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Impact of Structural Parameters on Time Period of Reinforced Concrete Building

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Abstract: To understand the seismic performance and lateral load effects on a structure, it is essential to evaluate the time period. The time period is crucial in estimating lateral loads which contributes to seismic assessment. It depends on the structure's mass and stiffness, influencing its behavior under lateral loads. This study examines various parameters affecting the time period of an RC building, following IS 1893(part I):2002. Using ETABS software, reinforced concrete special moment-resisting frame models are analyzed to illustrate the impact of building stiffness, mass & height on the fundamental translational natural time period**.**

Index Terms: Natural Time Period, Equivalent Static Method, Etabs, Stiffness & Mass of Building

I. INTRODUCTION

Buildings oscillate during earthquake shaking. The oscillation causes inertia force to be induced in the building. The intensity and duration of oscillation, and the amount of inertia force induced in a building depend on features of buildings, called their dynamic characteristics, in addition to the characteristics of the earthquake shaking itself. The important dynamic characteristics of buildings are modes of oscillation and damping. A mode of oscillation of a building is defined by associated Natural Period and Deformed Shape in which it oscillates.

Natural Period Natural Period (T_n) of a building is the time taken by it to undergo one complete cycle of oscillation. It is an inherent property of a building controlled by its mass m and stiffness k. These three quantities are related by its units are seconds (s). Thus, buildings that are heavy (with larger mass m) and flexible (with smaller stiffness k) have larger natural period than light and stiff buildings. Buildings oscillate by translating along X, Y or Z directions, or by rotating about X, Y or Z axes, or by a combination of the above.

$$T_n = \sqrt{\frac{m}{k}}$$

Fundamental Natural Period of Buildings

Every building possesses several natural frequencies at which it offers minimal resistance to external effects such as earthquakes and wind, as well as internal effects like vibrations from motors. Each natural frequency and its associated deformation shape constitute a natural mode of oscillation. The mode with the smallest natural frequency (largest natural period) is called the fundamental mode. The natural period associated with this mode is the fundamental natural period T_1, and the corresponding frequency is the fundamental natural frequency f_1. Regular buildings restrained at their base from translation in three directions have three fundamental translational natural periods Tx_1, Ty_1, Tz_1, corresponding to oscillation along the X, Y, and Z directions, respectively, and one fundamental rotational natural period $T_{\theta 1}$ associated with rotation about the Z axis.

Seismic Analysis Methods

Seismic analysis often uses the equivalent lateral force method, where the base shear, calculated based on the structure's mass and fundamental period, is distributed as lateral forces along the building height according to code formulas. This conservative method simplifies analysis and reduces computational effort. There are three methods of seismic analysis of structures i.e.

1. **Equivalent Static Lateral Force Method:** Simplest, requires minimal computation. Forces are based on the code-specified fundamental period with empirical modifiers. The design base shear is computed and distributed along the building height according to mass and stiffness distribution formulas.
2. **Response Spectrum Method:** Involves dynamic analysis using a spectrum of potential earthquake responses.
3. **Time History Method:** Uses detailed time-dependent simulations of earthquake forces.

In this study, we adopt the Equivalent Static Lateral Force Method. The design base shear is calculated and distributed along the building height based on relative rigidity and the floor diaphragm action, as per clause 7.7.2 of IS 1893(Part 1):2002. This approach is appropriate for buildings with regular mass and stiffness distribution.

Objective: The objective of this study is to determine effect of stiffness, mass & height of building on the time period of RC building.

II. METHODOLOGY

A numerical result is used to explain the concept of natural period and the factors that influence it. Reinforced concrete moment resistant frame buildings are used to illustrate the concept; some properties of these buildings are listed in Table No. 3.5. One of these buildings, namely a five storey building, is chosen as the basis, and is hereinafter called the Benchmark Building. It is a bare frame with a plinth beam (and no slab) at ground floor level.

- Structural Element Sizes
    - Beams: 300 × 400 mm
    - Columns: 400 × 400 mm
    - Slab: 150 mm thick
- Material Properties
    - Grade of Concrete & Steel Reinforcement Bars : M30 & Fe 415
- Loading
    - Dead Load on beams from infill wall : 10 kN/m
    - Thickness & Clear height of infill wall : 0.3m & 2.60m
    - Unit Weight of infill wall : 20 kN/m^3
    - Live load on floor : 3 kN/m^2
- Seismic Consideration:
    - Seismic Zone –IV (Zone factor, Z=0.24)
    - Soil Type - II (Medium Soil)
    - Importance Factor – 1 (Residential Building)
    - Response Reduction Factor – 5 (special RC moment resistant frame)
- Load Combinations

    In the limit state design of reinforced concrete structures, the following load combinations shall be accounted for clause 6.3.1.2 IS: 1893-2002, Part 1:
    - 1.5(DL + IL)
    - 1.2(DL + IL ± EL)
    - 1.5(DL ± EL)
    - 0.9DL ± 1.5EL
- Basic Assumptions
    - Rigid slab (Diaphragm - It is a horizontal system, which transmit lateral forces to the vertical resisting elements)
    - Fixed base - The frames of building are assumed to be fixed at their base on an infinitely rigid foundation.
    - Slab type-membrane

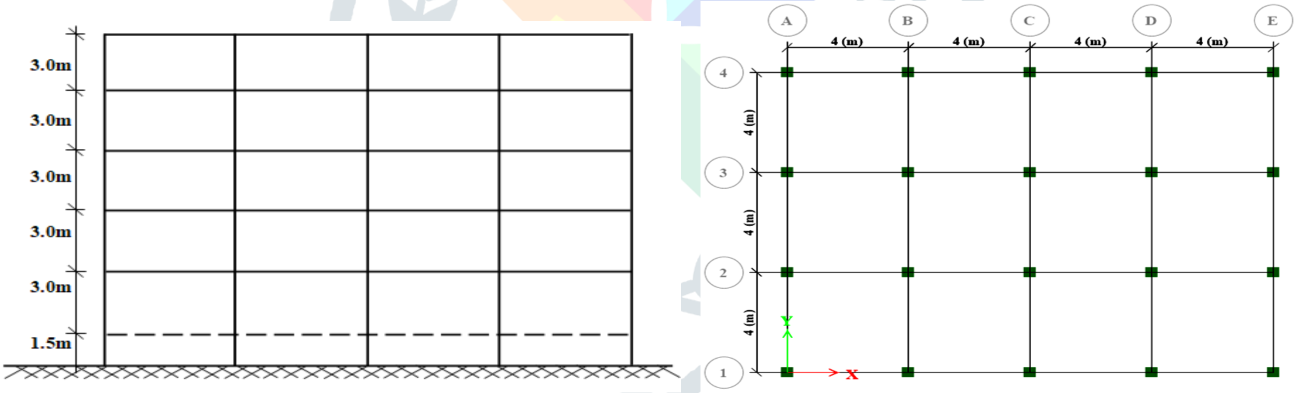

Figure No. 1: Five-storey Benchmark Building: Plan & Elevation (All dimensions are in m)

Table No. 1: Buildings Considered for Illustrating Concept of Natural Period

Note:

1. Bay length in each plan direction is 4m (centre to centre).
2. All columns at each storey are of the same size except building C1.
3. All beams in all buildings are of the same size (300mm × 400mm)

Model	Description	No. of Storeys	Number of Bays		Column Dimension (mm × mm)
			X	Y	
A1	2 - storey building	2	4	3	400 X 400
B1	5-storey building	5	4	3	400 X 400
C1	10-storey building	10	4	3	600 X 600
D1	25-storey building with varying column size along building height	25	4	3	Upper 5 Storey 400 X 400
					Middle 10 Storey 600 X 600
					Bottom 10 Storey 800 X 800

D2	25-storey building	25	4	3	800 X 800
D3	25-storey building with imposed mass 10% larger than building D2	25	4	3	800 X 800
D3	25-storey building with imposed mass 20% larger than building D2	25	4	3	800 X 800

III. RESULT ANALYSIS

1. EFFECT OF STIFFNESS

Increasing the column size increases both stiffness and mass of buildings. But, when the percentage increase in stiffness as a result of increase in column size is larger than the percentage increase in mass, the natural period reduces. Hence, the usual discussion that increase in column size reduces the natural period of buildings does not consider the simultaneous increase in mass; in that context, buildings are said to have shorter natural periods with increase in column size.

Buildings D1 and D2 are two 25-storey buildings with different column sizes along the elevation; building D2 has column size of 800×800 throughout the height, while building D1 has smaller column size (of 400×400) in the upper 5 storey and column size (of 600x600) in middle 10 storey**.** Thus, building D2 (with 800×800 column throughout) is relatively stiffer than Building D1 and the fundamental period of the stiffer building D2 (4.11 sec) is higher than that of the building D1 (3.88 sec). The deformed shape of the building indicates that most of the deformation is occurring only in the lower storey (because of shear-type of lateral deformation in the building), where the columns size is same. Hence, the influence on the overall natural period is not perceptible.

Table No. 2: Effect of stiffness on fundamental natural period in X & Y direction

Model	No. of Storey	Column Dimension (mm × mm)	Time period in X -direction, T_{x1} (sec)	Time period in Y-direction, T_{y1} (sec)
D1	25	Upper 5 Storey (400 X 400)	3.69	3.88
		Middle 10 Storey (600 X 600)		
		Bottom 10 Storey (800 X 800)		
D2	25	(800 X 800)	3.91	4.11

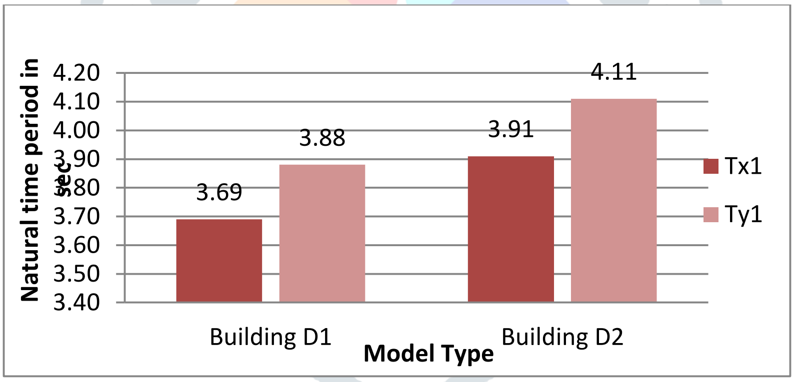

Figure No. 2: Effect of stiffness on fundamental natural time period

2. EFFECT OF MASS

Mass of a building that is effective in lateral oscillation during earthquake shaking is called the seismic mass of the building. It is the sum of its seismic masses at different floor levels. Seismic mass at each floor level is equal to full dead load plus appropriate fraction of live load. The fraction of live load depends on the intensity of the live load and how it is connected to the floor slab. Seismic design codes of each country/region provide fractions of live loads to be considered for design of buildings to be built in that country/region. An increase in mass of a building increases its natural period. Buildings D2, D3 and D4 are all 25-storey buildings with same plan size, elevation and column sizes, but with different floor mass**.** Imposed floor mass in buildings D3 and D4 are 10% and 20% larger, respectively. Fundamental translational natural periods of heavier buildings D3 (4.34 sec) and D4 (4.55 sec) are larger than that of building D2 (4.11 sec).

Table No. 3: Effect of mass on fundamental natural period in X & Y direction

Model	Mass of Building	Natural time period in X -direction, T_{x1} (sec)	Natural time period in Y-direction, T_{y1} (sec)
D2	M	3.91	4.11
D3	1.1M	4.12	4.34
D4	1.2M	4.32	4.55

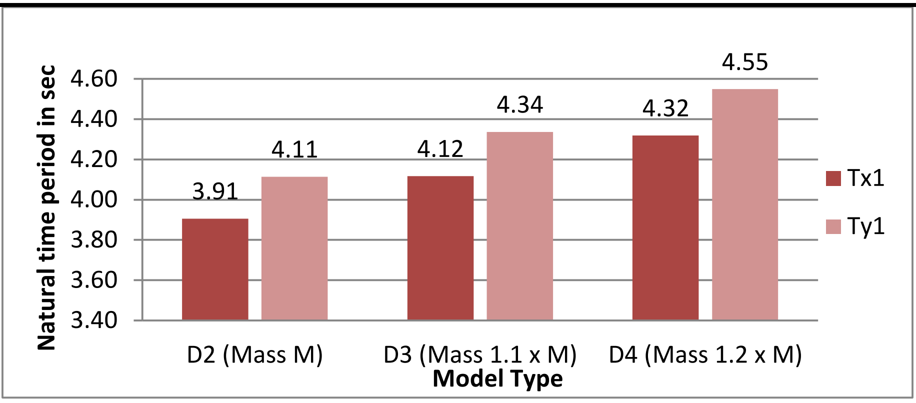

Figure No. 3: Effect of mass on fundamental natural time period

3. EFFECT OF BUILDING HEIGHT

As the height of building increases, its mass increases but its overall stiffness decreases. Hence, the natural period of a building increases with increase in height. Buildings A1, B1, C2 and D1 have same plan size, but are of different heights.

Taller buildings have larger fundamental natural period than shorter ones (Figure 4.3); the fundamental translational natural periods of 25-storey building D2, 10-storey building C1, 5-storey building B1 and 2-storey building A1 are 4.11s, 1.55s, 0.90s and 0.36s, respectively.

Table No. 4: Effect of building height on fundamental natural period

Model	No. of Storey	Natural time period in T_n in sec
A1	2	0.36
B1	5	0.90
C1	10	1.55
D2	25	4.11

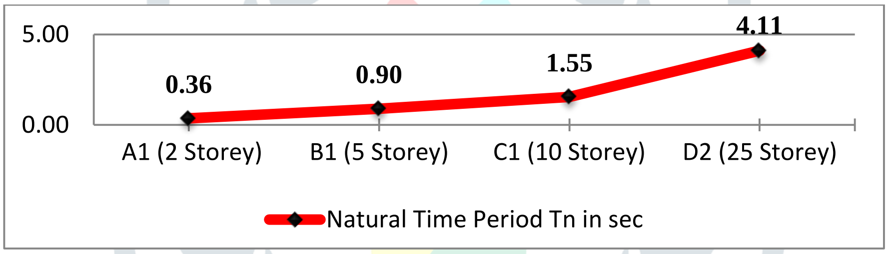

Figure No. 4: Effect of building height on fundamental natural time period

IV. CONCLUSIONS

1. Increasing the column size increases both stiffness and mass of buildings. But, when the percentage increase in stiffness as results of increase in column size is larger than the percentage increase in mass, the natural period reduces. It can be observed that increase in stiffness up to some extent, reduces natural period but later it increasing natural period.
2. With the increasing mass of building, natural period is also increased.
3. As the height of building increases, its mass increases but its overall stiffness decreases. Hence, the natural period of a building increases with increase in height.

REFERENCES

[1] D. Guney and A.O. Kurusu,(2011) "optimization of the configuration of infill wall in order to increase seismic resistance of building structure"., international journal of physical sciences vol -6(4) pages 698 to 706.
[2] Jaswant N. Arlekar, et al (1997), “Seismic Response of RC Frame Buildings with Soft First Storeys” Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat, 1997, New Delhi.
[3] Arlekar, J.N.; S. K. Jain and C.V.R Murty (1997) Seismic response of RC frame buildings with soft first storeys. Proceedings of CBRI golden jubilee conference on natural hazards in urban habitat New Delhi.
[4] Jawid Ahmad Tajzadah and Proff. Vimlesh V. Agrawal”Effect of Column Size, Shape and Orientation on Seismic Performance of RC Building”.
[5] Poncet, L. and Tremblay, R.”Influenceof mass irregularity on the seismic design and Performance of multi-storey braced steel frames”.
[6] Andre´ Furtado and Maria Teresa de Risi “Recent Findings and Open Issues concerning the Seismic Behaviour of Masonry Infill Walls in RC Buildings”.
[7] Anurag Waghide , Akhil Bhardwaj , S.C.Gupta”Review of behavior of infilled walls”.
[8] Diptesh Das and C. V. R. Murty, “Brick Masonry Infills in Seismic design of RC framed Buildings”.
[9] 9. C. V. R. Murty, Rupen Goswami, A. R. Vijayanarayanan and Vipul V. Mehta, “Earthquake Behaviour of Buildings”.