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Seismic Behavior of Multi-Storied Buildings

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Abstract

The present study deals with the comparison of base shear of multi storied buildings with dimensions 20x20mts, 30x30mts,40x40mts,60x60mts at different zones and different types of soils as per IS:1893(part: I):2002. A total of 224 multi storied buildings are analyzed for this paper. This work helps in understanding the effect of earthquake with increase in area and height of multi storied buildings and also the increase of base shear for different zones and soil conditions.

I. Introduction

Vibrations which disturbs the earth's surface caused by waves generated inside the earth are termed as earthquakes. It is said that earthquakes will not kill the life of human but structures which are not constructed in considering the earthquake forces do. At present a major importance has given to earthquake resistant structures in India for human safety. India is a sub-continent which is having more than 60% area in earthquake prone zone. A majority of buildings constructed in India are designed based on consideration of permanent, semi-permanent, movable loads. But earthquake is an occasional load which leads to loss of human life but also disturbs social conditions of India.

II. Need for study

India having different soil conditions and different earthquake intensity places with more than 60% area is prone to earthquakes, should develop earthquake resistant structures in consideration to IS:1893(part: I):2002. India classified into 4 seismic zones namely zone II, III, IV, V, having different types of soils which increases the importance of understanding of effect of base shear in consideration to various types of soils in same zone also. Response of structures to earth's surface vibrations is a function of type of soil available at site conditions. Response acceleration coefficient (S_a/g) for 5% damping is calculated for rock, medium, soft soils. Zone factor value indicates expected intensity of earthquake in different seismic zones.

Zone factor values are given in table no. 1

Zone	II	III	IV	V
Intensity	Low	Medium	Severe	Very severe
Zone value	0.1	0.16	0.24	0.36

The particulars of places for different seismic zones are:-

Zone II comprises of: east costal portion of pondicherry and vishakhaptnam, Madhya Pradesh and part of uttar Pradesh (Bhopal, Nagpur, Aurangabad, jaipur, Udaipur, Jodhpur and Jhansi), part of Rajasthan, interior parts of southern India excluding coast line (Bangalore, Mysore, Hyderabad, Tanjavur, Madurai, Nagapur, Bhilai and Rourkela).

Zone III comprises of: parts of Gujarat, Punjab, Uttar Pradesh, Rajastan and west Bengal (Surat, Rajkot, Bikaner, Patiala, Bhatinda, Agra, Lucknow, Allahabad, Durgapur), east and west coast lines of Tamilnadu, Andhra Pradesh, Orissa, West Bengal, Karnataka, Kerala and Maharastra. (Chennai, Kalpakkam, Nellore, Vijayawada, Bhubaeswar, Kolkata, Mumbai, Goa, Mangalore and Calicut.).

Zone IV comprises of: Jammu & Kashmir, Uttarkhand and Punjab, Darjeeling, Nainital, Shimla, Roorkee, Dehradun, Delhi, Chandigarh, Ghorakhpur, Patna, Himalayas.

Zone V comprises of: Himalayas, Jammu & Kashmir, Himachal Pradesh, Bhuj area of Gujarat, Bihar and North Eastern states (srinagar, Bhuj, Dharbhanga, Guwahati, Imphal, Jorhat and Kohima).

Importance factor relates to the importance of structure. I = 1.5 for important service buildings and community buildings, I = 1.0 for other buildings. The response reduction factor considered for study is 5.0 for special RC moment resisting frame (SMRF). Analysis of considered 224 multi storied structures are made by using Equivalent static load method as per IS: 1893(part: I):2002.

III. Study parameters of multi storied buildings

Type of building : multi storied buildings
Zones : II, III, IV, V
Types of soils : Rocky (hard), Medium, Soft soils.
Importance factor: 1.0, 1.5
Number of stories: G+4, G+9, G+14.
Height of ground storey: 3.5mts
Floor to floor height: 3.5mts
Live load: 3.5Kn/m^2
Materials: M30 and Fe415
Seismic analysis: Equivalent static load method as per IS: 1893 (Part 1):2002.

Calculated values of natural time period and response acceleration coefficients for different multi storied buildings are:-

Table no. 2. For 20x20mts multi storied building:

Storey	Natural time period (T_a)	Response acceleration coefficient (S_a/g) Rocky soils	Medium soils	Soft soils
G+4	0.382	2.5	2.5	2.5
G+9	0.734	1.361	1.851	2.273
G+14	1.086	0.920	1.251	1.536

Table no. 3. For 40x40mts multi storied building:

Storey	Natural time period (T_a)	Response acceleration coefficient (S_a/g) Rocky soils	Medium soils	Soft soils
G+4	0.270	2.5	2.5	2.5
G+9	0.519	1.925	2.318	3.215
G+14	0.768	1.301	1.769	2.173

Table no. 4. For 30x30mts multi storied building:

Storey	Natural time period (T_a)	Response acceleration coefficient (S_a/g) Rocky soils	Medium soils	Soft soils
G+4	0.382	2.5	2.5	2.5
G+9	0.599	1.667	2.267	2.784
G+14	0.887	1.127	1.532	1.882

Table no. 5. For 60x60mts multi storied building:

Storey	Natural time period (T_a)	Response acceleration coefficient (S_a/g) Rocky soils	Medium soils	Soft soils
G+4	0.220	2.5	2.5	2.5
G+9	0.519	1.925	2.618	3.215
G+14	0.768	1.301	1.769	2.173

IV. Results and discussions

Increase of base shear with change in zones and soils are studied. For soft soils and zone IV and V base shear values are very severe in nature for all the considered multi storied buildings. With increase in height and area of buildings the effect of earthquake has also increased.

Effect of earthquake zone on base shear: the increase of base shear is given in tabular

Table no. 6. Comparison of base shear with zones:

ZONE VS ZONE	Increased value
II to III	1.6
II to IV	2.4
II to V	3.6
III to IV	1.5
III to V	2.25
IV to V	1.5

Effect of type of soil on base shear: the increase of base shear with effect of type of soil on base shear is given in table no. 7.

Table no. 7. Comparison of base shear with types of soils:

SOIL VS SOIL	Increased value
ROCKY to MEDIUM SOILS	1.36
ROCKY to SOFT SOILS	1.67
MEDIUM to SOFT SOILS	1.23

BASE SHEAR FOR G + 4 STOREYS:

STOREY /ZONE	20X20		30X30		40X40		60X60	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	628.7344	943.1016	1179.609	1769.414	1889.234	2833.852	3784.734	5677.102
III	1005.975	1508.963	1887.375	2831.063	3022.775	4534.163	6055.575	9083.363
IV	1508.963	2263.444	2831.063	4246.594	4564.163	6801.244	9083.363	13625.04
V	2263.444	3395.166	4246.594	6369.891	6801.244	10201.87	13625.04	20437.57

Base shear values of G + 9 multi storey in different types of soils:
Dimensions of building: (20x20) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	729.011	1093.517	991.4549	1487.182	1217.448	1826.172
III	1166.418	1749.626	1586.328	2379.492	1947.917	2921.876
IV	1749.626	2624.44	2379.492	3536.238	2921.876	4382.814
V	2624.44	3936.659	3569.238	5353.856	4382.814	6574.221

Base shear values of G + 14 multi storey in different types of soils:
Dimensions of building: (20x20) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	1026.058	1539.087	754.4547	1131.682	1259.939	1889.909
III	1641.693	2642.539	1207.128	1810.691	2015.903	3023.854
IV	2462.539	3639.809	1810.691	2716.037	3023.854	4535.781
V	3639.809	5540.713	2716.037	4074.056	4535.781	6803.671

Base shear values of G + 9 multi storey in different types of soils:
Dimensions of building: (30x30) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	1659.58	2489.371	2257.03	3385.544	2771.5	4157.25
III	2655.329	3982.993	3611.247	5416.871	4434.4	6651.6
IV	3982.993	5974.49	5416.871	8125.306	6651.6	9977.4
V	5974.49	8961.734	8125.306	12187.96	9977.4	14966.1

Base shear values of G + 14 multi storey in different types of soils:
Dimensions of building: (30x30) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	1712.182	2568.273	2328.569	3492.853	2859.345	4289.017
III	2739.491	4109.237	3725.71	5588.565	4574.952	6862.427
IV	4109.237	6163.856	5588.565	8382.847	6862.427	10293.64
V	6163.856	9245.784	8382.847	12574.27	10293.64	15440.46

Base shear values of G + 9 multi storey in different types of soils:
Dimensions of building: (40x40) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	3049.059	4573.588	4146.72	6220.08	5091.929	7637.893
III	4878.494	7317.741	6634.752	9952.128	8147.086	12220.63
IV	7317.741	10976.61	9952.128	14928.19	12220.63	18330.94
V	10976.61	16464.92	14928.19	22392.29	18330.94	27496.41

Base shear values of G + 14 multi storey in different types of soils:
Dimensions of building: (40x40) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	3138.968	4708.451	4268.994	6403.492	5242.076	7863.115
III	5022.348	7533.522	6830.391	10245.59	8387.322	12580.98
IV	7533.522	11300.28	10245.59	15368.38	12580.98	18871.48
V	11300.28	16950.43	15368.38	23052.57	18871.48	28307.21

Base shear values of G + 9 multi storey in different types of soils:
Dimensions of building: (60x60) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	7417.958	11126.94	10069.02	15103.52	12387.99	18581.98
III	11868.73	17803.1	16110.43	24165.64	19820.78	29731.17
IV	17803.1	26704.65	24165.64	36248.46	29731.17	44596.76
V	26704.65	40056.97	36248.46	54372.69	44596.76	66895.14

Base shear values of G + 14 multi storey in different types of soils:
Dimensions of building: (60x60) mts.

STOREY /ZONE	ROCKY SOILS		MEDIUM SOILS		SOFT SOILS	
	I = 1.0	I = 1.5	I = 1.0	I = 1.5	I = 1.0	I = 1.5
II	7615.73	11423.6	10357.4	15536.1	12718.27	19077.41
III	12185.17	18277.75	16571.83	24857.75	20349.24	30523.85
IV	18277.75	27416.63	24857.75	37286.63	30523.85	45785.78
V	27416.63	41124.94	37286.63	55929.94	45785.78	68678.67

Present study will help to civil engineers and students the behavior of multi storied building with change in zone and soil types with increase in height and area of buildings. Gives an idea of increase of base shear value with zones and soil types.

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