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SEISMIC EVALUATION OF ASYMMETRIC COMPOSITE MULTISTOREY BUILDINGS WITH AND WITHOUT VISCO-ELASTIC DAMPER

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Abstract— *Seismic tremor starts at the profundity underneath the earth surface and upsets the structure. In this exploration we are study the comparision between G+14 working with and without dampers with various shapes of building(C, L and T) areas. In this structure we will consider evaluation of cement M20 and grade of steel Fe 355 and will look at the outcomes from both method static method and response spectrum method by utilizing E-Tabs 2015 software. Connection properties are utilized in E-Tab programming depend on kinds of dampers (Visco-elastic damper and fluid viscous damper) from the investigation the Lateral displacement, story drift both are reduces. Base shear is increased when we are utilizing dampers compared to without dampers.*

Keywords: *Dampers, seismic, composite*

1. INTRODUCTION

As most earthquakes arise from stress build-up due to deformation of the earth's crust, understanding of seismicity depends heavily on aspects of geology, which is the science of the earth's crust, and also calls upon knowledge of the physics of the earth as a whole, i.e. geophysics.

The return period of an earthquake in a given region depends up on its seismicity. An earthquake may be classified in to one of the three categories:

1. Minor earthquake – it may occur frequently say once in every 5 to 10 years.
2. Moderate earthquake – it may occur say once in every 20 to 30 years.
3. Severe earthquake – it may occur once in a life time of the building say once in 75 to 100 years [2].

Earthquake Ground Motions (EQGMs) are the most dangerous natural hazards where both economic and life losses occurred. These motions are caused by seismic waves which are generated by the release of strain energy at the focus. These waves shall travel with different velocities, amplitudes and levels of energy. Thus, the amplitudes and directions of these ground motions vary randomly with the time. That is why earthquake loading is called randomly varying load.

1.1 Profiled Deck / Composite Slab

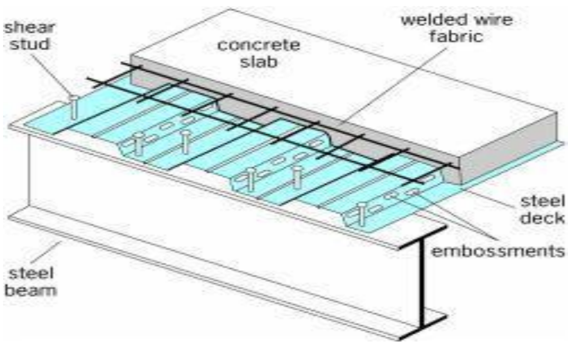

Figure 1–Composite Slab

1.2 Dampers

In physics, damping is a phenomenon in which the amplitude of an oscillation tends to reduce after every cycle in an oscillatory motion, particularly in case of harmonic oscillator. Friction is generally considered as one such damping effect. In engineering terms, damping can be mathematically modelled as any force which is in sync with the velocity of object and opposite in direction to it. If such a force is proportional to the speed or velocity, as for a simple mechanical gelatinous damper, the force *F* may be related to the velocity *v given* by F= -c*v*, where *c* is the viscous damping coefficient (N-s/m). The rate of decreasing amplitude depends upon the amount of damping. The advantage of damping is to control the amplitude of vibration [2].

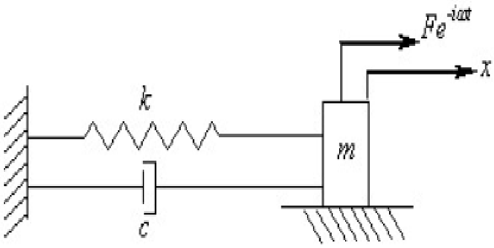

Figure –2 Mass and spring damping system

An ideal mass and spring damping system with mass *m* (kg), viscous damper of damping coefficient *c* (in N-s/ m or kg/s) and spring constant *k* (N/m) is subjected to an oscillatory vibration or force then the damping force is given by,

$F_s = -kx \quad F_d = -cv = -c\,(dx/dt) = -c\dot{x}$

By applying the Newton's second law, the total force (F tot) on the body is given by, $F = ma$ or $F = m\ddot{x}$

Hence by equating, we get

$m\ddot{x} + kx + c\dot{x} = 0$

1.3 Types of Dampers

There are mainly two types of dampers used in present industry

1. Fluid Viscous dampers
2. Viscoelastic dampers

2. STATEMENT OF THE PROBLEM

Equivalent Lateral Force Method (ELFM) and Response Spectrum Method (RSM) of analysis have been adopted to study the seismic behaviour of plan asymmetric composite buildings during earthquakes as per IS 1893 (Part 1): 2002 codal provisions. ETABS 2015 software package is used to carry out the static analysis and dynamic analysis. The present study is devoted for the investigation of seismic behaviour of asymmetric structures and reduction of seismic induced torsional moment and other parameters like lateral displacement, storey drift and base shear values in composite structures. Visco-Elastic dampers are used to reduce seismic induced torsional moment. In order to capture exact behaviour, all the analyses are performed on complete three dimensional models of the structures.

2.1 OBJECTIVE OF THE STUDY

- To understand the behaviour of plan asymmetric composite buildings under seismic loading.
- To study the importance of Response Spectrum Method of analysis in the seismic analysis of asymmetric composite structures and to make the comparison between the structural responses obtained from dynamic analysis and equivalent static analysis.
- To study the parameters like lateral displacement, storey drift, Time period, base shear and torsion in asymmetric composite building having L, T and C-shape.
- To study the parameters like lateral displacement, storey drift, Time period, base shear and torsion by providing Visco-elastic dampers at re-entrain corners at every floor in asymmetric composite building having L, T and C-shape.
- To study the effect of Visco-elastic damper in different types of asymmetric composite building.

3. MATERIALS AND METHODOLOGY

In the present dissertation work, G+14 storey asymmetric composite multi-storey buildings with and without dampers are considered.

3.1 DESCRIPTION OF BUILDING DIMENSION

Table: 1 Building dimension details

Number of storey	15
Number of bays along X-direction	6
Bay width along X-direction	8m
Number of bays along Y-direction	6
Bay width along Y-direction	6m
Total dimension of building	40m X 30m
Floor to Floor height	4m

3.2 DESCRIPTION OF MATERIAL PROPERTIES

Table: 2 Material Property details

Grade of Concrete	M20
Grade of Structural steel	Fe355
Density of Concrete	25.0 kN/m3
Density of Steel	78.5 kN/m3
Young's Modulus of Concrete	22360.68 N/mm2
Young's Modulus of Steel	210000.00 N/mm2
Poisson Ratio of Concrete	0.20
Poisson Ratio of Steel	0.30

3.3 DESCRIPTION OF SECTION PROPERTIES

Table: 3 Section Property details

Deck Slab	Grade of Concrete	M20
	Depth of Deck Slab	150mm with 20mmΦ Shear Connectors
Beams	Grade of Structural Steel	Fe355
	All Primary beams	ISMB 450
	All Secondary beams	ISMB 250
Columns	Grade of Structural Steel	Fe355
	All Columns	ISHB 450

3.4 DESCRIPTION OF TYPES OF LOAD AND THEIR INTENSITIES

Table: 4 Type of Loads and their intensities details as per IS 875 (Part 2):1987

Live Load	3.0 kN/m^2
Floor Finish Load	1.0 kN/m^2
Roof Load	2.0 kN/m^2

3.5 DESCRIPTION OF SEISMIC PROPERTIES

Table: 5 Seismic property details as per IS 1893 (Part 1): 2002

Importance Factor	I	1.0
Zone Factor	Z	0.36
Response Reduction Factor	R	3.0
Soil type	-	II
Damping Ratio	-	2%

3.6 DESCRIPTION OF LINK PROPERTIES

Table: 6 Link properties details

Type of Damper	-	Viscoelastic
Effective Stiffness	Ke	85745.7kN/m
Effective Damping	De	2451.4kN-s/m

3.7 DESCRIPTION OF LOAD COMBINATIONS

The following are the load combinations which are adopted for the analysis of asymmetric composite building as per IS 1893(Part 1):2002 are as shown below in tabular column.

Table: 7 Load Combinations considered as per IS: 1893 (Part -1) - 2002

Analysis Methods	Load Combinations
Equivalent Static Method of Analysis	1.2 (DL+IL+EQX) 1.2 (DL+IL+EQY) 1.5 (DL+EQX) 1.5 (DL+EQY) 0.9 (DL) + 1.5 (EQX) 0.9 (DL) + 1.5 (EQY)
Response Spectrum Method of Analysis	1.2 (DL+IL+SPECX) 1.2 (DL+IL+SPECY) 1.5 (DL+SPECX) 1.5 (DL+SPECY) 0.9 (DL) + 1.5 (SPECX) 0.9 (DL) + 1.5 (SPECY)

Where,
DL = Dead Load
IL = Imposed Load
EQX and EQY = Earthquake load in X and Y direction
SPECX and SPECY = Earthquake load in X and Y direction

3.8 PLANS AND MODELS

Plans and 3D Rendered Models of L, T and C- Shape buildings are considered.
Here,
Model 1 – L- Shape Composite building without Viscoelastic damper.
Model 2 – L-Shape Composite building with Viscoelastic damper.
Model 3 – T- Shape Composite building without Viscoelastic damper.
Model 4 – T-Shape Composite building with Viscoelastic damper.
Model 5 – C- Shape Composite building without Viscoelastic damper.
Model 6 – C-Shape Composite building with Viscoelastic damper.

4. METHODOLOGY

In the present study, the modelling and analysis of the G+14 storey composite asymmetric building is carried out by using ETABS 2015 software. Only elastic analysis such as Equivalent Static Lateral Force Method (ESLFM) and Response Spectrum Method (RSM) are adopted for the analysis of plan-asymmetric L, T and U shaped composite structures and there by both the methods is compared. The reduction of seismic induced torsional moment and other parameters like lateral displacement, storey drift and base shear can be achieved by introducing dampers at re-entrain corners of irregular composite building.

4.1 Equivalent Static Lateral Force Method (ESM)

The total design lateral force or design base shear along principal directions is given in terms of design horizontal seismic coefficients and seismic weight of the structures. Design horizontal seismic coefficient depends on the zone factor of the site, importance of the structure, response reduction factor of the lateral load resisting elements and the fundamental period of the structure. The procedure generally used for the equivalent static analysis is explained below:

4.1.1 Determination of fundamental natural period (T_a) of the buildings

$T_a = 0.075h^{0.75}$ for moment resisting RC frame building without brick infill walls
$T_a = 0.085h^{0.75}$ for moment resisting steel frame building without brick infill walls
$T_a = 0.09h/\sqrt{d}$ All other buildings including Moment resisting RC frame building with brick infill walls
Where,
'h' is the height of building in m
'd' is the base dimension of the building at plinth level in m, along the considered direction of the lateral force.

4.1.2 Determination of base shear (V_B) of the building

$V_B = A_h \times W$
Where,
$A_h = (Z/2)*(I/R)*(S_a/g)$ is the design horizontal seismic coefficient, which depends on the seismic zone factor (Z), importance factor (I), response reduction factor (R), and the average response acceleration coefficients (S_a/g).
S_a/g in turn depends on the nature of the foundation soil (rock, medium or soft soil sites), natural period and damping of the structure.

4.1.3 Distribution of design base shear

The design base shear V_B thus obtained shall be distributed along the height of the building as per the following expression:

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

Where, Q_i is the design lateral force, W_i is the seismic weight, h_i is the height of the i^{th} floor measured from base and n is the number of stories in the building.

4.2 Response Spectrum Method (RSM)

The response spectrum represents an envelope of upper bound responses based on several different ground motion records. For the purpose of the seismic analysis the design spectrum given in IS 1893 (Part 1):2002 is used. This spectrum is based on strong motion records of eight Indian earthquakes.

Following procedure is generally used for the response spectrum analysis:

(i) Select the design spectrum.
(ii) Determine the mode shapes and periods of vibration to be included in the analysis.
(iii) Read the level of response from the spectrum for the period of each of the modes considered.
(iv) Calculate participation of each mode corresponding to the single degree of freedom response read from the curve.
(v) Add the effect of modes to obtain combined maximum response.
(vi) Convert the combined maximum response into shears and moments for use in design of the structure.
(vii) Analyse the building for the resulting moments and shears in the same manner as the static loads.

According to the code, dynamic analysis may be performed using either response spectrum method or time history analysis method. In either method, the design base shear (V_B) is compared with a base shear (V_B) calculated using fundamental time period T_a. It suggests that when V_B is less than V_B, all the response quantities must be suitably scaled by multiplying with V_B/V_B.

The code IS 1893(Part 1):2002 suggests that the number of modes to be used in the analysis be such that the total of modal masses of all modes considered is at least 90% of the total seismic mass. The modes are considered as closely spaced if the natural frequencies differ from each other by 10% or less of the lower frequency. The peak response quantities are combined using complete quadratic combination (CQC) method. Alternatively, it accepts square root of sum of squares (SRSS) method be used for modes which are not closely spaced. If there were few closely-spaced modes, then it suggests the use of sum of absolute values (ABS) method and rest of the modes could be combined using CQC method.

5. RESULTS AND DISCUSSIONS

Lateral displacement of L-shape asymmetric composite G+14 storey building along longitudinal direction with respect to Equivalent Static Method of Analysis

Storey	1.2 (DL + IL + EQX)	
	Equivalent Static Method of Analysis	
	Lateral Displacement in mm	
	Model 1	Model 2
15	227.80	96.80
14	220.50	90.40
13	211.20	83.60
12	199.80	76.50
11	186.40	69.10
10	171.30	61.50
9	154.80	53.60
8	137.30	45.80
7	119.10	38.10
6	100.30	30.60
5	81.30	23.50
4	62.20	16.90
3	43.30	11.10
2	25.10	6.20
1	8.80	2.30
Ground Floor	0.00	0.00

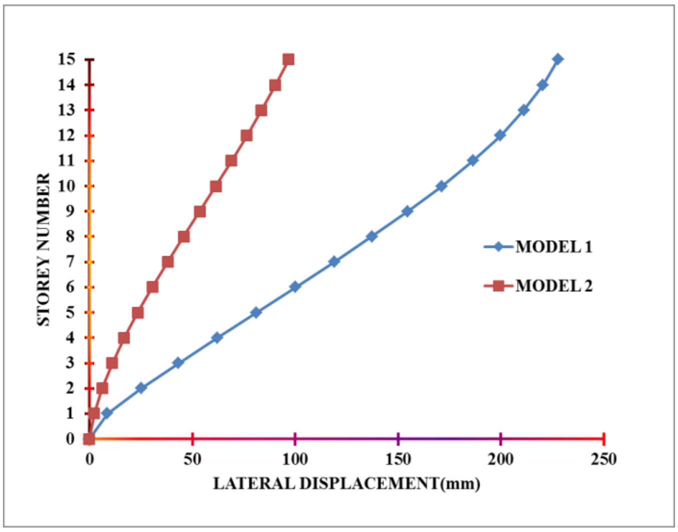

Figure: 3 – Lateral displacement profile of L-shape asymmetric composite G+ 14 storeys building along longitudinal direction with respect to Equivalent Static Method of Analysis

Conclusion

The conclusions that are drawn from the results discussed in the present study are :

- Viscoelastic damper effectively reduces the Lateral displacement of G+14 Storey Asymmetric composite building without dampers by 80.59% for L-Shape building, 82.48% for T-Shape building and 81.90% for C-Shape building.

- Viscoelastic damper effectively reduces the Inter storey drift of G+14 Storey Asymmetric composite building without dampers by 67.64% for L-Shape building, 68.27% for T-Shape building and 67.59% for C-Shape building.

- Viscoelastic damper effectively reduces the Fundamental Natural Period of G+14 Storey Asymmetric composite building without dampers by 51.75% for L-Shape building, 56.78% for T-Shape building and 51.19% for C-Shape building.

- Viscoelastic damper effectively increases the Base Shear of G+14 Storey Asymmetric composite building for all shapes compared with the building without damper.

SCOPE FOR FUTURE STUDY

The present work can be extended by considering the following parameters:

- The torsional behaviour is very critical in the inelastic range of the materials. Generally, under severe seismic loading, structure undergoes yielding. The inelastic response of the structure also plays an important role in earthquake resistant design of structures. Inelastic seismic analysis procedures like static pushover analysis and inelastic time history analysis can be performed to understand the actual behaviour and collapse mechanism of the structure.
- Soil flexibility is not considered in the present study. Building resting on different soil strata may undergo seismic induced torsion. Also the flexible soil increases the period and lateral displacement of the structure. This can be studied in detail.

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