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# Analysis and Design of G+5 Building with Time History Analysis by Using Staad Pro

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**ABSTRACT:** The primary purpose of this project is to use STAAD Pro to study and design a multi-story structure [G + 5 (3 dimensional frame)]. The design process includes manually calculating loads and assessing the whole structure using STAAD Pro. STAAD-Pro analysis employs Limit State Design in accordance with the Indian Standard Code of Practice. STAAD.Pro is the professional's preferred solution. We began by analysing three-dimensional footage and personally verifying the software's correctness against our findings. The findings were quite accurate. We originally analysed and developed a G+5-story structure [3-D Frame] for all potential load combinations [dead, live, wind, and seismic]. STAAD.Pro has a very interactive user interface that enables users to create frames and enter load values and dimensions. The structure is then analysed and members with reinforcement details for RCC frames are designed using the designated criteria. Our final project included the correct analysis and design of a G + 5 three-dimensional RCC frame subjected to a variety of load combinations. The materials were defined, and the beam and column members' cross-sections were given. Additionally, the supports at the structure's base were defined as fixed. Additionally, the rules of practise to be followed for design purposes were stated, along with other critical aspects. The structure was then analysed and members designed using STAAD.Pro.

**KEYWORDS:** Manual Design, STAAD Pro, Analysis, RCC Frame, Load.

## I. INTRODUCTION

### 1.1 GENERAL

Building construction is the branch of engineering that deals with the construction of structures such as residential homes and offices. A simple building may be defined as an area surrounded by walls that has a roof, food, clothing, and other necessities for human survival. Early people lived in caves, above trees, or under trees to protect themselves from wild animals, rain, and sun, among other things. As time progressed, humans began to dwell in huts constructed of wood branches to provide a more permanent shelter from the elements. The shelters of the past have been transformed into lovely homes in modern times. Wealthy individuals live in luxurious homes with modern amenities.

### 1.2 THE EARLY MODERN PERIOD AND THE INDUSTRIAL REVOLUTION

With the advancement of scientific knowledge, as well as the introduction of new materials and technologies, architecture and engineering began to diverge, and the architect began to concentrate on aesthetics and humanistic aspects of building design, often at the expense of technical aspects of construction.

The Industrial Revolution, on the other hand, opened the way to widespread mass production and consumption. In the early twentieth century, aesthetics became a requirement for the middle class as beautiful objects, which were previously only available via pricey handicraft, became more affordable through machine manufacture.



### **1.3 OBJECTIVES OF PRESENT STUDY**

Following are objectives of present study to analyze the structure.

1. To study the literature available for understanding the effects on structural performance.
2. To study the structure with wind load as per IS 875 part 2.
3. To study the structure considering seismic load as per IS 1893-2002.
4. To analyze and perform design of building for the results of bending moment, reactions and axial force.
5. To perform the Foundation design, Column design, Beam design and Slab design of G+5 building.

## **II. LITERATURE REVIEW**

This chapter discusses about the different literature papers regarding the analysis of building with different loads and different conditions with the help of software.

### **1. Rao S. K. [2012], (Design concept of Pre-engineered building)**

Reputed that modular steel structures were designed for resistant to moisture, adverse weather conditions, earthquakes, termites and fire that provide you with lifelong durability, safety and very low cost-maintenance. modular steel building is very simple and economical with the necessary Architectural, Engineering and Construction with pre-engineered steel buildings. For design of a modular steel building steel is used which offers low cost, strength, durability, design flexibility, adaptability and recyclability. Steel is the very important Materials which are used for modular steel building. It negates from regional sources. It also means choosing reliable industrial products which come in a huge range of shapes and colors; it means rapid site installation and less energy consumption. It means choosing to commit top principles of sustainability. Infinitely a recyclable, steel is the material that reflects the imperatives of sustainable development

### **2. Ghagare K.K., [2014], (Seismic Analysis and Design of Multistory Building)**

Studied that, modular steel building analysis consist of two store two bay steel structure. Complete analysis of structure was done considering Dead Load, Live Load, Wind Load and Seismic load in various combinations a per IS:800:2007, IS:1893: 2002, IS:875:1987 etc. Since the structure is symmetrical in nature, some of important analysis remark are highlighted for various load case consideration for outer and inner frame. While, analysis, each inner and outer frame consisting of 36 members in total, various key Dead Load, Live Load & Wind Load, the results of beam end forces or axial forces reflects that even though wind force was considered maximum design force values for combination of Dead Load & Live Load with specified factor

### **3. Rao. G. P. and Pradeep. V [2014], (Comparative Study of Pre-Engineered and Conventional Industrial Building)**

Conveyed that modular steel structures could be easily designed by simple design procedures in accordance with country standards. Low weight flexible frames of modular steel building offer higher resistance to earthquake loads. PEB roof structure was almost 26% lighter than Conventional Steel Building. In secondary members, light weight "Z" purlins are used for modular steel structure, whereas heavier hot-rolled sections were used for Conventional steel building.

## **III. PERFORMANCE ANALYSIS**

### **3.1 General**

The importance of the nature of sub soil and base isolation for the seismic response of structure has been demonstrated in many earthquakes, but a reasonable understanding of factors involved has only recently begun to emerge. Relation between period of vibration of structure and period of supporting soil is profoundly important regarding the seismic response of base isolated structure. The nature of sub soil may influence the response of structure in three ways.



- The phenomenon of soil amplification may occur, in which the seismic excitation at bed rock is modified during transmission through the overlying portion of soil foundation. This may cause amplification effect.
- The fix base dynamic properties of the structure may be significantly modified by presence of soil overlying bed rock. This will include change in mode shape and period of vibration.
- A significant part of vibration energy of flexibly supported structure may be dissipated by material damping and radiation damping in supporting medium.

### 3.2 Modeling of building

For the study, one type of hypothetical RCC buildings are considered. In this study, (G+5) building structure is considered. The data assumed for the frame structure is given in Table 4.1. Following different models are analyzed.

Model I: A 5 storey conventional RCC building

### 3.3 PROBLEM STATEMENT

Floor to floor height: 3000 mm

Height of plinth: 450 mm

Beam size: 200X380 mm

200X300 mm

200X600 mm

Column size: 200X300 mm

230X380 mm

200X530 mm

Depth of foundation: 1000 mm

Roof load: 1.5 KN/m<sup>2</sup>

Live load: 1.5 KN/m<sup>2</sup>

Floor finish load: 1 KN/m<sup>2</sup>

Slab thickness: 100 mm

120 mm

Seismic load as per IS 1893- 2012

M20 Grade Concrete, Fe 500 steel

**Table 1: Earthquake Force Data for Response Spectrum Analysis**

Zone	II, III
Response Reduction factor	3
Importance factor	1.5
Damping Ratio	0.05

For generating the earthquake forces in the analysis, joint weight has been provided as per appropriate column load at appropriate joints. Software for the analysis generates effective seismic forces as per the various factors defined above.

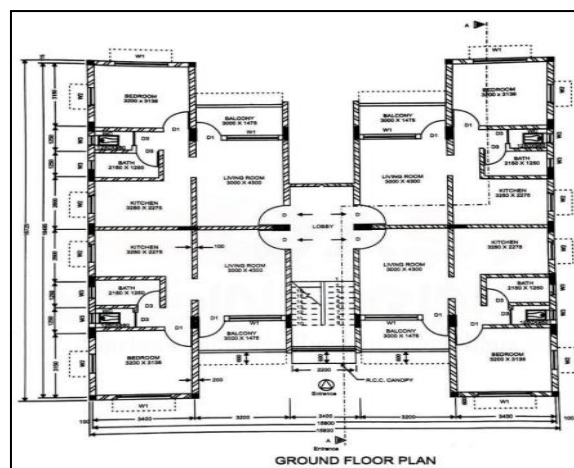
The different loading combinations for the analysis of the building considered are shown in table.

**Table 2: Different Loading Combinations for Analysis of Building**

Sr. No	Load Combination
1.	1.5 (DL + LL)
2.	1.2 (DL + LL + EQX)
3.	1.2 (DL + LL + EQZ)
4.	1.2 (DL + LL - EQX)
5.	1.2 (DL + LL - EQZ)
6.	1.5 (DL + EQX)
7.	1.5 (DL + EQZ)
8.	1.5 (DL - EQX)
9.	1.5 (DL - EQZ)
10.	0.9 DL + 1.5 EQX
11.	0.9 DL + 1.5 EQZ
12.	0.9 DL - 1.5 EQX
13.	0.9 DL - 1.5 EQZ

Modeling and analysis of multistorey framed structure consisting of ordinary moment resisting frames, subjected to various different load conditions involve large degrees of freedom to be formulated. Hence huge stiffness matrix evaluation and subsequent computation of forces becomes a tedious job for hand calculations. The problem at hand can be solved with the help of software like STAAD/ETABS/ANSYS etc. for analyzing and designing multistoried buildings models. The model is analyzed using structural design software STAAD Pro 2007 structural engineering software. For being validated by many structural design firms and many scrutinizing authorities as well the post processing graphical capabilities for viewing bending moment diagrams, shear force diagrams, deflection diagrams are used to the fullest extent to verify logical behavior pattern by engineering common sense.

**PLAN**



**Fig 1: Ground floor plan**

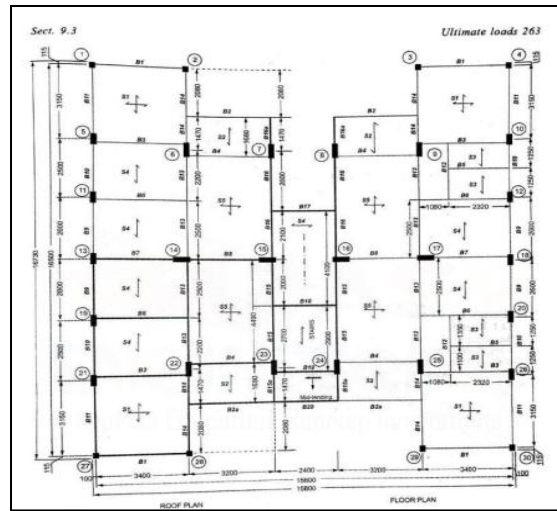


Fig 2: Structural plan

(Source: Illustrated design of reinforced concrete buildings- Dr. S.R. Karve, 2001)

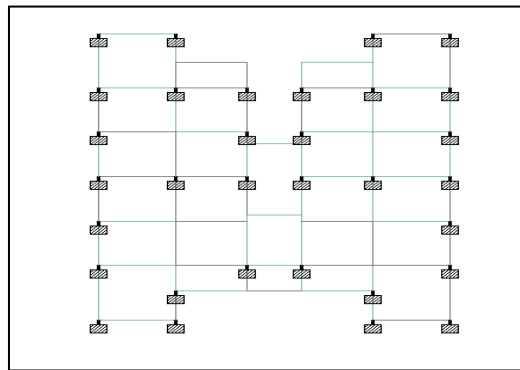


Fig 3 : Plan view

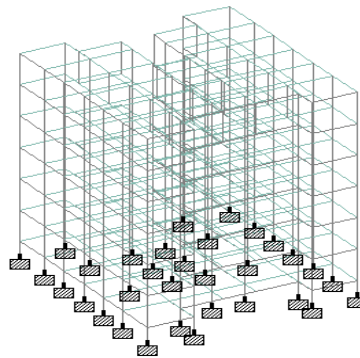


Fig 4 : 3 D View of G+5 building

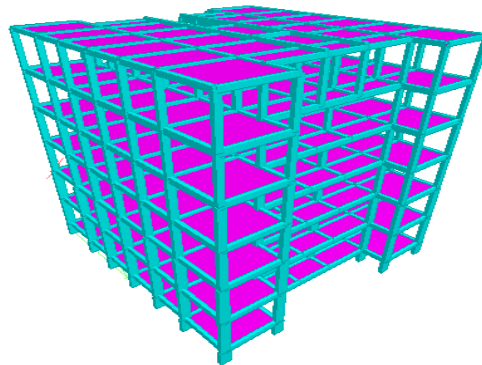


Fig 5: 3 D rendered View of G+5 building

#### IV. DESIGN

This chapter discusses the design of beam, column, slab, staircase and footing by manual design.

##### 4.1 DESIGN OF BEAMS

Beams transfer load from slabs to columns. beams are designed for bending.

In general, we have a two types of beam: single and double. Same as to the columns geometry and perimeters of the beams are assigned. Design beam command is assigned and analysis is carried out, now the reinforcement details are taken.

###### 1. *Beam design:*

A reinforced concrete beam should be able to resist the tensile, compressive and shear stress induced in it by loads on the beam.

###### 2. *Singly reinforced beams:*

In the single reinforced simply supported beams steel bars are placed near bottom of the beam where they are more effective in resisting in a tensile bending stress. I cantilever beams reinforcing bars placed near the top of the beam, for the same reason as in the case of a simply supported beam.

###### 3. *Doubly reinforced concrete beams:*

It is reinforced under compression tension regions. The necessity of the steel of compression region arises due to two reasons. When depth of beam is restricted. The strength availability a singly reinforced beam is in adequate. At a support of continuous beam where the bending moment changes sign such as situation may also arise in design of a beam circular in plan

Figure 6 shows the bottom and top reinforcement details at three different sections. These calculations are interpreted manually.

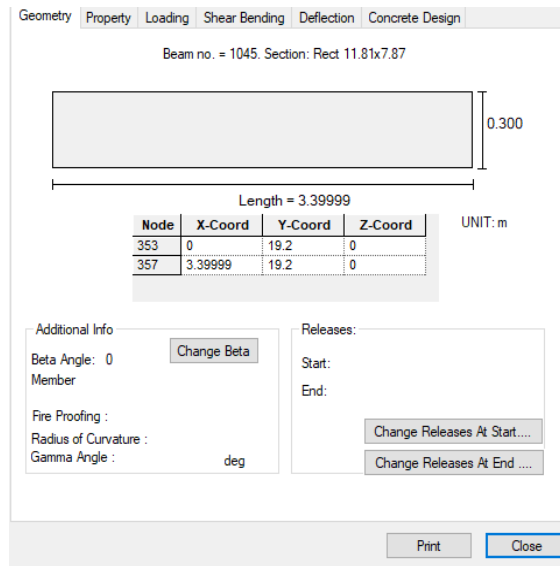


Fig 6. diagram of the reinforcement details of a beam

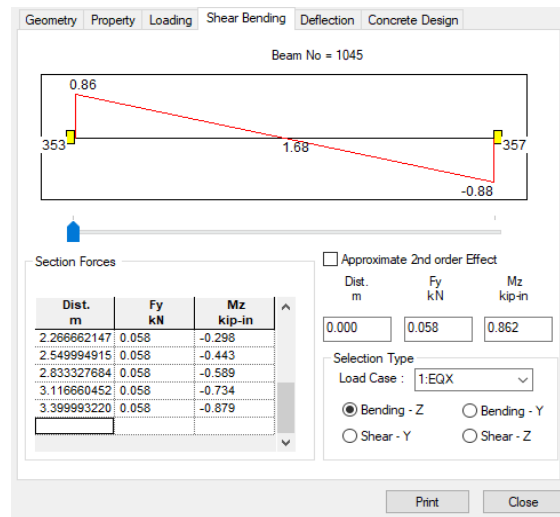


Fig.7 The following diagram shows the bending shear

#### 4.2 DESIGN OF COLUMNS

A column or strut is compression member, which is used primary to support axial compressive loads and with a height of at least three times its least lateral dimension.

A reinforced concrete column is said to be subjected to an axially loaded when line of the resultant thrust of loads supported by column is coincident with the line of Center of gravity of the column in the longitudinal direction.

Depending upon the architectural and structural requirement and loads to be supported, R.C columns may be cast in various shapes i.e., square, rectangle, and hexagonal, octagonal, circular. Columns of L shaped / T shaped are also sometimes used in multi-storeyed buildings.





**4. Positioning of columns:**

Some of the principles which help to guide the positioning of the columns are as follows: -

- A. Columns should be preferred to be located at or near the corners of the building and at the intersection of the wall, but for the columns on the property line as the following requirements some area beyond the column, the column can be shifted inside along a cross wall to a provide the required area for the footing with in the property line. Alternatively, a combined or the strap footing may be provided.
- B. The spacing between the columns is driven by lamination on spans of supported beams, as the spanning of the column decides the span of the beam. As the span of the of the beam increases, the depth of the beam, and hence the self-weight of the beam and the total weight increases.

**5. Column design:**

A column is defined as element basically used to support axial compressive loads and with a height of three times of its least lateral dimension. The strength of column depends upon a strength of materials, shape and size of cross section, length and degree of proportional and dedicational restrains at its ends.

The ratio of effective column length to least lateral dimension is called as slenderness ratio.

In our structure we have the 3 types of columns.

- Column with beams on two sides, three sides, four sides

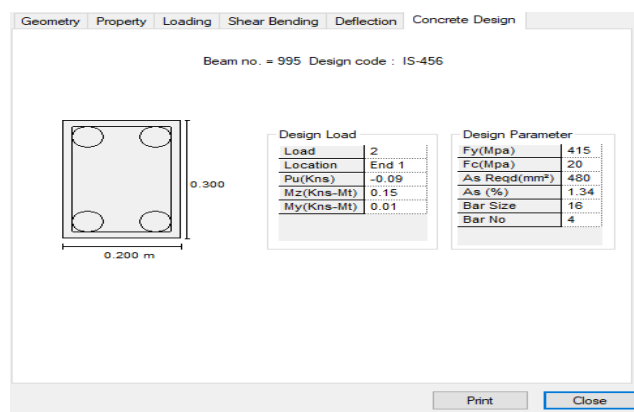
The column design is done by selecting the column and from geometry page assigns dimensions of the columns. Now analyze the column for loads to see the reactions and total loads on the column by seeing loads design column by the giving appropriate parameters like

1. Minimum reinforcement, maximum, bar sizes, maximum and minimum spicing.
2. Select the correct design code and input design column command to the entire column.
3. Now run analysis and choose any of the column to collect the reinforcement details

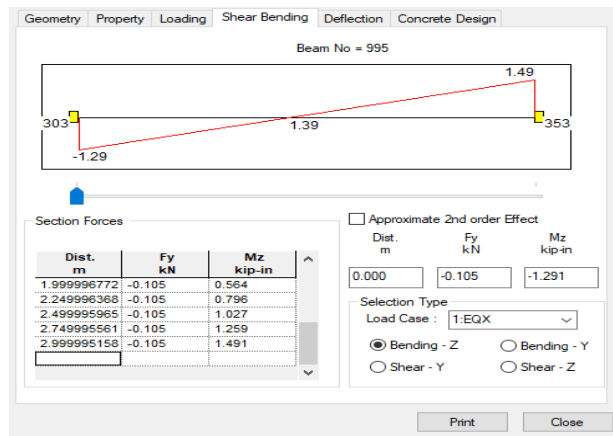
The following figure shows reinforcement details of a beam in staad. The figure represents details regarding

1. Transverse reinforcement
2. Longitudinal reinforcement

The type of bars to be used, amount of steel and loading on the column is shown below.



**Fig 8 reinforcement details of a column**



The following figure 9 shows the deflection of the column

### 4.3 DESIGN OF SLABS

Slab design:

Slab is a plate elements forming floor and roofs of buildings carrying distributed loads primarily by the flexure.

One-way slab:

One-way slab are those in which length is more than twice breadth it can be simply supported beam or a continuous beam.

Two-way slab:

When slabs are supported to four sides two ways a spanning action occurs. Such as slab are a simply supported on any or continuous or all sides deflections and the bending moments are considerably reduces as compared to those in a one-way slab

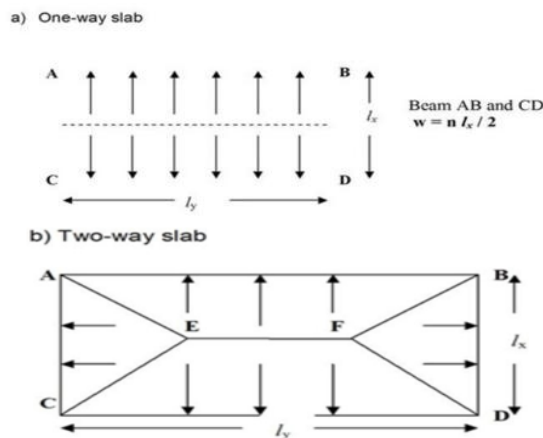


Fig 10 A Diagram of load distribution of one way and two way slabs

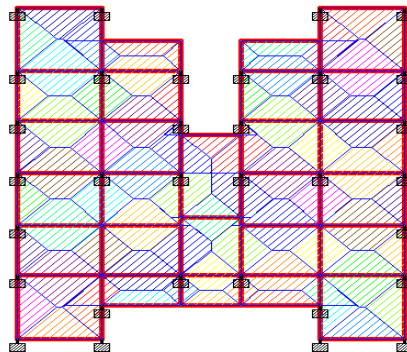


Figure 11 Distribution of loads in all slabs.

### V. RESULT AND DISCUSSION

This chapter discusses about different results acting on G+5 building. Results we can find out from Staap pro software are base reaction, axial force, displacement and bending moment as shown in following figures. Also this chapter discusses the comparison between the manual results and the software results of the building.

Wind load in +X direction

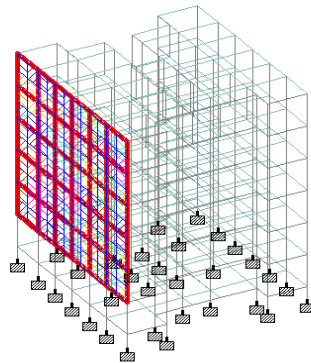


Fig 12: Wind load in +X direction

Wind load in +Z direction

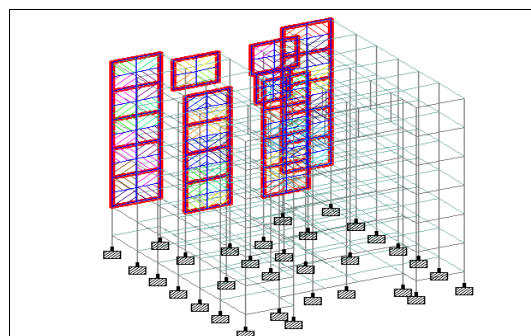


Fig 13: Wind load in +Z direction

Reactions

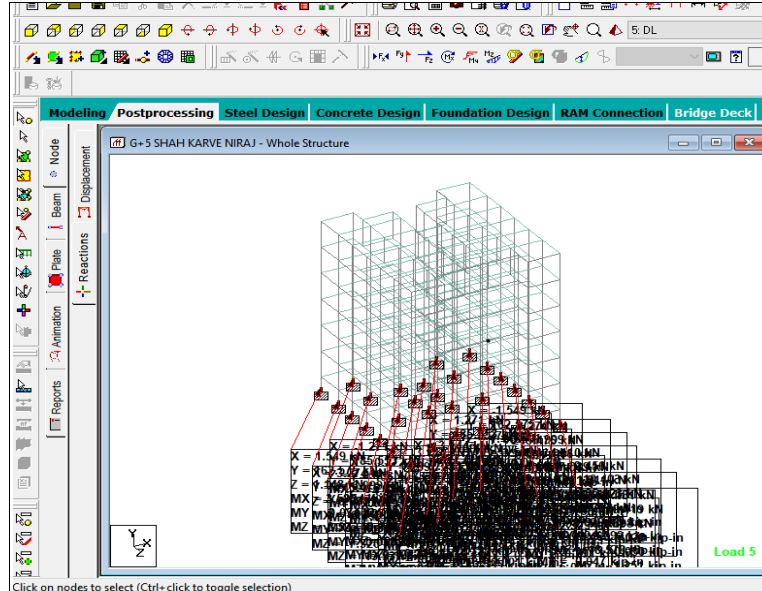


Fig 14: Reactions

Axial force

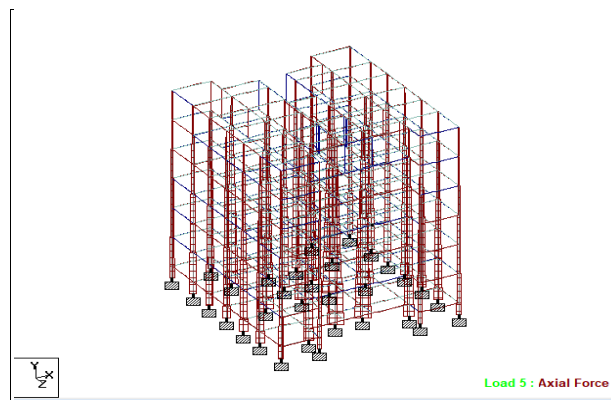


Fig 15: Axial force

Table no 3: Comparison of software and manual design:

COMPONENT	SOFTWARE RESULTS	MANUAL RESULTS	DIFFERENCE
BEAM no. 1045	Ast= 560 mm <sup>2</sup>	Ast= 480 mm <sup>2</sup>	14.28%
COLUMN no. 995	Ast= 480 mm <sup>2</sup>	Ast= 478 mm <sup>2</sup>	0.41%
SLAB no. 833	Ast= 1065 mm <sup>2</sup>	Ast= 780 mm <sup>2</sup>	5%
FOOTING no. 1	Ast= 836.12 mm <sup>2</sup>	Ast= 766.99 mm <sup>2</sup>	8.26%



Table 4: Time period in sec and frequency in Hz

Mode	Frequency Hz	Period seconds
1	1.083	0.923
2	1.326	0.754
3	1.411	0.709
4	2.948	0.339
5	3.771	0.265
6	3.953	0.253

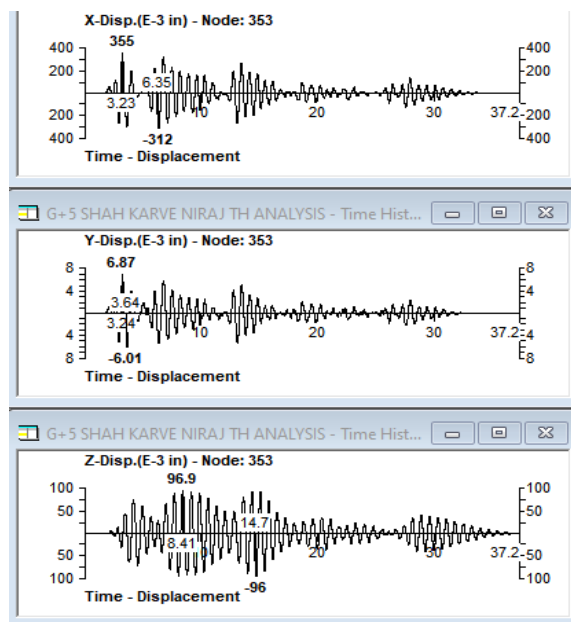


Fig 16: Time versus displacement graph

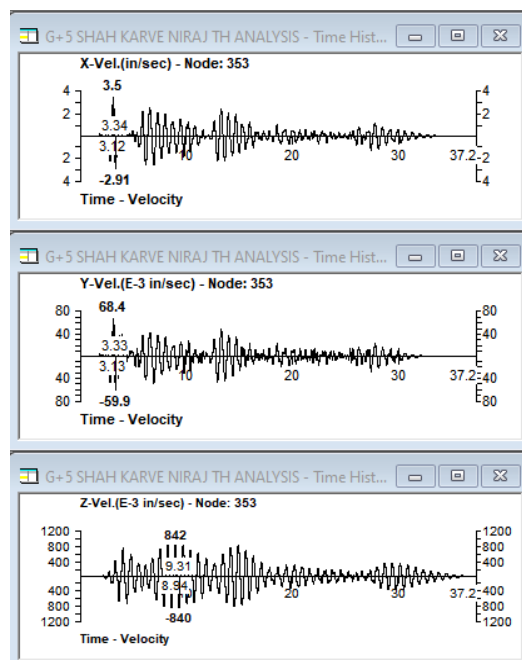


Fig 17: Time versus velocity graph

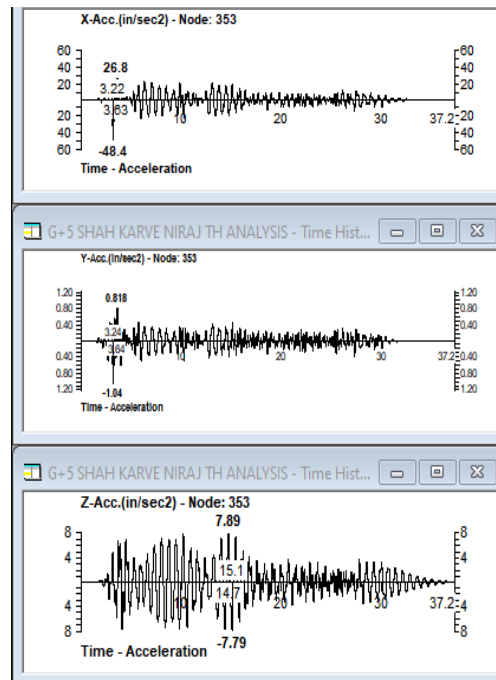


Fig 18: Time versus acceleration graph

Table 5: Displacement, velocity and acceleration graph

	Displacement (mm)	Velocity (mm/s)	Acceleration (mm/s <sup>2</sup> )
<b>X-direction</b>	355	3.5	26.8
<b>Y-direction</b>	6.87	68.4	0.818
<b>Z-direction</b>	96.9	842	7.89

Above table shows displacement, velocity and acceleration values for X, Y and Z direction.

## VI. CONCLUSION

Designing using software such as Staad pro saves a significant amount of time in the design process. It is possible to gather detailed information on each and every member utilising staad pro. The programme allows you to acquire the whole list of failed beams as well as the Better Section. The use of software helps to increase accuracy. In conclusion, we may say that there is a distinction between theoretical and practical work performed. Because practical labour will broaden the span of one's learning, it is highly recommended. As we get more information in a scenario where we have a large deal of practical experience, we can use it more effectively. We have a very poor bearing capacity, hard soil, and a footing that has been done in an isolated area. As we performed time history analysis we have graphs of time versus displacement, time versus velocity and time versus acceleration. And under the performance of time history analysis structure is safe for earthquake resistance.

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