Planning and Seismic Design of Hostel Building with Soft Storey and Floating Column

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Abstract— Nowadays due to unavailability of space we need to construct building in vertical direction, i.e buildings to be constructed as multistory buildings. in order to provide parking for the vehicle in a building it is necessary to construct a structure with soft storey. Sometimes due to uncertainty of any floor it may be necessary to provide a column which doesn't have footing which is called as floating column. Analysis of a structure with soft storey and floating column at top storey has been carried out as an experimental work to study the behavior of structure with soft storey and floating column under gravity and seismic loading conditions.

Keywords: Soft Storey, Floating Column, Planning and Seismic Design

I. Introduction

Generally, in the seismic design of ordinary, middle / high-rise buildings, structural characteristics are kept uniform in a building in order to avoid damage concentration to certain stories. However, it is extremely difficult to incorporate a structural design suited for the characteristics of each function adequately in general for the multifunctional building. For a base-isolated structure capable of reducing seismic force to a building, the degree of freedom in the structural design of an upper building gets somewhat high. For the base-isolated structure, however, a seismic isolation system is often installed on the bottom story to prevent seismic input from entering a building directly. This is also because movable parts other than base-isolation materials are minimized by reducing plumbing crossing the seismic isolation story and preventing the elevator shaft from passing across the seismic isolation story deformed largely in the horizontal direction. For an ordinary base isolated structure, therefore, the clearance required between the building and its peripheral ground constitutes a great restriction on the harmony and continuity between the surroundings and the building on the ground level. This has a major impact on building plans under the present condition. This Report named “Planning and Seismic Design of Hostel Building with Soft story and Floating column”.

A. *Soft Storey*

A soft story building is a multi-story building in which one or more floors have windows, wide doors, large unobstructed commercial spaces, or other openings in places where a shear wall would normally be required for stability as a matter of earthquake resistant design. A typical soft story building is an apartment building of three or more stories located over a ground level with large openings, such as a parking garage or series of retail businesses with large windows. Soft storey is the one of which the rigidity is lower than any other storey's due to the fact that it has not got the walls with the same properties the other ones have. If vertical load bearing structural elements and partitioning wall continue in all the storeys, there is no soft storey in the construction. Soft storeys are generally present at the entrance floors of the buildings as shown in fig 1. This situation depends on the constructional properties of the cities and countries. If dwellings and trade centers are at the same building, soft storeys are more common, if not, soft storeys are rare.

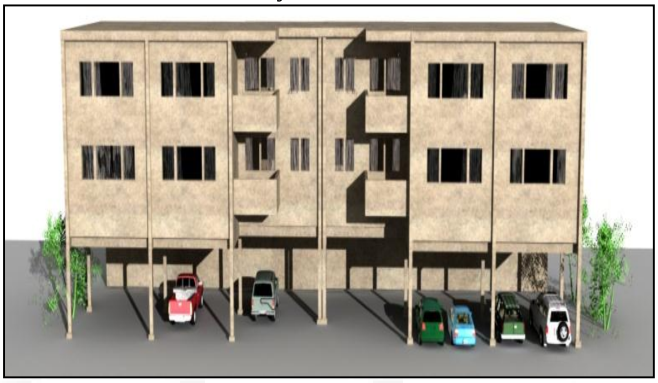

Fig. 1: Soft Storey

B. Floating Column

The term floating column is also a vertical element which ends (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path. The beams in turn transfer the load to other columns below it. Such columns where the load was considered as a point load. There are many projects in which floating columns are already adopted, especially above the ground floor, so that more open space is available on the ground floor. These open spaces may be required for assembly hall or parking purpose.

The column is a concentrated load on the beam which supports it as shown in fig 2. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. However, this need not be done at the cost of poor behaviour and earthquake safety of buildings. Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimized. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features. Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structures cannot be demolished, rather study can be done to strengthen the structure or some remedial features can be suggested.

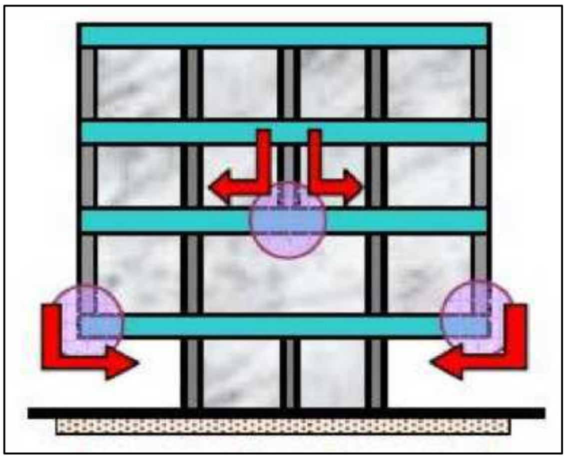

Fig. 2: Floating Column

II. METHODOLOGY

A. Preparation of Plan

Plan is prepared using Auto CADD 2014.

B. Load Calculations

Dead load of slab = Area of Slab X Density of concrete.
Dead load of column =area of column x density of concrete.
Dead load of wall =area of wall x density of wall.
Dead load of parapet wall=area of parapet wall x density of parapet wall.

1) Dead Load on Beams

Area of Slab load on Beams = Slab area divided into 4 triangles and area of each triangle i.e (½ x base x height).
Slab Weight on Beams = Dead Load of Slab X Area of slab.
Slab Weight on Beam / meter =(Slab Weight on Beam) / Length of Beam. -------- (1)
Self-Weight of Beam= Area x Density of Concrete.-------(2)
Self-weight of Wall / meter =Area X Density of Wall-----(3)
Total Weight on the beam is Calculated by adding Equation (1)+(2)+(3)

2) Live Load on Beams

Area of Slab load on Beams = Slab area divided into 4 triangles and area of each triangle i.e (½ x base x height).
Slab Weight on Beams = Dead Load of Slab x Area of slab.
Slab Weight on Beam / meter = (Slab Weight on Beam) / Length of Beam.
3.3 Seismic load analysis (as per is 1893: 2002, part-1)
Live Load =50% of Live Load
Dead Load= Dead Load of all Structural Elements (i.e Beams, Columns, Floors, Wall)
Concentrated Mass= Concentrated mass of all floors
Direction and Eccentricity = X & Y

C. Structural Period

For Medium soil sites
$T = (0.09 \times h)/\sqrt{d}$
Factors and Coefficients
Seismic Zone Factor, Z [IS 1893: 2002, part-1 Table 2]
Response Reduction Factor, R [IS 1893: 2002, part-1 Table 7]
Importance Factor, I [[IS 1893: 2002, part-1 Table 6]
Site Type [[IS 1893: 2002, part-1 Table 1] = II
Spectral Acceleration Coefficient, S_a /g [IS 1893: 2002, part-1, clause 6.4.5]
Seismic Coefficient, A_h [IS 1893: 2002, part-1, clause 6.4.2]

$$\alpha_h = (Z/2) \times (Sa/g) \times (I/R)$$

Design Seismic Base Shear:

The total design lateral force or design seismic base shear (V_B)along any principal direction shall be determined by the following expression:
$V = A_h W$
Where,
A_h = Design horizontal acceleration spectrum value, using the fundamental natural period T, in the considered direction of vibration.
w = Seismic weight of the building.
Distribution of Design Force: Vertical Distribution of Base Shear to Different Floor Level

The design base shear (V) computed shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

Where
Q_i =Design lateral force at 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 is the number of levels at which the masses are located.

III. PLAN OF PROPOSED BUILDING & DETAILS

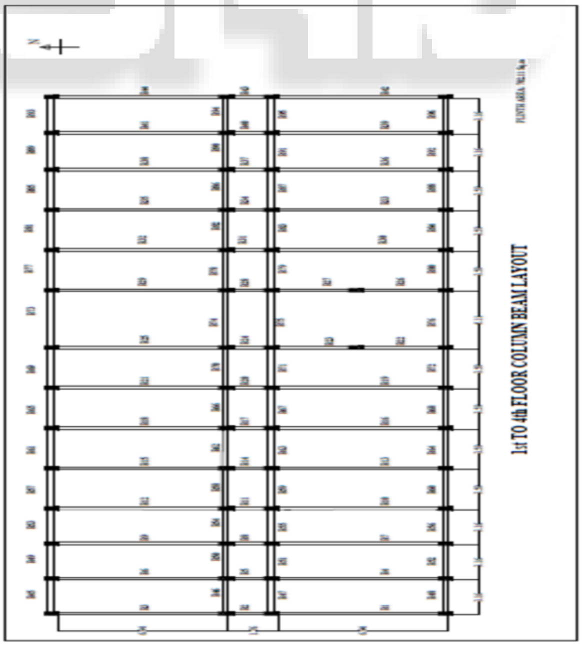

Fig. 3: Column Beam Layout For 1st to 4th Floor

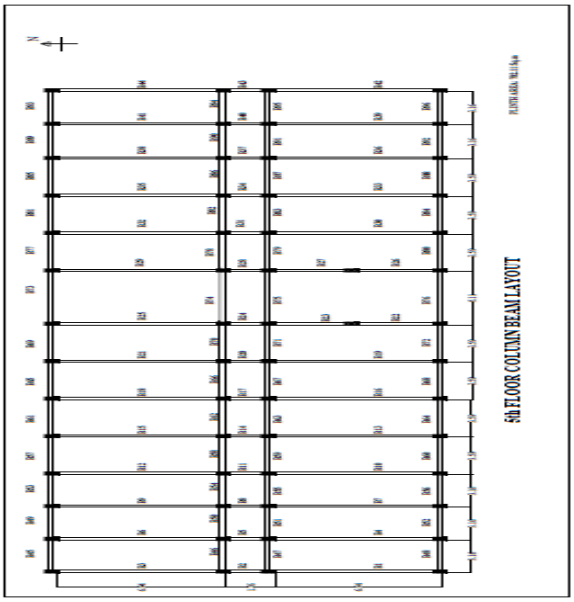

Fig. 4: Column Beam Layout for 5th Floor

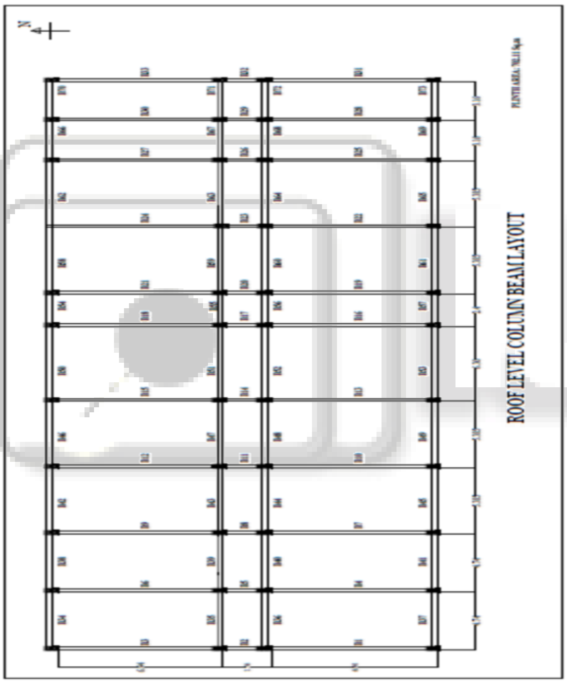

Fig. 5: Column Beam Layout for Roof

A. *Building Details*

- Type of structure = Multi-storied building.
- Zone = III (Moderate).
- Number of stories = G+5.
- Ground storey height = 3.5m.
- Floor to floor height = 3.5m.
- Walls = 0.23m thick.
- Materials = M25 and Fe 415.
- Seismic Analysis = Equivalent Static method. (IS: 1893 PART-1, 2002)
- Size of main Column = (0.3x0.8) m.
- Size of Floating Column = (0.30x0.35) m.
- Size of Beam = (0.23x0.8) m.
- Size of Beam = (0.23x0.5) m.
- Size of Beam resting under floating column = (0.23x0.6)m.
- Total Depth of slab = 0.15m.
- Parapet wall Thickness = 0.15m.
- Parapet wall height = 1m.
- Density of concrete = 25kN/m^3.
- Density of wall (Brick Masonry) = 18kN/m^3.
- Density of Parapet wall= 18kN/m^3.
- Live load on slab = 5kN/m^2.
- Live load on Roof = 1.5kn/m^2.
- Floor finish = 1.5kN/m^2.
- Terrace Finish = 1.5kN/m^2.
- Terrace water proofing = 1.5kN/m^2.

IV. ANALYSIS USING ETABS

Models are obtained from ETABS as shown in fig 6 and shear force diagrams and bending moment diagrams of the various structural elements. Following steps are performed in the analysis.

1) Step 1- Select the base units and design codes.
2) Step 2- Set up grid lines for required plan.
3) Step 3- Define storey levels.
4) Step 4- Define section properties.
5) Step 5- Draw structural objects.
6) Step 6- Select objects.
7) Step 7- Assign properties.
8) Step 8- Define load patterns.
9) Step 9-Assign loads.
10) Step 10- Define load cases.
11) Step 11-View the model.
12) Step12- Analyze the model.
13) Step 13- Display results for checking.
14) Step 14- Design the model.
15) Step 15- Generate detail documents.
16) Step 16- Output results and reports.
17) Step 17- Save the model.

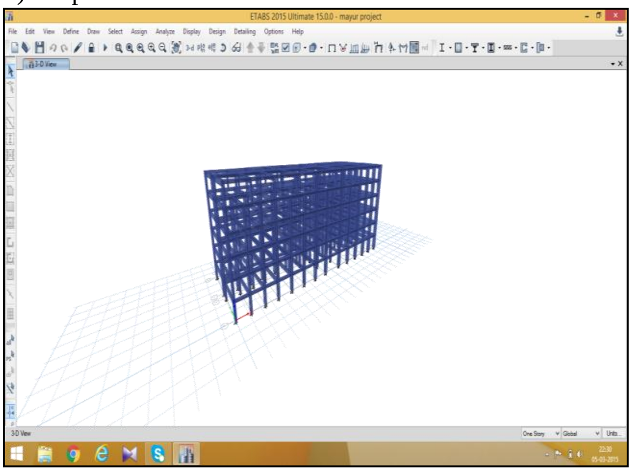

Fig. 6: Extruded Model of Proposed Building

V. RESULTS

The hostel building was analyzed using ETABS software by applying dead load and live load, and the following results were obtained

Direction and Eccentricity

Direction = X

Structural Period
Period Calculation Method = User Specified
For Medium soil sites
T = (0.09 x h)/√d
= (0.09 x 21)/√46.06
= 0.278sec
Factors and Coefficients
Seismic Zone Factor, Z [IS 1893:2002 :Part 1 Table 2]
Z=0.16
Response Reduction Factor, R [IS1893:2002 :Part 1 Table 7]
R=5
Importance Factor, I [IS1893:2002 : Part 1 Table 6]
I=1
Site Type [IS1893:2002 : Part 1 Table 1] = II
Seismic Response
Spectral Acceleration Coefficient, [IS1893:2002: Part 1 6.4.5] S_a/g=2.5
Equivalent Lateral Forces
Seismic Coefficient, Ah [IS 6.4.2]

$$A_h = \frac{ZI\frac{S_a}{g}}{2R}$$

=0.16x1x2.5/(2x5)
=0.04

A. *Calculated Base Shear*

Direction	Period Used (sec)	Seismic Coefficient, Ah	W (kN)	Vb (kN)
X	0.278	0.04	71136.8617	2845.4745

Table 1: Calculated Base Shear

B. *Applied Story Forces*

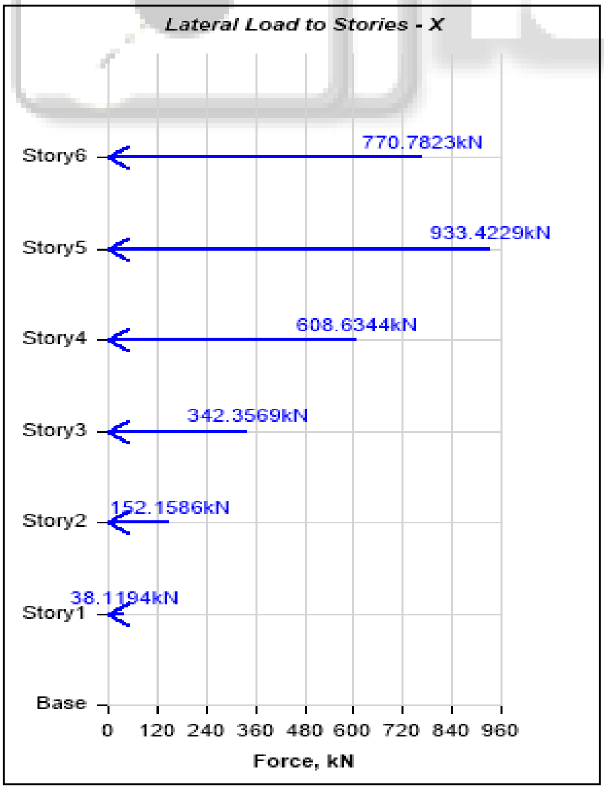

Fig. 6: Lateral Loads to Stories at x Direction

Story	Weight	Height	$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$	Base shear
	kN	m	kN	kN
Story 6	10438.05	21	770.7823	770.7823
Story 5	11946.38	17.5	933.4229	1704.2052
Story 4	12187.88	14	608.6344	2312.8396
Story 3	12187.88	10.5	342.3569	2655.1965
Story 2	12187.88	7	152.1586	2807.355
Story 1	12192.29	3.5	38.1194	2845.4745
Base	-	0	0	0

Table 2: Applied Story forces

C. *Direction and Eccentricity*

Direction = Y

1) *Structural Period*

Period Calculation Method = User Specified
For Medium soil sites
T = (0.09 x h)/√d
= (0.09 x 21)/√15.64
= 0.478sec

2) *Factors and Coefficients*

Seismic Zone Factor, Z [IS 1893:2002 :Part 1 Table 2]
Z=0.16
Response Reduction Factor, R [IS1893:2002 :Part 1 Table 7]
R=5
Importance Factor, I [IS1893:2002 :Part 1 Table 6]
I=1
Site Type [IS1893:2002 :Part 1 Table 1] = II

3) *Seismic Response*

Spectral Acceleration Coefficient, [IS1893:2002 :Part 1 6.4.5] $\frac{S_a}{g} = 2.5$
Equivalent Lateral Forces
Seismic Coefficient, Ah [IS 6.4.2]

$$A_h = \frac{ZI\frac{S_a}{g}}{2R}$$

=0.16x1x2.5/(2x5)
=0.04

D. *Calculated Base Shear*

Direction	Period Used (sec)	Seismic Coefficient, Ah	W (kN)	V_b (kN)
Y	0.478	0.04	71136.8617	2845.4745

Table 3: Calculated Base shear

E. Applied Story Forces

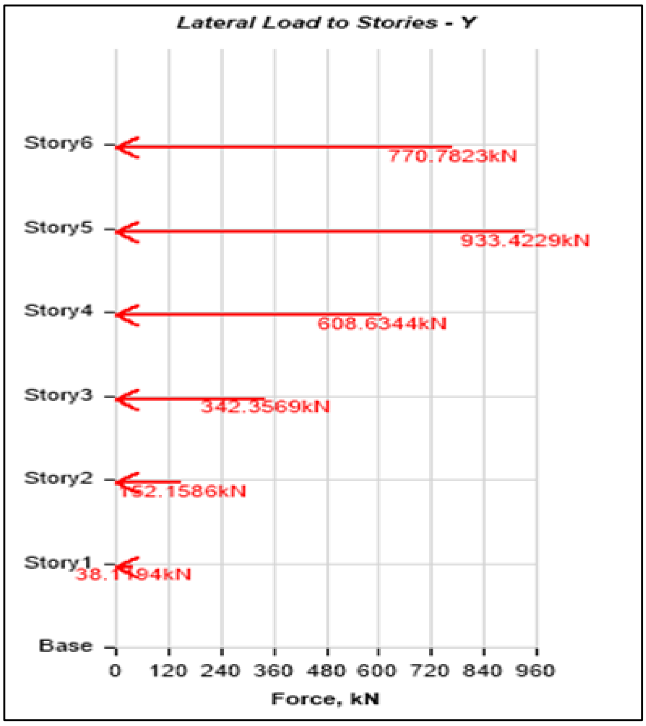

Fig. 7: Lateral loads to stories at y direction

Story	Weight	Height	$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$	Base shear
	kN	M	kN	kN
Story 6	10438.05	21	770.7823	770.7823
Story 5	11946.38	17.5	933.4229	1704.2052
Story 4	12187.88	14	608.6344	2312.8396
Story 3	12187.88	10.5	342.3569	2655.1965
Story 2	12187.88	7	152.1586	2807.355
Story 1	12192.29	3.5	38.1194	2845.4745
Base	-	0	0	0

Table 4: Applied Story forces

F. Load Combinations

For the design load combinations were considered as per the clause 6.3.1.2 of IS 1893 part 1 2002,

Name	Load case	Scale factor
1.5*(DL+LL)	Dead	1.5
1.5*(DL+LL)	Live	1.5
1.5*(DL+EQX)	Dead	1.5
1.5*(DL+EQX)	EQX	1.5
1.5*(DL-EQX)	Dead	1.5
1.5*(DL-EQX)	EQX	-1.5
1.5*(DL+EQY)	Dead	1.5
1.5*(DL+EQY)	EQY	1.5
1.5*(DL-EQY)	Dead	1.5
1.5*(DL-EQY)	EQY	-1.5
0.9DL+1.5EQX	Dead	0.9
0.9DL+1.5EQX	EQX	1.5
0.9DL-1.5EQX	Dead	0.9
0.9DL-1.5EQX	EQX	-1.5
0.9DL+1.5EQY	DL	0.9
0.9DL+1.5EQY	EQY	1.5
0.9DL-1.5EQY	Dead	0.9
0.9DL-1.5EQY	EQY	-1.5
1.2*(DL+LL+EQX)	Dead	1.2
1.2*(DL+LL+EQX)	Live	1.2
1.2*(DL+LL+EQX)	EQX	1.2
1.2*(DL+LL-EQX)	Dead	1.2
1.2*(DL+LL-EQX)	Live	1.2
1.2*(DL+LL-EQX)	EQX	-1.2
1.2*(DL+LL+EQY)	Dead	1.2
1.2*(DL+LL+EQY)	Live	1.2
1.2*(DL+LL+EQY)	EQY	1.2
1.2*(DL+LL-EQY)	Dead	1.2
1.2*(DL+LL-EQY)	Live	1.2
1.2*(DL+LL-EQY)	EQY	1.2

Table 5: Load Combinations

Storey	Displacement
6	50.6
5	46.8
4	42.3
3	36.1
2	28.9
1	20.7
Base	0

Table 6: Storey Displacement in x Direction

Storey	Displacement
6	16
5	14.6
4	12.7
3	10.3
2	7.7
1	4.8
Base	0

Table 7: storey displacement in y direction

G. Shear force and bending moment diagram for beams

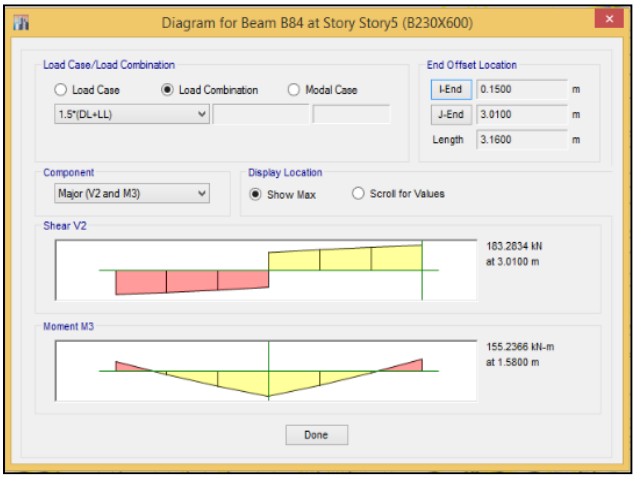

Fig. 8: beam under floating column (230 x 600) mm.

Fig. 9: beam of size (230X500) mm.

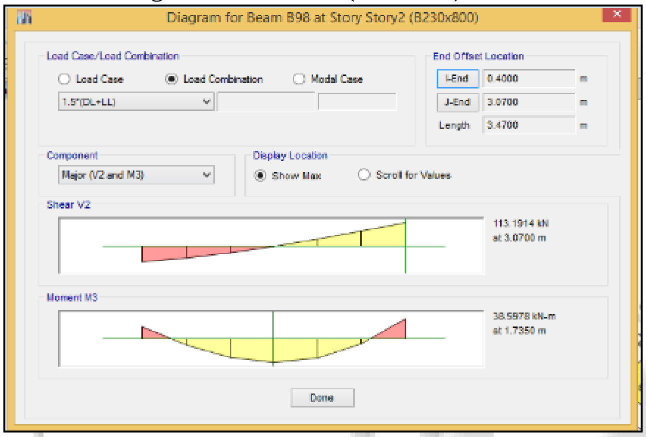

Fig. 10: beam of size (230X800) mm.

H. Shear force and bending moment diagram of columns

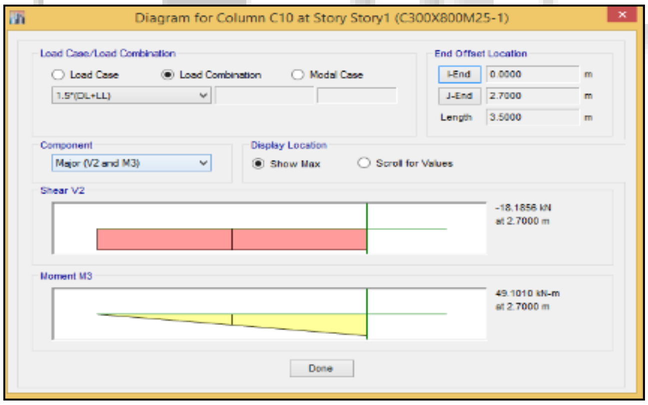

Fig. 11: column of size (300X800) mm.

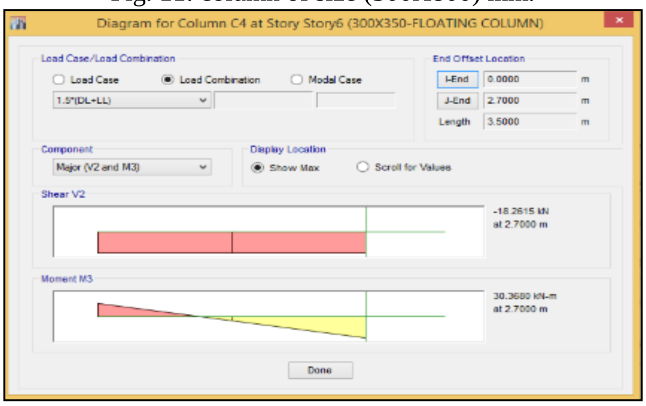

Fig. 12: column of size (300X350) mm (floating Column).

I. Detailing of beams

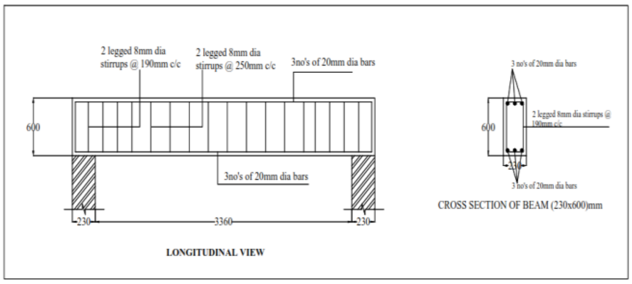

Fig. 13: Detailing of Beam under floating Column (230x 600) mm

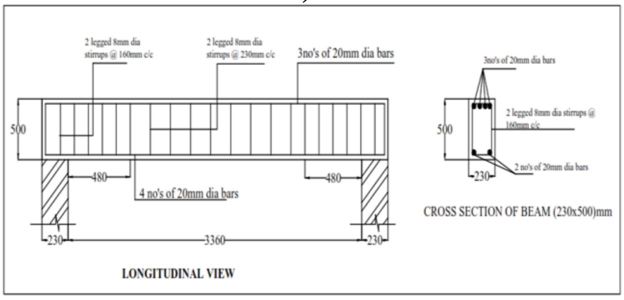

Fig. 14: Detailing of Beam (230 x 500) mm.

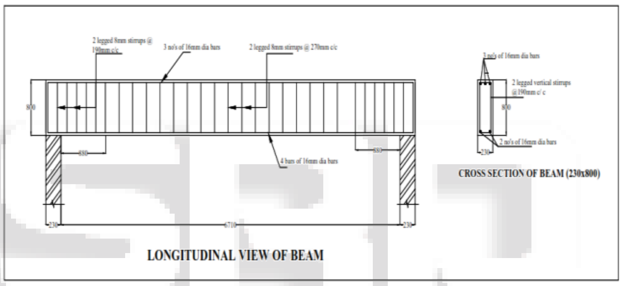

Fig. 15: Detailing of Beam (230 x 800) mm.

J. Detailing of column

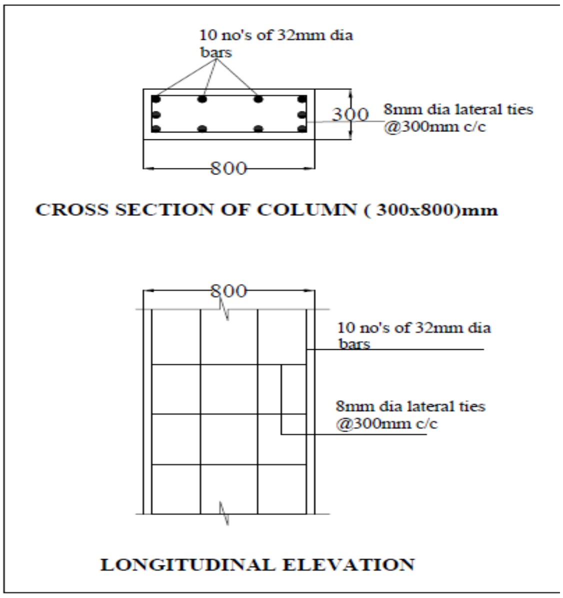

Fig. 16: Detailing of Column (300 x 800) mm.

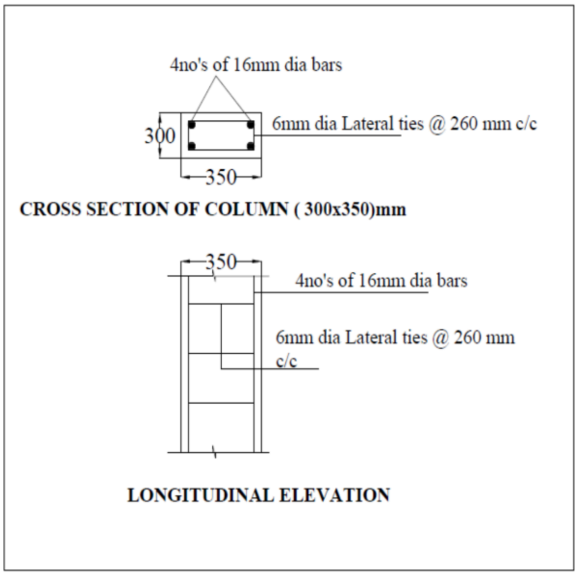

Fig. 17: Detailing of Column (300 x 350) mm (Floating Column).

VI. Conclusions

1) Design & detailing of storey having Floating Column under gravity & seismic loads is estimated.
2) Design & detailing of Structure with soft storey under ground motion is obtained.
3) Behaviour of Beam Supporting Floating Column is obtained.
4) Analysis of each Storey is carried out which comes in zone III & members are designed to resist seismic forces.
5) Reinforcement details for the Seismic resistant hostel building are obtained.
6) Lateral force or seismic force along height of the structure is obtained.
7) Base shear at each storey level is calculated.

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