IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

THE RESPONSE SPECTRUM ANALYSIS OF MULTISTOREYED BUILDING BY STAADPRO SOFTWARE

[1] Shubham Suresh Desai, [2] Prof. S. R. Suryawanshi, [3] Dr. N.V. Khadake
[1-2-3] Department of Civil Engineering,
[1-2-3]JSPM's Imperial College of Engineering and Research,
Wagholi (Savitribai Phule Pune University), Pune- 412207.

Abstract: A Reinforced Cement Concrete framed structure is a formation of multiple building components such as slabs, beams, columns, and foundations into a single unit. In this type of structure, the transfer of weight occurs sequentially; the beams receive a load from the slabs, then beams give it to the columns, then received it to the lower columns, and ultimately to the foundation. The foundation then transfers the load to the soil. The analysis outputs are applied to validate the structure's accuracy for future use. Nowadays, all types of forces can be calculated by using analysis software. The principal objective of this project is "The Response Spectrum Analysis of Multi-storeyed Commercial Building (G+7) by STAADPRO Software". To design the structure, designers highly recommended the STAADPRO software. In this project, to develop the economic design of the G+7 building through response spectrum analysis Staadpro software is used. Staadpro is the leading design software in present days used by many structural designers. According to the design of IS: 1893 (Part III) seismic design is used to perform the analysis of this structure. The results observed that the multi-storeyed buildings are stiff for earthquake excitation as modal participation.

***Index Terms* - RCC, Staadpro, G+7 Storey, Software, Analysis.**

I. INTRODUCTION

An earthquake can vary in magnitude, ranging from imperceptible tremors to violent events capable of launching objects and people into the air, causing widespread devastation in cities. Seismicity, or the seismic activity of a region, is determined by the frequency, type, and size of earthquakes experienced over time.

With rapid urbanization leading to the construction of numerous multi-storeyed buildings, many existing reinforced concrete (RC) structures in seismic zones are ill-equipped to withstand earthquakes. A significant portion of India is susceptible to high levels of seismic hazards, highlighting the importance of seismic safety in building design, especially for high-rise structures. Seismic loads must be carefully accounted for during the design process to accurately assess the behavior of structures. Past major earthquakes have exposed the shortcomings of buildings, resulting in damage or collapse. Research has shown that buildings with regular shapes tend to perform better during earthquakes. As earthquakes cause the ground to vibrate, structures supported on the ground experience induced motion and inertia forces.

Therefore, analyzing and designing structures according to the Indian seismic code IS 1893 (Part 1) 2002 is crucial. The objective is to design buildings that can withstand earthquakes with an acceptable level of damage without collapsing and impacting lives and livelihoods. Response spectrum analysis, which considers the interaction between ground acceleration and the structural system based on multiple ground motion records, is employed. The design spectrum of IS 1893 (Part 1): 2002 is used for seismic analysis, and the building model is analyzed using STAADPRO software. The lateral loads generated by STAADPRO correspond to seismic zone III and the 5% damped response spectrum specified in IS 1893 (Part 1): 2002.

II. RESEARCH METHODOLOGY

The first stage in the structural design process involves the design of the building structure using specialized software such as ETABS and STAADPRO. In this research, a symmetrical plan for a 7-story reinforced concrete structure is being considered. The design process follows the guidelines provided by the IS1893-2002, Part-1 code for Zone II, which governs earthquake loads. Dynamic analyses are conducted using the response spectrum method, with a damping ratio of 3% and scale factors as specified in the IS code. The material properties are assumed to be linear static, and response spectrum analysis is performed.

2.1 Model Generation:

To create an accurate representation of the building structure, the model is generated using one of three methods: the snap node method, the coordinate method, or copy-paste method. In this research, the copy-paste method is used, as it is the most commonly employed technique for creating structures of any geometry.

2.2 Modeling the Building:

The objective of the model design is to faithfully capture the characteristics of high-rise buildings. Several buildings with the same floor plan dimensions but varying numbers of stories (in this case, 7 stories) are considered for the study. The floor plans are divided into six by four bays, with a center-to-center distance of 3 meters by 3 meters. The height of each floor is assumed to be 3 meters, while the plinth height is 5 meters above the foundation base.

2.3 Assigning Property:

To accurately represent the structural elements, such as beams, columns, and slabs, property dimensions such as width and thickness are assigned using the Property page in the software's toolbar.

2.4 Supports:

There are three types of supports provided to a structure: fixed support, pinned support, and roller support. In the software, options for pinned and fixed supports are available, while roller support can be created by releasing the Fx and Mz components using fixed support.

2.5 Assigning Loads:

The structure is subjected to two main types of loads: dead load and live load. The dead load includes the self- weight of the structure, while the live load consists of superimposed loads. Additionally, wind and seismic forces are taken into account. Definitions for wind and seismic loads are provided, and various load cases are assigned to the structure. These load cases should be entered after the necessary definitions have been provided.

By following this procedure, the structural design process is carried out, ensuring an accurate representation of the high-rise building. The resulting model and analysis can be used to study the behavior and response of the structure under various loads, providing valuable insights for the design and safety assessment of similar structures.

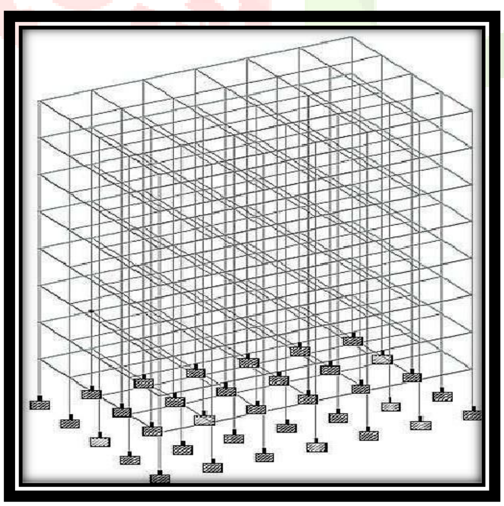


Figure 1. Elevation of the Structure

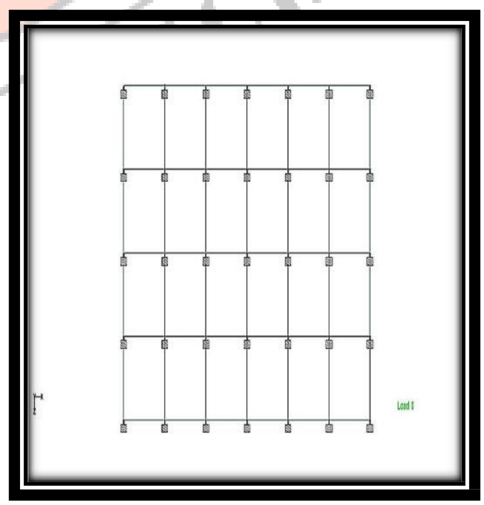


Figure 2. Plan of the Structure

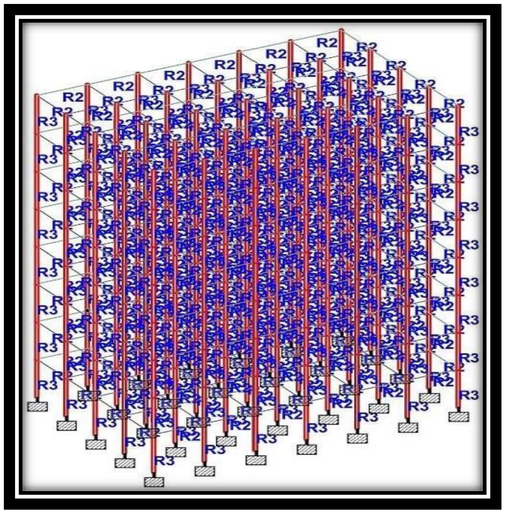


Figure 3. Assigning Columns

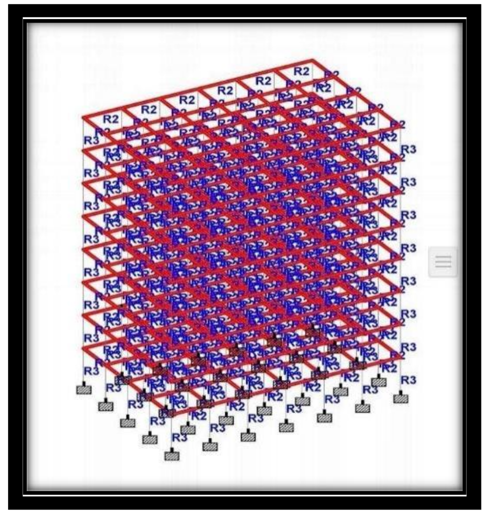


Figure 4. Assigning Beams

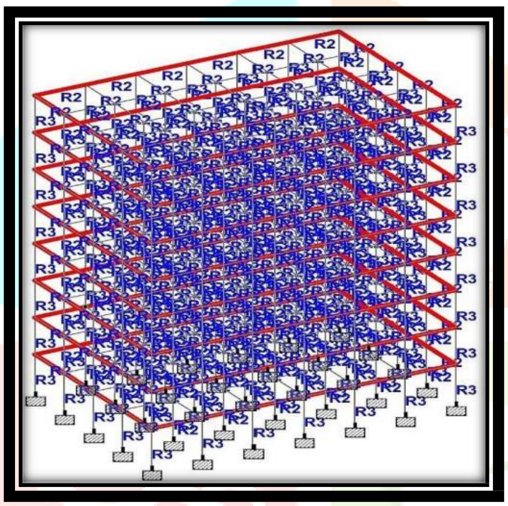


Figure 5. Assigning Plate

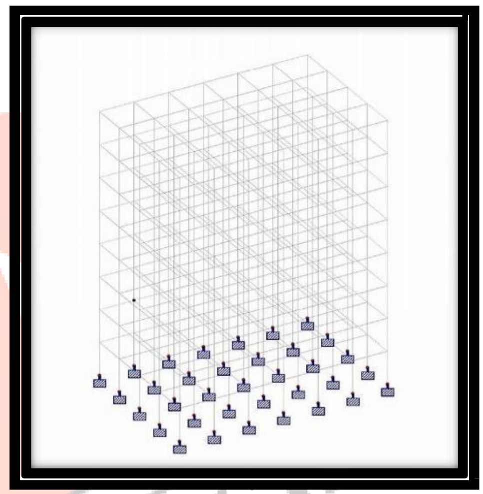


Figure 6. Assigning Fixed Supports

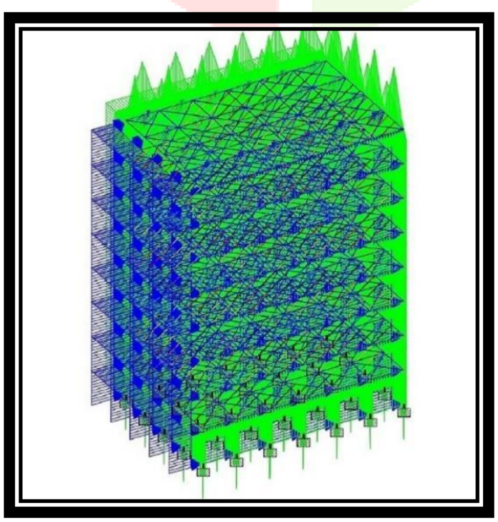


Figure 7. Response Spectrum Analysis

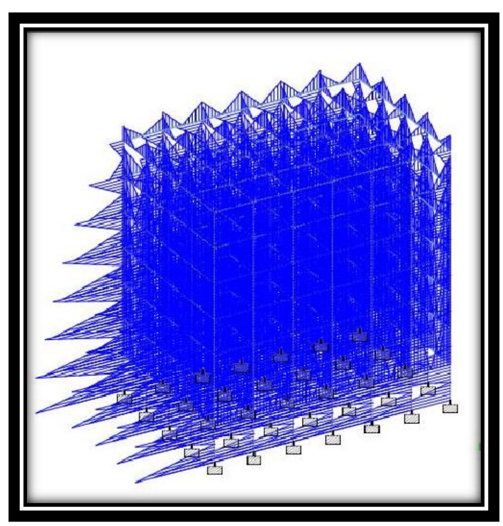


Figure 8. Shear Force Diagram

III. RESULT

The response spectrum analysis in STAAD.Pro yielded the following natural frequencies and corresponding mode shapes for Load Case.

Table No.1 Natural Frequencies

CALCULATED FREQUENCIES FOR LOAD CASE 1

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	1.162	0.86061
2	1.239	0.80726
3	1.272	0.78621
4	3.653	0.27374
5	3.902	0.25630
6	3.921	0.25504

Table No.2 Peak storey shear calculation

STORY	LEVEL IN METE	PEAK STORY SHEAR IN KN	
		X	Z
7	21.00	5268.27	4935.94
6	18.00	10784.03	9846.86
5	15.00	15206.77	13827.20
4	12.00	18735.38	17020.51
3	9.00	21585.38	19566.36
2	6.00	23580.60	21308.96
1	3.00	24392.97	22004.90
BASE	0.00	24392.97	22004.90

Table No.3 Base shear calculation

	MASS PARTICIPATION FACTORS IN PERCENT						BASE SHEAR IN KN		
MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	0.00	0.00	0.00	0.000	0.000	0.000	0.00	0.00	0.00
2	80.38	0.00	0.00	80.385	0.000	0.000	23957.34	0.00	0.00
3	0.00	0.00	80.02	80.385	0.000	80.021	0.00	0.00	21652.94
4	0.00	0.00	0.00	80.385	0.000	80.021	0.00	0.00	0.00
5	10.38	0.00	0.00	90.762	0.000	80.021	4589.40	0.00	0.00
6	0.00	0.00	10.02	90.762	0.000	90.044	0.00	0.00	3919.89
					TOTAL SRSS	SHEAR	24392.97	0.00	22004.90
					TOTAL 10PCT	SHEAR	24392.97	0.00	22004.90
					TOTAL ABS	SHEAR	28546.74	0.00	25572.83
					TOTAL CSM	SHEAR	28546.74	0.00	25572.83
					TOTAL CQC	SHEAR	24392.97	0.00	22004.90

IV. VALIDATION

Peak storey shear calculation

STORY	LEVEL IN METE	PEAK STORY SHEAR IN KN X	PEAK STORY SHEAR IN KN Z
7	21.00	5268.27	4935.94
6	18.00	10784.03	9846.86
5	15.00	15206.77	13827.20
4	12.00	18735.38	17020.51
3	9.00	21585.38	19566.36
2	6.00	23580.60	21308.96
1	3.00	24392.97	22004.90
BASE	0.00	24392.97	22004.90

To calculate base shear, we have considered the following data:
Type of structure- High rise RCC frame structure
Occupancy- office building
Number of storeys-7 Intermediate
storey height-3m
Type of soil- medium soil
Length of Building- 18m
Height of Building-24m
No. of bays along the length- 6
No. of bays Along Height-8
No. of bays along width - 4
Column Size-0.50m × 0.50m
Beam Size-0.35m × 0.35m
Slab Thickness-0.125 m
Dead Load-1 kN/m²
Live Load-3.125 kN/m²
Zone Factor-V (Z=0.36)
Damping Ratio-0.5%

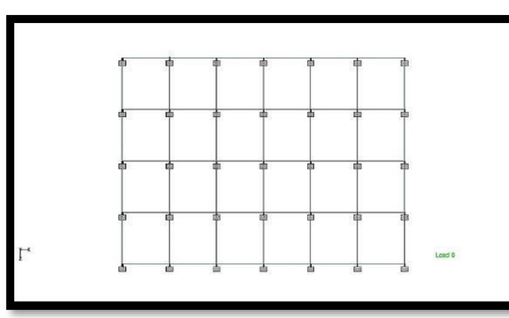


Figure 9. Plan of building

Wall Thickness- 0.23 m
Design life- 50 years
Base Shear= Vb= W* Ah
Where W= Seismic Weight of building
Ah=Z/2*I/R*Sa/g

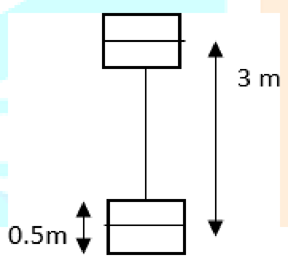
To calculate W: Dead load + Live Load (Slab+Beams+Columns+Wall)

1. **Slab:** Dead Load= Area*Density*thickness

= (18*12) *25*0.25
=675 kN
There are two types of slabs in structure: roof slab and floor slab For roof slab: Floor finish=0.4 kN/m2
DL for roof slab= 0.4 * (18*12)=86.4 kN
Therefore, Total dL for roof slab=675+86.4= 761.4 kN Also, for the floor slab: Floor finish= 0.8 kN/m2
DL for floor slab= 0.8* (18*12) =172.8 kN
Therefore, Total dL for floor slab=675+172.8= 847.8 kN

1. **Beams:**

Size of beam=0.35m*0.35m
Self-weight of beam=0.35*0.35*1(per unit length) *25
=3.0625 kN/m length
Length of beam
Transverse beam Longitudinal beam
Length of transverse beam= 3-(0.25)2=2.9375m   Length of longitudinal beam= 3(0.25)2=2.9375m



There are 28 beams in the transverse direction and 30 beams in the longitudinal direction. Therefore, the length of the beam along the transverse direction = 28*2.9375=82.25 m
Self-weight of transverse beam= 82.25*3.0625= 251.89 kN.
Similarly, the length of the beam along longitudinal direction=30*2.9375=87.9m
Therefore, the self-weight of longitudinal beams=87.9*3.0625=269.19 kN.
So, the total self-weight of beam= 251.89+269.19=521.08 kN

2. **Wall:**

Self-weight= Thickness*Density of brick*1 (Considering unit height)
=0.23*20*1
=4.6 kN/m per meter length per meter height
Length of a wall along the transverse and longitudinal directions.
For transverse direction:
For one wall :3-(0.25)2=2.9375m
For total wall: 2.9375*28= 82.25m
Therefore, self-weight of transverse wall= 4.6*82.25=378.35 kN/m for per meter height
For Longitudinal direction:
For one wall :3-(0.25)2=2.9375m
For total wall: 2.9375*30= 88.125m
Therefore, the self-weight of the longitudinal wall=4.6*88.125=405.375kN/m per meter height.

3. **Columns:**

Self-weight= Size of column* Density * No. of columns
=0.50*0.50*25*35
=218.75 kN/m

4. **To calculate seismic load** Live load on the roof= 0 Live load on floor slab=50% (L.L.>3 kN/m2) Therefore, Live load = 0+0.5*(3.125)

LL on roof slab =1.5625 kN/m2

5. **To calculate seismic load** Live load on the roof= 0
Live load on floor slab=50% (L.L.>3 kN/m2)
Therefore, Live load = 0+0.5*(3.125)
LL on roof slab =1.5625 kN/m2

6. **Lumped mass:**

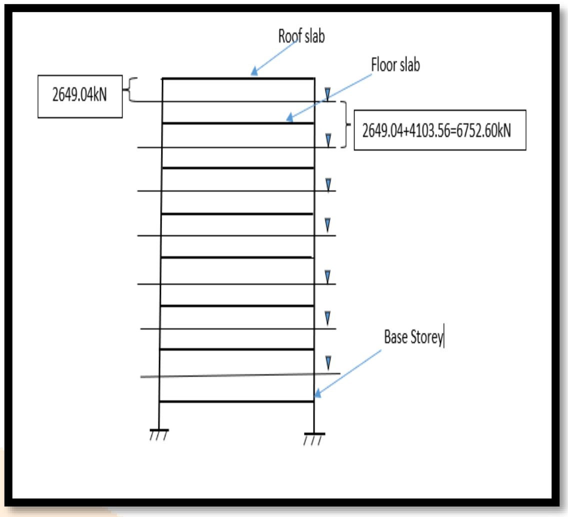


Figure 10. Lumped mass: transfer of seismic weight from center to center of storey

7. **The total load on the roof slab**
= DL on the roof slab +LL on the roof slab
=Weight on roof slab+ Self weight of beam+ self-weight of column +Self weight of wall+ LL on roof

Here, For column height: storey height/2 = 3/2= 1.5 m
For the height of the wall: (Storey height-half width of beam-half width of the beam)/2
= (3-0.35/2-0.35/2)/2
=1.325 m
Therefore, TL on the roof slab=
761.4+521.08+(218.75*3/2) + [(378.35 +405.375) *1.325] +0
=2649.04 kN

8. **Also, total load for floor slab**= DL on the floor slab +LL on the floor slab
= Weight on floor slab+ Self weight of beam+ self-weight of column +Self weight of wall+ LL on floor Here, For column height: storey height/2+ storey height/2= 3/2+3/2= 3 m
For height of wall: [(3-0.35)/2] *2=2.65 m
Total load for floor slab=847.8+521.08+(218.75*3) + [(378.35 +405.375) *2.65] +1.5625
=4103.56 kN
Therefore, the total seismic weight of each floor=6752.60+(4103.56*5)
W=27270.4 kN
Now to calculate Ah,
Ah=Z/2 * I/R* Sa/g ……. (IS 1893: 2016 Cl.No.6.4.2)
Where, Z= Zone factor= 0.36 (Building is in V zone)
I= Importance factor=1 …. (IS 1893:2016 table no.6)
R=Response reduction factor= 5 … (Special RC moment-resisting frame i.e., SMRF - IS 1893:2016 table no.7)
According to the table for Sa/g,
T=0.09h/√d where h= height of building= 24 m
d = length of direction along which seismic effect occurs Therefore, for x direction: d=18 m
Therefore, time period T= 0.09*24/√18= 0.509
From the spectral acceleration coefficient graph value of Sa/g for 0.509 time period = 2.5 Ah= Z/2*I/R*Sa/g
=0.36/2*1/5*2.5
Ah =0.9
Therefore, base shear force along x direction Vb= W*Ah
=27270.4*0.9
Vb=24543.36 kN
Similarly, for z-direction: d=12 m
Therefore, time period T= 0.09*24/√12= 0.623
From spectral acceleration coefficient graph value of Sa/g for 0.623 time period = 1.36/T = 1.36/0.623=

2.182
Ah= Z/2*I/R*Sa/g
=0.36/2*1/5*2.18
Ah =0.78
Therefore, base shear force along z direction Vb= W*Ah
=27270.4*0.78
Vb=21270.912 kN
Now comparing with base shear values from staadpro software calculation
it is observed that the values for both x and z directions are approximately the same as the values calculated manually. It states that the results from staadpro are validated with manual calculation.

V. CONCLUSION

The reinforced concrete structure of the building is designed, and a response spectrum analysis is conducted. The analysis provides us with information about the displacement, shear force, and bending moment at each story of the structure.

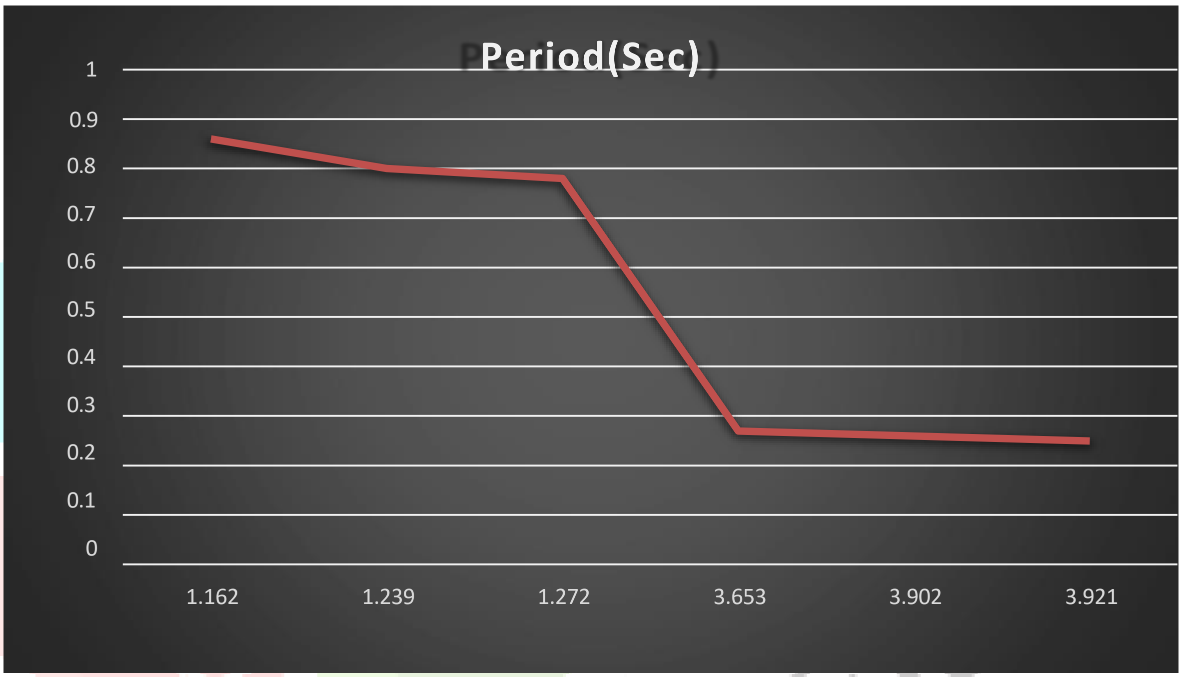


Figure 11. Graph Showing Frequency vs Period

Figure 11 illustrates a graph depicting the relationship between frequency and period. It can be observed that as the time increases, the frequency decreases. This indicates an inverse proportionality between frequency and time. The building R.C.C. structure is designed and Response Spectrum analysis is performed.

VI. ACKNOWLEDGMENT

I would like to express my sincere gratitude to all the individuals and organizations that have contributed to the publication of this research paper. Also, I would like to thank my family and friends for their encouragement and support throughout the research process.

VII. FUNDING

The authors did not get any financial support for this research of article, authorship and publication.

REFERENCES

[1] Dr. Dubey S.K, Sangamnerkar P., Agrawal A., 2015. Dynamics Analysis of Structures Subjected to Earthquake Load. International Journal of Advance Engineering and Research Development, 2(9).

[2] IS 875:1987 (Part 2) Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Part 2 Imposed Loads, Second Revision, Bureau of Indian Standard, New Delhi, India.

[3] Rampure A., Mangulkar M. N., 2016. Comparison Between Response Spectrum and Time History Method of Dynamic Analysis of Concrete Gravity Dam. Open Journal of Civil Engineering, 6**:** 329-334.

[4] IS: 456:2000, Code of Practice for Plain and Reinforced Concrete. Bureau of Indian Standard, New Delhi, India.

[5] PATIL M., N., Sonavane Y., march 2015. Seismic Analysis of Multi-storeyed Building. International Journal of Eng. And Innovative Technology. ISSN: 2277-3754, 4(9).

[6] Pardeshi S., Jan 2016**.** Study of Seismic Analysis and Design of Multistorey Symmetrical and Asymmetrical Building, International Research Journal of Engg. And Technology. ISSN:2395-0056,03(1).

[7] Gottala, a., Kintali K., Dr. Shaik Yajdhani, July 2015. Comparative Study of Static and Dynamic Seismic Analysis of A Multistoried Building. IJSTE - International Journal of Science Technology & Engineering, 2(1).

[8] Vinayak Kulkarni, Swapnil Cholekar, Hemant Sonwadekar, June 2014**.** Effect of Openings of Shear Wall in High Rise Buildings. International Journal of Applied Science and Engineering Research, 3(4).

[9] Maison Bruce F. and Ventura Carlos E. DYNAMIC ANALYSIS OF THIRTEEN-STORY BUILDIN. Journal of Structural Engineering, 117(12).

[10] Arlekar Jaswant N, Jain Sudhir K., and Murty C.V.R 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.

[11] Awkar J. C. and Lui E.M., 1997. Seismic analysis and the response of multistorey semirigid frames. Journal of Engineering Structures, 21(5): 425-442.

[12] Bardakis V.G., Dritsos S.E. 2007. Evaluating assumptions for seismic assessment of existing buildings. Soil Dynamics and Earthquake Engineering: 223–233.

[13] Sukumar Behera May 2012. Seismic analysis of multistorey building with Floating Column. Department of Civil Engineering NIT, Rourkela- 769008.

[14] S.K. Shama Banu and G. Shahani Priyanka 2015. Study of behavior of Seismic Evaluation of Multi-storeyed Building with Floating Column. Journal of Computer Engineering in Research Trends, 2(12).

[15] Badgire Udhav S and Shaikh A.N. 2015. Analysis of Multistorey Building with Floating Column. Journal of Engineering Research, 4(9).

[16] Srikanth M.K, 2014. Seismic Response of Complex Buildings with Floating Column for Zone II AND Zone V. International journal of engineering research online, 2(4).

[17] Nakul A. Patil, 2016. Comparative Study of Floating and Non- Floating Columns with and Without Seismic Behavior. International Conference on Science and Technology for Sustainable Development (ICSTSD).

[18] S.B. Waykule, Dr. CP Pise and C.M. Deshmukh, 2016. Study of behavior of floating column for seismic analysis of multistorey building. Journal of Civil Engineering and Technology, 7(6).

[19] Saurabh G Lonkar and Prof. Riyaz Sameer Shah Dec 2015. Comparative Study of Static and Dynamic Analysis of Multi Storey Regular and Irregular Building. International Jouranl of Research in Engineering Science and Technologies. (IJRESTs),1(8).

[20] Ranjit V surve, Prof. D. S. Jagatap and Prof. Y. P. Pawar April 2015.
Performance Based Analysis of Multistoried Building with Soft Story at Different Levels. International Journal of Engineering, Research and Technology, 4(4).
[21] Prof Swapnil B. Cholekar and Basavalingappa S.M July 2015.
Comparative analysis of multistoried RCC and Composite building due to mass irregularity. International Research Journal of Engineering and Technology (IRJET), 2(4).
[22] Cinthia, P. K. Umesha, Nagesh R Iyer and N Lakshmanan Dec 2015. Performance Based Seismic Evaluation of RC Framed Building. The Institution of Engineers (India), 96(4): 285-294.

[23] Prof. Sakthi A. Manchalwa, Akshay S.Puri and Vishakha Aswale April 2016. comparative study of analysis and design of RC frame. International Journal of Science, Engineering and Technology Research (IJSETR).

[24] B K Raghu prasad, Vinay S, Amarnath K May 2016. Seismic Analysis of Building Symmetric and Asymmetric in Plan. SSRG International Journal of Civil Engineering (SSRG-IJCE).

[25] Prof. Keerthi Gowda B.S, Mr. Syed Tajoddeen **,** May 2014. Seismic Analysis of Multistory Building with Floating Columns. 1st annual conference on innovations and developments in civil engineering**.**

[26] Ms. Priyanka D. Motghare, 2016. Numerical Studies of Rcc Frame with Different Position of Floating Column. Technical Research Organization India, 2(1): ISSN 2395-7786.

[27] Sharma R. K, Dr. Shelke N. L. 2016. Dynamic Analysis of RCC Frame Structure with floating Column. International Journal of Advanced Research in Science, Engineering and Technology.,03(06): (ISSN 2350-0328)

[28] Ms. Waykule. S. B, Dr.C.P. Pise, Mr. C.M. Deshmukh, Mr. P. Pawar, Mr. S. S Kadam, Mr. D. Mohite, Ms.S.V. Lale, 2017. Comparative Study of floating column of multi storey building by using software. International Journal of Engineering Research and Application, 07(1): (ISSN 2248).