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Response Spectrum Analysis of Bare Frame & X-Bracing System on R.C. Building using ETABS

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Abstract —*In seismic design of RCC building, Bracings act as the major earthquake resisting member. Bracing system is a great potential for lateral load resistant. The properties of this bracing dominate the response of the building and therefore it is important to evaluate to seismic response. In this, present G+10 storied RCC structure is taken for earthquake analysis. Two types of structure Bare frame & X-braced frame are considered for the study. Response Spectrum Analysis is carried out using ETABS software. The parameters considered for the analysis are Base shear, Story drift & Story displacement.*

Keywords*-Base Shear, Displacement, Drift, Response Spectrum method, Seismic Analysis.*

Abbreviation:

R	*Response reduction factor*
g	*Acceleration due to gravity*
W	*Seismic weight of the structure*
I	*Importance factor*
V_B	*Design seismic base shear*
V_{ik}	*Shear force in storey i in mode k*
IL	*Response quantity due to imposed load*
DL	*Response quantity due to dead load*
Z	*Zone factor*

I. INTRODUCTION

Earthquakes are the phenomenon that releases high amount of energy in short time through the earth. In the early of twentieth century, structural engineers became conscious of potential hazard induced by strong earthquakes. Structures designed to resist moderate and frequently occurring earthquakes must have sufficient stiffness and strength to control deflection and prevent any possible collapse. The structures should be designed in a way that they have enough resistant against severe earthquakes and they should also provide comfort and peace of mind to the residents who live there against weaker earthquakes. In other words, a structure not only dissipate a considerable amount of imported energy by its ductile behavior, but also it should be able to control the deformations and transfer the force to the foundation through enough lateral stiffness in ground motions. Braced frame system offer an attractive solution to satisfy multiple design Objectives. Their elastic properties provide the stiffness and strength needed to achieve operational performance objectives, which are primarily defined by the performance of non-structural elements. If detailed properly, their displacement and energy dissipation capacities can meet severe inelastic deformation demands resulting from extreme events.

The design of tall buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The design criteria are, strength, serviceability, stability and human comfort. Earthquakes have become a frequent event all over the world. It is very difficult to predict the intensity, location, and time of occurrence of earthquake. Structures adequately designed for usual loads like dead, live, wind, etc. may not be necessarily safe against earthquake loading. It is neither practical nor economically viable to design structures to remain within elastic limit during earthquake. The design approach adopted in the Indian Code IS 1893(Part I): 2002 'Criteria for Earthquake Resistant Design Of Structures' is to ensure that structures possess at least a minimum strength to withstand minor earthquake occurring frequently, without damage; resist moderate earthquakes without significant structural damage though some non-structural damage may occur; and aims that structures withstand major earthquake without collapse. Structures need to have suitable earthquake resistant features to safely resist large lateral forces that are imposed on them during frequent earthquakes. Ordinary structures for houses are usually built to safely carry their own weights. Low lateral loads caused by wind and therefore, perform poorly under large lateral forces caused by even moderate size earthquake. These lateral forces can produce the critical stresses in a structure, set up undesirable vibrations and, in addition, cause lateral sway of structure, which could reach a stage of discomfort to the occupants.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.

II. STUDY AREA AND PROBLEM IDENTIFICATION

From past earthquakes it is observed that if the structures are not properly analyzed and constructed with required quality, then it may lead great destruction and loss to human lives. It has been proved that many of structures are fully or partially damaged due to earthquake. This fact was never ignored while design of multistoried buildings by the structural engineers, researchers to ensure safety against earthquake forces while erection. So, there is need to determine seismic responses of such buildings. Seismic analysis of the structure is carried out for determination of seismic responses by different analysis methods which is important techniques for structural seismic analysis especially when the evaluated structural response is non- linear in nature. Due to fast urbanization construction of a large number of multistoried buildings, many existing RC buildings located in seismic zones are deficient to withstand earthquakes. Seismic safety of these building is of importance. Hence, it is necessary to take in to account the seismic load for the design of high-rise buildings. Seismic loads are required to be carefully modeled so as to assess the real behavior of structure with a clear understanding that damage is expected but it should be regulated. Multistoried buildings are designed as per Earthquake code IS: 1893-1984. But during Bhuj earthquake, in Ahmedabad two buildings which were designed as per IS:1893-1984 and were found to be seriously damaged due to mass irregularity as a swimming pool was located at the 10th floor. Here excess mass leads to increase in lateral inertia forces, reduced ductility of vertical load resisting elements and increased propensity towards collapse. Excess mass on higher floors produce more unfavorable effects than those at lower floors.

The response spectrum represents an envelope of upper bound responses, based on several different ground motion records. This method is an elastic dynamic analysis approach that relies on the assumption that dynamic response of the structure maybe found by considering the independent response of each natural mode of vibration and then combining the response of each in same way. This is advantageous in the fact that generally only few of the lowest modes of vibration have significance while calculating moments, shear and deflections at different levels of the building.In this present work non-linear dynamic analysis of G+10 storied RCC building having mass irregularity considering different time histories is carried out. Here a G+10 stories building with mass irregularity has been modeled for seismic analysis. The effects on floor which has different loads (mass irregularity) in multistoried building with response spectrum analysis by ETABS software. ETABS provides both static and dynamic analysis for wide range of gravity, thermal and lateral loads.

III. METHODOLOGY

E-TABS 2016 software is used to develop 3D model and to carry out the analysis. In this study, 10 storey RC buildings of Bare frame and X-braced models are fixed at base. The building has plan dimensions of (72 m x 72 m) and symmetric about both X and Y directions to avoid torsional effects as shown in fig.2. The storey height is 3m in the entire floor and 3.3m in the ground Floor. Building is designed according to IS: 456-2000 and earthquake loading will be applied as per IS: 1893-2002. For the models, live load and dead load are taken as 3 kN/m2 and 1 kN/m2 respectively. Load combinations are applied as per the recommendation of Indian standard codes. M25 grade concrete and Fe415 structural steel is used. Equivalent static method will be used for seismic analysis Seismic parameters considered for this study are as follows:

- Zone factor for seismic zone III = 0.16
- Soil site factor for medium soil condition = II
- Importance factor = 1
- Response reduction factor = 5

For the analysis of the buildings the following dimensions are considered which are elaborated below in table 1.

Table:-1 Dimensions of Building Components

No. of stories	10
Beam size	300x600mm
Column size	600x600mm
Slab thickness	125mm
Steel bracing	ISA 150x150x15

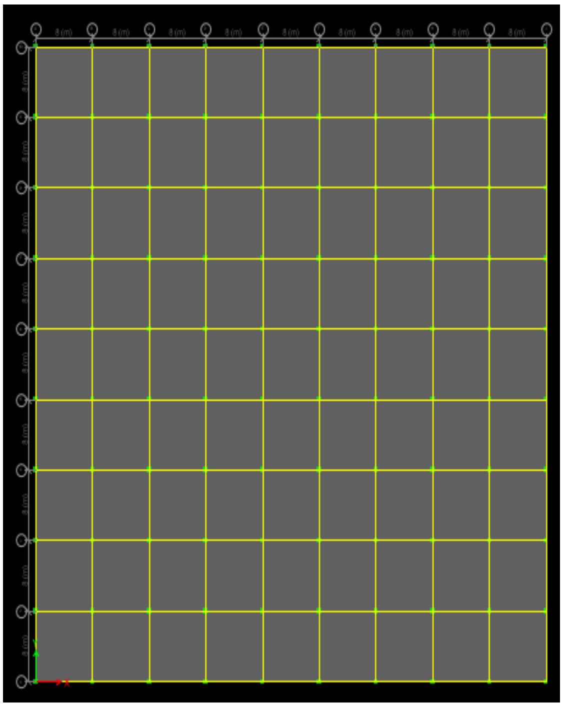


Figure:-1 Plan of Building

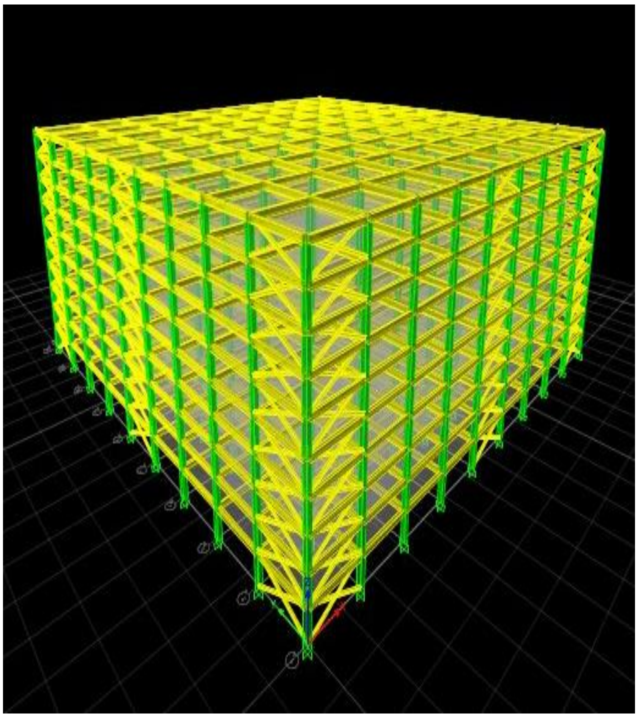


Figure:-2 3D view of X-Braced Frame

IV. RESULTS

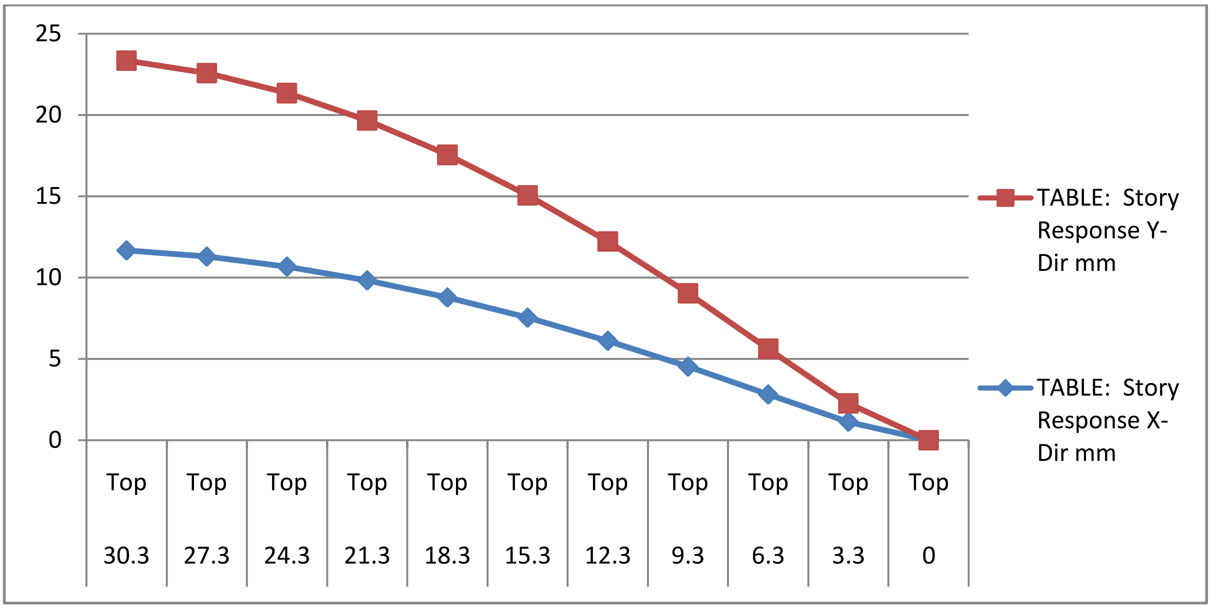
From the results of analysis, it's observed that the value of top storey drift, top storey displacement and top storey stiffness in x and y direction are same.

A. STOREY DISPLACEMENT:-

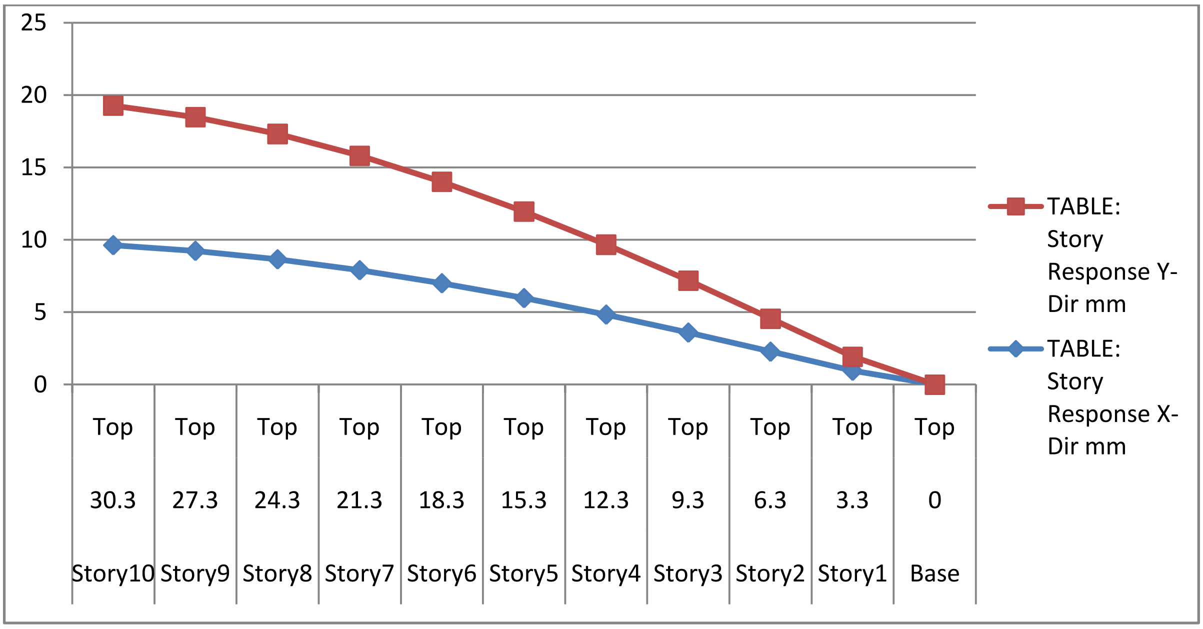
Table:- 2 Top Storey Displacement

Model	Response Spectrum Max. Storey Displacement (mm)
Bare Frame	11.671
X – Braced Frame	9.632

From the table 2 following observations are drawn for the Storey Displacement.



Graph:- 1 Max. Storey Displacement in Bare Frame



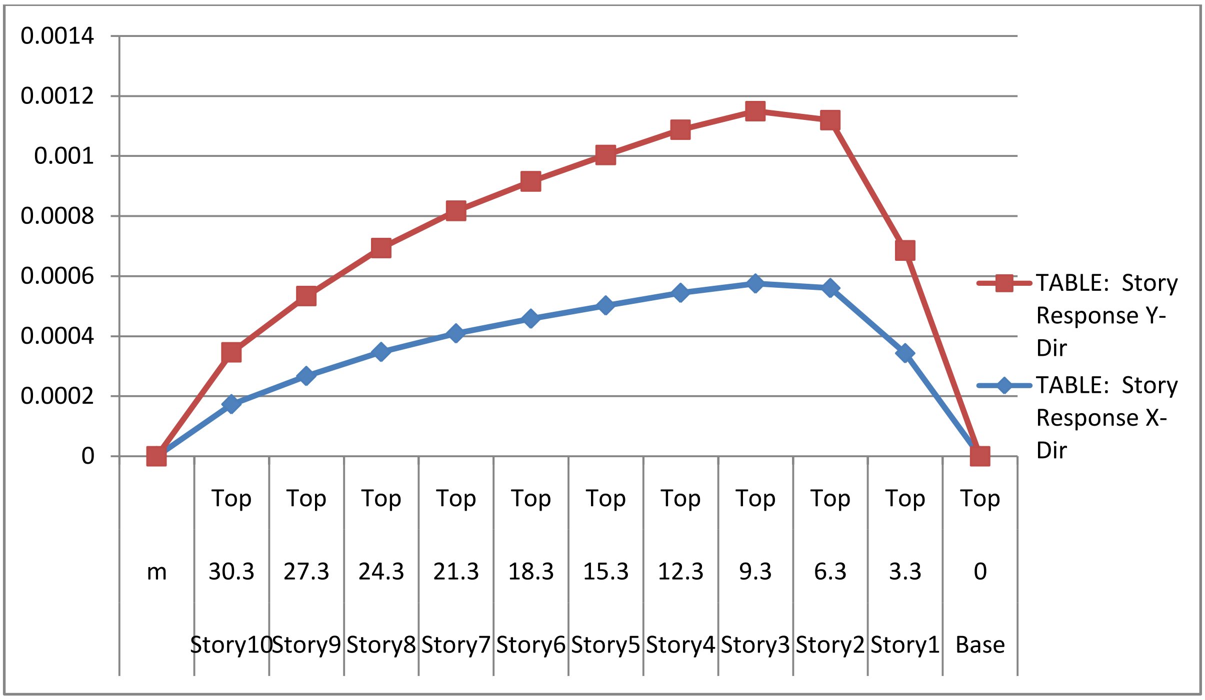
Graph:- 2 Max. Storey Displacement in X-Braced Frame

B. STOREY DRIFT:-

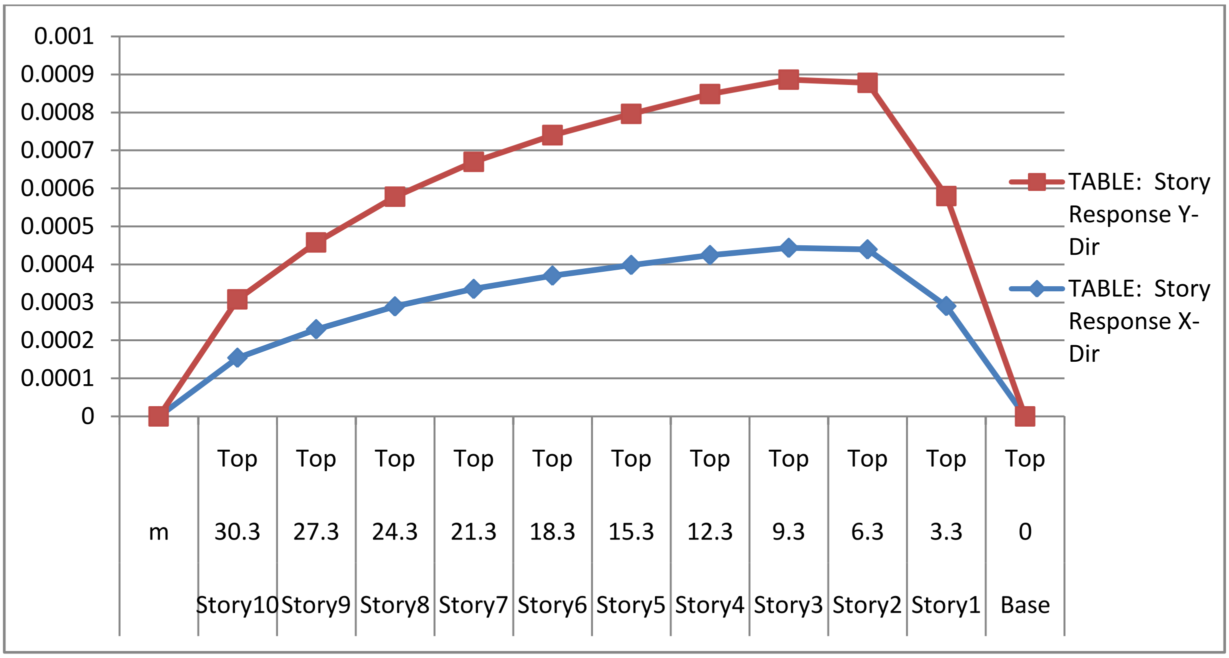
Table:- 3 Top Storey Drift

Model	Response Spectrum Max. Storey Drift (mm)
Bare Frame	0.000173
X – Braced Frame	0.000154

From the table 3 following observations are drawn for the Storey Drift.



Graph:- 3 Max. Storey Drift in Bare Frame



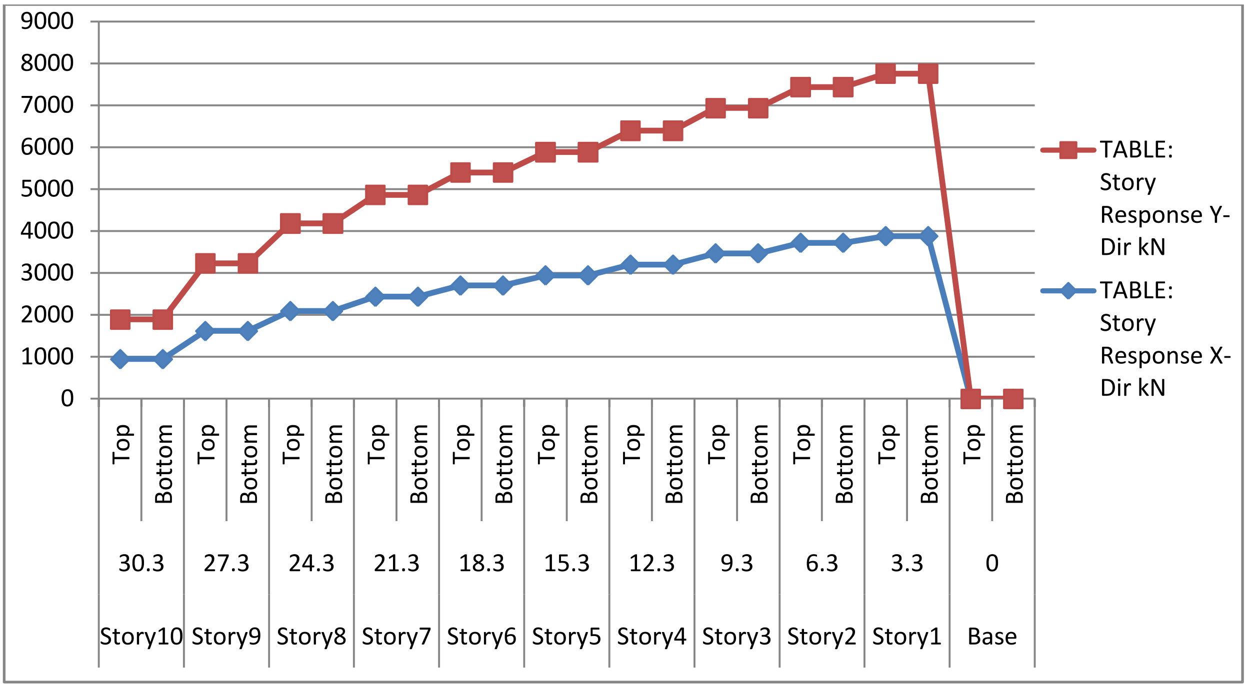
Graph:- 4 Max. Storey Drift in X-Braced Frame

C. BASE SHEAR:-

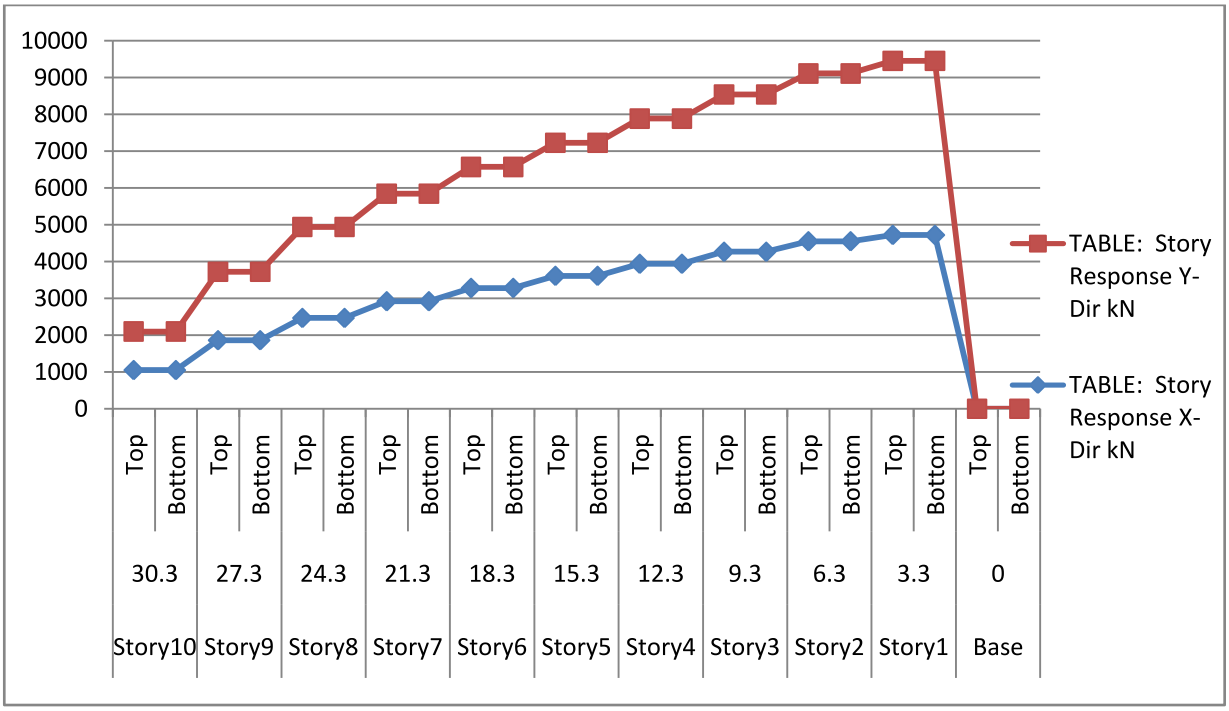
Table:- 4 Top Base Shear

Model	Response Spectrum
Bare Frame	944.6195
X – Braced Frame	1049.8395

From the table 4 it is observed that after applying bracings in the buildings the Base Shear increases.



Graph:- 5 Base Shear in Bare Frame



Graph:- 6 Base Shear in X-Braced Frame

V. CONCLUSION

The following conclusions are drawn based on present study:-

- Bracing imparts better strength and stiffness to the structure.
- It is observed that the steel braced buildings base shear increases compared to without steel bracing which indicates that the stiffness of building increases.
- Addition of bracings to the bare frames shows reduction in lateral displacement and storey drift.

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