International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:268
Vol.2, No.2, February 2013 DOI:10.15693/ijaist/2013.v2i2.26-29

Seismic Behaviour of R.C.C Frames with Mezzanine Floor

C.Yoganantham[1] , M. Helen Santhi[2]
[1]M.Tech Student, [2]Professor, Department of Civil Engineering, VIT University, Chennai.

***Abstract* - The aim of this paper is to study the seismic behaviour of a multi-storey building with mezzanine floor. Two G+3 storey buildings with plan dimension of 10.98 m x 10.98 m have been chosen for the analysis purpose. One of the buildings has a mezzanine floor in 1st floor. STAAD pro software has been used to analyse the structures. The displacement, frequency and time period of the models are calculated and it is found that building with mezzanine floor having less performance against lateral force.**

***Keywords*- *S*eismic force, Mezzanine floor, Frequency, Mode shapes, Displacement**

1. INTRODUCTION

A typical RC building is made of horizontal members (beams and slabs) and vertical members (columns and walls), and supported by foundations that rest on ground. The system comprising of RC columns and connecting beams is called a RC Frame.

Fig 1 Total horizontal earthquake force in a building increases downwards along its height.

The RC frame participates in resisting the earthquake forces. Earthquake shaking generates inertia forces in the building, which are proportional to the building mass. Since most of the building mass is present at floor levels, earthquake-induced inertia forces primarily develop at the floor levels. These forces travel downwards – through slab and beams to columns and walls, and then to the foundations from where they are dispersed to the ground. As inertia forces accumulate downwards from the top of the building, the columns and walls at lower storeys experience higher earthquake-induced forces (Figure 1) and are therefore designed to be stronger than those in storeys above.

1.1. Mezzanine Floor

A mezzanine floor is an intermediate floor between main floors of a building, and therefore typically not counted among the overall floors of the building. Often, a mezzanine is low ceiling and projects in the form of balcony. The balcony is also used for the lowest balcony in theatre, or the first few rows of seats in that balcony. Framing at mid height of column of structural elements such as slabs, beams, and girders divide the column in two segments.

Fig 2 Mezzanine Floor

2. ANALYTICAL INVESTIGATION

Model Development

Two G+3 storey buildings with a plan dimension of 10.98 m x 10.98 m have been chosen for the analysis purpose. The models are developed using the software STAAD Pro. One of the models is having the mezzanine floor at the first floor. Analysis and design has been done for gravity load and seismic loads.

Input Parameters :

Zone factor	- 0.16(zone III)
Response reduction factor	-5
Soil factor	- 2
Grade of concrete	- M25
Grade of reinforcing steel	-Fe415
Live load	- 3kN/m^2
Thickness of slab	- 150 mm

Load Combinations:

- ✓ Dead Load + Live Load (DL+LL)
- ✓ Dead Load + Live LOAD (1.5 DL + 1.5 LL)
- ✓ Dead Load +Live Load +Seismic Load(1.2(DL + LL+ SL)
- ✓ Dead Load + Live Load - Seismic Load(1.2(DL + LL- SL)
- ✓ Dead Load - Seismic Load (1.5(DL – SL))
- ✓ Dead Load + Seismic Load (0.9DL + 1.5SL)
- ✓ Dead Load - Seismic Load (0.9DL – 1.5 SL).

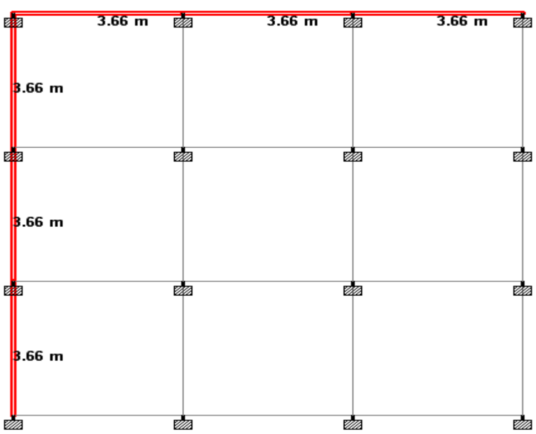


Fig 3 Plan View of Building

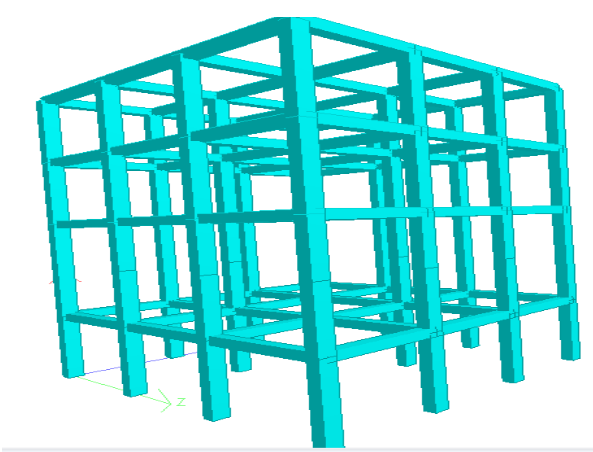


Fig 4 3-D View of Normal Floor Building

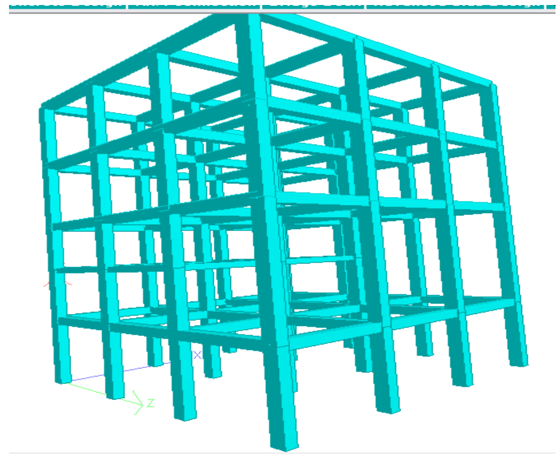


Fig 5 3-D View of Mezzanine Floor Building

Calculation of seismic weight:

The dimensions of the building elements are

Beam	= 350 X 350 mm.
Beam(for mezzanine floor only)	= 230 X 230 mm.
Column	= 350 X 450 mm.
Floor thickness	= 150 mm.
Floor thickness(for mezzanine floor only)	= 125 mm
Infill wall thickness	= 230 mm.

The seismic weight of the Ground floor, First floor, Second floor, Third floor are1278.96 kN, 1613.32 kN, 1278.96 kN, 968.90 kN, respectively.

Seismic coefficient method

The seismic coefficient method is the simplest method of calculating the force distribution for the framed buildings. First the fundamental time period for the frame is determined using the empirical formulae given in the IS. Then the base shear is calculated and is distributed at different floor levels.

(i)Fundamental Natural period

Soft storey frame

$T_x = 0.09h/\sqrt{d}$

$T_x \approx T_z = 0.373$ s

Where

T_x, T_z = Fundamental natural period along longitudinal and transverse direction

h = Height of the building in m

d = Base dimension of the building in m, along the considered direction of the lateral force

(ii) Design horizontal Seismic Coefficient (A_h)

International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:268
Vol.2, No.2, February 2013 DOI:10.15693/ijaist/2013.v2i2.26-29

A_h = (Z/2) × (I/R) × (Sa/g)
= 0.066

Where
A_i= Design horizontal acceleration spectrum Value
Z= Zone factor
Sa/g = Average response acceleration co-efficient
R = Response reduction factor
I = Importance factor

(iii) Base Shear (V_B)

V_B = A_h × W
= 359.44 kN.

V_B = Base Shear
W = Seismic Weight of the building

(iv)Distribution of lateral force along the Height of the Frame. The Design Base shear(V_B) computed shall be distributed along the height of the building as per the following expression

$$Qi = \frac{VB \times Wi\ hi2}{\sum_{j=1}^{n} Wi\ hi2}$$

Where
Q_i = Design lateral force of floor i
W_i = Seismic weight of floor i
h_i = Height of floor I measured from base
n = Number of storeys in the building

Table 1. The distribution of lateral force along the height of the frame.

Storey Level	W_i (kN)	h_i (m)	$W_i\,hi^2$ (kN.m^2)	$Qi = \frac{VB \times Wi\ hi2}{\sum_{j=1}^{n} W\ i\ hi2}$ (kN)
4	968.9	13.72	182384.2	146.00
3	1404.69	10.67	159922.4	128.00
2	1613.32	7.62	93676.5	75.00
1	1404.69	3.05	13067.1	10.46

3. RESULTS AND DISCUSSION

The various parameters compared here are

I. Displacement of normal and mezzanine floor building
II. Time period of normal and mezzanine floor building
III. Mode shape of normal and mezzanine floor building

3.1 Displacement of normal and mezzanine building

The displacement of building is the horizontal movement of building during the application of lateral force on the structure due to earthquake or by wind.

A normal building and mezzanine building move horizontally by the same amount. However, the mezzanine floor is stiffer as compared to the normal building, stiffness of a building means resistance to deformation – the larger is the stiffness, larger is the force required to deform it. So mezzanine floor are less ductile and deform less compared to normal building. If a mezzanine is not adequately designed for such a large force, it can suffer significant damage during an earthquake. So due to ductility the mezzanine floor displacement will be less while compared to normal building. Figure 6 shows the displacements.

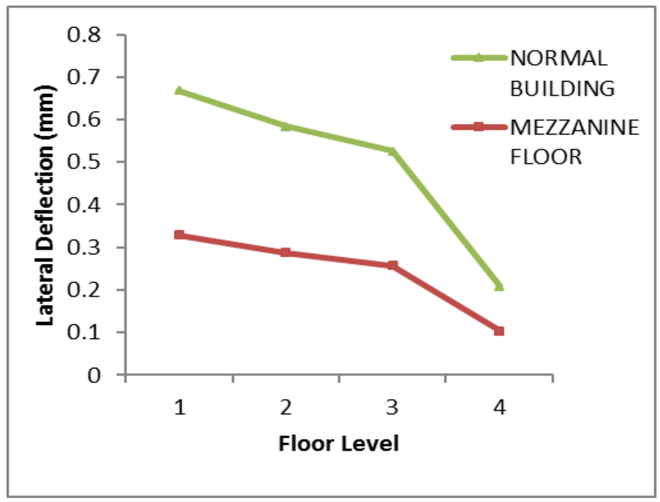


Fig 6 Displacement of the Structures

3.2 Time Period

Time period variation of six modes is plotted which gives an insight into the behaviour of the structure.These are the time periods of both the normal and mezzanine buildings. It can be seen that the difference in time period of normal building is higher than the mezzanine floor building. The fundamental time period of the structures obtained from the analysis is well compared with that of the codal provision.

Table 3.1 Time Period(Sec) of the Structures

MODE	TIME PERIOD(SEC)	
	NORMAL BUILDING	MEZZANINE FLOOR BUILDING
1	0.34004	0.32848
2	0.29620	0.28778
3	0.26962	0.25647
4	0.10494	0.10423
5	0.08731	0.08706

6	0.07439	0.07391

3.3 Frequency

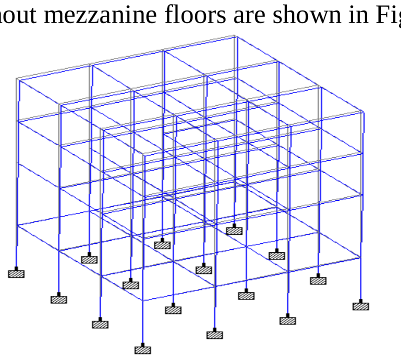
The Frequency variation of six modes is plotted which gives an insight into the behaviour of the structure.These are the frequency of both the normal and mezzanine buildings. We can clearly see that difference in frequency of normal and mezzanine floor building, as per the table 3.2 normal building has high frequency while compared to mezzanine floor building.

Table 3.1 Frequency (Sec) of the Structures

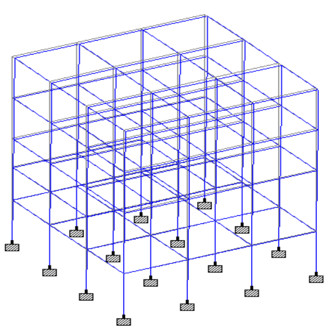
MODE	FREQUENCY(CYCLES/SEC)	
	NORMAL BUILDING	MEZZANINE FLOOR BUILDING
1	2.941	3.044
2	3.376	3.475
3	3.709	3.899
4	9.529	9.594
5	11.453	11.487
6	13.443	13.530

3.5 MODE SHAPES OF MODELS

The fundamental mode shapes of the model structures with and without mezzanine floors are shown in Figure 7.



(a) Without Mezzanine



(b)with Mezzanine
Fig. 7 First Mode Shape of models

4. CONCLUSION

This paper consists of analytical and theoretical investigations carried out on two kinds of buildings. One is the normal building and the other is mezzanine floor building, both of them are analysed and designed using the software STAAD Pro.

- Displacement of normal R.C framed building is more when compared to R.C. mezzanine building subjected to seismic force.
- The fundamental frequency of the mezzanine floor is higher than that of building without mezzanine. This shows that the building with mezzanine floor is stiffer than the other building.

REFERENCES

[1] xuemeiliang and gustavo j. parra-montesinos(2004) *"seismic behavior of reinforced concrete column-steel beam subassemblies and frame systems"* journal of structural engineering © asce / february 2004 / 311

[2] saptadipsarkar(2011) *"design of earth-quake resistant multi-storied rcc building on a sloping ground"* 2011

[3] narayanansambu potty and sirajuddin, m(2011) *"assessment of buildings for seismic resistance"* malaysian journal of civil engineering 23(1):86-104 (2011)

[4] mulgund g. v. and dr. kulkarni a. b. *" seismic assesement of rc frame buildings with brick masonry infills"* international journal of advanced engineering sciences and technologies vol no. 2, issue no. 2, 140 – 147

[5] is 1893(part):2002 criteria for earthquake resistant design of structures.

[6] http://www.askactive.com/mewzzanine-floors/mezzanine-floor-design