Analysis and design of g+7 residential building using STAADPRO software

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Abstract
The main aim of structural engineer is to design the structures for a safe technology in the computing field; the structural engineer can dare to tackle much more large and complex structure subjected to various type of loading condition. Carrying out a complete design of the main structural elements of a multi – storied building including slabs, beams, columns and footing.Getting real life experience with the engineering practices. The structure should be so arranged that it can transmit dead, the wind and imposed loads in a direct manner to the foundations. The general arrangement should ensure a robust and stable structure that will not collapse progressively under the effects of misuse or accidental damage to any one element

Keywords:*Analysis, Design, STAAD PRO, Residential building, shear force, bending moment and axial force.*

I. INTRODUCTION

In every aspect of human civilization we needed structures to live in or to get what we need. But it is not only building structures but to build efficient structures so that it can fulfill the main purpose for what it was made for. Here comes the role of civil engineering and more precisely the role of analysis of structure. The design consists of G+7 residential building. The building is designed for the four residential flats at single floor. Residential flat consists of four 1BHK at single floor. The floor to floor distance is 3m. There are many traditional methods to solve design problem, and with time new software"s also coming into play. Here in this project work based on software named "STAAD. Pro" has been used. The full form of STAAD is STRUCTURAL AIDED ANALYSIS AND DESIGN .We have chosen STAAD Pro because of its advantages like easy to use interface, conformation with the Indian Standard Codes, versatile nature of solving any type of problem, accuracy of the solution. "STAAD. Pro" is the professional"s choice for steel, concrete, timber, aluminum and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more. To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behavior.

II. LITERATURE REVIEW

Various literatures are reviewed which are based on study of analysis of seismic forces and its impact effect on living life. Literature review focused on various work done by various authors on analysis of seismic forces under various zones of earthquakes the. Seismic analyses are performed using various software. Review also explained studies Performed to reduce or control seismic effect and its hazardous effect

Patil A. S, (2013) studied nonlinear dynamic analysis of 10 storied RCC building. Considering different seismic intensities and also studied seismic response of such building. The building under consideration is modeled with the help of SAP 2000-15 1 software and 5 different time histories have been used. The result of the study shows similar variations pattern in seismic response such as base shear and storey sdisplacements and concluded that time history is realistic method used for seismic analysis. It provides a better check to the safety of structure analyzed and designed.

M.S. Aainawala et al. (2014). Comparative study of multi-stored R.C.C Building with and without shear walls.He did done the comparative study of multi-stored R.C.C Building with and without shear walls.

They applied the earthquake load to a building for G+12, G+25, G+38 located in zone II, zone III, zone IV and zone V for different cases for shear wall position.It was observed that multistoried R.C.C building with shear wall is economical as compared to without shear wall. As per analysis, it was concluded that displacement at different level in multi-stored building with shear wall is comparatively lesser as compared to R.C.C building without shear wall. This is important for building design and use of shear walls.

Mahesh et al., 2014, compared the behavior of G+11 multi-storeyed building of regular and irregular configuration under earth quake is complex and it varies of wind loads are assumed to act simultaneously with earth quake loads. In this paper a residential building. Of G+11 multi storied building is studied for earth quake and wind load using ETABS and STAAD PRO.

In Prof Dr. Qaiseruz Zaman Khan's 2010paper Response spectrum analysis of 20 story building has been conferred in detail and comparison of static and dynamic analysis and design results of buildings up to 400 feet height (40story) in relations of percentage decrease in bending moments ad shear force of beams, bending moments of columns, top story deflection and support reaction are conferred.

Mohan et al., 2011.Compared and studied linear equivalent static analysis performed for regularbuildings up to 90m height in zone I and II, dynamic analysis should be performed for regular and irregular buildings in zone IV and V. In present work, two. Multi stored buildings, one of six and other of eleven stories have been modeled using. Software package SAP 2000 for earthquake zone V in India

III. METHODOLOGY/PROCEDURE

Step - 1: Initial setup of Standard Codes and Country codes.

Step - 2: Creation of Grid points & Generation of structure

After getting opened with STAAD PRO we select a new model and a window appears where we had entered the grid dimensions and story dimensions of our building.

Step - 3: Defining of property

Here we had first defined the material property by selecting define menu material properties. We add new material for our structural components (beams, columns, slabs) by giving the specified details in defining. After that we define section size by selecting frame sections as shown below & added the required section for beams, columns etc.

Step - 4: Assigning of Property

After defining the property we draw the structural components using command menu. Draw line for beam for beams and create columns in region for columns by which property assigning is completed for beams and columns.

Step - 5: Assigning of Supports

By keeping the selection at the base of the structure and selecting all the columns we assigned supports by going to assign menu joint\frame Restraints (supports) fixed.

Step - 6: Defining of loads

In STAAD PRO all the load considerations are first defined and then assigned. The loads in STAAD PRO are defined as using static load cases command in define menu.

Step - 7: Assigning of Dead loads

After defining all the loads. Dead loads are assigned for external walls, internal walls in STAAD PRO.

Step - 8: Assigning of Liveloads

Live loads are assigned for the entire structure including floor finishing

Step - 9: Assigning of wind loads

Wind loads are defined and assigned as per IS 875 1987 PART 3 by giving wind speed and wind angle.

Step - 10: Assigning of Seismic loads

Seismic loads are defined and assigned as per IS 1893: 2002 by giving zone, soil type, and response reduction factor in X and Y directions.

Step - 11: Assigning of load combinations

Using load combinations command in define menu 1.5 times of dead load and live load will be taken as mentioned in above.

Step - 12: Analysis

After the completion of all the above steps we have performed the analysis and checked for errors.

Step - 13: Design

After the completion of analysis we had performed concrete design on the structure as per IS 456:2000. STAAD PRO performs the design for every structural element.

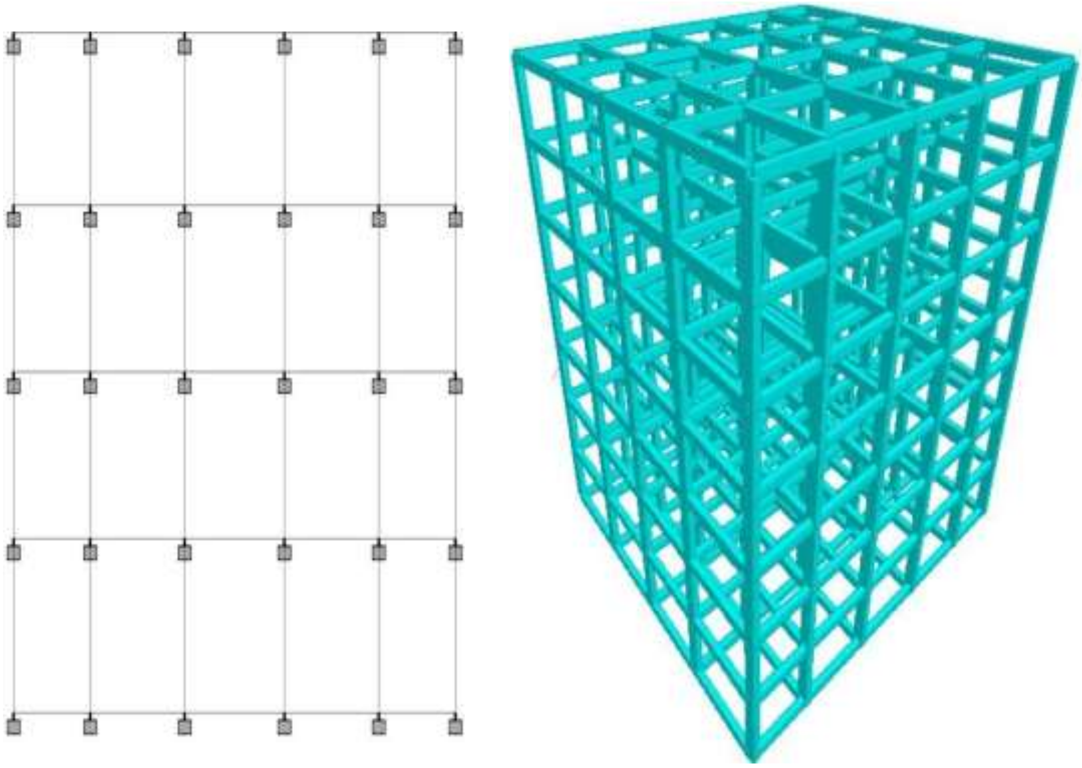


Fig1: Modeling in STAAD pro

IV. MODELING AND ANALYSIS

1. SEISMIC DESIGN FORCE

Earthquake shaking is random and time variant. But, most design codes represent the earthquake-induced inertia forces as the net effect of such random shaking in the form of design equivalent static lateral force. This force is called as the Seismic Design Base Shear VB and remains the primary quantity involved in the force-based earthquake-resistant design of buildings. This force depends on the seismic hazard at the site of the building represented by the Seismic Zone Factor Z. Codes reflect this by the introduction of a Structural Flexibility Factor Sa/g. This philosophy is introduced with the help of Response Reduction Factor R, which is larger for ductile buildings and smaller for brittle ones Thus, the design of earthquake effects is not termed as earthquakeproof design. Instead, the earthquake demand is estimated only based on concepts of the probability of evidence, and the design of earthquake effects is termed as earthquake-resistant design against the probable value of the demand. The Design Base Shear VB is taken as per the Indian Seismic Code IS 1893 (Part 1) – 2016.

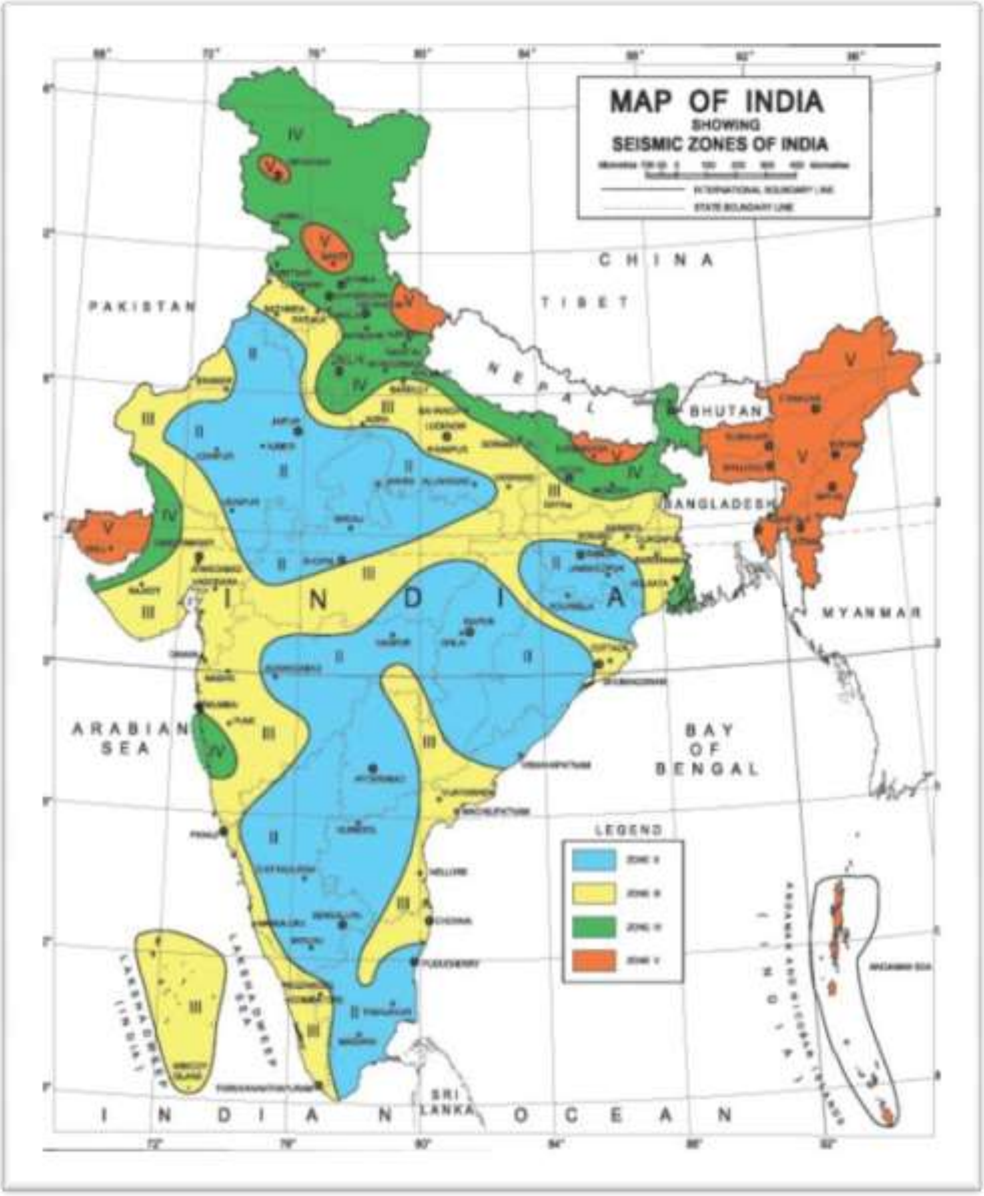


Fig2:Seismic zone in according to IS 1893 (Part 1) – 2016.

2. ANALYSIS OF G+7 BUILDING

2.1. IS 1893:2002 CODAL PROVISIONS

2.1.1. DYNAMIC ANALYSIS

Dynamicanalysis is performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following buildings.

a) REGULAR BUILDINGS - Those greater than 40 m in height in Zones IV and V, and those greater than 90 m in height in Zones II and III.

b) IRREGULAR BUILDINGS - All framed buildings higher than 12 m in Zones IV and V, and those greater than 40 m in height in Zones II and III.

2.1.2 RESPONSE SPECTRA

The response spectra considered according to the Indian Standard for design is as shown in Figure 2.1 where consideration for different type of soil is based on appropriate natural periods and damping of the structure and these curves represent free ground motion. The spectral acceleration coefficient i.e. (Sa/g) taken as per IS 1893 (Part 1): 2002 is as follows, which is considered for designing the structure.

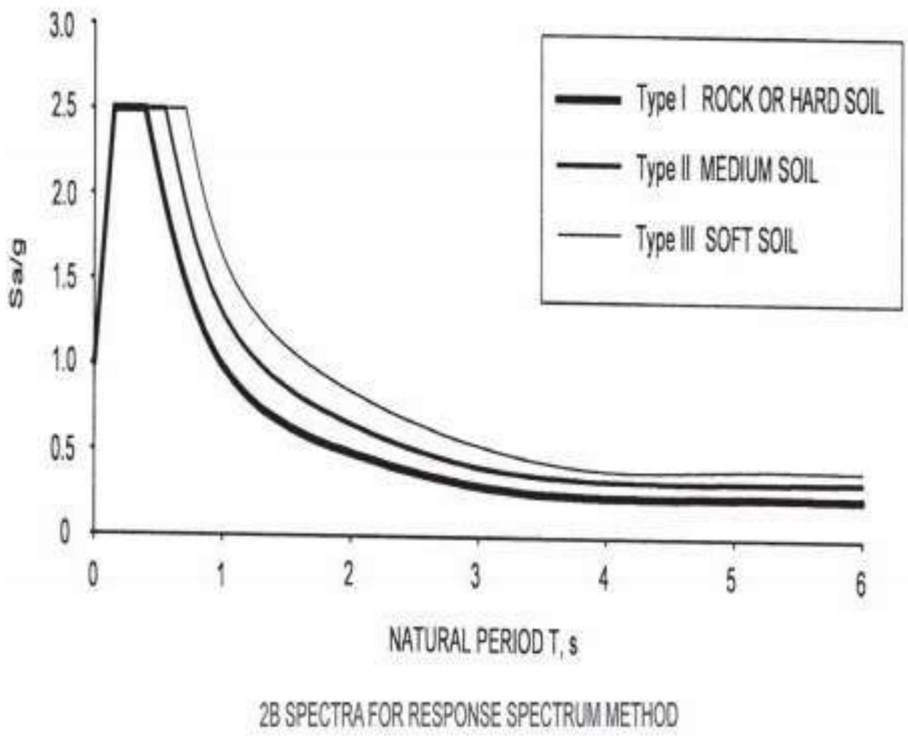


Fig3: Response Spectra for rock and soil sites for 5% damping

TYPES OF SOIL

According to the 1893 code guidelines the following type of soil was considered: For medium soil- All soils with N between 10 and 30, and poorly graded sands or gravelly sands with little or no fines (SP), with N > 15. Table 1 represents the rerun column design specification.

STATEMENT OF THE PROJECT

- Live Load: 3.0 KN/Sq.m
- Thickness of slab: 150 mm
- Location of the site: Ahmednagar in Seismic Zone-III
- Type of Soil: Medium Soil, (Type-II as per IS: 1893 (Part-1))
- Allowable bearing pressure: 200 KN/Sq.m
- Each Storey Height: 3 m
- No of Floors: Ground+7
- External Wall Thickness: 230 mm
- Internal Wall Thickness: 150 mm
- Column Size: 300x550 mm
- Beam Size: 300x400 mm
- Wind Load: As per IS: 875-1987 (Part-3)
- Earthquake Load: As Per IS: 1893-2002 (Part-1)

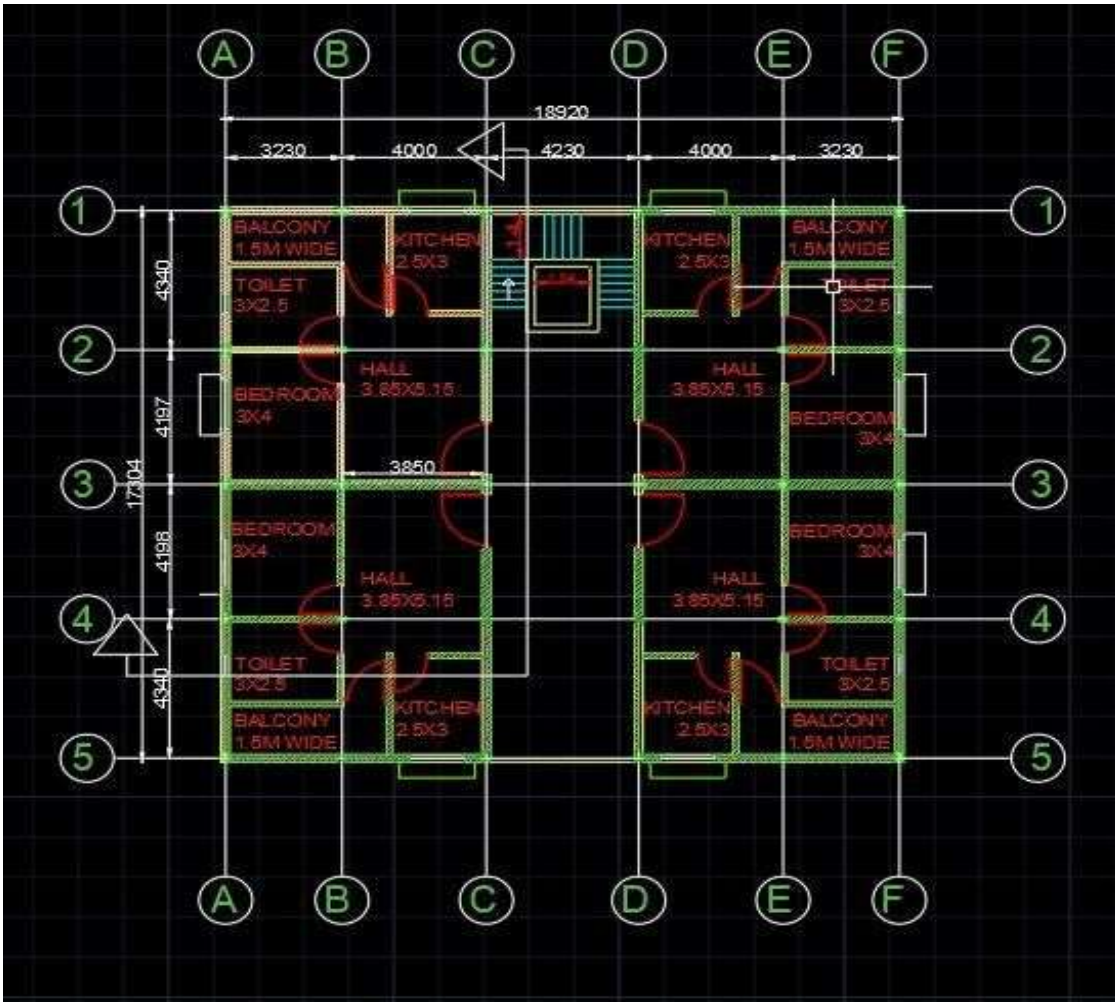


Fig4: Typical Plan View of G+7 Residential Building.

2.2 LOADS

The reinforced concrete structures are designed to resist the following types of loads.

1. DEAD LOAD

Dead loads are permanent or stationary loads which are transferred to the structure throughout their life span. Dead loads mainly cause due to self-weight of structural members, permanent partitions, fixed equipment"s and fittings.

RC PROPERY

- Column Size: 300x550 mm
- Beam Size: 300x400 mm

A. DEAD LOAD CALCULATION

a) LOAD CALCULATIONS

SELF - WEIGHT OF SLAB LOAD:

Floor loads for 150mm thick slab
Thickness of slab -150mm
Unit weight of reinforced concrete - 25.00kn/m3
= 0.150 x 25
= 3.75 KN/m2
Dead load of slab = 3.75kn/m2
Floor finishes = 1kn/ m2

= 3.75+1

= 4.75 KN/m2
Total load of slab = 4.75kn/ m2

b) SELF-WEIGHT OF BEAM LOAD:
Beam Size- 300x450mm
Unit weight of reinforced concrete - 25.00kn/m3
= 0.3 x 0.4 x 25
= 3Kn/m3

c) WALL LOADS

EXTERNAL WALL
230mm thick wall for 3.0 heights
Thickness of wall „b‟ : 0.23m
Height of walls „h‟ - 3.0mm
Unit weight of brick masonry γ – 19kN/m3
= 0.23 x 3.0 x 19
Total load h*b* γ = -13.11 kN/m

INTERNAL OR PARTITION WALLS
150mm thick wall for height 3.0m
Thickness of wall „b‟ - 0.15m
Height of walls „h‟ - 3.0m
Unit weight of brick masonry „γ‟ – 19kN/m3
= 0.15 x 3.0 x 19
Total load h*b* γ = 8.55 kN/m

PARAPET & BALCONY WALL LOAD
Thickness of wall „b‟ - 0.230m
Parapet wall „h‟ - 1.00m
Unit weight of brick masonry „γ‟ – 19kn/m3
= 0.230 x 1 x 19
Total load h*b* γ = 4.37 kn/m3

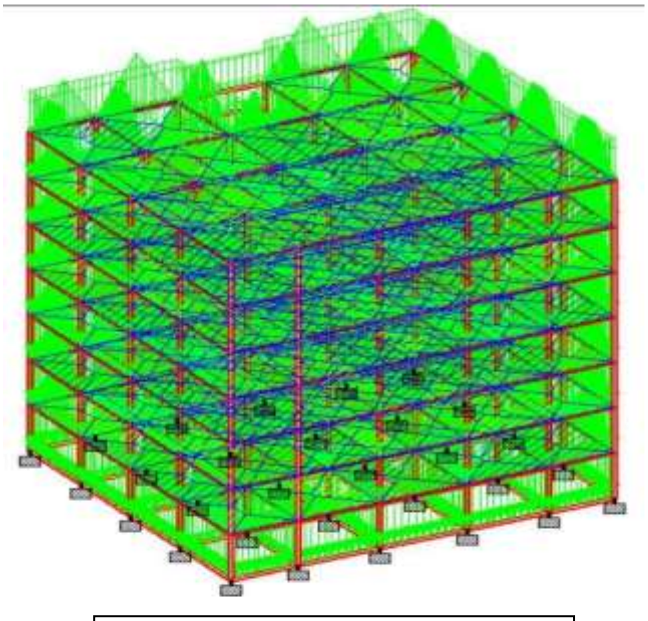


Fig5:Dead Load of g+7building

B. LIVE LOADS (OR) IMPOSED LOADS

These are the loads that change with time. Live loads or imposed loads include loads due to thepeople occupying the floor, the weight of movable partitions, the weight of furniture and materials. The live loads to be taken in the design of buildings have been given in IS 875 (part-2) -1987. Some of the common live loads used in the design of buildings are given below:

LIVE LOAD AS PER CODE IS: 875 (PART-2)

Living rooms 2.000kn/ m2

Staircase, corridor 3.000kn/ m2Terrace 1.5 kn/ m2

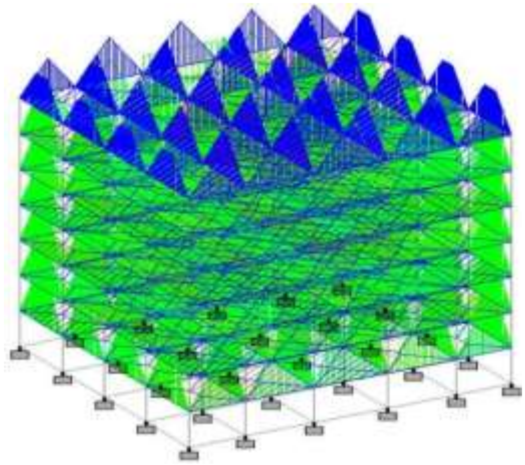


Fig6:Live Load of g+7 Building

C. WIND LOADS

The horizontal load caused by the wind is called as wind loads. It depends upon the velocity of wind and shape and size of the building. Complete details of calculating wind loads on structures are given in IS 875(part -3)-1987.

For low rise building say up to four to five stories, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Design Wind Speed Vz = Vb x K1 x K2 x K3

Where

Vb- Design Wind Speed

K1- Probability factor

K2 – Terrain factor

K3- Topography Factor

Exposure factor is -1.0 (As per code)

D. EARTHQUAKE FORCES

Earthquake forces are horizontal forces caused by earthquake and shall be computed in accordance with IS 1893-1984.

SESMIC LOAD CALCULATIONS

Area = Ahmednagar

Zone = III

Length of the building „lx" = 18.69 m

Width of the building „lz" = 17.074 m

Height of the building „h" = 21.0 m

Ta = 0.09h/d^0.5

Zone factor Z = 0.1 ((Page 16 of 1893-2002)

X-DIRECTION

T = 0.09h/d2 = 0.09 x 21/18.69 Sq. Root

Px = 0.101 sec

Z-DIRECTION

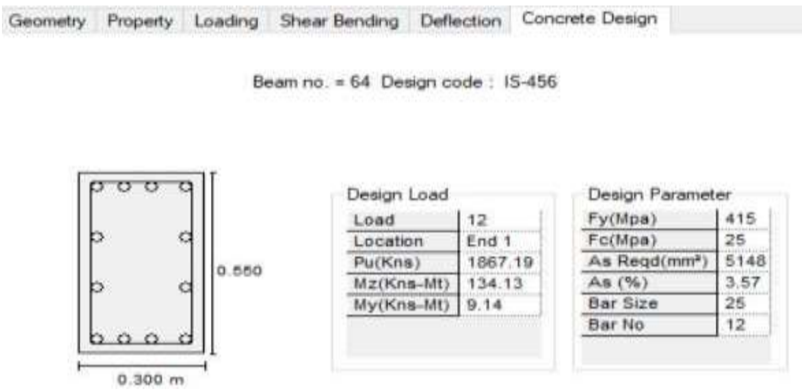
$T = 0.09h/d2$

= 0.09 x 21/17.074 Sq. Root
Pz = 0.11 sec

Response reduction factor R = 3.0 (Page 23 of 1893-2002)
Px = 0101
Pz = 0.110
Importance factor I = 1.0 (Table 6 of 6.4.2)
Soil interaction factor SS = 2.0 For Medium soil
Self- weight -1(As per Code) Member weight -18.5Kn/m2

DESIGN CONSTANTS

Using M25 and Fe 415 grade of concrete and steel for beams, slabs, footings, columns
Therefore: -
Fck= characteristic strength for M25 N/mm2
Fy= Characteristic strength of steel – 415N/mm2



V. RESULT AND DISCUSSION

The results obtained are as discussed below

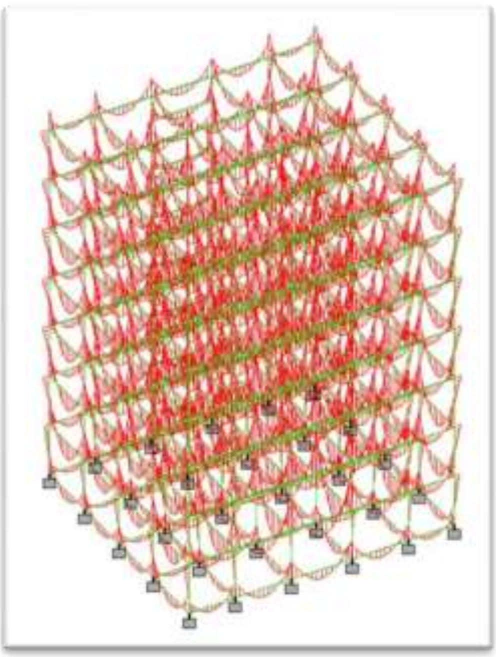
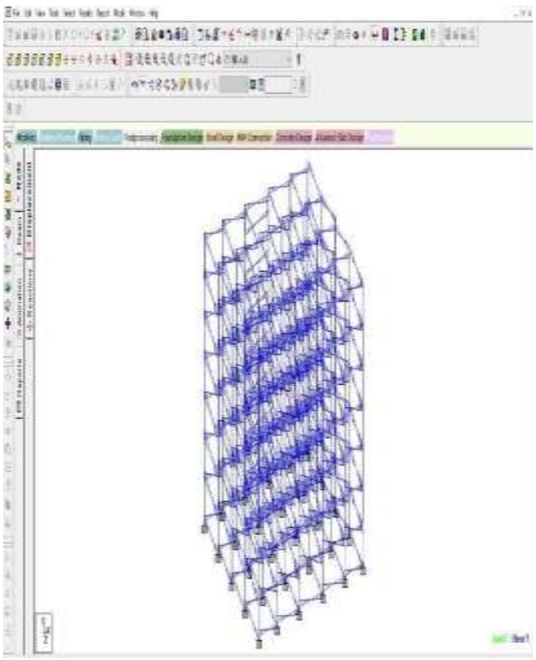


Fig5: Bending moment Diagram



B E A M N O. 1 D E S I G N R E S U L T S
M25 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3230.0 mm SIZE: 300.0 mm X 400.0 mm COVER: 25.0 mm
SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 807.5 mm 1615.0 mm 2422.5 mm 3230.0 mm

TOP 245.78 0.00 0.00 0.00 245.78
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

BOTTOM 0.00 227.35 227.35 227.35 0.00
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

Fig6: Shear Force Diagram

SUMMARY OF PROVIDED REINF. AREA

SECTION 0.0 mm 807.5 mm 1615.0 mm 2422.5 mm 3230.0 mm

TOP 4-10í 3-10í 3-10í 3-10í 4-10í
REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

BOTTOM 3-10í 3-10í 3-10í 3-10í 3-10í
REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

SHEAR 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í
REINF. @ 275 mm c/c @ 275 mm c/c @ 275 mm c/c @ 275 mm c/c @ 275 mm c/c

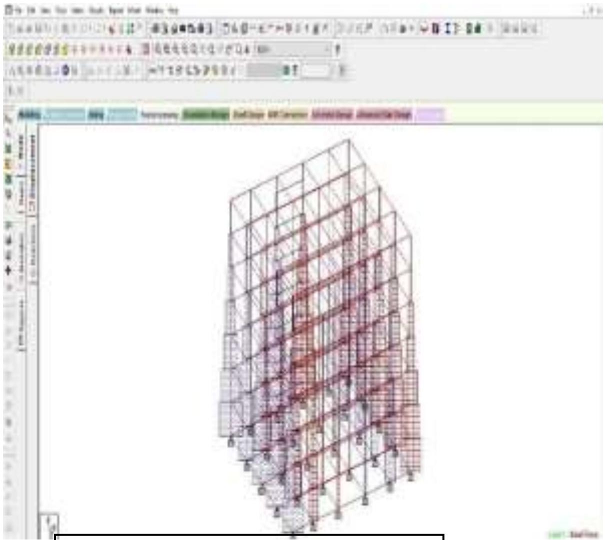


Fig7: Axial Load ON Building

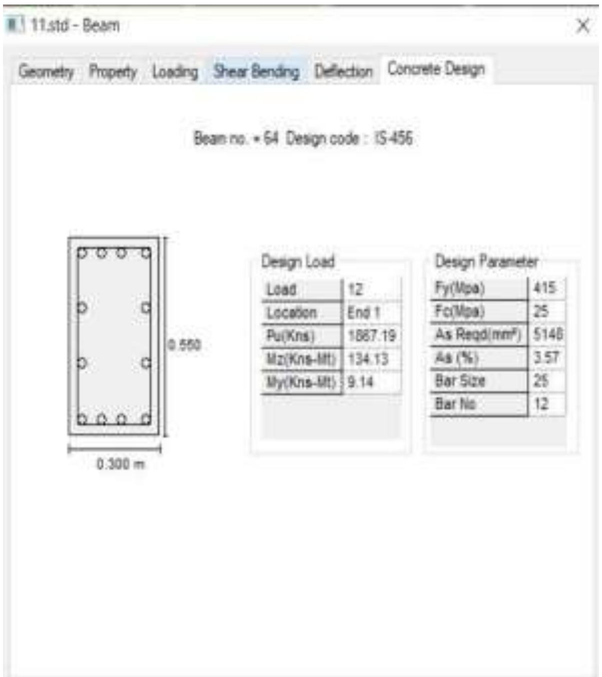


Fig8: Column Reinforcement detailing

C O L U M N NO. 64 D E S I G N R E S U L T S

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3000.0 mm CROSS SECTION: 550.0 mm X 300.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 12 END JOINT: 15 SHORT COLUMN

REQD. STEEL AREA : 5148.00 Sq.mm.
REQD. CONCRETE AREA: 159852.00 Sq.mm.
MAIN REINFORCEMENT : Provide 12 - 25 dia. (3.57%, 5890.49 Sq.mm.)
(Equally distributed)
TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 3400.65 Muz1 : 139.67 Muy1 : 300.31

INTERACTION RATIO: 0.99 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 12
END JOINT: 15 Puz : 3623.40 Muz : 154.43 Muy : 343.17 IR: 0.85

VI. CONCLUSION

Short term deflection of all horizontal members is within 20mm.The structural components of the building are safe in shear and flexure.Amount of steel provided for the structure is economic.Proposed sizes of the elements can be used in the structureSTAAD PRO has the capability to calculate the reinforcement needed for any concrete section.

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