Comparative Study of Buildings by IS standards and ASCE Standards under Seismic Forces

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Abstract: ***This research article is intended to compare the seismic analysis of various shapes of high rise buildings with different International Codes. Two different famous structural building codes have been adopted. Those are Indian Standard and American Standard. In R.C. buildings, frames are considered as main structural elements, which resist shear, moment and torsion effectively. These frames be subjected to variety of loads, where lateral loads are always predominant. Infrastructures of Gulf countries are always notable as they mainly follow AMERICAN standards & EURO standards for construction development. In view of the demand of such code of practice across the developing countries like India, an attempt is made to compare AMERICAN standards with INDIAN standards under Seismic Forces.***

Keywords: Response Spectrum**,** Indian standards, American standards, Seismic Analysis

1. Introduction

We all know that earthquake is a devastating disaster on planet earth. Earthquake codes are revised period by period and updated improvements in the representation of ground motions, soils and structures. Moreover, these revisions have been made in recent years. The Indian Standard Code (IS 1893:2016(Part-1)) was also revised in 2001 and has been effect since 2002. Most recent data of earthquake show that the irregular distribution of mass, stiffness and strengths may cause serious damage in structural system.

1.1 Research and Significance

Tall buildings and towers are attracting civilization from last two decades. From last two decades, metro cities expanded vertically because of the requirement of the large population in urban areas have facing the problem of urban population explosion, scarcity of land, high land prices and unwieldy sprawl of cities and towns, attempts have been made in our major cities to provide more built-up space vertically for both working and living. High rise buildings are constructed to ensure economical use of land in areas where land is scarce and its cost is high. Tall building structures are subjected to lateral loads due to wind and earthquakes. Therefore lateral stiffness is a major consideration in the design of various components in tall buildings. The structural form of a high rise building is influenced strongly by its function, while having to satisfy the requirements of strength and serviceability under all probable conditions of gravity and lateral loading. A structural engineer has to choose a system, which would effectively resist these lateral loads and still meet the economic constraints. Of all the natural calamities, earthquakes and floods are probably the most disastrous leading to large scale destruction of lives and property. In recent times, earthquakes have been very frequent in India, China and several other countries. Latur, Bhuj are the notable earthquakes of recent times in India which had caused massive destruction of human lives and property. Many of the tall buildings had collapsed in these earthquakes and the reasons attributed were poor design and construction practices.

Codal provision is one of the basic and important aspects for a structural design, especially for the high rise building. Different codal provisions are affecting design parameter which leads its effect on the specification and cost of building.

For developing country like India standard specifications are always differ than the developed countries like American and European etc. Standard specifications those developed are good enough for construction practices carried out through the country.

On the other hand standards which contain some parameters that are differ or additionally incorporated with respect to each other as per the situations/conditions demands. In such cases it is always found interesting to compare various standard specifications for particular parameters.

Infrastructures of Gulf countries are always remarkable and it is observed that they mostly follow ASCE standards for variety of structures. So comparison of such codes is very much important from point of facilitating good construction practices in developing Countries like India.

1.2 Objectives

The objectives of research are stated below:

1) Seismic Analysis of L-Type and T-Type shape of G+10 buildings by IS1893(Part-I):2002 Criteria for Earthquake Resistant Design of Structures.
2) Seismic Analysis of L-Type and T-Type shape of G+10 buildings by ASCE 7-10: Minimum Design loads for Buildings and other Structures.
3) Comparing the results of Indian standards with American Standard.

2. Methods of Seismic Analysis

Structural analysis methods can be divided into the following categories

- Equivalent Static Analysis
- Response Spectrum method
- Time history method
- Linear Dynamic Analysis

Equivalent Static Method

Seismic analysis of most structures is still carried out on the assumption that the lateral (horizontal) force is equivalent to the actual (dynamic) loading. This method requires less effort because, except for the fundamental period, the periods and shapes of higher natural modes of vibration are not required. The base shear which is the total horizontal force on the structure is calculated on the basis of the structure's mass, its fundamental period of vibration, and corresponding shape. The base shear is distributed along the height of the structure, in terms of lateral force, according to the code formula. Planar models appropriate for each of the two orthogonal lateral directions are analyzed separately, the results of the two analyses and the various effects, including those due to torsional motions of the structure, are combined. This method is usually conservative for low to medium-height buildings with a regular configuration.

Response Spectrum Method

Multiple modes of responses can be taken into account using this method of analysis. Except for very complex or simple structure, this approach is required in many building codes. The structure responds in a way that can be defined as a combination of many special modes. These modes are determined by dynamic analysis. For every mode, a response is perused from the design spectrum, in view of the modal frequency and the modal mass, and they are then combined to give an evaluation of the aggregate response of the structure. In this we need to ascertain the force magnitudes in all directions i.e. X, Y & Z and afterwards see the consequences for the building. Different methods of combination are as follows.

- Absolute-peak values are added together.
- Square root of the sum of squares(SRSS).
- Complete quadratic combination(CQC).

In our present study we have used the CQC method to combine the modes. The consequence of a response spectrum analysis utilizing the response spectrum from a ground motion is commonly not quite the same as which might be computed from a linear dynamic analysis utilizing the actual earthquake data.

Time History Method

A linear time history analysis overcomes all the disadvantages of a Modal Response Spectrum Analysis provided non-linear behaviour is not involved. This method requires greater computational efforts for calculating the response at discrete times. One interesting advantage of such a procedure is that the relative signs of response quantities are preserved 34 in the response histories. This is important when interaction effects are considered among stress resultants.

3. Problem Formulation

Multi-storied Reinforced concrete, moment resisting space frame have been analyzed using professional software. L-Type and T-Type shape of G+10 buildings frame with six bays in horizontal and six bays in lateral direction is analyzed by Equivalent Static Method and Response Spectrum Method. The plan dimensions of buildings are shown in table below. The plan view of building, 3D view of different frames is shown in figures below.

Table 1: Building Details

Parameters	Values
Material used	M35 & FE500
Plan dimension	18mX18m
Ht. of each storey	3m
Ht. of bottom storey	2m
Density of concrete	25KN/m^3
Poisson Ratio	0.2-concrete and 0.15-steel
Density of masonry	20KN/m^3
Code of Practice adopted	IS456:2000 , IS1893:2002 ACI 318-10 , ASCE 7-10
Seismic zone for IS 1893 : 2002	V
Maximum acceleration parameters S_S & S_1 for ASCE 7-10	S_S=1.4 , S_1=0.4
Importance Factor	1
Response Reduction Factor	For IS 1893(R)=5 , For ASCE (R)=8
Foundation soil	Medium
Slab thickness	150mm
Wall thickness	230mm
Floor Finish	1KN/m^2
Live load	3 KN/m^2
Live load on roof	1.5 KN/m^2
Earthquake load	As per IS 1893-2002 & ASCE 7-10
Size of beam	300mmx500mm
Column size	450mmx450mm
Model to be analyze	L-Type and T-Type shape of (G+10) buildings
Ductility class	IS1893:2002 SMRF ASCE 7-10 SRCMF

3.1 Plan of Structures

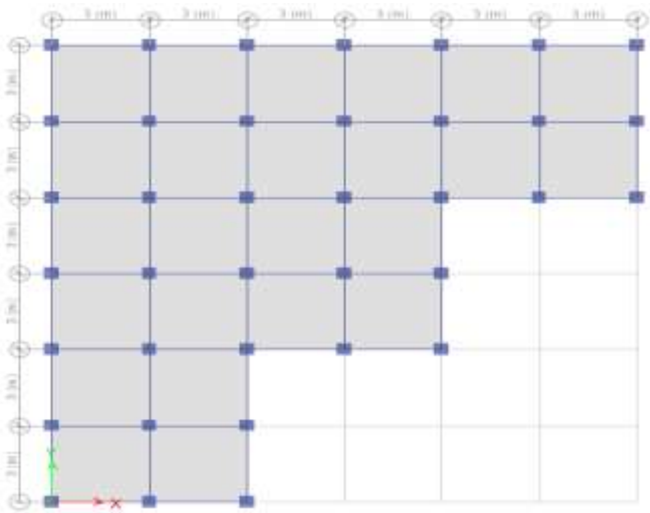

Figure 1: Plan of L-Type structure

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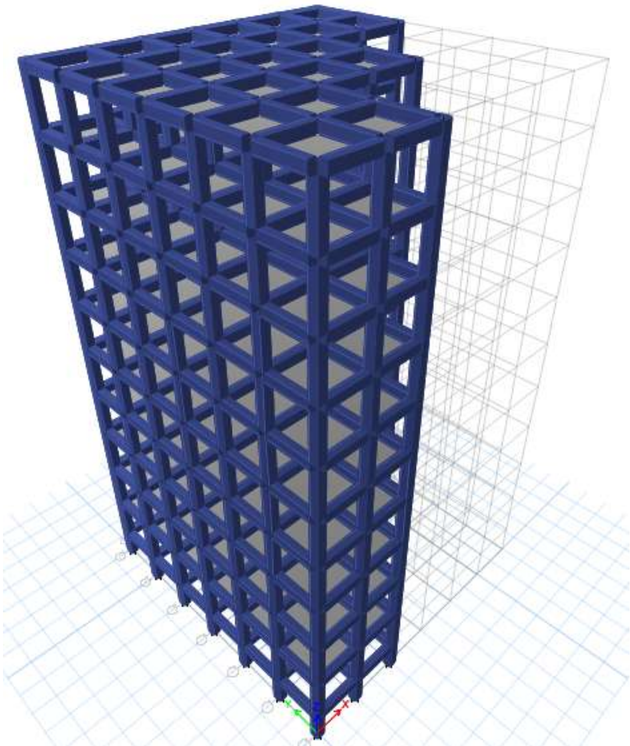

Figure 2: 3D view of structure

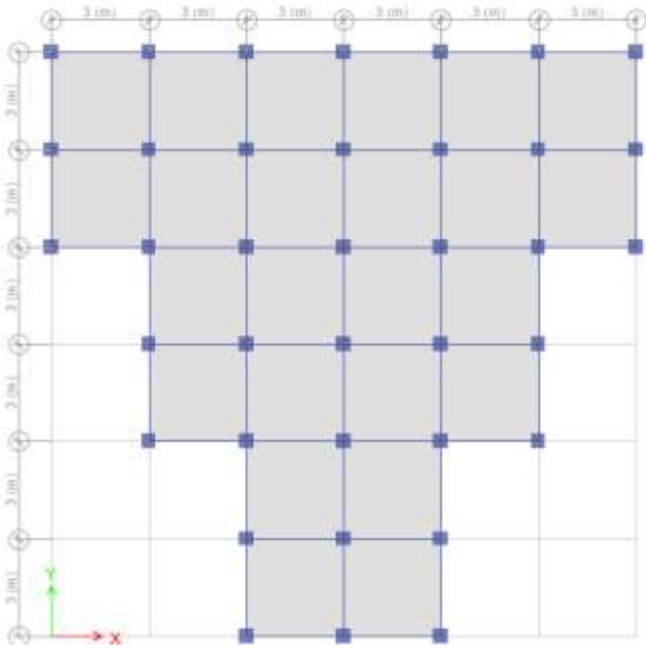

Figure 3: Plan of T-Type structure

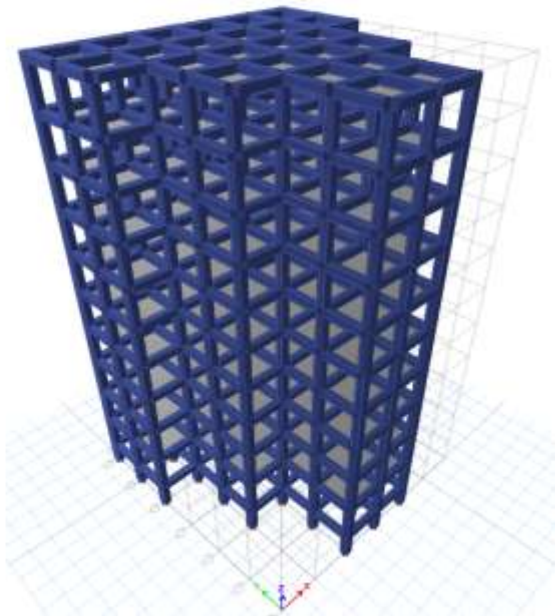

Figure 4: 3D view of structure

4. Results and Discussions

Response spectrum analysis was performed on both structure by Indian Code and American Code. The storey shear, displacement, storey drift and base shear were calculated for each floor and graph was plotted for both structures.

4.1 Comparison of L-Type buildings

Following are the results showed in the graphs are values of seismic analysis of structure. Due to symmetrical plan values along X-direction and Y-direction are same.

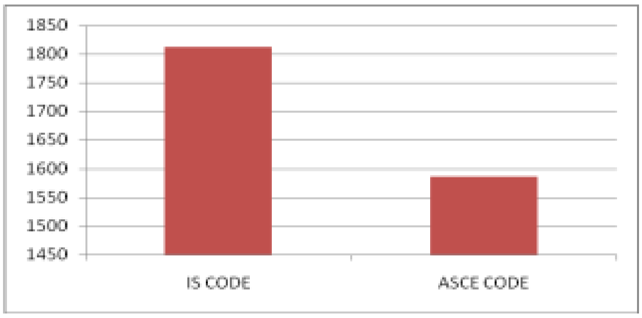

Chart-1: Base shear of L-Type building

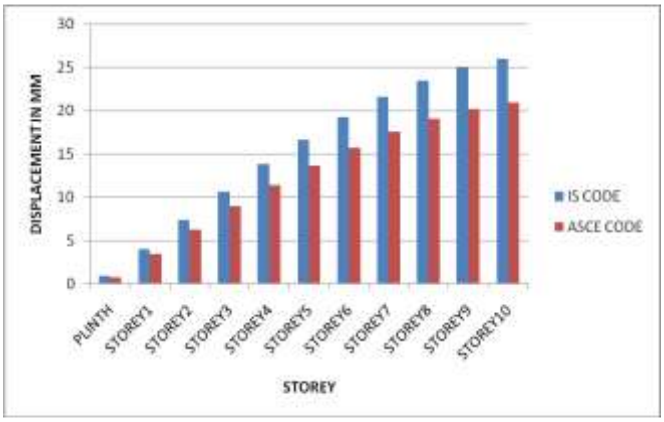

Chart-2: Displacement of L-Type building

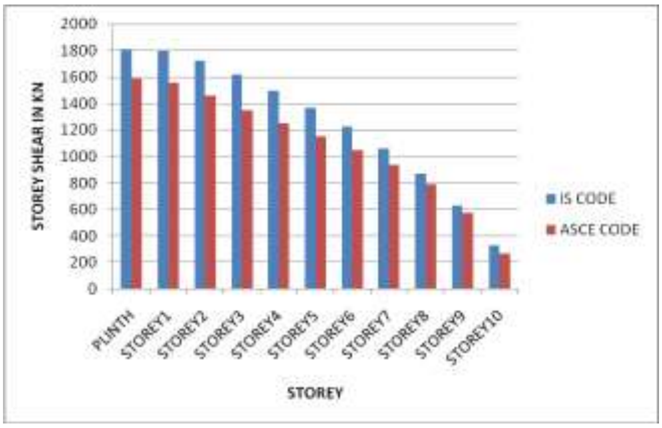

Chart 3: Storey shear of L-Type building

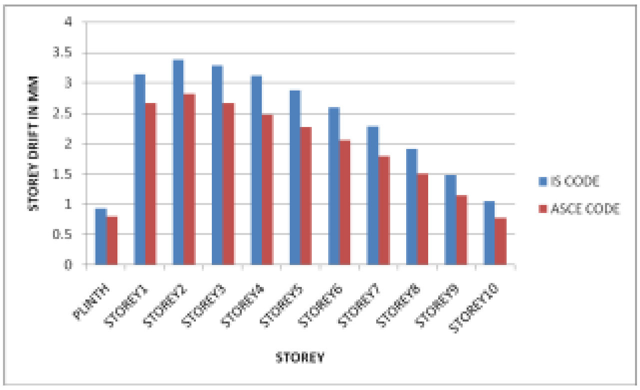

Chart 4: Storey drift of L-Type building

Maximum base shear value was obtained in Indian Code due to high ground acceleration as shown in graph. The maximum storey displacement occurs at the top of the storey according to both scenario. The maximum values of storey displacement obtained in Indian standard with compared to American standard. Similarly the maximum values for storey shear and drift also occur in Indian standard.

4.2 Comparison of T-Type buildings

Following are the results showed in the graphs are values of seismic analysis of structure.

4.2.1 Comparison along X-direction

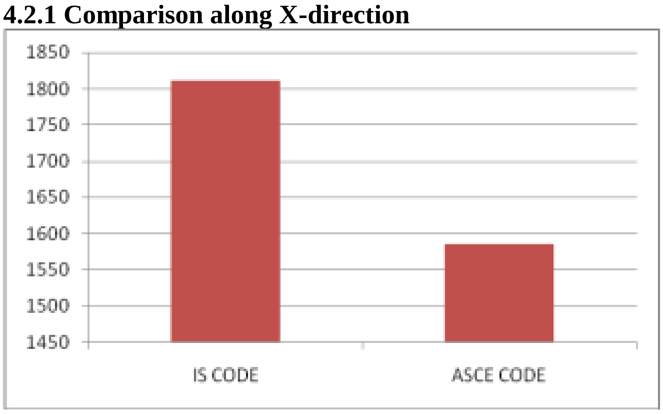

Chart-5: Base shear along X-direction

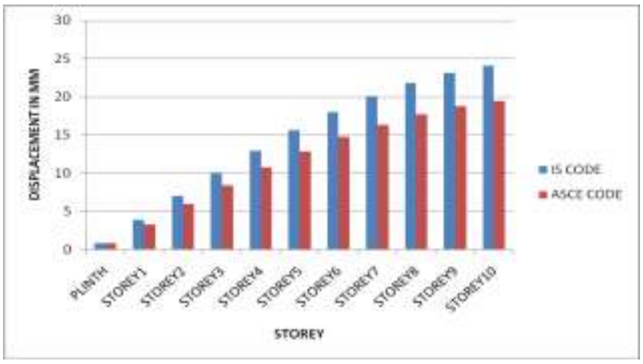

Chart 6: Displacement along X-direction

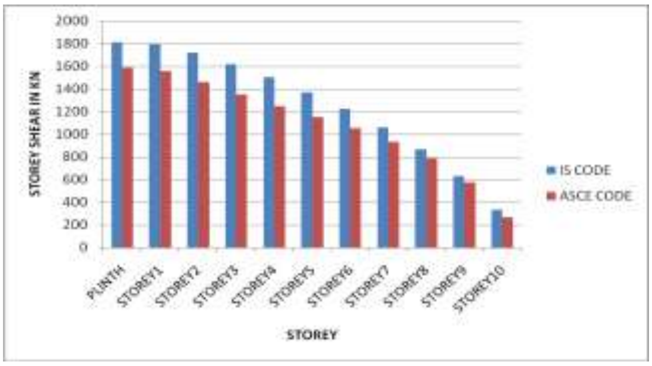

Chart 7: Storey shear along X-direction

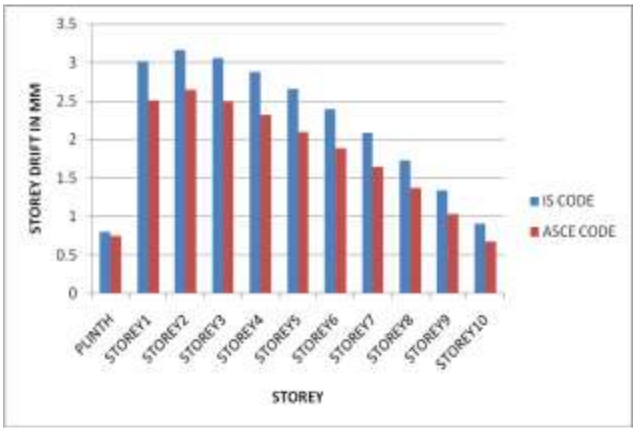

Chart 8: Sorey drift along X-direction

4.2.1 Comparison along Y-direction

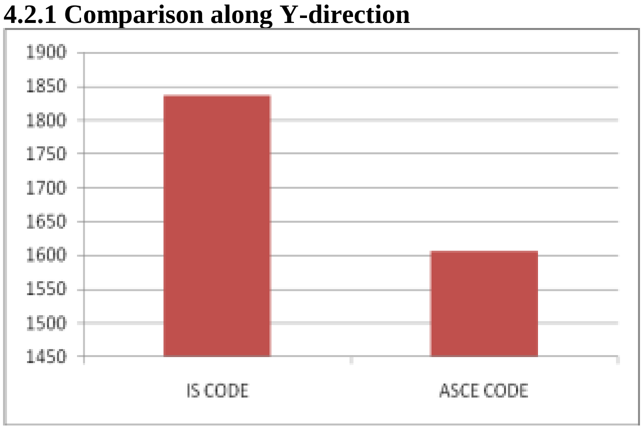

Chart-9: Baser shear along Y-direction

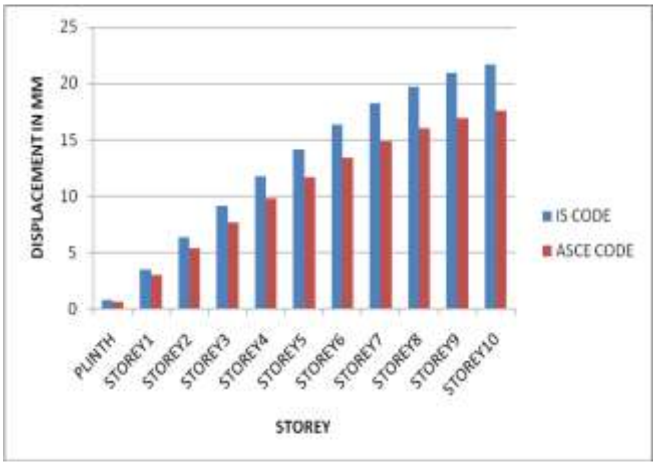

Chart 10: Displacement along Y-direction

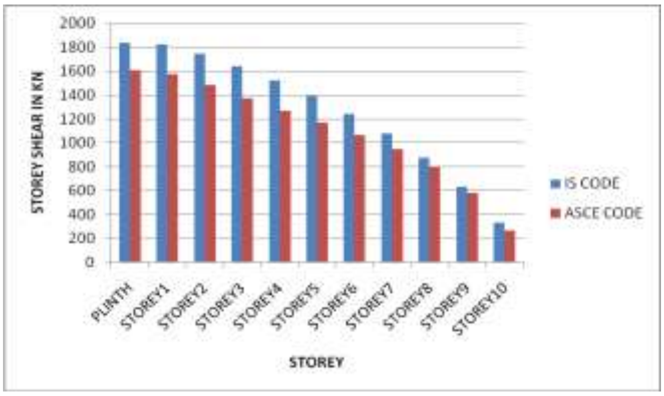

Chart 11: Storey shear along Y-direction

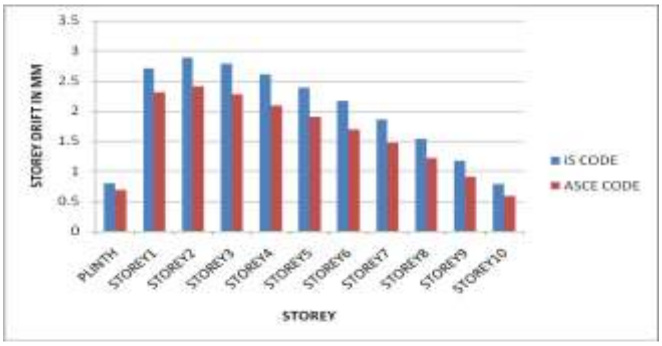

Chart 12: Storey drift along Y-direction

Maximum base shear value was obtained in Indian Code due to high ground acceleration as shown in graph along both X-direction and Y-direction. The maximum storey displacement occurs at the top of the storey according to both scenario. The maximum values of storey displacements obtained in Indian standard with compared to American standard. Similarly the maximum values for storey shear and drift also occur in Indian standard.

5. Conclusion

Based on the analysis results following conclusions have been drawn:

1) Base shear For RCC Frame is maximum according to IS-1893:2002 as compared with ASCE 7-10.
2) As Storey Height is increases, base shear is increases due to increase in weight of structure in both country codes.
3) Storey displacement is considerably reduces in American Standard as compare to Indian Standard.
4) Displacement for T-Type and L-Type models it increases up to 0.23 and 0.24 times in case of Indian code as compare to American Standard along both X-direction and Y-direction because of high ground acceleration.
5) As height of structure is increases the displacements are varying on higher side.
6) Storey shear for T-Type and L-Type models it increases up to 0.14 and 0.23 at top and bottom and 0.15 and 0.24 times at top and bottom in case of Indian code as compare to American Standard because of high ground acceleration.
7) Values for storey shear along X-direction and Y-direction are nearly similar.
8) The maximum storey drift occur in Indian standard as compared with American standard.
9) For T-Type and L-Type models drifts are 0.19 and 0.18 times higher in Indian standard as compare to American standard.
10) On the basis of analysis the values of Indian standard are more as compare to American standard because of lack of seismic data such as detailed ground acceleration for different timings and etc.

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