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Parametric Study on Time Period of a Structure

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Abstract
In the seismic risk assessment and mitigation, the estimation of fundamental period of buildings is an important aspect both for design of new buildings and performance assessment of existing ones. Depending on mass and stiffness, the fundamental period is a global characteristic describing the behavior of building under seismic loads. In order to estimate the lateral loads acting on a structure, it is first necessary to determine the period of vibration. Time period formula mentioned in IS code relates the overall height and base dimension of the structure. In this paper a parametric study on time period of a structure is carried out as per IS code (IS 1893(part I):2002) using ETABS software. Time period calculation is done using software and it is compared with the value obtained through the formula provided as per IS code. A parametric study is done varying the beam dimension, column dimension, number of bays, number of storeys and the variation in time period was studied. These parameters contribute to the stiffness of the structure and hence there was variation in time period values as per the ETABS software. The study showed that not only height and base dimension of the building is involved in time period determination but also the beam dimension, column dimension, number of bays, number of storeys affects the time period. Hence it is inferred that these parameters should also be considered in time period calculation of structures.

Keywords: Beam dimension, Column dimension, ETABS software, Stiffness, Time period.

Introduction

In earthquake design and analysis of a reinforced concrete structure, time period plays a vital role. Hence the determination of natural time period is very important aspect in earthquake design. Based on this time period, it is easier to understand the global demands on a structure under certain given seismic input. This property (time period) is dependent on factors such as mass, stiffness and the strength of the structure. Time period is also affected by several factors such as section dimensions, number of storeys, number of bays, loading, structural regularity, reinforcement, etc. The phenomenon of cracking is generally ignored in the calculation of time period. Cracking generally occurs under gravity loading and after moderate seismic action. In order to estimate the lateral loads acting on a structure, it is first necessary to determine the period of vibration. For the creation of safe and economical earthquake resistant structures, calculation of time period is very important. Many design codes are available for the design of earthquake resistant structures. These relationships are for force based design which will estimate the time period and hence the base shear force can be predicted. Here a parametric study on time period of a structure is carried out as per IS code using ETABS software. ETABS is software which is generally used these days for the design and analysis. ETABS can handle the largest and most complex building models. Time period calculation is done using software and it is also done manually. Various parameters such as dimension of columns, beams, each storey height, loading etc is varied and the changes in the time period are studied.

Methods

A G+6 storey building is modeled using the software called ETABS considering certain specifications such as dimensions, support, loading. After analyzing the model, the time period value is obtained. The time period value is also obtained manually from the formula provided in IS code (IS 1893(part1):2002). The values obtained from software and from the IS code is studied and the results are depicted in the graphs considering various parameters such as beam ratio, column ratio, number of bays, number of storeys. The time period formula is mentioned below.

Determination of fundamental natural period (Ta) of the buildings

Ta = 〚 0.075h 〛 ^(0.75) For moment resisting RC frame building without brick infill wall

Where,

h – Height of building in m

Ta – Time period of structure in sec

$Ta = (0.09h)/\sqrt{d}$ For moment resisting RC frame building with brick infill wall

Where,

d – Base dimension of the building at the plinth level along the considered direction of earthquake shaking in m

Building Specification

Table 1: Building Specification

No of storeys	G+6
No of bays (X direction)	4
No of bays (Y direction)	4
Spacing of each bay	2.5m
General beam dimension	230x450mm
General column dimension	230x450mm
Other beam dimension	230x230, 230x450, 230x500mm
Other column dimension	230x230, 230x450, 230x500mm
General Slab thickness	130mm
General storey height	3m
General Grade of concrete (slabs & beams)	M25
General Grade of concrete (columns)	M30

Loading Details

Slab load (dead) = 4.25 kN/m²

Live load on roof slab = 1.5 kN/m²

Live load on rest of the slabs = 2.5 kN/m²

Masonry load on beams = 13 kN/m

Masonry load on beams (roof) = 4 kN/m

Earthquake loading (IS 1893(Part 1):2002):

Zone: III i.e., Z=0.16

Soil type: II

I=5

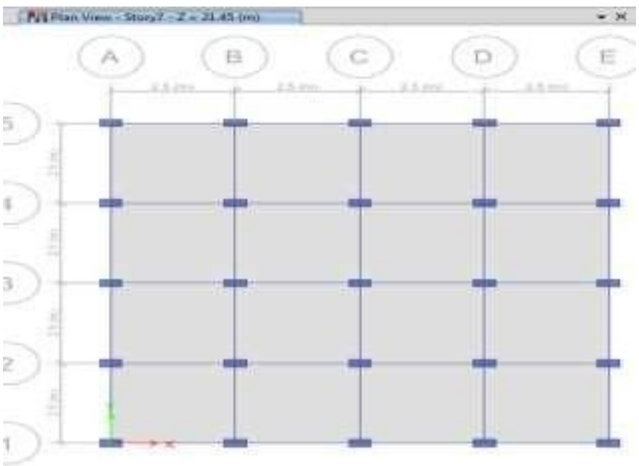

Figure 1: Plan view of model

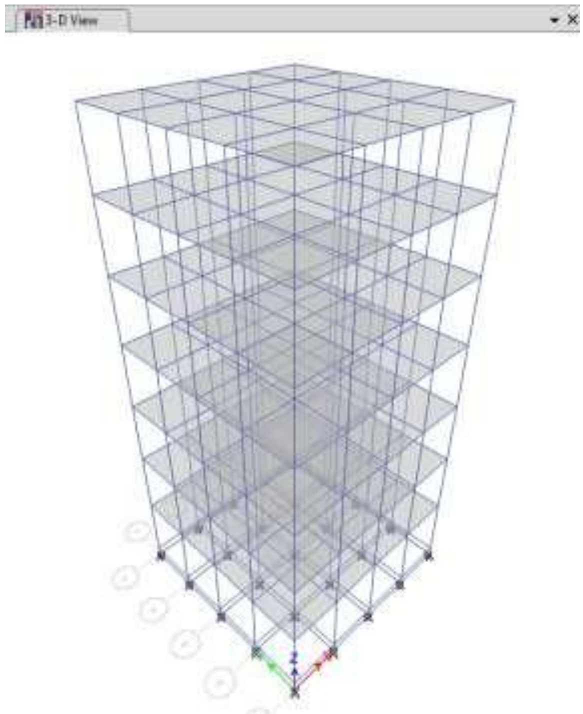

Figure 2: 3-D view of model

Results

As per the formula provided in IS code (IS 1893(part1):2002), the time period value obtained

$Ta = 0.075h^{(0.75)} = 0.7735$ sec

Where h =22.45m

$Ta = (0.09h)/\sqrt{d} = 0.6250$ sec

Where d =10.45m

The time period value with infill wall is less compared to the result without infill wall because the brick infill wall adds to the stiffness of the building and makes the building more rigid.

Beam Ratio

A general model is considered by varying the beam dimensions (considering beam ratios as 0.46, 0.5, 1). The time period values obtained from the ETABS software in two directions is mentioned below. In the graph shown the time period values are plotted along Y-axis and beam ratios are plotted along X-axis.

Table 2: Time period values for beam ratio consideration as per ETABS

BEAM DIMENSION (mm)	BEAM RATIO	Ta (sec) ETABS (X)	Ta (sec) ETABS (Y)
230X500	0.46	0.827	1.255
230X450	0.5	0.866	1.275
230X230	1	1.475	1.78

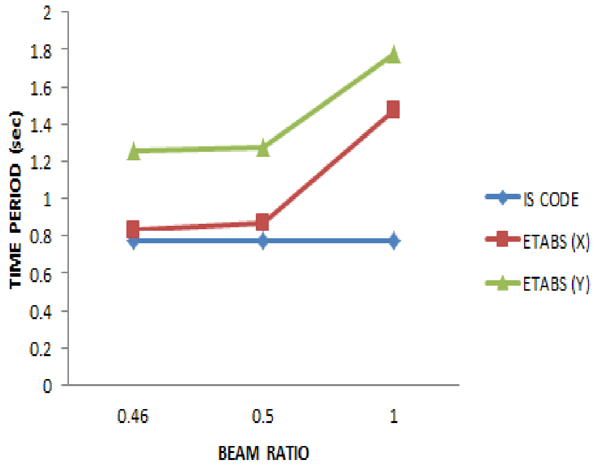

Figure 3: Graph showing time period values for beam ratio as per ETABS & IS code

As the depth of the beam increases, the stiffness also increases and hence the time period value reduces and hence the structure is rigid. As the depth of the beam is reduced, the stiffness reduces and hence the time period increases.

Column Ratio

A general model is considered keeping beam dimensions constant i.e., 230x450mm and varying the column dimensions (considering column ratios as 0.46, 0.5, 1). The time period values obtained from the ETBAS software in two directions is mentioned below. In the graph shown the time period values are plotted along Y-axis and column ratios are plotted along X-axis.

Table 3: Time period values for column ratio consideration as per ETABS

COLUMN DIMENSION (mm)	COLUMN RATIO	Ta (sec) ETABS (X)	Ta (sec) ETABS (Y)
230X500	0.46	0.815	1.237
230X450	0.5	0.866	1.275
230X230	1	1.604	1.604

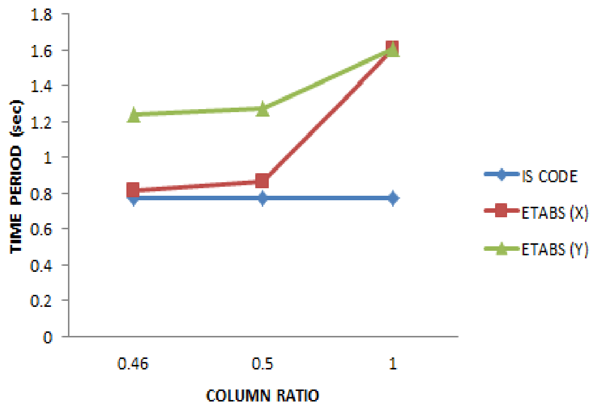

Figure 4: Graph showing time period values for column ratio as per ETABS & IS code

As the depth of the column is increased, the stiffness increases and hence the time period value reduces and hence the structure is rigid. As the depth of the column is reduced then the stiffness reduces and hence the time period increases.

Number of Bays

A general model is considered having a dimension of 10m in X direction and 10m in Y direction. Spacing of grids is varied from model to model.

- Model with 4 bays: spacing of each bay = 2.5m
- Model with 3 bays: spacing of 1st bay = 3m, spacing of 2nd bay = 3m, spacing of 3rd bay = 4m
- Model with 2 bays: spacing of each bay = 5m

Number of bays is varied in X direction keeping 4 bays along Y direction as constant. Similarly number of bays is varied from model to model in Y direction keeping 4 bays along X direction as constant and the time period is noted.

Table 4: Time period values by varying the number of bays in X direction as per ETABS

NUMBER OF BAYS	Ta (sec) ETABS (X)	Ta (sec) ETABS (Y)
2	1.260	1.532
3	1.001	1.380
4	0.866	1.275

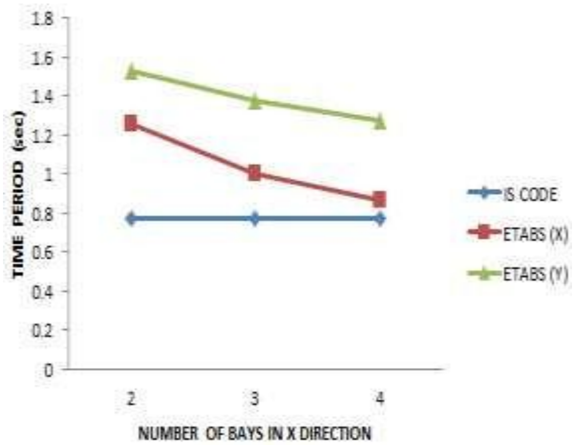

Figure 5: Graph showing time period values by varying the number of bays in X direction as per ETABS & IS code

Table 5: Time period values by varying the number of bays in Y direction as per ETABS

NUMBER OF BAYS	Ta (sec) ETABS (X)	Ta (sec) ETABS (Y)
2	1.070	1.761
3	0.943	1.456
4	0.866	1.275

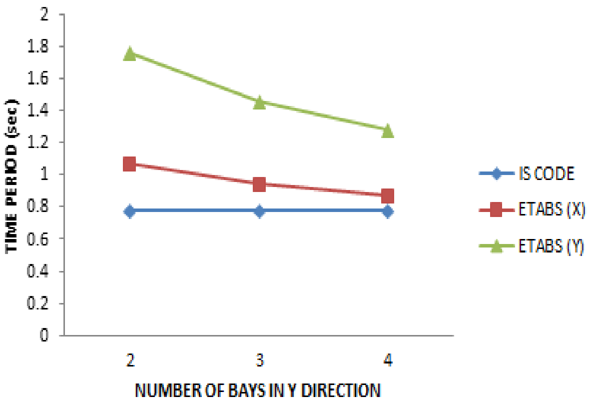

Figure 6: Graph showing time period values by varying the number of bays in Y direction as per ETABS & IS code

As the number of bays is increased, the stiffness increases and hence the time period reduces. Hence as per the values obtained from the software the time period is more for less number of bays.

Number of Storeys

When the storey height is changed keeping the overall height of the structure constant, then the number of storeys also gets changed.

Overall height = 22.45m

- Each storey height = 2.5m, number of storeys = G+7, pstorey height = 2.45m
- Each storey height = 3m, number of storeys = G+6, pstorey height = 1.45m
- Each storey height = 3.5m, number of storeys = G+5, pstorey height = 1.45m

Table 6: Time period values by varying the number of storeys as per ETABS

NUMBER OF STOREYS	Ta (sec) ETABS (X)	Ta (sec) ETABS (Y)
G+7	0.822	1.085
G+6	0.866	1.275
G+5	0.893	1.450

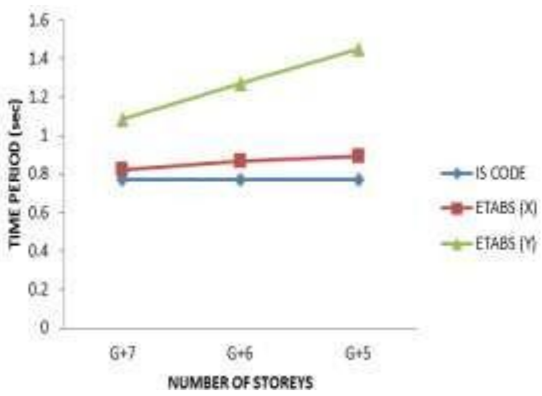

Figure 7: Graph showing time period values by varying the number of storeys as per ETABS & IS code

From the graph it is observed that for a given height of the building, as the number of storeys is increased the time period value also reduces.

Conclusion

- Larger the size of beams, greater is the stiffness. Hence the time period reduces.
- The variation in column dimension has an impact on time period. Greater the column dimensions greater is the stiffness of the structure and hence lesser is the time period.
- More the number of bays, it gives more stiffness to the structure and so the time period reduces. Less number of bays will show a higher time period results.
- For a given height of building if number of storeys is increased then it gives high stiffness and hence less time period.
- The variation in time period results show that other parameters also affect time period along with overall height and base dimension of the structure.

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