Time History Analysis of the Base Isolated Steel Structure

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Abstract

In this research paper the main part of study was to check the response of the base isolation of the steel structure under time history analysis. Base isolation is one of the most widely accepted seismic protection systems used in structures in earthquake prone areas. The base isolation system separates the structure from its foundation and primarily moves it relative to that of the upper structure. The aim of this study is to reduce the base shear and story drifts due to earthquake ground excitation, applied to the superstructure of the building by installing base isolation devices at the foundation level and then to compare the different performances between the fixed base condition and base-isolated condition. In this study, the (G+9) unsymmetrical steel. Structure is used as test model. Friction base isolator is used as isolation system in this study. Nonlinear time history analysis is used on both of fixed base and base isolated structure. The comparative study of the acceleration, displacement and base shear was carried out for both fixed base and base isolated structure. It is found that the displacement is increased with period of the structure in case of base isolated structure and the acceleration is reduced and vice versa.

Keywords:- *displacement, base shear, acceleration, base isolation, nonlinear time history analysis, friction base isolator.*

I.INTRODUCTION

EARTHQUAKE

Earthquakes are the earth's natural means of releasing stress. When the earth's plates move against each other, stress is put on the lithosphere. When this stress is great enough, the lithosphere breaks or shifts (elastic rebound theory).earthquake never kill people it is structures made by us which are deficient to sustain earthquake forces. The earthquake generates or induces forces into the structure members which lead to their failure if they aren‟t able to cope up. As the plates move, they put forces on themselves and each other. When the force is large enough, the crust is forced to break. When the break occurs, the stress is released as energy which moves through the earth in the form of waves, which we feel and call an earthquake.

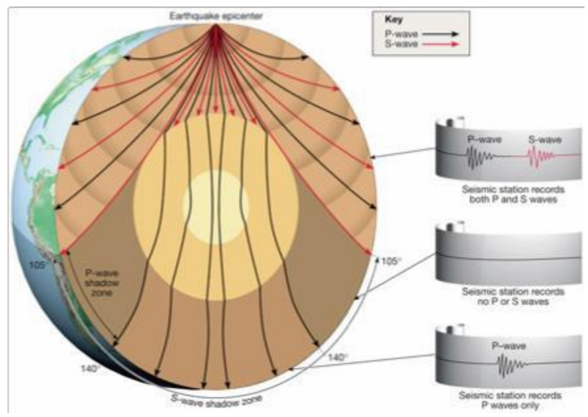


Fig 1

Energy is released during an earthquake in several forms, including as movement along the fault, as heat, and as seismic waves that radiate out from the "source" and causes the ground to shake, sometimes hundreds of km's away. A seismic wave is simply a means of transferring energy from one spot to another within the earth. Although seismologists recognize different types of waves, we are interested in only two types: p (primary) waves, which are similar to sound waves, and s (secondary) waves, which are a kind of shear wave. Within the earth, p waves can travel through solids and liquids, whereas s waves can only travel through solids.

The speed of an earthquake wave is not constant but varies with many factors. Speed changes mostly with depth and rock type. P waves travel between 6 and 13 km/sec. S waves are slower and travel between 3.5 and 7.5km/sec.

FRICTION BASE ISOLATOR

The friction base Isolator consists of central rubber core, sliding rings, peripheral rubber core with the outer covering of rubber. The friction Base Isolator is represented mathematically as shown in the figure. Whereas K stands for Stiffness for damping for displacement and the X is showing the direction.

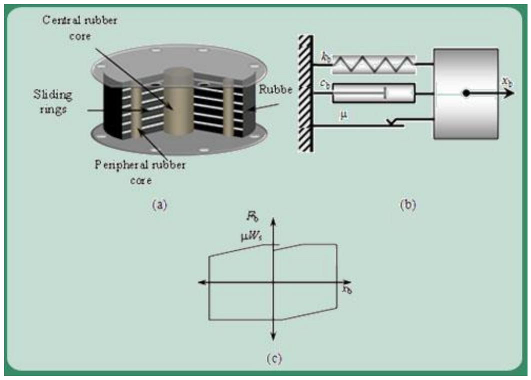


Fig 2

Stiffness of isolator = 1.7 x 10^6 kn/m Radius of sliding face = 0.0254m

TIME HISTORY ANALYSIS

Provides for linear or nonlinear evaluation of dynamic structural response under loading which may vary according to the specified time function. Dynamic equilibrium equations, given by

$$K\,u(t) + c\,{}^{d}/_{dt}\,u(t) + m\,d^{2}/_{dt}\,u(t) = r(t),$$

are solved using either modal or direct-integration methods. Initial conditions may be set by continuing the structural state from the end of the previous analysis. :

Step size – direct-integration methods are sensitive to time-step size, which should be decreased until results are not affected.

Hht value – a slightly negative hilber-hughes-taylor alpha value is also advised to damp out higher frequency modes, and to encourage convergence of nonlinear direct- integration solutions.

Non-linearity: material and geometric nonlinearity, including p-delta and large-displacement effects, may be simulated during nonlinear direct-integration time-history analysis.

Links – link objects capture nonlinear behavior during modal (fna) applications.

II. DETAILS OF MODEL

The models which have been adopted for study are unsymmetrical (G+9) and one symmetrical building located in zones III and the Elcentro Earthquake was considered.

2.1 T SHAPED STRUCTURE

2.2 L SHAPED STRUCTURE

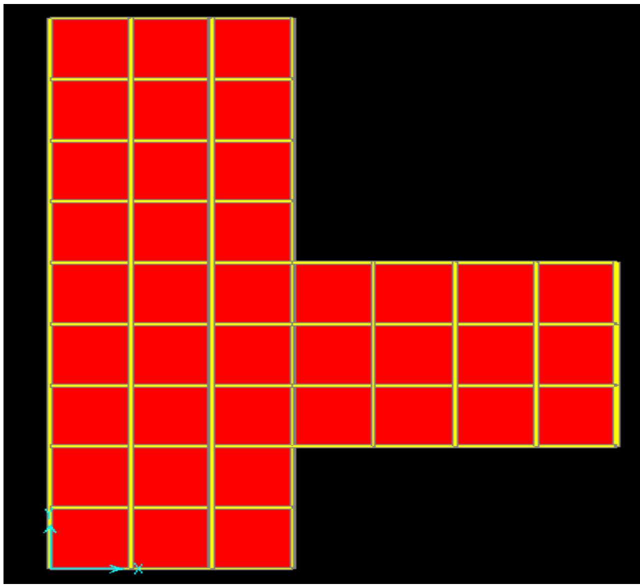


Fig 2a

Length in x direction = 36m

Length in y direction = 35m

Height in z direction = 35m

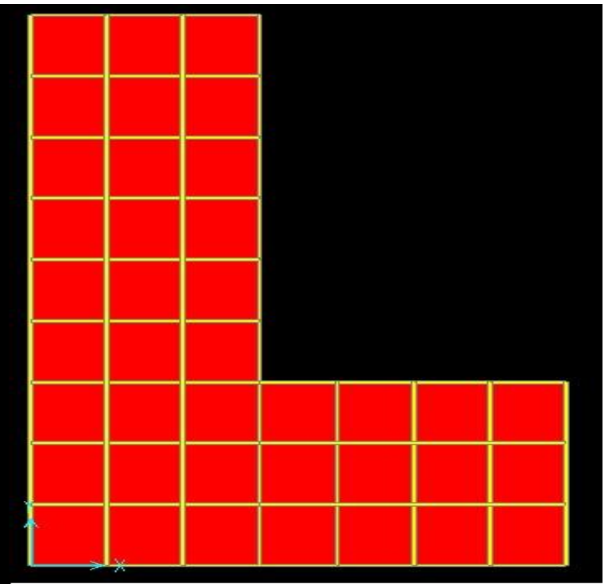


Fig 2b

Length in x direction = 36m

Length in y direction = 35m

Height in z direction = 35m

SQUARE SHAPED STRUCTURE

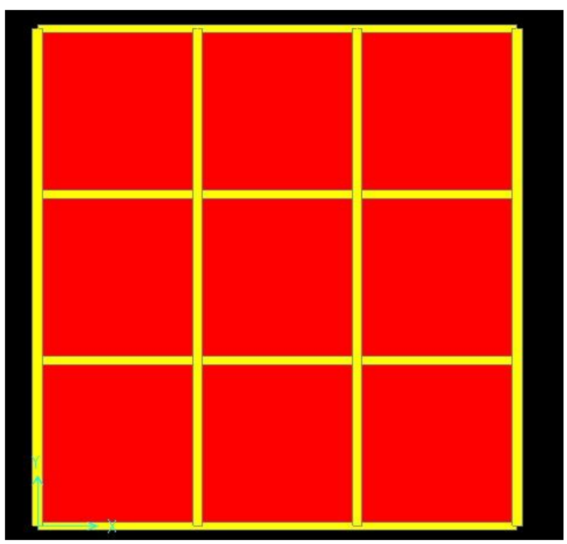


Fig 2c

Length in x direction =15m Length in y direction =15m Length in z direction =35m

MATERIAL AND STRUCTURAL PROPERTIES: Beam, column and slab specifications are as follows:
Column = ISHB 250
Beam = ISMB400

Slab thickness=120mm

Floor thickness =150mm

The required material properties like mass, weight density, modulus of elasticity shear modulus and design values of the material used can be modified as per requirements or default values can be adopted. Beams and column members have been defined as „frame elements with the appropriate dimensions and reinforcement. Soil structure interaction has not been considered and the columns have been restrained at the base. Slabs are defined as area elements having the properties of shell elements with the required thickness.

STEEL PROPERTIES

Mass per unit volume = 7.85 kN Weight per unit volume = 75.85 kN/M^3
Modulus of elasticity, Ec = 2.5x10^7 kN/m^2
Damping ratio= 0.05
Poisson's ratio= 0.20
Shear modulus = 1500
Co-efficient of thermal Expansion = 5.5x10^ -6

Live loads have been assigned as uniform area loads on the slab elements as per IS 1893 (part 1) 2002
Live load on 2002 all other floors = 3.0 KN/m^2

The design lateral loads at different floor levels have been calculated corresponding to fundamental time period and are applied to the model. In our case, the slabs have been modelled as rigid diaphragms and in this connection, the centre of rigidity(mass) and centre of gravity of building is considered same in order to neglect the effect of torsion. E.L in Y (Ux) direction
=8.331x10^- 4 KN/m^2 E.L in X (Uy) direction (30%) = 2.5x10^-4 KN/m

III. ANALYSIS RESULTS

Case I (T SHAPED STRUCTURE)

In the first case the T shaped Structure was considered and the following results were acquired under time History Analysis.

- Joint Acceleration
- Joint Displacement
- Base Shear

Joint acceleration

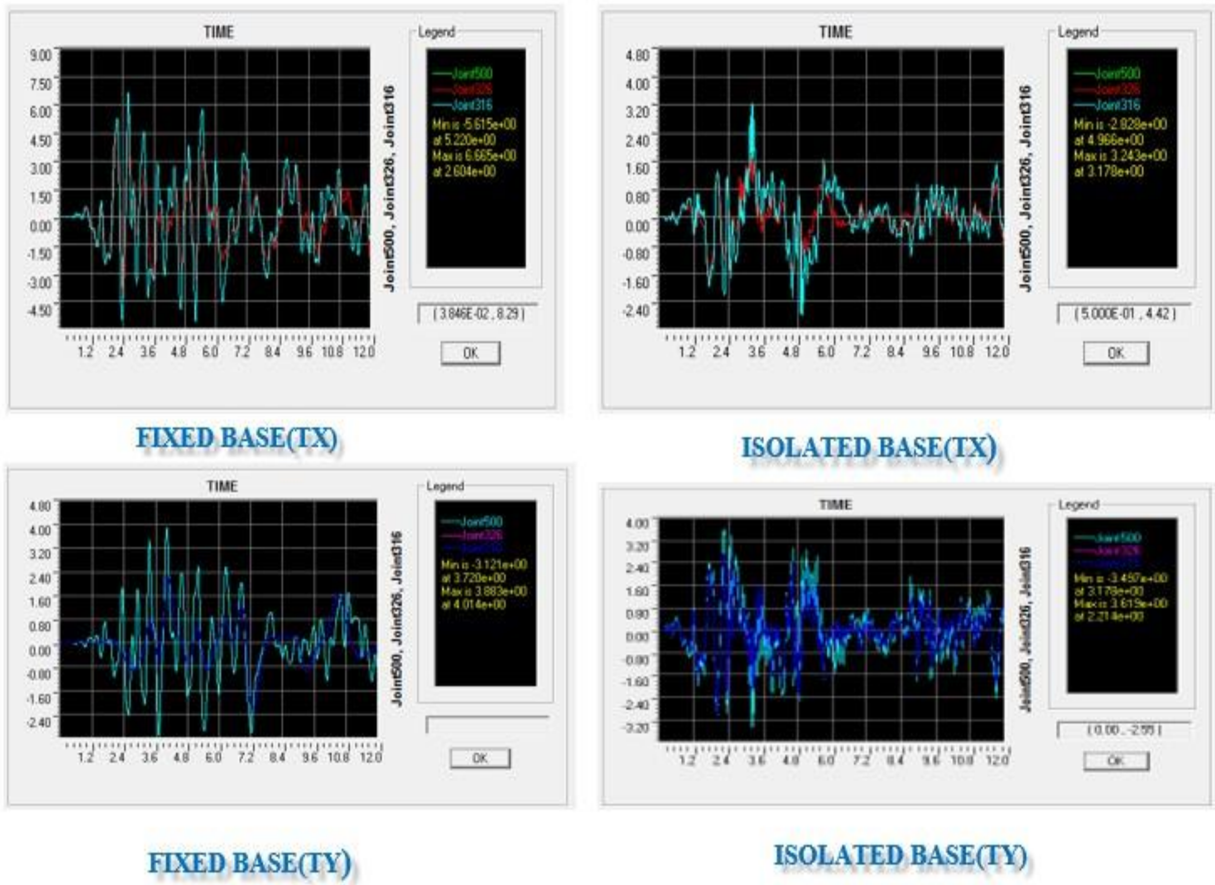


Fig 4(a)

Figure 4(a) shows graph between time and acceleration in x direction and y direction for both fixed base and isolated base. Minimum and maximum acceleration for both directions in both bases. The nodes considered for the observation are Node 500,361,326.from the value observed values the acceleration seen in the base isolated structure is less as compared to the Structure with Fixed base system.

Joint displacement

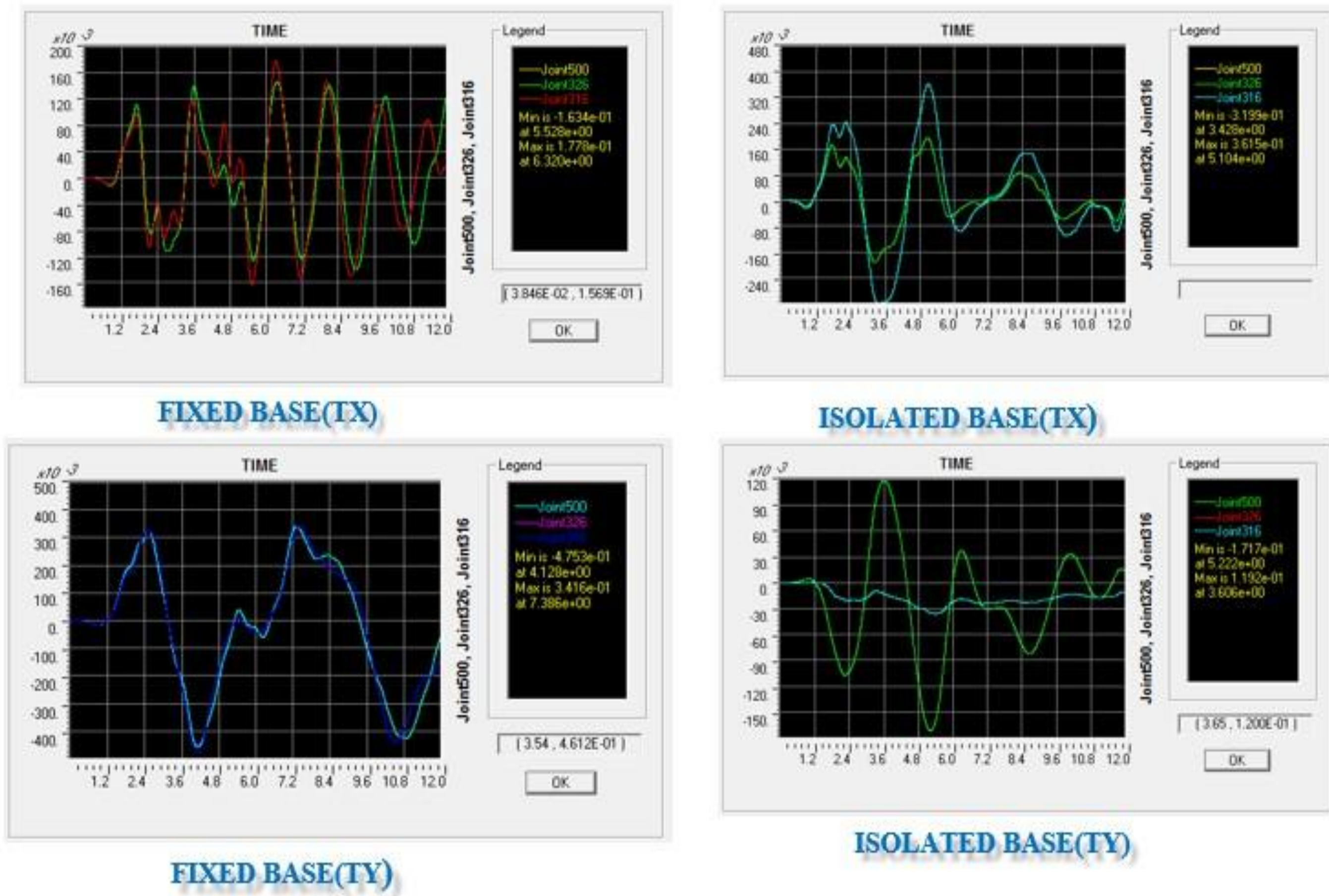


Fig 4(b)

Figure 4(b):-it shows graph between time and displacement in x direction and y direction for both fixed base and isolated base. Minimum and maximum displacements for both directions are recorded for both the bases. Joint that was considered joint No 500,326,316. The displacement with the fixed base system is less as compared to the Base Isolated System as in case of base isolated system the structure is allows displacing.

Base shear

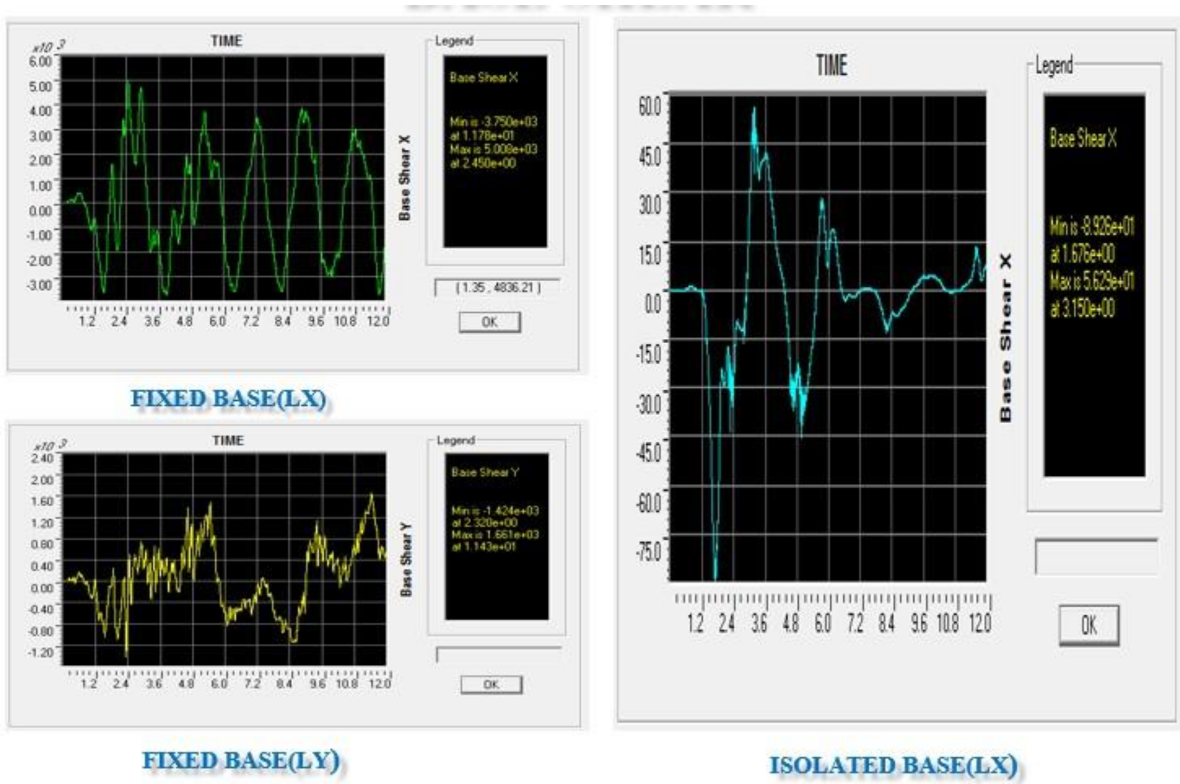


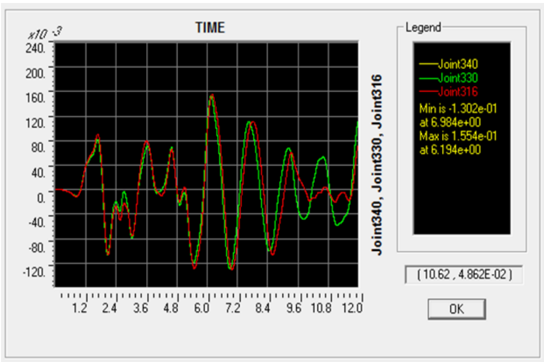
Fig 4(c)

Figure 4(c):-it shows graph between time and base shear in x direction and y direction for fixed base and isolated base in x direction. The base shear in the y direction was zero as the structure was free to move so no induced shear was generated in the structure but in the x direction the base shear was very high as compared to the base isolated structure since the base shear is very low this will result in less damage to the structure.

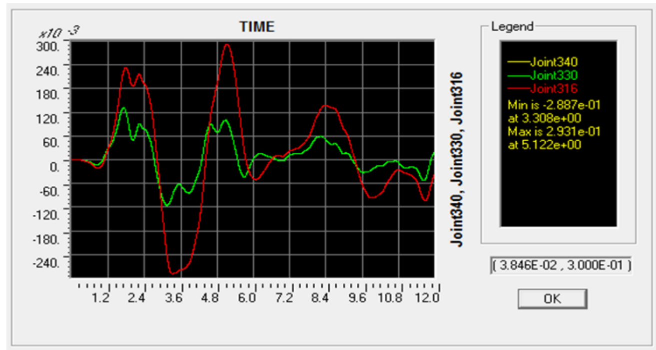
CASE II (L SHAPED STRUCTURE)

The graph generated between time versus various components such as Acceleration,displacement,Base Shear are shown below

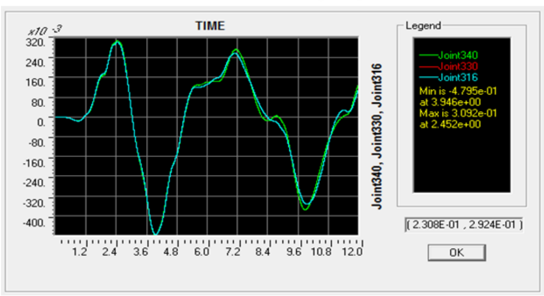
Joint acceleration



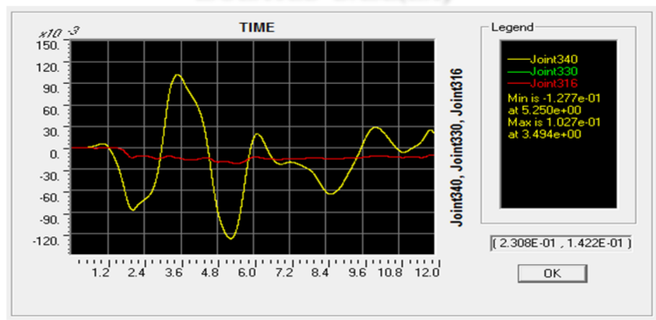
FIXED BASE(LX)



ISOLATED BASE(LX)



FIXED BASE(LY)

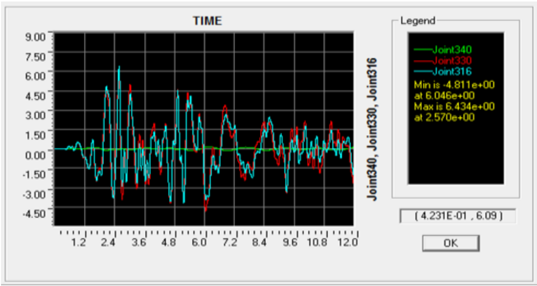


ISOLATED BASE(LY)

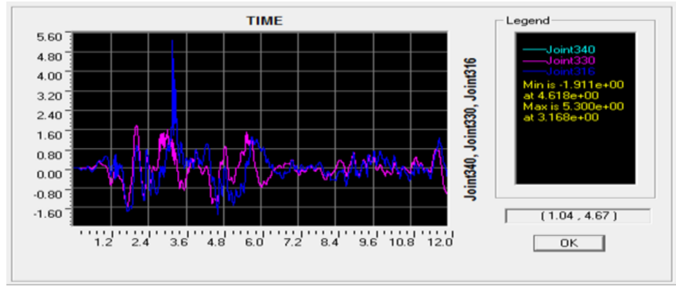
Fig 5(a)

Fig 5(a) :-it shows graph between time and displacement in x direction and y direction for both fixed base and isolated base in the case of PLAN 2L. Minimum and maximum displacements for both directions are recorded for both the bases.

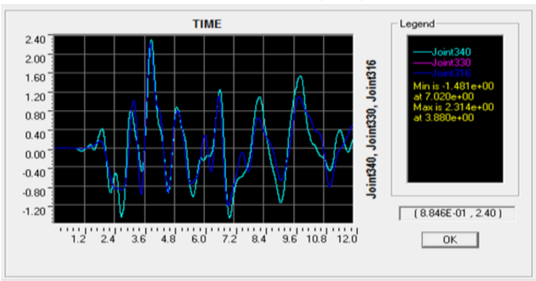
Joint displacement



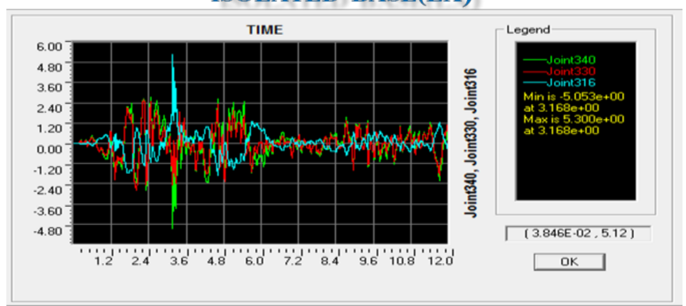
FIXED BASE(LX)



ISOLATED BASE(LX)



FIXED BASE(LY)

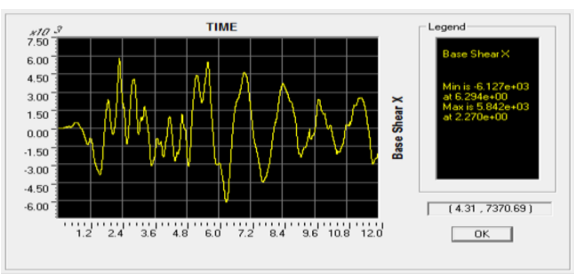


ISOLATED BASE(LY)

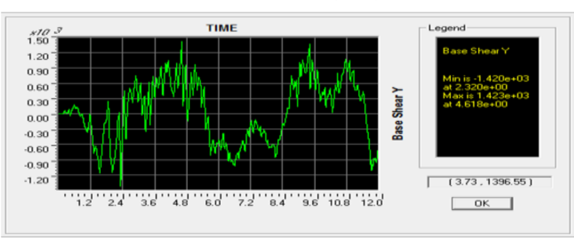
Fig 5(b)

Fig 5(b):-it shows graph between time and acceleration in x direction and y direction for both fixed base and isolated base in case of PLAN 2L. Minimum and maximum acceleration for both directions in both bases.

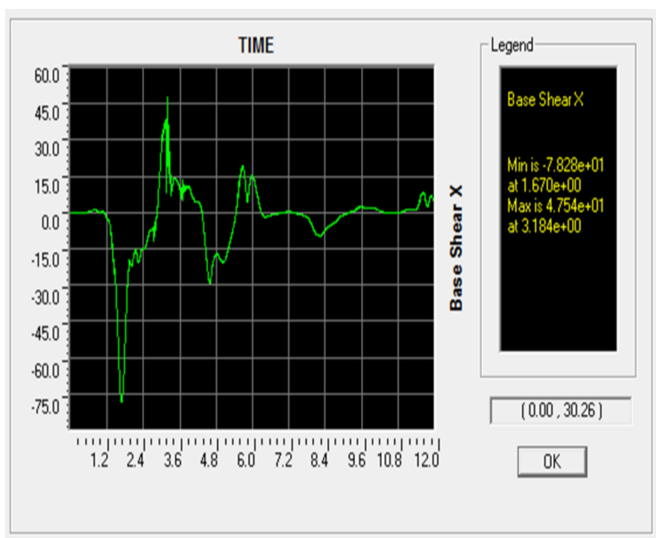
Base shear



FIXED BASE(LX)



FIXED BASE(LY)



ISOLATED BASE(LX)

Fig 5(c)

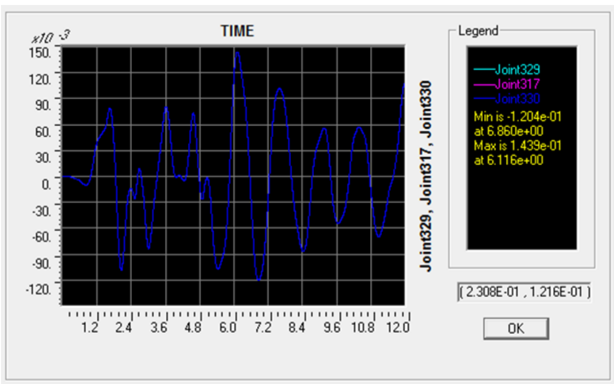
Fig5(c) :-it shows graph between time and base shear in x direction and y direction for fixed base and isolated base in x direction in the case of plan 2L. Minimum and maximum base shear for both directions are recorded in fixed base and x direction in isolated base. Very less base shear was obtained in x direction with the base isolated structure and zero base shear was experienced in y direction for the said structure.

Case III (SQUARE STRUCTURE (S SHAPED)

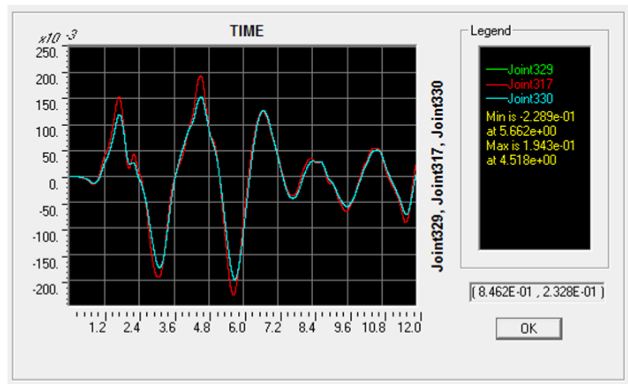
The graph showing various parameters are stated below and the model was considered as reference model. The various parameters that were studied are stated below.

- Joint acceleration
- Joint displacement
- Base shear

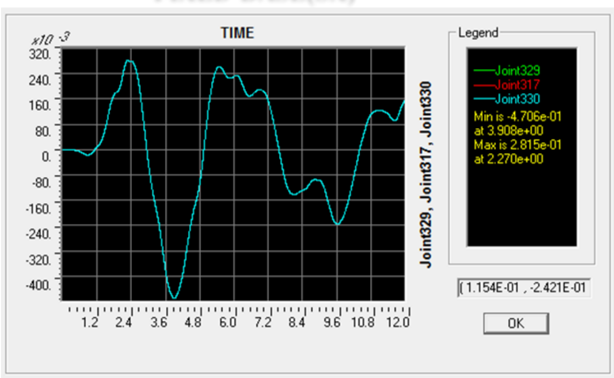
Joint acceleration



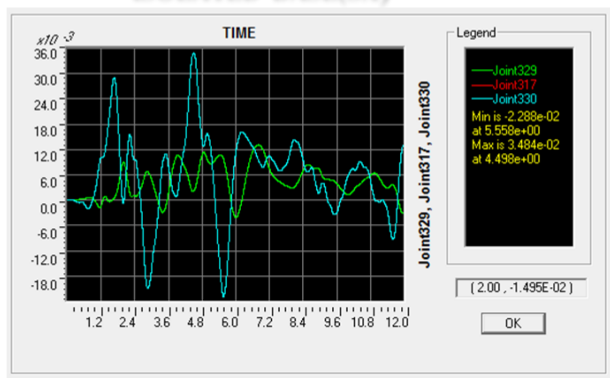
FIXED BASE(SX)



ISOLATED BASE(SX)



FIXED BASE(SY)



ISOLATED BASE(SY)

Fig 6(a)

Fig 6(a):-it shows graph between time and displacement in x direction and y direction for both fixed base and isolated base in the case of PLAN 3S. Minimum and maximum displacements for both directions are recorded for both the bases.

Joint displacement

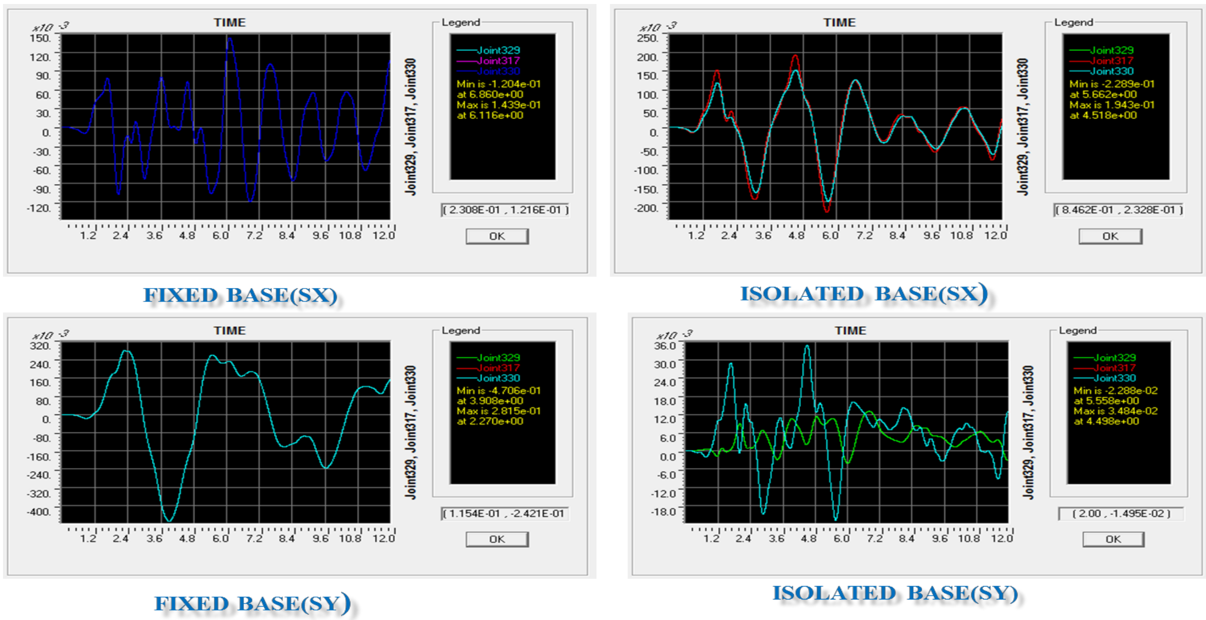


Fig 6(b)

Figure 6(b):-it shows graph between time and acceleration in x direction and y direction for both fixed base and isolated base in case of PLAN 3S. Minimum and maximum acceleration for both directions in both bases.

Base Shear

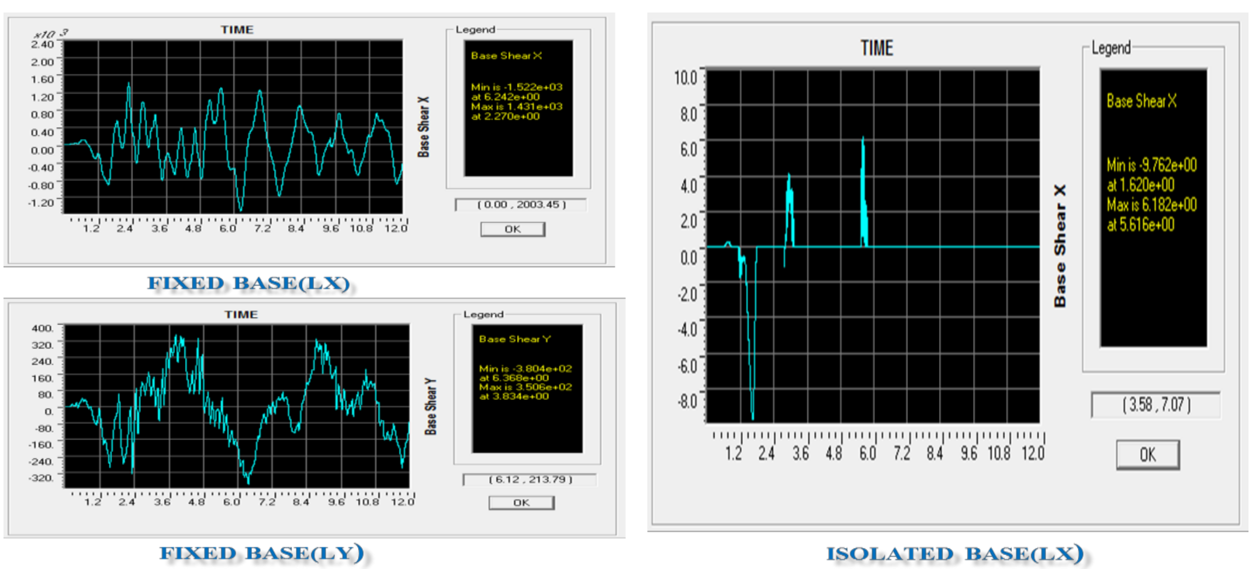


Fig 6(c)

Figure 6(c):-it shows graph between time and base shear in x direction and y direction for fixed base and isolated base in x direction in the case of plan 3S. Minimum and maximum base shear for both directions was recorded in fixed base and x direction in isolated base.

In all the three cases we observed that the structure provided with the provision of base isolation performed well as compared to the structure with fixed base and in the case of acceleration when the acceleration is getting reduced due to induction of base isolated so logically the force induced in the structure will be less and the structure is venerable to very minimum or no damage.

IV. CONCLUSION

The T shaped structure showed the best performance in all the test analysis and if provided with base isolation can perform well in earthquake. So we concluded that with proper criteria for Base Isolation any Plan Irregularity doesn't matter much.

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