Optimization of Seismic Response by Steel Framed Structures on Sloping Ground

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Abstract – *The unpredictable nature of earthquakes leads to the importance of seismic studies. Earthquake proof structure is impossible but earthquake resistant structure is possible. This study is an analysis of a G+30 steel framed structure on sloping ground using ETABs software. In addition to the guidelines of IS 1893-2002- part1, effect of Fluid Viscous Dampers (FVD) for different capacities, position and base isolators are analyzed in this study. This study aims at the optimization of seismic response by the structure by reducing the displacement of the building.*

Key Words: Seismic Analysis, Optimization, FVD, Base isolator, ETABs

1. INTRODUCTION

Earthquake is one of the most dangerous natural disaster. All the past earthquake histories can give a painful list of loses. This leads to the importance of seismic studies. The population is shooting up daily, so the needs of basic amenities like dwelling places, hospitals, educational institutions etc.. are also increasing. This leads to the need for alternatives. Most probably we build our taller structures on the flat ground in the sense of safety and easiness.

When we think about alternative solutions, sloping ground can be used instead of flat ground. High rise buildings are more prone to the lateral forces even on a flat ground. In that sense, high rise building on a sloping ground will be very dangerous and need special care in construction. Lack of availability of natural materials make us to use steel structures, which will not damage the nature and also can be reused. Hence, there is a need for the study of steel framed high rise building on a sloped ground.

IS 1893-2002- part1 gives us the guidelines for the design of earthquake resistant structures. In addition to this, there are several methods adopted for the buildings to improve their seismic resistance. Dampers and base isolators are the most commonly used techniques. Dampers convert the seismic energy to any other form of energy like heat energy, thereby reducing the impact of seismic energy on the building. Base isolators helps in separating the building from the ground. Energy transfer from the ground to the building is thus reduced.

Earthquake proof building is not possible but the building can be made earthquake resistant, there by leaving the structure functional even after the earthquake. Displacement and drift are the main concern for the tall buildings during the earthquake. So, this study aims at reducing the displacement effect of tall buildings by the optimal utilization of available earthquake resistant aids.

1.1 Scope of the Project

- Due to the increased urbanization and climatic changes, chances of earthquake are increasing, and we must take proper precautions to counteract its effects.

- Population is increasing and we need to find alternatives for all our basic requirements like, high rise building on the sloping ground.

- Optimization of the seismic response of the most dangerous situation of a building will help to crack the ideal situations also.

1.2 Objectives of the Project

Optimization of the seismic response of high rise buildings on the most dangerous conditions like sloping ground by reducing the displacement of the building to the maximum possible level by using FVD and elastomeric rubber isolator.

Effect of FVD will be analysed for the different capacities and position. Elastomeric rubber bearing is incorporated to the most suitable case of FVD and analysed.

2. METHODOLOGY

G+30 steel framed structure is analyzed in this study. An engineer always need a tool to design, analyze and obtain desired responses to understand the behavior of structures regarding civil engineering. ETABs software is used in this study. The model is analyzed for different conditions. Geometric details of the model is shown below;

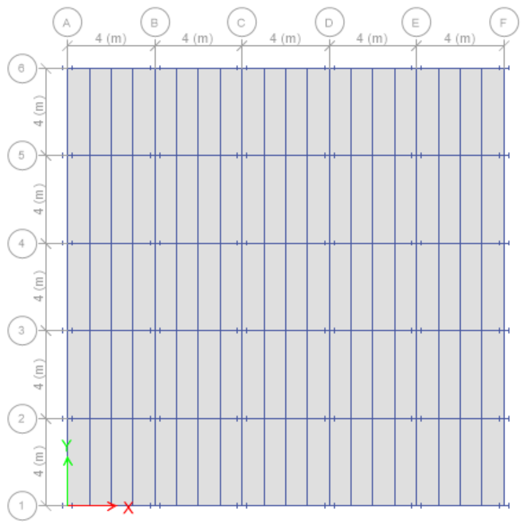

Fig – 1: Plan of the model

The model is developed in the software based on the following details.

Table -1: Model details

No. of Storey	30
Storey height	4m
Total height of building	120m
Thickness of slab	150mm
Grade of concrete	M25
Grade of steel	Fe500
No. of bays in X and Y-direction	5
Column size	ISWB450
Beam size	ISWB450
Composite beam size	ISLB275
Zone	V
Response reduction factor	5
Soil type	medium (Type II)
Live load	3KN/sqm
Floor finish load	1KN/sqm

The model thus developed is analyzed for different cases.

Gazzli USSR earthquake is used for the time history analysis.

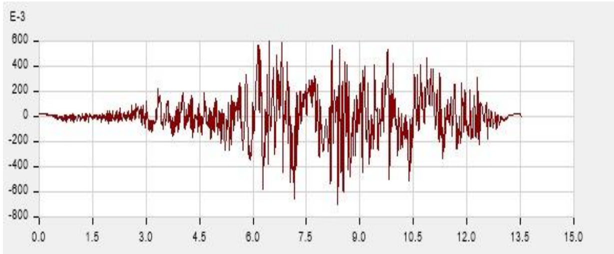

Fig – 2:Ground acceleration data of Gazzli USSR

Model analyzed as per IS 1893-2002-Part1: Seismic analysis is done for the model thus developed without any special techniques. Displacement of the topmost story is important in this study.

Model analyzed with FVD for getting the suitable position of FVD: FVD with a strength of 250 KN, 500KN, 750KN and 1000KN are incorporated to the model in two different positions. First, FVD is applied at the center of the geometry of the structure and analyzed. Then FVD is applied at the corners of the building and analyzed. Best suitable position is concluded based on the displacement data obtained.

Model is analyzed with FVD with different strength: In this stage, the model with different strength is analyzed. Variation of displacement data with the increase in the strength of FVD is studied here.

Model is analyzed with FVD and base isolator: In this stage, model is incorporated with the suitable FVD and base isolator. Elastomeric rubber bearing is used as isolator here. Building is analyzed and displacement data obtained.

The results of these four case are studied and optimal solution for the improvement of seismic response is concluded.

Table – 2: Viscous damper properties (from viscous damper design guide written by Nathan Canney.)

Force (KN)	Taylor Model Number	Spherical bearing bore diameter (mm)	Bearing thickness (mm)	Clevis depth (mm)	Weight (Kg)
250	17120	38.1	33	83	41
500	17130	50.8	44	102	82
750	17140	57.15	50	129	136
1000	17150	69.85	61	150	193

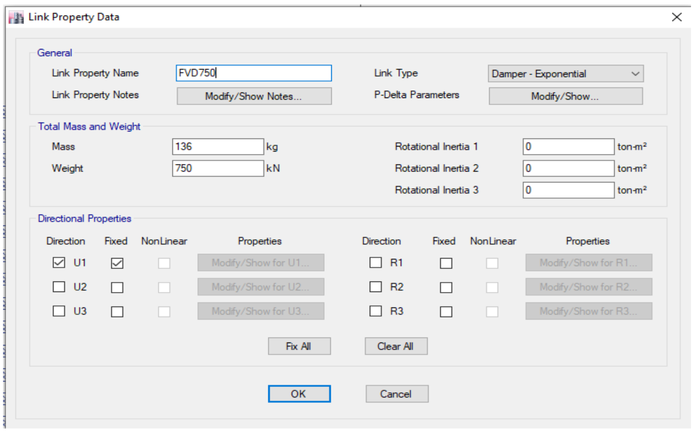

Fig – 3: Property data for viscous damper in ETABs

Fig -4:3D view of the model

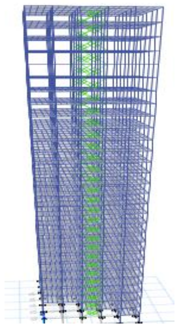

Fig -5: 3D view of the model with FVD at the center span

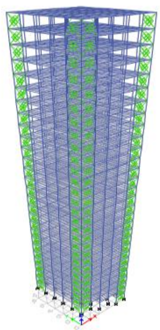

Fig – 6: 3D view of the model with FVD at the corner points

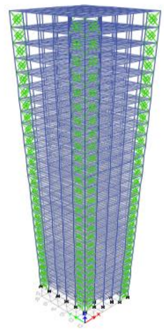

Fig – 7:3D view of the model with FVD and base isolator

The time history analysis of the model for the different cases is done and comparison is made based on the top story displacement of the model in X- direction.

3. RESULTS AND DISCUSSIONS

G+30 storied steel framed structure is analyzed in this study. The aim of this study is to find a solution for the better performance of the building by the optimal use of all the available sources. Top story displacement, which is very critical for the seismic performance is assessed in this study. Here, the most unsafe situation is used. Once the most unsafe situation is solved, all the other situations can be easily solved.

Dampers and base isolators are used in this study for the assessment of seismic response by the building. Fluid viscous dampers can dissipate seismic energy and wind energy, while the other dampers like friction dampers cannot dissipate wind energy. Elastomeric base isolators can isolate the building from the ground without taking up any space of the building.

In the first analysis, the model is analyzed without any dampers or base isolators and the top story displacement of the model, which is the critical value is found to be 227mm.

In the second case, the model is analyzed for getting the suitable position for placing the viscous dampers. The model is analyzed for the dampers at the center span and for the dampers at the corner points. The values of the top story displacement obtained is 225mm and 107mm respectively. So from the results of this stage, the suitable position for placing FVD is at the corner points as shown in the fig-5.

Table -3: Top story displacement of the model for different position of FVD

Strength of FVD	Top storey displacement based on the position of FVD (mm)	
	FVD at the centre span	FVD at the corner points
250	225	107
500	212.6	102.869
750	198.5	97.289
1000	192	90.71

In the third case, FVD with different strength is analyzed in the same model. FVD of various strength like 250KN, 500KN, 750KN and 1000KN are used in this stage. Top story displacements are obtained as 107mm, 102.869mm, 97.289mm and 90.71mm respectively. It is assessed that as the strength of FVD used increases, seismic resistance of the building also increases respectively.

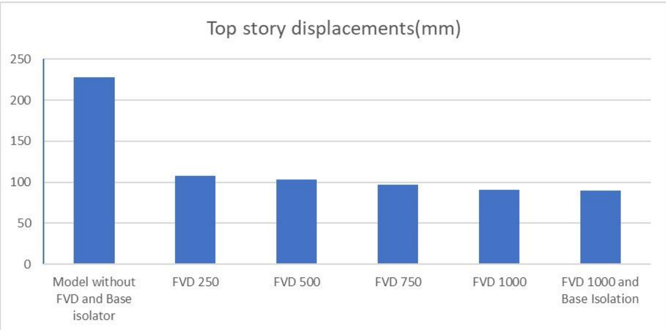

Chart-1: Comparison of performance of FVD

In the last case, the model is analyzed for the combined effect of FVD and base isolator. FVD of strength 1000KN is used here. Top story displacement is obtained as 90mm, further reduction in the top story displacement is resulted.

3. CONCLUSIONS

Population is increasing daily and the need of all the basic requirements are going to be increased in the near future. So we have to be ready with all the possible solutions for such problems which are going to rise shortly. Also, earthquake which was assumed to be a scenario of northern parts of India is coming to hit southern parts as well in the near future. Terrific landslides, soil erosions etc… are pointing to the pathetic situation of future. In the name of technology and development we destroyed our nature and now, it is the time to solve the worst situations of our life with the same technology. This study was a small thought on this and a software analysis of this need is made. From this study, it is inferred that, by the use of viscous dampers, seismic effect on the buildings, even on a sloping ground can be reduced. The position and the power of the dampers will affect its performance. Corner points are found to the best place for FVD from this study and also, as the strength of FVD increases, its efficiency also increased respectively. Base isolation is another method to improve the performance of the building on seismic effects. On applying a combination of dampers and base isolator (elastomeric rubber bearing), the seismic performance of the building is optimized.

So, from this study, it is concluded that, by the application of dampers of better capacity on the right place and with suitable base isolators, seismic resistance of the building can be optimized even in the most unsafe conditions.

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