ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

Seismic Evaluation of Reinforced Concrete Frame Structure based on Zone and Soil Type

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***Abstract:*— Analysis of reinforced concrete structure is very essential in civil engineering structures. As the advancement in various fields, various software and advance technique are used in analysis and design of RCC buildings. The aim of structural design is to design a structure so that it suffices its intended purpose during its intended lifetime with adequate safety (in terms of strength, stability and structural integrity) and economy. For the analysis of structure various load cases are considered. Such as dead load, live load, earthquake load, wind load. The analysis results depend on the load combinations. In olden age, most of the structure are analysed for gravity loads such as dead load and live load and designed based on the results obtained. Since last decades India is subjected to many earthquake shocks varies for small to moderates. To check the effect of change in soil type and the zone, the seismic analysis is carried out. Analysis results are presented in this paper which shows the variation in lateral forces on structure is depending on the zone & soil type.**

***Key word:*-- Dead load, Live load, Load combination, Earthquake, Seismic Analysis, Lateral forces**

I. INTRODUCTION

Need for evaluating the seismic forces on the structure come into focus in India after Bhuj Earthquake in 2001.Prior to that most of the structures are analyzed for gravity load and designed for the gravity loads. Earthquake exerts the lateral forces on structure which causes increase in stresses, shear forces and bending moment along with alteration in the nature of stresses at different points. Bracci Reinhorn and Mander (1995), investigated the behavior of the gravity load designed (GLD) reinforced concrete frame structure subjected to seismic motion. For experimental and analytical study, a three storey 1:3 scale model was constructed with strength and reinforcing details with current non-seismic provisions of ACI-318-89.The model was tested using earthquake representing minor-moderate earthquake zones. Another paper by Chandler and Nelson (2001), present the codified procedures for seismic design, developed over last 40 years. This has been supported by wide-range, multi-disciplinary research in the field of engineering seismology and geology, engineering seismology, soil dynamics, system dynamics and mechanics of material. Chandrashekaran etal (2002), discuss the effect of poor planning and construction practices of multi-storeyed buildings in India. Also it presented the variation in the Base Shear for structure as per IS 1893:1984 and IS 1893:2002.

Uma and Meher (2004), discussed about the modelling aspect of beam column joint to capture the shear effect within panel zone and some salient feature is given. Reinforced concrete building is design as per IS code, hence many existing reinforced concrete building may not comfort without using current code of earthquake to give lateral strength and ductility. Gravity load carrying capacity and lateral load strength in reinforced concrete frame structure preserve earthquake action. In Binici and Ozcebe (2006), the failure modes and measured deformation limit obtained from the large data base of experiment, a diagonal compression strut and tension tie model is developed the model is verified with a number of reinforced concrete frame.The performance based seismic evaluation method of one storey and multistorey building are represented in Ozaki and Azahata (2008). Several level of strong earthquake ground motion can be developed using shear and torsion strength capacity ratio in X and Z direction in urban area. Cinitha etal (2012), discussed about the different seismic zone map of Indian subcontinent emphasis that more than 60% of land is under severe in moderate earthquake and approximate habitat requirement is 20-25 lakhs of building in each year. Priyaranjan (2012), represent various method of seismic evaluation are discussed and also analysis of the performance of structure in different zone and soil condition are studied. The aim is to study the seismic analysis of existing building located in seismic different zone by using the method of evaluation. Indian standard IS 1893-2002 (part1) is followed for the equivalent static analysis and response spectrum method analysis procedure. The building is modelled in commercial software by using STAAD-PRO, SAP and STRUD seismic force demand for each individual member is calculated for the design base shear as required by IS 1893-2002 (part1). Sabu and Pajgade (2012), discuss most of the engineering structure greatest damages due to the earthquake. India has largest number of earthquakes in last century. More than 50% of area of country is suffer from damaging earthquakes. During last century four greatest earthquakes

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ISSN (Online) 2456-1290
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occurs are. Great Assam earthquake (1897), Kanga earthquakes (1905), Bihar Nepal earthquakes (1934), Assam earthquake (1950).In recent time, damaging earthquake occurs in Bihar Nepal earthquake (1988). Past earthquake have shown that, significant percentage of structures attain light to moderate damage, hence such structure may collapse. These structures impose a potential risk to human life and economic assets and the environment.

The study on the seismic effect on structure and evaluation of seismic forces on a structure depending on various parameters such as type of soil, zone, etc. are presented in this paper. The seismic analysis of different models of frame structure (G+5, G+8) is carried out using STRUDS and STADD PRO., considering various parameters and variation in seismic forces are determined and analysis results are studied.

II. METHODS OF SEISMIC ANALYSIS

Indian standard IS 1893-2002 (part1) is followed for the equivalent static analysis and response spectrum method analysis procedure. The building is modelled in commercial software by using STAAD-PRO, SAP and STRUD seismic force demand for each individual member is calculated for the design base shear as required by IS 1893-2002 (part1). Seismic evaluation method:

A. Preliminary Evaluation

B. Detailed Evaluation

Seismic Evaluation: The seismic evaluation is carried out on G+5 and G+8 structures. The evaluation is done by using Equivalent Static Load method. It is the simplest method of analysis because the forces depend on the code based fundamental period of the structure with some empirical modifiers. The design base shear is to be computed as whole and then it is distributed along the height of the building based on some simple formulae for buildings with regular distribution of mass and stiffness. In case of rigid diaphragm action, the lateral shear in any horizontal plane shall be distributed to the various element of lateral force resisting system on the basis of relative rigidity (clause 7.7.2 of IS 1893(part 1):2002).

a. Determination of base shear: The total design lateral force or design base along any principal direction shall be determined by the following expression, clause 7.5 of IS 1893 (part 1) 2002

VB = AhW

Where,

Ah = design horizontal seismic coefficient for a structure

W = seismic weight of building

The design horizontal seismic coefficient for a structure Ah is given by:

Ah = (Z/2)*(I/R)*(Sa/g)

Where,

Z = Zone factor

I = important factor

Sa/g = the average response acceleration coefficient for any type of soil. These values are given for 5% of damping of structure; for other value of damping it is modified according to table 3 of IS 1893 (part 1): 2002.

The fundamental natural period for a building are given in clause 7.6 of IS 1893 (part 1): 2002 and it is summarized as:

Ta = 0.075h0.75 moment resisting RC frame building without brick infill walls

Ta= 0.085h0.75 moment resisting steel frame building without brick infill walls

Ta = 0.09h/√d all other buildings including moment resisting RC frame building with brick infill walls

h is the height of building in meter and d is the base dimension of building at plinth level in meter, along the considered direction of lateral force.

Type of soil (rock or hard soil, medium soil, soft soil)

R is the response reduction factor; depending on the perceived seismic damage performance of the structure. I/R ratio should not exceed 1.

b. Lateral distribution of base shear: IS 1893 (part 1): 2002 of lateral force along the height of building as per the following expression.

Q_i=V_B

$$\frac{Wi * hi\text{^}2}{\sum_{i=1}^{n} Wi * hi\text{^}2}$$

Where:

= design lateral force at floor i,

Wi = seismic weight of floor i,

hi = height of floor I measured from foundation i,

n = number of stories in the building or the number of levels at which masses are located

Parametric Study: In this project, analysis of the structure is carried out by considering the various parameters such as

- Load cases
- IS code (IS 1893 (Part-1):2002)
- Zone factor (Clause 6.4.2)
- Type of soil (Hard, Medium and Soft)
- Height of structure

The load combonations are given in IS 1893-2002 Part 1. For the analysis purpose, the load combination used is 1.2(DL+LL+EL)

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Vol 2, Issue 3, March 2017

Structural Details of Model: Table shows structural details of building.

Table No1: Structural details

Sr. No.	Description	Detail
1	Column	300 x 400mm
2	Beam	230 x 400mm
3	Material	Concrete M20
4	Floor Height	3 m
5	Bay	10m

Analysis of G+5 model: For the analysis of G+5 model, the various loads considered and the effect on the seismic forces and the base shear due to the change in zone and soil type presented below. The table indicates the seismic weight for which the G+5 model was analysed.

Table No.2 Seismic weight of G+5 model

Floor - Level	Dead Load kN	Live Load kN	Live Load Percentage	Effective Live Load kN
Floor 1	600.51	96	25	24
Floor 2	875.82	96	25	24
Floor 3	875.82	96	25	24
Floor 4	875.82	96	25	24
Floor 5	875.82	96	25	24
Floor 6	643.55	96	0	0
Total	4747.34	576	- -	120

Figure 1 shows the variation of base shear for G+5 model for the given load on the basis of zone and soil type.

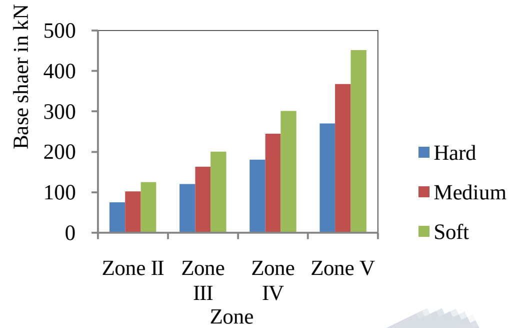

Fig. 1. Base shear comparison for different zone and soil type

The graph shows an increasing pattern for the value of base shear from zone II to zone V for G+5 model. Also, the values of base shear are found to be increasing from hard to soft soil for all the zones.

The variations of the seismic forces storey wise on the basis of soil type are shown in graph for the particular zone of earthquake. For each zone separate graph depicts the variation on seismic forces.

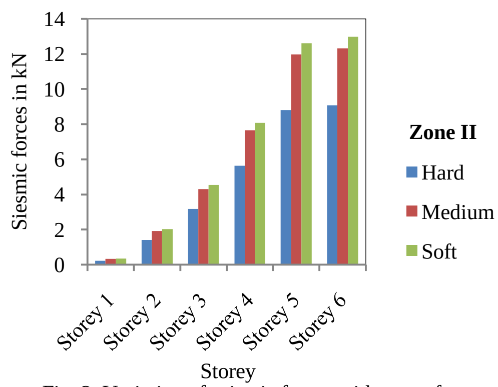

Fig. 2. Variation of seismic forces with type of soil

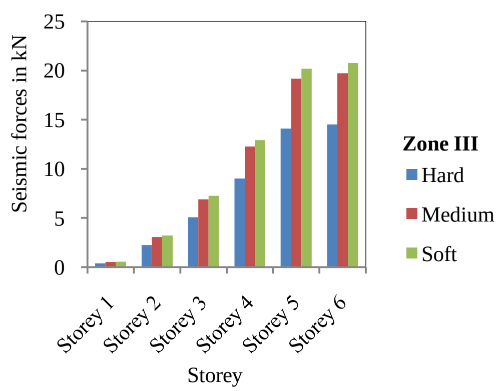

Fig. 3. Variation of seismic forces with soil type

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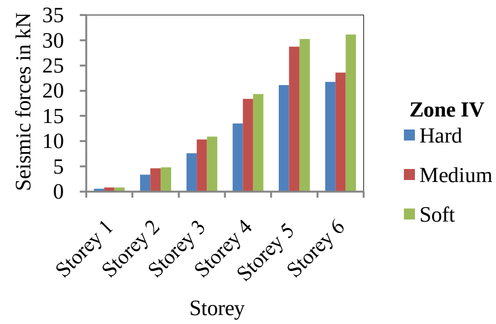

Fig. 4. Variation of seismic forces with soil type

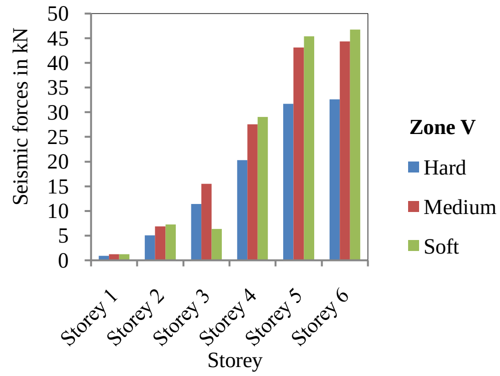

Fig. 5. Variation of seismic forces with type of soil

From graph, (i.e. fig. 2, fig 3, fig.4 and fig. 5) it is clear that the value of the seismic forces is more in soft soil for all zones as compared to the other soil and continuously increasing from zone II to zone V and hard soil to soft soil.

Analysis of G+8 model: For the analysis of G+8 model, the various loads considered and the effect on the seismic forces and the base shear due to the change in zone and soil type presented below. The table indicates the seismic weight for which the G+8 model was analysed

Table No.3 Seismic weight G+8 model

Floor - Level	Dead Load kN	Live Load kN	Live Load Percentage	Effective Live Load kN
Floor 1	593.42	96.00	25.00	24.00
Floor 2	861.65	96.00	25.00	24.00
Floor 3	861.65	96.00	25.00	24.00
Floor 4	861.65	96.00	25.00	24.00
Floor 5	861.65	96.00	25.00	24.00
Floor 6	861.65	96.00	25.00	24.00
Floor 7	861.65	96.00	25.00	24.00
Floor 8	861.65	96.00	25.00	24.00
Floor 9	636.46	96.00	0.00	0.00
Total	7261.40	864.00	- -	192.00

Fig. 6 shows the variation of base shear for G+8 model for the given load on the basis of zone and soil type.

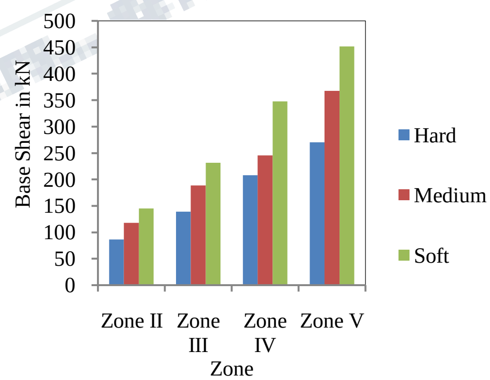

Fig. 6. Base shear comparison for different zone and soil type

The above graphs show the increase in value of base shear from zone II to zone V for G+8 model. Also, the base shear value is increasing from hard soil to soft soil. The pattern is maintained for all zones.

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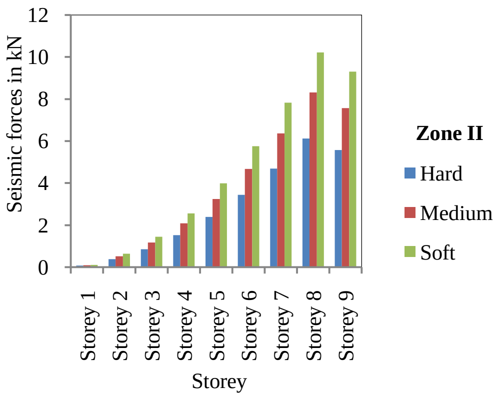

Fig. 7. Varitation of seismic forces with soil type

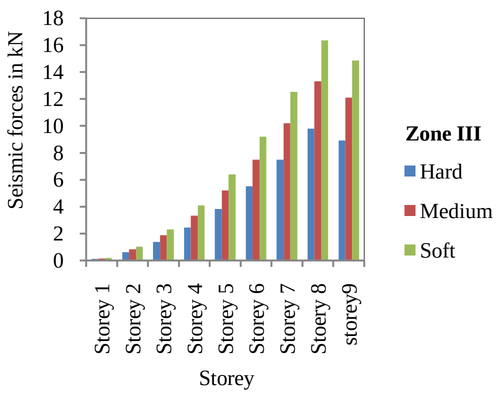

Fig. 8. Variation of seismic forces with soil type

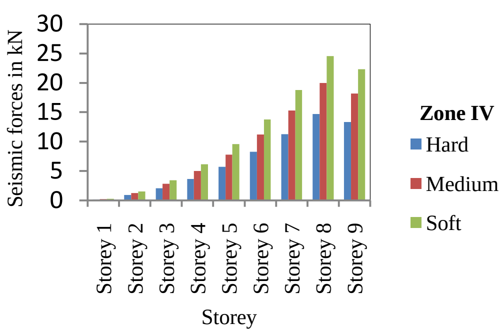

Fig. 9. Varition of seismic forces with soil type

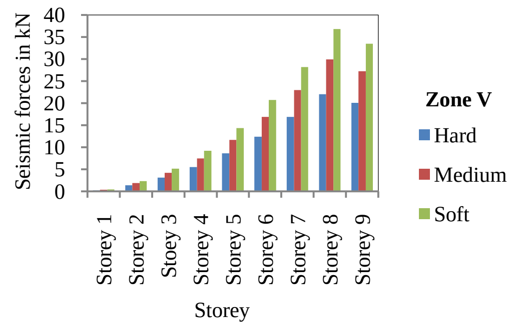

Fig. 10. Variation of seismic forces with soil type

The graphs (i.e. fig. 7., fig. 8., fig. 9 and fig. 10) shows that the value of seismic forces is more in soft soil for all zones as compared to other and continuously increasing from zone II to zone V and hard to soft soil.

III. CONCLUSIONS:

1.
2. The value of base shear increases 36% from hard to medium soil and increases 67% from hard to soft soil for all the zones for G+5 and G+8 model.
3. The average variation of seismic is more from 1st to 2nd storey & then it is decreases as height increases up to 3.71% at last storey for G+5 model.
4. The average variation is more from 1st to 2nd (442.67 %) storey & then it is decreases as height increases up to 30.28 % at 8th storey & suddenly seismic forces decreases up to 8.67 % from 8th to 9th storey for G+8 model.
5. The final conclusion that can be drawn out is that height creates a large effect on structure as height increases the value of seismic forces increases & intensity increase 1st to 2nd story then the percentage variation in seismic forces decreases form storey to storey.
6.

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