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Study of base shear and storey drift by dynamic analysis

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Abstract -In the present paper, effect of height of building on base shear, lateral forces and storey drift is evaluated by using STAAD software and the results are compared with IS1893 (Part1:2002). For these purpose seismic coefficient method (SCM) specified in IS1893 (Part1:2002) is taken into consideration and results are obtained in STAAD by SCM. The study includes the modeling of two buildings having plan areas 15 m x9 m and 25mx15m and the height is varied from 3m, 6m, 9m and 12m. The study is conducted by varying the geometrical properties of the structure but the seismic properties are kept constant. The buildings are located in zone II region. The results obtained for base shear and other design parameters obtained from STAAD software match with IS1893:2002. Spring mass model with the lateral forces are also plotted for the different buildings. Percentage change in storey shear for the different buildings is also evaluated. It can be observed that as the height and area of building increases the base shear and storey drift increases.

Index Terms—**Base shear, Earthquake Seismic coefficient method, STAAD software.**

I. INTRODUCTION

An earthquake may be defined as release of elastic energy by sudden slip on a fault and resulting ground shaking and radiated caused by slip. Earthquakes are one of the worst among the natural disasters. About 1 lakh earthquakes of magnitude more than three hit the earth every year. According to a conservative estimate more than 15 million human lives have been lost and damage worth hundred billions of dollars has been inflicted in the recorded history due to these. Some of the catastrophic earthquakes of the world are Tangshan of China (1976, Ma=7.8, casualty > 3 lakhs), Mexico city (1985, casualty > 10,000) and North-West Turkey (August 17, 1999, Ma=7.4, casualty > 20,000). In India, casualty wise, the first three events are Kangra (>20,000), Bihar-Nepal (>10,653) and Killari (>10,000). Moreover, Indian-Subcontinent, particularly the northeastern region, is one of the most earthquakes-prone regions of the world. The concept of earthquake magnitude was first developed by Richter (e.g., Richter 1958), and hence, the term "Richter scale". The value of magnitude is obtained on the basis of recordings of earthquake ground motion on seismographs. In practice, there are several different definitions of magnitude; each could give a slightly different value of the magnitude. Hence, magnitude is not a very precise number. Usually, earthquakes of magnitude greater than 5.0 cause strong enough ground motion to be potentially damaging to structures. Earthquakes of magnitude greater than 8.0 are often termed as great earthquakes. Intensity indicates the violence of shaking or the extent (or potential) of damage at a given location due to a particular earthquake. Thus, intensity caused by a given earthquake will be different at different places. Prior to the development of ground motion recording instruments, earthquakes were studied by recording the description of shaking intensity. This lead to the development of intensity scales which describe the effects of earthquake motion in qualitative terms. An intensity scale usually provides ten or twelve grades of intensity starting with most feeble vibrations and going upto most violent (*i.e.,* total destruction). The most commonly used intensity scales are: *Modified Mercalli (MM) Intensity Scale* and the *Medvedev-Sponhener-Karnik (MSK) Intensity Scale*. In India, IS 1893(Part 1): 2002, is used to calculate earthquake loads on the structures. In this Indian Standard, three methods of analysis are given. In the first method, which is used for most of the buildings, static earthquake loads are obtained at each floor of building using empirical time period. This method is termed as Equivalent Static Analysis (ESA) or Seismic Coefficient Method (SCM), it is very easy to use and is based on empirical time period and empirical distribution of earthquake loads on each floor along the height of the building. Next method given in IS 1893 is Response Spectrum Analysis (RSA), wherein, from the structural model of building, natural frequencies and natural modes are obtained. For this purpose, free vibration analysis is performed, wherein mass of structure is to be properly modeled. For determining seismic forces we have the design horizontal seismic coefficient given in equation 1

$$A_h = \frac{z}{2}\frac{I}{R}\frac{Sa}{g} \qquad (1)$$

The third method given in IS 1893 is Time History Analysis (THA). In the time history analysis (THA), dynamic response is obtained by using either modal superposition method or numerical integration method. Here time history of ground acceleration is used and dynamic response in the form of time history of response is obtained. Figure 1 shows the seismic zone and intensity map of India. Literature reviewed for the study includes *Shimazaki (1992)*[13] who investigated the storey shear distribution of high rise reinforced concrete buildings for the purpose of the earthquake resistant design. The invariant oscillatory mode shape of the building designed with the appropriate shear distribution was investigated and revealed approximately same elastic stiffness mode shape. The results show that the seismic coefficient obtained by SRSS method using elastic stiffness is the best and this higher mode effect can be ignored. The investigation of storey overturning moment showed that the axial load of first storey column could be reduced from the value obtained by the seismic load in the design which considered higher mode effects.

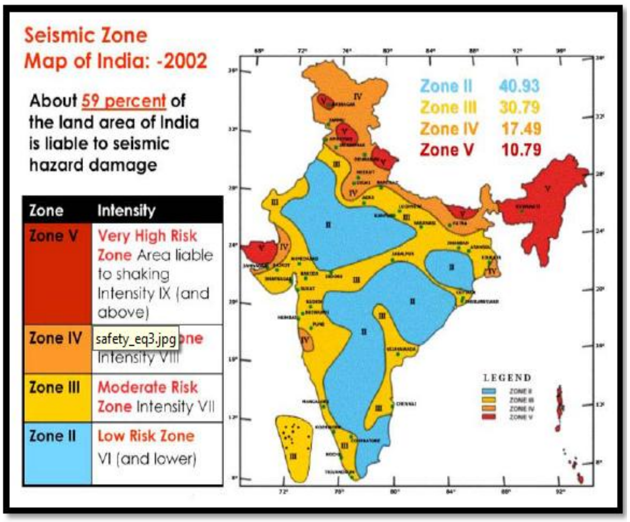

Fig 1. Seismic Zone and Intensity map of India.

Murthy and Jain (1994) [10] reviewed the Indian seismic code (IS 1893:1984) provisions on the building systems. Proposals were made to upgrade the code based on some of the research findings and to bring it at par with the seismic codes of some of the countries with advanced seismic provisions. Inconsistencies in some of the Indian codal provisions were identified and recommendations were made to overcome them. *Jain and Navin (1995)*[9] assessed seismic over strength of multistory reinforced concrete framed by non linear pseudo analysis on four bay three six and nine story frames designed for seismic zones I to V as per Indian codes.. The dependence on seismic zone is strongest. The average over strength of these frames in zones V and I is 2.84 and 12.7 respectively. The over strength increases as the number of stories decreases moreover the over strength of three storey frame is higher than nine storey frame by 36% in zone in V and 49% in zone I. Further inferior frames have 17% (zone V) to 47% (zone I) higher over strength as compared to the exterior frames of same building.. *Otani (2004)* [11] reviewed the development of earthquake resistant design of buildings and discussed the current problem in earthquake engineering related to design of reinforced concrete structure. Measurement of ground accelerations started in 1930 and response calculation was made possible in 1940s. Design response spectra were formulated in the late 1950s and 1960s.Non linear response was introduced in seismic design in 1960s and capacity design was generally introduced in 1970s for collapse safety. The study also included damage to reinforced buildings during Kolbe earthquake. The study emphasized that the building should satisfy on performance based engineering. As damage control and maintenance of building would become major issue in future therefore new materials structures and construction technology should be utilized. *Ahirwar et al. (2008)* [2] studied seismic load estimation for multistory buildings as per IS: 1893-1984 and IS: 1893-2002 recommendations. The study aims to determine and compare the seismic forces on buildings computed as per the last two version of IS: 1893. Four multistory buildings, three to nine storey heights, are considered. Seismic Coefficient, Response Spectrum and Modal Analysis Methods are used to compute the seismic forces on these buildings. Four multistory RC framed buildings ranging from three storied to nine storied were considered and analyzed. The process gives a set of five individual analysis sequences for each building and the results are used to compare the seismic response viz. storey shear and base shear computed as per the two versions of seismic code. The seismic forces, computed by IS: 1893-2002 are found to be significantly higher, the difference varies with structure properties. It was concluded that such study needs to be carried out for individual structure to predict seismic vulnerability of RC framed buildings that were designed using earlier code and due to revisions in the codal provisions may have rendered unsafe. *Bhattacharya (2010)*[4] attempted to investigate the proportional distribution of lateral forces evolved through seismic action in each storey level due to changes in mass and stiffness of building. As per the BIS provisions, a multistory symmetrical building is considered as simplified lump mass model for the analysis with various mass and stiffness ratios. The sway pattern of multi storied building under seismic excitation is taken under consideration with parabolic shape functions. The result concludes as a building structure with high mass and stiffness ratio provides instability and attracts huge storey shear. A proportionate amount of mass and stiffness distribution is advantageous to control over the storey and base shear. The main objective of study was to determine the effect of the natural frequency of the moment Resistant Frame structure under parabolic Shape Functions. *Bagheri et.al (2012)*[3] modeled multi-storey irregular buildings with 20 stories using software packages ETABS and SAP 2000 v.15 for seismic zone V in India. The effect of the variation of the building height on the structural response of the shear wall building is studied. Dynamic responses of building under actual earthquakes, EL-CENTRO 1949 and CHI-CHI Taiwan 1999 have been investigated. The study also highlights the accuracy and exactness of Time History analysis in comparison with the most commonly adopted Response Spectrum Analysis and Equivalent Static Analysis. The analysis of structure by using equivalent static method, time history method and response spectrum method has been surveyed. The storey displacements and displacement of center of mass results have been obtained by using both static and dynamic analysis. *Patil et.al (2013)* [12] described seismic analysis of high-rise building using program in STAAD Pro with various conditions of lateral stiffness system. Some models are prepared that is bare frame, brace frame and shear wall frame. Analysis was done with response spectrum method. The effect of bare frame, brace frame and shear wall frame was studied under the earthquake loading. The results are studied for response spectrum method. The main parameters considered in this study to compare the seismic performance of different models are storey drift, base shear,

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story deflection and time period. The analysis would produce the effect of higher modes of vibration & actual distribution of forces in elastic range in a better way. Test results including base shear, story drift and story deflections are presented and get effective lateral load resisting system.

II. MODELLING IN STAAD

STAAD is powerful design software licensed by Bentley. Staad stands for structural technique for analysis and design. Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, where as analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis. To calculate S.F.D and B.M.D of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. STAAD pro is a very powerful tool which does this job in just few minutes. STAAD is a best alternative for high rise buildings. To perform dynamic analysis in STAAD following steps must be followed:

i. Geometric Modeling
ii. Sectional Properties and Material Properties
iii. Supports : Boundary Conditions
iv. Loads & Load combinations (Dynamic)
v. Analysis Specification and Design command

(i) Geometric Modeling

To model any structure in STAAD the first step is to specify the nodal co-ordinate data followed by selection of elements from element library. For the present work beam elements are selected to model the structure.

(ii) Sectional & Material Properties

The element selected for modeling is then assigned the properties if the element is beam the cross section of beam is assigned. For plate elements thickness is assigned. After assigning the sectional property to the member it is important to assign it with member properties. Material properties include modulus of elasticity, poisson's ratio; weight density, thermal coefficient, damping ratio and shear modulus

(iii) Support and boundary condition

After assigning the sectional and material properties, boundary condition is assigned to the structure in form of fixed, hinged and roller support to structure. In the present work boundary condition is assigned in form of fixed support.

(iv) Load and load combination

Loads are a primary consideration in any building design because they define the nature and magnitudes of hazards are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability) throughout the structure's useful life. The anticipated loads are influenced by a building's intended use (occupancy and function), configuration (size and shape) and location (climate and site conditions). Ultimately, the type and magnitude of design loads affect critical decisions such as material collection, construction details and architectural configuration. Thus, to optimize the value (i.e., performance versus economy) of the finished product, it is essential to apply design loads realistically. In the present project works following loads are considered for analysis.

(i) **Dead Loads (IS- 875 PART 1).**
(ii) **Live Loads (IS 875 PART 2).**
(iii) **Earthquake Loads by SCM (IS 1893:2002)**

In addition to the above mentioned loads, dynamic loads in form of Response Spectrum method can also be assigned. STAAD also uses IS 1893 – 2002 (Part 1) parameters mentioned below to evaluate seismic output parameters in form of design seismic coefficient, base shear storey shear and mass participation factor.

1. Seismic Zone Coefficient
2. Response Reduction Factor
3. Importance Factor
4. Soil Site Factor
5. Type of Structure
6. Damping Ratio (obtain Multiplication Factor for Sa/g)
7. Depth of Foundation below Ground Level

In the present study above mentioned parameters are kept constant and discussed in the seismic analysis results. After assigning the primary and generated load case to the structure the combination of loads are assigned. Table 1 shows primary and load combination assigned to the structure.

Table 1 Primary and Load combination

Type	L/C	Name
Primary	1	DL
Primary	2	LL
Primary	3	EQX+
Primary	4	EQX-
Primary	5	EQZ+
Primary	6	EQZ-
Combination	7	1.5(DL+LL)
Combination	8	1.5(DL+EQX+)
`Combination	9	1.5(DL+EQX-)
Combination	10	1.5(DL+EQZ+)
Combination	11	1.5(DL+EQZ-)
Combination	12	1.2(DL+LL+EQX+)
Combination	13	1.2(DL+LL+EQX-)
Combination	14	1.2(DL+LL+EQZ+)
Combination	15	1.2(DL+LL+EQZ-)
Combination	16	0.9DL+1.5EQX+
Combination	17	0.9DL+1.5EQX-
Combination	18	0.9DL+1.5EQZ+
Combination	19	0.9DL+1.5EQZ-

(v) Analysis Specification and design command

After assigning the loads to the structure, analysis is done to evaluate the shear force bending moment and dynamic

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results in form of base shear, storey drift and lateral forces. After analysis design can be executed in STAAD as it includes various international codes and the structure can be designed using these codes. After following above mentioned steps the results obtained from the study are summarized in the next section.

III. SEISMIC ANALYSIS RESULTS IN STAAD

Using STAAD software two building plan areas having plan area 15m x 9m and 25m x15m as shown in figure 2 respectively is modeled. Figure 3 shows the sectional properties diagram for the buildings. The two buildings are varied in height. For the purpose of study the height is varied from 3m, 6m, 9m and 12m respectively. Table 2 and 3 shows the geometric properties for the above mentioned buildings. The dynamic parameters taken for the analysis is summarized in table 4. The load calculations assigned to the structure is also discussed. Dynamic results obtained from seismic analysis of building model by SCM are summarized as shown by table 5, 6, 7 and 8 respectively.

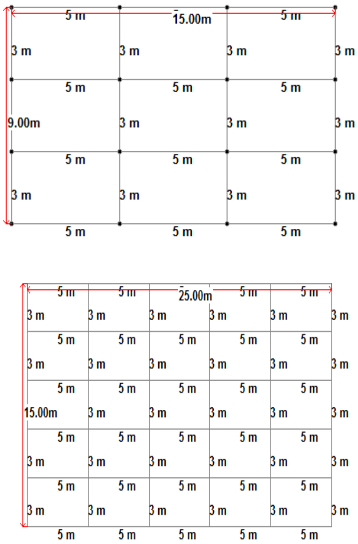

Fig 2 Plan areas of 15mx 9m and 25m x 9m building

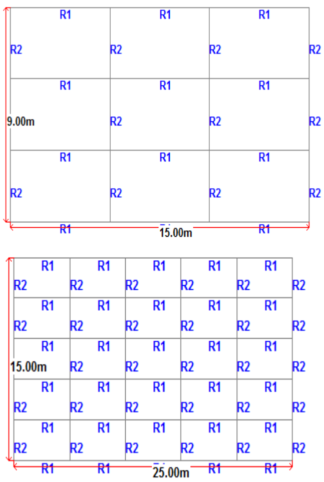

Fig 3 Sectional Properties of 15mx 9m and 25m x 9m building

Plan Area	Structure	Member Properties	Size B x D (mm)
25m x15m	G+3	Beams R1 R2 Columns Slab	 300x450 300x300 450 x 450 Thickness=125mm
	G+6	Beams R1 R2 Columns Slab	 300x450 300x300 550 x 550 Thickness=125mm
	G+9	Beams R1 R2 Columns Slab	 300x450 300x300 650 x 650 Thickness=125mm
	G+12	Beams R1 R2 Columns Slab	 300x450 300x300 750 x 750 Thickness=125mm

Table 2 Geometrical and Sectional Properties for 15m x9m plan area.

Plan Area	Structure	Member Properties	Size B x D (mm)
15m x9m	G+3	Beams R1 R2 Columns Slab	 300x450 300x300 450 x 450 Thickness=125mm
	G+6	Beams R1 R2 Columns Slab	 300x450 300x300 550 x 550 Thickness=125mm
	G+9	Beams R1 R2 Columns Slab	 300x450 300x300 650 x 650 Thickness=125mm
	G+12	Beams R1 R2 Columns Slab	 300x450 300x300 750 x 750 Thickness=125mm

Table 3 Geometrical and Sectional Properties for 25m x15m plan area

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Table 4 Seismic Load Parameters

Seismic Load Parameters	Value
1. Zone factor	0.1
2. Response Reduction factor	5
3. Importance Factor	1.5
4. Type of soil strata	2 (Medium)
5. Damping	5%

After assigning sectional properties, support conditions, static and dynamic loading along with combination of loading following dynamic results are tabulated and compared. Table 5 shows the comparison of design horizontal seismic coefficient for different buildings where T is fundamental natural period, h is the total height of building measured from the base of building and d is the base dimension of the building measured in the direction in which seismic force is considered. In the present work seismic forces are compared and measured in x directions so all the calculations are made in x direction. Sa/g is the spectral acceleration coefficient calculated as per clause 6.4.2 mentioned in IS 1893:2002. Ah is the design horizontal seismic coefficient It can be observed from the table 5 that design seismic coefficient parameters calculated by IS 1893:2002 and STAAD match accurately. Table 6 shows the comparison of base shear by STAAD and IS 1893:2002. It is important to note that that table 7 shows a sample calculation of weight actually. Moreover it can be stated that the weight calculated from IS 1893:2002 exactly match with that obtained from STAAD. The load calculations are also discussed.

Load Calculations:

1) Dead load:

Slab Weight Calculation:

Thickness of slab=0.125m
Density of concrete= 25kN/m^3
Self Weight of slab= Density of concrete x Thickness of slab
= 25x0.125
= 3.125kN/m^2
Floor Finish at floor level = 1.5 kN/m^2
Total Slab Weight at floor level= 4.625 kN/m^2

Wall load calculation:

Width of the outer wall=150mm
Width of the inner wall=115mm
Beam size=300x450mm
Height of floor =3m
Wall Weight (outer) = Thickness of wall x Height of wall x Density of brick wall
= 0.23 x (3-0.45) x 20
= 7.65kN/m
Wall Weight (inner) = Thickness of wall x Height of wall x Density of brick wall
= 0.115 x (3-0.45) x 20
= 5.865kN/m

Weight of parapet wall = 0.15 x 1 x 20
= 3kN/m

2) Live load:

Floor load:

Live Load Intensity specified (Public building) = 4 kN/m^2
Live Load at roof level =1.5 kN/m^2

After comparison of weight calculations in table 7, Table 8 shows the comparison of storey shear of G+3 building for the two plan areas discussed earlier. Table 9, 10 and 11 shows the comparison of storey shear of G+6, G+9 and G+12 building respectively. Moreover table 12, 13, 14 and 15 shows the comparison of storey drift of G+3, G+6, G+9 and G+12 building respectively. In the next section conclusions are discussed.

Table 5 Comparison of Design horizontal seismic coefficient Ah

Plan area	Structure	Time (sec) $T = \frac{0.09h}{\sqrt{d}}$ IS 1893:2002	Time (sec) STAAD	Sa/g IS 1893:2002	Sa/g STAAD	A_h $A_h = \frac{Z}{2}\frac{I}{R}\frac{S_a}{g}$ IS 1893:2002	A_h STAAD
15m x9m	G+3	0.337	0.337	2.5	2.5	0.0375	0.0375
	G+6	0.546	0.546	2.5	2.5	0.0375	0.0375
	G+9	0.755	0.755	1.801	1.801	0.0270	0.027
	G+12	0.964	0.964	1.41	1.41	0.0212	0.0212
25mx15m	G+3	0.261	0.261	2.5	2.5	0.0375	0.0375
	G+6	0.423	0.423	2.5	2.5	0.0375	0.0375
	G+9	0.585	0.585	2.325	2.325	0.0349	0.0349
	G+12	0.747	0.747	1.821	1.821	0.0273	0.0273

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Table 6 Comparison of Base Shear

Plan area	Structure	Weight of structure (W) (kN) IS 1893:2002	Weight of structure (W) (kN) STAAD	Base Shear= A_h x W V_B (kN) IS 1893:2002	Base Shear= A_h x W V_B (kN) STAAD
15m x9m	G+3	8739.63	8739.63	327.74	327.74
	G+6	15888.42	15888.42	595.81	595.81
	G+9	24017.21	24017.21	648.46	648.46
	G+12	33342.00	33342.00	706.85	706.85
25mx15m	G+3	22165.58	22165.58	831.20	831.20
	G+6	40082.57	40082.57	1503.10	1503.10
	G+9	59523.39	59523.39	2077.36	2077.36
	G+12	81420.87	81420.87	2222.79	2222.79

Table 7 Weight Calculations of G+3 Building

LEVEL OF ROOF	SLAB LOAD (kN)	LL (kN)	BEAM (kN)	COLUMN (kN)	WALL (kN)	TOTAL (kN)
ROOF	624.375	101.3	283.5	121.5	144	1274.625
3	624.375	270	283.5	243	648.72	2069.595
2	624.375	270	283.5	243	648.72	2069.595
1	624.375	270	283.5	243	648.72	2069.595
GL	0	0	283.5	324	648.72	1256.22
				WT	IS 1893	8739.63
					STAAD	8739.63

Table 8 Comparison of storey shear G+3 Building

Floor	Storey Shear 15x9 (kN)	Storey Shear 25x15 (kN)	% Increase in Storey Shear
Third Floor	115.41	291.1	152.23
Second Floor	117.86	299.83	154.4
First Floor	64.38	164.16	154.99
Ground Floor	26.96	66.9	148.15
Plinth level	3.11	7.41	138.26
Base shear	327.74	831.2	153.62

Table 9 Comparison of storey shear G+6 Building

Floor	Storey Shear 15x9 (kN)	Storey Shear 25x15 (kN)	% Increase in Storey Shear
Sixth Floor	132.67	333.48	151.36
Fifth Floor	162.64	418.36	157.23
Fourth Floor	120.70	304.88	152.59
Third Floor	82.86	209.30	152.59
Second Floor	52.12	131.66	152.61
First Floor	28.47	71.93	152.65
Ground Floor	11.93	27.2	128
Plinth level	1.43	3.36	134.97
Base shear	595.81	1503.10	152.28

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Table10 Comparison of storey shear G+9 Building

Floor	Storey Shear 15x9 (kN)	Storey Shear 25x15 (kN)	% Increase in Storey Shear
Ninth Floor	104.92	339.72	223.79
Eight Floor	143.42	465.76	224.75
Seventh Floor	115.74	375.61	224.53
Sixth Floor	91.0	295.37	224.58
Fifth Floor	69.25	196.12	183.21
Fourth Floor	50.46	163.8	224.61
Third Floor	34.64	112.45	224.62
Second Floor	21.79	70.74	224.64
First Floor	14.95	38.64	158.46
Ground Floor	5.0	16.17	223.4
Plinth level	0.62	1.88	203.23
Base shear	648.46	2077.36	220.35

Floor	Storey Shear 15x9 (kN)	Storey Shear 25x15 (kN)	% Increase in Storey Shear
Twelfth	89.08	292.92	228.83
Eleventh	128.67	423.97	229.5
Tenth	109.4	260.64	138.24
Ninth Floor	91.70	302.12	229.47
Eight Floor	75.54	248.92	229.52
Seventh Floor	60.96	200.88	229.53
Sixth Floor	47.94	157.96	229.5
Fifth Floor	36.48	120.14	229.33
Fourth Floor	26.58	87.60	229.57
Third Floor	18.25	60.14	229.53
Second Floor	11.48	37.82	229.44
First Floor	6.27	20.66	229.51
Ground Floor	2.63	8.65	228.9
Plinth level	0.34	1.04	205.88
Base shear	706.85	2222.79	214.46

Table11 Comparison of storey shear G+12 Building

Table 12 Comparison of Storey drift G+3 building

Floor	Storey Drift (mm) 15x9	Storey Drift (mm) 25x15	% Increase in Storey drift
Third Floor	7.72	8.03	4.02
Second Floor	6.75	7.05	4.44
First Floor	5.1	5.33	4.51
Ground Floor	3	3.15	5.00
Plinth level	0.91	0.96	5.49

Table 13 Comparison of Storey drift G+6 building

Floor	Storey Drift (mm) 15x9	Storey Drift (mm) 25x15	% Increase in Storey drift
Sixth Floor	20.1	20.48	1.89
Fifth Floor	18.9	19.3	2.12
Fourth Floor	16.27	17.34	6.58
Third Floor	14.27	14.65	2.66
Second Floor	11.1	11.43	2.97
First Floor	7.63	7.9	3.54
Ground Floor	4.14	4.32	4.35
Plinth level	1.15	1.22	6.09

Table 14 Comparison of Storey drift G+9 building

Floor	Storey Drift (mm) 15x9	Storey Drift (mm) 25x15	% Increase in Storey drift
Ninth Floor	28.57	36.69	28.42
Eight Floor	27.42	35.29	28.70
Seventh Floor	25.74	33.19	28.94
Sixth Floor	23.5	30.34	29.11
Fifth Floor	20.76	26.83	29.24
Fourth Floor	17.61	22.82	29.59
Third Floor	14.18	18.43	29.97
Second Floor	10.59	13.81	30.41
First Floor	7	9.16	30.86
Ground Floor	3.6	4.77	32.50
Plinth level	0.95	1.27	33.68

Table 15 Comparison of Storey drift G+12 building

Floor	Storey Drift (mm) 15x9	Storey Drift (mm) 25x15	% Increase in Storey drift
Twelfth	38.45	47.92	24.63
Eleventh	37.23	46.51	24.93
Tenth	35.64	44.61	25.17
Ninth	33.57	42.14	25.53
Eight	31.07	39.11	25.88
Seventh	28.15	35.55	26.29
Sixth	24.9	31.53	26.63
Fifth	21.39	27.17	27.02
Fourth	17.69	22.56	27.53
Third	13.89	17.78	28.01
Second	10.1	13	28.71
First	6.46	8.35	29.26
Ground	3.22	4.19	30.12
Plinth level	0.81	1.06	30.86

The above results are compiled in form of a spring mass model showing the lateral forces acting on each storey of the various buildings. Figure 4 shows the lateral force distribution of G+3, G+6 G+9 and G+12 of a building having plan area 15mx9m whereas figure 5 show the lateral force distribution of G+3, G+6 G+9 and G+12 of a building having plan area 25mx15m.

IV. CONCLUSIONS

In the present study, an attempt is made to compare the results obtained from Seismic Coefficient Method (SCM) specified in IS 1893:2002 using STAAD. Different models of G+3, G+6, G+9 and G+12 are modeled in STAAD. The

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seismic analysis is carried out taking into consideration that all the buildings are located in zone II i.e. Nagpur region as per code. The base shear, lateral forces at each storey along with the storey drift are tabulated and compared with each model. The spring mass model shows the lateral forces at each storey.

The major conclusions drawn from the present study are as follows:

1. It can be observed that the design seismic coefficient parameters such as fundamental natural period and spectral acceleration coefficient calculated by IS 1893:2002 match accurately by STAAD software.
2. The design horizontal seismic coefficient obtained by STAAD also matches with code.
3. The most important parameter for earthquake design i.e. base shear obtained from all models matches perfectly with the code.
4. The weight of building is also calculated manually and matched with that obtained by software.
5. From the above study it can be stated that for G+3 building whose plan area is increases by 177.78% (15mx9m=135m^2 and 25mx9m=375m^2) the increase in base shear is153.62%.
6. For G+6, G+9 and G+12 the increase in base shear is by 152.28%, 220.35% and 214.4% respectively.
7. Moreover for plan area (15mx9m) and varying height the base shear is increased by 81.79%, 97.85% and 115.67% for G+6, G+9and G+12.
8. For plan area (25mx15m) and varying height the base shear is increased by 80.8%, 150% and 167.41% for G+6, G+9and G+12. Thus base shear has drastic effect on 25x15 plan area building in comparison to 15mx9m building.
9. The lateral forces result for G+3 building show that for plan area 15mx9m and 25mx15m the average increase in lateral force is by 149.61%.
10. For G+6, G+9 and G+12 buildings it can be observed that the average increase in storey shear is by 147.75%, 212.71% and 221.19% respectively. Thus G+12 is the most critical one.
11. It is interesting to note from spring mass model that the worst hit floor is eight floor of G+9 building having plan area 25mx15m as it is subjected to a lateral force of 465.76kN.
12. The storey drift results suggest that for G+3 building the average increase in drift is by 4.69%.
13. For G+6, G+9 and G+12 the average increase in storey drift is 3.77%, 30.13% and 27.18% respectively.
14. The twelfth floor of G+12 building having plan area 25mx9m is drifted maximum by 47.92mm.
15. The maximum base shear is also borne by G+12 building plan area 25mx9m and its value is 2222.79kN.

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APPENDIX

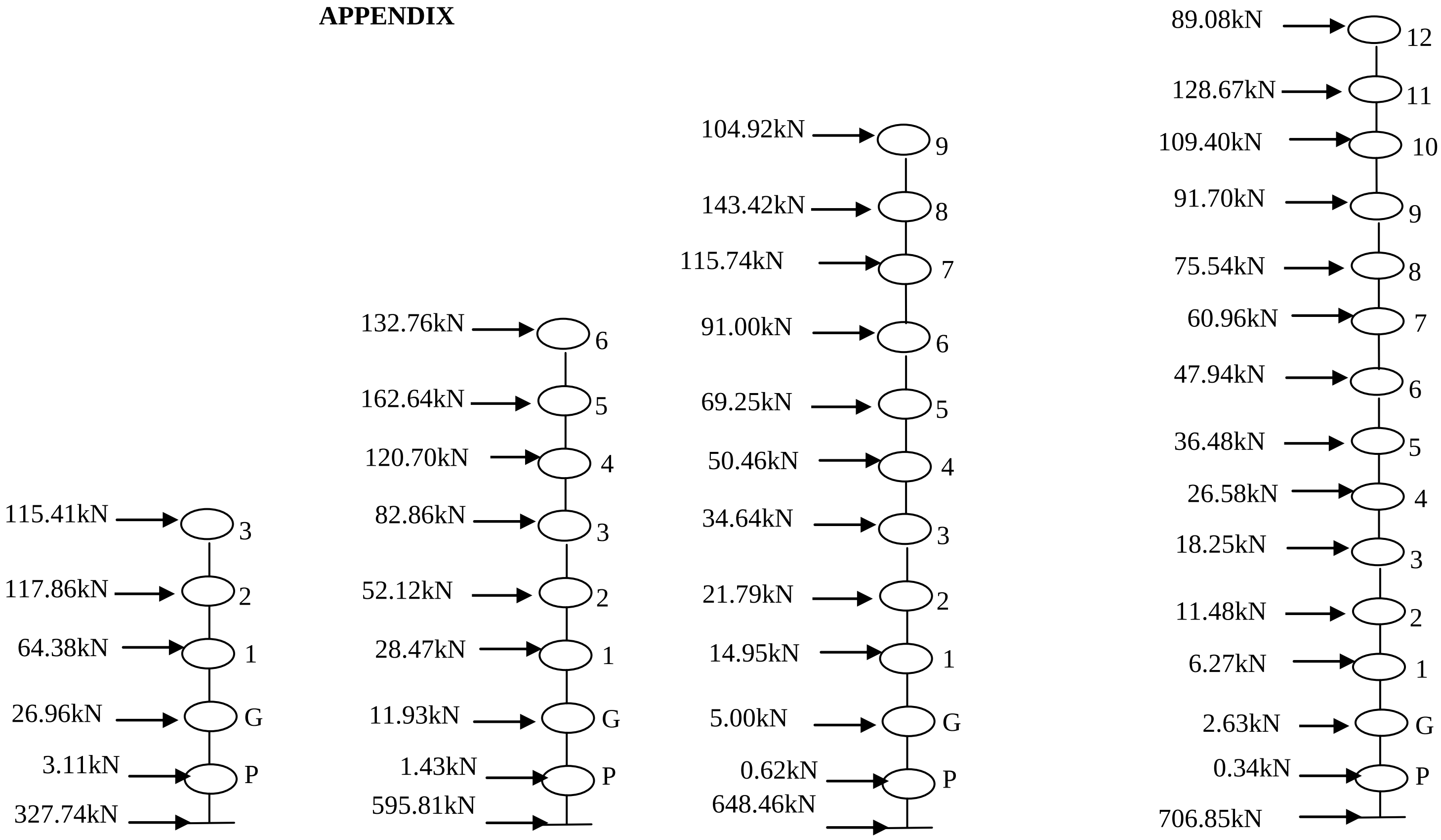

Fig 4 Lateral force distributions of G+3, G+6, G+9 and G+12 building of 15mx9m plan area

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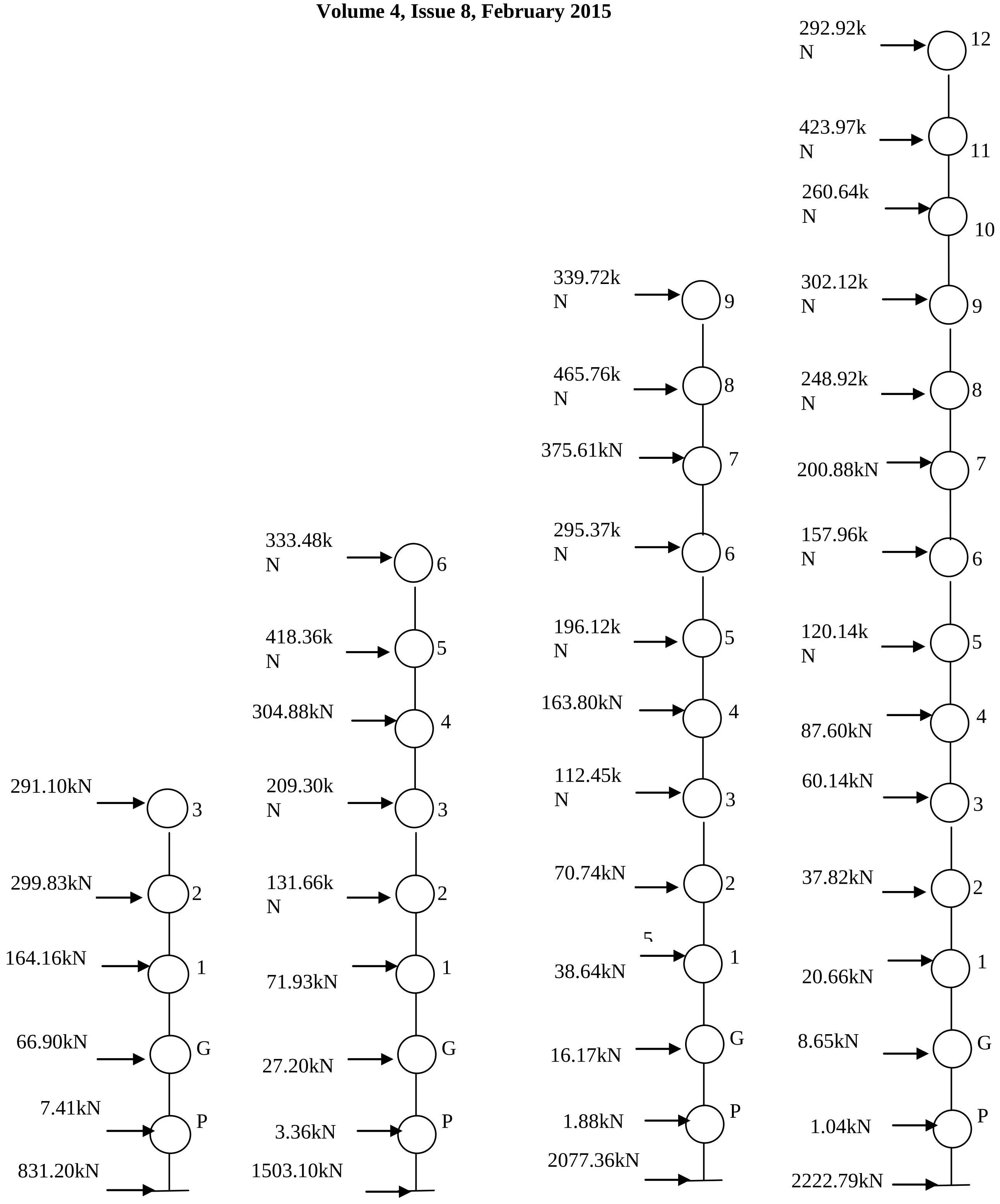

Fig 5 Lateral force distributions of G+3, G+6, G+9 and G+12 building of 25mx15m plan area