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EFFECTS OF VARIOUS STRUCTURAL DOMAIN OVER FUNDAMENTAL TIME PERIOD OF RC STRUCTURES

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ABSTRACT

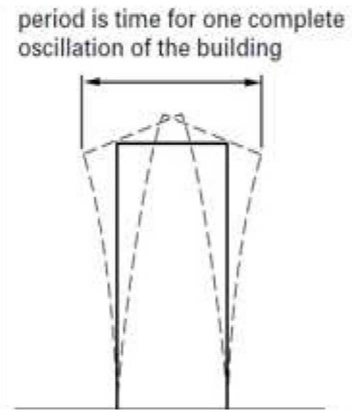
When a structure is subjected to an earthquake, the seismic forces propel the structure into motion and vibrate the structure in different directions. The time that the structure takes for a single oscillation is called the time period. The longest of these is called the natural time period. The natural time lag and damping of the structure has phenomenal effects on the response of structures. According to IS 1893 (2002), the approximate natural time span (T) in seconds is affected by two parameters: the height of the structure and secondly the base dimension of the building. In this study, parameters are examined that, in addition to height and base dimensions, can extend the natural time span of RC structures. The lengthening of the natural time periods leads to an improved response of the RC structure. The time course analysis of various R.C. Imperial Valley (1940) ground motion models were performed using CSI Etabs 2016 and SAP 2000.

KEYWORDS:

Number of floors, natural time period (T), response, natural frequency (Fn), Storey height.

INTRODUCTION

All structures erected at great expense and structures of reasonable importance, located specifically in seismically activated areas, require security for them. The design of such structures requires improved Response when these structures are faced with the challenge of with standing earthquakes. In this study, we investigated how the response of the structure can be improved. In essence, the parameters not considered by IS 1893 (2002) that govern the natural frequencies and natural time periods are examined. The Influence of such parameters on the natural frequency and the natural time of the structure was the main concern of this study. The past historic earthquakes that the Earth has been subject to have given us someclues as to the dynamics of the structure. From previous earthquakes we have found that the structure's response depends on the acceleration to which the structure is subjected, and this in turn depends on the frequency. Response improves when the natural vibrational frequency of structures is reduced for avariety of reasons. The decrease in the natural frequency means the increase in the natural time period (T). Increasing the natural time span means that the structure becomes more flexible and does not attract the lateral forces to the extent that other structures with a lower value of (T) did. According to our investigation, the parameters that also play an essential role in the increase or decrease play a role.



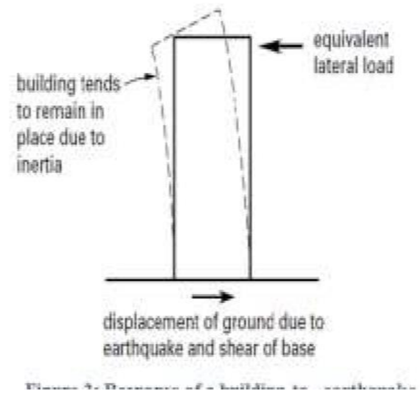


Figure 1: Period of a Building ***Figure 2:*** Response of a building to earthquake

$$\mathbf{f_n = \frac{1}{2\pi}\sqrt{K/M}}$$

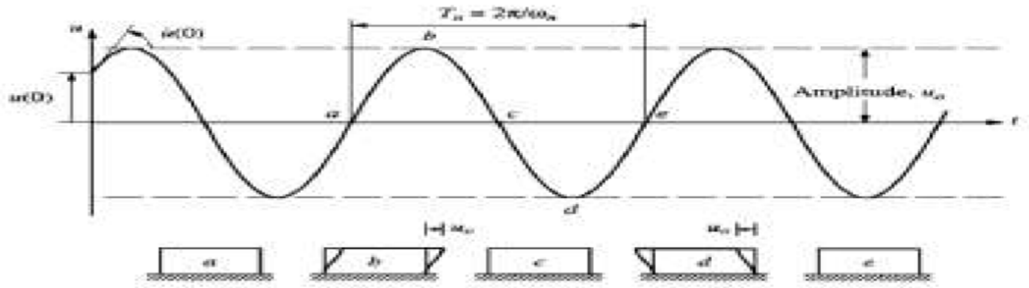
And the natural period (T_a) (of a moment resistance frame) is the function of the height of the structure from the base (h), excluding the basement if the basement walls are in place.

$$\mathbf{Ta = 0.075h^{0.75}}$$

$$\mathbf{T_a = \frac{0.09}{\sqrt{d}}}$$

Connected to the ground floor deck and including the basnconnected.This means that neither the story height (h) nor the number of stores (n) are taken in to account for the approximate calculation of these parameters. The natural frequency is the inverse of the natural time period, i.e. H. as the frequency decreases, the time period increases and vice versa.

$$\mathbf{\frac{1}{T_n} = f_n}$$



1.2 Literature Review

Nilesh V Prajapati [1]. Presents a working study on seismic analysis of a structure. In their study, they found that the number of floors in IS 1893 (2002) was not considered in calculating the natural span and frequency of the structure. In his study, he analyzed a 70 x 70 m building with a height between 60 m and 90 m. All modeling work was carried out using the analysis software Staad pro. He made several models of different heights, starting at 3m and increasing by 0.25m for each model. Also, in each model, an increment of one floor is made as the number of floors increases and the floor height increases, ultimately leading to an increase in the overall height of the structure. This leads to an increase in the natural time period. Finally, the natural time span calculated from Staad pro and the empirical formula from IS 1893 were compared.

L. Lin, N. Naumoski, S. Foo and M. Saatciogl [2] conducted a study on the prolongation of the natural time spans of reinforced concrete by structures during nonlinear seismic response. In their study, they analyzed three types of structures, namely low-rise structures, mid-rise structures and tall structures. A push over analysis was performed for these structures. The ground movements of the Vancouver earthquake were taken into account for the study. A set of 40 previously recorded acceleration plots representing the Vancouver regions seismic movements were used. Each structure was subjected to a series of seismic excitations that elicited responses ranging from elastic to inelastic responses. The undamped vibrations of the structure after the end of each excitation move were analyzed to calculate the first modal period of the structure. The calculated periods were then analyzed statically to establish a relationship between the lengthening of the natural time period and the intensity of the seismic excitations. It was then found that the mean lengthening of the period is almost linearly proportional to the intensity of the movements. They also included that for the intensity producing a global ductility of 5.0, the mean extended period is 55% higher than the corresponding elastic first mode, allowing the period extension for any global ductility level considered to determine.

Abbas Ali Dhundasi [3]. This article mainly dealt with estimating the natural time span of different types of reinforced concrete flood tanks. In this study, the researcher conducted the investigation on the natural periods of Intze and Funnel type pools. The researcher modeled Intze and Funnel type tanks with different step heights in three sets, i.e. H. 16 m, 20 m and 24 m. The type of stage is also varied, i. H. Frame platform and shaft platform. A total of 27 models were prepared and analyzed for the "full water", "half full water" and "empty water" states. The capacity of the water tank was also retained as variants in the study for 10 lakh, 15 lakh and 20 lakh liters Water. Analysis of each structure was performed with SAP 2000 analysis software. The important finding was that the time for the tank to be full is longer than that for the tank to be empty. Secondly, the period of time increases with the head of the same. Also, as the capacity increases, the period of time increases, and Intze tanks with wells are preferable for use. The study resulted in a simplified period-height-based equation was proposed for use. The proposed equation $\mathbf{T_{a=0.00013H}2}$., where H is the deployment height in meters.

Mehmet MetinKose [4]. The performance of buildings largely depends on the strength and deformability of structural members. A study was conducted examining the parameters that can affect the natural period of RC buildings with filled walls. Various selected parameters were building height, number of bays, ratio of the area of the glass walls to the floor area, ratio of the filled panels to the total number of panels, type of frame. Around 190 models of different properties were modeled and the effect of the selected parameters was examined in a filled RC frame. In general, the natural period is calculated by discarding the fills, but the fills exhibit nonlinear behavior. A 3D finite element modeling was carried out for the analysis. It was found that RC frames with filled walls had reduced periods of about 5-10% as the rigidity of the structures increased. The presence of shear walls also shortened the time with or without filled walls by about 6-10%. It was also concluded that the natural time span of various structures calculated by the code is shorter than the time span suggested by the software, which was calculated using exact eigenvalues.

1.3 Objective

The main aim of this study is to investigate the influence of the selected parameters over the natural period of the structure. The selected parameters are the height of the floor and the number of floors. In this work, the effect of these two parameters on the natural frequency and the natural time period of the structure is investigated. In this work, different RCC models were created and compared for the natural frequency as well as the natural time period of each structure. The number of floors and the height of each floor were varied. A total of seven models were prepared for analysis. Nonlinear time history analysis with direct integration method was used. The ground motions of the Imperial Valley earthquake were used for both the X and Y directions.

II. System Development

All seven numbers of the RCC models were created with the Etabs 2016 analysis software. In all models, both the ground plan dimensions and the height have been kept almost constant. The building examined was an existing residential building with a floor plan size of 54.60 m x 22.80 m and a height of approx. 80 m. The storey height of the first model was retained at 3.0 m, later in the subsequent models Increased the floor height by 0.25m for each model until the height in each floor reached 4.5m. The height of each floor was kept constant in a model. Since the projectile height was increased by 0.25 m in each model, the number of projectiles in each model decreased. The effect of increasing the ground level on time was checked in each model. The plan of the structures, which was constant for each model, is presented below:

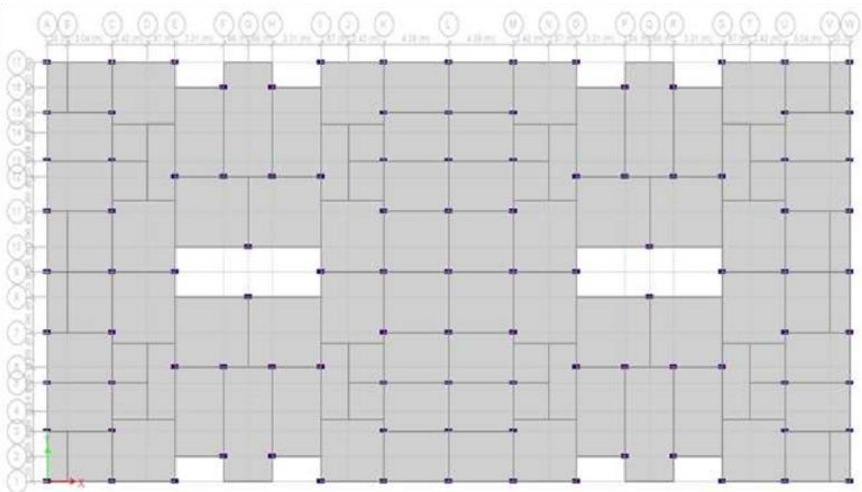


Figure 4: Plan of the Structural Model

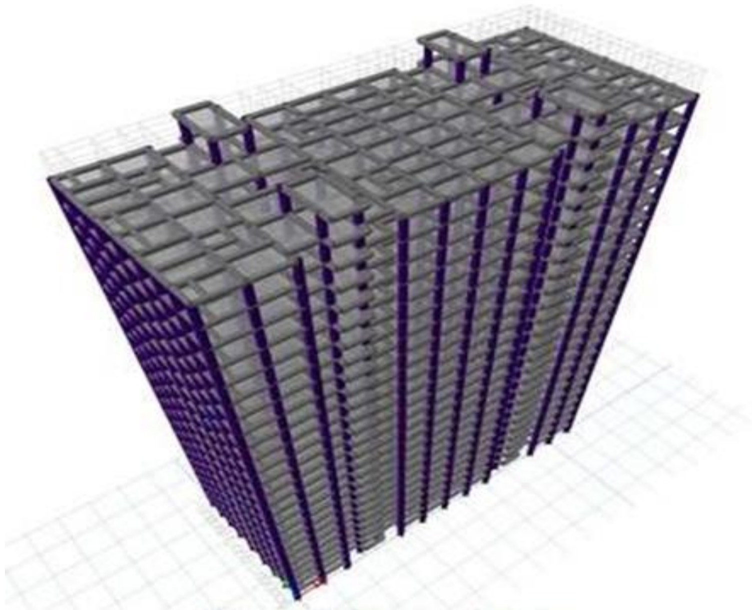


Figure 5: 3D extruded view

The material properties, general specification of buildings, structural specifications,load specifications and load combinations are given in Table No. 1, 2, 3, 4 and 5 reused.

***Table 1*: Material Properties**

1.	Grade of concrete	M25
2.	Grade of reinforcing steel	Fe 500
3.	Grade of steel	Fe 345
4.	Density of concrete	25 KN/m^3
5.	Density of brick masonry	19 KN/m^3
6.	Damping ratio	5%

***Table 2*: General Specification of buildings**

1.	Plan Dimensions	54.60m X 22.80m
2.	Height of the structure	80m
3.	Height of storeys	3m - 4.5m
4.	Interval of storey height in each model	0.25m
5.	Thickness of Slabs	150 mm
6.	Internal Wall thickness	150 mm
7.	External wall thickness	150 mm
8.	Waist slab thickness	150 mm

9.	Depth of footings	3 m

***Table 3*: Structural Specifications of Buildings**

1.	Type of sections	R.C.C.
	Sizes of Column sections	
2.	Columns (C1)	230 X 380
3.	Columns (C2)	230 X 450
4.	Columns (C3)	230 X 530
	Sizes of beam sections	
5.	Primary Beams	230 X 530
6.	Secondary beams	230 X 450
7.	Tertiary beams	230 X 380

***Table 4:* loading Specifications**

1.	Floor load	1.0 KN/m^2
2.	Live load	3.5 KN/m^2
3.	Live load on Staircase tower	2.0 KN/m^2
4.	External wall load	10 KN/m
5.	Internal wall load	10 KN/m
6.	Code for RCC	IS 456 (2000)
7.	Code for Earthquake analysis	IS 1893 (2002)
8.	Zone	V (very severe)
9.	Zone factor (Z)	0.36
10.	Importance factor	1.0
11.	Moment resisting frame type	OMRF
12.	Response reduction factor	3.0
13.	Site soil type	Medium (II)

Table 5: **Load Combinations**

1.	0.9DL+1.5EQX
2.	0.9DL-1.5EQX
3.	0.9DL+1.5EQY
4.	0.9DL-1.5EQY
5.	1.2(DL+LL+EQX)
6.	1.2(DL+LL+EQY)
7.	1.2(DL+LL-EQY
8.	1.5(DL+EQX)
9.	1.5(DL+EQY)
10.	1.5(DL+LL)
11.	1.5(DL-EQX)
12.	1.5(DL-EQY)
13.	1.2(DL+LL-EQY)

III. Results and Discussion

All RCC structures were modeled and analyzed using the finite element-based software ETABS 2016. A total of seven RCC structures were modeled for the comparative analysis of various parameters. Parameters such as natural frequency, natural time and reaction acceleration were compared. All seismic parameters necessary for the purpose of analysis were taken into account from IS 1893-(2002) and Y directions.

3.1 Natural Frequency:

The natural frequency of each model with different floor heights was evaluated and compared for four different modes. It was compared in (Figure 5). It can be clearly seen that the natural frequency continues to decrease as the storey height increases. The values of the frequency values for different modes at the respective ground level are given in the table.

Table 6: **Natural frequencies**

Sr. no	Storey height (m)	Natural Frequency (Etabs)			
		Mode 1	Mode 2	Mode 3	Mode 4
1.	3.00	0.128	0.153	0.201	0.392
2.	3.25	0.121	0.145	0.191	0.367
3.	3.50	0.114	0.137	0.182	0.346
4.	3.75	0.113	0.136	0.180	0.343
5.	4.00	0.109	0.132	0.179	0.331
6.	4.25	0.106	0.128	0.175	0.321
7.	4.50	0.104	0.126	0.168	0.305

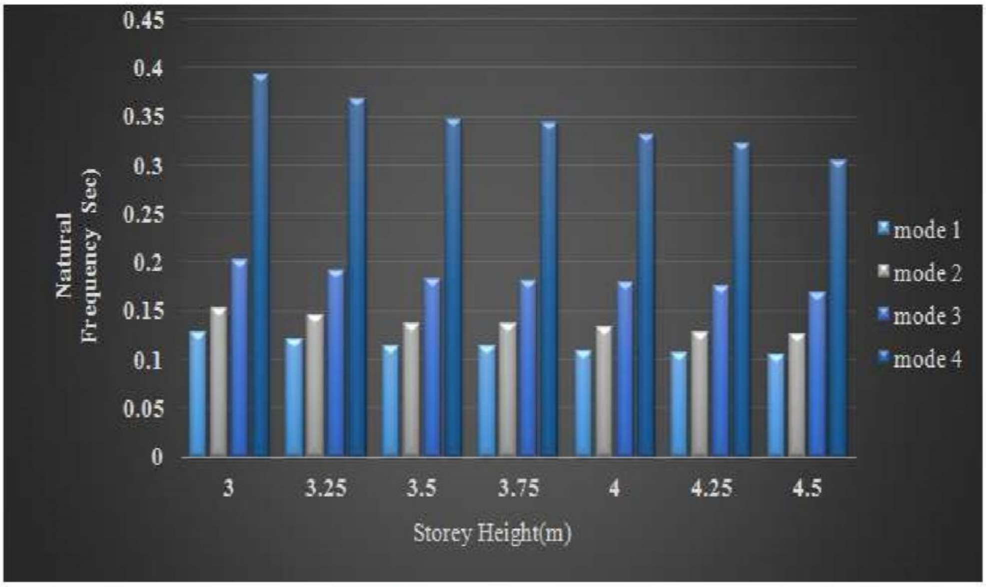


Figure 5: Natural Frequency for different floor heights

3.2 Natural Time Period:

The basic objective of this study was to evaluate the effects of increasing the floor heights. Number of floors in the natural period. The results are shown in Table 7. The time period was compared for different modes for different floor heights. From this it becomes clear that both the floor height and the number of floors are taken into account. The number of floors increases the life of the structure and increases linearly. Increasing the natural time span ultimately leads to an improved response of the structure.

Table 7: **Natural time periods**

Sr. no	Story height (m)	Natural Time Period (Etabs)			
		Mode 1	Mode 2	Mode 3	Mode 4
1.	3.00	7.754	6.495	4.986	2.552
2.	3.25	8.274	6.912	5.247	2.726
3.	3.50	8.771	7.305	5.492	2.892
4.	3.75	8.775	7.312	5.537	2.897
5.	4.00	9.133	7.580	5.598	3.017
6.	4.25	9.433	7.812	5.725	3.119
7.	4.50	9.567	7.879	5.931	3.284

3.3 Response Acceleration

The reaction acceleration diagram of different structures for different periods of time is shown in Fig. 7. The graph shows that as the natural time span increases, the acceleration also decreases.

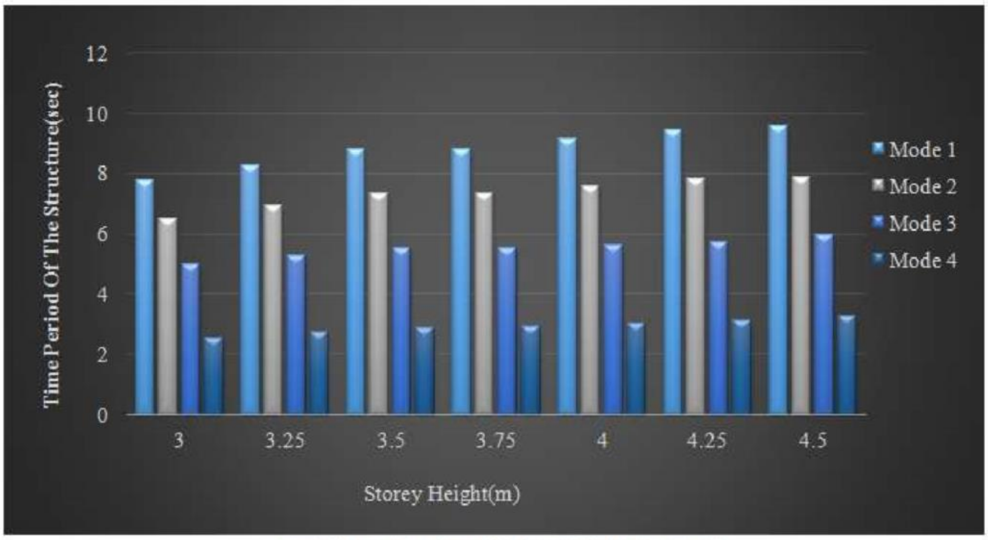


Figure 6: Time Period for different floor heights

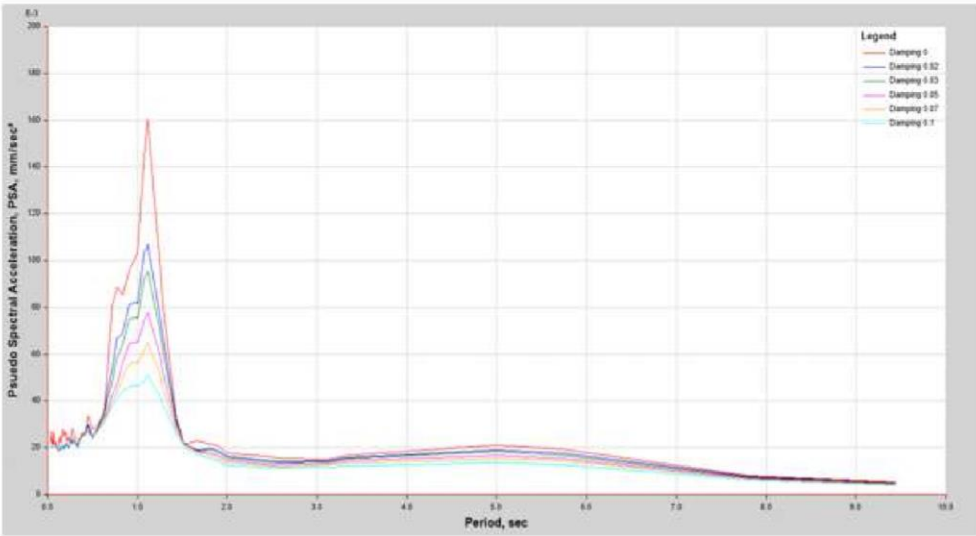


Figure 7: Response Acceleration graph

IV. Conclusions

In this comparative study, various buildings with different storey heights and different number of storeys were compared. By observing all the models, results, tables and graphs, the following conclusions were drawn:

- ❖ The variation of the floor height for the same structure in different models shows that the natural frequency for the lower floor height structures is larger and the frequencies for the higher floor height structures are lower.
- ❖ With increasing storey height, the time span of the structure increases, even if the overall height of the structure remains the same.
- ❖ As the number of floors in the structure increases, so does the period.
- ❖ This means that the natural span is also a function of floor height and number of floors.
- ❖ As the natural time span of the structure increases, the response of the structuIt is also suggested that the influence of storey height and storey count in IS-1893 must be considered when calculating the natural time periods of structuresre is improved due to minimized spectral accelerations of the structure.

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