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Design And Analysis Earthquake Resistence Hospital Building

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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. 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. 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 without considering earthquake loads using STAAD.pro software. Then the building was analysed for earthquake loads as per Equivalent static analysis method and after obtaining the base shear as per IS1893: 2002, again detailing has been obtained using STAAD.pro.

INTRUDUCTION

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.

A list of natural and man-made earthquake sources

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
• Microseism	• Cultural noise (Industry, Traffic, etc)

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 Latur Dist, Maharashtra State. The total built up area of the hospital building is 3550 square meters and has four floors (Ground floor +4). The Hospital building consists of various divisions like Ortho ward, Orthopaedic ward, Ophthalmology ward, ENT ward, major and minor operation theatres, outpatient ward, scanning and X-ray Centre and medicine store room, etc. The building is located in seismic prone zone (zone factor II). 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. The present study deals with seismic analysis using Equivalent static analysis of (G+4) story R.C.C buildings using Structural Analysis and Design (STAAD Pro.) software.

STRUCTURAL MODELLING

Overview

In this chapter, Hospital building description is presented. In section 4.2 six story regular reinforced concrete building is explained. Next in section 4.3 materials properties of both steel and concrete are shown. In section 4.4 Gravity loads, dead load, live load as well as combination loads are presented and the end structural elements are introduced.

Irregular RC Building

Four story regular reinforced concrete building is considered. The beam length in transverse direction are 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. 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.

Material Properties

Table 4.2 shows the assumed properties of concrete and steel bar taken as per IS 456.

Table 4.2: Properties of Concrete and Steel bar as per IS 456[7]

Concrete Properties		Steel Bar Properties	
Unit weight (γ_c)	25 kN/m^3	Unit weight (γ_s)	76.33kN/m^3
Modulus of elasticity	21718.8MPa	Modulus of elasticity	2x10^{5}MPa
Poisson ratio (ν_c)	0.17	Poisson ratio (ν_s)	0.3
Thermal coefficient (α_c)	1x10^{-5}	Thermal coefficient(α_s)	1.2x10^{-5}
Shear modulus (ς_c)	9316.95MPa	Shear modulus (ς_s)	76.8195MPa
Damping ratio (ς_c)	5%	Yield strength	415MPa
Compressive strength (F_c)	25MPa	Compressive strength (F_s)	485MPa

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 assumed300mm 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 4.3: Beam length and cross section dimension.

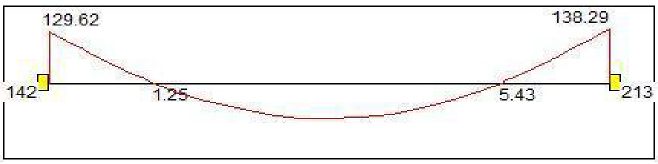
Structural Element	Cross section (mm x mm)	Length (m)
Beam in (x) longitudinal direction	350 x 600	3m (four numbers) 6.75m (two numbers) 6.25m
Beam in (z) transverse direction	350 x 600	3m (three numbers) 2m (two numbers)

Reinforced Structural design

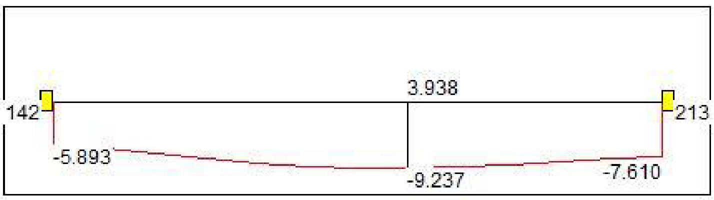
Having decided on a plan of the building and having obtained the beam and column dimensions and decided on the loads as per the relevant IS codes, the next steps in the project are the analysis and determining of the maximum moments, thrust and shears in beams, design of section and reinforcement arrangements for slab, beam, columns and walls and detail drawings and bar schedules.

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. 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.



Bending moment diagram of beam No.412



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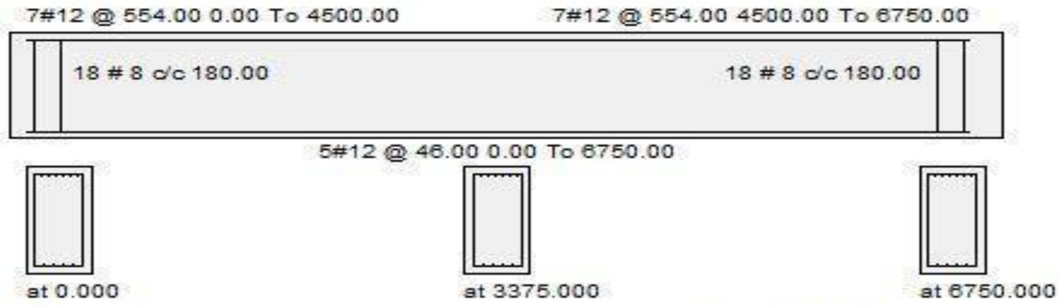
Deflection diagram of beam No.412



Design Load

Mz Kn Met	Dist Met	Load
89.71	3.4	3
-129.62	0	3
-138.29	6.8	3

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	25
Depth(m)	0.600000023
Width(m)	0.300000011
Length(m)	6.75

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

Figure 5.1 Bending moment, Deflection diagram and concrete design by details

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.

In the first method, different partial safety factors are applied to dead, live, wind and earthquake forces to arrive at the design ultimate load. In the IS: 456-2000 code, while considering earthquake effects, wind loads are also taken into account, assuming that both severe wind and earthquake do not act simultaneously. The American and Australian code recommendations are similar but with different partial safety factors. The dynamic analysis involves the rigorous analysis of the structural system by studying the dynamic response of the structure by considering the total response in terms of component modal responses.

ZONE FACTOR (Z):

- The values of peak ground acceleration given in units ‘g’ for the maximum considered earthquake.

- The value of (Z/2) corresponds to design basis earthquake damage control in limit state.
- Based on history of seismic activities, the entire country has been divided into four zones. The zone factor from table 2(IS 1893:2002)

Table 6.1: Zone factor values

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

Zone Factor Values

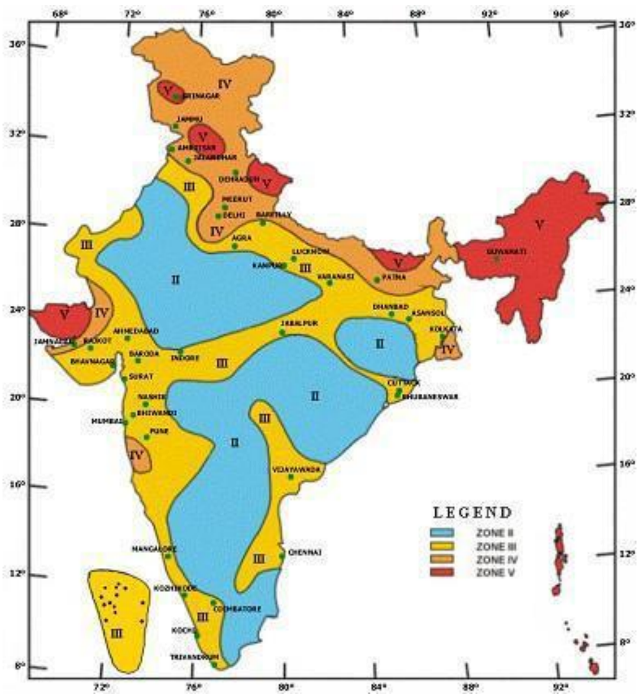


Figure 6.1: Seismic Map of India

RESPONSE REDUCTION FACTOR (R):

R is the response reduction factor and controls the permitted damage in design basis earthquake. The minimum value of R is 3 and maximum is 5, however to use higher values of R, special ductile detailing requirements are a must and the designer is accepting more damages but in the controlled manner. The Response reduction factor is obtained from table 7(IS 1893:2002).

IMPORTANCE FACTOR (I):

I is the importance factor and permitted damage could be reduced by setting the value of I more than '1'. For the buildings like **'HOSPITALS'**, communication and community buildings the value is 1.5 from table 6 (IS 1893:2002).

SEISMIC WEIGHT (W):

Seismic weight of the building is measured in Kilo Newton. Seismic weight includes the dead loads (that of floor, slabs, finishes, columns, beams) Seismic weight includes only a part of Imposed loads, for example 25% to 50% of imposed loads for buildings from table 8 (IS 1893:2002).

SOIL CLASSIFICATION:

- Sa/g is the lateral acceleration to be established in m/s2. For 5 % of damping three different types of curves are recommended in IS 1893:2002 for different stiffness of supporting media- Rock, Medium soil and Soft soil.
- The classification of soil is based on the average shear velocity for 30m of rock or soil layers or based on average Standard Penetration Test (SPT) values for top 30m.

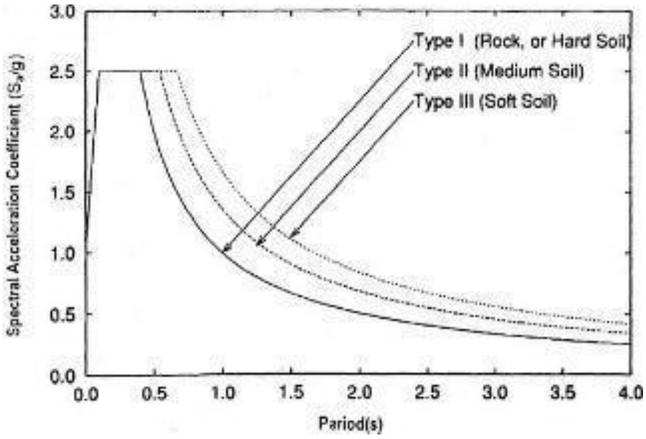


Figure 6.2: Classification of Soil Graph

Conclusion

In the present study, G+4 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 IS456:2000. Then building is designed considering the earthquake loads as per IS1893: 2002. The detailing has been done as per both approaches. Since Afghanistan does not have any earthquake code, Indian Standard codes have been used in the analysis and design.

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