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Study of Correlation between Period of Vibration and Height of Building for R. C. and Steel Frame Building

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Abstract: Response spectrum analysis is a method to estimate the structural response to short, non deterministic, transient dynamic effect. Example, of such events are earthquakes and shocks. Since exact time history of load is not known, it is difficult to perform time-dependent analysis. Dynamic loads are loads which changes with time fairly quickly in Comparision to structures natural frequency. Response spectrum method is based on special type of mode superposition. The idea is to provide an input that gives a limit to how much an Eigen mode having a certain natural frequency and damping can be excited by an event of this type. The response spectrum is a function of natural frequency of oscillator and of its damping. In this paper we will find out the relations between Height of building and Displacement, Height of building and period of vibrations.

Keywords-Storey, Height of Structure, Time Period, Response spectrum analysis, Slenderness Ratio, Coupling Effect.

I. Introduction

An earthquake (also known as a quake, tremor or temblor) is the shaking of the surface of the Earth resulting from a sudden release of energy in the earth's lithosphere that creates seismic waves. Earthquakes can range in size from those that are so weak that they cannot be felt to those violent enough to propel objects and people into the air, and wreak destruction across entire cities. The seismicity, or seismic activity, of an area is the frequency, type, and size of earthquakes experienced over a period of time. The word Tremor is also used for non-earthquakeseismic rumbling. At the Earth's surface, earthquakes manifest themselves by shaking anddisplacing or disrupting the ground. When the epicentre of a large earthquake is located offshore,the seabed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger volcanic activity.

In its most general sense, the word Earthquake is used to describe any seismic event—whether natural or caused by humans, generates seismic waves. Earthquakes are caused mostly by ruptureof geological faults but also by other events such as volcanic activity, landslides, mine blasts,and nuclear test. An earthquake's point of initial rupture is called its focus. The Epicentre is the point at ground level directly above the hypocenter.

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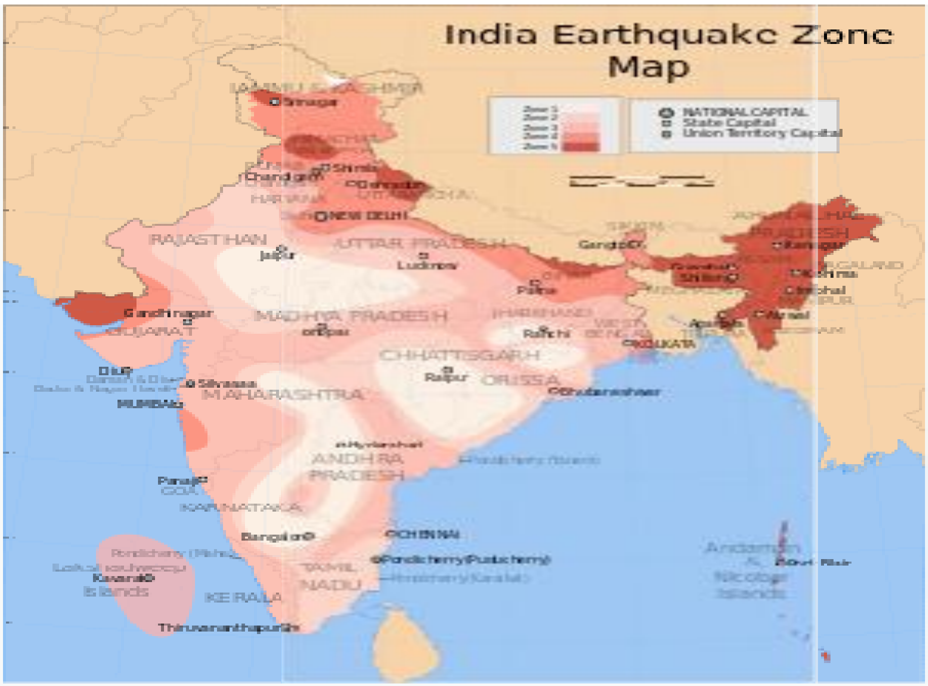

Earthquake Zones in India

The Indian subcontinent has a history of devastating Earthquake. The major reason for the high frequency and intensity of the earthquakes is that the Indian plate is driving into Asia at a rate of approximately 47 mm/year. Geographical statistics of India show that almost 54% of the land is vulnerable to earthquakes. A World Bank and United Nation report shows estimates that around 200 million city dwellers in India will be exposed to storms and earthquakes by 2050.[2] The latest version of seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2002] assigns four levels of seismicity for India in terms of zone factors. In other words, the earthquake zoning map of India divides India into 4 seismic zones (Zone 2, 3,

4 and 5) unlike its previous version, which consisted of five or six zones for the country.

According to the present zoning map, Zone 5 expects the highest level of seismicity whereasZone 2 is associated with the lowest level of seismicity.

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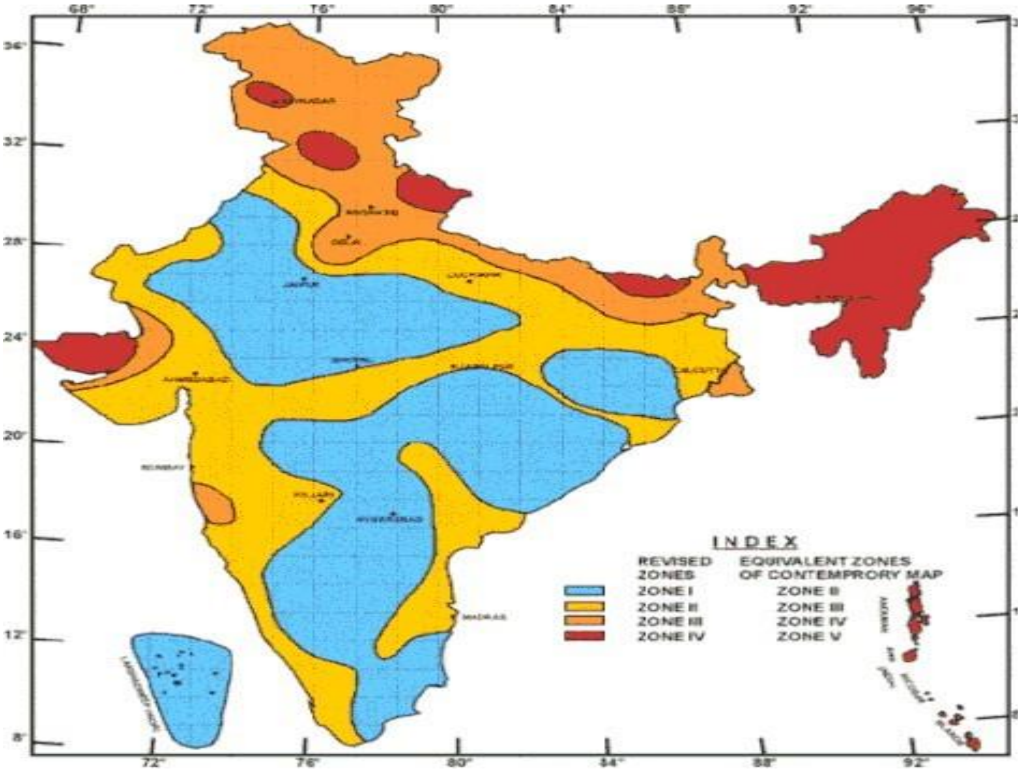

Zone 5

Zone 5 covers the areas with the highest risk of suffering earthquakes of intensity MKS IX or greater. The IS code assigns a zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 (the maximum horizontal acceleration that can be experienced by a structure) is indicative of effective (zero period) level earthquakes in this zone. It is referred to as the Very High Damage Risk Zone.

Zone 4

This zone is called the High Damage Risk Zone and covers areas liable to MSK VIII. The IS code assigns a zone factor of 0.24 for Zone 4. In Bihar the northern part of the state near the border of India and Nepal, is also in Zone 4.

Zone 3

This zone is classified as a Moderate Damage Risk Zone which is liable to MSK VII. The IS code assigns a zone factor of 0.16 for Zone 3. Several Megasites like Mumbai, Chennai lie in thiszone.

Zone 2

This region is liable to MSK VI or lower and is classified as the Low Damage Risk Zone. The IScode assigns a zone factor of 0.10 for Zone 2.

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Zone 1

Since the current division of India into earthquake hazard zones does not use Zone 1, no area of India is classed as Zone 1.Future changes in the classification system may or may not return this zone to use.

Response Spectrum Analysis

A response spectrum is a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency, that are forced into motion by the same base vibration or shock The resulting plot can then be used to pick off the response of any linear system, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes. The science of strong ground motion may use some values from the ground response spectrum (calculated from recordings of surface ground motion from seismographs) for correlation with seismic damage.

If the input used in calculating a response spectrum is steady-state periodic, then the steady-state result is recorded. Damping must be present, or else the response will be infinite. For transient input (such as seismic ground motion), the peak response is reported. Some level of damping is generally assumed, but a value will be obtained even with no damping.

Response spectra can also be used in assessing the response of linear systems with multiple modes of oscillation (multi-degree of freedom systems), although they are only accurate for low levels of damping. Modal analysis is performed to identify the modes, and the response in that mode can be picked from the response spectrum. These peak responses are then combined to estimate a total response. A typical combination method is the square root of the sum of the squares (SRSS) if the modal frequencies are not close. The result is typically different from that which would be calculated directly from an input, since phase information is lost in the process of generating the response spectrum.

The main limitation of response spectra is that they are only universally applicable for linear systems. Response spectra can be generated for non-linear systems, but are only applicable to systems with the same non-linearity, although attempts have been made to develop non-linear seismic design spectra with wider structural application. The results of this cannot be directly combined for multi-mode response.

Response spectra are very useful tools of Engineering for analyzing the performance of structures and equipment in earthquakes, since many behave principally as simple oscillators. Thus, if you can find out the natural frequency of the structure, then the peak response of the building can be estimated by reading the value from the ground response spectrum for the appropriate frequency.In most building codes in seismic regions, this value forms the basis for calculating the forces that a structure must be designed to resist Seismic analysis.

As mentioned earlier, the ground response spectrum is the response plot done at the free surface of the earth. Significant seismic damage may occur if the building response is 'in tune' with components of the ground motion, which may be identified from the response spectrum. This was observed in the 1985 Mexico City Earthquake where the oscillation of the deep-soil lake bed was similar to the natural frequency of mid-rise concrete buildings, causing significant damage. Shorter (stiffer) and taller (more flexible) buildings suffered less damage.

Slenderness Ratio

The slenderness ratio of a wall is defined as a function of the effective height divided by either effective thickness or the radius of the gyration of the wall section. It is highly related to the slenderness limit that is the cut-off between elements being classed "slender" or "stocky". Slender walls are vulnerable to buckling failure modes, including Euler in-plane buckling due to axial compression, Euler out-of-plane buckling due to axial compression and lateral torsional buckling due to bending moment. In the design process, structural engineers need to consider all these failure modes to ensure that the wall design is safe under various kinds of possible loading conditions.

Coupling Effect on Shear Wall

In actual structural systems, the shear walls may function as a coupled system instead of isolated walls depending on their arrangements and connections. Two neighboring wall panels can be considered coupled when the interface transfers longitudinal shear to resist the deformation mode. This stress arises whenever a section experiences a flexural or restrained warping stress and its magnitude is dependent on the stiffness of the coupling element. Depending on this stiffness, the performance of a coupled section will fall between that of an ideal uniform element of similar gross plan cross-section and the combined performance of the independent component parts. Another advantage of coupling is that it enhances the overall flexural stiffness dis- proportionally to shear stiffness, resulting in smaller shear deformation.

II. Review of Literature

Markanday Giri, Sagar Jamle, “Response Spectrum Analysis Over Flat Slab Shear Wall Interface”. In this paper flat slab is designed with the help of D.D.M, E.F.M, and finite element method. Correlation with analysis by software with these above building cases could be done. Various cases which are not shown by various researchers such as plain flat slab, flat slab, flat slab inclusive of with its interaction to flat slab could be used for further technical work. Response spectrum method could be used in these cases for determining seismic response over the structural parts.

Thribhuvan Gowda K P, Kavan M R, “Response spectrum analysis of Multiutility Building”. when a structure is subjected to earthquake, it responds by vibrating. An earthquake force can be resolved into three mutually perpendicular directions-the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure

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to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. The supporting soil influences the behavior of the structure due to its ability to deform. The response of the structure with fixed foundation has been done in this study. The objectives of the present work is to study the behavior of a multi storied R C building irregular in plan subjected to earth quake load at different Soil condition by adopting Response spectrum analysis. The present study is limited to reinforced concrete (RC) building with four different zones II, III, IV and V and three different soil I, II and III. The building model in the study has six storey with constant storey height of 3mand foundation of 1.5m height. The analysis is carried out with the help of FEM software.

M. Nuray Aydinoglu, "A Response Spectrum- Based Nonlinear Assessment Tool For Practice: Incremental Response Spectrum Analysis (IRSA)". Response Spectrum Analysis (RSA) procedure has become a standard analysis tool in traditional strength-based design of buildings and bridges under reduced seismic loads. RSA has been recently extended to estimate nonlinear seismic demands. The Incremental Response Spectrum Analysis (IRSA) procedure is based on a straightforward implementation of RSA at each piecewise linear incremental step in between the formation of consecutive plastic hinges. The practical version of IRSA works directly with smoothed elastic response spectrum and makes use of the well-known "equal displacement rule" to scale modal displacement increments at each piecewise linear step. IRSA can be characterized as an adaptive multi-mode pushover procedure, in which modal pushover analyses are simultaneously performed for each mode at each incremental step under appropriately scaled modal displacements followed by an application of a modal combination rule. Examples are given to demonstrate the practical implementation of IRSA.

III. Software Used

STAAD PRO V8i SS6

IV. DETAILING

1) Size of Beam - 0.23X0.3 mt.

2) Plate Thickness - 0.12 mt.

3) Surface Thickness - 0.12 mt.

4) Support - Fixed

5) SIESMIC DETAIL:

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1 Code - IS 1893- 2002/2005

2 Zone/(Z) - V/(0.36)

3 Response reduction factor(R) - 5

4 Importance factor(I) - 1

6) Soil Class - Medium

7) Ceiling Plaster - 0.55 kn/m^2

8) Flooring (Tile) - 0.45 kn/m^2

9) Flooring (Screeding) - 0.5 kn/m^2

10) Height of each floor - 3 mt

11) Length of each bay in X direction - 3 mt

12) Length of each bay in Y direction - 3 mt

V. Calculations

1) Live Load on Floor = 0.12 x 25 = 3 Kn/m^2

2) Dead load on Floor = 3+ 0.55+0.45+0.5 = 4.5 Kn/m^2

3) Self weight of beam = 0.23 x 0.3 x 25 = 1.725 Kn/m

4) Pressure of shear wall surface = 0.12 x 25 = 3 kn/m^2

5) Pressure of plate element = 0.12 x 25 = 3 kn/m^2

6) Value in X direction = $(Z/2)$ X (I/R) = 0.036

(For R.S.A. Method)

VI. Values for Time Period and Node Displacement

SR NO.	BAY	FLOOR	LxWxH	TIME PERIOD (R.C. FRAME)	TIME PERIOD (STEEL FRAME)	C.G. NODE DISPLACEMENT
1	3X3	G+4	9X9X15	0.57165	0.64786	1.162
2	3X3	G+5	9X9X18	0.65541	0.74280	2.585
3	3X3	G+6	9X9X21	0.73574	0.83384	4.105
4	3X3	G+7	9X924	0.81324	0.92167	5.761
5	3X3	G+8	9X9X27	0.88835	1.00679	7.837
6	3X3	G+9	9X9X30	0.96140	1.08958	10.176

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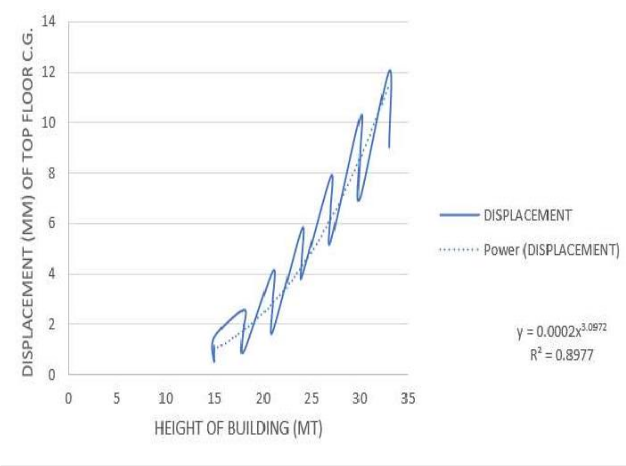
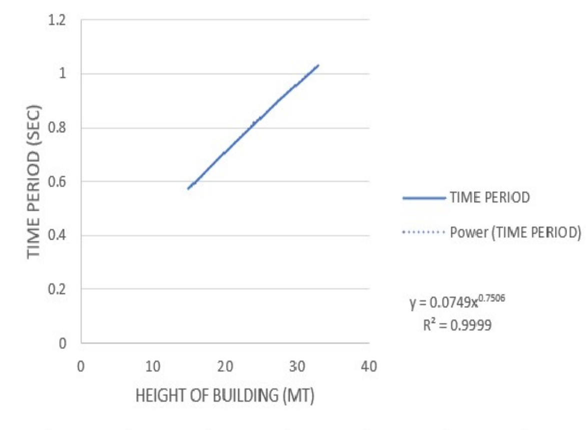
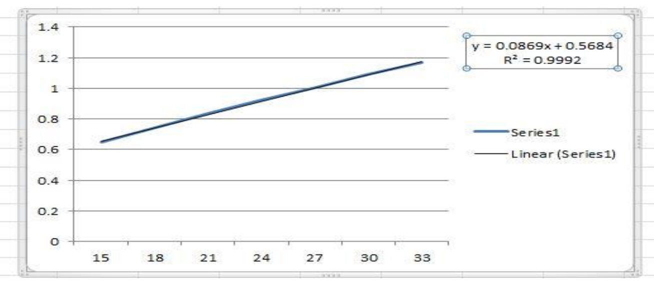
7	3X3	G+10	9X9X33	1.03263	1.17031	12.043
8	4X4	G+4	12X12X15	0.57165	0.64786	1.003
9	4X4	G+5	12X12X18	0.65541	0.74280	1.936
10	4X4	G+6	12X12X21	0.73574	0.83384	2.973
11	4X4	G+7	12X12X24	0.82134	0.92167	4.494
12	4X4	G+8	12X12X27	0.88835	1.00679	6.5
13	4X4	G+9	12X12X30	0.96140	1.08958	8.764
14	4X4	G+10	12X12X33	1.03263	1.17031	9.034
15	5X5	G+4	15X15X15	0.57165	0.64786	1.010
16	5X5	G+5	15X15X18	0.65541	0.74280	1.947
17	5X5	G+6	15X15X21	0.73574	0.83384	2.776
18	5X5	G+7	15X15X24	0.81324	0.92167	3.874
19	5X5	G+8	15X15X27	0.88835	1.00679	5.302
20	5X5	G+9	15X15X30	0.96140	1.08958	7.023
21	6X6	G+4	18X18X15	0.57165	0.64786	0.544
22	6X6	G+5	18X18X18	0.65541	0.74280	0.934
23	6X6	G+6	18X18X21	0.73574	0.83384	1.731
24	7X7	G+4	21X21X15	0.57165	0.64786	1.5

VII. Graph





HEIGHT VS DISPLACEMENT GRAPH
HEIGHT OF BUILDING VS TIME PERIOD



HEIGHT OF BUILDING VS TIME PERIOD(STEEL WALL)

VIII. Conclusion

1) We have got values of time period and displacement for all buildings.

2) We have plotted graph of 'HEIGHT VS DISPLACEMENT' and 'HEIGHT VS TIME PERIOD'.

3) We have also got the equation for HEIGHT VS TIME PERIOD as "$\mathbf{Y= 0.0749X^{0.7506}}$"

4) Equation for HEIGHT OF BUILDING VS DISPLACEMENT is "$\mathbf{Y = 0.0002X^{3.0792}}$."

5) We have also got the equation for HEIGHTVS TIME PERIOD as **"Y= 0.0869X + 0.5684".(STEEL FRAME)**

6) As height of building increases, displacement also increases.

7) As height of building increases, time period also increases.

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