Seismic Performance Evaluation of Hospital Building (G+5) Analysis and Comparison by Changing the Size of Rectangular Column and Beam Using STAAD Pro.

Ashish Thapak[1], Kamlesh Kumar Choudhary[2]

[1]*M. Tech Scholar,* [2]*Professor*

[1,2]*Saraswati Institute of Engineering & Technology, Jabalpur, India*

Abstract: Structural design is the primary aspect of civil engineering. The foremost basic in structural engineering is the design of simple basic components and members of building viz., slabs, beams, columns and footings. The first step in any design is to decide the plan of the particular building. The location of beams and columns are decided [8]. Then the vertical loads like dead and live loads are calculated. Once the loads are obtained, the component which takes the load first i.e. the slabs can be designed. From the slabs, the loads are transferred to the beams. The loads coming from the slabs onto the beam may be trapezoidal or triangular. Depending on this, the beam may be designed. The loads (mainly shear) from the beams are then transferred to the columns. For designing columns, it is necessary to know the moments they are subjected to. For this purpose, frame analysis is done by Moment Distribution Method [1]. Most of the columns designed in this project were considered to be axially loaded with uniaxial bending. Finally, the footings are designed based on the loading from the column and also the soil bearing capacity value for that particular area. All component parts are checked for strength and stability. The building was initially designed as per IS 456: 2000[11] without considering earthquake loads using STAAD.pro software [2]. Then the building was analyzed for earthquake loads as per Equivalent static analysis method and after obtaining the base shear as per IS1893: 2016.

Keywords: STAAD.pro, IS1893:2016, slabs, beams, columns and footings, seismic analysis, Equivalent static analysis, (G+5) story RC buildings.

I. INTRODUCTION

Earthquake is the result of a sudden release of energy in the earth's crust that creates seismic waves. The seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time[8,9].

Buildings are subjected to ground motion. PGA (Peak Ground Acceleration), PGV (Peak Ground Velocity), PGD (Peak Ground Displacement), Frequency Content, and Duration play predominant rule in studying the behavior of buildings under seismic loads.

The new hospital block is located at the province of Mazar-e-Sharif, Afghanistan. The total built up area of the hospital building is 611.2 square meters and has five floors (Ground floor +5). The Hospital building consists of various divisions like Ortho ward, Orthopedic ward, Ophthalmology ward, ENT ward, major and minor operation theatres, outpatient ward, seminar halls for medical students, scanning and X-ray Centre and medicine store room, etc.

Table 1 : Seismic Sources	
Natural Source	**Man-made Source**
Tectonic Earthquakes	Controlled Sources (Explosives)
Volcanic Earthquakes	Reservoir Induced Earthquakes
Rock Falls/Collapse of Cavity	Mining Induced Earthquakes
Micro seism	Cultural noise (Industry, Traffic, etc)

The building is located in seismic prone zone (zone factor III). Since hospitals are very important buildings and need to remain standing after the earthquake, the design of such buildings needs to be done as per earthquake design considerations. Account [5-6]. In this study, the seismic performances of 9- story reinforced-concrete building are evaluated and compared by the nonlinear static pushover analysis and nonlinear dynamic analysis. The present study deals with seismic analysis using Equivalent static analysis of (G+5) story RC buildings using Structural Analysis and Design (STAAD Pro.) software.

II. OBJECTIVE AND SCOPE

Since hospital is the most important place during a disaster to give humanitarian aid and medical treatment, it is important to make sure that the hospital building can withstand the earthquake. The objective of this study is to make comparisons of analysis and design of a (G+5) story hospital building. Several cases of seismic loads will be applied to the building.

Seismic analysis code for (G+5) story hospital building, Indian Standard Code (IS 1893-2002) will be used for this study [8]. The building will be designed according to the Earthquake resistant considerations.

The present study deals with an Equivalent Static Analysis of 6 story RCC hospital building using Structural Analysis and Design (STAAD Pro.) software [6].

III. METHODOLOGY

1. Review the existing literature and Indian design code provision for analysis and design of the earthquake resistant building.
2. The different types of structures are selected. The selected structures are modelled.
3. Performing linear analysis for selected building for both gravity load, and earthquake loads and then a comparative study of both is obtained from the analysis.
4. Also design the building manually for design and analysis results obtained and compare with the area of steel of the models obtained.
5. Using structural analysis and design Software ETABS and STAAD Pro and comparing both results.
6. Observation of results and discussions.

IV. STRUCTURAL MODELLING

A. Irregular RC Building

Six story regular reinforced concrete building is considered. The beam length in (x) transverse direction is 3m (four numbers), 6.75m (two numbers), and 6.25m and beams in (z) longitudinal direction are 3 x 3m (three numbers), 2m (two numbers), and 6.25m. Figure 1 shows the plan of the six story Hospital building having 7 bays in x-direction and six bays in z-direction. Story height of each building is assumed 4m. Figure 4.2 shows the frame (A-A) and (01-01) of six story RC Hospital building. Beam cross section is 300x600 mm and Column cross section is 500x500 mm.

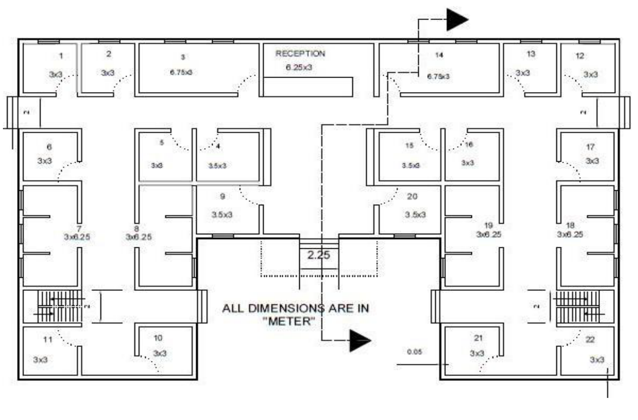

Figure 1; Plan of six- story RC building (all dimensions are in mm)

General Data

Structure = G + 5

Floor height (First Floor to Fifth Floor) = 4.0m

Grade of concrete (for all structural elements) = M-25

Unit weight of concrete = 25kN/m^3

Unit weight of cement mortar = 24kN/m^3

Unit weight of water = 10kN/m^3

Unit weight of Brick = 20kN

A slab load of 3.75 KN/m2 is considered for analysis. The wall load is taken as 20 KN/m. A floor finish load of 1.5 kN/m^2 is applied on all beams of the RC building as per IS 875 (part1). A live load of 4 KN/m2 is provided as per IS 875 (part2). Table 2 shows the gravity loads taken for the building.

Table 2: Load values for building

Dead and live loads	Value
Slab load (dead load)	3.75 kN/m^2
Wall load (dead load)	16.6 kN/m
Floor finish (dead load)	1.5 kN/m^2
Live load	4 kN/m^2

The structure is analyzed and designed for live load, seismic load as per IS-1893-2016 and dead load consisting of self-weight of beams, columns and slabs. The following figures show the different loads acting on the building.

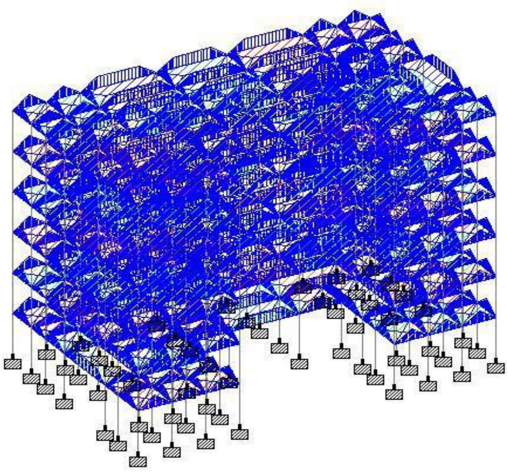

Figure 2; The live load acting on the structure

Table 3: Properties of Concrete and Steel bar as per IS 456

Properties	Concrete	Steel Bar
Unit weight	25 kN/m^3	76.33kN/m^3
Modulus of elasticity	21718.8MPa	2x105MPa
Poisson ratio	0.17	0.3
Thermal coefficient	1x10^{-5}	1.2x10^{-5}

Shear modulus	9316.95MPa	76.8195MPa
Compressive strength	25MPa	485MPa

B. Structural Elements

The six-story irregular reinforced concrete Hospital building was analyzed for gravity loads in STAAD Pro. For the comparative study, beam and column dimensions are assumed 300mm x 600mm and 500mm x 500mm. Height of the story is 4m and beam length in longitudinal direction is taken 3m, 6.75m, and 6.25m and in transverse direction is taken 3m, 2m, and 6. 25m.These dimensions and cross sections are summarized in

Table 4: Beam and column length and cross section dimension.

Structural Element	Cross section (mm x mm)	Length (m)
Beam in (x) longitudinal direction	300mm x 600mm	3m (four numbers)
		6.75m (two numbers)
		6.25m
Beam in (z) transverse direction	300mm x 600mm	3m (three numbers)
		2m (two numbers)
		6.25m
columns	500mmx 500mm	4m

C. Designing of beam

A reinforced concrete beam is designed to resist tensile, compressive and shear stresses caused by the loads on the beam. The beam is analyzed first in order to calculate bending Moment and shear force.

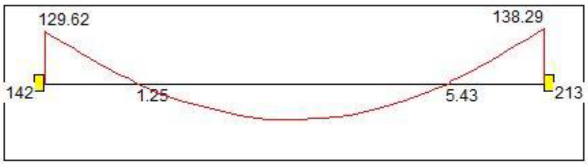

Figure 3 ; Bending moment diagram of beam No.412

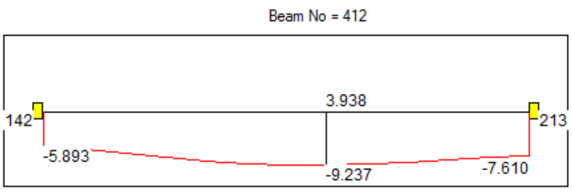

Figure 4 ; Deflection diagram of beam No.412

The breadth of the beam is taken considering the thickness of the wall and the width of the column so that effective transfer of the load from beam to column is achieved. The depth of the beam is from one-tenth to one-sixth of the length of the beam. In the present design, all beams are of rectangular shape, with breadth and depth of the beam as 300mm and 600mm respectively and total number of beams is 370.

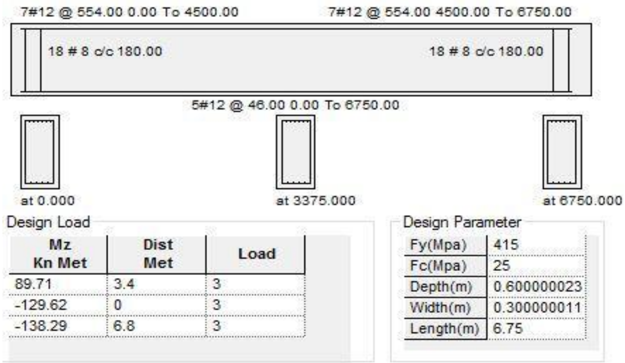

Figure 5; Reinforcement details for beam No.412 in STAAD Pro. Using design code IS- 456:2000

D. Designing of Columns

A column is a member carrying direct axial load which causes compressive stresses. All columns are designed separately. The columns are subjected to bending moment and axial loads. The column section is designed just below the beam column joint and just above the beam column joint and larger of the two reinforcements is adopted. The numbers of columns are 606. The design moment is obtained from IS456:2000 code[11].

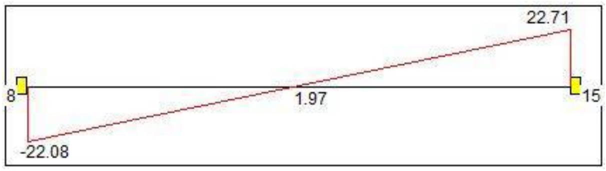

Figure 6 ; Bending moment diagram of column No. 14

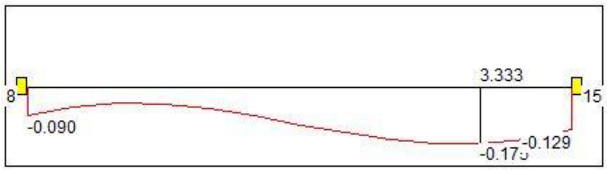

Figure 7 ; Deflection diagram of column No. 14

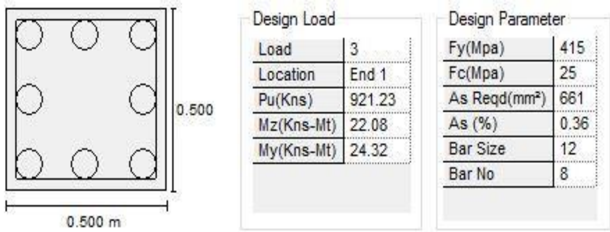

Figure 8; Reinforcement details of column No.14 in STAAD Pro. Using design code IS- 456:2000

IV SEISMIC LOAD CALCULATION

During an earthquake, ground motions are developed both horizontally and vertically in all directions and radiating from the epicenter. Due to these ground motions, the structure vibrates inducing inertial forces on them. Hence structures located in seismic zones are designed and detailed to ensure strength, serviceability and stability with acceptable levels of safety under seismic forces.

Many structures are now being suitably designed to withstand earthquakes. This can be seen from the satisfactory performance of a large number of reinforced concrete structures subject to severe earthquake in various parts of the world.

The Indian standard codes IS: 1893-1984 and IS: 13920-1993 have specified the minimum design requirements of earthquake resistant design, probability of occurrence of earthquakes, the characteristics of the structure and the foundation and the acceptable magnitude of damage.

Determination of design earthquake forces is computed by the following methods,

1) Equivalent static lateral loading.
2) Dynamic Analysis.

Table 5: Zone factor values

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.1	0.16	0.24	0.36

FOR G+5 STORY BUILDING

1) Slab load = (31.75 x19.25-13.75 x 8.125) x 0.15 x 25

Slab load = 1873 kN

2) Floor finish = (31.75 x 19.25 -13.75 x 8.125) x 1.5

Floor finish = 749 kN

3) Weight of all beams = {(4 x31.75+6 x9+1x13.75)

+6 x19.25+2 x14.25)} x0.6x0.3x25

Weight of all beams =1524.375 kN

4) Weight of Columns in floors = 64 x4 x0.5 x0.5x25

Weight of Columns in floors = 1600 kN

5) Weight of brick infill in floors = {(4 x31.75+6 x9+1x13.75)

+6 x19.25+2 x14.25)} x 4 x 0.25 x 20

Weight of brick infill in floors =6775 kN

According to IS1893-2016 if the live load is up to and including 3KN/m^2, the percentage of live load is 25% and more than 3KN/m2, then 50% of it will be lumped on floors.

Live load in a typical floor = (31.75x19.25-13.75 x 8.125)

x 4 x 0.5

Live load in a typical floor = 999 kN

The live load is taken zero at roof.

Seismic weight calculation of the structure,

W=W1+W2+W3+W4+W5+W6

W1, W2, W3, W4 and W5

are the seismic weights respectively.

Table 6: Calculation of Seismic of weight of G+5 story building

i	Wi (KN)	Wi (KN)
1	1873+749+1524.375+1600+6775+999	13520.38
2	1873+749+1524.375+1600+6775+999	13520.38
3	1873+749+1524.375+1600+6775+999	13520.38
4	1873+749+1524.375+1600+6775+999	13520.38
5	1873+749+1524.375+1600+6775+999	13520.38
6	1873+749+1524.375+(1600/2)+(6775/2)	8333.875
	Σ	75935.75

Seismic weight is found to be equal to 75935.75 kN

The result below is after analyzing by using Staad Pro.

Table 6 shows the base shear in Tx and Tz

```
************************************************************
*                                                          *
* TIME PERIOD FOR X 1893 LOADING =     0.38300 SEC         *
* SA/G PER 1893=     2.500, LOAD FACTOR= 1.000             *
* VB PER 1893=    0.0600 X     74365.16=     4461.91 KN    *
*                                                          *
************************************************************

************************************************************
*
* TIME PERIOD FOR Z 1893 LOADING =     0.49200 SEC
* SA/G PER 1893=     2.500, LOAD FACTOR= 1.000
* VB PER 1893=    0.0600 X     74365.16=     4461.91 KN
*
************************************************************
```

Manually the calculation of base shear = 4556.145 kN

Software calculation = 4461.91kN

4461.91kN <4556.145 kN so it is safe

Table 7 showing the base shear force laterally distributed by Staad Pro analysis

i	hi(m)	Qi (KN)
1	4	61.189
2	8	245.189
3	12	551.676
4	16	980.757

5	20	1647.06
6	24	976.039
		Σ = 4461.91

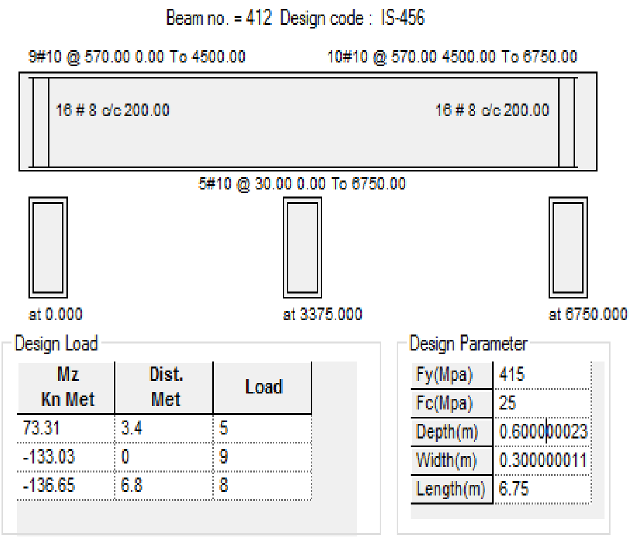

Figure 9; Shows the details of beam due to Seismic load combination

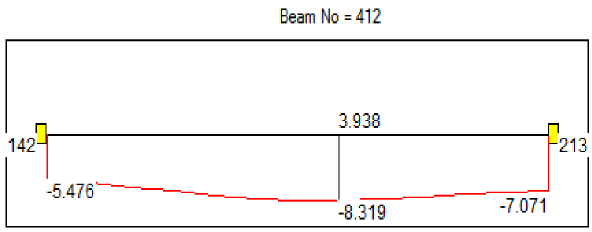

Figure 10 ; Beam deflection due to seismic combination load

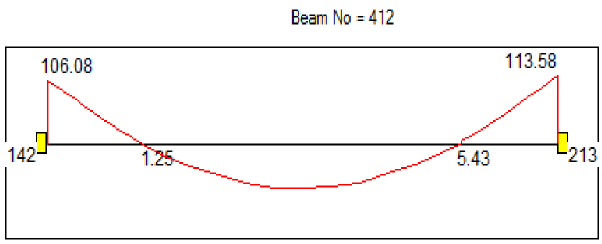

Figure 11; Bending moment due to seismic combination load

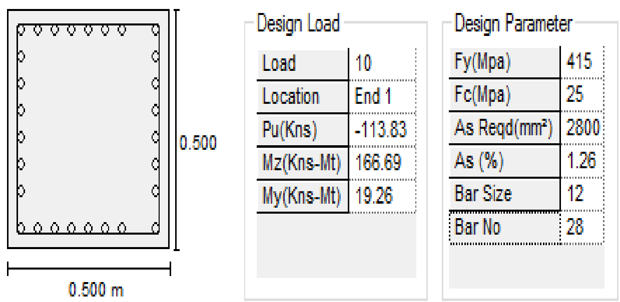

Figure 12; Shows the Column details due to Seismic Load Combination

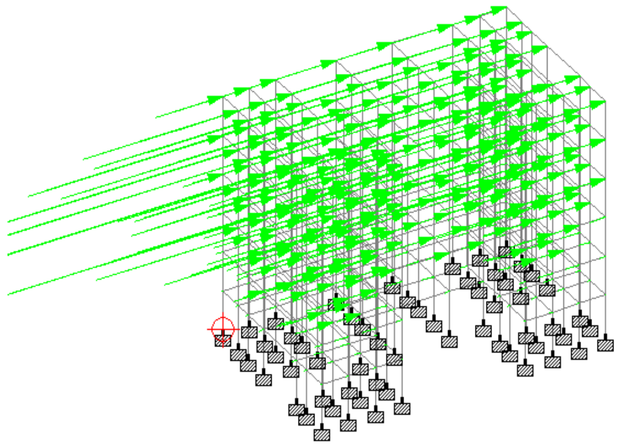

Figure 13 ; showing the seismic load acting from +x direction (Isometric view)

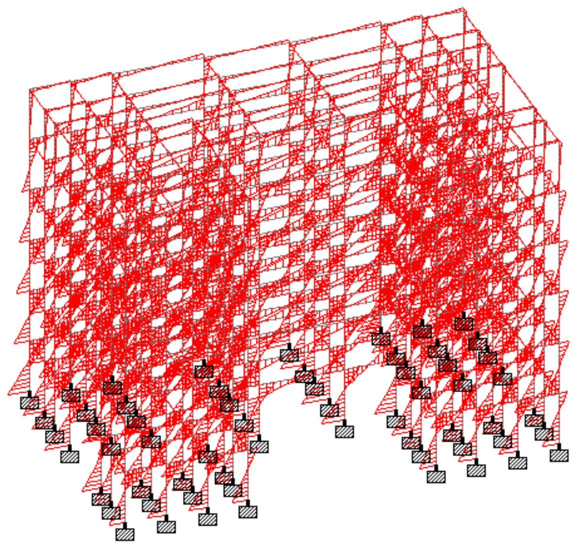

Figure 14; Bending moment diagram due to seismic force from +x direction

V. CONCLUSION

In the present study, G+5 Hospital building has been drawn in Auto CAD software and designed (Beams, Columns, Footings and Seismic load analysis by using Equivalent Static method) using STAAD Pro software. The dead load, live load and earthquake loads are calculated using IS: 456-2000 and IS 1893: 2002. Concrete grade M25 and HYSD bars Fe415 as per IS: 1786-1985 are used.

Originally, the building was designed without earthquake loads as per IS 456:2000. Then building is designed considering the earthquake loads as per IS1893: 2016. The detailing has been done as per both approaches.

REFERENCES

[1] Saha, Sowrav & Ali, Mohamed & Chisanga, Wyman & Yasin, Abdikarim (2021). Design and Analysis of Multistorey (G+14) Residential Building Using Staad. Pro & Autocad. International Journal of Scientific Research in Civil Engineering. 70-82. 10.32628/IJSRCE215311.

[2] Alkari, Alaukik & Meshram, Sangita & Baig, Aasif. (2021). Seismic Analysis of Structure Considering Soil Structure Interaction. IOSR Journal of Engineering.

[3] Zhou, G.-Y & Li, T.-C. (2020). Slope a seismic stability analysis method based on static and dynamic finite elements. 31. 2303-2308

[4] Agashe, Rashmi & Deshmukh, Vaishanvi & Khomane, Sharad & Patle, Gaurav & Yadav, Kushal. (2020). To Study Analysis and Design of Multi-Storey building using STAAD-pro.and Comparing with Manual Calculations.

[5] Song, Fei& Chen, R.-Y & Ma, Li-Qiu& Zhao, Jian. (2018). Stability Analysis of Reinforced Slope Based on Limit Equilibrium Method. Tehnicki Vjesnik. 25. 224-229. 10.17559/TV-20170317114554.

[6] Gopichand, Addanki & Mendu, Jugal Kishore. (2018). ANALYSIS AND DESIGN OF MULTISTORIED BUILDING (G+6) USING E-TABS AND SLOPE DEFLECTION METHOD.

[7] Mohammad Naser and A.V.Asha 2015 "Seismic analysis and design of hospital building by equivalent static analysis"

[8] Explanatory Examples on Indian Seismic Code IS 1893 (Part I)

[9] Explanatory Examples on Indian Seismic Code IS 1893 (Part II)

[10] IS 10262-2009 Indian standard recommended guide lines for concrete mix design.

[11] IS 456-2000 Plain and reinforced concrete code of practice.