Comparative Study of High-Rise Structure in Different Soil Condition

Abhishek Mishra[1], Anand Gaurav Yadav[2], Kumar Vanshaj[3]

[1]*Assistant Professor, Civil Engineering Department, Institute of Engineering and Technology, Lucknow, INDIA*
[2]*M. tech Scholar, Civil Engineering Department, Institute of Engineering and Technology, Lucknow, INDIA*
[3] *Assistant Professor, Civil Engineering Department, Institute of Engineering and Technology, Lucknow, INDIA*

---***---

Abstract - Seismic analysis is the process of calculating the response of a structure that has been subjected to earthquake stimulation. We all know that earthquakes are natural occurrences that can produce the most disastrous effects on structures. As a result, a building should be safe for people by applying proper design and detailing of structural sections to ensure that they are earthquake-resistant. As a result, earthquake protection construction necessitates seismic investigation and planning.
This study was based on a seismic analysis and design of a G+20 RCC building in **ZONE-IV (Medium and Hard Soil).** The imposed dead and live loads, as well as the beam, column, and slab designs, are obtained. **STAAD-PRO CONNECT** software was used to examine the total structure.
STAAD PRO is frequently used to analyse and design a structure while taking earthquake forces into account, as well as to examine and investigate the behaviour of storey drift, storey stiffness, storey displacement, and foundation shear in multi-storey buildings.

***Key Words*:** Seismic Analysis, Base Shear, Story Drift, Story Displacement, Load Assignment, Staad- Pro Connect.

1.INTRODUCTION

The development of high-rise buildings is required due to population and land constraints. We use the traditional method of manual building design, which takes longer and has a higher risk of human error. As a result, to acquire a more precise result, software is required. STAAD Pro Connect is a widely used civil engineering structural application that can address problems like wind and seismic analysis utilising various load combinations to confirm many codes like IS456:2000, IS1893:2002, IS875:1987, and IS1893:2016, among others.

STAAD stands for **"STRUCTURAL AIDED ANALYSIS AND DESIGN."** STAAD Pro Connect is one of the greatest programs for analyzing structures and even designing structures based on the results of the study. We choose STAAD Pro due of the following benefits.

- User-friendliness
- Observance of Indian Standard Codes
- Adaptability in solving a wide range of problems
- Boost productivity and save time
- The accuracy of the solution

It's crucial to know what kinds of loads are acting on a structure before you can analyze it. The following are some of the different types of loads that a structure may encounter:

1) Dead weight

2) Load in progress

3) Earthquake loads or seismic loading

• The self-weight of the structure, including the walls, is referred to as **dead load.**

• A temporary load acting on structural parts is referred to as a **live load**.

• The force exerted by wind pressure is referred to as **wind load**.

• The lateral forces exerted by the waves created during an earthquake are referred to as **seismic loads**.

2. Body of Paper

Literature Review

Ankit Bhaskar, Ajay Kumar, Mamta Gupta, Anurag Upadhyay, Surya Prakash Sharma (2020)[1] They thought of doing a comprehensive plan of the principal auxiliary components of a multi–celebrated structure including sections, pillars, segments, and footing in this research of seismic design & analysis of (G+6) residential building in zone 3& 4 utilizing staad-pro and its cost estimation. They discovered that if we take 12.5% extra steel when changing a building from zone 3 to zone 4, the building will stay in zone 4.

C . V. Siva Rama Prasad, Sumith . K, Shivani. R, Tejaswini. R (2019)[2] In this a general structure of 7 stories are considered for analysis and design considering seismic loads by Indian codal provisions IS- 456:2000, SP-16, IS-1893:2002. The software's GUI
provides cool and easily understandable for a user to work.

Sangeeta Uikey, Er. Rahul Satbhaiya (2020)[3] The investigation in this paper is based on STAAD Pro Software's

Seismic Response Analysis of Tall Buildings. This research analyzed and developed a G+4, G+9, G+14, and G+19 story building, as well as testing it for all feasible load combinations (Dead, live, wind, and seismic loads). It is carried out in order to compare the performance of different companies.

Rashmi Agashe, Marshal Baghele, Vaishanvi Deshmukh, Sharad Khomane, Gaurav Patle, Kushal Yadav (2020) [4] This project is mostly centered on the structural framed building's theoretical design and analysis. Analyze and design a G+4 story residential building structure using the IS Code method. To complete the study and verification of the overall structure, manual design was performed, which was then confirmed using STADD Pro. When they were creating a G+4 storey residential building, they realized that the construction could sustain all loads.

Dr. S . G Makarande , Vikas V Agrawal , Prof. G. D Dhawale , A.B Dhawane , Prof. M . R Nikhar (2019)[5] "Analysis and design of a multistory building using Staad Pro and manual calculation for two seismic zones" is the title of this project. The study considers an attempt to assess and design a building utilizing staad-pro G+9 building. The analysis and design are carried out in accordance with the IS456:2000 regulation. To compare beam, column, footing, design, and seismic data for the same structure in two distinct seismic zones by using staad pro software and manual calculations.

K Aparna Shrivastav (2016)[6] The examination of K Aparna Shrivastav (2016)[7] was based on seismic analysis and residential building design (G+5). The study and design process for the G+5 residential building in Zone III. Under seismic zone III, seismic load exceeds wind load in this G+5 Building research. Due to meteorological circumstances such as coastal areas and hilly stations, wind pressures for high-rise buildings are significant. Seismic forces were the most common source of damage to structures in buildings.

OBJECTIVES

- Investigate the seismic performance of multi-story structures in the case of an earthquake.
- A comparison of the seismic behavior and performance of multi-story structures built in hard, medium, and soft soil. V seismic zone
- Analyse the model in terms of Deflection, torsion, Storey shear and Moment force along its Heights Style Equations.
- Modelling of a G+20-story building on STAAD Pro Connect and application of various loads, load calculations owing to various loading combinations, and structural analysis and design on STAAD-Pro Connect.

METHODOLOGY

For design purposes, IS Codes such as IS 1893:2016(Part 1) and IS 456:2000 was used. The required architectural plan, beam and column sizes for analysis and design purposes are acquired from a multi-story building construction site.

The below is the method adopted in this research for seismic design and analysis of multi-story buildings (G+20):

• **Equivalent Static Analysis**: In earthquake engineering, the equivalent lateral force for an earthquake is a unique idea. Analyzing simple regular structures with analogous linear static methods, on the other hand, is frequently sufficient. Most codes of practice for normal, low-to medium-rise buildings allow this. It all starts with determining **the base shear force** and how it is distributed on each level using the computations provided by the code Equivalent static analysis can thus work well for low to medium-rise buildings with small coupled lateral-torsional effects; however, buildings with high coupled lateral-torsional effects are not well suited for the method, and more complex methodologies must be used.
We utilized the "Equivalent Static Method" for both STAAD and manual computations.
The planned dimensions of a 21-story OMRF building are presented below:

1.	Size of beam	400 x 400 mm
2.	Size of column	600 x 650 mm
3.	Size of building	15 x15 m
4.	No. of storey	21
5.	Height of storey	3
6.	Thickness of slab	150 mm
7.	D.L of slab including finishes	4 KN/m2
8.	Weight of partition on floor	2 KN/m2
9.	Live load on each floor	3 KN/m2
10	Live load on the roof	3.75 KN/m2
11	Concrete density	25 KN/m3
12	Characteristic compressive strength	40 N/mm2
13	Steel grade	Fe500
14	Soil below foundation	Medium Soil, Hard Soil
15	Building located	Zone IV
16	Type of building	OMRF
17	Damping ratio	5%

1: Modelling: In order to take into account, the type of structure, the Geometry and Structural Wizard tool was used.

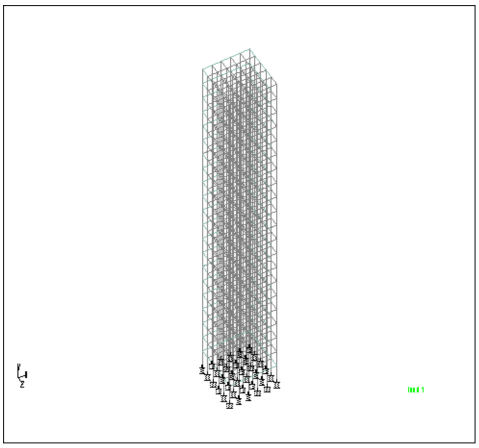


Fig.1 (a) Isometric view of model

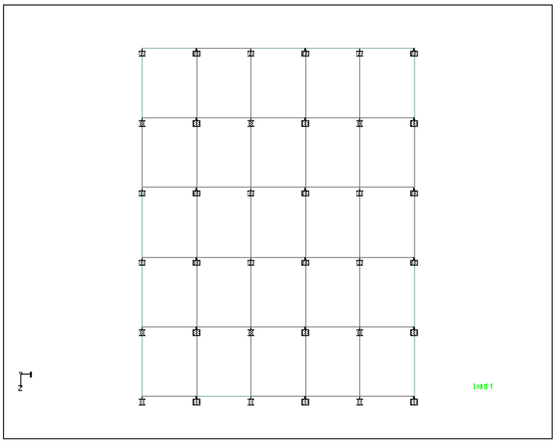


Fig 1 (b): Top view of model

Step 2: Nodal Point Generation: A nodal point has been established on that model based on the design for the arrangement of columns in the building**.**

Step 3: Property Definition: On STAAD-Pro, use the General-Property command to specify the property according to the size requirements for the relevant building. As a result, after assigning selected beams and columns, beams and columns have been generated.

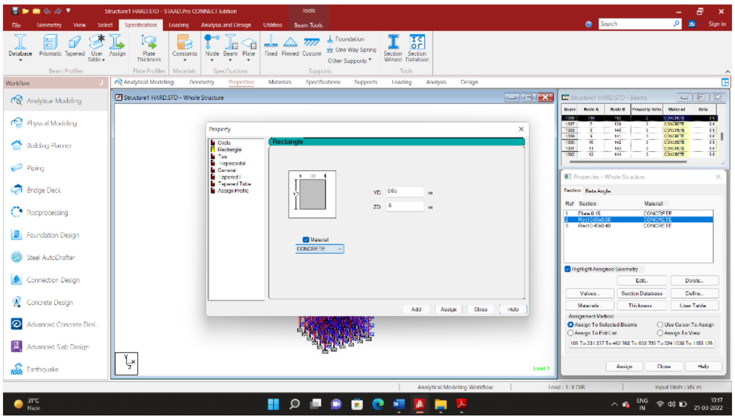


Fig 2: Defining Property of model

Step 4: Assign Support and Member Properties: After selecting columns with the Node Curser and assigning cross-sections based on load calculations and property definition, column definition at supports has been presented as fixed underneath each column.

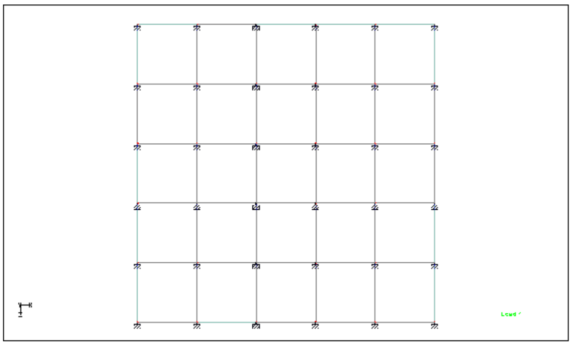


Fig.3 (a) Assignment of Fixed support

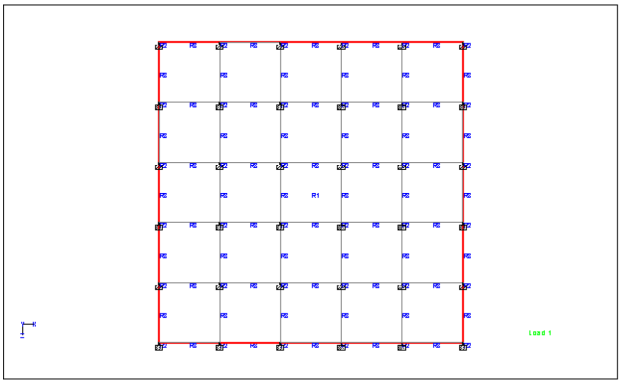


Fig.3 (b) Member Properties

Step 5:3D-Rendering: After you've assigned the member property, you'll need to render it.

Fig.4 3D-Rendering

Step-6: Load Assignment:

a. Dead load

The weight of walls, partitions, floor finishes, false ceilings, floors, and other permanent standing construction in buildings is referred to as the dead load. The dead load loads are calculated using the measurements and unit weights of various construction elements. Plain concrete and reinforced concrete have unit weights of 25kN/m3. 19kN/m3 is the unit weight of masonry. The dead load has been assigned according to IS:1893 (Part 1)-2016 on the basis of member load, floor load, and self-weight of the beams.

b. Live Load

The members have been assigned a live load of 2kN/m in accordance with IS:875 (part 2)-1987.

c. Seismic Load

After determining the seismic load in accordance with IS: 1893 (Part 1): 2016, the seismic load was allocated with respect to the +X, -X, +Z, and –Z directions, each with its own seismic factor.

d. Load combination

The model has been allocated required load combinations instances for seismic analysis based on specified loading combinations supplied in the Indian standard CODES, which are also included in STAAD-Pro CONNECT.

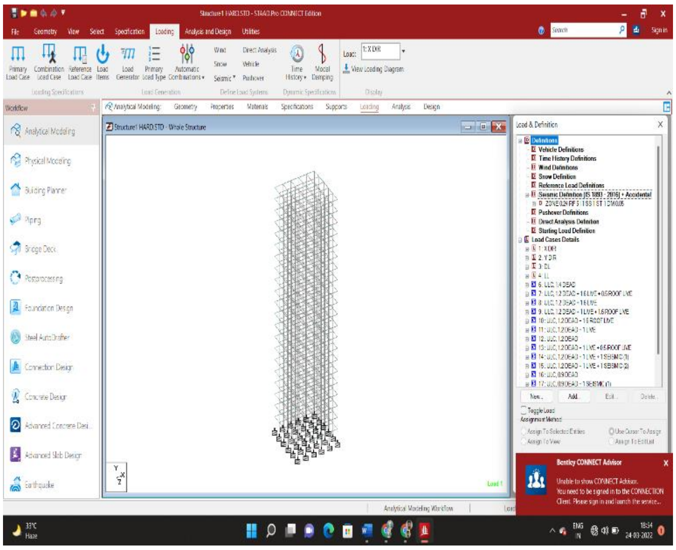


Fig.5 (a)Assigning Load case and Definitions

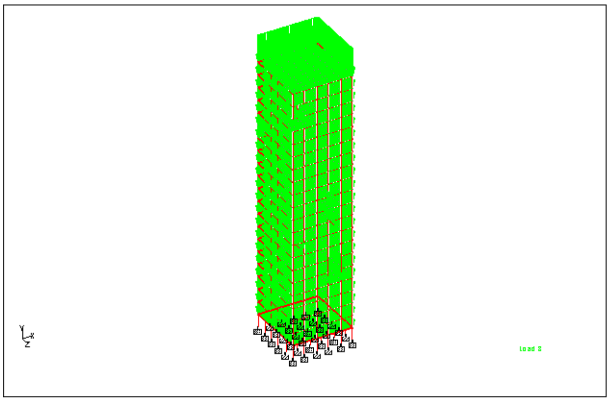


Fig.5 (b) Self Weight of the Structure

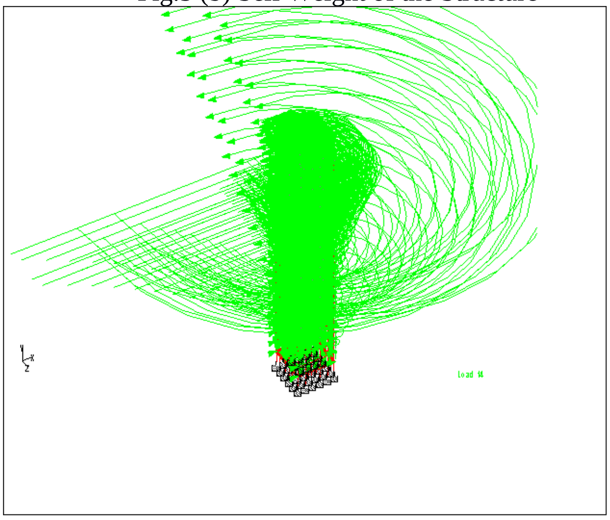


Fig.5 (c) Live Load And Auto Combination Effect

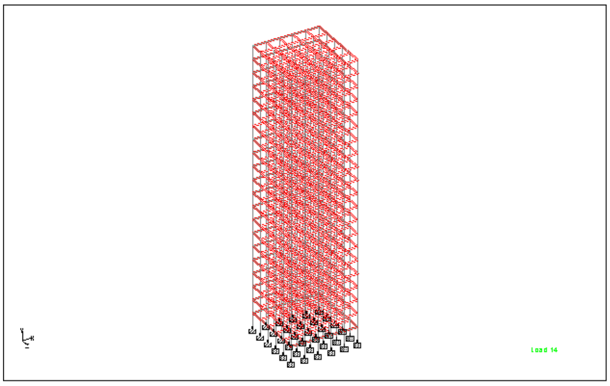


Fig.5 (d) Assigning Member Weight

Step-7: Structural analysis on STAAD-Pro CONNECT

The structure is examined and a full analysis of forces and bending moments is done using the Post processing mode to recognize their shear forces, bending moment diagrams to check whether they are safe or not after adding Analysis/Print.

Step 8: Structure Design on STADD-Pro Connect

The design is carried out in accordance with IS 456:2000 for RCC. The design specifications are M25 concrete and Fe415 steel. To obtain the final design, a percentage steel of 3% was defined according to IS Code standards, and design parameters were allocated to each beam and column.

Step 9: Generate the output

After that, an output file including the structural design of each individual beam and column member of the structure is generated.

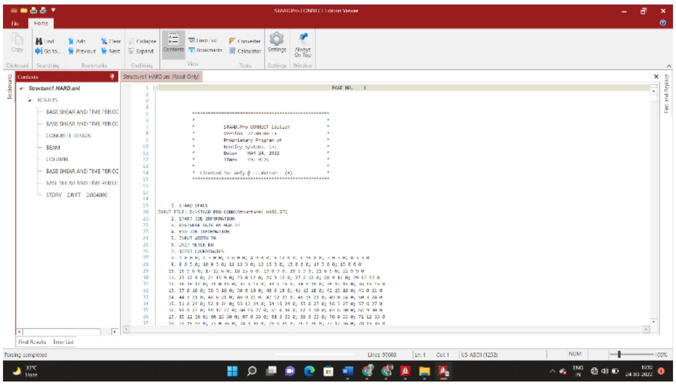
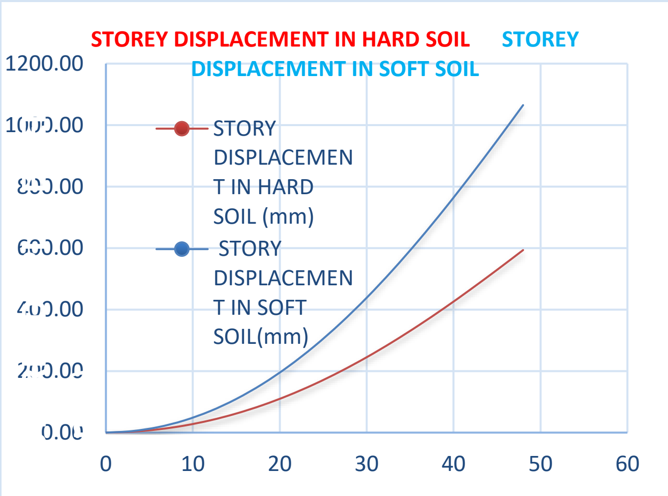


Fig.6 Output Result

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 03 | March - 2022 ISSN: 2582-3930

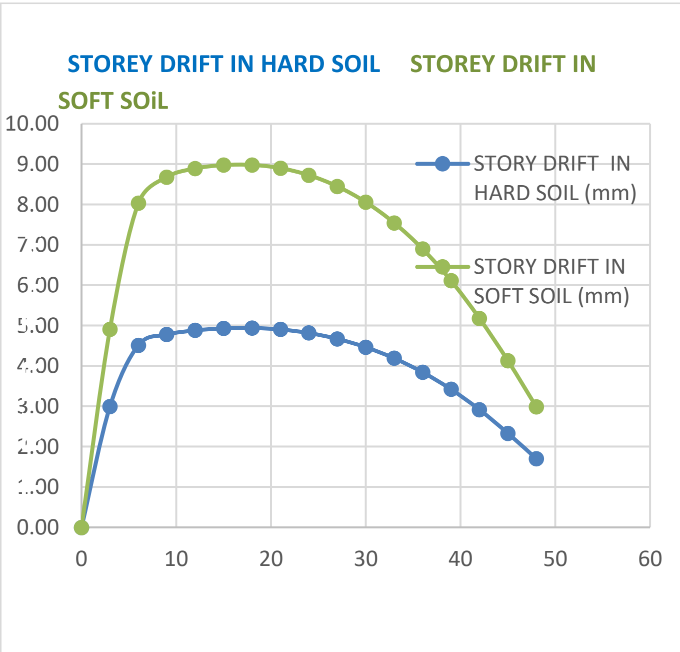
RESULTS AND DISCUSSIONS

Maximum story displacement: The comparison report of maximum story displacement for model M1 and M2 is given in the graph 1. The story displacement is the lateral sway of the story with respect to its base. For Both two-model story displacement is gradually increasing form base and maximum at top story. It is observed that the value of story displacement increases with decrease in stiffness property of soil stratum hence it is highest for model M1 with soft soil and lowest in case of M2 with hard soil.



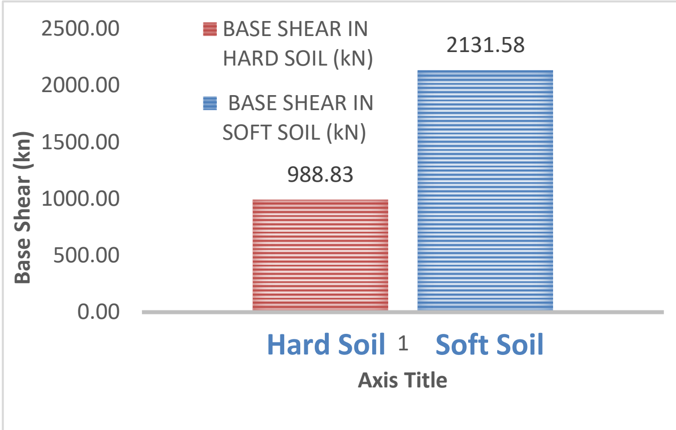
Graph 1

Maximum story drift: The comparison report of maximum story drift for model M1 and M2 which is Hard and soft soil is given in the graph 2. Story Drift is the relative displacement between the floors above or below the story under consideration. (IS 1893-2016 Clause 4.21). As it is concluded from the graph that Story drift is greater for soft soil than hard soil.



Graph 2

Base Shear: The comparison report of maximum Base Shear for model M1 and M2 which is Hard and soft soil is given in the graph 3. It is the horizontal lateral force in the considered direction of earthquake shaking that the structure shall be designed for. (IS 1893 -2016 clause 4.7). As it is concluded from the graph that Base Shear for soft soil is greater for hard soil.



Graph 3

Displacements:

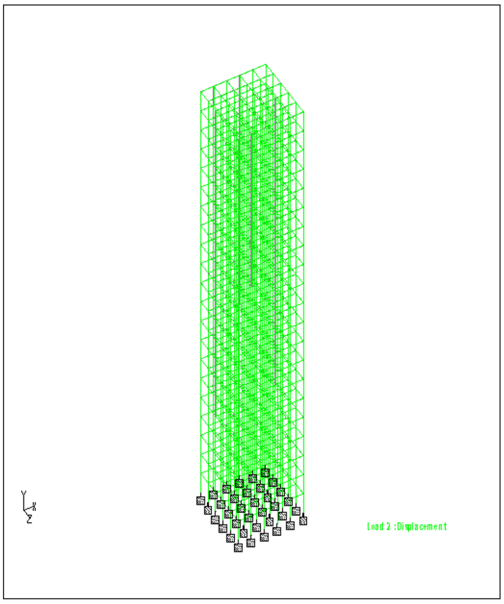


Fig.7: a) X-Direction

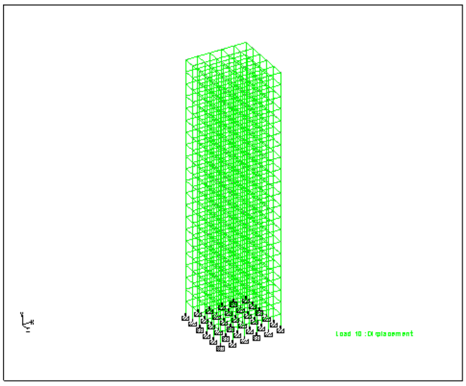


Fig.7(b) Y-Direction

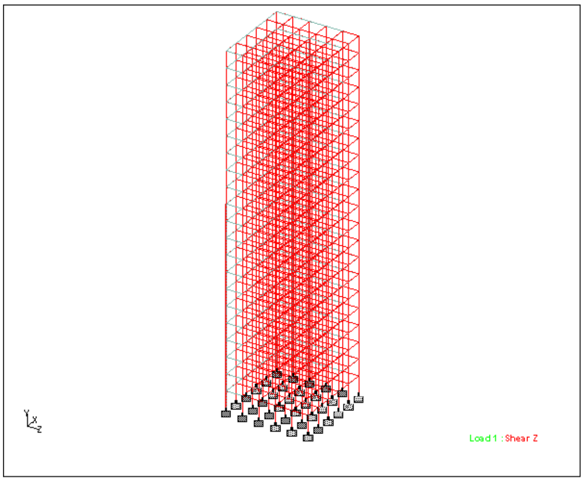


Fig. 8(C) FZ

Axial Force:

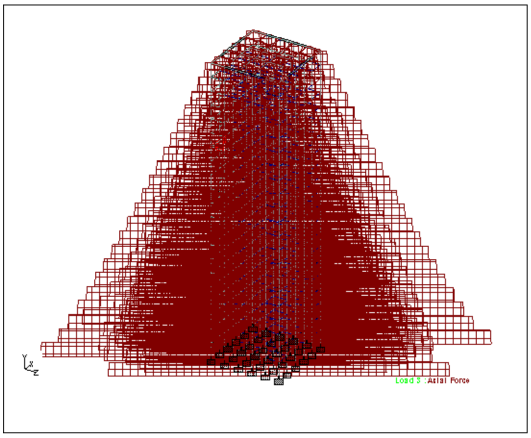


Fig. 8(a) FX

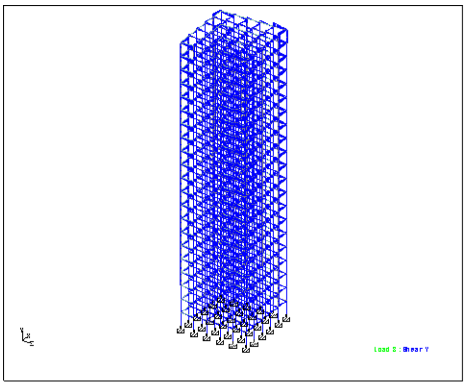


Fig. 8(a) FY

Torsion/Bending of Beam:

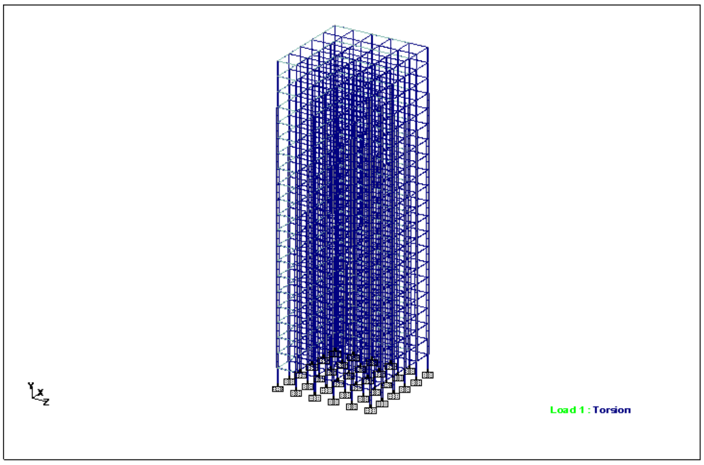


Fig. 9(a) MX

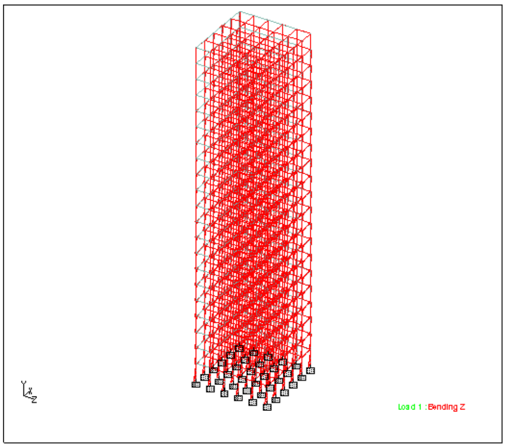


Fig. 9(b) MZ

Combine Results:

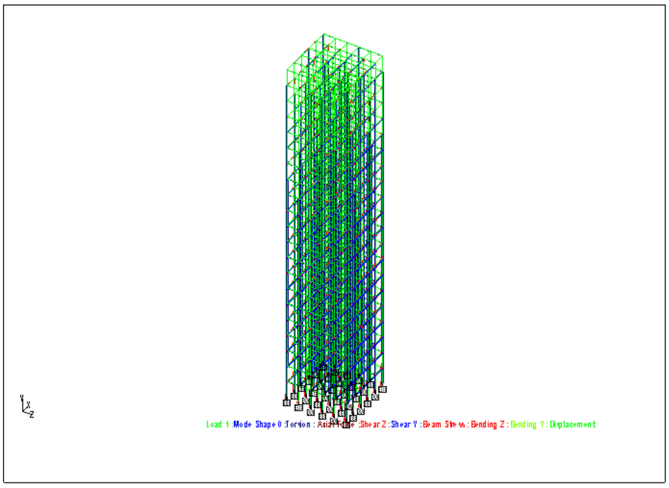


Fig.10

3. CONCLUSIONS

• When compared to the both Soft and Hard soil and the base shear value is more in the soft soil.
• When compared to the both soft and hard soil the story drift value is more in the soft soil.

• It is observed that the value of story displacement increases with decrease in stiffness property of soil stratum hence it is highest for model M1 with soft soil and lowest in case of M2 with hard soil.

REFERENCES

[1] Barkha Verma and Anurag Wahan "Effect of Different Soil Conditions on Seismic Response of Multi-Storey Irregular Model using STAAD Pro. V8i"(2019) published on 9 sept 2019.

[2] Sunil Rathore , Ankit Pal , Arvind Vishwakarma (2020) "Accumulative Stability Increment of MultiStoried Building Rested Over Soft, Medium and Hard Soil ", International Journal of Innovative Research in Science, Engineering and Technology. Vol. 7, Issue 7 April 2020.

[3] Amer Hassan Shilpa Pal (2018) "Effect of soil condition on seismic response of isolated base buildings ", International Journal of Innovative Research in Science, Engineering and Technology. september 2018.

[4] Awanti Lodhi , Satyendra Dubey , Vedant Shrivastava (2020) "Effect of Hard & Soft Soils and Seismic Zones on Shifting Height of SMRF Framed Structures", International Journal of Innovative Research in Science, Engineering and Technology. Vol. 6, Issue 10 March 2020.

[5]Vanadeep Cotipallia, T Srinivasb, and Vegiraju Naresh Kumar Varmac (2020) " study on story shear amd base shear for irregular G+3 , G+6 Structures in Seismic Zones II and III Erected on all Three Soils.

[6]Alaukik K. Alkari, Sangita S. Meshram and Aasif M Baig(2021) "Seismic Analysis of Structure Considering Soil Structure Interaction", International Journal of Innovative Research in Science, Engineering and Technology Issue on February 2021.

[7]R Arun ,K suhana and L. Saicharan Reddy (2019) "Seismic base shear variation between regular and irregular RCC structure in various zones by STAAD.PRO". International Journal of Innovative Research in Science, Engineering and Technology. Vol. 5, Issue 2 March 2019.

[8] IS: 1893(part 1): 2016, "Criteria for Earthquake Resistant Design of Structures", part 1-General provisions and buildings, fifth revision, Bureau of Indian Standards, New Delhi, India.

[9] IS: 456-2000(Indian Standard Plain Reinforced Concrete Code of Practice)– Fourth Revision.

[10] IS: 875-1987 (part-2) for Live Loads or Imposed Loads, code practice of Design loads (other than earthquake) for buildings and structures.