Abstract — The aim of the thesis is to arrive the Seismic behaviour of multi-storey Building with mezzanine floor. A G+4 storey building with plan dimension of 9.45m x 9.60m building have been chosen for analysis purpose. The model consists of two mezzanine floors one in the 1st floor and one in the 3rd floor. And two G+2 models are considered with plan dimension of 2.30m x 2.30m, one model is taken as normal framed structure and another one is taken as framed structure where mezzanine floor is introduced at ground floor. CATIA V5 for modelling and HYPERMESH 11, ANSYS 12 and STAAD Pro. software’s have been used to analyse the structures. The displacement, overall Time period and shear stress of the models are calculated and it is found that building with mezzanine floor having less performance against lateral force. Because it is having less Displacement, Time period etc., while compared to building without mezzanine floor.

INTRODUCTION

During past earthquakes, reinforced concrete (RC) frame buildings that have columns of different heights within one storey, suffered more damage in the shorter columns as compared to taller columns in the same storey. Many situations with short column effect arise in buildings, during earthquake shaking all columns move horizontally by the same amount along with the floor slab at a particular level. If short and tall columns exist within the same storey level, then the short columns attract several times larger earthquake force and suffer more damage as compared to taller ones. The short column effect also occurs in columns that support mezzanine floors or loft slabs that are added in between two regular floors. Poor behaviour of short columns is due to the fact that in an earthquake, a tall column and a short column of same cross-section move horizontally by same amount Δ. The short column is stiffer as compared to the tall column, and it attracts larger earthquake force. Stiffness of a column means resistance to deformation—the larger is the stiffness, larger is the force required to deform it.

MEZZANINE FLOOR

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. Due to this addition of Mezzanine floor or loft slab between two regular floors “SHORT COLUMN” effect occurs in those columns.

RESPONSE SPECTRUM

This method is done by using STAAD Pro. Here seismic coefficient method is being default with. The input data is explained here. Initially the masses in the form of loads are assigned in all possible directions.

ZONE

- Zone factor from table 2 of IS 1893:2002.

RF

- Response reduction factor from table 7 for special moment resisting frames.

I

- Importance factor as per table 6.

SS

- Soil factor and 1 for hard soil, 2 for medium soil and 3 for soft soil.
for soft soil. Depending on its programme calculated the average response.

ST - Type of structure 1 for RC structure, and 3 for all other buildings.

DM - Damping ratio to obtain multiplying factor for calculating Sa/g for 0.05 damping

**ANALYTICAL INVESTIGATION**

Two models of G+2 storey building with a plan dimension of 2.30m x 2.30 m of the building have been chosen for analysis purpose. One model is taken as normal framed structures. Another one is taken as framed structure and introduced mezzanine floor at ground floor. Each analysis and design has been done for gravity load and lateral loads.

**INPUT PARAMETERS:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZONE FACTOR</td>
<td>0.16</td>
</tr>
<tr>
<td>RESPONSE REDUCTION FACTOR</td>
<td>5</td>
</tr>
<tr>
<td>SOIL FACTOR</td>
<td>2</td>
</tr>
<tr>
<td>GRADE OF CONCRETE</td>
<td>M25</td>
</tr>
<tr>
<td>GRADE OF REINFORCING STEEL</td>
<td>Fe415</td>
</tr>
<tr>
<td>LIVE LOAD</td>
<td>3KN/M²</td>
</tr>
<tr>
<td>THICKNESS OF SLAB</td>
<td>120 MM</td>
</tr>
</tbody>
</table>

**LOAD COMBINATIONS:**

1. DEAD LOAD + LIVE LOAD (1.0 DL + 1.0 LL)
2. DEAD LOAD + LIVE LOAD (1.5 DL + 1.5 LL)
3. DEAD LOAD + SEISMIC LOAD (1.5DL + 1.5 SL)
4. DEAD LOAD - SEISMIC LOAD (1.5DL - 1.5 SL)
5. DEAD LOAD + LIVE LOAD + SEISMIC LOAD (1.2DL+0.3LL+1.2SL)
6. DEAD LOAD + LIVE LOAD - SEISMIC LOAD (1.2DL+0.3LL-1.2SL)

the paper will be sent. Proofs are sent to the corresponding author only.
A. Figures

II. MODELLING – CATIA V5:

III. CATIA V5: CATIA V5 builds on powerful smart modeling and morphing concepts to enable the capture and reuse of process specifications and intelligence. The result is an easily scaleable, web-enabled system that covers all user requirements within the digital extended enterprise, from the simplest design to the most complex processes. This capability allows optimization of the entire product development process while controlling change propagation. CATIA V5 moves beyond traditional parametric or variational approaches, accelerating the design process and helping designers, engineers, and manufacturers increase their speed and productivity. CATIA V5 has an innovative and intuitive user interface that unleashes the designer’s creativity. Context-sensitive integrated workbenches provide engineers with the tools they need for the task at hand, and they are beneficial for multi-discipline integration. The workbenches have powerful keyboard-free direct object manipulators that maximize user productivity. CATIA V5 applications are based on a hybrid modeling technology. These applications provide expanded digital product definitions, process definitions, and review functions capable of operating on projects with any degree of design complexity. CATIA V5 has produced domain-specific applications that have addressed global digital enterprise requirements that span the areas of mock-up, manufacturing, plant, and operations.

IV. PARAMETERS CONSIDERED:

BEAM - 150 X 100 MM
COLUMN - 100 X 100 MM
SLAB THICKNESS - 120 MM
COLUMN HEIGHT - 1000 MM (TOP STOREY)
1500 MM (BOTTOM STOREY)

V. LENGTH OF EACH BAY - 1000 MM

Electronic Image Files (Optional)
You will have the greatest control over the appearance of your figures if you are able to prepare electronic image files. If you do not have the required computer skills, just submit paper prints as described above and skip this section.

1) Easiest Way: If you have a scanner, the best and quickest way to prepare non-color figure files is to print your tables and figures on paper exactly as you want them to a

**ANSYS:**

ANSYS is a finite element analysis (FEA) software package. It uses a preprocessor software engine to create geometry. Then it uses a solution routine to apply loads to the meshed geometry. Finally it outputs desired results in post-processing.

Finite element analysis was first developed by the airplane industry to predict the behavior of metals when formed for wings. Now FEA is used throughout almost all engineering design including mechanical systems and civil engineering structures.

ANSYS is used throughout industry in many engineering disciplines. This software package was even used by the engineers that investigated the World Trade Center collapse in 2001.

**PARAMETERS CONSIDERED:**

- Compressive strength of concrete: 25
- Young's modulus of concrete: 2.5E10 N/m²
- Poisson's ratio: 0.17
- Density: 2500 N/m³
The various parameters compared here are:

- Displacement of normal and mezzanine floor building
- Time period of normal and mezzanine floor building
- Shear stress of normal and mezzanine floor building

### 3.1 Numerical Calculation of Overall Stiffness and Time Period of Structures:

Using the following formulae overall stiffness and time period are found:

\[
\text{Stiffness } (K) = \frac{12 \times E \times I}{h^3}
\]

Where Young’s modulus of concrete \( E \) = 5000 \( \sqrt{f_{ck}} \)

\[
\text{Moment of inertia } (I) = \frac{b \times d^3}{12}
\]

\[
\text{Time period } (T_n) = \frac{2 \times \pi}{\omega_n}
\]

Where natural frequency \( (\omega_n) = \sqrt{\frac{K}{m}} \)

\[
\text{Overall mass of the structure } (m) = \frac{W}{g}
\]

Therefore, for normal building:

- No. of columns = 9
- Total weight of structure = total weight of beams + slab = 33 KN
- Lateral load = 50 KN
- Total mass of structure = \( \frac{33 \times 10^3}{9.81} + 50000 \) = 53360 N
- Stiffness of ground floor \( (K_1) = \frac{(12 \times 2.5 \times 10^10 \times 0.0833 \times 10^{-4} \times 9)}{1.5^3} \) = 6.664 x 10

- Stiffness of 1st floor \( (K_2) = \frac{(12 \times 2.5 \times 10^10 \times 0.0833 \times 10^{-4} \times 9)}{1^3} \) = 22.491 x 10

- Total stiffness of building = \( K_1 + K_2 \)
Therefore, for mezzanine floor building

No. of columns = 9

Total weight of structure = total weight of beams + slab

= 36.42 KN

Lateral load = 50 KN

Total mass of structure = 36.42*10^3/9.81 + 50000

= 53710 N

Table 3.2.1 Comparison of Displacement of Structures in STAAD Pro

<table>
<thead>
<tr>
<th>NODE</th>
<th>NORMAL BUILDING</th>
<th>MEZZANINE FLOOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>3.019</td>
<td>2.269</td>
</tr>
<tr>
<td>14</td>
<td>3.021</td>
<td>2.267</td>
</tr>
<tr>
<td>22</td>
<td>3.011</td>
<td>1.706</td>
</tr>
<tr>
<td>23</td>
<td>3.013</td>
<td>1.705</td>
</tr>
</tbody>
</table>

So due to ductility the mezzanine floor displacement will be less compare to normal building.

Therefore, for mezzanine floor building:

\[ \text{Overall Time period} = \frac{2p}{\sqrt{\frac{29155000}{3360}}} = 0.2688 \text{ sec} \]

\[ \text{Overall Time period} = \frac{2p}{\sqrt{\frac{2691330}{53710}}} = 0.0887 \text{ sec} \]

Stiffness of ground floor (K1) = \( \frac{(12\times2.5\times10^9\times0.0833\times10^{-4}\times5)}{1.5^3} \)

= 3.7022 x 10^6 N/m

Stiffness of 1st floor (K2) = \( \frac{(12\times2.5\times10^9\times0.0833\times10^{-4}\times9)}{1^3} \)

= 22.491 x 10^6 N/m

Stiffness of 1st floor (K3) = \( \frac{(12\times2.5\times10^9\times0.0833\times10^{-4}\times4)}{1^3} \)

= 9.996 x 10^6 N/m

Stiffness of 1st floor (K4) = \( \frac{(12\times2.5\times10^9\times0.0833\times10^{-4}\times4)}{0.35^3} \)

= 233.143 x 10^6 N/m

Stiffness of ground floor (K1) = \( 29.155 \times 10^6 \text{ N/m} \)

Stiffness of 1st floor (K2) = \( 269.33 \times 10^6 \text{ N/m} \)
Time period:

Time period variation of six modes is plotted which gives an insight into the behaviour of the structure.

<table>
<thead>
<tr>
<th>MODE</th>
<th>TIME PERIOD (SEC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NORMAL BUILDING</td>
</tr>
<tr>
<td>1</td>
<td>0.46237</td>
</tr>
<tr>
<td>2</td>
<td>0.46237</td>
</tr>
<tr>
<td>3</td>
<td>0.40688</td>
</tr>
<tr>
<td>4</td>
<td>0.12185</td>
</tr>
<tr>
<td>5</td>
<td>0.11937</td>
</tr>
<tr>
<td>6</td>
<td>0.11937</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NODE NO</th>
<th>SHEAR STRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NORMAL FLOOR</td>
</tr>
<tr>
<td>9939</td>
<td>-4.46E+07</td>
</tr>
<tr>
<td>9967</td>
<td>-4.77E+07</td>
</tr>
<tr>
<td>10131</td>
<td>1.46E+06</td>
</tr>
<tr>
<td>10161</td>
<td>-4.81E+07</td>
</tr>
</tbody>
</table>

COMPARISON OF SHEAR STRESSES FOR DIFFERENT NODES IN ANSYS
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