SEISMIC ANALYSIS OF G+7 RC BUILDING USING NON-CONVENTIONAL SIZE OF COLUMN AND BEAM TO REDUCE THE DEFLECTION BY STAAD.Pro

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Abstract: The earthquake is a nature phenomenon which can generate the most destructive forces on structure. Therefore, building should be safe for lives by proper design and detailing of structural members in order to have a ductile form a failure, so structure in well-being against seismic power of multistoried working. There is need of seismic examination study and planning to earthquake protection structure.
The goal of seismic resistance construction is to erect structures that fare better during seismic activity than their conventional counterparts. The project report comprises of seismic analysis and design of G+7 RC building. A G+7 storied structure for the seismic investigation and it is situated in zone-III district in India (MP,Indore). The present project deals with seismic analysis of multistoried residential building G+7 by using conventional & non-conventional size of column and beam to reduce the deflection by STAAD.Pro. The dead load and live load & seismic load applied and design for beam, column, slab and footing are obtained. Total structure was analyzed by computer by using STAAD-PRO software. Various software now-a-day are available & STAAD-PRO is most common used for analysis and designing of a building by considering the earthquake forces and to review & study the behavior of multistoried building by Equivalent Static Lateral Force Method.
Keywords: STAAD-Pro, Residential building, Seismic Analysis, Design, load, assign, property, bending moment and axial force.

1. INTRODUCTION

Day-by-day increase in population growth in cities of India for several acceptable reasons and deficiency of land area so that there is a requirement of design and seismic analysis of multi storied building before construction work starts. Multi storied buildings are designed for the basic need of people. These buildings are the shelter for all the human beings and help grown up the infrastructure to the city. So, we need a residential building to serve the people. The main object of the project is to modify the general design of multi storied building with seismic effect. Seismology is the study of vibration of earth mainly caused by earthquakes and seismic waves that move through and around the earth.

A seismic design of high-rise building has assumed considerable important in recent times. In traditional method adopted based on fundamental mode of the structure and distribution of earthquake forces as static forces at various stories may be adequate for structure of small height subjected to earthquake of very low intensity but as the number of the stories increases the seismic design demand more rigorous.

1.1 history of how earthquake resistance building is design

The history of earthquake-resistant building design evolved as a response to the destructive impact of earthquakes. Ancient civilizations inadvertently incorporated flexible construction techniques. In the 20th century, the understanding of seismic forces improved, leading to base isolation techniques, damping systems, and the use of reinforced concrete and steel structures. Building codes were established to regulate seismic design. Recent advancements in technology and materials continue to refine earthquake-resistant strategies, making structures more resilient to seismic hazards.

1.2 Introduction to STAAD-Pro

Our paper involves analysis and design of multistoried (7-story) using a worldwide most common used designing software STAAD-Pro.

i. Advantages of STAAD-Pro:

- Confirmation with Indian standard Codes,
- Versatile nature of solving any type of problem,

- Easy to use interface,
- Accuracy of the solution.

ii. Features:

- STAAD-Pro features a user interface, visualization tools, powerful analysis and design appliance with advanced limited element and dynamic analysis efficiency.
- From model generation, analysis and design to output visualization and result verification, STAAD-Pro is the specialist's best choice for-concrete, steel, aluminum, timber and cold-formed steel design of low and high-raised multistoried buildings, culverts, petrochemical plants, tunnels, bridge, piles and much more.

1.3 Getting Started

In this paper, methodology of structural analysis and design on STAAD-Pro and step by step procedure of has been explained with the help of diagrams. Further, load calculations have been explained in depth/thickness and manual seismic load calculations have also been included in this paper.

2. OBJECTIVES

- The main objective is to estimate and check seismic response of building and analyze & design it on that basis of using conventional and non-conventional size of beam and column and to reduce the deflection using STAADPro software.
- Design and seismic analysis of multistoried building before construction work using STAAD-Pro Software using.
- Modeling of 7-storey building and application of different loads on STAAD-Pro, load calculations due to different loading combinations, analysis and design of structure on STAAD-Pro.

3. METHODOLOGY

Our project has focused on enhancing the structural integrity of the building to withstand seismic forces efficiently. By employing non-conventional sizes of columns and beams, you've managed to significantly reduce deflection, as well as displacement of beams, node displacement, and bearing end forces. This indicates a thorough consideration of various aspects of structural behavior under seismic loading.Utilizing STAADpro for modeling and analysis adds another layer of assurance regarding the building's ability to resist seismic loads effectively.Furthermore, the recognition that buildings may still deflect under seismic loading, but with enough time for people to evacuate safely, demonstrates a commitment to ensuring the safety of occupants, which aligns with the primary objective of your project. This proactive approach to safety is commendable and reflects a comprehensive understanding of structural dynamics and human safety considerations.

a) 1st building

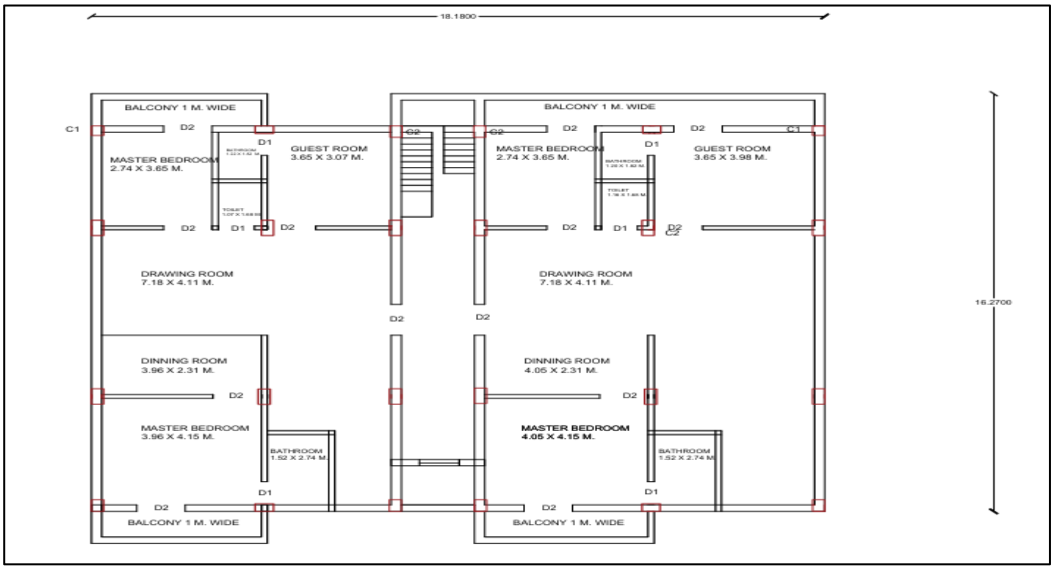

Figure No. 1.1: Typical Plan of building having conventional sizes of column and beam

b) 2nd building

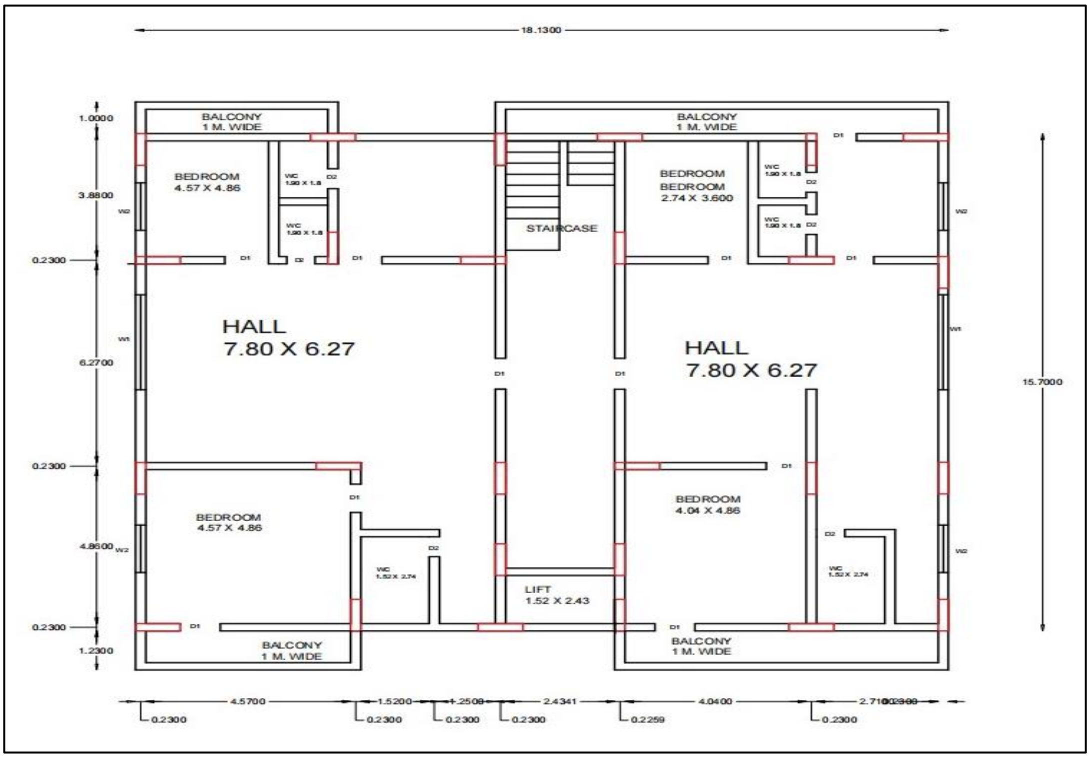

Figure No. 1.2: Typical Plan of building having conventional sizes of column and beam

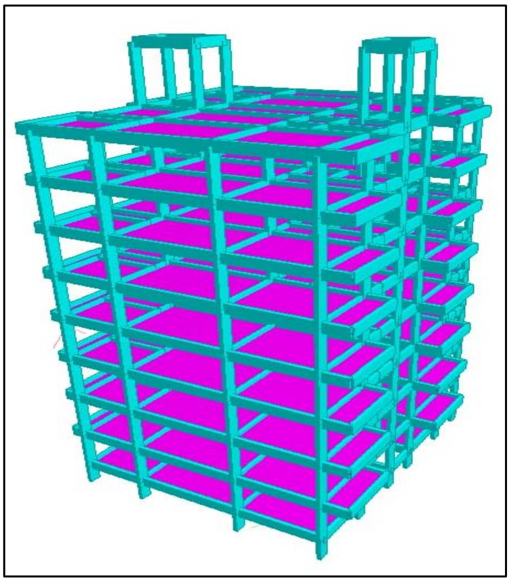

Figure No. 2.1: 3D Modal Of 1st Building

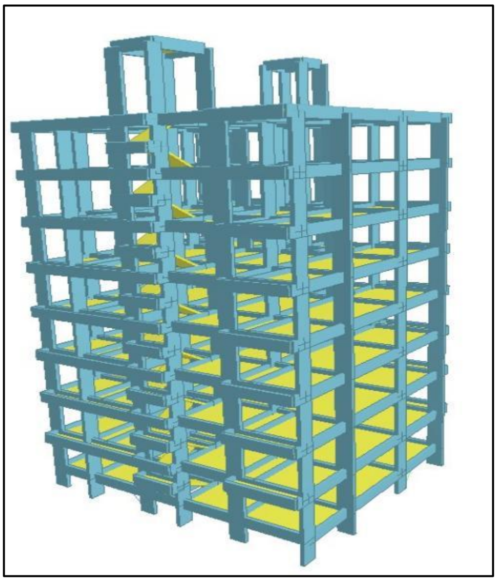

Figure No.2.2: 3D Modal Of 2nd Building

3.1 Details of building

- Live Load: 3.0 kN/m^2
- Thickness of slab: 150 mm
- Seismic zone: 3(Moderate zone)
- Location of the site: Indore, Madhya Pradesh
- Type of Soil: Medium Soil, (Type-II as per IS: 1893 (Part-1))
- Each Storey Height: 3.35 m

- No of Floors: Ground+7
- Compressive strength of concrete = 25000kN/m^2
- Yield strength of shear reinforcement = 415000 kN/m^2
- Maximum % of longitudinal reinforcement allowed = 2.5
- Carpet area = 17.68 x 15.24 m
- Plinth beam = 230 x 300 mm
- Earthquake Load: As Per IS: 1893-2002 (Part-1)

1st building :
Inner column size = 300 x 600 mm
2no.'s of corner column = 0.3 x 0.375mm
Column size = 300 x 450 mm
Secondary beam (cantilever and interior beam) = 200 x 300 mm

2nd building :
Beam size = 230 x 700 mm
Column size = 230 x 1000mm

3.2 Loads
The reinforced concrete structures are designed to resist the following types of loads.
- Live load
- Dead load
- Earthquake load

3.3 Manual calculation
Calculation of LL:
LL on typical slab = 2 kN/m²
LL on terrace (Roof) slab = 1.5 kN/m² (Accessible), 0.75 kN/m² (Inaccessible)
LL on Staircase = 3 kN/m²
Therefore, LL on mid-landing beams = $w \times \frac{L}{2} = \frac{3 \times 5.62}{2}$ = 8.46 kN/m
Calculation of Water tank load
Assume per capita demand = 200 liter/day
Assume 5 persons in each flat
Therefore, water required per flat = 200 x 5 = 1000 liter/day.
Number of flats = 14
Therefore,
Total capacity of tank required = 14 x 1000 = 14000 liter = 140 kN
Area of slab supporting water tank = 2.74 m x 3.81 m
Water tank load = 140 2.74 x 3.81 = 13.41 kN/m²,
Hence assume 15 kN/m².
Calculation of Staircase loads
i. Waist slab (150 mm to 175 mm thick) = 0.120 x 25 = 3 kN/m²
ii. Steps load (R = 180 mm; T = 300 mm) = 1/2 x 0.180 x 0.300 x 25 = 0.675 kN/m²
iii. FF = 2 kN/m²
Total load = 3+0.675 + 2 = 5.675 kN/m²
UDL on mid-landing beams = W ×L/2 = 5.675 x 5.64/2 = 16.0035 kN/m
Calculation of Lift Load
For a lift machine room above the roof of a multi-story building, we may consider an imposed load of 10 kN/m². Assuming an impact allowance of 50%, this will result in 15 kN/m².

3.3.1 First building manual calculation
(Building with conventional sizes of beam and column)
Calculation of DL:
1. Self-weight
(Volume of element x density)
Self-weight of total column = 2815.25 kN
Self-weight of total beam = 5314.2 kN
2. Wall Load

UDL on beams (in kN/m) = (ht. of wall - Overall depth of beam) x thickness of wall x 20
Thickness of exterior walls = 0.230 m
Thickness of interior wall = 0.115 m
Height of wall = 3.35 m
Size of beams = 0.230m x 0.450m
UDL on exterior beams = (3.35-0.450) x 0.230 x 20 = 13.34 kN/m
UDL on interior beams = (3.35-0.450) x 0.115 x 20 = 6.67 kN/m
UDL on terrace floor beams due to parapet wall of 1m height = 1 x 0.230 x 20 = 4.6 kN/m

3. Slab Load

Typical slab:
FF = 2 kN/m² (1 to 2)
Assume slab of 150 mm thickness
Therefore, self-weight of slab = 0.150 x 25 = 3.75 kN/m²
Total = 2 + 3.75 = 5.75 kN/m²
Terrace slab:
FF + Water proofing = 2 + 0.75 = 2.75 kN/m²
Total = 2.75 +3.75 = 6.5 kN/m²

Equivalent Static Method:

VB = Ah × W
VB = Design Base Shear
W = Seismic Weight
W = DL + 0.25 LL for LL ≤ 3 kN/m² = DL + 0.5 LL for LL > 3 kN/m²
Ah = Horizontal Acceleration Coefficient

$$Ah = \frac{Z}{2} x \frac{I}{R} x \frac{Sa}{g}$$

Z = Zone factor (Table 3, IS 1893 Part 1: 2016) = 0.16
I = Importance factor (Table 8, IS 1893 Part 1: 2016) = 1.2
R = Response Reduction factor (Table 9, IS 1893 Part 1: 2016) = 3

$\text{Tx} = \frac{0.09 \times h}{\sqrt{dx}} = \frac{0.09 \times 26.665}{\sqrt{17.4374}} = 0.567$ sec

$\text{Tz} = \frac{0.09 \times h}{\sqrt{dy}} = \frac{0.09 \times 26.665}{\sqrt{14.859}} = 0.610$ sec

$(Sa/g)x = \frac{1.36}{Tx} = \frac{1.36}{0.567} = 2.398$

$(Sa/g)z = \frac{1.36}{Tz} = \frac{1.36}{0.610} = 2.229$

$(Ah)x = \frac{0.16}{z} \times \frac{1}{5} \times 2.398 = 0.0383$

$(Ah)z = \frac{0.16}{z} \times \frac{1}{5} \times 2.229 = 0.0356$

Total DL = 38399.06 kN (From STAAD Output)
Total LL = 4881.01 kN
W = DL + 0.25×LL = 38399.06 + 0.25 × 4881.06 = 39619.325 kN
(VB)x = 0.038×39619.325 = 1505.53 kN
(VB)z = 0.035×39619.325 = 1386.67 kN

3.3.2 Second building manual calculation

(Building with non-conventional sizes of column and beam)

Calculation of DL:

1. Self-weight

(Volume of element x density)

Self-weight of total column = 4379.7 kN

Self-weight of total beam = 874.7065 kN

2. Wall Load

UDL on beams (in kN/m) = (ht. of wall - Overall depth of beam) x thickness of wall x 20

Thickness of exterior walls = 0.230 m
Height of wall = 3.35 m
Size of beams = 0.23m x 0.700m
UDL on exterior beams = (3.35-0.700) x 0.23 x 20 = 12.19 kN/m
UDL on terrace floor beams due to parapet wall of 1m height = 1 x 0.230 x 20 = 4.6 kN/m

3. Slab Load

Typical slab:
FF = 2 kN/m² (1 to 2)
Assume slab of 150 mm thickness
Therefore, self-weight of slab = 0.150 x 25 = 3.75 kN/m²
Total = 2 + 3.75 = 5.75 kN/m²
Terrace slab:
FF + Water proofing = 2 + 0.75 = 2.75 kN/m²
Total = 2.75 +3.75 = 6.5 kN/m²

Equivalent Static Method:

VB = Ah x W
VB = Design Base Shear
W = Seismic Weight
W = DL + 0.25 LL for LL≤ 3 KN/m² = DL + 0.5 LL for LL > 3 kN/m²
Ah = Horizontal Acceleration Coefficient
Ah= $\frac{Z}{2}$ x $\frac{I}{R}$ x $\frac{Sa}{g}$
Z = Zone factor (Table 3, IS 1893 Part 1: 2016) = 0.16
I = Importance factor (Table 8, IS 1893 Part 1: 2016) = 1.2
R = Response Reduction factor (Table 9, IS 1893 Part 1: 2016) = 3
Tx = $\frac{0.09\times h}{\sqrt{dx}} = \frac{0.09 \times 26.665}{\sqrt{17.4374}}$ = 0.567 sec
Tz = $\frac{0.09\times h}{\sqrt{dy}} = \frac{0.09\times 26.665}{\sqrt{14.859}}$ = 0.610 sec
(Sa/g)x = $\frac{1.36}{Tx} = \frac{1.36}{0.567}$ = 2.438
(Sa/g)z = $\frac{1.36}{Tz} = \frac{1.36}{0.610}$ = 2.229
(Ah)x = $\frac{0.16}{2}$ x $\frac{1}{5}$ x 2.438 = 0.0383
(Ah)z = $\frac{0.16}{2}$ x $\frac{1}{5}$ x 2.229 = 0.0356
Total DL = 38399.06 kN (From STAAD Output)
Total LL = 4881.01 kN
W = DL + 0.25LL = 38399.06 + 0.25 x 4881.06 = 39619.325 kN
(VB)x = 0.038 x 39619.325 = 1505.53 kN
(VB)z = 0.035 x 39619.325 = 1386.67 kN

4. RESULT AND DISCUSSION

We compare the results of both buildings in terms of deflection, displacement, shear force, bending moment. We got the results on STAAD.Pro output as follows,

i. Max. displacement occurs on terrace floor beams no. 76,77,78 inconsideration got the results with respect to beam are 0.158m, 0.145m, 0.313m of building having conventional sizes of column and beam, also results with respect to beam are 0135m, 0.135m, 0.136m.

ii. Max, deflection occurs on the terrace column no. 71,72,73,74. 78 inconsideration got the results with respect to column are 0.158m, 0.145, 0.131m, 0.128m of building having conventional sizes of column and beam, also results with respect to 0.135m,0.135m,0.135m,0.136m.

iii. Result of shear force and bending of critical forms building having conventional sizes of column and beam are as follows:

Max. axial shear force (Fx) are 4569.853kN. Max. shear force in Y axis (Fy) are 598.77kN

Max. shear force Z axis (Fz) are 379.801kN.

Max. axial bending moment (Mx) are 95.377kN-m,Max. shear force in Y axis (My) are 278.188kN-m

iv. Max. shear force Z axis (Fz) are 531.7441kN-m.

Result of shear force and bending of critical forms form building having non-conventional sizes of column and beam are as follows:

Max. axial shear force (Fx) are 8169.879kN. Max. shear force in Y axis (Fy) are 516.992kN

Max. shear force Z axis (Fz) are 443.893kN.

Max. axial bending moment (Mx) are 163.901kN-m,Max. shear force in Y axis (My) are 756.436kN-m, Max. shear force Z axis (Fz) are 830.802kN-m

5. CONCLUSION

To conclude, that we achieved a building design that exhibits reduced deflection and displacement compared to the initial structure. We have reduce maximum percentage deviation up to 69% on the basis of displacement and in deflection we got reduction up to 45% maximum with respect to building having conventional sizes of column and beam.

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