Effect Of Area And Height Of Building On Lateral Forces Using Scm And Rsm

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ABSTRACT:

In the present paper, a comparative study of seismic coefficient method and response spectrum method using STAAD software with IS1893 (Part1:2002). For these purpose three different storey buildings having plan areas 100, 200 and 300m2are analyzed using STAAD software and the results obtained are compared using seismic coefficient method & response spectrum method mentioned in IS 1893:2002. It is important to note that the study is conducted for variation in geometrical properties of building but the seismic properties for all these buildings is same. The buildings are located in zone IV region. The results obtained for base shear and other design parameters obtained from STAAD software match with IS1893:2002. The value of base shear obtained by seismic coefficient method and response spectrum method was also compared. In addition to this lateral force distribution obtained from SCM and RSM are also compared. After analysis these buildings are also designed for the results obtained from seismic coefficient method and response spectrum method. The percentage variation in concrete and steel consumption by the two methods is also studied.

Keywords: Response spectrum method, seismic coefficient method, STAAD software, base shear.

1. INTRODUCTION:

Structures constructed in seismically active areas are subjected to the risk from earthquakes. The degree of seismic protection and level of acceptable structural damage depend on many design consideration. Generally accepted seismic design philosophy requires that the structure should be able to resist minor earthquakes without damage but with possibility of some non structural damage and resist major earthquakes without collapse, but may suffer some structural and non structural damage. Research efforts are being made to understand earthquake loading properly and to make structural analysis more and more refined. With the availability of computing machines, analysis and design of structures is being done using computer software. For a framed building, modeling comprises of beams and columns along with the loads applied and boundary condition. Usually, in computer oriented structural analysis, three-dimensional models of buildings are used. After achieving a reasonably good structural model, next stage is to use appropriate analysis method to obtain seismic response.

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. The mass of slab and mass corresponding to appropriate amount of imposed load are considered along with the mass of beam and column. Using natural frequencies and mode shapes, static earthquake loads and response in each mode are obtained. These modal responses are combined using any one modal combination rules, i.e. Sum of Square Root of Squares (SRSS), Combined Quadratic Combination (CQC) and Absolute Sum (ABS). 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. It is to be noted that if modal superposition method is used to obtain dynamic response, then modal responses are combined using algebraic sum.

RSA uses modal quantities such as modal frequencies, modal mass etc. Response spectrum is more rigorous than equivalent static analysis. Due to combination of modes by different methods one can get good results while performing response spectrum analysis. In the RSA also static loads are calculated, which are obtained using modal properties of structure. The modal combination rules have a very peculiar property i.e. in these combinations; sign of modal response is lost. The modal combination rules, wherein maximum modal responses are considered are used only in RSA.

The present study discusses comparative study between seismic coefficient and response spectrum method as per IS 1893:2002 is presented. STAAD software is used for numerical study. For comparison of the seismic methods of G+3, G+5 and G+7 buildings having plan area 100, 200 and 300m2 are modeled and analyzed using STAAD. As per Indian code (IS 1893:2002) earthquake zones are classified into four zones namely II, III, IV and V. In the present study the geometrical properties of building are varied but the seismic properties for all these buildings are same. The buildings are located in zone IV region. Moreover the results are further compared with the different methods used for analysis. The results obtained for base shear and other design parameters obtained from STAAD software match with IS1893:2002. The value of base shear obtained by seismic coefficient method and response spectrum method was also compared. After obtaining the analysis results, the buildings are designed for its structural components. And a comparative study of the design results obtained by these two methods is also explained.

2. MODELING IN STAAD:

STAAD is powerful design software licensed by Bentley. Staad stands for structural 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
iii. Material Properties
iv. Supports : Boundary Conditions
v. Loads & Load combinations (Dynamic)
vi. Special Commands
vii. Analysis Specification
viii. Design command

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.

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

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.

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.

Dead Loads (IS- 875 PART 1):

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. In the study following loads are taken under dead load. Figure1 shows the dead load assigned to G+3 building in STAAD.

Slab Weight

Σ Loads on beams of walls

Slab Weight Calculation:

Thickness of slab=0.15m

Density of concrete= 25kN/m^3

Self Weight of slab= Density of concrete x Thickness of slab

= 25x0.15

= 3.75kN/m^2

Floor Finish at floor level = 1 kN/m^2

Water Proofing at Terrace =2 kN/m^2

Total Slab Weight at floor level= 4.75 kN/m^2

Total Slab Weight at terrace = 5.75 kN/m^2

Wall load calculation:

Width of the wall=230mm

Beam size=300x450mm

Height of the wall=3.6m

Wall Weight = Thickness of wall x Height of wall x Density of brick wall

= 0.23 x (3.6-0.45) x 20

= 14.49kN/m

Weight of parapet wall = 0.23 x 1 x 20

= 4.6kN/m

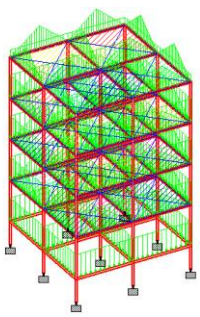


Figure 1 STAAD model showing dead load.

Live Loads (IS 875 PART 2):

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. In staad we assign live load in terms of U.D.L .we has to create a load case for live load and select all the beams to carry such load. The following loads come under live loads. Figure 2 shows STAAD model subjected to live load.

Σ Floor load

Floor load:

Live Load Intensity specified = 4 kN/m^2

Live Load at roof level =1.5 kN/m^2

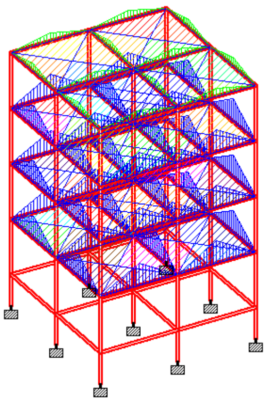


Figure 2STAAD model showing live load.

In addition to the above mentioned loads some generated loads are also applied to the structure in STAAD. The generated load cases assigned to the structure are as follows:

1. Wind Load
2. Seismic Co-efficient Method
3. Repetitive Moving Load

In the present work only seismic load is assigned to the structure. In addition to this dynamic loads are assigned to the structure in form of Response Spectrum. 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

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-

3. Seismic Analysis Results in STAAD

Using STAAD software G+3, G+5 and G+7 building models are analyzed. Figure 3 shows the plan of $100m^2$, $200m^2$ and $300m^2$ models selected for analyzing G+3, G+5 and G+7 buildings. The results obtained from seismic analysis of building model by SCM and RSM are summarized as shown by 5, 6, 7 and 8 respectively. The seismic parameters taken for seismic analysis of building by using seismic coefficient method (SCM) and response spectrum analysis (RSM) are as follows. Table 2, 3 and 4 shows the geometrical properties and sectional properties taken for analyzing G+3, G+5 and G+7 buildings.

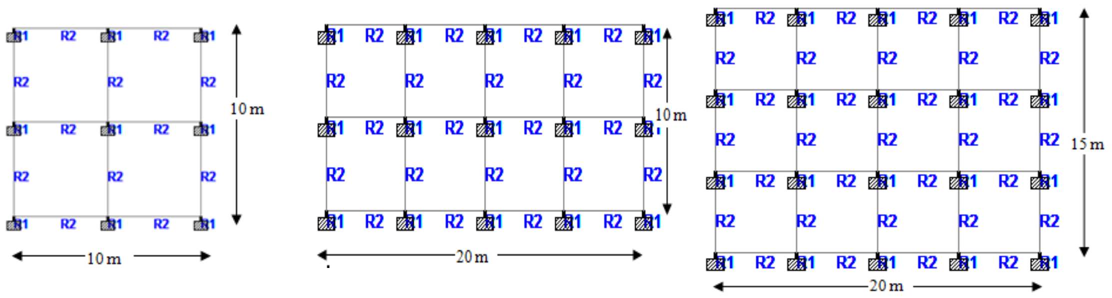


Figure 3 Plan of G+3, G +5 and G+7 models selected for analysis

Table 2 Geometrical and Sectional Properties (G+3 Building)

Floor Height =3.6m	Structural Member	Size (mm)
Total Height of Building (h) =16.4 m	Beam (R2)	300x450
Depth of foundation =2 m	Column (R1)	300x300
	Slab	150

Table 3 Geometrical and Sectional Properties (G+5 Building)

Floor Height =3.6m	Structural Member	Size (mm)
Total Height of Building (h) =16.4 m	Beam (R2)	300x450
Depth of foundation =2 m	Column (R1)	400x400
	Slab	150

Table 4 Geometrical and Sectional Properties (G+7 Building)

Floor Height =3.6m	Structural Member	Size (mm)
Total Height of Building (h) =16.4 m	Beam (R2)	300x450
Depth of foundation =2 m	Column (R1)	500x500
	Slab	150

Seismic Load Parameters:

1. Zone factor = 0.24
2. Response Reduction factor = 5
3. Importance Factor =1.5
4. Type of soil strata= 2
5. Damping =5%

Table 5 Comparison of Base shear by SCM and RSM

Storey	Base shear kN (vB) (SCM)	Base shear kN (vb) (RSM)	vB/Vb
G+3:100m^2	615.86	189.52	3.25
G+3:200m^2	1159.31	348.89	3.32
G+3:300m^2	1896.19	480.28	3.95
G+5:100m^2	705.44	259.06	2.72
G+5:200m^2	1635.66	538.37	3.04
G+5:300m^2	2168.38	673.54	3.22
G+7:100m^2	736.96	329.04	2.24
G+7:200m^2	1706.20	584.78	2.92
G+7:300m^2	2442.14	799.19	3.06

Table65Comparison of storey shear G+3 Building (SCM & RSM)

Plan area	Floor	SCM (kN)	RSM (kN)	% Change in Storey Shear
100	Third Floor	216.56	57.75	73.33
	Second Floor	220.27	59.91	72.80
	First Floor	137.7	34.79	74.73
	Ground Floor	37.3	32.23	13.59
	Plinth level	3.32	4.84	45.78
	Base shear	615.86	189.52	69.23
200	Third floor	411.45	104.24	74.67
	Second floor	412.53	111.65	72.94

	First Floor	250.4	65.29	73.93
	Ground floor	78.96	59.32	24.87
	Plinth level	6.03	8.39	39.14
	Base shear	1159.31	348.89	69.91
300	Third floor	620.7	135.8	78.12
	Second floor	764.7	159.97	79.08
	First Floor	364.0	91.53	74.85
	Ground floor	134.8	82.36	38.90
	Plinth level	10.9	11.1	1.83
	Base shear	1896.19	480.28	74.67

Table 7Comparison of storey shear G+5 Building (SCM & RSM)

Plan area	Floor	SCM (kN)	RSM (kN)	% Change in Storey Shear
100	Fifth Floor	183.9	56.24	69.42
	Fourth Floor	213.6	72.56	66.03
	Third Floor	143.7	41.09	71.41
	Second Floor	92.25	29.55	67.97
	First Floor	46.84	27.85	40.54
	Ground Floor	19.78	27.8	40.55
	Plinth level	5.34	3.97	25.66
	Base shear	705.44	259.06	63.28
200	Fifth Floor	479.56	119.60	73.54
	Fourth Floor	556.68	132.07	73.42
	Third Floor	284.61	93.33	64.82
	Second Floor	173.37	77.98	65.88
	First Floor	105.40	57.36	24.09
	Ground Floor	33.25	51.21	39.27
	Plinth level	2.79	6.82	1.38
	Base shear	1635.66	538.37	67.08
300	Fifth Floor	548.43	135.95	75.21
	Fourth Floor	671.4	188.2	71.97
	Third Floor	451.28	116.15	74.26
	Second Floor	295.22	76.8	73.99
	First Floor	145.5	81.15	44.23
	Ground Floor	52.70	67.78	28.61
	Plinth level	4.28	8.11	89.49
	Base shear	2168.38	673.54	68.94

Table 8Comparison of storey shear G+7 Building (SCM & RSM)

Plan area	Floor	SCM	RSM	% Change in Storey Shear
100	Seventh Floor	141.88	60.97	57.03
	Sixth Floor	195.6	78.95	59.64
	Fifth Floor	147.22	46.42	68.47
	Fourth Floor	105.78	32.1	69.65
	Third Floor	71.25	28.57	59.90
	Second Floor	43.44	25.68	40.88
	First Floor	22.42	28.46	26.94
	Ground Floor	8.32	24.33	1.92
	Plinth level	1.05	3.56	2.39
	Base shear	736.96	329.04	55.35
200	Seventh Floor	350.3	106.09	69.71
	Sixth Floor	443.7	138.19	68.86
	Fifth Floor	338.78	86.61	74.43
	Fourth Floor	240	59.0	75.42
	Third Floor	161.4	50.55	68.68
	Second Floor	98.18	47.47	51.65
	First Floor	50.73	50.82	0.18
	Ground Floor	18.76	40.83	1.17
	Plinth level	4.5	5.22	16.00
	Base shear	1706.20	584.78	65.73
300	Seventh Floor	538.45	127.84	76.26
	Sixth Floor	633.0	188	70.30
	Fifth Floor	476.56	134.92	71.69
	Fourth Floor	342.22	84.86	75.20
	Third Floor	230.18	63.36	72.47
	Second Floor	120.2	70.41	41.42
	First Floor	72.46	74.27	2.50
	Ground Floor	26.82	49.87	85.94
	Plinth level	2.25	5.66	1.51
	Base shear	2442.14	799.19	67.28

The above results are summarized for base shear and figure 4 shows the comparison of base shear for different buildings by SCM and RSM. The percentage variation of base shear by SCM and RSM is also plotted as shown by figure 5 and 5A.

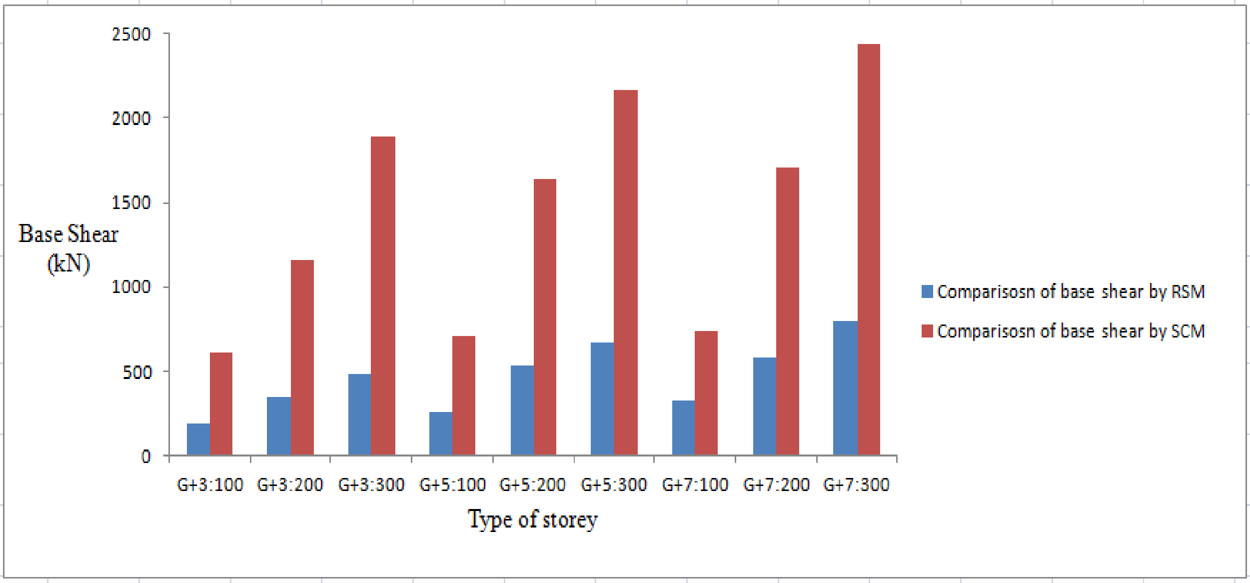
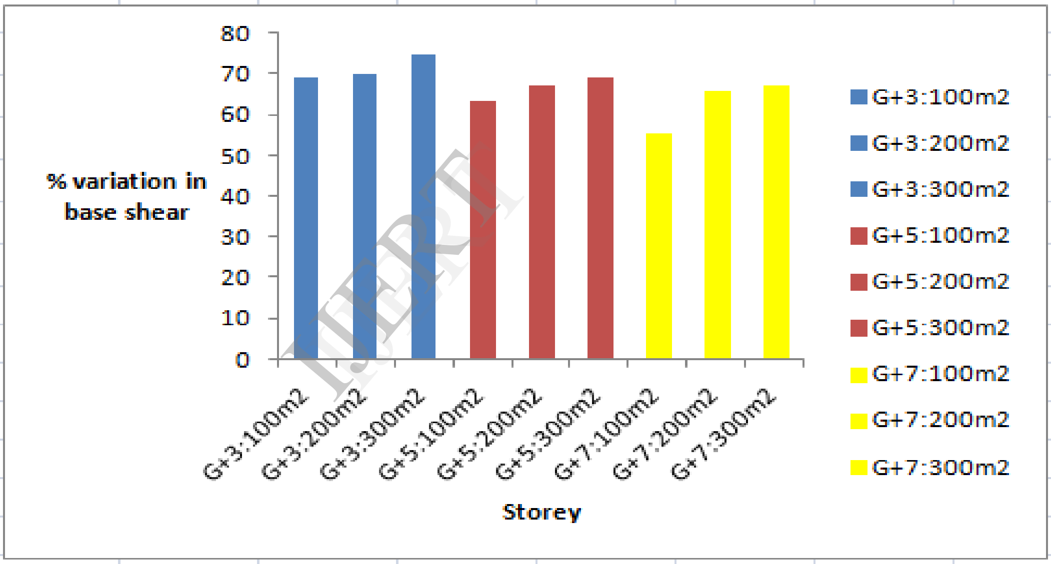
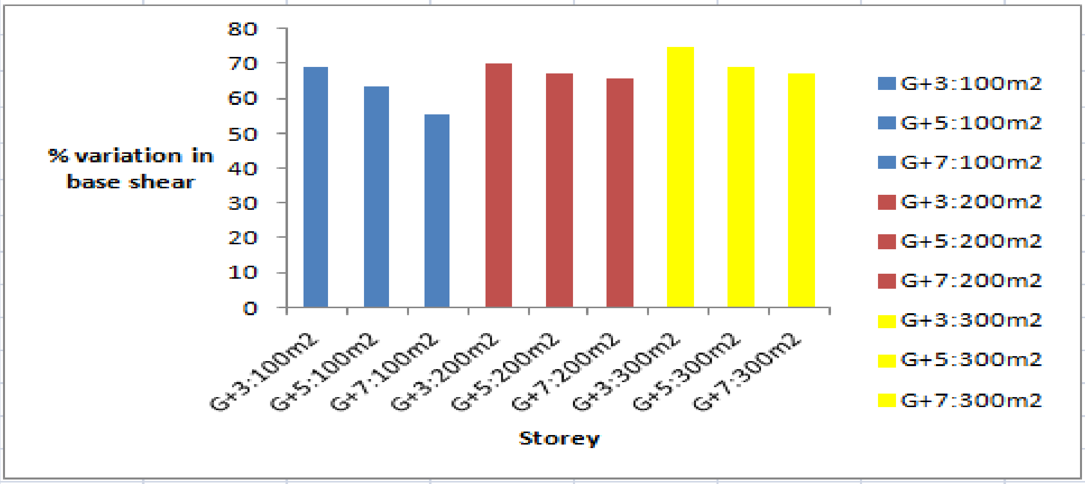


Figure 4 Comparison of base shear for different buildings by RSM and SCM.



Graph shows percentage variation in base shear by change in plan area (Fig 5)



Graph shows percentage variation in base shear by change in height . (fig 5A)

The total quantity of concrete and steel required in the constructions of these buildings by SCM and RSM is also summarized by table 9and 10 respectively. A plot of quantity of concrete and steel obtained from SCM and RSM is also presented. Figure 8 shows the comparison of concrete quantity obtained by SCM and RSM whereas Figure 9 shows the comparison of steel quantity obtained by SCM and RSM

Table 9 Comparison of Quantity of concrete by SCM and RSM

	Concrete (m^3) (SCM)	Concrete (m^3) (RSM)
G+3 :100	204.3	164.42
G+3 :200	379.72	304.60
G+3 :300	567.71	456.32
G+5 :100	353.86	289.62
G+5 :200	714.77	566.16
G+5 :300	935.4	755.96
G+7 :100	524.41	430.1
G+7 :200	884.86	701.86
G+7 :300	1296.73	1119.35

Table 10 Comparison of Quantity of steel by SCM and RSM

	Steel(MT) (SCM)	Steel (RSM)
G+3 :100	18.00	15.80
G+3 :200	34.94	29.50
G+3 :300	49.30	44.10
G+5 :100	25.14	22.26
G+5 :200	47.50	40.90
G+5 :300	68.50	59.37
G+7 :100	33.80	29.65
G+7 :200	62.22	54.00
G+7 :300	90.56	79.02

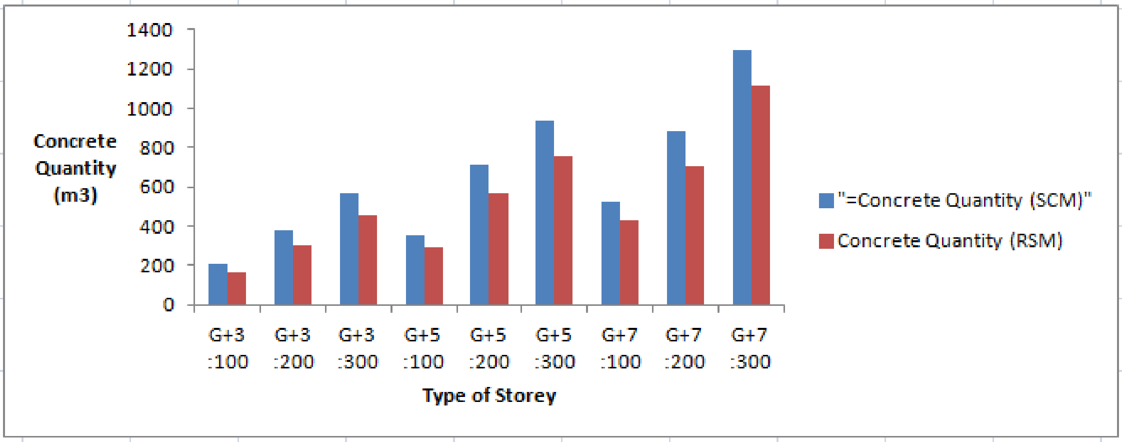


Figure 8 Comparison of Concrete Quantity by SCM and RSM

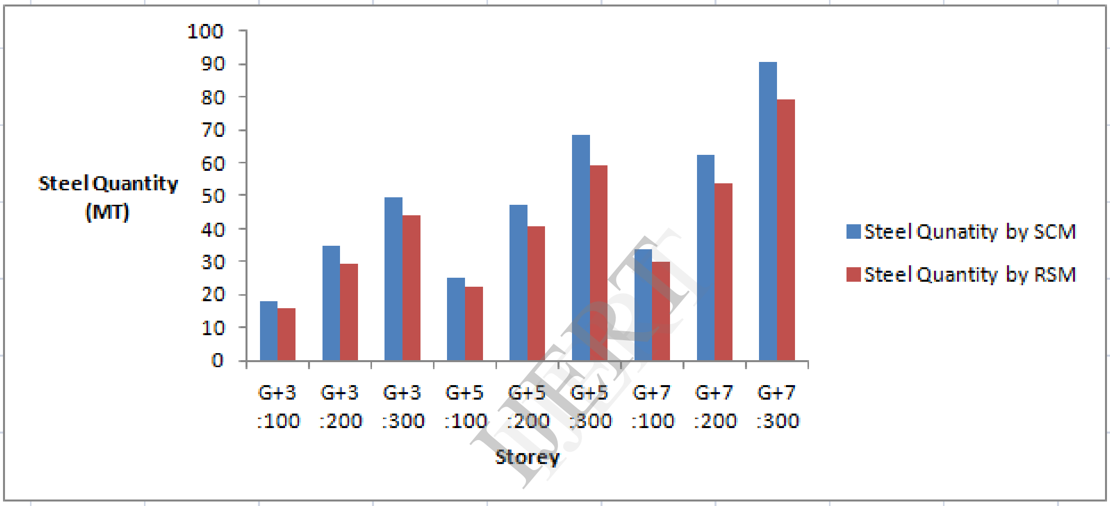


Figure 9 Comparison of Steel Quantity by SCM and RSM

4. SUMMARY AND CONCLUSION:

In the present study, an attempt is made to compare the results obtained from SCM and RSM using STAAD and IS 1893:2002. Different models of G+3, G+5 and G+7 are prepared in STAAD. The seismic analysis is carried out taking into consideration that all the buildings are located in zone IV. In addition, design of all these models is also done. Schedule for beams columns slabs and footings were also prepared for these buildings. At the end quantity of concrete and steel requirement by SCM and RSM was also evaluated for these models. In the next section all the conclusions obtained from the present study is discussed.

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

1. For G+3 building, due to increase in plan area the variation in base shear by SCM and RSM increases.
2. For G+3 building the percentage variation in base shear for 100m^2 is 69.23% and for 200m^2 and 300m^2 is 69.91% and 74.67% respectively
3. For G+5 building, due to increase in plan area the variation base shear by SCM and RSM increases.
4. For G+5 building the percentage variation in base shear for 100m^2 is 63.28% and for 200m^2 and 300m^2 is 65.47% and 68.94% respectively
5. For G+7 building, due to increase in plan area the variation base shear by SCM and RSM increases.
6. For G+7 building the percentage variation in base shear for 100m^2 is 55.35% and for 200m^2 and 300m^2 is 65.73% and 67.28% respectively
7. For 100m^2 plan area and increase in height of building the percentage variation in base shear by SCM and RSM reduces.

8. For $100m^2$ plan area the percentage variation in base shear for G+3 building is 69.23% and for G+5 and G+7 building is 63.28% and 55.35% respectively
9. For $200m^2$ plan area and increase in height of building the percentage variation in base shear by SCM and RSM reduces.
10. For $200m^2$ plan area the percentage variation in base shear for G+3 building is 69.91% and for G+5 and G+7 building is 67.08% and 65.73% respectively
11. For $300m^2$ plan area and increase in height of building the percentage variation in base shear by SCM and RSM reduces.
12. For $300m^2$ plan area the percentage variation in base shear for G+3 building is 74.67% and for G+5 and G+7 building is 68.94% and 67.28% respectively.
13. The quantity of concrete required for G+3:100m ^{2}, G+3:200m^2 and G+3:300m^2 is obtained as 204.3, 379.72 and 567.71 m^3 respectively by SCM
14. The quantity of concrete required for G+3:100m ^{2}, G+3:200m^2 and G+3:300m^2 is obtained as 164.42, 304.6 and 456.32 m^3 respectively by RSM
15. The quantity of concrete required for G+5:100m ^{2}, G+5:200m^2 and G+5:300m^2 is obtained as 353.86, 714.77and 935.4 m^3 respectively by SCM
16. The quantity of concrete required for G+5:100m ^{2}, G+5:200m^2 and G+3:300m^2 is obtained as 289.62, 516.66and 755.96 m^3 respectively by RSM
17. The quantity of concrete required for G+7:100m ^{2}, G+7:200m^2 and G+7:300m^2 is obtained as 524.41, 884.86and 1296.73m^3 respectively by SCM
18. The quantity of concrete required for G+7:100m ^{2}, G+7:200m^2 and G+7:300m^2 is obtained as 430.1, 701.86and 1119.35m^3 respectively by RSM
19. The quantity of steel required for G+3:100m ^{2}, G+3:200m^2 and G+3:300m^2 is obtained as 18.0, 34.94 and 49.3MT respectively by SCM
20. The quantity of steel required for G+3:100m ^{2}, G+3:200m^2 and G+3:300m^2 is obtained as 15.8, 29.5 and 44.1MT respectively by RSM
21. The quantity of steel required for G+5:100m ^{2}, G+5:200m^2 and G+5:300m^2 is obtained as 25.14, 47.5 and 68.5MT respectively by SCM
22. The quantity of steel required for G+5:100m ^{2}, G+5:200m^2 and G+5:300m^2 is obtained as 22.26, 40.9 and 59.37MT respectively by RSM
23. The quantity of steel required for G+7:100m ^{2}, G+7:200m^2 and G+7:300m^2 is obtained as 33.8, 62.22and 90.56MT respectively by SCM
24. The quantity of steel required for G+7:100m ^{2}, G+7:200m^2 and G+7:300m^2 is obtained as 29.65, 54.0 and 79.02MT respectively by RSM

5. REFERENCES

1. Agarwal, P., Shrikhande, M. (2006) "Earthquake Resistant Design of Structures", *Prentice-Hall of India*.
2. Ahirwar, S.K., Jain, S.K., and Pande, M. M. (2008). "Earthquake loads on multistory buildings as per IS1893-1984 and IS: 1893-2002: a comparative study." *Proceedings of the 14th World Conference on Earthquake Engineering, Beijing, China, October 12-17.*
3. Autocad (2010). Software application for computer aided design and drafting, *Autodesk, U.S.A.*
4. Bagheri, B., Firoozabad, E.S., and Yahyaei, M. (2012). "Comparative study of static and dynamic analysis of multi storey irregular building." *World Academy of Science, Engineering and Technology*, 71, 1920-1924.
5. Freeman, S.A. (2007). "Response spectra as a useful design and analysis tool for practicing structural engineers." *ISET Journal of Earthquake Technology*, 44, 25-37.
6. IS 1893 (2002). "Indian Standard criteria for Earthquake Resistant Design of structures Part 1: General Provisions and Buildings", Fifth Revision, *Bureau of Indian Standards (BIS), New Delhi*.
7. IS 456 (2000). "Indian Standard Plain Reinforced Concrete Code of Practice", Fourth Revision, *Bureau of Indian Standards (BIS), New Delhi*.
8. IS 875 (1987). "Indian Standard Code of Practice for Design Loads (Other Than Earthquakes) For Building and Structures Part 1: Dead Loads –Unit Weights of Building materials and stored materials", Second Revision, *Bureau of Indian Standards (BIS), New Delhi*.
9. IS 875 (1987). "Indian Standard Code of Practice for Design Loads (Other Than Earthquakes) For Building and Structures Part 2: Imposed Loads", Second Revision, *Bureau of Indian Standards (BIS), New Delhi*.
10. Jain, S.K. and Navin, R. (1995). "Seismic over strength in reinforced concrete frames." *Journal of Structural Engineering*, 580-585.

11. Murthy, C.V., and Jain, S.K. (1994). "A review of IS 1893-1984 provisions on seismic design of buildings." *The Indian Concrete Journal,* 619-629.
12. Otani, S. (2004). "Earthquake Resistant Design of Reinforced Concrete Buildings Past and Future." *Journal of Advanced Concrete Technology,* 1, 3-24.
13. Patil, S.S., Ghadge, S.A., Konapure, C.G., and Ghadge, C.A. (2013). "Seismic Analysis of High Rise Building by Response Spectrum." *International Journal of Computational Engineering Research*, 3, 272-279.
14. Shimazaki, K. (1992). "Seismic coefficient distribution of high rise reinforced concrete buildings." *Earthquake Engineering Tenth World Conference, Balkema Rotterdam*.
15. STAAD-Pro (2008). Structural analysis software, "Static and Dynamic Finite Element Analysis of Structures." *Bentley, USA*.