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Analysis of a Structural and Sesmic Design of an Auditorium

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I. Introduction

1.1 General

Though the land, air and water of the planet earth provides cradle for the existence of life , they also cause disasters in the form of earthquakes, wind storms and floods leading to a large scale loss of life and property. Earthquake is moving phenomenon of soil or we can say that vibrations which disturb the earth surface due to waves inside the surface of earth is termed as earthquake. Earthquake can damage the structures which are not constructed according the earthquake consideration. A large number of building designed in India according to static and permanent loads but earthquake is an occasional loads. Present time in India approximately more than 60% area is under earthquake prone zone. So it is important to design the structures according to seismic forces. Earthquake damages the substructure and superstructures. Substructures is the lower part of buildings i.e.; foundation of buildings and superstructures is the part of buildings that rests above the ground level. It is important to understand the behavior of substructures due to seismic loads (soil-foundation interaction) and behavior of superstructures due to seismic loads (beam, column, slab, beam-column joint etc).

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

1.2 Auditorium

An **auditorium** is a room built to enable an audience to hear and watch performances. Auditoria can be found in entertainment venues, community halls, and theaters, and may be used for rehearsal, presentation, performing arts productions, or as a space. The term is taken from Latin (from auditorium fromauditorius ("'pertaining to hearing'")); the concept is taken from the Greek auditorium, which had a series of semi-circular seating shelves in the theatre, divided by broad 'belts', called diazomata, with eleven rows of seats between each.

Auditorium, the part of a public building where an audience sits, as distinct from the stage, the area on which the performance or other object of the audience's attention is presented. In a large theatre an auditorium includes a number of floor levels frequently designed as stalls, private boxes, dress circle, balcony or upper circle, and gallery. A sloping floor allows the seats to be arranged to give a clear view of the stage. The walls and ceiling usually contain concealed light and sound equipment and air extracts or inlets and may be highly decorated.The term auditorium is also applied commonly to a large lecture room in a college, to a reception room in a monastery, and, rarely, to the audience area in a religious building. This project deals with planning phase, analysis phrase and the design phase.The purpose of structural analysis and design is to enable the designers to design the structure with adequate strength, stiffness, and stability.

1.3 Components of an Auditorium

The typical structural members of an auditorium building are the beam, column, slab, roof truss

A. Beam

Beams are structural elements that resists loads applied laterally to their axis. They typically transfer loads imposed along their length to their end points where the loads are transferred to walls, columns, foundations, and so on.

B. Column

A column is a vertical structural member intended to transfer a compressive load. For example, a column might transfer loads from a ceiling, floor or roof slab or from a beam, to a floor or foundations. They have good compressive strength.

C. Slab

A slab is a structural element, made of concrete, that is used to create flat horizontal surfaces such as floors, roof decks and ceilings. A slab is generally several inches thick and supported by beams, columns, walls, or the ground. A slab of reinforced concrete that serves as a flat roof. Concrete slabs can be prefabricated off-site and lowered into place or may be poured in-situ using formwork.

D. Roof Truss

A joint framed structure that sustained the *inclined, vertical* or *horizontal loads.* A truss consist of angles, channels, plates and eye bars. It is a framework, typically consisting of *rafters, posts,* and *struts,* supporting a roof, bridge or other structure. They are supporting the roofs of auditoriums, cinema halls, stadiums, railways, stations, airports and others.

1.4 Structural Design

The aim of structural design is to achieve an acceptable probability that the structure being designed will perform the function for which it is created and will safely withstand the influence that will act on it throughout its useful life. These influences are primarily the loads and the other forces to which it will be subjected. The effects due to temperature fluctuations, foundation settlements etc. should be also considered. The design methods used for the design of reinforced concrete structures are working stress method, ultimate load method and limit state method.

1.5 Seismic Design

Seismic design is a vital process of structural analysis while designing a building, which is subjected to Earthquake ground motions, such that the facility continues to function and serve its purpose even after an Earthquake. Seismic Engineering has evolved over a period of time, the complexity of analysis which used to contain numerous iterations of formulas have now been automated with tools like ETABS, STAAD. Pro, ROBOT, TEKLA and others. These tools results in advantageous outcomes including but not limited to safe, stable & durable structure along with optimization of design & cost-efficient structures. Hospital & Educational Buildings are special structures with high importance factor ranging around 25-50% analysis score than the residential or commercial structures.

1.6 Need for Seismic Design

The main objectives of seismic design are:

- Foresee the potential consequences of strong earthquakes on urban areas and civil infrastructure.
- Design, construct and maintain structures to perform at earthquake exposure up to the expectations and in compliance with building codes.[3]

A properly engineered structure does not necessarily have to be extremely strong or expensive. It has to be properly designed to withstand the seismic effects while sustaining an acceptable level of damage. In our project we are planning to analyze and design the auditorium which will have a capacity to accommodate 700 people and is to be built in Pondicherry The software which is used for the project is STAAD pro V8i.

1.7 Soil Types

The soil condition is an essential field to study before seismic analysis of structure. The seismic wave generated from the focus below the ground level first interact with the soil then with rest of the structure hence the effect of the earthquake also depends upon the stiffness property of the soil stratum. According to IS 1893-2002 code -

- **Type A:** It is composed of Rock or hard soils. It consists of well graded gravel (GW) or well graded sand both with less than 5 percent passing 75mm sieve. Well graded gravel- sand mixtures with or without fines (GW-SW). Poorly- graded sand (SP) or clayey sand 3 (SC), all having N having above 30. Stiff to hard clays having N above 30, where N is corrected Standard Penetration test value.
- **Type B:** It is composed of Medium or stiff soils. It consists of poorly graded sands or poorly graded sands or poorly graded sands with gravel (SP) with little or no fines having N between 10 and 30. Stiff to medium stiff fine- grained soils, like of low compressibility (CL) having N between 10 to 30.
- **Type C:** It is composed of soft soils. All soft soils other than SP with N< 10. The various possible soils are ; Silts of intermediate compressibility (MI). Silts of high compressibility (MH). Clays of intermediate compressibility (CI). Clays of high compressibility(CH). Silts and clays of intermediate to high compressibility (MI-MH or CI-CH). Silt with clay of intermediate compressibility (MI-CI). Silt with clay of high compressibility (MH-CH).**1.6**

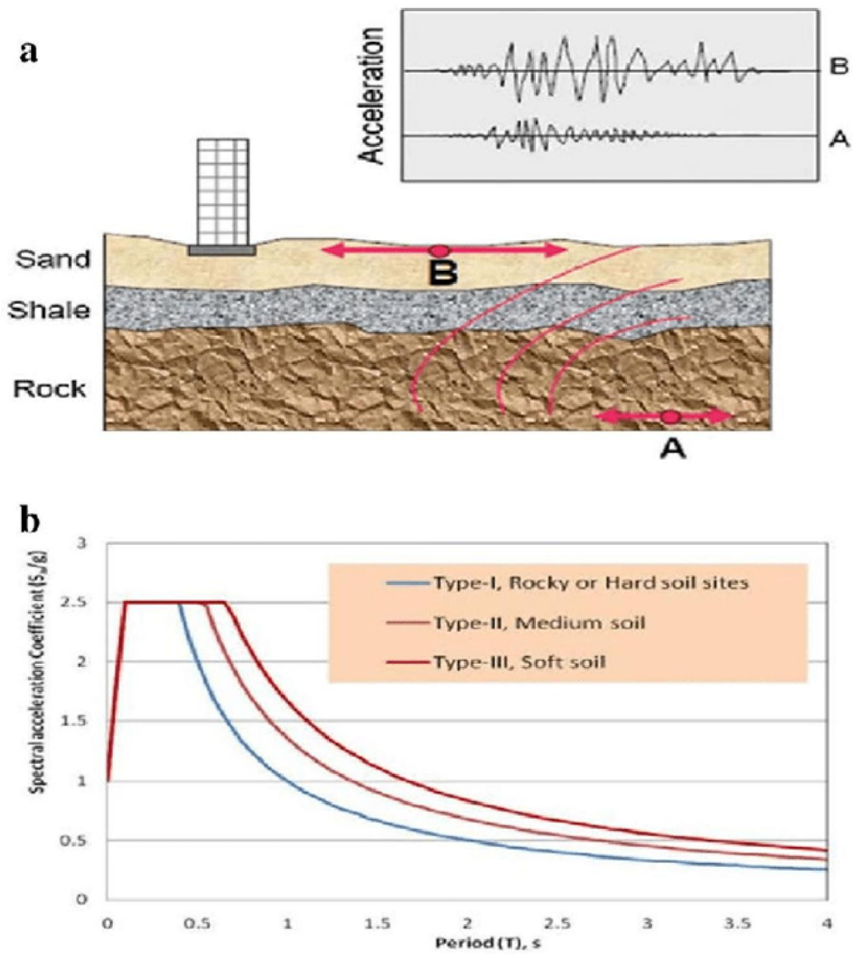

Figure: Types of soil structures

1.8 Parameter Study

The main parameters considered in this study to compare the seismic performance of different models are storey drift, base shear, story displacement and time period.

1.8.1 Base Shear

Base shear is an estimation of the maximum expected lateral force that will occur due to the seismic ground motion at the base of the structure.

1.8.2 Storey Drift

Storey drift is the lateral displacement of a floor relative to the floor below, and the storey drift ratio is the storey drift divided by the storey height. You can obtain graphs showing the height-wise distribution of displacement, storey drift and storey drift ratio.

1.8.3 Lateral Displacement

Lateral displacement is important when structures are subjected to lateral loads like earthquake and wind loads. Lateral displacement depends on height of structure and slenderness of the structure because structures are more vulnerable as height of building increases by becoming more flexible to lateral loads.

1.8.4 Story Displacement

Storey displacement is important when structures are subjected to lateral loads like earthquake and wind loads. Displacement depends on height of structure and slenderness of the structure because structures are more vulnerable as height of building increases by becoming more flexible to lateral loads.

1.8.5 Time Period

Time required for the undamped system to complete one cycle of free vibration is the natural time period of vibration of system in unit of second.

1.9 Software's Used

1.9.1 AUTOCAD

AutoCAD® is computer-aided design (CAD) software that architects, engineers, and construction professionals rely on to create precise 2D and 3Ddrawings.Draft, annotate, and design 2D geometry and 3D models with solids, surfaces, and mesh objects. Automate tasks such as comparing drawings, counting, adding blocks, creating schedules, and more.

1.9.2 STAAD or (STAAD.Pro)

It is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was bought by Bentley Systems.[1][2]

STAAD.Pro is one of the most widely used structural analysis and design software products worldwide. It can apply more than 90 international steel, concrete, timber and aluminium design codes.

STAAD can be used for analysis and design of all types of structural projects from plants, buildings, and bridges to towers, tunnels, metro stations, water/wastewater treatment plants and more.

1.10 Objective

Objective of this paper is to perform the seismic analysis and design of a multipurpose auditorium with varying soil conditions for a seating capacity of 700 audience, at Puducherry state. In this paper details of the analysis and design of an auditorium done by the software package called as STAAD PRO. It is thought that such a study would help to perform an economical and environment friendly design and construction of an auditorium at this location.

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1.11 Scope

- To compare the seismic analysis of the auditorium under different soil conditions.
- To study how seismic analysis and design is to be carried out in StaadPro

1.12 Advantages of Auditorium

There are a myriad of events that can be hosted in an auditorium. Here is an extensive list.

- Weddings
- Lectures
- Trade shows, conferences and conventions
- Concerts and performances
- Memorials
- Student functions, such as graduations
- Special church services
- Proms
- Birthday and anniversary parties

❖ Most auditoriums are operated in an efficient and professional manner. A friendly, trained staff helps to make sure your occasion is a memorable one for each of your guests.

❖ Nowadays, with up-to-date computer technology, most auditoriums can compose and send out Email messages directly to each of your guests or employees. With a secure Internet link, they'll have the convenience of purchasing their tickets directly online. After purchase, tickets can even be delivered to them through their Email address, saving time and money.

❖ It's all so free and easy and offers a great advantage your guests. Many auditoriums even offer a discount for large groups. Special needs of guests are also taken into account, as wheelchairs and elevator services are provided.

❖ Other special requirements, such as the usage of alcohol, should be checked prior to the hosting of an event. Events hosting places usually need to have an alcohol license before serving, so make sure this is in place or can be obtained in order to prevent any surprises on your special day.

❖ You will also need to book well in advance of your need of the auditorium. This will require planning on your part, and it's vital you don't wait until the last minute.

❖ Most auditoriums have specified hours of operation for events. It's a good idea to inform your guests of the hours in advance and abide by them to create an atmosphere of harmony with the hardworking staff.

❖ Another excellent benefit from using one of these brilliant places is basically that you as being the planner, is definitely not responsible for cleaning after it's across. This bonus, plus security needs, special setup, theft or damage are typical contained Ina NY financial arrangements during reservation.

1.13 Methodology

1.13.1 General

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. A methodology does not set out to provide solutions. A methodology offers the theoretical underpinning for understanding which method, set of methods, or best practices can be applied to a specific case, for example, to calculate a specific result.

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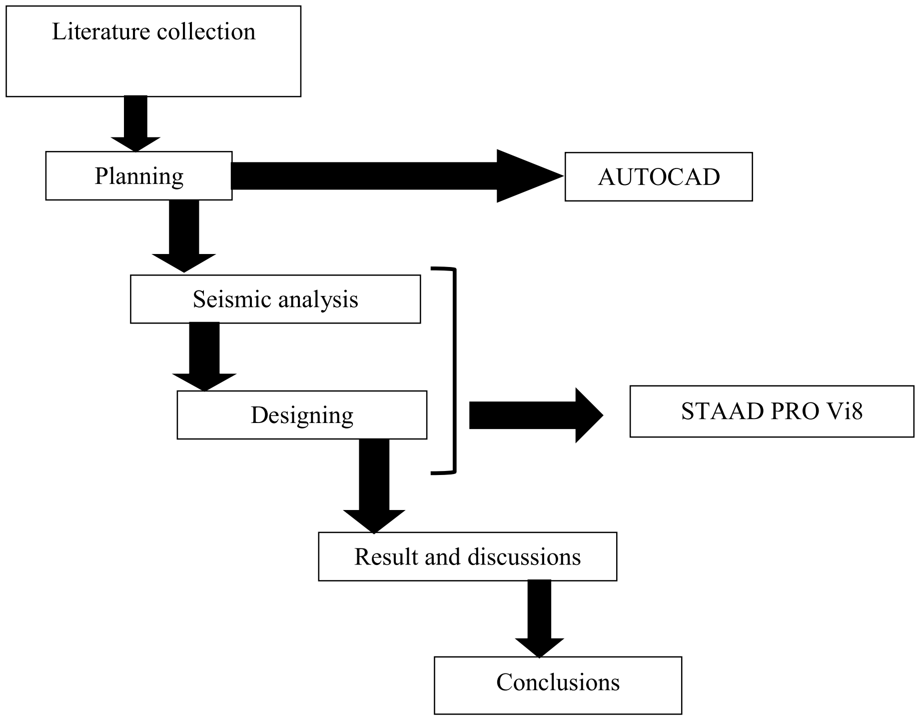
1.13.2 Flow Chart



II. LITERATURE REVIEW

2.1 General

This chapter covers the analysis and design of auditorium buildings under seismic loads and varying soil conditions. In this chapter a brief review of previous studies on analysis and design of auditorium building under seismic loads on different soil conditions is carried out. The objective of this review is to identify the contributions established by other researchers on seismic analysis and design of an auditorium building under different soil conditions.

2.2 Review of Literatures

Akshay K. Ghuge, et al (2021) : The project was aimed on the analysis and design of an auditorium building located at Aurangabad City in Maharashtra State.The construction of auditorium presents a solution of many cultural events programs being held.It was analysis using STADD.PRO using generic loading which proved to be premium software of great potential in analysis and design sections of construction industry. All the structural components were detailed by using AutoCAD 2016. The analysis and design were done according to standard specifications. Used IS-456:2000 & SP-16, for the design of the STRUCTURAL MEMBERS. i.e., followed the LIMIT STATE method. The various difficulties encountered in the design process and the various constraints faced by the structural engineer while meeting the requirements of architectural drawing were also well. Materials used are M20 grade concrete and Fe 415 steel unless mentioned in the particular design elements.

Mr. Rahul Sawant, Dr. M. N. Bajad (2015) : The primary goals of this investigation were: (i) to characterize the inelastic displacement and drift demand, respectively for SDOF and MDOF systems exposed to earthquake ground motions; (ii) to quantify the influence of both aspects intrinsic of structures, such as stiffness, ductility and hysteretic behaviour, and factors pertaining to the exterior context, such as earthquake magnitude, source-to-site distance, and local soil-site conditions; and (iii) to evaluate inelastic displacement and drift ratios so that the assessment of the inelastic displacement and drift demands can be accomplished from maximum elastic displacements and drifts. In order to characterize the inelastic behavior of the MDOF systems representative of real multi-storey frame structures, an equivalent discrete shear-type model has been adopted. The results of a statistical study of inelastic displacement and drift ratios computed for the SDOF and MDOF systems subjected to a large number of strong motion records and enduring prescribed levels of inelastic deformation have been presented.

Manoj. Nallanathel, et al (2018) : The building was analyzed & designed using STAAD Pro. The dimensions of column is 0.3*0.8 m & beam 0.3 *1.5 m are challenge think to sustain with an maximum bending moment with an critical section of beam &column .Actually beam design for long span construction should be prefer PT beams instead of R.C.C beam. Normally if we use PT beam is size should be reduce half of the depth of beam size. In this case our project deals R.C.C beam 1.5 m depth of beam but PT beam size is 0.75 m. The maximum footing size is 4.0*4.0 mts with deep of 1.5 m. STAAD Pro give satisfactory results when checked with manual design also.

Ch. Pratyusha, V. Vijaya Kumar (2017) : Planning has been done for 1200 students in accordance with the specifications made by NATIONAL BUILDING CODE and IS 2526:1963(Code of practice for acoustical design of Auditorium and conference halls). This project gives the brief Idea about how to analyze and design .Auditorium with minimum facilities required.Used AUTOCAD 2010,Staad Pro V8i effective representation of drawings.Used IS-456:2000 & SP-16, for the design of the STRUCTURAL MEMBERS. i.e., followed the LIMIT STATE method.Materials used are M20 grade concrete and Fe 415 steel unless mentioned in the particular design elements.The construction of auditorium presents a solution of many cultural events programs being held. In this project Seating Arrangement has provided as per NBC. It was analysis using STADD .PRO using generic loading

Shankar Saj T K, SachinSaj T K (2019) : An auditorium is designed for 1000 seating capacity and with the dining hall. Considering the present market trend, artificial lighting and ventilation are adopted. Trussed roof with false ceiling is proposed. In this project work, we have included Load Calculation, Design of Slabs, Stairs, Beams, and Columns and Footing. 2D analysis of the building was done using the Software STAAD Pro. Moreover, manual calculations were done in accordance with the relevant codes. Architectural drawings have been prepared.

A. Murali Krishna, et al (2012) : With the increasing seismic activities in the recent times an efficient design of the pile foundations to resist the estimated earthquake loads is a major concerned issue. In this interest, this study deals with the estimation of the seismic loads on a super structure as per the two international codes selected, IS 1893 and EN 1998. Different cases are considered assuming the location of the structure to be in different seismic zones of India and on different ground types (Type C and Type D). The estimated seismic loads are applied to the SAP2000 model of the structure and analyzed to find the maximum (design) foundation loads. Liquefaction potential was evaluated, before proceeding to the pile design, for the selected soil profiles in the Guwahati region. Then the pile is designed for a selected case of seismic zone V and the ground type C. The pile is first designed for using the Indian Standard IS 2911. Then the design was checked against lateral deflection and limiting moment capacity of pile for the estimated lateral loads and moments under seismic condition using commonly used method called the Characteristic Load Method. Further the seismic design is revised for both the cases considering the soil profile to be liquefiable. It is to conclude that ground conditions should be considered much prior in the analysis of any structure to evaluate the seismic loads acting on the structure which will further influence the foundation design loads and foundation capacity.

Ketan Bajaj, et al (2013) : The following conclusion has been found from the present study are:- All the 54 buildings are analyzed in the software SAP-2000 with the configuration as shown in table 1 and the result of all them are with respect to the base shear, story drift and lateral deflection. It has been seen that with the change in zone and soil the lateral load varies extensively. With the change in soil property from hard to medium and from hard to soft the lateral deflection has increased by 53.33 and 60.25% respectively for flexible base. In case of flexible foundation with change in zone from III too IV and from III to V with same hard soil the deflection has increased by 12.07% and 24.72% respectively for the same type of symmetric building. It has been seen with the change in soil property from hard to medium and from hard to soft the base shear has increased by 26.85% and 43.25% respectively for flexible base. But as if we compared the same for zone V and zone III, the base shear has increased approximately same. In case of flexible foundation, with the change in zone from III too IV and from III to V with same hard soil the deflection has increased by 10.68% and 21.53% respectively for the same type of symmetric building. Similar change is seemed in case of soft and medium soil for different story of building. It has been found that with the change in soil property from hard to medium and from hard to soft the base shear has increased by 18.25% and 25.36% respectively for flexible base; similar pattern has seemed in the building. It has also concluded that change in zone from III too IV and from III to V with same hard soil the deflection has increased by 10.68% and 21.53% respectively for the same type of symmetric building. Similar change is seemed in case of soft and medium soil for different story of building.

Badhirae. a (2019) : The project was aimed on the analysis and design of an auditorium building located at Kozhikode. This project gave an example exposure to various field practice in the analysis and design of multi storied building. The analysis was done using the software package STAAD Pro V8i, which proved to be premium software of great potential in analysis and design sections of construction industry. All the structural components were designed manually and detailed using AutoCAD 2013. The analysis and design were done according to standard specifications. The various difficulties encountered in the design process and the various constraints faced by the structural engineer while meeting the requirements of architectural drawing were also well.

S. Harish, et al (2017) : The project is about "Designing and Planning of Auditorium". As this is a prayer hall all the members of the staff assemble here. The total project includes designing of structural members like slab, beams, columns, footings. The designing has been done based on reference of IS code 456:2000 for concrete and SP 16 for steel. The software AutoCAD was used for drawings (plan, section, &elevation) and for drawing reinforcement details of slabs, columns, beams &footings. Various load combinations as per IS code were used, considering seismic load as the major apart from other loads. The structure is stable under various load combinations. This project concludes that the moments and forces appearing in the structure were significantly lower than in case of plane frame under similar loading conditions. Also the project shows that for long spans structures are considerably cost effective than plane frame structures.

B. Neelima, et al (2012) : Time periods of the structure invariably decrease with the increase of soil stiffness. The time periods for buildings with cellar are observed more compared to the buildings without cellar. Due to earthquake forces, base shear decreases with the increase of soil stiffness. However, the variation in shear is insignificant irrespective whether the buildings are with or without cellar. In general, it is seen that the displacement values increase with the decrease of soil stiffness, which is mainly attributed due to the rocking effect of the soil. It is also observed that there is a wide variation in the decrease of displacements from loose soil to hard rock at ground floor level when compared with the displacements at top storey level. The soil damping normally ranges from low value for flexible structure on rigid foundation to a high value for rigid structures on flexible foundations. Particularly for structures like nuclear power plants, which are more rigid than high rise buildings, the influence of soil-structure interaction is more significant. It is necessary to consider soil-structure interaction effect when structures rest on loose soils.

Ibrahim Oz, et al (2020) : Changes in the seismic demands were investigated by comparing the roof drift ratios corresponding to exceedance probabilities of 50%, 10% and maximum. Distribution of values clearly indicated that most critical results were obtained under soft soil conditions, and results obtained from the soft soil cases were significantly separated from the others. Drift demands of moderate soil cases are closer to fixed and stiff soil cases with respect to soft soil conditions. Relative demand increase under soft soil case is much more evident in low story buildings with respect to higher ones. Effect of soil conditions on the number of collapsed buildings is also investigated and compared. Distribution of results have shown that a number of collapsed buildings are almost similar in fixed-base, stiff and even in moderate soil cases. However, under soft soil conditions the number of collapsed buildings increase and the level of increment is much more significant in old and low story buildings. A distinct increase in the number of collapsed three- and four-story buildings indicates that the fragility of old and low story buildings on weak soil conditions is much higher. Performance of new buildings, on the other hand, is not as critical as the old ones. Higher seismic capacities of new constructions suppress the deteriorating effects of soft soil conditions and reduce the collapse risk of new buildings.

Barkha Verma and Anurag Wahane (2019): It is observed that the value of story displacement increases with decrease in stiffness property of soil stratum hence it is highest for model M3 with soft soil and lowest in case of M1 with hard soil. The maximum storey displacement at top storey in model M3 is approx. 1.23 times the displacement in

M2 model and approx. 1.67 times the displacement in M1 model. It is observed that the value of compressive stress in columns is maximum in model M3 and minimum in model M1 so it can be concluded that the stresses in the structural members increases with the reduction of stiffness property of soil. The maximum compressive stress at bottom storey in model M1 is 1.23 times the compressive stress in model M2 and 1.59 times the compressive stress in model M1. The steel quantity required is maximum for model M3 and minimum in case of model M1. Steel quantity for model M3 is approx. 1.23 times the quantity of steel for model M2 and approx. 1.59 times quantity of steel of model M1 approx. So it can concluded that the quantity of steel increases with decrease in stiffness property of the soil.

Amer Hassan and Shilpa Pal (2018) : The paper shows that the story displacement increases with the increased fexibility of the soil; in other words, soft soil conditions produced the largest displacement compared with hard soil and medium soil. It is also observed that the displacement produced due to time history analysis being more than the displacement produced due to response spectrum analysis in hard soil conditions with an increase of 5%. However, it decreases by 9.5% and 18% for medium soil condition and soft soil condition, respectively. The maximum story drift is produced in the first floor above the isolators for various soil conditions which attributes to the fexibility introduced by isolators. It is also observed that the story drift increases with increase in fexibility of soil. Thus, the largest drifts are created in soft soil condition. Hard soil and medium soil conditions are suitable for multi-story isolation structures according to the response of base isolation building.

Gourav B N, et al (2021) : As the seismicity of the building increases care should be taken by the structural engineers to counter the seismic energy and to safe guard the building. With the change in soil property from hard to medium and from hard to soft the lateral deflection was increased. In Seismic Zone - 2, 3 & 5 the values of maximum Shear forces & maximum bending moment are decreasing in hard soil strata when compared with soft soil strata & found the least for the same. By referring to above collected journals we observe that most of the journals were based on modelling and analysis of either different seismic zones or soil types. But the combination of both seismic zones and soil types for a G+30 storey building using Etabs was not studied by any of the above mentioned journals.

Runbahadur Singh, et al (2019) : Analytical investigations have been carried out to study the behaviour of structure founded on different types of soil with and without shear wall. Based on this work following conclusions can be drawn. The natural time period of structure increases when soil structure interaction is considered on base isolated structure. Effect of soil structure interaction is predominant for soils with soft and medium strata. As the number of storey increases in the building the base shear and displacement are increases. It can be concluded that shear wall placing at adequate locations is more significant in case of base shear and displacement. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake. Displacement in buildings is increased from soft to hard soil.

2.3 Literature Summary

- As the soil type moved from hard to medium and medium to soft soil the base shear increases correspondingly.
- It is necessary to consider soil-structure interaction effect when structures rest on loose soils.
- Displacement value increases with decrease in soil stiffness.
- Time period of the structure also invariably decreases with increase in soil stiffness.
- Depending upon the method of analysis chosen the percentage of reinforcement steel required also vary.
- Base shear, story drift and lateral deflection are the main parameters affected by the type of soil condition and other soil properties.

III. Analytical Investigation

3.1 Planning

The term planning of building by an engineer is used to mean the arrangement of all the units of a building on all floors and at all levels and also it takes into consideration the height and level to accommodate the space enclosed by

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walls, floors and roofs.

3.1.1 Location details of the site

The proposed site is at, Puducherry district, Puducherry. Table 1 gives the details of the proposed auditorium:

Table 1: Location details

District/State	Puducherry
Type of auditorium	Multipurpose auditorium
Type of soil in the site	Medium and soft soil
Type of structure	RCC /steel
Estimated capacity	700
Estimated area	1300m2

3.1.2 Planning of Auditorium

A number of standard codes approved by Indian Standard institutions has specified the following minimum requirements for the construction of the auditoriums:

1. FRONT AND REAR OPEN SPACES:

No person shall erect a building unless it is set back at least 6m from the regular line of the street or from the street if no such regular line exists.

2. PLAN AREA:

Plan area of the building is to be fixed at an occupant load of range 0.6 to 0.9 m2/member. Drawings were done using AutoCAD.

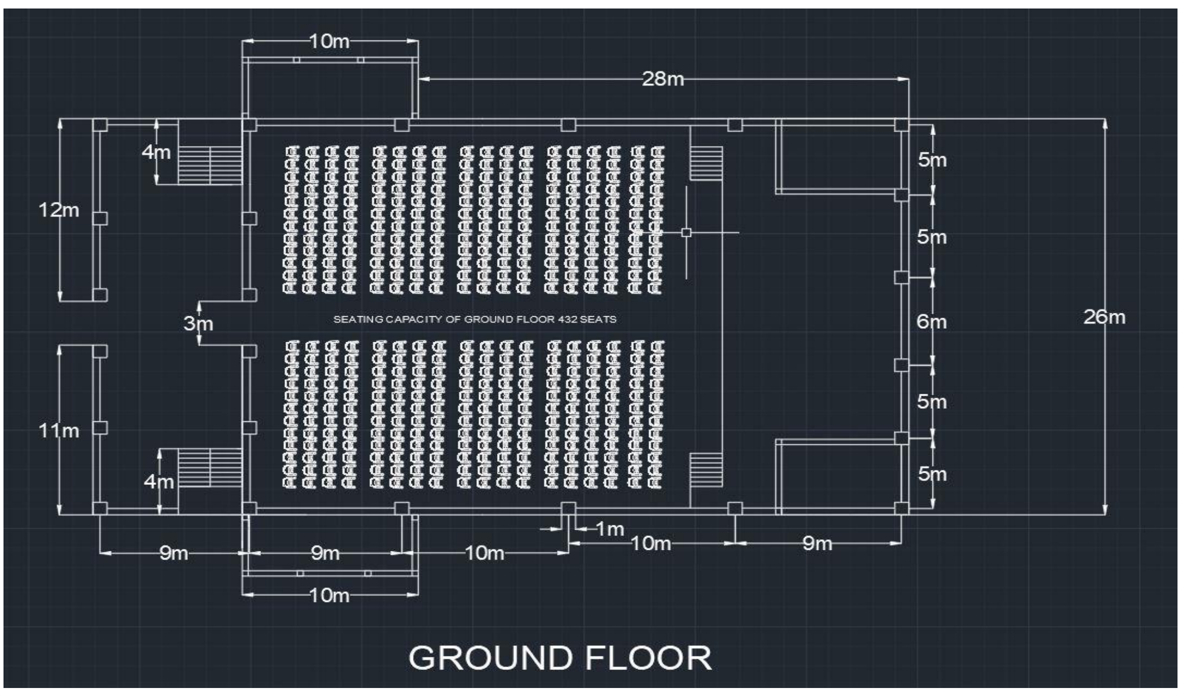

Figure 3.1: Ground floor plan

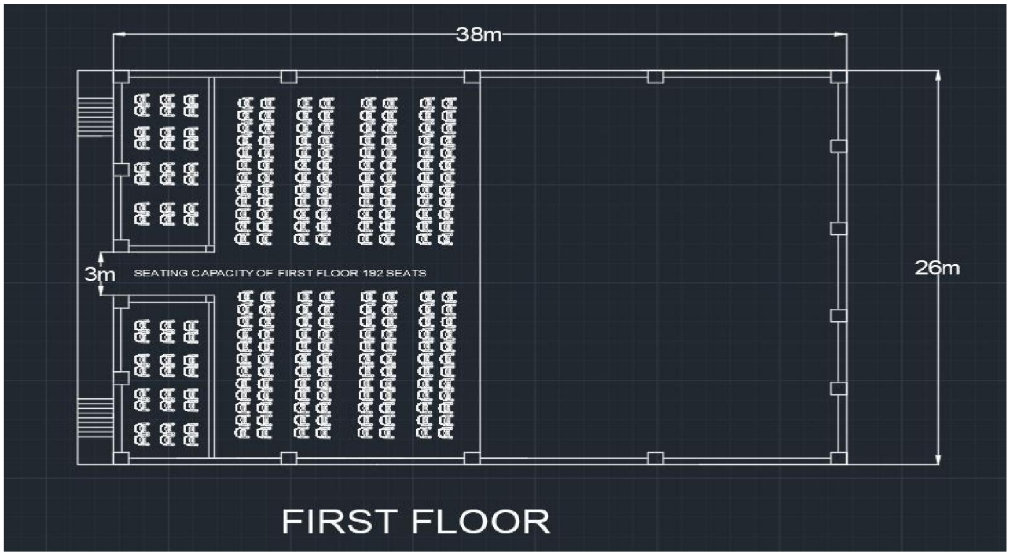

Figure 3.2: First floor plan

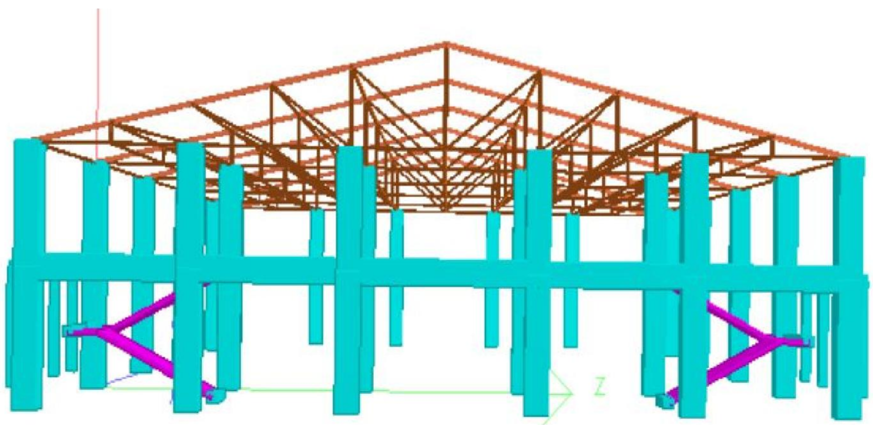

Figure 3.3: 3D Front view

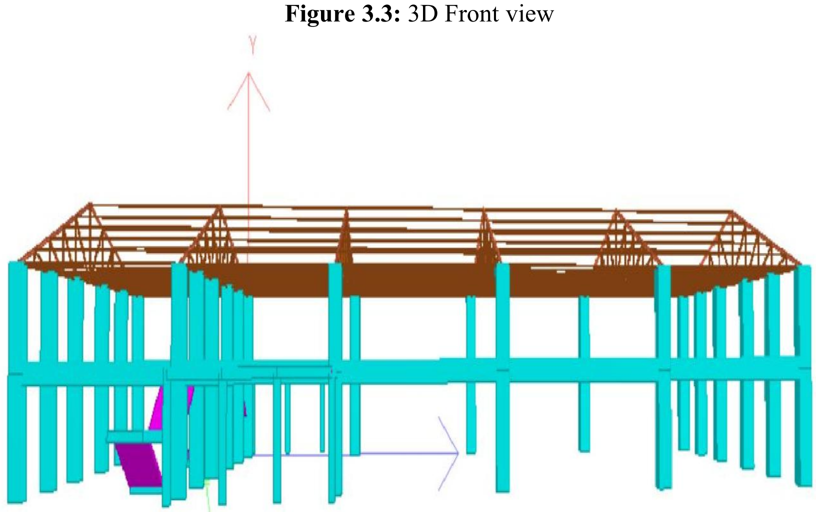

Figure 3.4: 3D Side view

3.2 Structural Analysis

Structural analysis of structure is essential before starting construction work. It provides the details of the size of the foundation, the size of the column and beam, and reinforcement details that are sufficient to carry the load acting on the structure. As discussed in the above sections, structural analysis was done using STAAD PRO Vi8 software. The structural properties used is given in table 2 given below

Table 2: Structural Property

PARTICULAR OF ITEMS	PROPERTIES
Type of support	Fixed
Number Of Stories	G+1
Total Height of Structure	13.5
Floor Height 1	5.5
Floor Height2	3.5
Main Beam Size	750mm*450mm
Secondary Beam Size	350mm*350mm
Main Column Size	750mm*750mm
Secondary Column Size	350mm*350mm
Slab/Plate Thickness	150mm

3.3 Codes Used

- IS 456 : 2000 (Plain and reinforced concrete)
- IS 875 : 1987 (Design loads) ¬ Part 1 - dead loads -Unit Weights of Building Materials and Stored Materials ¬ Part 2 – Imposed Loads ¬ Part 3 – Wind Loads ¬ Part 5 - Load Combination
- IS 1893(part 1) : 2002(Earthquake resistant design of structures)
- IS 13920 : 1993 (RC Structures subjected to seismic force)
- Design aids for IS 456 (SP16) 26

3.4 Seismic Parameters (As Per Is 1893 Part -1 :2002)

The impact of earthquake on structures depends on the stiffness of the structure, stiffness of the soil media, height and location of the structure, etc. According to IS 1893 -2002, Seismic Parameters. Seismic parameter used for the analysis are given in table 3

Table 3: Seismic Parameter Used For Analysis

Seismic Zone	Zone - 3
Seismic Intensity	Moderate
Zone Factor Z	0.16
Response Reduction Factor R	5
Importance Factor I	1.5
Soil Type (Case 1)	Medium soil
Soil Type (Case 2)	Soft soil
Damping Ratio	5%

3.5 Design Parameter (As Per Is 456: 2000)

Concrete design of the models are done by referring IS 456-2000. The design parameter used are given in table 4

Table 4: Concrete Design Parameter

Grade of Concrete	M30
Grade of Main & Secondary Steel	Fe415
Density of Reinforced Concrete	25 KN/m3
Beam cover	30 mm

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Column cover	40 mm
Slab cover	25 mm
Max. size of main reinforcement	60 mm
Max. size of secondary reinforcement	12 mm
Max. percentage of longitudinal reinforcement allowed	6%

3.6 Calculation of Primary Loads

IS 875 (PART-1) is referred for the values of unit weight of the structural materials for calculation of dead load and IS 875 (PART-2) is referred for the value of floor live load and roof live load.

Dead Load of the Beam and Column - This can be provided by applying load factor -1

Dead Load of the Slab = (unit weight of reinforced concrete X thickness of the slab) = 3 KN/m2

Dead Load of the wall = (unit weight of the brick masonry X thickness X wall height)

Dead Load of Exterior wall = 15 KN/m

Dead Load of Interior Wall = 8 KN/m

Live Load = 4 KN/m2

Roof Live Load = 1.5 KN/m2

Floor finish = 1 KN/m2

Water roofing = 2 KN/m2

Load Combinations - In the limit state design of reinforced concrete structures, the load combinations shall be accounted for as per IS

3.7 STAAD Modeling and Analysis

3.7.1 Deflection

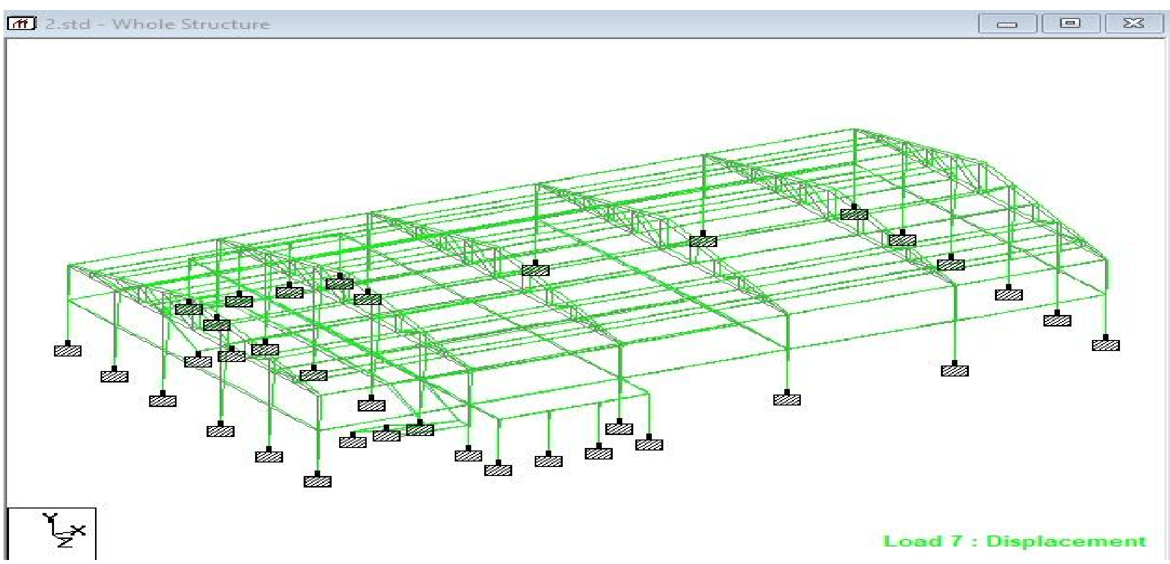

Figure 3.5: Deflection diagram for medium soil

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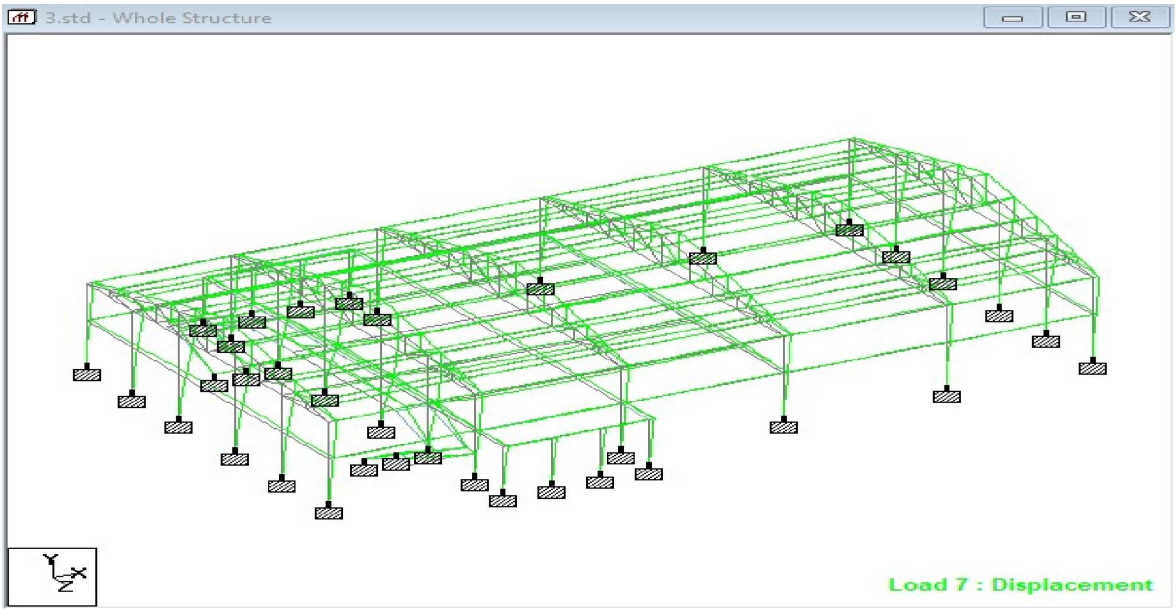

Figure 3.6: Deflection diagram for soft soil

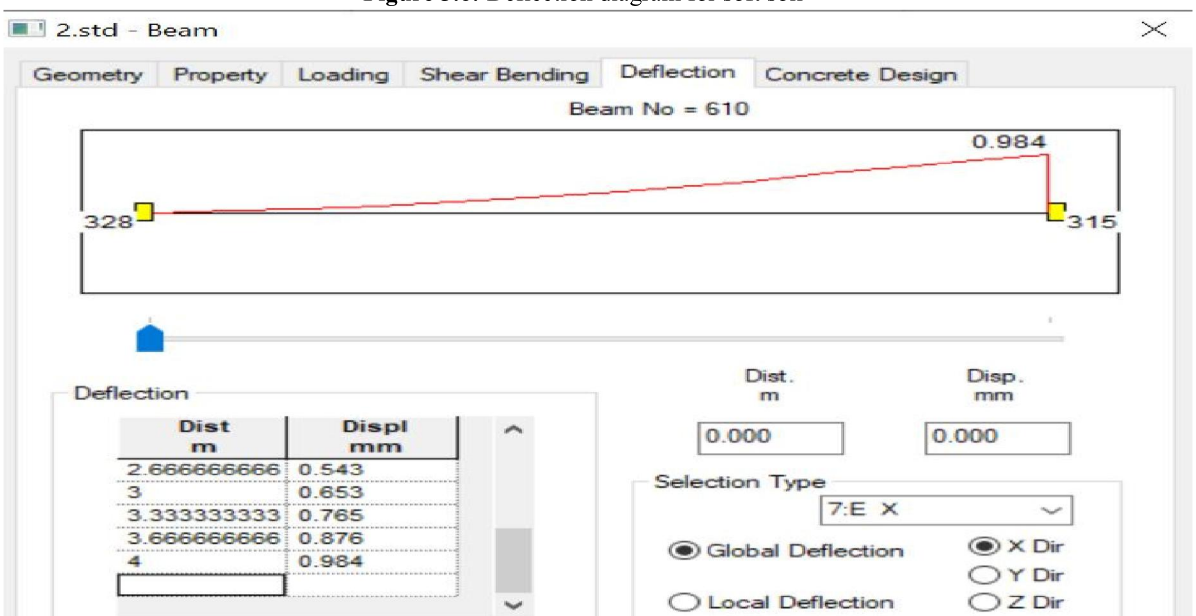

Figure 3.7: Column deflection for medium soil

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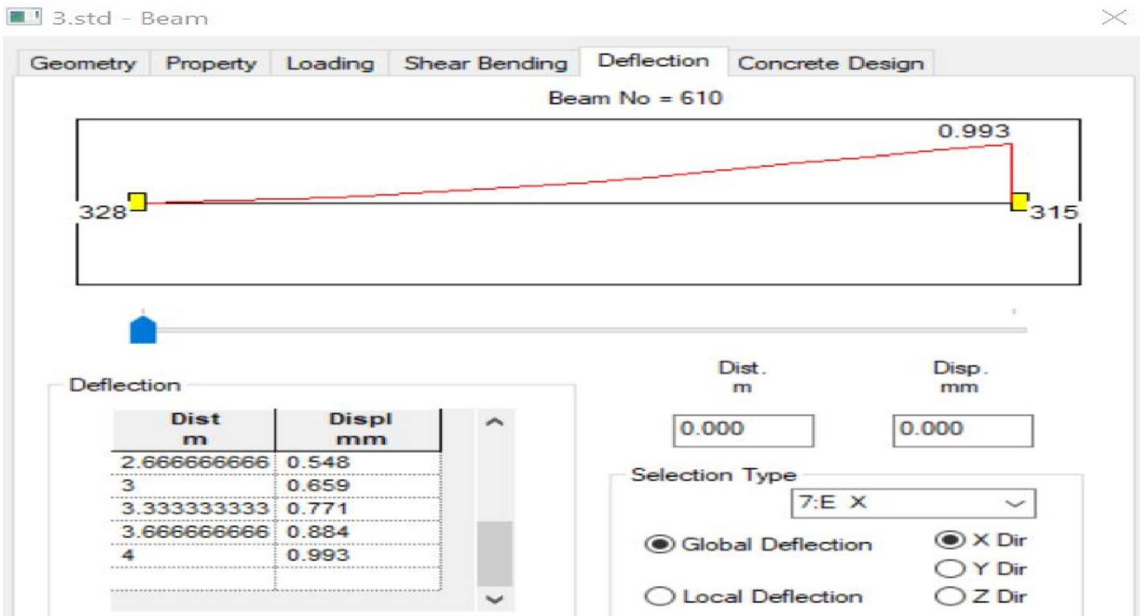

Figure 3.8: Column deflection for soft soil

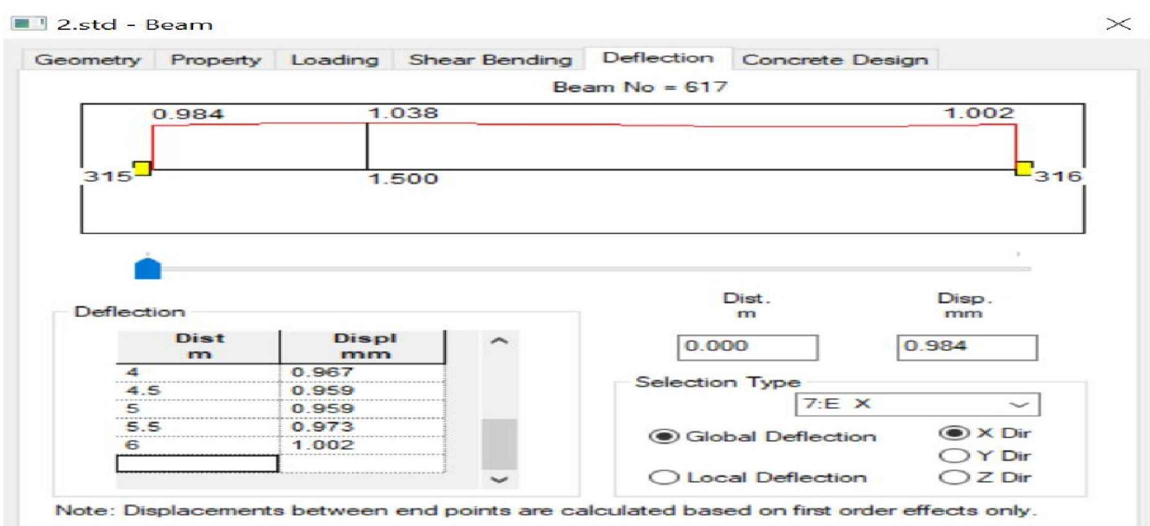

Figure 3.9: Beam deflection for medium soil

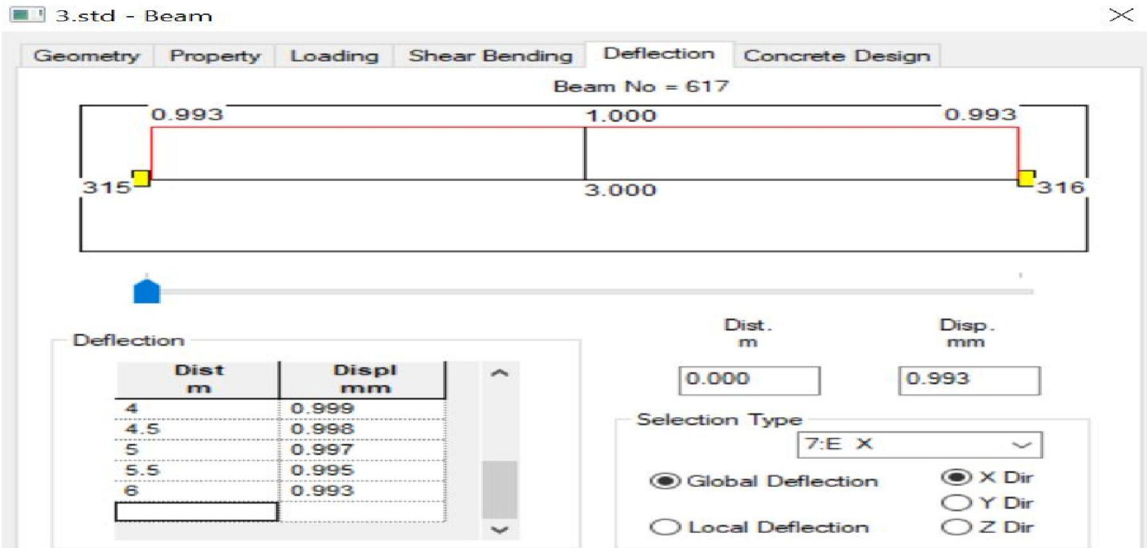

Figure 3.10: Beam deflection for soft soil

3.7.2 Bending Moment and Shear Force

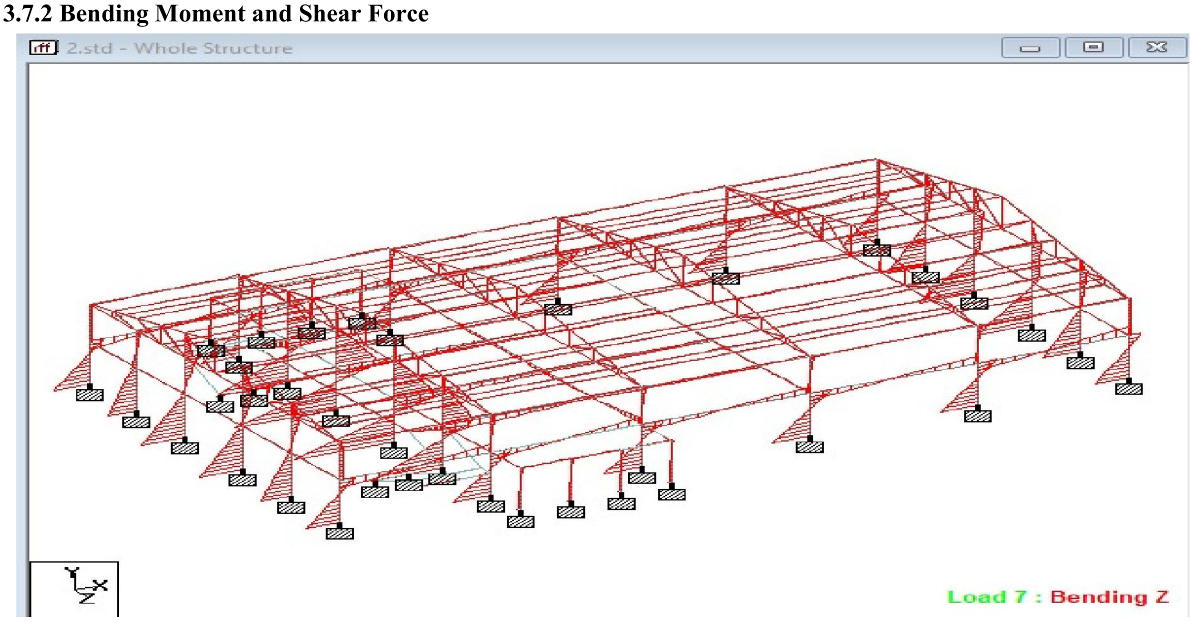

Figure 3.11: Bending moment diagram for medium soil

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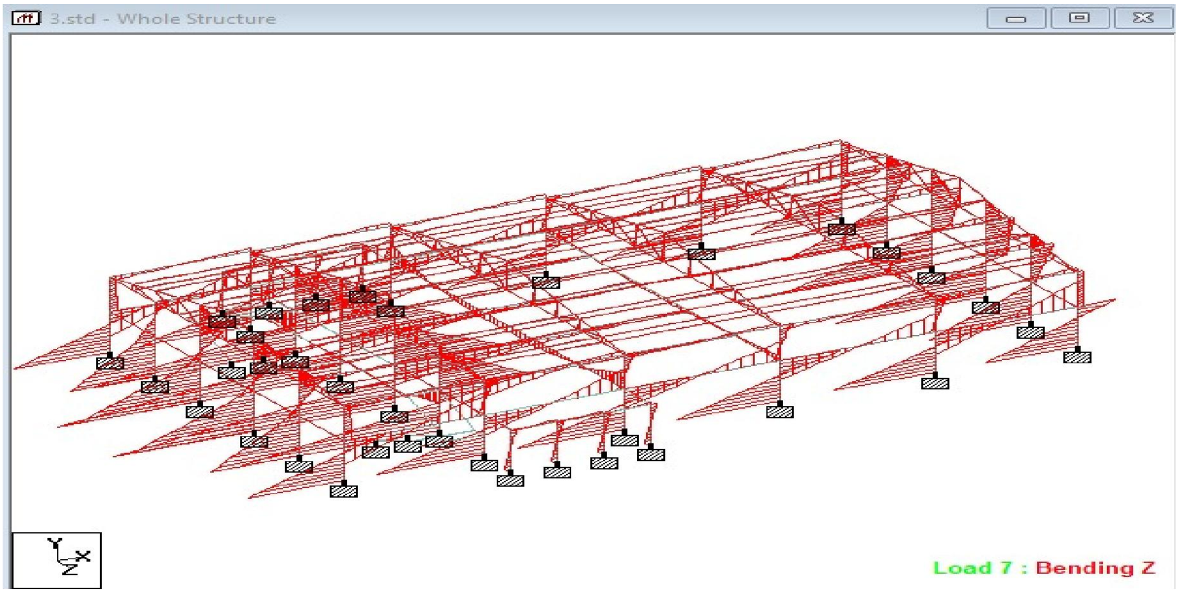

Figure 3.12: Bending moment diagram for soft soil

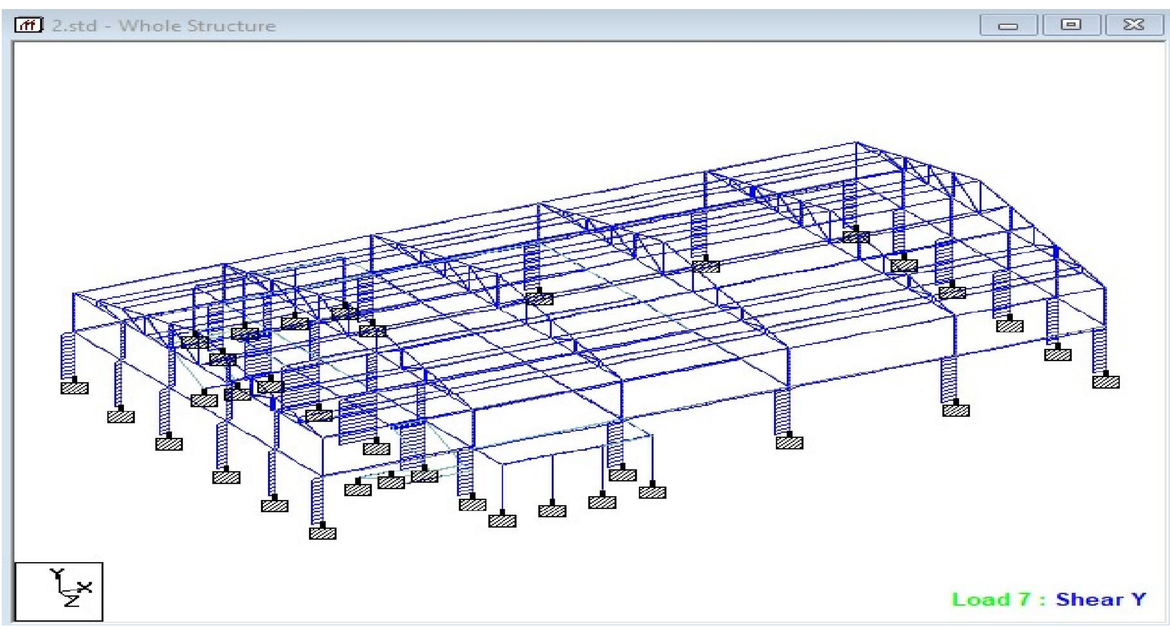

Figure 3.13: Shear force diagram for medium soil

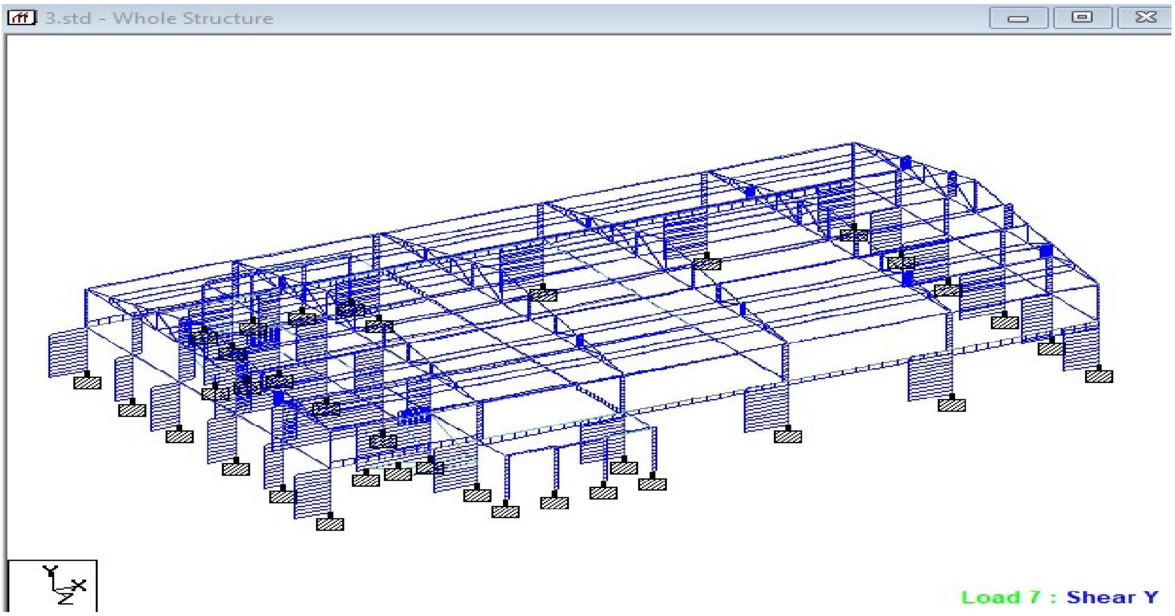

Figure 3.14: Shear force diagram for soft soil

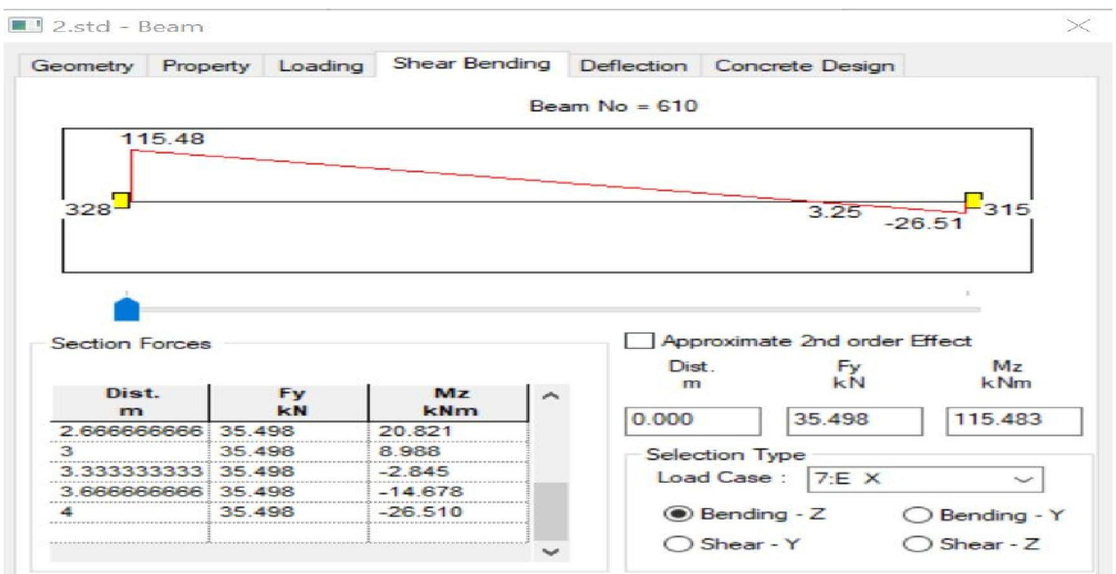

Figure 3.15: Column shear bending diagram for medium soil

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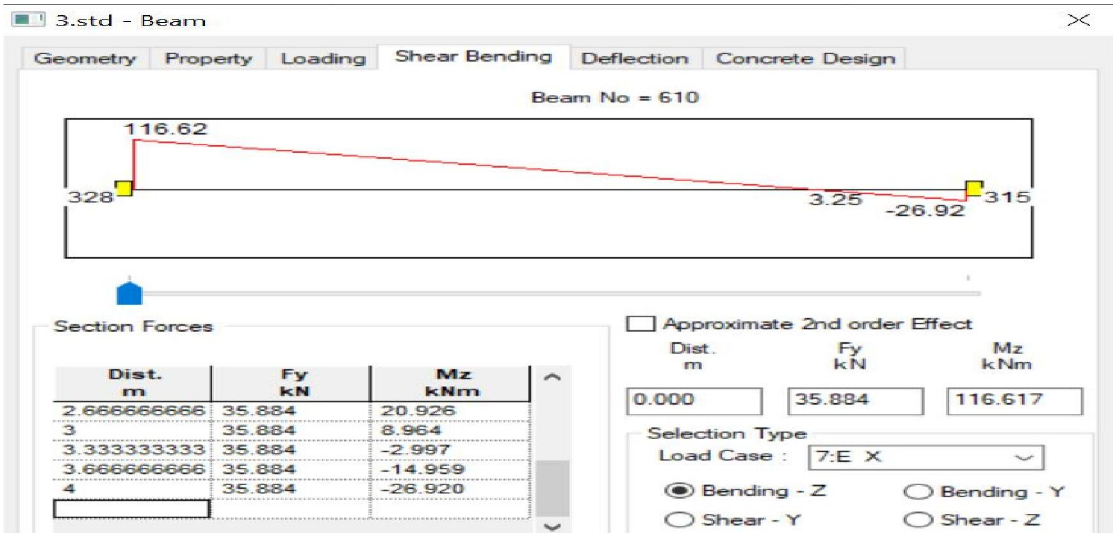
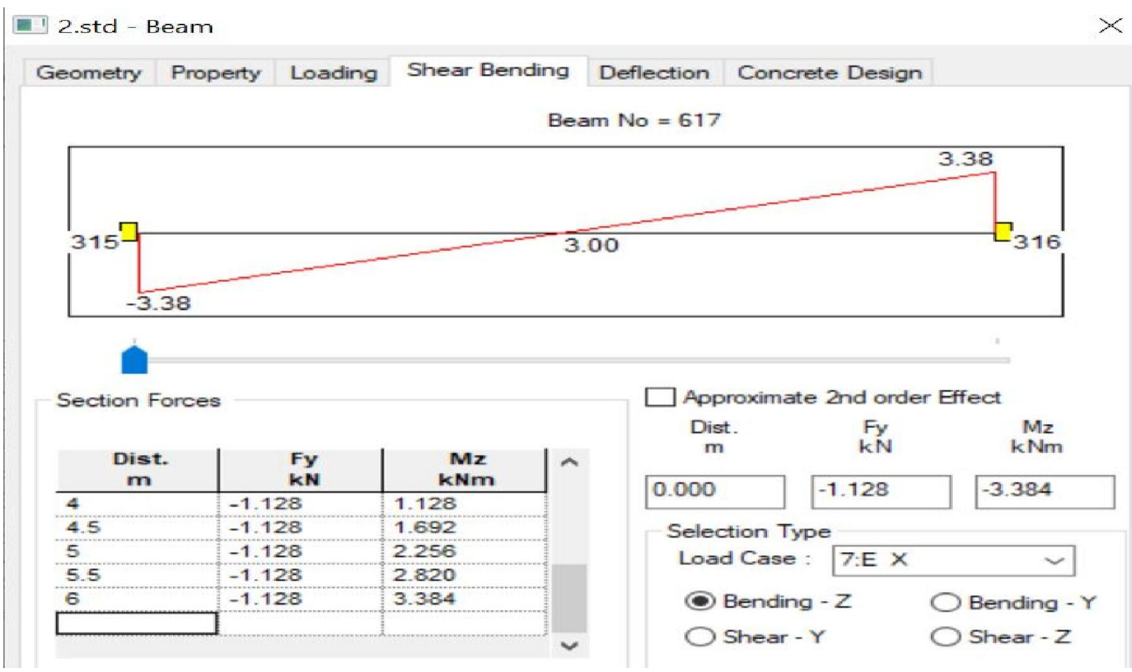


Dist. m	Fy kN	Mz kNm
2.666666666	35.884	20.926
3	35.884	8.964
3.333333333	35.884	-2.997
3.666666666	35.884	-14.959
4	35.884	-26.920

Figure 3.16: Column shear bending diagram for soft soil



Dist. m	Fy kN	Mz kNm
4	-1.128	1.128
4.5	-1.128	1.692
5	-1.128	2.256
5.5	-1.128	2.820
6	-1.128	3.384

Figure 3.17: Beam shear bending diagram for medium soil

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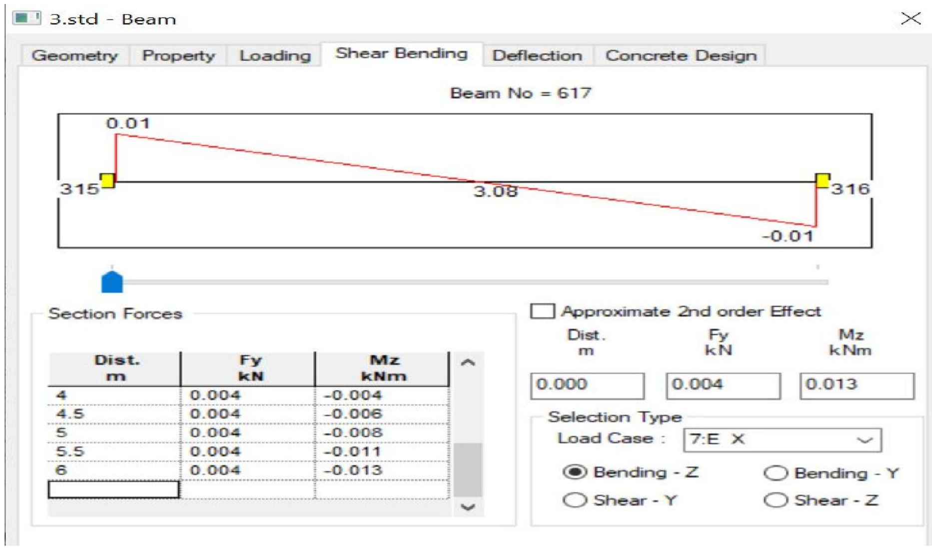

Figure 3.18: Beam shear bending diagram for soft soil

3.8 Design

Designing is an art of finding out dimensions of a structural member and amount of other materials (reinforcement, prestressing etc.) which will be sufficient to withstand different types of loads and forces applied on that member, at the same time it will be economic and providing serviceability. In other words, "the basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure during its intended life".

As soon as the analysis of structure is completed results of analysis such as bending moment, shear force, deflection etc. are viewed followed by design phase thus the design parameters listed in below table are inputted to the software and assigned to structure now the structure is once again analysed with the input parameters and checked for any errors, since we don't get any errors the design details of each and every member in the structure is thrown out by STAAD.Pro.

Some of the structural elements are designed satisfying the structural property and the analysis made using the software are listed below.

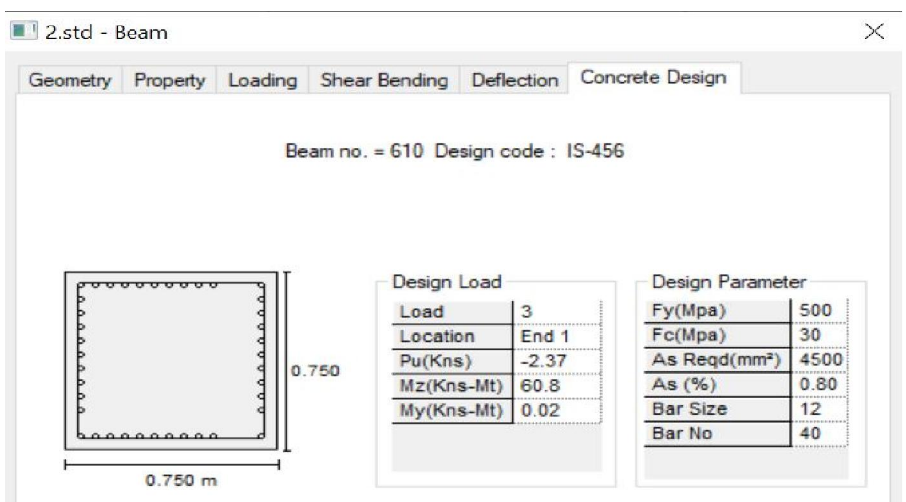

Figure 3.19: Main column design for medium soil

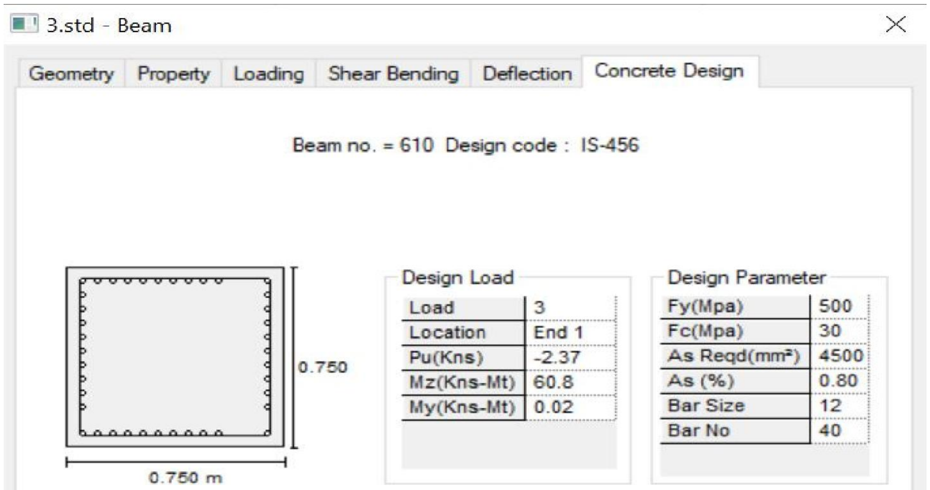

Figure 3.20: Main column design for soft soil

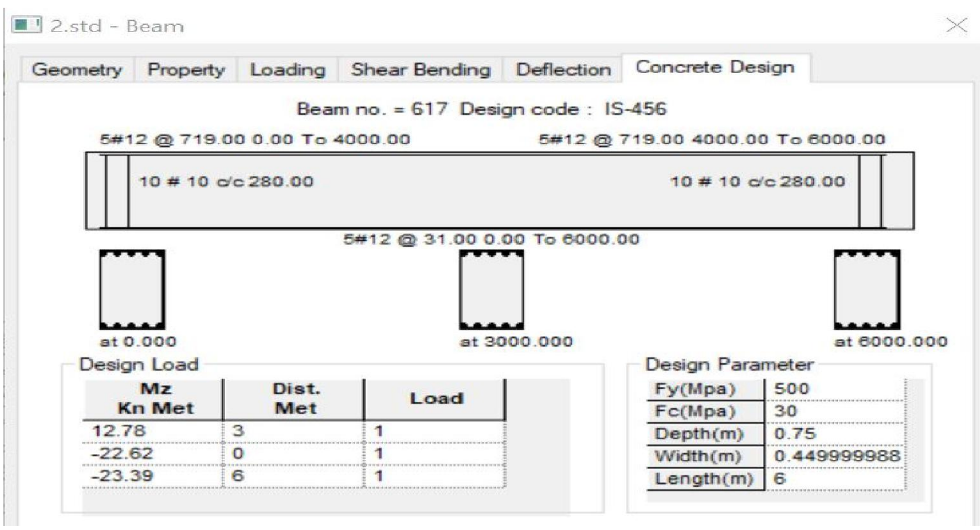

Figure 3.21: Main beam design for medium soil

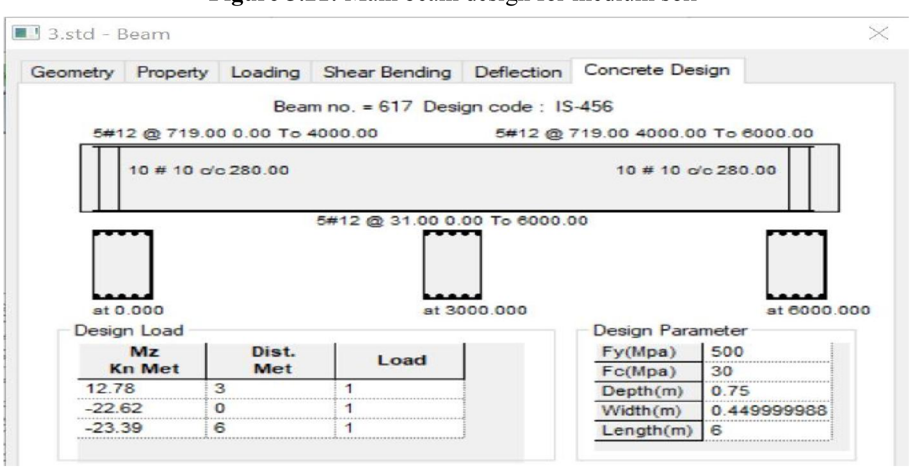

Figure 3.22: Main beam design for soft soil

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IV. Results and Discussion

From the analysis process the values obtained are plotted as bar graph and line graph. Base shear and storey drift are the two parameters which are compared here for medium soil condition and soft soil condition. Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. It is high in soft soil condition. The storey displacement is the lateral sway of the story with respect to its base. According to the report the value of storey displacement at 4.5m are maximum in both medium and soft soil conditions.

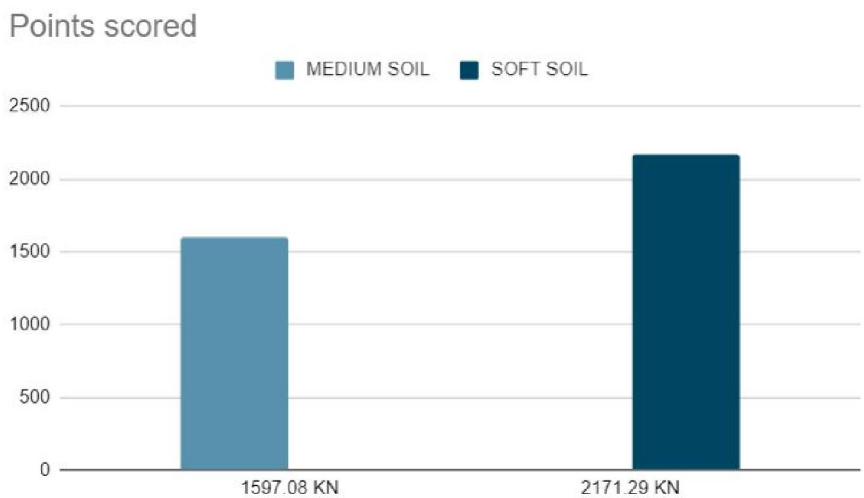

Figure 4.1: Base shear comparison for medium and soft soil

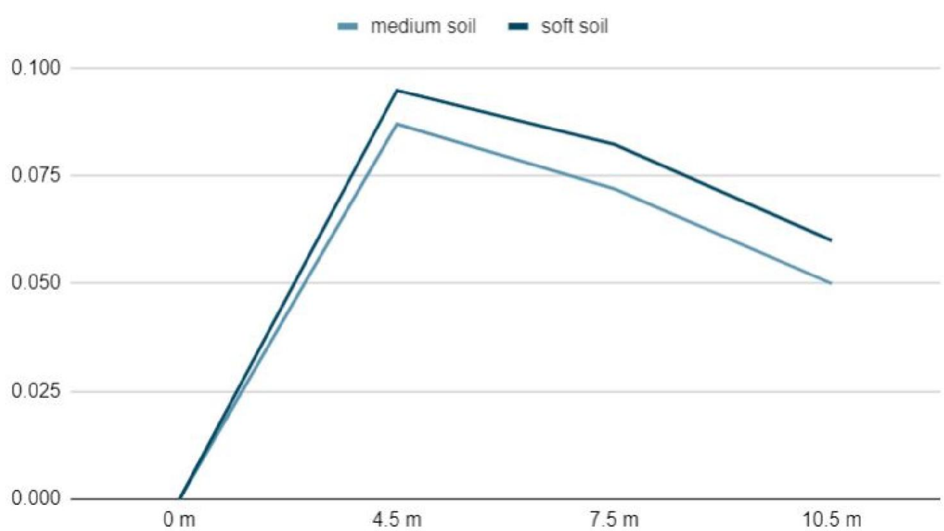

Figure 4.2: Storey drift through line chart

The auditorium was analysed and designed for seismic loads under medium and soft soil conditions.

- The base shear for the given auditorium in medium soil was found to be - 1597.08 KN
- The base shear for the given auditorium in soft soil was found to be - 2171.29KN
- The maximum storey drift in the auditorium under medium soil condition was found to be - 0.087 cm
- The maximum storey drift in the auditorium under soft soil condition was found to be - 0.0948 cm

V. Conclusion

- The base shear increases significantly as the soil condition changes from medium soil to soft soil.
- In our case the base shear increased by 35.95%
- The storey drift is also affected due to the change in the soil conditions, it increases as the soil stiffness decreases.
- In our case the storey drift increased in the range of 8% to 14%.

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