.056	202160.7	200688.9	200811.4	201031.6	201115.1	201106.3
0.061	206230.3	204252.5	203800.6	203176.6	202728.5	202289
0.067	211773.5	199901.2	201210.6	201922.3	202085	202203.8
0.071	219233.7	200774.5	200157.7	200566.4	201120	201819.6
0.077	202457.6	204207.1	204748.5	205266.9	205542.6	205793.5
0.083	224743.9	212354.3	211979.1	212164.3	212143.8	211740.1
0.091	237819.7	225245.6	224589.9	222955.1	221415.9	219451
0.1	246925.5	238848.1	236507.3	232845.7	229988.6	226642.9
0.111	259937.3	249248.7	246406.1	242483	239672.7	236453.5
0.118	238897.4	244887	245985.6	245623.3	244077.1	241468.4
0.125	268207.7	257016.3	254009.4	250378.6	248202.2	245848.7
0.133	303253.8	278624.5	270331.2	256713.3	250965.2	250442.6
0.143	371378.2	278449.1	267789.8	262211.3	261073.6	259069
0.148	368370.7	282375.4	272756.4	270310.2	268012.5	264805.9
0.154	354845.1	286796.7	283094	278405	274866.4	270552.4
0.155	354642	289606.3	283933.1	279188.4	275601	271211.4
0.167	312809.1	301208.2	294207.6	290425.2	287255.9	282127.8
0.171	353030.2	335668.6	321978.1	297012	292315.6	286123.2
0.177	473771.9	405870.4	382725.2	345045.2	315104.9	290450.4
0.182	553794.2	456150.3	422243.8	370869.5	333110	293156
0.186	540709.5	461054	429044.1	378414.2	344485.4	307332
0.2	493223.7	449904.5	440550.2	414239.8	384726.5	342823.4

0.213	621430	549194.7	524938	478847.2	436078.9	380521.3
0.227	1175380	787684.4	700879.4	581743.9	492292.9	399377.9
0.242	1914359	894779.1	780347.6	616024.4	505339.6	396839.8
0.248	1345637	865569.7	747172.7	577766.9	464976.5	374126.4
0.25	1302842	832916.1	723501.6	565526.3	459125.7	364192.9
0.257	950124	675114.4	594546.7	472097.1	397417	351074.1
0.278	551408.9	496618.9	472921	426755.7	397930.2	362112
0.298	605266	532413.7	500510.7	443785.3	406070.7	369602.3
0.303	617972.7	534901.3	502523.6	445163.3	409729.5	367681.1
0.333	688472.9	536295	498441.8	449046.8	411217.3	369268.7
0.357	681216.7	547852	495121.1	426638.5	397349.6	357378.6
0.385	738013.2	604563	548952.4	465800.5	409968.2	346008.3
0.417	738115.7	590597.3	535092.6	465752.9	409431.5	343431.6
0.455	740183.5	600060.9	543055.4	450090.2	379377.8	304842.6
0.5	629674.3	482415.5	441524.9	379556.9	329442.2	277717.4
0.556	424475.4	346032.4	322737.1	283151.2	251444	222280.3
0.625	323234.4	280055.9	269590.8	247150.3	234300.7	213154.6
0.667	498282.1	384251.7	345547.7	284840.9	251963.9	224549
0.714	907851.2	526985.1	449820.6	343455.9	281673.7	234427.1
0.734	1117934	539796.2	456918.4	346768.1	281041.5	234724.9
0.769	762287.3	479666.9	410214.1	318459.8	273327	228851.7
0.773	822601.9	469757.2	403624.7	314821.4	271967.1	227863
0.833	448886.1	358157.5	324271.4	277532.8	242128.9	207509.9
0.896	340592.5	285485.3	266558.1	233717.4	207170	181931.4
0.909	320296.1	274851.4	255860.7	224913.9	199092.7	177379.5
1	224867.2	201354.7	191342.5	173208.9	157880.7	139307.9
1.111	152586.5	141908.8	136775	128065.9	119937.1	109743.5
1.25	116178.3	108732.8	105465.8	99336.46	94081.68	87291.44
1.429	72634.92	69164.41	67441.82	64898.82	62540.67	59556.94
1.667	46014.49	42149.89	41186.51	39305.82	37655.38	35297.41

2	27966.24	27121.81	26803.05	26232.85	25698.59	25001.57
2.5	14625.61	14562.58	14652.09	14947.42	15453.25	16279.44
3.333	7662.99	7753.36	7926.44	8337.85	8944	9812.58
5	3063.61	3209.98	3370.6	3795.21	4246.09	5025.18

Table-4.12: Response Spectrum Curve Data for Model-3

4.4.4.) Response Spectrum Curve for Spectral Acceleration vs. Time for T Shape with Curved Beam (M4)

The Chart of the response spectrum curve of the model-4 due to applied time history data is given below: -

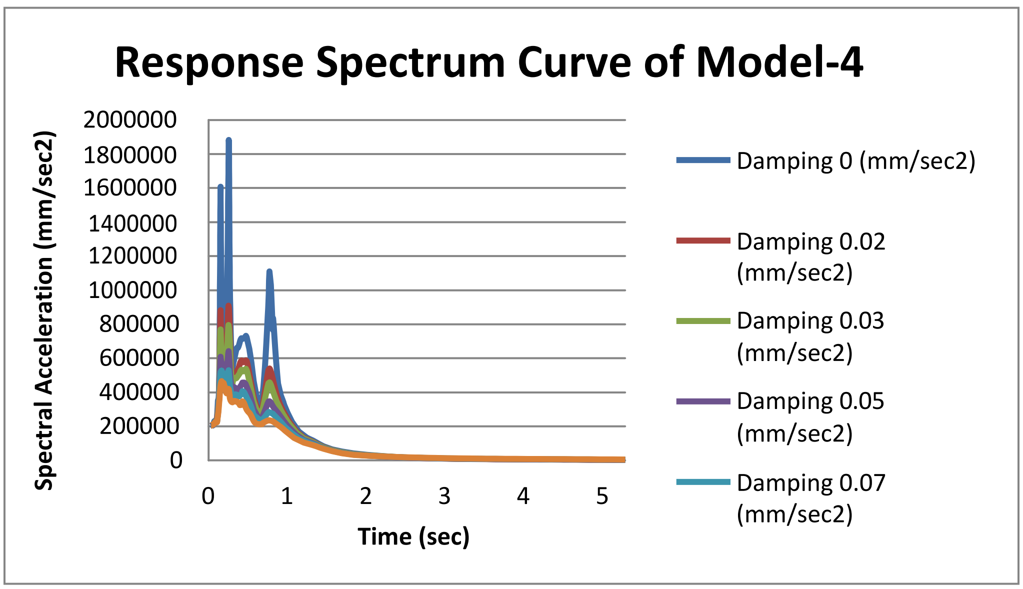

Figure 4.7: Response Spectrum Curve for Model-4

Period (sec)	Damping 0 (mm/sec2)	Damping 0.02 (mm/sec2)	Damping 0.03 (mm/sec2)	Damping 0.05 (mm/sec2)	Damping 0.07 (mm/sec2)	Damping 0.1 (mm/sec2)
0.03	203948	204368	204233.8	204101.3	204089.3	204187.3
0.036	205566.3	205381.7	205375	205435	205506.4	205600.3
0.04	206745.7	206671.2	206673.6	206680.8	206693	206719.5
0.045	208241.4	208292.3	208329.3	208318.7	208271.8	208214.6
0.05	205123.7	208676	208973.6	209221.6	209311.5	209347
0.056	210409.1	211227	211121.5	210949.4	210877.4	210862.5
0.061	209897	211193.5	211486.4	211887.6	212171.3	212437.5
0.067	228580.5	217294.6	216392.1	215914.7	215805	215697.3
0.071	220568	220575.9	220275.2	219837.2	219467.8	218925.4
0.077	228023.4	227169.2	226372	225053	224005.6	222723.4
0.083	220800.4	229139.6	229703.2	229081.2	227863.4	226084.2
0.091	239566.6	226312.8	228837.8	229713.5	228934.7	227362.8
0.1	250123.2	235083.6	232329.6	229300.6	227026.6	225140.1
0.111	349571.4	299020.6	288329.3	275291.7	266599.2	256164.9
0.118	339290.1	327119.7	324072.1	315998.8	306155	290195.8
0.125	422536.3	380576.8	383802.1	375459.5	358247.5	328441.8
0.133	829285.9	645641.9	584049.9	489867.3	437185.5	386394.6
0.142	1598963	878694	766557.1	607628.7	508765.3	437254.8
0.143	1529317	870047.7	760684.4	603899.7	517145.3	442831.5
0.154	923436.6	703800.4	636185.4	575296.6	526513	465354.3
0.154	915527.3	701991.8	636014.4	574348.5	525990.4	465141.7
0.161	510452.9	552648.5	548179.1	521041	485265.3	431402.9
0.167	529149.8	532427.8	530686.4	514891.4	488532	442460.1
0.177	783556.5	661628.1	620921.5	558535.8	510485.3	452873.8
0.181	819696.6	678955.3	631453.6	560605.2	508543.8	449042.2
0.182	810065.9	675654	628946.4	558490.2	506502.3	447200.9
0.2	586514.5	546060.5	539441.7	511970.8	476666.2	422464.8
0.213	685739.9	600841.9	571259.9	515937.1	464405.9	395881.6

0.227	1214799	797550	700670.6	580278.5	490964.3	397268
0.237	1683064	903952.8	793264	636227.2	526877.7	418146.6
0.243	1870874	894133.9	777246	621490.9	516487.5	413509.7
0.25	1283988	836537.7	733068.5	582396.8	479741.5	389440.7
0.257	948929.6	705180.7	628582.9	508856.4	428077	361009.3
0.278	531746.2	469367	448190.1	406627.6	377230.1	342482.9
0.298	579109.1	512358.9	483095.4	431005.1	386026	348515
0.303	586365.9	513854.7	484155.8	431486	386278.8	346758.5
0.333	650841	518180.8	482110	421625	386201.5	345914.1
0.357	668195.1	541482.7	491306.3	410754	375292.1	337433.2
0.385	710833.6	581294.5	527193.3	438447.8	384866.7	324960
0.417	715575.7	576881.4	523156.8	457342	404202.2	342431.3
0.455	722753	585347.5	529460	438296.7	369457.5	297820.1
0.5	619637.8	478266.7	438100.5	376234.5	327346.6	270750.5
0.556	419655.7	343743.1	320680.2	281341.1	250033.3	220989.6
0.625	320385.1	278694.3	268222.3	246493	233564.8	212360.9
0.667	493142.9	381233.1	343374.5	283486.4	251371.2	223899.5
0.714	897185.4	524565.1	447618.1	342366.6	280911	234476.5
0.735	1121021	538461.8	456037.5	345890.7	280858.8	234495.8
0.769	767679.3	480813	411197.9	319214.9	273764.5	229343.9
0.773	834015.5	470184.8	404122.8	315294.7	272319.6	228289.1
0.833	451321.9	360178	325826.6	278631.6	242584.4	208301.1
0.897	341593.1	285987.8	267200.1	233849	207530.2	182995.8
0.909	322643.7	276437.2	257442.2	226162.5	199789.8	177917.6
1	226622.1	202839.5	192902.1	174296.5	159178.2	139742.2
1.111	154069.2	143203.9	138236.5	128740.4	120835.2	109837.6
1.25	116575.9	109638.5	106263.9	100796.7	95627.46	89488.42
1.429	72156.41	68610.23	67110.65	64571.59	62670.78	60828.79
1.667	45981.59	42177.7	41256.35	39554.25	38064.65	35947.5
2	27725.54	26848.4	26504.12	25849.69	25352.12	24822.79
2.5	14587.85	14534.97	14569.45	14882.62	15274.56	16071.08
3.333	7651.55	7743.59	7883.01	8291.61	8828.59	9669.06

5	3057.95	3190.09	3355.09	3741.53	4182.31	4896.63

Table-4.13: Response Spectrum Curve Data for Model-4

4.3.5.) Response Spectrum Curve for Spectral Acceleration vs. Time for plus Shape Without Curved Beam (M5)

The Chart of the response spectrum curve of the model-5 due to applied time history data is given below: -

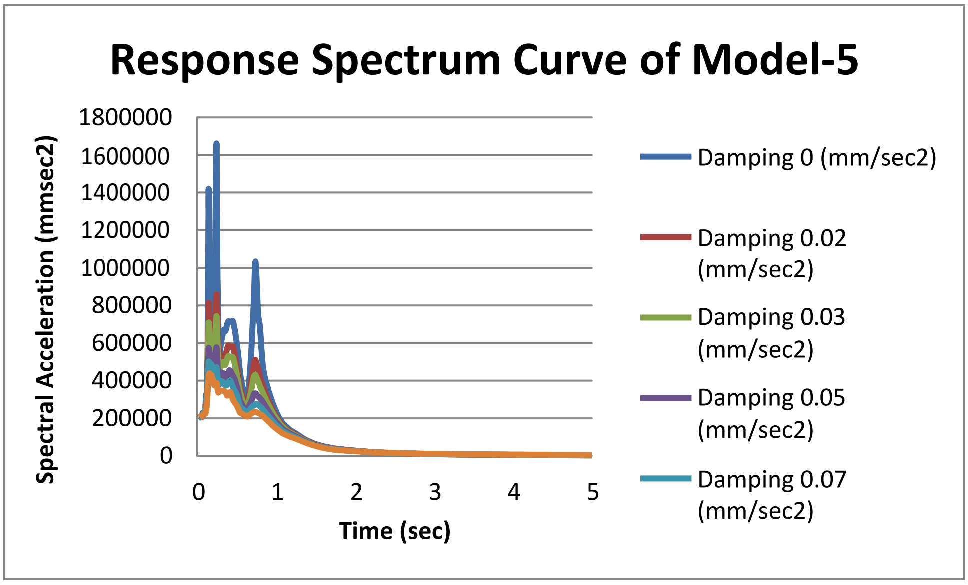

Figure 4.8: Response Spectrum Curve for Model-5

Period (sec)	Damping 0 (mm/sec2)	Damping 0.02 (mm/sec2)	Damping 0.03 (mm/sec2)	Damping 0.05 (mm/sec2)	Damping 0.07 (mm/sec2)	Damping 0.1 (mm/sec2)
0.03	204295.1	204715.3	204584.4	204456.7	204447.6	204547.9
0.036	205893.1	205712	205705.8	205766.2	205837.8	205931.9
0.04	207060.6	206986.4	206988.7	206995.9	207007.9	207034
0.045	208540.9	208588.8	208624.8	208613.3	208565.9	208507.6

0.05	205443.9	208964	209258.2	209502.4	209589.7	209622.3
0.056	210675.9	211484.6	211379.1	211206.2	211132.1	211113.1
0.061	210171.3	211448.4	211735.8	212128	212404.2	212661.1
0.067	228608.3	217469.4	216575.3	216097	215982.2	215867
0.071	220676.3	220695.6	220395.1	219954.5	219582.4	219037
0.077	228021.7	227167.2	226377.4	225070.2	224031.2	222758.3
0.083	220884.8	229070.6	229617.9	228998	227795.3	226038.4
0.091	235158	226277	228739.8	229590	228823.5	227276.2
0.1	246809.8	238448.2	235767.9	231667.8	228619.1	225276
0.111	328091.2	278678.5	267978.3	254657.4	245611.3	238900.5
0.118	316972.8	304058.9	300503	291617.7	281228.1	264873.7
0.122	378983.5	340100.1	331602	318369.4	304725.5	283879.7
0.125	414219	356174.6	354110	344087.5	326282.6	305784.2
0.127	502176.2	415653.7	393043.4	367790.8	342620.8	322429
0.129	527937.6	441206.4	412656	384394.5	356125.3	332342.1
0.133	767899.5	589859.4	530209.1	459619.9	416281.3	366419.1
0.143	1414579	811567.8	708392.7	569807.9	500269.3	428292
0.143	1404392	806329.1	704590.4	573328	502860.5	430022.3
0.154	908362.5	683320.5	621007.9	536550.7	494201.6	439569.1
0.156	785191	648049.8	601681.7	526866.8	475668.7	430746
0.167	500486.9	505385.5	505030.1	492279.6	468821	426405.7
0.178	769215.8	639138.9	596789	533528	486244.2	430976
0.182	776156.6	644113.3	598411	529949.2	479998.3	423753.9
0.2	577956.5	529098	511674.9	486169.2	452889.1	401720.8
0.213	655488.5	579860.6	550023.8	495136.3	444802.4	378648.9
0.227	1125268	729773.3	652760.7	534599.3	447957	376033.3
0.243	1662520	860080.3	744803.9	577919	473316	388349.2
0.25	1194881	790544.8	672186.7	536799.2	456251.2	375776.9
0.263	773887.8	603797.9	533803.3	444725	381392.8	340752.1
0.278	547561.9	475514.2	455152.8	414902.7	379112.9	345455
0.299	599465.1	524393.6	495194.4	443334.2	398634.4	347966.8
0.303	611551.7	523697.5	494246.8	442079.9	397345.9	347469.7

0.333	666992.1	534196.1	498123.2	434914.1	391279.8	346186
0.357	667284.8	538299	487247.6	406574	376085.1	339072.4
0.385	711163.2	581445.6	527295.6	437595.2	383458.9	321548.5
0.417	713729.2	579093.7	524829.5	454176.4	401372.9	340038.5
0.455	710956.6	575491.4	520379.6	430497.2	362120.5	296325.2
0.5	600723.2	474544.4	435115.1	372591.5	324594.6	268164.4
0.556	400743.9	337558.2	315063.9	275043.9	245643.6	220919.3
0.625	296684.3	270299.5	259442.1	244936	231616.2	210107.3
0.667	450762.1	353862.6	317504.2	269576.1	248876.9	221180.3
0.714	807375.9	490054.8	418218.4	325752	271287.8	233185.5
0.737	1034712	510252.5	432115	331980	276193.3	234340.4
0.769	759646.8	471650.4	403964	316697.9	274910.7	229181
0.794	683769.6	418772	371062.6	306413.7	267335	223833.2
0.833	469429.9	370912.9	334622.8	284979.1	246741.7	211867.5
0.898	353859.7	294296.4	274090.3	241252.3	213325.9	185536.7
0.909	337953.5	285246.1	266478.7	233343.8	207033	181676
1	232980.8	209136.3	198469.7	180090.6	164207	144305.7
1.111	158327.8	147089.7	142156.2	132695.1	124496.4	113508.3
1.25	119557.9	112370	109063.5	103349.2	98281.38	91930.51
1.429	74202.9	70524.28	68829.87	66198.56	64396.38	62445.44
1.667	45300.98	43218.87	42279.3	40568.99	39070.6	36927.98
2	28345.39	27487.07	27116.1	26443.63	25947.93	25391.88
2.5	14717.09	14651.42	14650.57	15000.08	15352.11	16200.15
3.333	7712.56	7806.76	7924.12	8365.28	8880.5	9757.64
5	3081.88	3209.29	3380.2	3762.61	4218.75	4919.5

\

Table-4.14: Response Spectrum Curve Data for Model-5

4.3.6.) Response Spectrum Curve for Spectral Acceleration vs. Time for plus Shape with Curved Beam (M6)

The Chart of the response spectrum curve of the model-6 due to applied time history data is given below: -

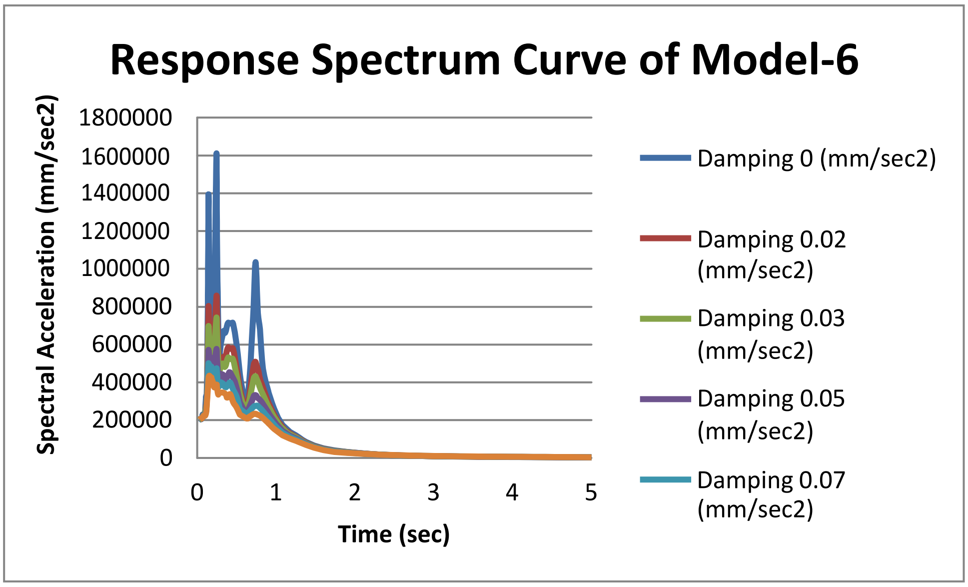

Figure 4.9: Response Spectrum Curve for Model-6

Period (sec)	Damping 0 (mm/sec2)	Damping 0.02 (mm/sec2)	Damping 0.03 (mm/sec2)	Damping 0.05 (mm/sec2)	Damping 0.07 (mm/sec2)	Damping 0.1 (mm/sec2)
0.03	203984.3	204402.3	204272.6	204146.3	204137.8	204238.2
0.036	205575.8	205395.8	205389.8	205450	205521.3	205615
0.04	206738.1	206664.4	206666.8	206673.9	206685.9	206711.8
0.045	208212	208259.6	208295.3	208283.8	208236.5	208178.5
0.05	205138.5	208635.2	208927.4	209169.6	209256.2	209288.2
0.056	210340	211142.9	211037.9	210865.6	210791.7	210772.1
0.061	209842.7	211110.6	211395.7	211784.6	212058.3	212312.6
0.067	228156.1	217094.5	216206.2	215730.3	215615.5	215500
0.071	220283.6	220301.4	220002.4	219563.8	219193.3	218650.5
0.077	227578.8	226729	225944.4	224645.7	223613.4	222348.4
0.083	220501.8	228621.9	229164.1	228547.8	227353.5	225608.9
0.091	234133.3	225858.6	228300	229142.4	228381.7	226846.1
0.1	246648.3	238367	235712	231650.2	228629.7	225316.4
0.111	326408.8	277353	266661.7	253269.8	244430.6	238239.4
0.114	285505.3	283235.1	278159.3	267411.5	257609.7	245453.9

0.118	315648.2	302541.2	298841	289703	279111.9	262543.3
0.118	315611.6	302893.3	299224.8	290075.4	279452.2	262818.9
0.125	412485.7	353948.4	351686.7	341066.1	322926.5	304351
0.127	505805.1	417459.7	393518.5	366913.8	341705.5	322416.4
0.133	759604	582351.4	522876.6	456730.4	413248.6	363349.7
0.143	1393247	803046.3	698156.7	572115.9	501655.5	428812.8
0.143	1392131	803834.8	697827.7	572364.3	501839.1	428936
0.154	916669.6	682541.8	620661.3	530484.8	489163.5	435576
0.156	795136.4	647600.4	601197.8	526431.1	470929.1	426762
0.167	495879.8	501314.9	501259	489089.5	466139.2	424322.6
0.178	769781.8	636448.6	593290.4	529322.7	481964.7	427055.3
0.182	772007.3	638036	592684.8	524826.5	475397	419830.1
0.2	577233	528691.2	507536.3	482283	449300.9	398600.6
0.213	653324.7	577321.5	547387.1	492463.8	442232.3	376348.2
0.227	1105321	722615.3	646142.3	528275.4	442723.8	374857.4
0.244	1611361	859061.5	743707.6	577284.7	473395.9	388486.1
0.25	1189351	792086.9	673393.9	532823.7	454859.1	375071.5
0.263	771907.8	604708.5	535543.3	442368.1	380371.3	339796
0.278	550142.8	477190.1	455340.5	415362.6	378583.8	345150.5
0.299	604746.6	525025.4	495861.3	444096	399512.9	346908.3
0.303	614219	523924.7	494587.7	442623.8	398061.4	347354.7
0.333	668086.1	534972.1	498978.4	435893.8	391001.9	345997.9
0.357	665514.6	536689.6	485713	406261.4	375325.7	338502.6
0.385	709974.7	580586.4	526577.5	436364.5	382114.7	320257.1
0.417	712619.4	578356.7	524236	452738.2	400139.9	339062.2
0.455	708351.6	573438.2	518550.5	429036.7	360947.1	295974.1
0.5	597601.8	473425.9	434165.7	371713	323917	267700.7
0.556	398041.6	336605.9	314220.6	274375.4	245445.4	220735
0.625	293885.1	269650.3	258749.9	244765	231376.3	209808.8
0.667	446762.9	351121.3	315585	269593.2	248906.2	220818.8
0.714	795614.6	487866.1	416686.6	325280.8	271190.2	233116.4
0.739	1036082	508401	432380.8	332230	276231.6	234418.1

0.769	766896.8	473617.2	405574.7	317723.1	275653.9	229469.8
0.795	680872.8	420020	372247.1	306902.5	267846.7	224320.6
0.833	472684.2	373407.9	336490.4	286375.8	247474.7	212706.4
0.9	354188.5	294411.3	274416.1	241253.2	213197.8	185707.6
0.909	340074	286393.1	267650.6	234288.2	208021	182326.8
1	233736.3	209930.2	199126.6	180776.8	164789.4	144826.4
1.111	158788.8	147509.7	142578.4	133118	124884.8	113887.2
1.25	119884.3	112664.8	109367	103619.9	98563.65	92177.82
1.429	74437.99	70740.24	69019.52	66405.93	64585.09	62614.93
1.667	45416.45	43333.88	42392.64	40680.45	39179.36	37031.01
2	28412.76	27556.09	27182.55	26508.35	26012.4	25451.91
2.5	14724.18	14656.55	14658.9	15004.19	15350.22	16202.83
3.333	7715.33	7809.54	7923.77	8368.36	8879.86	9760.17
5	3082.78	3211.14	3380.75	3762.04	4219.46	4917.33

Table-4.15: Response Spectrum Curve Data for Model-6

4.4: Storey Stiffness

4.4.1: Storey Stiffness of Model-1 due to earthquake force EX and EY

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kN	mm	kN/m	kN	mm	kN/m
Story9	EX	4534.3237	1.121	4045506.815	0	0.036	0
Story8	EX	8905.9334	1.9	4686131.377	0	0.053	0
Story7	EX	12252.947	2.54	4823065.393	0	0.063	0
Story6	EX	14711.9775	3.006	4893519.308	0	0.068	0
Story5	EX	16419.6375	3.321	4944447.738	0	0.068	0
Story4	EX	17512.5399	3.508	4992406.925	0	0.065	0
Story3	EX	18127.2975	3.586	5054782.866	0	0.059	0
Story2	EX	18400.5231	3.513	5237677.666	0	0.054	0
Story1	EX	18468.8295	2.5	7387812.063	0	0.039	0

Story9	EY	0	0.031	0	3762.9115	1.223	3077497.755
Story8	EY	0	0.032	0	7390.791	2.152	3434368.96
Story7	EY	0	0.031	0	10168.3863	2.898	3508562.029
Story6	EY	0	0.029	0	12209.0685	3.445	3544498.255
Story5	EY	0	0.027	0	13626.209	3.819	3568252.904
Story4	EY	0	0.023	0	14533.1788	4.049	3589175.82
Story3	EY	0	0.022	0	15043.3494	4.163	3613766.616
Story2	EY	0	0.022	0	15270.0919	4.154	3675885.372
Story1	EY	0	0.016	0	15326.7775	3.331	4601321.069

Table-4.16: story stiffness Data for Model-1

4.4.2: Storey Stiffness of Model-2 due to earthquake force EX and EY

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kN	mm	kN/m	kN	mm	kN/m
Story9	EX	4538.6253	0.626	7249212.053	0	0.037	0
Story8	EX	8913.0097	1.02	8737116.807	0	0.054	0
Story7	EX	12262.1477	1.344	9122712.834	0	0.064	0
Story6	EX	14722.739	1.579	9321291.749	0	0.068	0
Story5	EX	16431.4829	1.736	9465040.292	0	0.068	0
Story4	EX	17525.079	1.826	9598788.36	0	0.065	0
Story3	EX	18140.2268	1.858	9764710.137	0	0.058	0
Story2	EX	18413.6258	1.811	10167428.07	0	0.052	0
Story1	EX	18481.9755	1.274	14503560.3	0	0.037	0
Story9	EY	0	0.031	0	3766.869	0.665	5667161.674
Story8	EY	0	0.032	0	7397.425	1.119	6612610.292
Story7	EY	0	0.031	0	10177.0694	1.485	6852476.962
Story6	EY	0	0.029	0	12219.2571	1.754	6965154.334
Story5	EY	0	0.027	0	13637.443	1.938	7036911.415
Story4	EY	0	0.024	0	14545.082	2.049	7098027.842

Story3	EY	0	0.023	0	15055.6289	2.1	7168796.12
Story2	EY	0	0.023	0	15282.5387	2.089	7317349.057
Story1	EY	0	0.016	0	15339.2661	1.694	9055061.418

Table-4.17: story stiffness Data for Model-2

4.4.3: Storey Stiffness of Model- 3due to earthquake force EX and EY

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kN	mm	kN/m	kN	mm	kN/m
Story9	EX	6065.5206	1.062	5711039.981	0	0.036	0
Story8	EX	11908.6085	1.848	6442350.475	0	0.053	0
Story7	EX	16382.2227	2.486	6588890.557	0	0.063	0
Story6	EX	19668.9597	2.955	6657226.897	0	0.068	0
Story5	EX	21951.4159	3.274	6705509.236	0	0.069	0
Story4	EX	23412.1879	3.468	6751210.488	0	0.067	0
Story3	EX	24233.8722	3.556	6815117.463	0	0.062	0
Story2	EX	24599.0652	3.498	7032066.334	0	0.057	0
Story1	EX	24690.3634	2.508	9844362.423	0	0.041	0
Story9	EY	0	0.015	0	4968.5432	1.218	4080822.733
Story8	EY	0	0.008	0	9754.8818	2.153	4531325.054
Story7	EY	0	0.003	0	13419.4223	2.904	4621763.846
Story6	EY	0	0.001	0	16111.7378	3.455	4663410.746
Story5	EY	0	0.001	0	17981.4013	3.834	4690065.482
Story4	EY	0	0.001	0	19177.9859	4.069	4713389.366
Story3	EY	0	0.001	0	19851.0648	4.187	4741216.879
Story2	EY	0	0.002	0	20150.2109	4.186	4813594.964
Story1	EY	0	0.012	0	20224.9975	3.354	6029538.101

Table-4.18: story stiffness Data for Model-3

4.4.4: Storey Stiffness of Model-4 due to earthquake force EX and EY

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kN	mm	kN/m	kN	mm	kN/m
Story9	EX	6074.4134	1.062	5718540.351	0	0.037	0
Story8	EX	11923.3233	1.848	6450807.463	0	0.054	0
Story7	EX	16401.395	2.487	6595928.681	0	0.063	0
Story6	EX	19691.4069	2.955	6663749.08	0	0.068	0
Story5	EX	21976.1373	3.274	6711518.842	0	0.069	0
Story4	EX	23438.3648	3.469	6756733.942	0	0.066	0
Story3	EX	24260.8678	3.557	6820202.087	0	0.061	0
Story2	EX	24626.4246	3.5	7036879.824	0	0.055	0
Story1	EX	24717.8139	2.509	9850545.167	0	0.039	0
Story9	EY	0	0.014	0	4976.3386	1.217	4090076.512
Story8	EY	0	0.007	0	9767.9381	2.153	4537585.104
Story7	EY	0	0.002	0	13436.5065	2.905	4625880.651
Story6	EY	0	0.001	0	16131.7813	3.457	4666439.203
Story5	EY	0	0.001	0	18003.4998	3.837	4692504.176
Story4	EY	0	0.001	0	19201.3997	4.072	4715380.3
Story3	EY	0	0.001	0	19875.2184	4.191	4742620.246
Story2	EY	0	0.001	0	20174.6934	4.19	4815293.692
Story1	EY	0	0.012	0	20249.5621	3.359	6028105.593

Table-4.19: story stiffness Data for Model-4

4.4.5: Storey Stiffness of Model-5 due to earthquake force EX and EY

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kN	mm	kN/m	kN	mm	kN/m
Story 9	EX	6931.8655	1.035	6696459.491	0	0.01	0
Story 8	EX	13604.3559	1.804	7541006.637	0	0.003	0
Story 7	EX	18712.9814	2.439	7671350.767	0	0.001	0
Story 6	EX	22466.2573	2.907	7727547.77	0	0.0004031	0
Story 5	EX	25072.6989	3.228	7766466.816	0	0.000396	0
Story 4	EX	26740.8215	3.427	7803630.564	0	0.001	0
Story 3	EX	27679.1405	3.522	7859293.022	0	0.001	0
Story 2	EX	28096.1711	3.474	8088173.24	0	0.002	0
Story 1	EX	28200.4288	2.504	11261734.39	0	0.009	0
Story 9	EY	0	0.006	0	5689.7084	1.181	4818841.291
Story 8	EY	0	0.002	0	11166.5204	2.131	5239453.123
Story 7	EY	0	0.001	0	15359.7047	2.893	5309348.232

Story 6	EY	0	0.001	0	18440.4115	3.45	5344420.518
Story 5	EY	0	0.001	0	20579.7912	3.834	5368178.615
Story 4	EY	0	0.0002086	0	21948.9942	4.072	5390581.202
Story 3	EY	0	0.001	0	22719.1709	4.194	5416741.739
Story 2	EY	0	0.001	0	23061.4717	4.201	5489302.795
Story 1	EY	0	0.007	0	23147.0469	3.392	6823986.765

Table-4.19: story stiffness Data for Model-5

4.4.6: Storey Stiffness of Model-6 due to earthquake force EX and EY

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kN	mm	kN/m	kN	mm	kN/m
Story 9	EX	6951.3116	1.036	6712607.043	0	0.01	0
Story 8	EX	13637.0405	1.806	7552134.86	0	0.003	0
Story 7	EX	18755.8017	2.443	7678645.37	0	0.001	0
Story 6	EX	22516.5241	2.912	7733544.574	0	0.001	0
Story 5	EX	25128.137	3.233	7772187.147	0	0.0003514	0
Story 4	EX	26799.5692	3.432	7809202.219	0	0.001	0
Story 3	EX	27739.7498	3.527	7864199.834	0	0.001	0
Story 2	EX	28157.6079	3.479	8093043.292	0	0.002	0
Story 1	EX	28262.0724	2.509	11263575.06	0	0.009	0

Story 9	EY	0	0.006	0	5705.3303	1.182	4827942.353
Story 8	EY	0	0.001	0	11192.682	2.134	5245161.959
Story 7	EY	0	0.001	0	15393.9357	2.897	5313659.084
Story 6	EY	0	0.001	0	18480.571	3.456	5348124.006
Story 5	EY	0	0.001	0	20624.0678	3.839	5371708.966
Story 4	EY	0	0.0002404	0	21995.9057	4.078	5393525.373
Story 3	EY	0	0.001	0	22767.5645	4.201	5419520.478
Story 2	EY	0	0.001	0	23110.524	4.208	5491416.732
Story 1	EY	0	0.006	0	23196.2639	3.399	6824899.717

Table-4.20: story stiffness Data for Model-6

4.5: Torsion and axial force

4.5.1 Torsion value and axial force of Model 1 at Re-entrant corner is given below

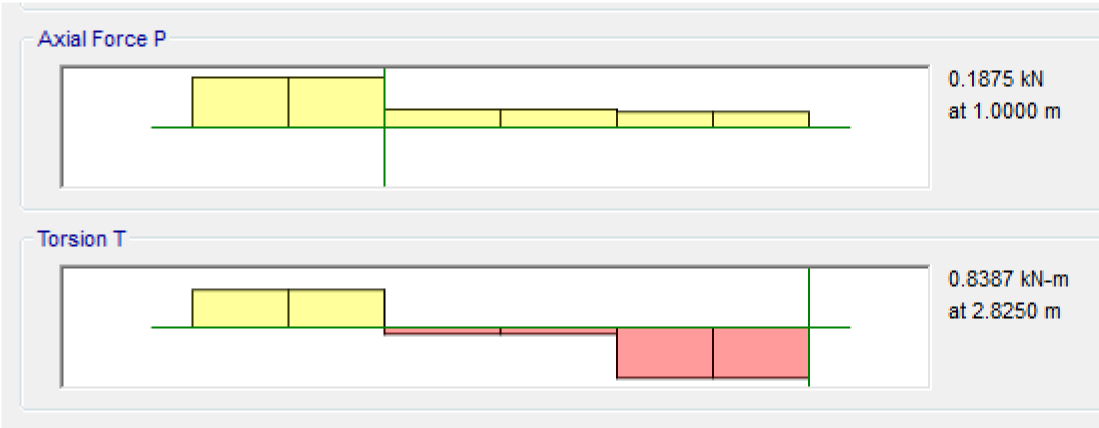

Figure 4.10: Torsion diagram for Model-1

4.5.2Torsion value and axial force of Model at Re-entrant corner is given below

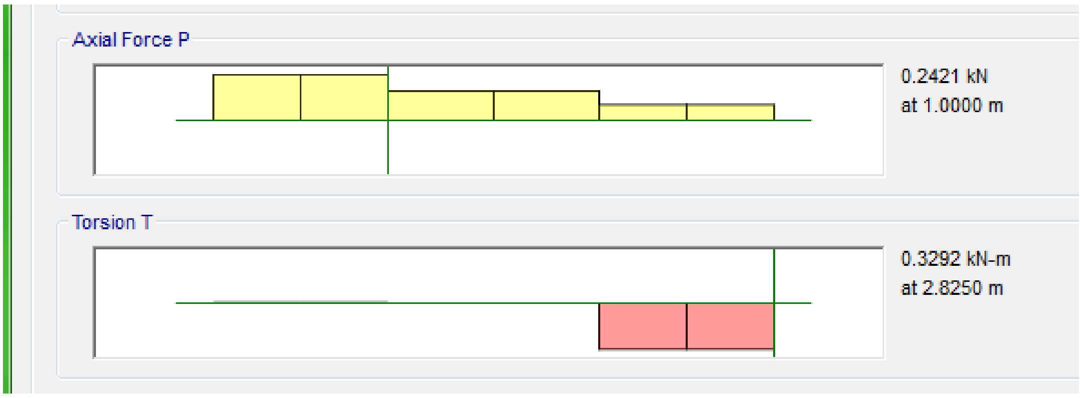

Figure 4.11: Torsion diagram for Model-2

4.5.3 Torsion value and axial force of Model 3 at Re-entrant corner is given below

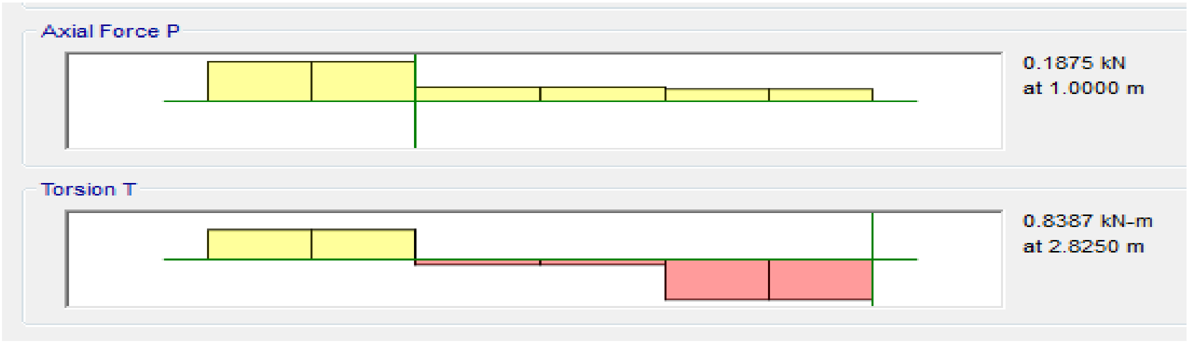

Figure 4.12: Torsion diagram for Model-3

4.5.4 Torsion value and axial force of Model 4 at Re-entrant corner is given below

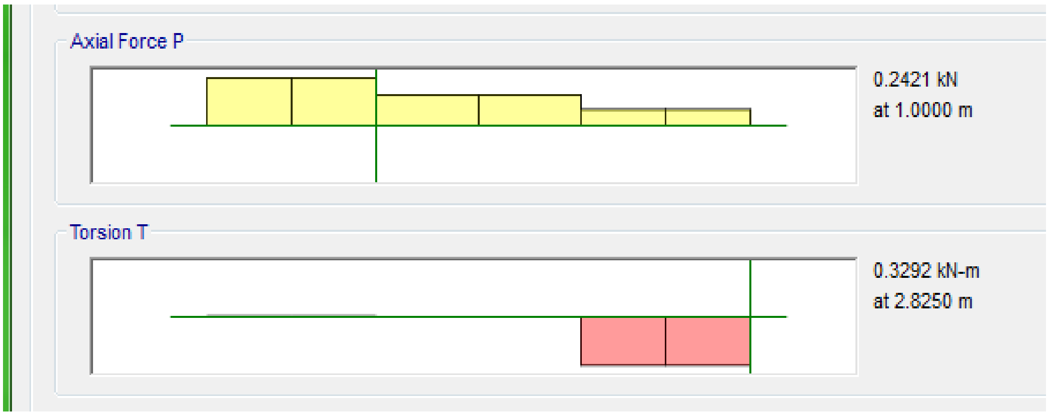

Figure 4.13: Torsion diagram for Model-4

4.5.5 Torsion value and axial force of Model 5 at Re-entrant corner is given below

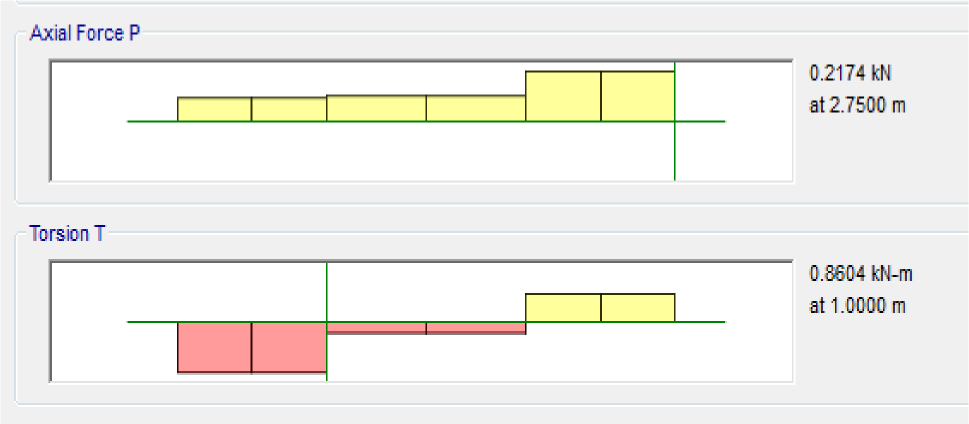

Figure 4.14: Torsion diagram for Model-5

4.5.6 Torsion value and axial force of Model 6 at Re-entrant corner is given below

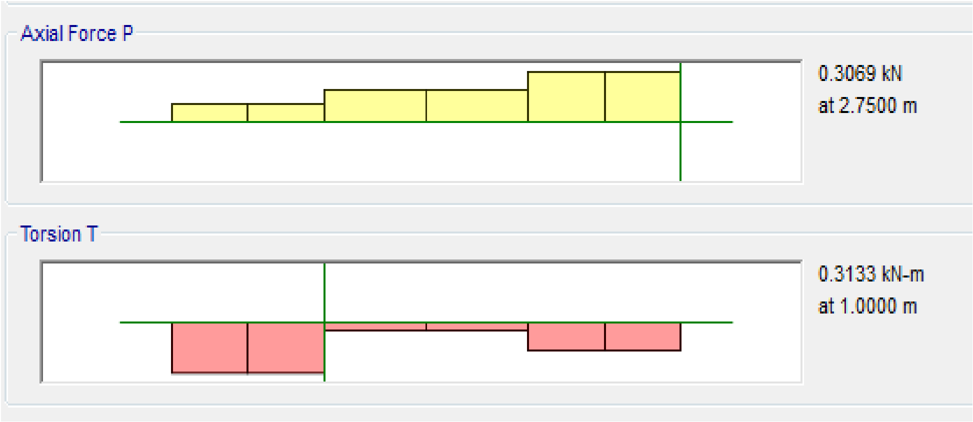

Figure 4.14: Torsion diagram for Model-6

CHAPTER-5

CONCLUSION

After analysis the above six model which have L, T and Plus (+) shape with and without curve beam and above curved beam provided slab which carry the live load 1KN/m2. We find that due to applied curved beam at the re-entrant corner which reduce the cracking condition at the re-entrant corner as well as in the building, which is given below:-

- As we know that storey-overturning moment increase from top storey to bottom storey and value of torsion also increasing. Before applied curved beam we found the torsion value in the beam at 1st storey near the re-entrant corner is about 08598 KN-m but apply curved beam at re-entrant corner then value of the torsion decrease about 51% at that beam and due to provide curved beam at re-entrant corner the value of the storey overturning moment is also decrease about 1%.

- Due to providing the curved beam at the re-entrant corner, the value of base shear is increase about 0.1% which is very low. From this data we can say that to avoid the effect of the re-entrant corner in the building we can provide the curved beam at the re-entrant.

- After study the modal time period in the above model with and without curved beam at the re-entrant corner, then find that model time period is almost same at the higher mode but at the lower model time period is decrease about 0.5 % by providing the curved beam at the re-entrant corner.

- From the above analysis result we found that the value of the storey stiffness is increasing by providing the curved beam at the re-entrant corner, which helps to resist the deformation at the storey of the building. By proving the curved beam at the re-entrant the value of the storey stiffness is increase about 0.6% as compared to without the curved beam at the re-entrant corner.

REFERENCES

[1 B K Raghuprasad, Vinay S, Amarnath.K, *"Seismic Analysis of Buildings Symmetric & Asymmetric in Plan"* SSRG International Journal of Civil Engineering 3.5 (2016): 24-28.

[2].Chaithra S, Anue Marry Mathew, “Behavioural Analysis On Asymmetric Buildings With Solid, Coupled And Shear Wall With Staggered Openings.” International Journal of Emerging Technology and Innovative Engineering Volume 2, Issue 8, August 2016 (ISSN: 2394 – 6598).

[3]. Sharath Irappa Kammar, Tejas D. Doshi, “Non Linear Static Analysis of Asymmetric building with and without Shear Wall.” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 02 Issue: 03 | June-2015.

[4 M. D. Bensalah et al., "Assessment of the Torsion Effect in Asymmetric Buildings under Seismic Loading", Applied Mechanics and Materials, Vols. 256-259, pp. 2222-2228, 2013

[5]. Desai R.M , Khurd V.G. , Patil S.P , Bavane N.U. “Behavior of Symmetric and Asymmetric Structure in High Seismic Zone”. International Journal of Engineering and Techniques - Volume 2 Issue 6, Nov – Dec 2016.

[6]. K. Bindumathi , K.Rajasekhar “comparision of percentage of steel quantities and cost of asymmetric commercial building under gravity loads and seismic loads”. International Journal of advance technology in engineering and science Volume 3 Issue 8, August-2015.

[7]. Shreyasvi .C, B. Shivakumaraswamy, “A Case Study on Seismic Response of Buildings with Re Entrant Corners”. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 4 Issue 05, May-2015.

[8].Neha P. Modakwar, Sanita S. Meshram, Dinesh W.Gawatre, "Seismic Analysis of Structures with irregularities", IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) e-ISSN: 2278-

[9]. Vaishnavi Vishnu Battul, Mithun Sawant, Tejashri Gulve, Rohit Deshmukh "Study of Seismic Effect on Re-entrant Corner Column". Journal of Advances and Scholarly Researches in Allied Education Vol. XV, Issue No. 2, (Special Issue) April-2018, ISSN 2230-7540

[10].Divyashree M, Gopi Siddappa " Seismic Behavior of RC Buildings with Re-entrant Corners and Strengthening". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 63-69

[11]. IS 1893 (Part 1). Indian Standard Criteria for Earthquake Resistant Design of Structures. Bureau of Indian Standards, 2016.