EXCITATION OF MULTI-STORIED BUILDING DUE TO RESONANT FREQUENCY

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ABSTRACT: A building endures dynamic motion when an earthquake occurs. This occurs because the structure is subjected to inertia forces that work in the opposite direction of the acceleration of seismic excitations. Seismic loads are the result of these inertia forces. They usually got by anticipating forces from outside the building. The building will be harmed by the intense motions caused by a seismic event. These occurrences cause structural harm to the building. Structures are normally built to withstand gravity; therefore they are well-suited to vertical movement. Seismic waves can move vertically, equally, or a combination of both, and they can come from any direction. Earthquake forces are similar to sound waves, which are produced at different frequencies and amplitudes. Distinguishing dynamic characteristics of structural building constructions is still a challenge. It intends to assess the performance of structures subjected to time-dependent loads. This paper discusses a method for identifying the attributes of multi-story structures based solely on their measured response to seismic ground excitations. The responses of a multi-story building are explored under twelve various seismic ground excitations. The spectral densities and singular values of the structure response were recorded and used to determine their dynamic features, such as modal frequencies, damping factors, and mode types like bending and torsion. The goal is to comprehend the structure's response behaviour under known input excitation while also recognizing the appearance of resonance phenomena.

Keyword's: Earthquake, Torsion, Modal frequencies

1. Introduction

Earthquakes produce a variety of complicated waveforms with different amplitudes and frequency. Large earthquakes produce seismic waves with larger amplitude but a lower frequency, whereas tiny earthquakes produce waves with a smaller amplitude but a higher frequency. Most structural failures are caused by a lack of bracing, shear resistance, or moment resistance in buildings. Seismic waves can travel in any direction and can move vertically, horizontally, or a combination of the two. Shorter, stiffer structures are more likely to be damaged by higher frequency earthquakes, while taller, more flexible structures are more likely to be damaged by lower frequency earthquakes. Buildings that are built at the same time as a seismic event have a tendency to resonance, causing more damage.

Structural analysis is primarily concerned with determining the nature of a structure when it is subjected to movement. This movement can be caused by the weight of items, such as people, furniture, wind, snow, and so on, or by some other type of excitation, such as an earthquake, ground shaking due to a nearby impact, and so on. In general, all of these loads are dynamic, including the structure's self-weight, because these loads were not present at some point in the past. On the basis of whether the associated activity has enough acceleration in contrast to the structure's natural frequency, a refinement is made between the dynamic and static investigations. The inertia forces (Newton's second law of motion) can be ignored if a load is delivered gradually enough, and the analysis can be simplified to a static analysis.

Structural dynamics is a type of structural analysis that examines how structures behave under dynamic (high-acceleration) loads. People, wind, waves, traffic, earthquakes, and blasts are all examples of dynamic loads. Dynamic loading can be applied to any structure. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis, among other things.

$$DAF = DLF = \frac{u_{max}}{u_{static}}$$

Where u denotes the structure's deflection as a result of the imposed load. For common loading functions, graphs of dynamic amplification factors vs. non-dimensional rising time (tr/T) exist. As a result, the DAF for a given loading can be easily determined from the graph, the static deflection for simple structures can be calculated, and the dynamic deflection can be calculated.

The response of a structure after some time during and after the application of a load is shown by a whole time history. You must solve the structure's equation of motion in order to obtain the whole time history of its reaction.

Modal analysis is utilized to decide a structure's vibration characteristics — natural frequencies and mode shapes. It is the most essential of all dynamic analysis types and is basically the beginning for other, more detailed dynamic analyses.

Many vibration issues are caused by resonance phenomena, in which operating forces excite one or more vibration modes. Vibration modes that are within the frequency range of the operational dynamic forces are always problematic. Any unique response (restricted or free) of a structure can be reduced to a reaction of discrete arrangement of modes, which is a critical property of modes.

The goal is to understand the structure's reaction behaviour under known information excitation while also knowing how resonance occurs.

2. Literature survey

Recent earthquakes, in which many concrete structures were severely damaged or collapsed, have emphasised the importance of evaluating building seismic preparedness. Around 60% of our country's land range is exposed to dangerous levels of seismic risk. We won't be able to keep a strategic distance from future earthquakes, but safe building methods can help to reduce the amount of damage and misfortune. This chapter presents a survey of the literature on structural seismic evaluation.

Girum Mindaye and Dr. Shaik Yajdani (2016) : A fundamental step in the design of a structure to resist earthquakes is the analysis of a structural system to determine the deformations and forces caused by applied loads or ground stimulation. Depending on the aim of the analysis in the design process, there are a variety of methodologies ranging from a simple linear analysis to a complex nonlinear analysis. In this research, the seismic response of a residential G+10 RC frame was studied and assessed using ETABS Ultimate 2015 software and linear analysis (approaches of Equivalent Static Lateral Force and Response Spectrum techniques) in accordance with IS- 1893-2002-Part-1

These analyses took into account distinct seismic zones as well as medium soil types in all zones.

i. OMRF frame type for zones II and III.

ii. For rest zones that use the OMRF and SMRF frame types.

Differential reactions such as lateral force, overturning moment, narrative drift, displacements, and base shear are plotted with a specific real purpose in mind to examine

Shashivendra Dulawat and Esar Ahmad (2016): A building's foundation is harmed by the solid development generated by a seismic event. Structures are designed to withstand gravity and, as a result, are usually well-suited to vertical movement. Earthquake forces behave similarly to sound waves, which have varying frequencies and amplitudes. A three-story building frame model is proposed, which will be exposed to symmetric motions. The rectangular structure is made up of four steel columns and four steel slabs that are spaced evenly between the columns. The goal is to understand the frame's response behaviour under known input excitation while also knowing how resonance occurs in multi-degree-of-freedom systems. Following the completion of the model, free vibration tests are performed to determine the model's true properties, such as solidity, damping ratio, and normal vibration frequencies. For excitations, a shake table is used, and the physical model's reaction is assessed in terms of amplitude, natural frequency, resonance frequency, acceleration, and mode shape. The results of the exploratory work are compared to Ansys programming.

Pralobh S. Gaikwad and Kanhaiya K. Tolani (2015) The main purpose of earthquake engineers is to design and build a structure that will cause the least amount of damage to the building and its auxiliary components during a quake. The research focuses on the dynamic analysis of RCC and steel structures with irregular shapes. Models of G+9 storeys of RCC and Steel with irregular floor plans are taken into account for the analysis. E TABS, an F.E. based programming, is used to deliver the examination. It is possible to resolve several parameters such as lateral force, base shear, narrative drift, and tale shear. The response spectra approach or the time history method are used in dynamic analysis.Dynamic should be used for both symmetrical and asymmetrical structures. Full nonlinear dynamic time history analysis is one type of dynamic analysis. If the RCC and Steel buildings are irregular, the Torsion effect will be formed in both buildings, which will then be compared to determine the efficiency of the building under the torsion effect.

Agung Budipriyanto* and Priyo Suprobo (2014): Recognizing dynamic structural properties and developing structures is still a challenging task. It intends to assess the structures' performance under time-dependent loads. This research describes a method for detecting the behaviour of multi-story structures based solely on their purposeful reaction to seismic ground excitations. The intelligibility of the structure's responses was used to validate the approach used for structural identification. The algorithm was used to determine the features of 14- and 20-story office buildings in seismically active areas. The reactions of these two structures were studied in the context of three different seismic ground movements. The response spectral densities and singular values of the buildings were analysed and used to identify their dynamic features, such as modal frequencies,

3. Methodology

Structural dynamics is a type of structural analysis that examines the behaviour of structures that have been subjected to dynamic (high-acceleration) loads. People, wind, waves, traffic, earthquakes, and blasts are all examples of dynamic loads. Dynamic loading can happen to any structure. Dynamic analysis can be used to find dynamic relocations, temporal histories, and modular research.

The dormant abilities established by a structure when it is revitalised by ways for dynamic burdens connected abruptly are also known as a dynamic examination (e.g., wind impacts, blast, and seismic tremor). A static load is one that does not change over time. A dynamic load is one that changes with time in a way that is typically faster than the structure's regular recurrence.

A dynamic analysis is also concerned with the inertia forces created by a structure when it is unexpectedly aroused by dynamic loads (e.g., wind blasts, explosion, and earthquake).

A static load is one that does not change over time. A dynamic load is one that changes with time at a rate that is faster than the inherent frequency of the structure. The structure's reaction may be resolved with static analysis if it changes gradually; however, if it shifts swiftly (in terms of the structure's ability to react), the reaction must be handled using dynamic analysis.

For simple structures, dynamic analysis can be performed manually; however, for complicated structures, finite element analysis can be used to determine the mode shapes and frequency

3.1 Response spectrum

A response spectrum is a depiction showing the peak or steady-state response (displacement, velocity, or acceleration) of a series of oscillators with varying natural frequencies that are constrained into motion by a similar base vibration or shock.

The following figure can then be used to isolate the response of any linear system based on its natural frequency of oscillation. Surveying the peak response of buildings to earthquakes is one such application. For connection with seismic harm, the science of strong ground motion may use a few values from the ground response spectrum (ascertained from seismograph recordings of surface ground motion).

3.2 Time history analysis

The response of a structure over time during and after the application of a load is shown by a whole time history. You should calculate the structure's equation of motion to get the whole time history of its reaction. A comprehensive time history will reveal a structure's response throughout time, both during and after the application of a load. You should assess the structure's equation of motion to find the whole time history of its reaction.

3.3 Modal analysis

A modal analysis calculates a system's frequency modes or natural frequencies, but not its full-time history reaction, in order to provide information. The natural frequency of a system is determined solely by the structure's stiffness and the mass of the structure's components (including self-weight). It does not use the load function. Knowing a structure's modular frequencies is critical since it allows you to verify that the frequency of any applied periodic loading does not coincide with a modular frequency, resulting in resonance and prolonged oscillations.

4. Analysis and results

4.1 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

4.1.1. Story Data

TABLE 1. Story Data

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
Story5	3000	15000	Yes	None	No
Story4	3000	12000	No	Story5	No
Story3	3000	9000	No	Story5	No
Story2	3000	6000	No	Story5	No
Story1	3000	3000	No	Story5	No
Base	0	0	No	None	No

TABLE2. Grid Lines

Grid System	Grid Direction	Grid ID	Visible	Bubble Location	Ordinate m
G1	X	A	Yes	End	0
G1	X	B	Yes	End	3
G1	X	C	Yes	End	6
G1	X	D	Yes	End	9
G1	X	E	Yes	End	12
G1	Y	1	Yes	Start	0
G1	Y	2	Yes	Start	3
G1	Y	3	Yes	Start	6
G1	Y	4	Yes	Start	9
G1	Y	5	Yes	Start	12

4.1.2. Grid Data

TABLE 3. Grid Systems

Name	Type	Story Range	X Origin m	Y Origin m	Rotation deg	Bubble Size mm	Color
G1	Cartesian	Default	0	0	0	1250	ffa0a0a0

4.2 . Properties

This chapter provides property information for materials, frame sections, shell sections, and links.

4.2.1. Materials

TABLE 4. Material Properties - Summary

Name	Type	E MPa	ν	Unit Weight kN/m³	Design Strengths
HYSD415	Rebar	200000	0	76.9729	Fy=415 MPa, Fu=485 MPa
M25	Concrete	25000	0.2	24.9926	Fc=25 MPa
M30	Concrete	27386.13	0.2	24.9926	Fc=30 MPa

TABLE 5. Material Properties - Concrete								
Name	E MPa	ν	α 1/C	G MPa	Unit Weight kN/m³	Unit Mass kg/m³	Fc MPa	Lightweight?
M25	25000	0.2	5.5E-06	10416.67	24.9926	2548.538	25	No
M30	27386.13	0.2	5.5E-06	11410.89	24.9926	2548.538	30	No

TABLE6. Material Properties - Rebar						
Name	E	α	Unit Weight	Unit Mass	Fy	Fu
	MPa	1/C	kN/m³	kg/m³	MPa	MPa
A615Gr60	199948	1.17E-05	76.9729	7849.047	413.69	620.53

4.2.2 Frame Sections

TABLE 7. Frame Sections – Summary		
Name	Material	Shape
Beam	M25	Concrete Rectangular
Column	M30	Concrete Rectangular
Column 1	M30	Concrete Rectangular

4.3 Loads

This chapter provides loading information as applied to the model.

4.3.1 Load Patterns

TABLE 8. Load Patterns			
Name	Type	Self Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
Eq x	Seismic	0	IS1893 2002
Eq y	Seismic	0	IS1893 2002

Shell load applied = 10 Kn/m

4.4Model (5 storey)

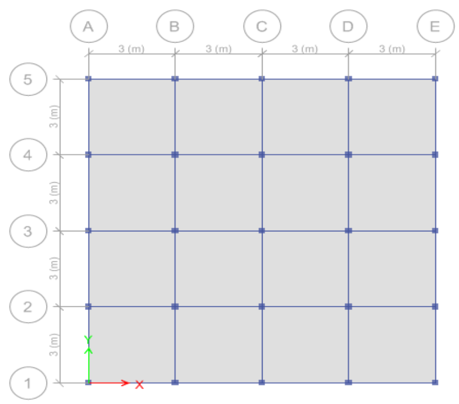


Figure 1. Plan of the structure

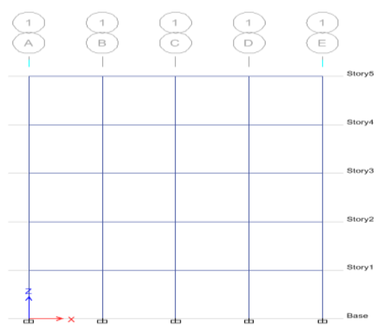


Figure 2. Elevation

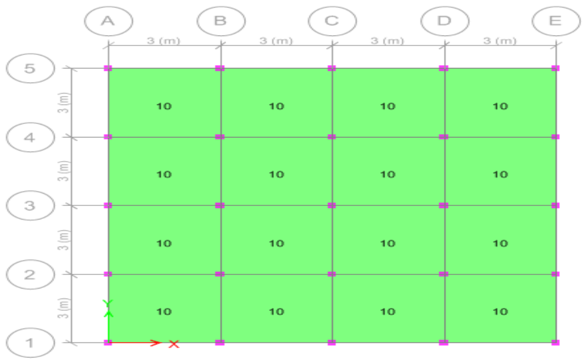


Figure 3. Assign of Loads

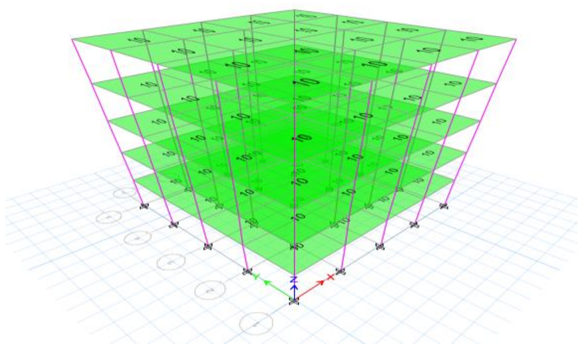
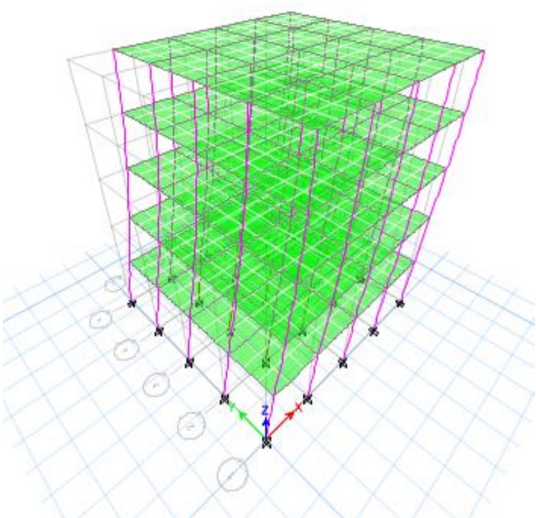
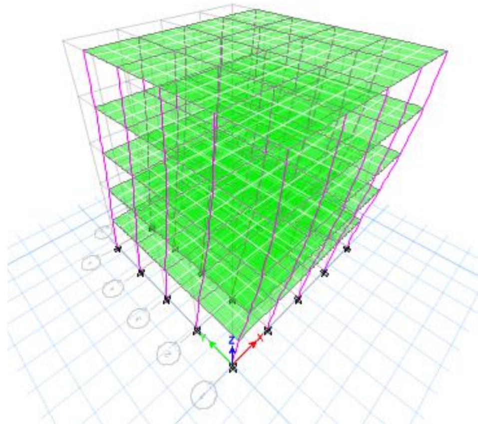


Figure 4. Load assigning

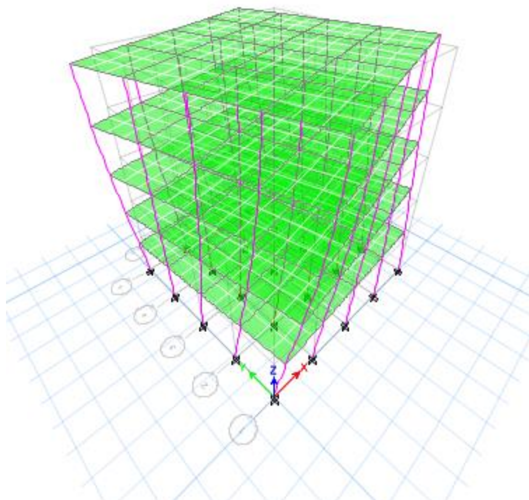
4.4 Mode assigning to the structure



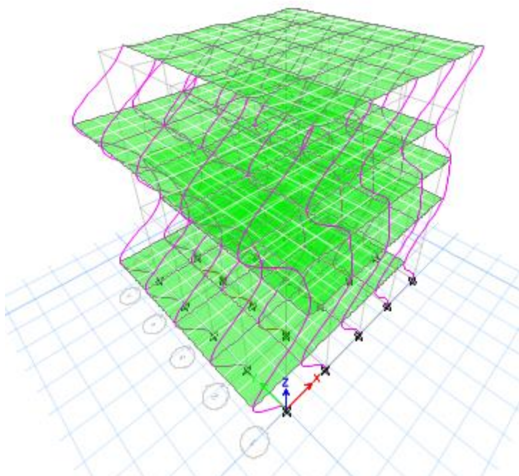
Mode 1



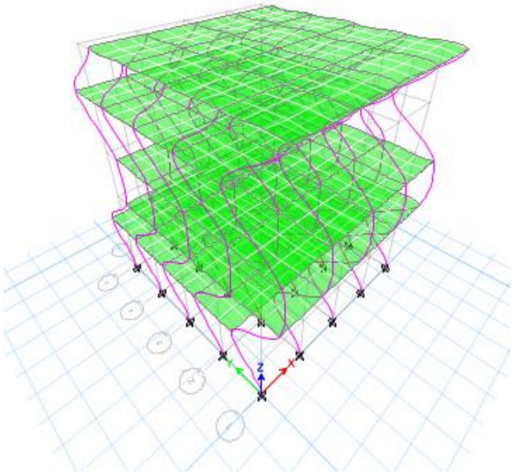
Mode 2



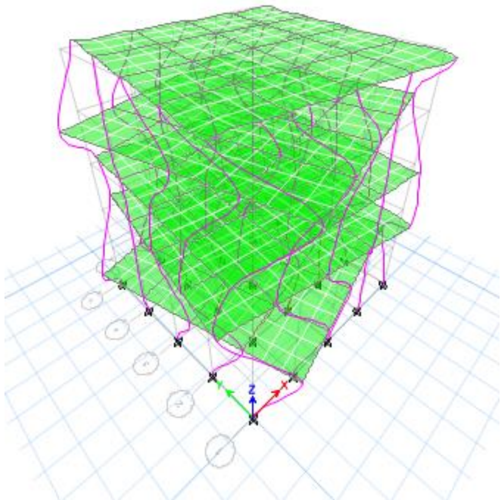
Mode 3



Mode 10



Mode 11



Mode 12

4.5 Response spectrum

4.51 Load patterns

1 Eq x – Seismic – IS 1893 2002
  - Direction – x
  - Seismic zone factor Z – 0.1
  - Site type – II
  - Response reduction factor – 3 (Regular building)

2 Eq y – Seismic – IS 1893 2002
  - Direction – y
  - Seismic zone factor Z – 0.1
  - Site type – II
  - Response reduction factor – 3 (Regular building)

4.5.2.Functions

- Response spectrum
  - Add new Function
    - Function name – Rs
    - Seismic zone z – 0.1
    - Soil type – II

4.5.3Load cases

- Add new case
  - Load case name = Rs x
  - Case type - Response spectrum
  - Load applied
    - Load type –Acceleration
    - Load name – U1
    - Function - Rs
    - Scale factor - 1
- Add new case
  - Load case name = Rs y
  - Case type - Response spectrum
  - Load applied
    - Load type –Acceleration
    - Load name – U2
    - Function - Rs
    - Scale factor - 1

4.5.4 Run analysis

4.5.4.1Display

- Show tables
- Base reactions

4.3. Results

4.3.1. Results (Storey-5) (Joint Acceleration-Input)Plot functions

Tha 1

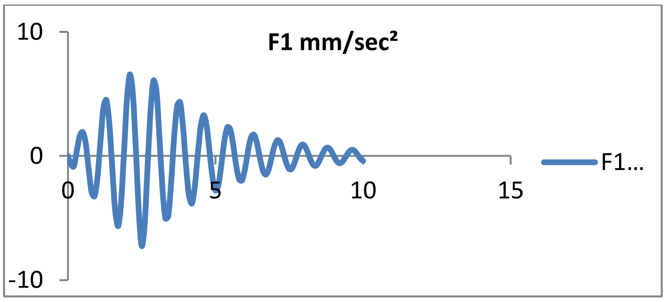


Figure 5. Time history of storey 5

Tha 2

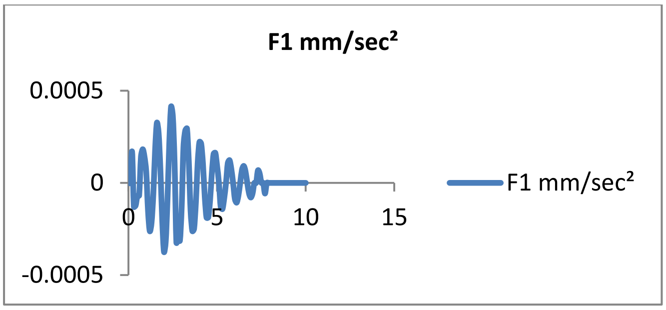


Figure 6. Time history of storey 5

Tha 3

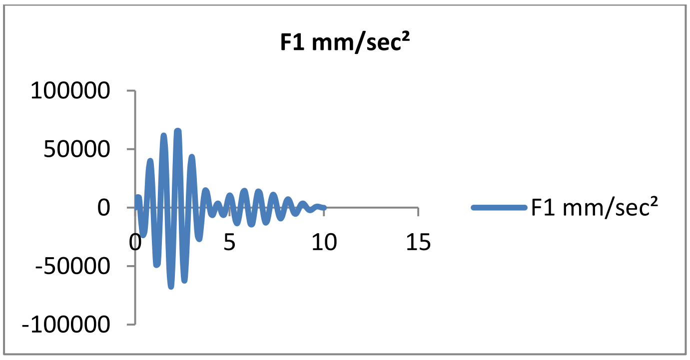


Figure 7. Time history of storey 5

Tha 4

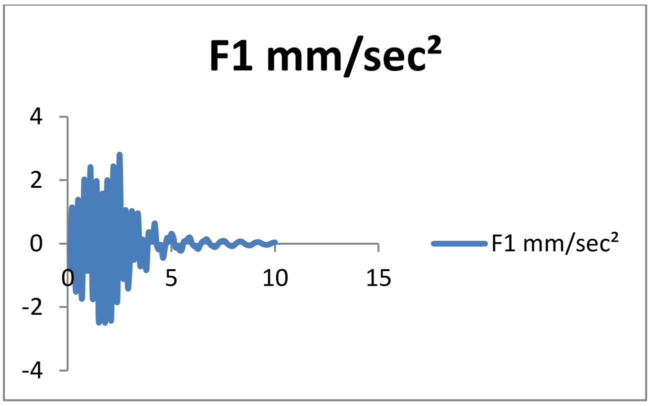


Figure 8. Time history of storey 5

Conclusion

In the present study an investigation has been done to determine the required minimum slab thickness from dynamic serviceability. Minimum slab thickness determination and comparison with slab thickness requirement investigated by Rakib (2013) is done. Floor frequency is dependent to mass of floor as well as the stiffness of the floor system. Increasing mass decreases the frequency and increasing stiffness increases the floor frequency. Floor frequency decreases with increase of span length and floor panel aspect ratio. ACI serviceability limit may not be sufficient for preventing floor vibration while span and aspect ratio is larger.

The current study has some limitations. The results are not sufficient to apply for all type of situations as so many other factors have not been considered. Advancement of current study can be done combining some other variables. The model was considered to be linearly elastic. To be more realistic with the results a finite element analysis with nonlinearly material properties can be performed. The asymmetric floor frames can be studied under the variables considered for symmetric frames. Different number of span and bay other than three can be studied. Study can be carried out for without partition wall load. Effect of result due to floor height change can be another part of study. Vibration effect due to other sources (machinery, traffic) can be studied. Only gravity load on floor is considered in the study

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