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Seismic Analysis and Design of G+7 Residential Building Using STAADPRO

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Abstract: ***Structural designing requires structural analysis and earthquake or seismic analysis of any structure prior to construction. Earthquake or seismic analysis is the calculation of the response of a structure subjected to earthquake excitation. Various seismic data are necessary to carry out the seismic analysis of the structures in this study the seismic response of the structures is investigated under earthquake excitation expressed in the form of member forces, joint displacement, support reaction and story drift. The response is investigated for g+7 building structures by using STAAD PRO designing software. We observed the response reduction of cases Ordinary moment resisting frame. In this case, we have taken earthquake zone 2, response factor 3 for Ordinary moment resisting frame and importance factor 1. Initially, we started with the designing of simple 2-dimensional frames and manually checked the accuracy of the software with our results. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for G+7 residential building RCC frames. The minimum requirements pertaining(Be appropriate) to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads. In order to be able to prevent or to minimize the occurrence of cracks, it is necessary to understand basic causes of cracking and to have knowledge about certain properties of building materials, the specification for mortar and concrete, the Architectural design of building, structural design, foundation design, construction practices & techniques and environments.***

Keywords: Seismic Analysis, Earthquake Excitation, Ordinary Moment Resisting Frame, Member Forces, Joint Displacement, Support Reaction, Storey Drift, Staad Pro V8i.

INTRODUCTION

1.0. GENERAL

The earthquake causes vibratory ground motions at the base of the structure, and the structure actively responds to these motions. In design system, it is customary to assume the structure as a fixed base system acted upon by inertia forces. Seismic design involves two distinct steps:

a) Determining or estimating the structure forces that will act on the structure
b) Designing the structure to provide adequate strength, stiffness, and energy dissipation capabilities to withstand these forces.

1.0.1. MOTIVATION

Day to day variations in the designing of the structures we were motivated to deal with this project. As civil engineering is much concerned with different designs to meet the necessity of human life we took this project.

1.1. OBJECTIVES OF PROJECT

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.

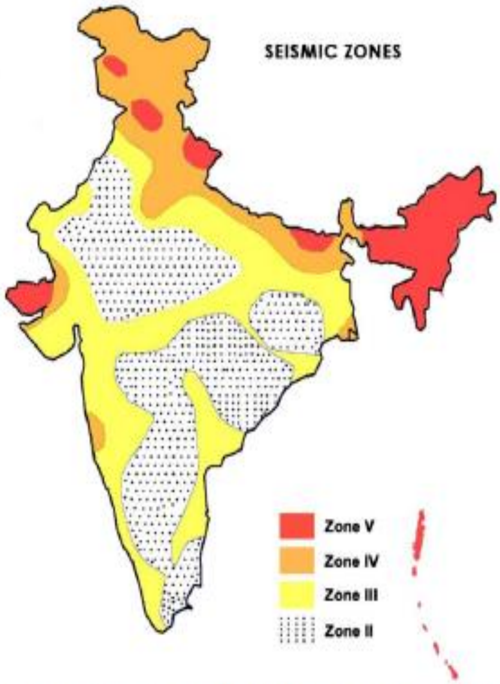
LIMITATIONS OF PROJECT

- Depending on the site area the number of floors is limited.

- Designing is completely based on IRC codes.
- If once the structure is designed for one purpose it cannot be used for another purpose if the load acting on it is increased than the designed.

2.1 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 earthquake-proof 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) – 2007.



'igure 2.1: *Sketch of Seismic Zone Map of India:* sketch based on the seismic zone of India map given in IS:1893 (Part 1) - 2007

ANALYSIS OF G+7 BUILDING

3.1. IS 1893:2002 CODAL PROVISIONS

3.1.1. DYNAMIC ANALYSIS

Dynamic analysis 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.

3.1.2 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. (S_a/g) taken as per IS 1893 (Part 1): 2002 is as follows, which is considered for designing the structure.

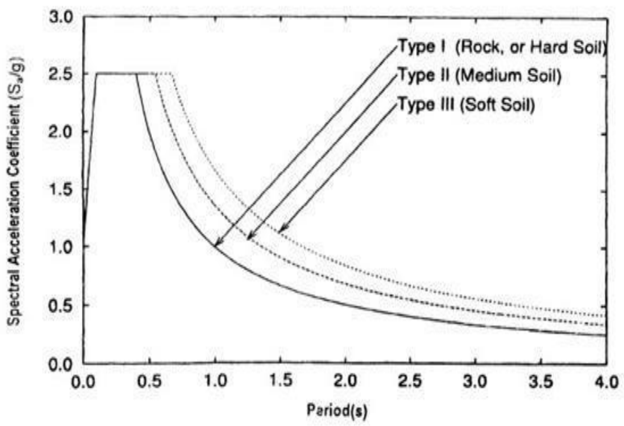


Fig. 3.0- Response Spectra for rock and soil sites for 5% damping

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.

STATEMENT OF THE PROJECT

- Live Load: 2.0 KN/Sq.m
- Thickness of slab: 120 mm
- Location of the site: Hyderabad in Seismic Zone-II
- Type of Soil: Medium Soil, (Type-II as per IS: 1893 (Part-1))
- Allowable bearing pressure: 150 KN/Sq.m
- Each Storey Height: 3 m
- No of Floors: Ground+7
- External Wall Thickness: 230 mm
- Internal Wall Thickness: 120 mm
- Column Size: 300x420 mm
- Beam Size: 300x450 mm
- Wind Load: As per IS: 875-1987 (Part-3)
- Earthquake Load: As Per IS: 1893-2002 (Part-1)

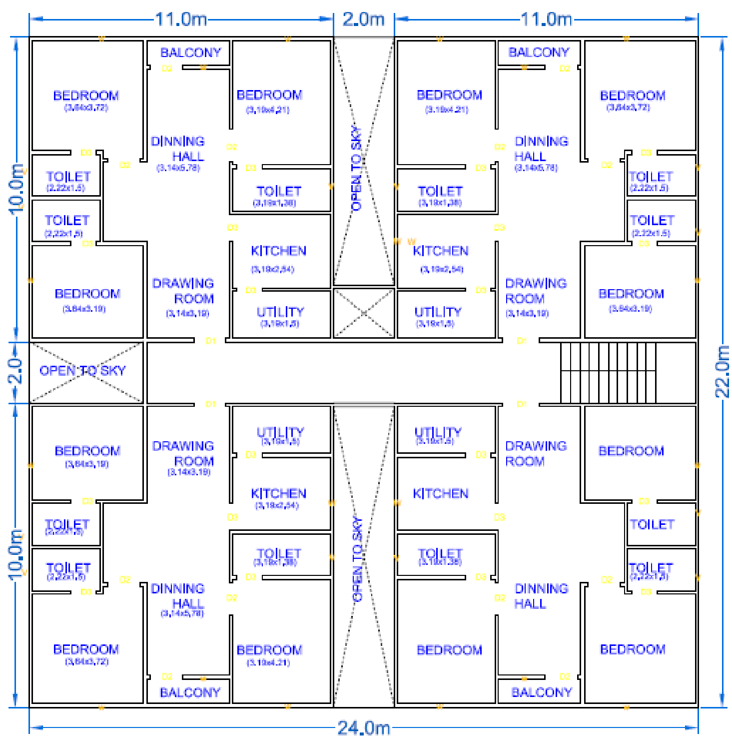


Fig.3.0.1.Typical Plan View of G+7 Residential Building.

3.2 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 equipments and fittings.

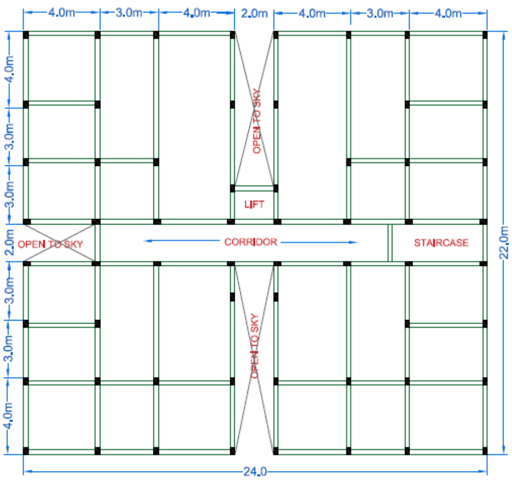


Fig.3.2. Typical Beam and Column Layout

RC PROPERY

- Column Size: 300x420 mm
- Beam Size: 300x450 mm

a) LOAD CALCULATIONS

SELF - WEIGHT OF SLAB LOAD:

Floor loads for 120mm thick slab

Thickness of slab -120mm

Unit weight of reinforced concrete - 25.00kn/m3

= 0.12 x 1x 25

= 3.0 KN/m^2

Dead load of slab = 3.0kn/m^2

Floor finishes = 1.50kn/ m^2

= 3.0 x 1. 5

= 4.5 KN/m^2

Roof Finishing: 1.0 KN/Sq.m

Total load of slab = 8.5kn/ m^2

b) SELF-WEIGHT OF BEAM LOAD:

Beam Size- 300x450mm

Unit weight of reinforced concrete - 25.00kn/m3

= 0.3 x 0.45 x 25

= 3.375Kn/m^3

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 - 19.2kN/m3

= 0.23 x 3.0 x 19.2

Total load h*b* γ = -13.248 kN/m^3

INTERNAL OR PARTITION WALLS

150mm thick wall for height 3.0m

Thickness of wall 'b' - 0.12m

Height of walls 'h' - 3.0m

Unit weight of brick masonry 'γ' - 19.2kN/m^3

= 0.12 x 3.0 x 19.2

Total load h*b* γ = -6.912 kN/m^3

PARAPET & BALCONY WALL LOAD

Thickness of wall 'b' - 0.115m
Parapet wall 'h' - 1.00m
Unit weight of brick masonry 'γ' - 19.20kn/m3
= 0.115 x 1 x 19.2
Total load h*b* γ = 2.208 kn/m^3

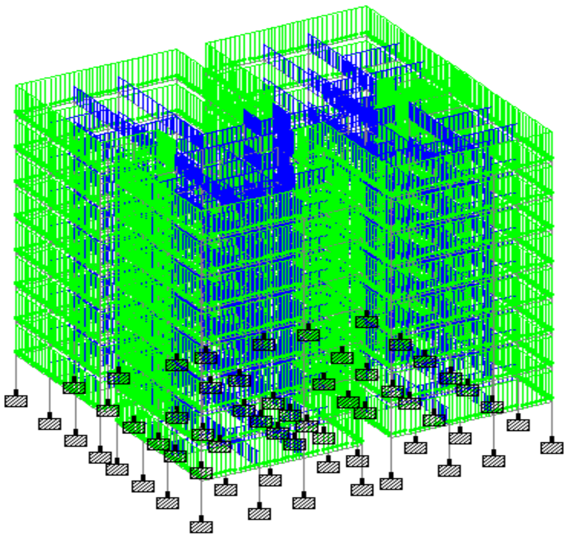


Fig. Dead Load of G+7 Building

2. LIVE LOADS (OR) IMPOSED LOADS

These are the loads that change with time. Live loads or imposed loads include loads due to the people 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)

Patient rooms	4.000kn/ m^2
Staircase, corridor	3.000kn/ m^2
Terrace, portico	2.000kn/ m^2

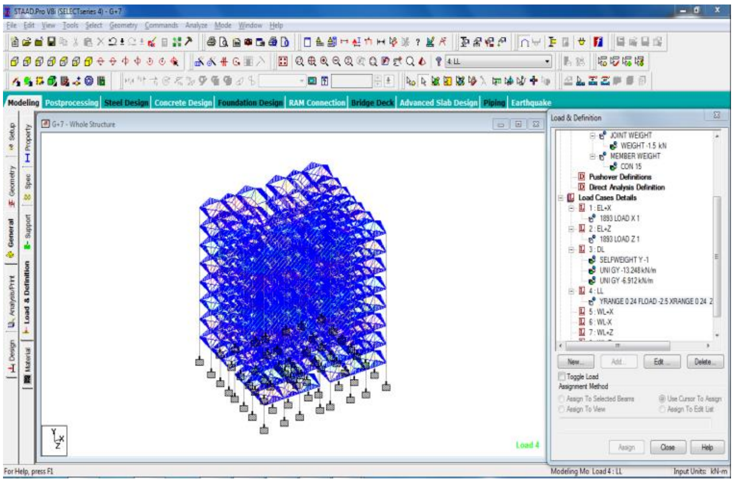


Fig. Live Load On G+ Building

3. 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 $V_z = V_b \times K_1 \times K_2 \times K_3$

Where

V_b- Design Wind Speed

K_1- Probability factor

K_2 – Terrain factor
K_3- Topography Factor
Exposure factor is -1.0 (As per code)

4. EARTHQUAKE FORCES

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

SESMIC LOAD CALCULATIONS

Area = Hyderabad
Zone = II
Length of the building 'lx' = 22.0 m
Width of the building 'lz' = 22.0 m
Height of the building 'h' = 24.0 m
T_a = $0.09h/d^{0.5}$
Zone factor Z = 0.1 ((Page 16 of 1893-2002)

X-DIRECTION

T = $0.09h/d^2$
= 0.09 x 24/22 Sq. Root
= 0.945/12.649
Px = 0.099 sec

Z-DIRECTION

T = $0.09h/d^2$
= 0.09 x 24/22 Sq. Root
= 0.945/8.30
Pz = 0.11sec

Response reduction factor R = 3.0 (Page 23 of 1893-2002)
Px = 0.099
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/m^2

DESIGN CONSTANTS

Using M20 and Fe 415 grade of concrete and steel for beams, slabs, footings, columns
Therefore: -
Fck= characteristic strength for M20 N/mm^2
Fy= Characteristic strength of steel – 415N/mm^2

5. SNOW LOADS

For buildings to be located in the regions where snow is likely to fall, snow load is to be considered IS 875(part-4)-1987 deals with the snow loads on roofs of the buildings.

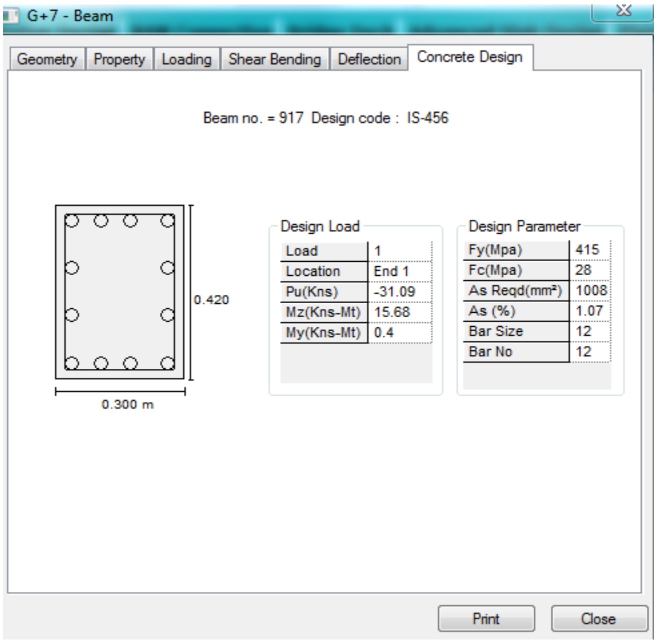


Fig. Column Design Detailing

RESULTS

As per the consideration, the area taken is Hyderabad zone-II, by the calculations the values obtained are Period in X=0.098sec and Period in Y=0.11sec.

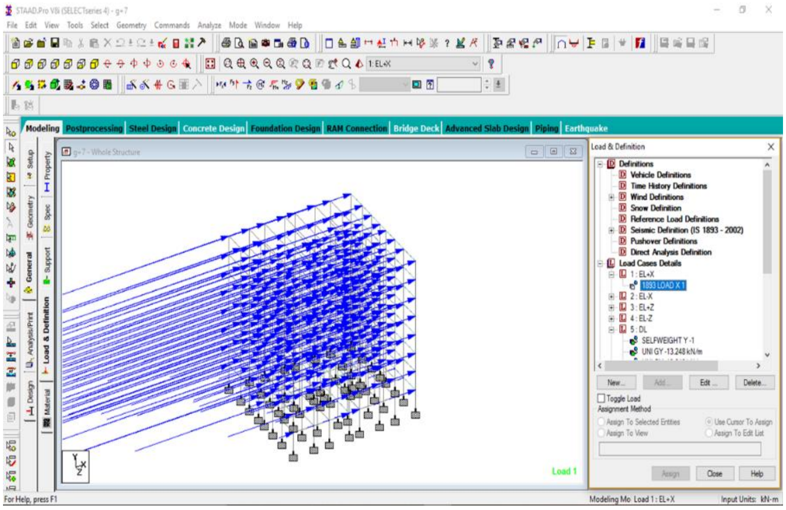


Fig.6.2. Earthquake Load in (+X Direction)

CONCLUSION

- In the earthquake resistant design of G+7 RC framed building the steel quantity increased by 1.517% to the convention concrete design. The steel quantity increased in the structure ground floor to higher floor i.e G+7 level of the structure.
- In this study of the G+7 building, seismic load dominates the wind load under the seismic zone –II. Basically, the wind pressure is high for high rise building based on weather conditions such as coastal areas, hilly stations. For Building prominently seismic forces create the major cause of damage to the structure.
- The Storey drift condition for considered G+7 building, the base drift=0.0 at every story. This says that the structure is safe under drift condition. Hence shear walls, braced columns are not necessary to be provided. Hence story drift condition is checked for the G+7 building.

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- THEORY OF STRUCTURES: B.C.PUNMIA
- DESIGN OF SLABS: Dr.G.P.CHANDRADHARA
-

IS CODE BOOKS REFERRED:

- IS RCC CODE 456-2000
- IS CODE 4326 (part-I)-1993 EARTHQUAKE RESISTANCE
- IS CODE OF DESIGN STRENGTH 1566
- IS CODE OF MILD STEEL 432-1982(part-1)
- IS CODE OF HYSD 1786-1985
- IS CODE OF LOADS 875 (part-2)-1987

