

Dynamic Analysis of Irregular Building with Box Type Shear Wall at Center under Different Type of Soil

Kajal Sarawade^{1,*}, Bhalchandra S.A.²

Abstract

Building engineers are being shown to accept High rise construction due to increase shortage and land cost. The development of high-rise buildings presents many challenges with the type of lateral load. In High rise buildings getting better efficiency and the high-strength shear wall is an effective solution. The Optimum location of the shear wall depends upon the structural shape of buildings. For irregular structures, inner shear walls provide more strength and durability of the structure, whereas outer shear walls exceeded the permissible limit of width of roof or roof space. During an earthquake seismic waves are transmitted to the surface of the earth by the shape of the local soil. The motion of earthquake wave passes through the ground which in turn alter the input motion with its ground related to motion. The physical characteristics of soil are the reason for a structural response of the structure. In this paper, unusual G+15 structure with the box type shear wall under a different type of soil in which are divided such as soft, medium, and hard soil, For earthquake zone III according to IS1893(part 1):2016 studied. the deviant structural behavior was analyzed by performing dynamic analysis using Staad Pro. Vi8 software. The axial force, base shear, moment, and displacement are read and ended the comment.

Keywords: Dynamic analysis, Box type shear wall, Soft, Medium, Hard Soil

INTRODUCTION

Nowadays, earthquakes occur more frequently. Earthquake analysis has traditionally focused on reducing the risk of loss of life. Various rear-loading systems are used in buildings to reduce the impact of this earthquake and wind load. Shear walls are one of the most common side load systems that are usually built-in high-rise buildings. Seismic movements are considered at the basic level, because of this shift in the seismic load. The seismic factor depends on the degree of gravity and strength of the ground material and the underlying structure. Therefore, the soil interaction (Different types of Soil) is an important consideration to consider during the design of a structure.

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The main functions of a shear wall can be described as follows:

1. Structural strength: The Shear wall should provide the lateral strength of the building with resistance to earthquakes, wind forces and transfer these forces to the base
2. Stabilization: Shear wall provides high structural strength on the side of the site, which reduces structural delays that occur and thus reduces structural damage.

The structure without a shear wall shows a higher deformation as compared to the shear wall. The ideal location and position of the shear wall using a genetic algorithm approach are close to the core of

the structure [1]. The shear wall can be of various shapes and sizes and can be placed in different areas of buildings. The position of the shear wall plays an important role in determining the behavior against lateral forces [2]. proper alignment of the shear wall helped to reduce the erosion of the floors in a typical rectangular structure and an irregular structure with an L-shaped shape [3].

Serious Problem of the Seismic design

With the design of high-rise buildings in regions that are prone to wind visibility and the effects of earthquakes often include [4]:

1. The High base for the not permanent development of the foundation.
2. Requirements for high extraction power near the foundation (earthquake).
3. High-pressure gravity on specific objects (and the use of high-strength materials) to reduce the structure of the structure and increase the ground area.
4. Development of ductility in buildings at the bottom of the building under high pressure of gravity (Seismic).
5. Control of erosion (wind and earthquake).
6. Damage control to allow for repair (earthquake).
7. Ensuring power outages and prevention of severe failures (earthquakes).

Site Selection

During an earthquake, Seismic waves are transmitted to the surface of the earth by the shape of the local soil. The motion of the earthquake waves passes through the ground, which in turn alters the input motion with its ground-related motion. The physical characteristics of the soil are the reasons for the structural response of the structure. When seismic forces are installed, the pressure on the ground can increase, depending on the type of foundation and the type of soil [5].

Subdivision of the land on which the building is located [4, 5],

Soil type I = Rock or hard soil (That soil, with a carrying capacity of more than 10t/m^2).

Type of soil II = Medium or hard soils (That soils, with a permissible allowance of less than or equal to 10t/m^2).

Type of soil III = Soft (That is the soil, subject to high sedimentation or fluid retention during earthquakes).

Soil should be avoided or pressed to improve so that it can harden or harden. The allowable load pressure will be determined according to the IS: 1888-1982 load test (Revision 1992). It is a common practice to increase the permissible bearing pressure by one-third, i.e., by 33%, when conducting soil analysis with materials such as large rock formations of rock formations, dense in very dense soils, and over compacted soils like a lump clay. For a building to react to movement, it needs to overcome its inertia, which leads to interactions between the structure and the soil [4].

Objectives

1. Analyze the irregular seismic structure zone III and the wall of the center shear box under different ground conditions using the Response spectrum method.
2. To study the variability of the main shear base, momentary bending, and subsequent movement in the line of the model made from Hard (Soil type I), Medium (Soil type II), The condition of the soft soil (Soil type III).
3. Study the performance of local soil conditions in earthquake zone structures.
4. Raise awareness of the importance of local conditions in the construction of earthquake structures.

India's code for earthquake analysis IS1893: 2002, identifies seismic zones to determine different levels of seismic intensity, including maps of major tectonic signals and lithological structures to gain an understanding of the impact of local conditions on earthquake resistance structure [6].

METHODOLOGY

For Analysis purposes, analytical methods used to deal with earthquake loading include equilibrium power systems, modal reaction, non-linear static (pushover), and offline history response method. Although there is increasing use of non-linear processes in construction, response history analysis is performed by a minority of architectural engineers, and among a few, the response history analysis is performed on a very small percentage of projects [7–9].

The effect of seismic volumes used on buildings can be viewed in two ways, according to 1893 (Part 1): 2016 namely:

Equivalent Static Method

Dynamic Analysis Method

The analytical model for the dynamic analysis of structures with irregular configurations should be such that they adequately represent the inconsistencies in the configuration of the structure. Dynamic analysis can be done in 2 ways,

- *Time History Method:* The method of time history will be based on the appropriate motion of the earth (preferably in line with the design speed of the desired range of natural times) and will be done using accepted principles of earthquake design.
- *Response Spectrum Method:* The term spectrum in engineering conveys the idea that the response of structures at different times is summarized in a single chart. This approach will be done using the design spectrum specified in the code or the design spectrum specific to the site with the structure modified in the project area. Construction dumping rates can be considered 2 and 5 percent critical, For purpose of steel reinforcement and reinforced concrete structures, respectively.

Dynamic analysis using the response spectrum method is designed for G + 15 storey irregular building T-shaped with box type shear wall using Staad pro. Software. Understanding the operation of a building due to the magnitude of the earthquake under the different types of ground on which the building is built. In Study IS1893 (Part 1): 2016 and IS875 were used and the results were compared.

Modelling

Analyze the unusual structure with a wall of shear type box in the center under a different type of soil that conducts the reaction method with the following methodology (Figure 1 and Table 1), The strength of the shear wall on each floor in each mode calculated by STAAD in accordance with IS 1893 (Part 1): 2016 is calculated from equation as below,

Table 1. Building configuration.

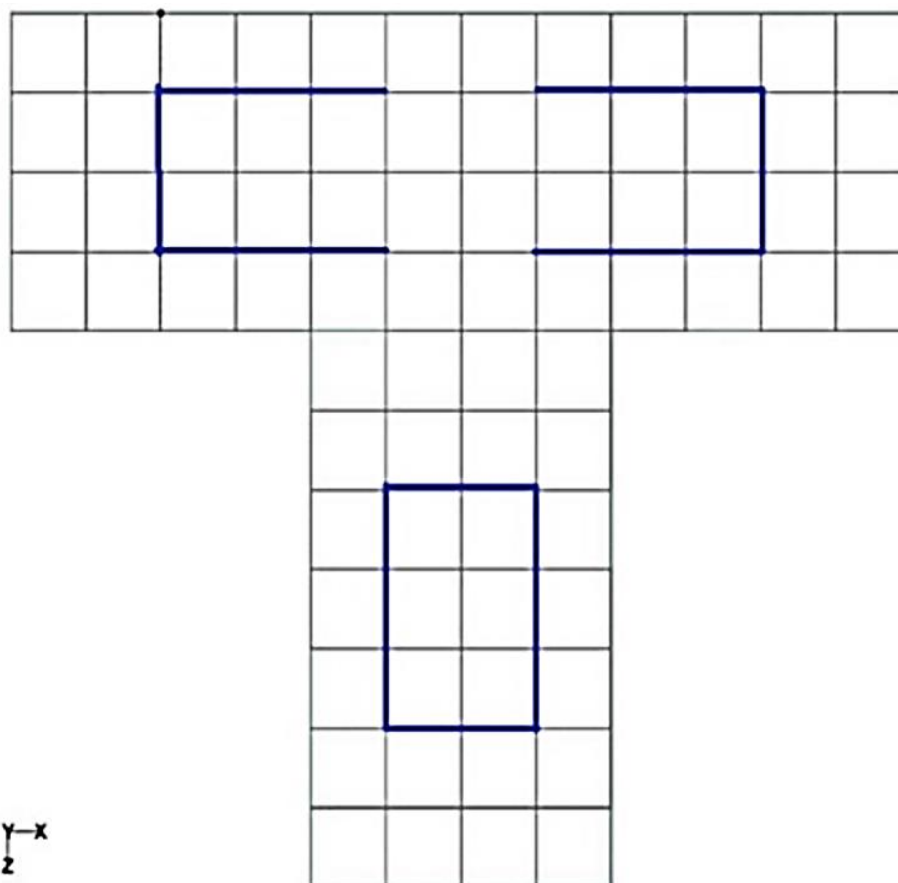
Total height of the building	48 m
Number of stories	15
Height of each storey	3 m
Grade of concrete	M25
Grade of steel	Fe 415
Depth of slab	150 mm
Size of beam	(300 × 450) mm
Size of Column	(350 × 750) mm
Shear wall thickness	200 mm

$$Q_{ik} = A_k \phi_{ik} P_k W_i$$

Here, horizontal acceleration spectrum value (A_k) and Seismic weight of floor i of the structure (W_i) is input (Figure 2, 3 Table 2).

Table 2. Loading.

Live load	3 KN/m ²
Floor finish	1 KN/m ²
Seismic loading	IS1893
Zone factor	Zone III (0.16)
Soil type	Type I (Hard soil) Type II (Medium or Stiff soil) Type III (Soft soil)
Importance factor	1
Response reduction factor	5
Eccentricity ratio	0.05
Wind loading	IS875
Wind speed	39 m/sec
Risk coefficient (K_1)	1
Terrain category type (K_2)	4
Topography (K_3)	1.05
Damping	5%

**Figure 1.** T Shaped Irregular Building with Box Type Shear Wall (Top View).

RESULTS

Axial Force

Table 3 and Figure 4 shows the value of axial force under different type of soil condition from One to Fifteen storey irregular building with inner box shear wall.

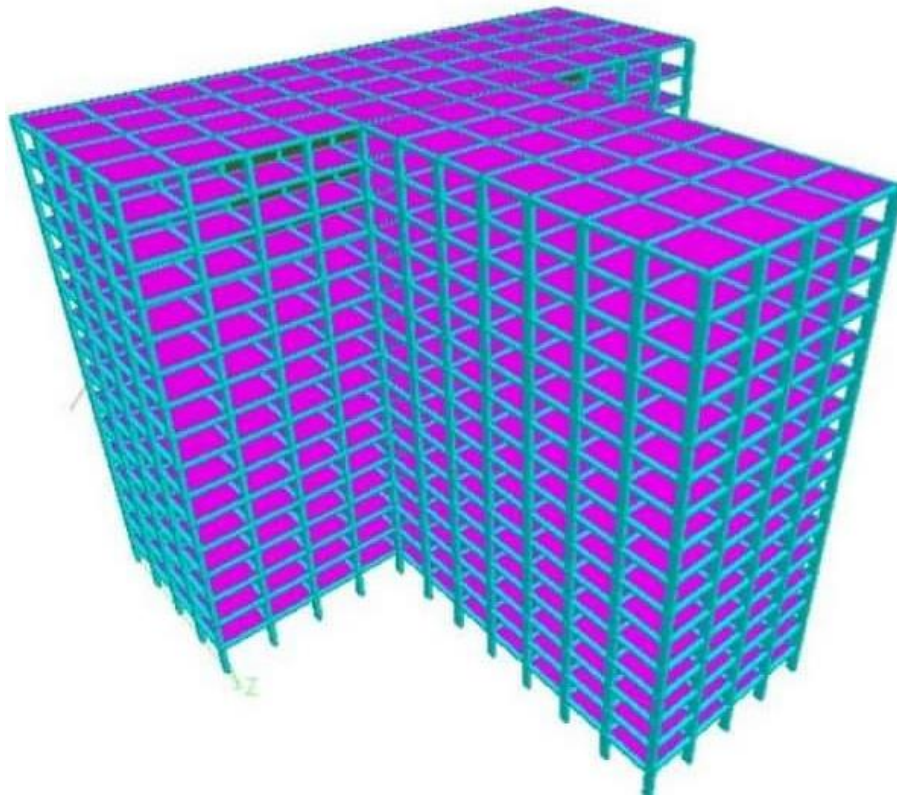


Figure 2. 3 D View.

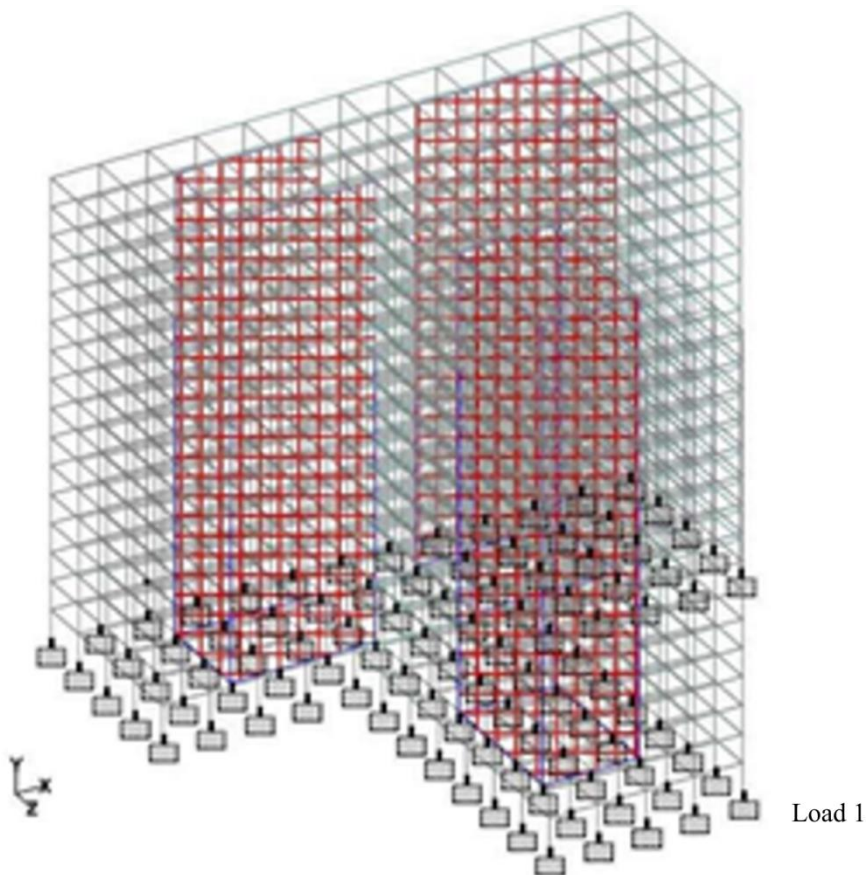
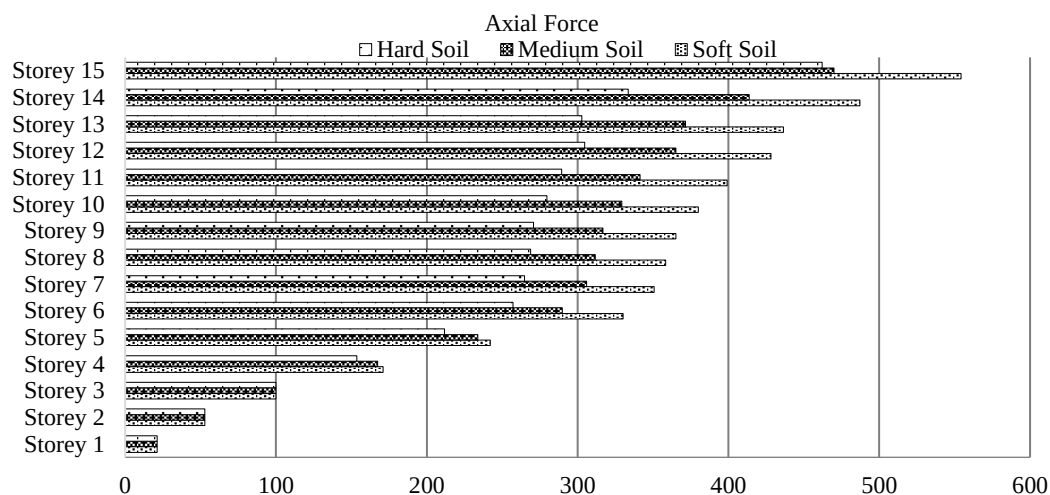


Figure 3. T Shaped Irregular Building with Box Type Shear Wall (3D View).

Table 3. Value of axial force under different type of soil condition.

Number of Storey	Axial Force (KN)		
	<i>Soft Soil</i>	<i>Medium Soil</i>	<i>Hard Soil</i>
15	554.22	470.03	462.15
14	487.16	413.84	333.47
13	436.48	371.43	302.76
12	428.13	365.19	304.71
11	399.09	341.42	289.43
10	380.00	329.38	279.68
9	365.17	316.74	270.82
8	358.44	311.59	268.74
7	350.02	306.05	264.74
6	330.17	289.92	257.19
5	242.08	233.88	211.67
4	171.08	167.31	153.68
3	100.02	100.02	100.02
2	52.75	52.75	52.75
1	21.20	21.20	21.20

**Figure 4.** Shows the value of axial force under different type of soil condition.

Comparison of Axial Force Results

As the soil condition changes from Soft to Hard, it is observed that the Axial forces in member decreases. The percentage reduction in axial forces ranges from 0 to 19.56 (Figure 5, Table 4).

Table 4. Different storey and reduction in Axial Force.

Number of Storey	% Reduction in Axial Force	
	<i>Soft to Medium soil</i>	<i>Medium to Hard soil</i>
15	15.19	19.59
14	15.05	19.42
13	14.89	18.50
12	14.70	16.56
11	14.45	15.23
10	13.32	15.09
9	13.26	14.50
8	13.07	13.75
7	12.76	13.50

Number of Storey	% Reduction in Axial Force	
	Soft to Medium soil	Medium to Hard soil
6	12.19	11.29
5	3.39	9.50
4	2.20	8.15
3	0	0
2	0	0
1	0	0

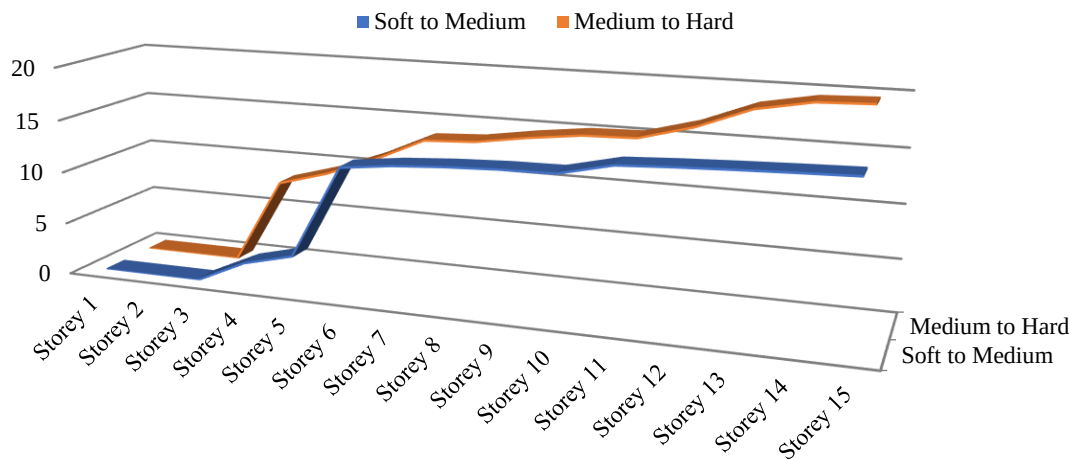


Figure 5. The soil condition changes from Soft to Hard.

Base Shear

Table 5 and Figure 6 shows the value of base shear under different type of soil condition from One to Fifteen storey irregular building with box type shear wall.

Table 5. Base shear under different type of soil condition.

Number of Storey	Base Shear (Y-Direction) KN		
	Soft Soil	Medium Soil	Hard Soil
15	766.12	626.23	441.37
14	744.19	608.30	428.73
13	721.09	589.41	415.42
12	695.63	567.92	398.51
11	668.18	559.60	410.07
10	654.49	548.13	402.88
9	542.55	457.65	341.02
8	454.02	385.74	289.19
7	358.15	305.43	248.83
6	335.08	312.00	255.12
5	271.34	258.37	213.80
4	249.23	249.23	209.13
3	187.03	187.03	187.03
2	150.12	150.12	150.12
1	92.80	92.80	92.80

Comparison of Base shear result

As the soil condition changes from Soft to Hard, it is observed that the Base shear in member decreases. The percentage reduction in base shear ranges from 0 to 29.52 Table 6 and Figure 7.

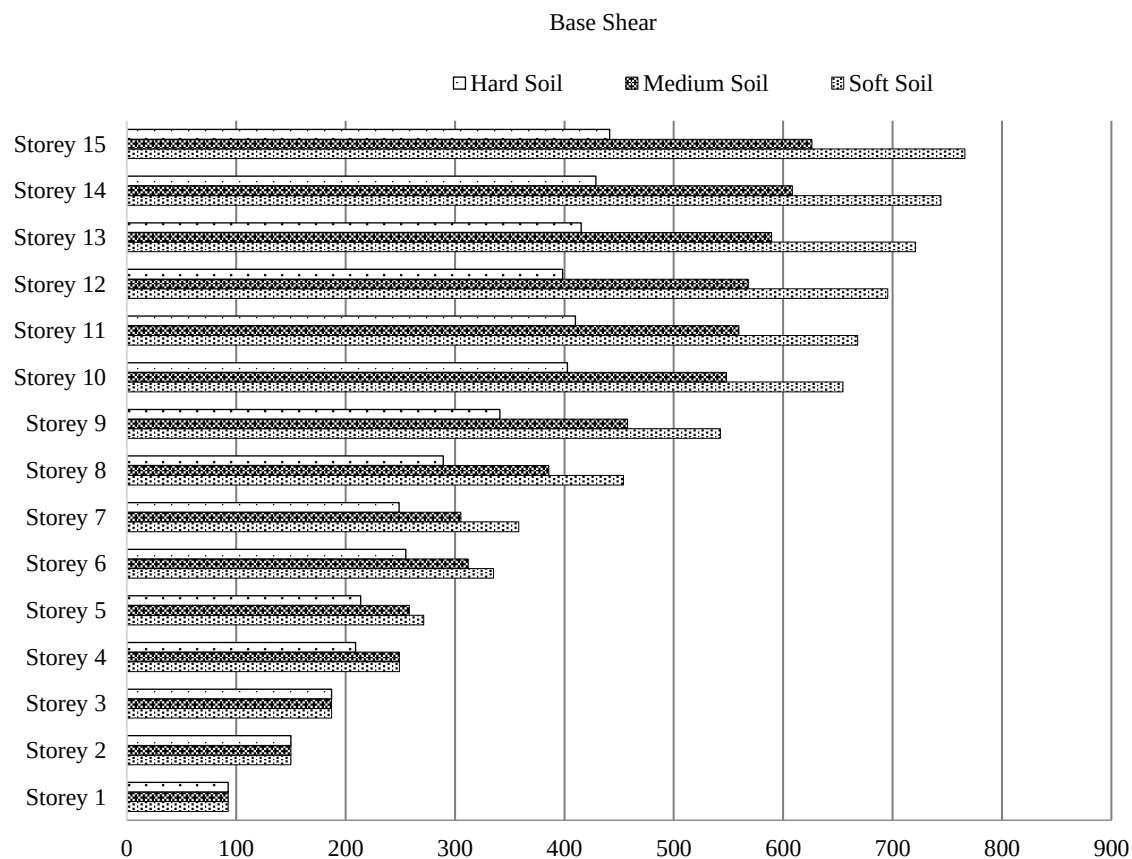


Figure 6. Different type of soil condition from One to Fifteen storey irregular building with box type shear wall.

Table 6. Soil condition changes from Soft to Hard.

Number of Storey	% Reduction in Base shear	
	<i>Soft to Medium soil</i>	<i>Medium to Hard soil</i>
15	18.26	29.52
14	18.26	29.52
13	18.26	29.52
12	18.36	29.83
11	16.38	26.72
10	16.25	26.50
9	15.65	25.48
8	15.04	25.03
7	14.72	18.53
6	6.89	18.23
5	4.78	17.25
4	0	16.09
3	0	0
2	0	0
1	0	0

Bending Moment

Table 7 and Figure 8 shows the value of Bending moment under different type of soil condition from One to Fifteen storey irregular building with box type shear wall.

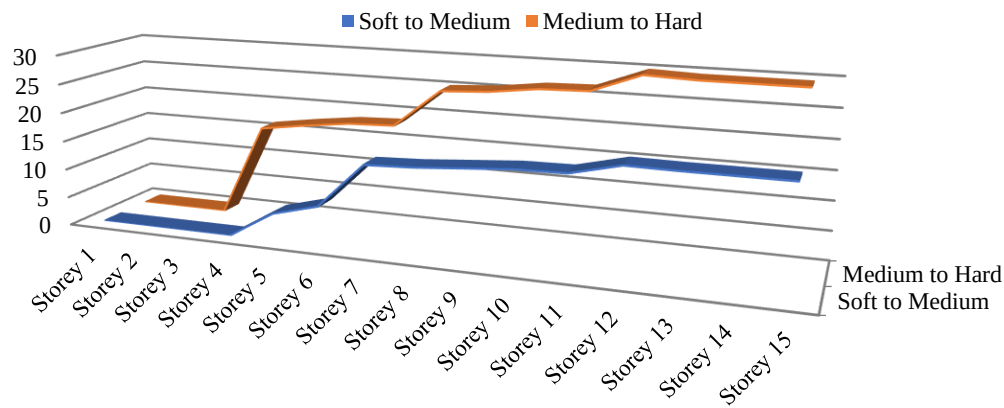


Figure 7. Soil condition changes from Soft to Hard.

Table 7. Bending moment under different type of soil condition from One to Fifteen storey.

Number of Storey	Bending Moment (Y-Direction) KN-M		
	Soft Soil	Medium Soil	Hard Soil
15	1.56	1.28	0.97
14	1.50	1.24	0.93
13	1.42	1.17	0.88
12	1.32	1.10	0.83
11	1.27	1.06	0.81
10	1.15	0.96	0.74
9	0.98	0.83	0.64
8	0.82	0.70	0.54
7	0.78	0.67	0.51
6	0.68	0.59	0.46
5	0.54	0.51	0.43
4	0.48	0.48	0.40
3	0.28	0.28	0.28
2	0.17	0.17	0.17
1	0.06	0.06	0.06

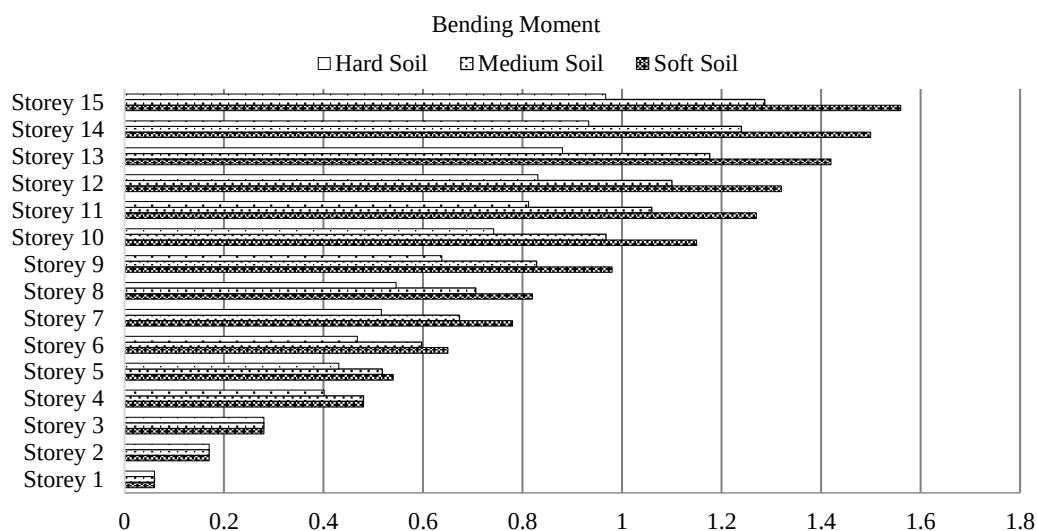
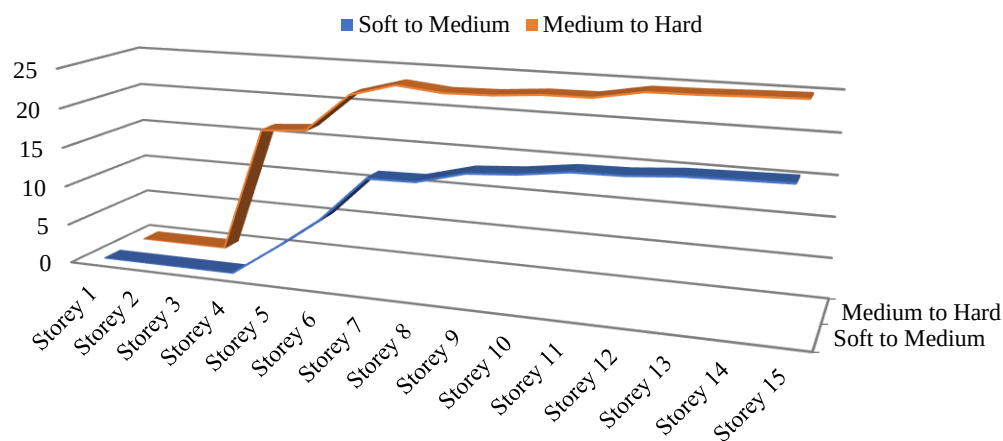


Figure 8. Bending moment under different type of soil condition from One to Fifteen storey.

Table 8. Bending moment in member decreases.

Number of Storey	% Reduction in Bending Moment	
	<i>Soft to Medium soil</i>	<i>Medium to Hard soil</i>
15	17.45	24.86
14	17.32	24.72
13	17.18	24.53
12	16.72	24.45
11	16.61	23.40
10	15.83	23.35
9	15.42	22.89
8	13.89	22.78
7	13.78	23.37
6	8.15	21.76
5	3.95	16.82
4	0	16.40
3	0	0
2	0	0
1	0	0

**Figure 9.** Bending moment in member decreases.**Comparison of Bending moment:**

As the soil condition changes from Soft to Hard, it is observed that the Bending moment in member decreases. The percentage reduction in bending moment ranges from 0 to 24.84 Table 8 and Figure 9.

Lateral Displacement

Table 9 and Figure10 shows the value of lateral displacement under different type of soil condition from One to Fifteen storey irregular building with box type shear wall.

Table 9. lateral displacement under different type of soil condition.

Number of Storey	Lateral Displacement (M)		
	<i>Soft Soil</i>	<i>Medium Soil</i>	<i>Hard Soil</i>
15	0.0310	0.0253	0.0178
14	0.0221	0.0180	0.0117
13	0.0164	0.0134	0.0094
12	0.0152	0.0124	0.0086

Number of Storey	Lateral Displacement (M)		
	<i>Soft Soil</i>	<i>Medium Soil</i>	<i>Hard Soil</i>
11	0.0135	0.0113	0.0083
10	0.0123	0.0103	0.0075
9	0.0107	0.0066	0.0049
8	0.0083	0.0070	0.0052
7	0.0068	0.0058	0.0047
6	0.0046	0.0043	0.0035
5	0.0031	0.0029	0.0024
4	0.0016	0.0016	0.0013
3	0.0005	0.0005	0.0005
2	0.0001	0.0001	0.0001
1	0	0	0

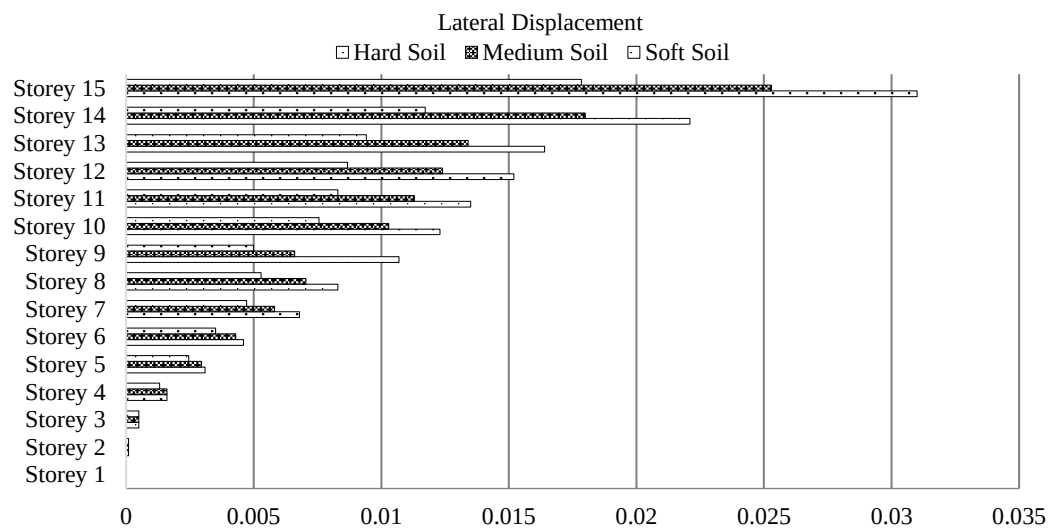


Figure 10. Lateral displacement under different type of soil condition.

Table 10. The lateral displacement in member decreases.

Number of Storey	% Reduction in Lateral Displacement	
	<i>Soft to Medium soil</i>	<i>Medium to Hard soil</i>
15	18.24	29.62
14	18.62	29.59
13	18.65	29.45
12	18.01	29.30
11	16.32	26.70
10	16.48	26.62
9	15.32	25.32
8	15.12	25.05
7	14.70	18.72
6	6.73	18.59
5	4.56	17.62
4	0	16.50
3	0	0
2	0	0
1	0	0

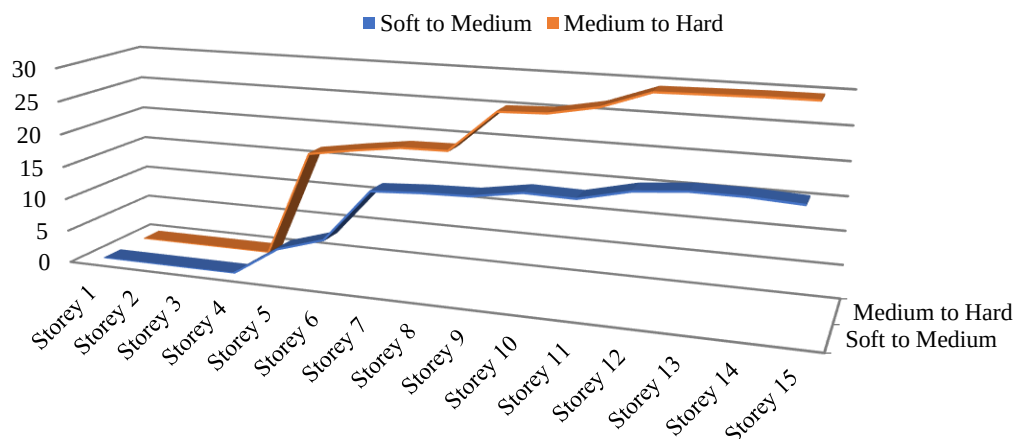


Figure 11. The lateral displacement in member decreases.

Comparison of Lateral Displacement

As the soil condition changes from Soft to Hard, it is observed that the lateral displacement in member decreases. The percentage reduction in lateral displacement ranges from 0 to 29.62 Table 10 and Figure 11.

CONCLUSIONS

The unusual T-shaped structure with the wall of the shear- box type was analyzed and constructed as providing codes and results compared to various aspects.

It is thought that up to 3 Storey Axial force values were similar to soft, medium, and hard soil.

Above 3 floors, the axial force values increase as the soil condition changes from Hard soil to medium and then medium to soft.

Percentage reduction in axial force from 0 to 15.19 when the soil condition changes from soft to medium and decreases from 0 to 19.59 when conditions change from medium to heavy.

It is found that when the soil conditions change the value of the Base shear does not change to three floors and then rises from the hard to the middle and soft respectively.

Percentage reduction on the shear base from 0 to 18.26 when the soil condition changes from soft to medium and decreases from 0 to 29.52 from medium soil to hard.

One to three storey of ground bending remains the same and increases above three floors as the soil types change from hard to medium to soft soil.

Percentage reduction in the bending moment from 0 to 17.45 when the soil condition changes from soft to medium and decreases by 0 to 24.86 from medium to heavy.

It is found that the rates of lateral displacement were similar in different types of soil conditions and increased by more than three floors as the soil type varied from hard to medium to soft soil.

Percentage reduction in lateral deformation from 0 to 18.24 when soil conditions change from soft to medium and reduce 0 to 29.62 when it changes from medium to heavy.

It is necessary to consider the Soil structure interaction to design a frame for a seismic force.

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