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A Comparative Study on Behaviour of High Rise Building with Shear Wall Under Seismic Analysis

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***Abstract*:- Earthquakes have been the cause of great disasters, right from the evaluation of earth, causing destruction to property, injury and loss of life. Due to rapid industrial development and concentration of population in cities, the effective design and construction of earthquake resistant structures plays a major part in the reduction of losses due to earthquakes. In this thesis , the earthquake response of 12 storied asymmetric building was studied using two methods- "Seismic coefficient method and modal analysis is using Response spectrum method". Analysis carried out in both the methods manually and by using software's(E tabs), For modal analysis in response spectrum method, natural frequencies and mode shape coefficients are determined by MAT LAB Program. A comparative study has been made on responses obtained from the both the methods.**

INTRODUCTION:

Considering the past information of earthquake, there is need in the demand of earthquake resisting building which can be fulfilled with the aid of supplying the shear wall structures inside the building. The decision regarding provision or shear wall to face up to lateral forces play maximum critical function in deciding on the suitable structural device for given structure. Generally systems are subjected to two types of forces i.e. Static and Dynamic. Static forces are steady even as dynamic forces vary with time.

In majority civil structures most effective static forces are considered at the same time as dynamic forces aren't calculated due to the fact the calculations are more complicated. This might also purpose disaster specifically during Earthquake because of seismic waves. By presenting shear wall in multi-storied building we can face up to seismic waves. By presenting shear wall in multi-storied building we can face up to seismic forces triggered due to earthquake. The masses are calculated by means of manually and ETABS software by offering shear wall of total structure.

METHODS OF EARTHQUAKE ANALYSIS:

Two broad approaches of earthquake analysis of multi – storied structures are

(i) Equivalent static force analysis.
(ii) Dynamic analysis.

(i) *Equivalent Static Force Analysis :*

Seismic analysis of most structures is still carried out on the assumption that the lateral force is equivalent to the actual dynamic loading . This method requires less effort because, expect for the fundamental period, the periods and shapes of higher natural modes of vibration are not required. The base shear which is the total horizontal force on the structure is calculated on the basis of the structure's mass, its fundamental period of vibration, and corresponding shape. The base end shear is distributed along the height of the structure, in terms of lateral forces, according to the code formula., Planar models appropriate for each of the two orthogonal lateral directions are analysed separately; the results of the two analyses and the various effects, including those due to torsional motions of the structure, are combined. This method is usually conservative for low to medium height buildings with a regular conformation.

(ii) ***Dynamic analysis:***

Static methods of seismic analysis are not accurate for complex structures which demand dynamic analysis for accuracy. Various methods of varying complexity have been developed for dynamic seismic analysis of structure. The two main methods currently used for dynamic analysis are

(i) Response spectrum analysis
(ii) Time history analysis

Response Spectrum Analysis :

It is dynamic method analysis. This method is also known as modal method or mode superposition method. The method is applicable to those structures where modes other than the fundamental one significantly affect the response of the structure. Generally, the method is applicable to analysis of the dynamic response of structures, which are asymmetrical or have areas of discontinuity irregularity, in their linear range of behaviour. In particular, it is applicable to analysis of force and deformations in multi-storey buildings due to medium intensity ground shaking, Which causes a moderately large but essentially linear response in the structure. In the calculation of structural response, the structure should be so represented by miss of an analytical or computational model that reasonable and rational results can be obtained by its behaviour. Where response spectrum method is used with modal analysis procedure, at least 3 modes of response of the structure should be considered expect in those cases where it can be shown qualitatively that either third mode or second mode produces negligible.

Time History Analysis:

It is a dynamic method analysis. This method is a useful technique for the elastic analysis of structure. A

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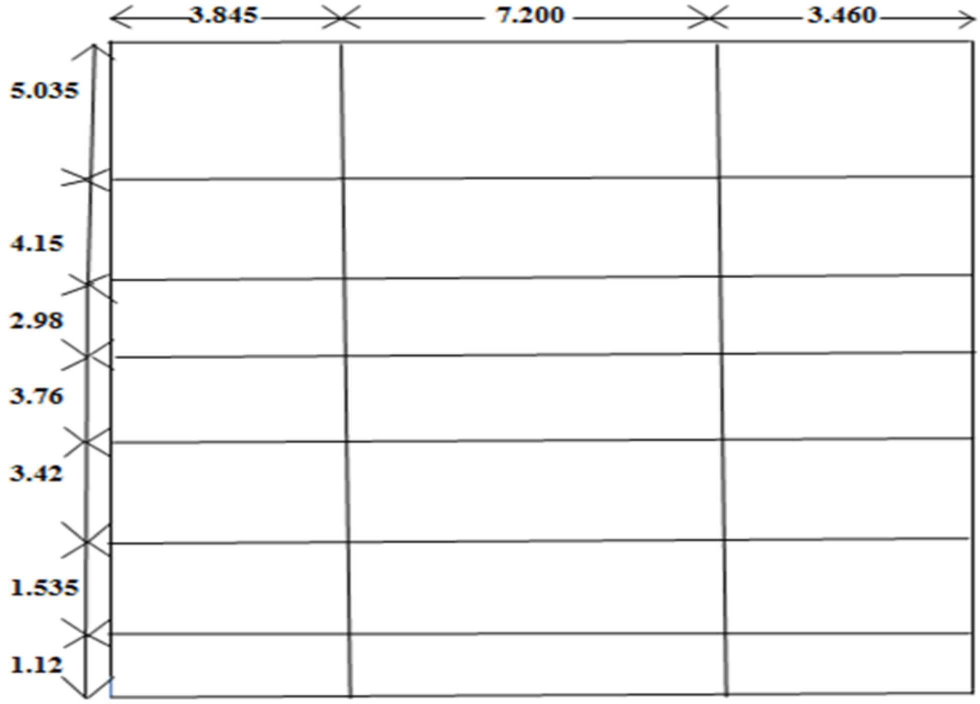
linear time history analysis overcomes all the disadvantages of a modal response spectrum analysis provided non-linear behaviour is not involved. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that present the expected earthquake at the base of the structure. The method consists of a step-by-step direct integration over a time interval. This method is applicable to both elastic and in elastic analysis.

METHODOLOGY:

1.Seismic analysis of 12 storeyed building of complete shear wall was considered.
2.Analysis on seismic coefficient method & response spectrum method as given in
IS 1893(Part-1):2002
3.Seismic coefficient method (manually & E tabs)
4.Response Spectrum method(By using modal analysis & Mat lab)
5.The lateral load distribution, the shear forces, the bending moments and drifts at various floor levels of the building are worked out.

ANALYSIS& RESULTS:

Seismic coefficient method(manual Calculation):



Building configaration

Design Parameters:

For seismic zone 3, the zone factor Z is 0.16(Table 2 of IS: 1893). Being an office building, the importance factor, I, is 1.2 (Table 6 of IS: 1893). Building is required to be provided with moment resisting frames detailed as per IS: 13920-1993. Hence, the response reduction factor, R, is 5. (Table 7 of IS: 1893 Part 1)

Number of bays along x direcion-3=14.505m
Number of bays along y direction-7=22m
Number of floors=12@3.6m ht/floor
Slab thickness:150mm
Floor finishes=1.0kN/m^2
Live load=3kN/m^2
Soil type=medium
Seismic zone=3

STEP 1: Calculation of lumped masses to various floor levels

Slab weight=22x14.505x0.15x25=1196.6KN
Floor finish=22x14.505x1 =319.11KN
Live load on floor =22x14.505x3/4 =239.3 KN
Seismic weight on each floor = 1196.6+319.11+239.3=1755.01KN
Seismic weight on roof floor=1196.6+319.11=1515.71KN

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Weight of walls=
3.45x0.165x(3.845(8)+7.2(8)+3.46(8)+5.035(4)+4.15(4)+2.98(4)+3.76(4)+3.42(4)+1.535(4)+1.12(4))
=2903.744KN
Weight of wall on roof=1451.872KN
lumped weight at each floor=1196.6+319.11+239.3+2903.744=4658.754KN
lumped weight at roof level=1196.6+319.11+1451.872=2967.582KN
Total seismic weight=4658.754(11)+2967.58=54213.874KN

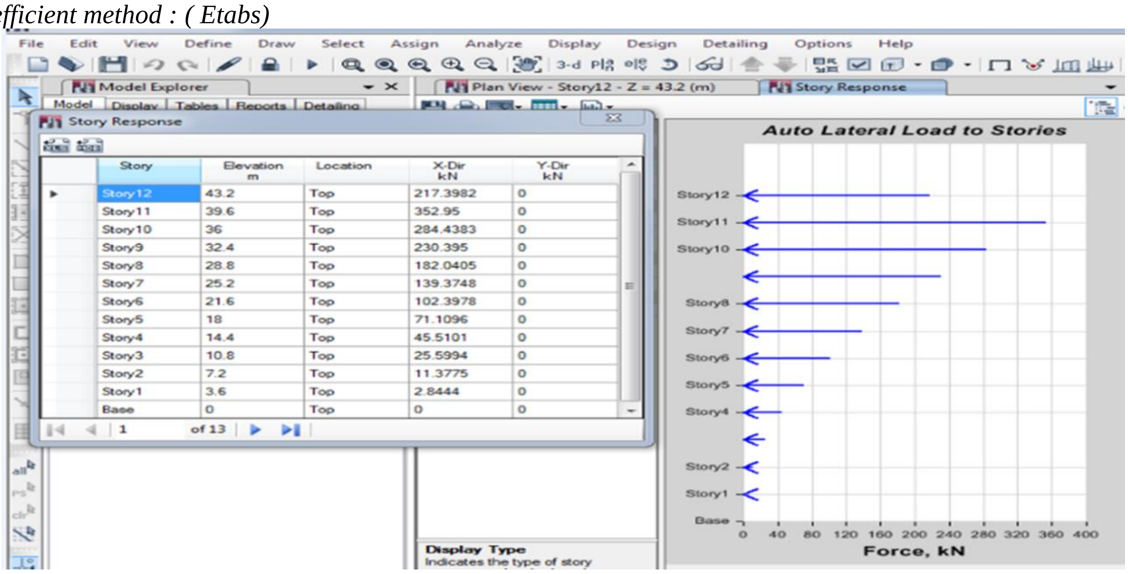
STEP 2: Determination of fundamental natural period
Ta=0.09*43.2/√22 (For medium stiffness soil)
=0.828 (as per IS 1893:2002)
Sa/g=1.642

STEP 3: Determination of design base shear
VB=Ah*W
Ah= Z/2 * I/R * Sa/g
= 0.16/2 *1.2/5 *1.642
=0.0315264
VB=0.0315264*54213.874=1704.168KN
VB= 1704.168KN

STEP4: Vertical distribution of base shear:

Floor No	Floor Weight (KN)	Height of the floor above base h_i (m)	$W_i h_i^2$	$\frac{Wi\,h_i^2}{\sum Wi\,h_i^2}$	$Q_i = V_B$ x $\frac{Wi\,h_i^2}{\sum Wi\,h_i^2}$
Roof	2967.58	43.2	5.538×10^6	0.153	261.50
11	4658.75	39.6	7.305×10^6	0.2020	345.25
10	4658.75	36	6.037×10^6	0.1669	285.260
9	4658.75	32.4	4.890×10^6	0.1352	231.079
8	4658.75	28.8	3.864×10^6	0.1068	182.53
7	4658.75	25.2	2.958×10^6	0.0818	139.809
6	4658.75	21.6	2.173×10^6	0.060	102.550
5	4658.75	18	1.509×10^6	0.0417	71.2723
4	4658.75	14.4	966.03×10^3	0.0267	45.634
3	4658.75	10.8	543.39×10^3	0.0150	25.637
2	4658.75	7.2	241.50×10^3	6.67×10^{-3}	11.413
1	4658.75	3.6	60.37×10^6	1.66×10^{-3}	2.852
SUM			$36.16X\ 10^6$		**1704 KN**

Seismic coefficient method : (Etabs)



Comparison of Seismic Lateral Load Values: (Manually and E tabs)

Storey Dof	Static Lateral Forces(KN)(Manually)	Static Lateral Forces(KN)(ETABS)
Roof	261.50	217.39
11	345.25	352.95
10	285.260	284.43
9	231.079	230.39
8	182.53	182.04
7	139.809	139.37
6	102.550	102.39
5	71.2723	71.109
4	45.634	45.510
3	25.637	25.594
2	11.413	11.377
1	2.852	2.8444
Total sum	1704	1670

Response Spectrum Method:

Storey number	Dynamic analysis
12	115.794
11	109.249
10	119.587
9	106.76
8	85.44
7	104.74
6	81.3
5	73.32
4	54.84
3	22.61
2	24.98
1	39.64
Sum	938.25

Storey number	Staticlateral forces(Manually)	Static lateral forces (Etabs)	Dynamic analysis
12	261.50	217.39	115.794
11	345.25	352.95	109.249
10	285.260	284.43	119.587
9	231.079	230.39	106.76
8	182.53	182.04	85.44
7	139.809	139.37	104.74
6	102.550	102.39	81.3
5	71.2723	71.109	73.32
4	45.634	45.510	54.84
3	25.637	25.594	22.61
2	11.413	11.377	24.98
1	2.852	2.8444	39.64
sum	**1704**	**1670**	**938.25**

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Seismic Response of 12 storeyed building by Seismic Coefficient Method :(Manually)

Storey	Floor Wt(KN)	Floor Ht from base(M)	Lateral Force(KN)	Storey shear(KN)	Storey Moment(KN-M)	Drift(MM)
12	2967.58	43.2	261.50	261.50	941.4	0.046
11	4658.75	39.6	345.25	606.75	3125.7	0.1075
10	4658.75	36	285.26	892.01	6336.93	0.1585
9	4658.75	32.4	231.07	1123.08	10380.08	0.1995
8	4658.75	28.8	182.53	1305.61	15080.2	0.232
7	4658.75	25.2	139.8	1445.41	20283.69	0.256
6	4658.75	21.6	102.5	1547.91	25856.16	0.274
5	4658.75	18	71.2	1619.11	31684.95	0.286
4	4658.75	14.4	45.6	1664.71	37677.906	0.2941
3	4658.75	10.8	25.63	1690.34	437636.1	0.298
2	4658.75	7.2	11.41	1701.75	49889.43	0.30
1	4658.75	3.6	2.852	1704.60	56025.9	0.30

Seismic Response of 12 storeyed building by Seismic Coefficient Method : (Etabs)

Storey	**Floor Wt(KN)**	**Floor Ht from base(M)**	**Lateral Force(KN)**	**Storey shear(KN)**	**Storey Moment(KN-M)**	**Drift(MM)**
12	2967.58	43.2	217.39	217.39	782.60	0.038
11	4658.75	39.6	352.95	570.34	2835.82	0.1016
10	4658.75	36	284.43	854.77	5913.00	0.1524
9	4658.75	32.4	230.39	1085.16	9819.57	0.1934
8	4658.75	28.8	182.04	1267.2	14381.49	0.2259
7	4658.75	25.2	139.37	1406.57	19445.14	0.2500
6	4658.75	21.6	102.39	1508.96	24877.40	0.269
5	4658.75	18	71.109	1580.06	30565.65	0.2817
4	4658.75	14.4	45.510	1625.57	36417.73	0.2898
3	4658.75	10.8	25.59	1651.17	42361.88	0.294
2	4658.75	7.2	11.377	1662.55	48347.13	0.2967
1	4658.75	3.6	2.844	1665.39	54342.54	0.2969

Seismic Response of 12 storeyed building Response spectrum Method :

Storey	**Floor Wt(KN)**	**Floor Ht from base(M)**	**Lateral Force(KN)**	**Storey shear(KN)**	**Storey Moment(KN-M)**	**Drift(MM)**
12	2967.58	43.2	115.79	115.79	416.85	0.046
11	4658.75	39.6	109.24	225.04	1227.00	0.1075
10	4658.75	36	119.58	344.63	2467.66	0.1585
9	4658.75	32.4	106.76	451.39	4092.66	0.1995
8	4658.75	28.8	85.44	536.83	6025.248	0.232
7	4658.75	25.2	104.74	641.57	8334.90	0.256
6	4658.75	21.6	81.30	722.87	10937.23	0.274
5	4658.75	18	73.32	796.19	13803.50	0.286
4	4658.75	14.4	54.84	851.03	16867.20	0.2941
3	4658.75	10.8	22.61	873.64	20012.304	0.298
2	4658.75	7.2	24.98	898.62	23247.33	0.30
1	4658.75	3.6	39.64	938.26	26625.066	0.30

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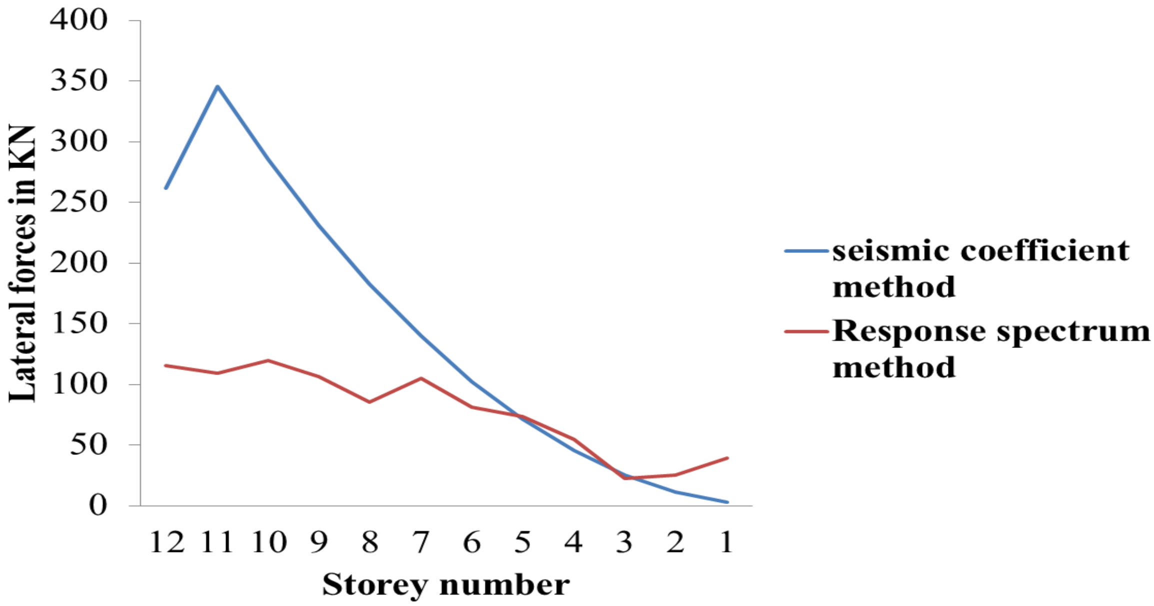
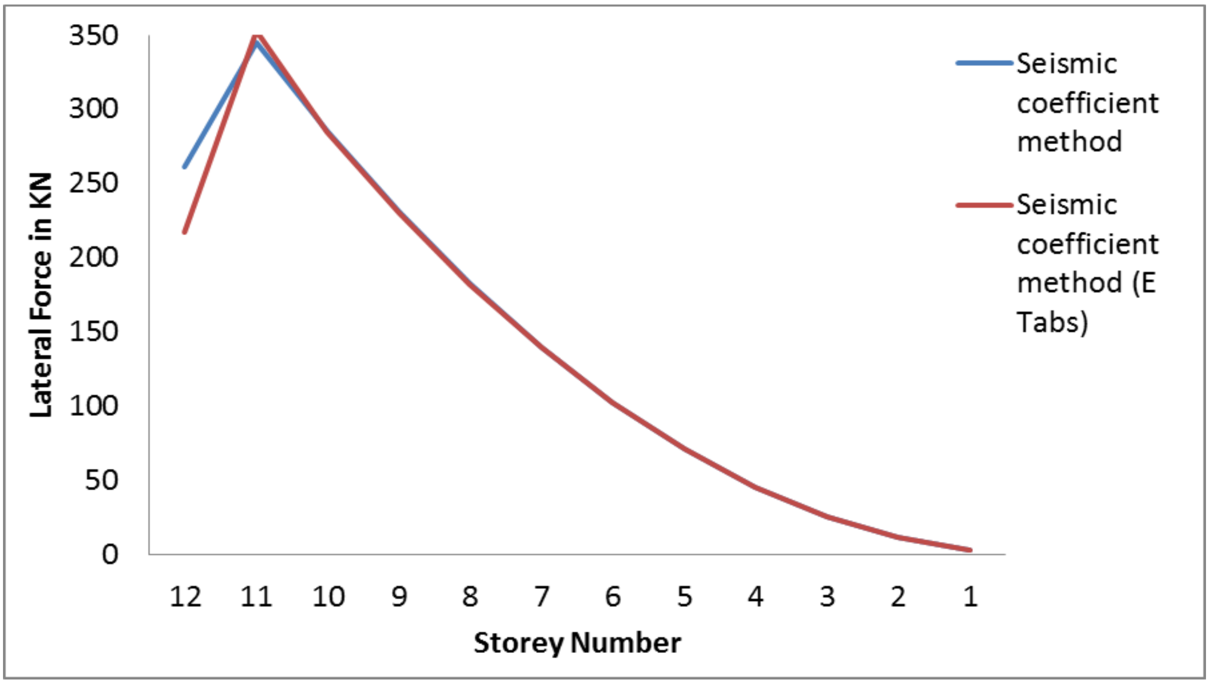
Graphs:

Lateral Forces:





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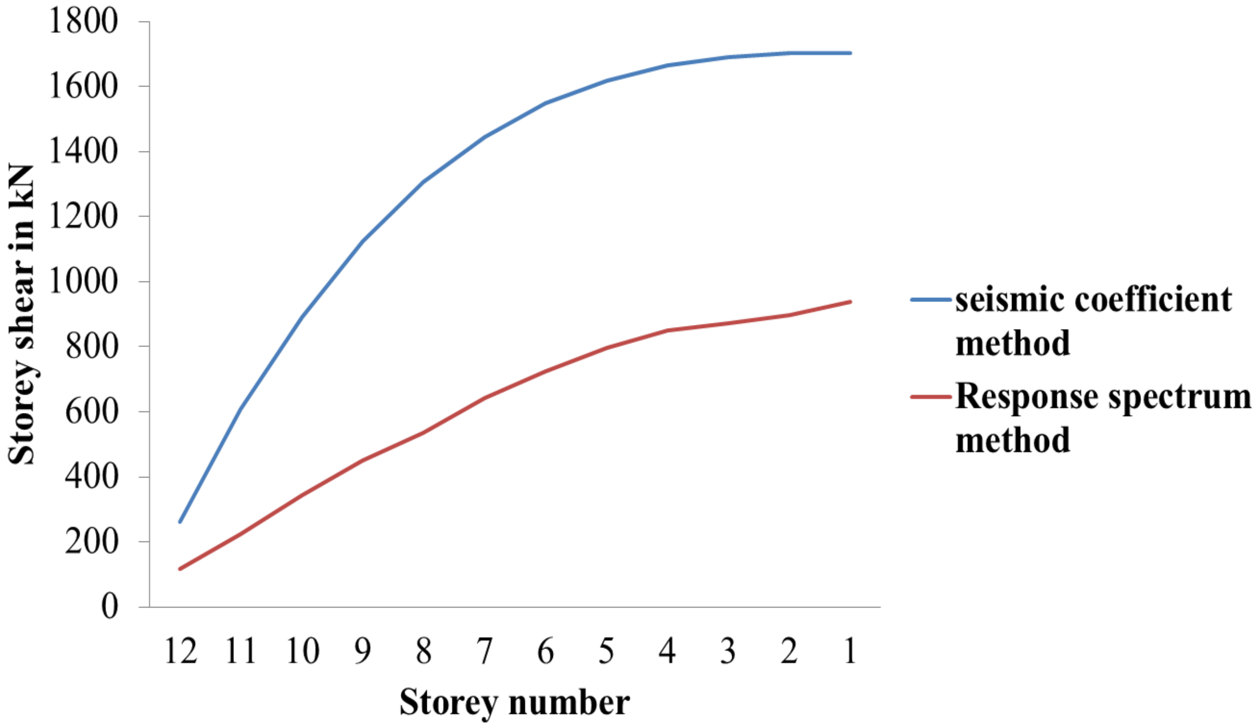
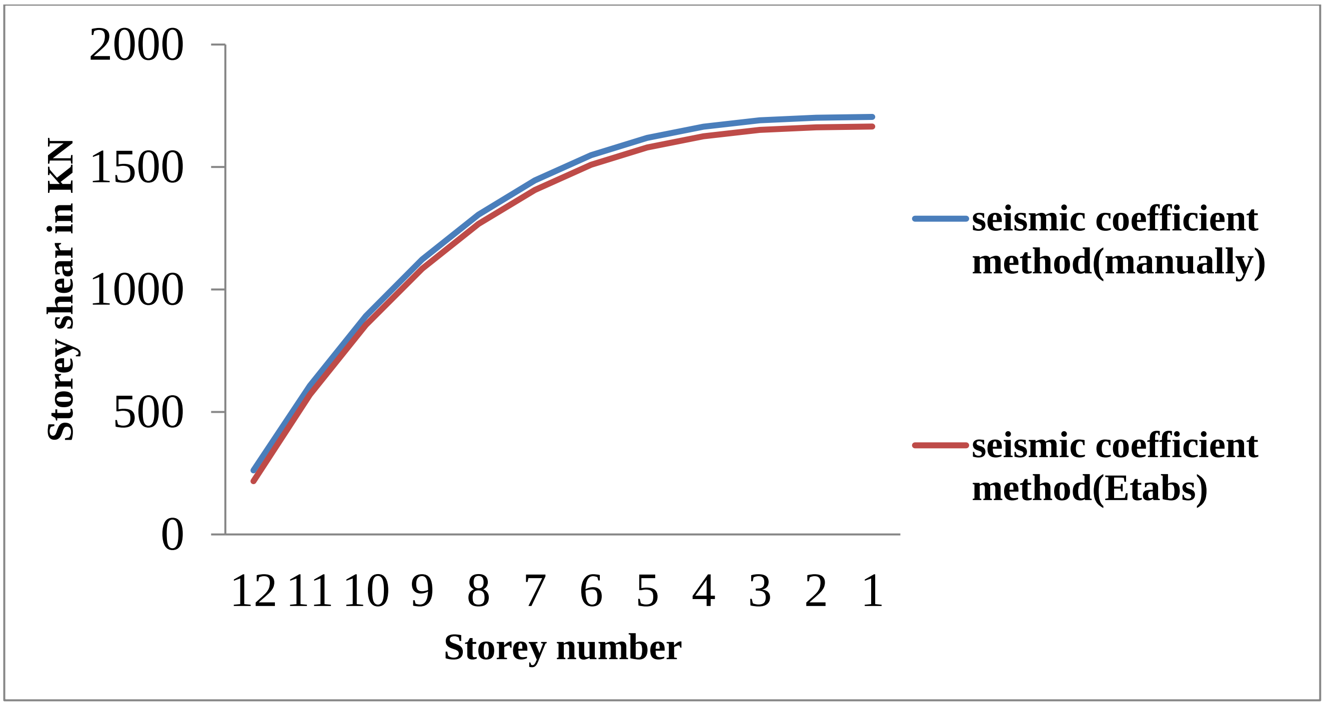
Storey shear :





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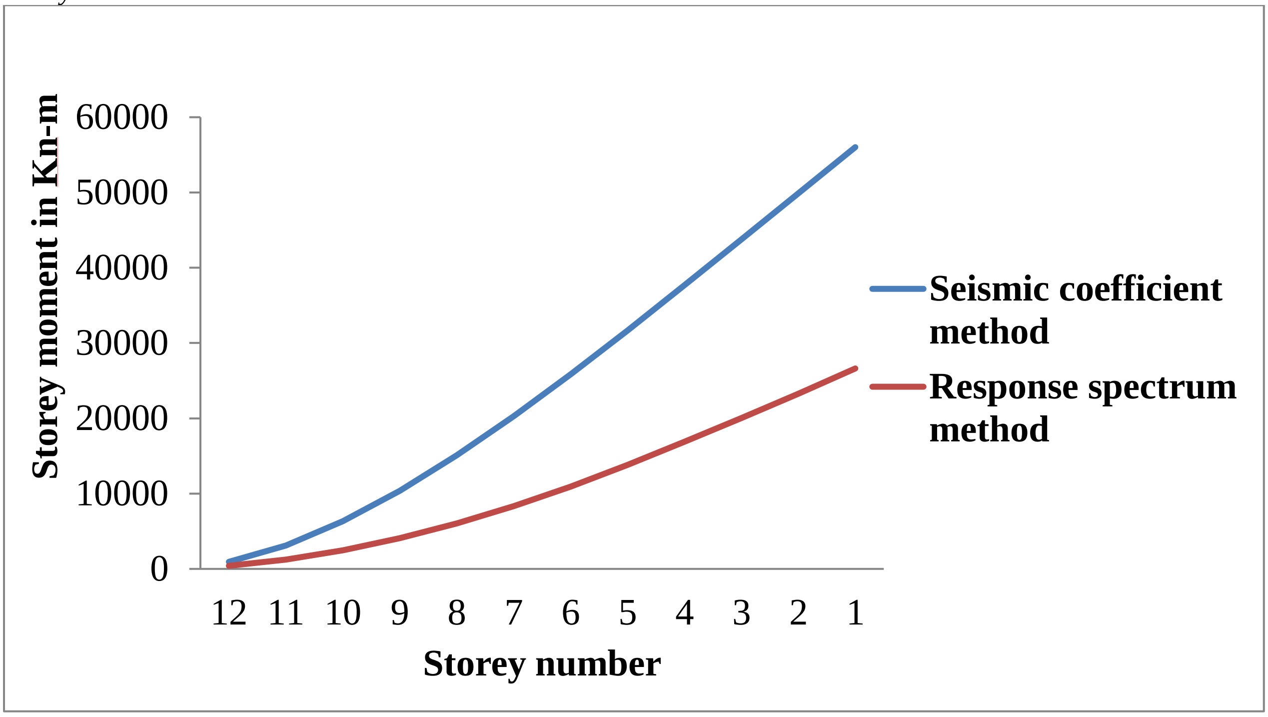
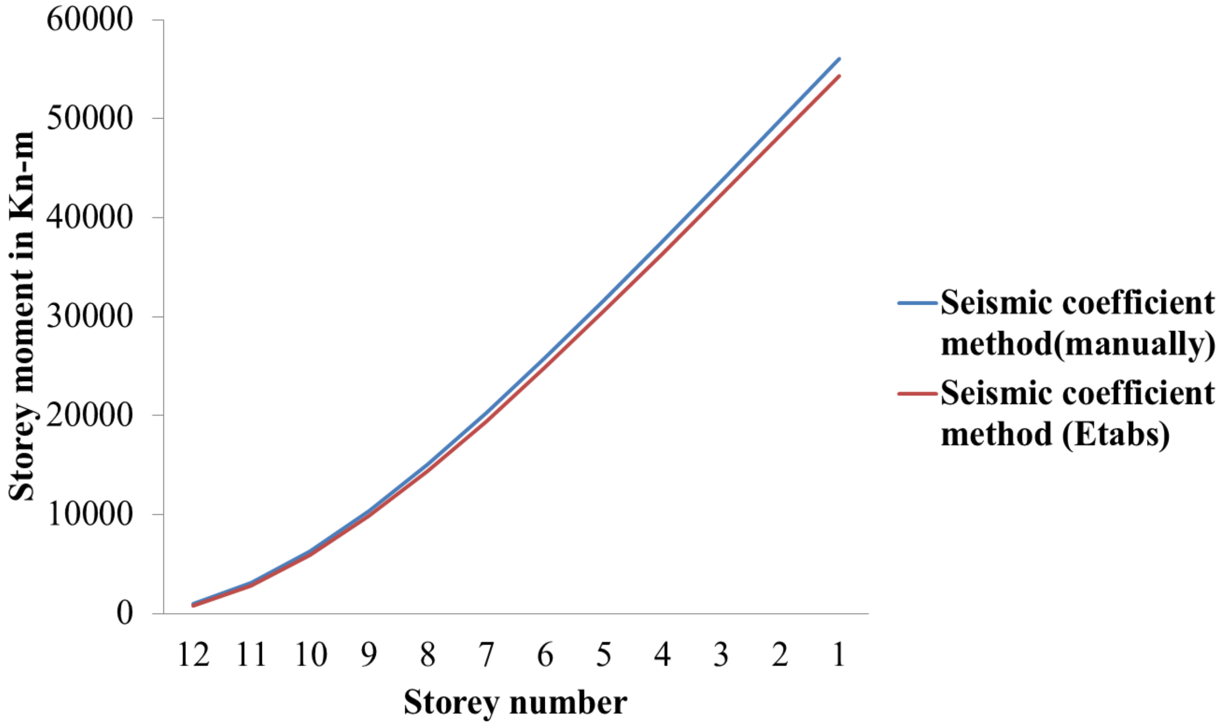
Storey Moment:





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CONCLUSIONS:

Based on the work presented in the thesis , the following conclusions are:

1.The seismic coefficient method is conservative at top floors compared to response spectrum method and vice-versa.

2. The base shear is high in seismic coefficient method when compared to the response spectrum method

3.The lateral load distribution is decreasing from a higher value to top floors to bottom floors in both seismic coefficient method and response spectrum method

4.Gradual increase in storey moments are observed from top storey to lower storey in both the methods.

5.Storey moments are high in seismic coefficient method compared to response spectrum method.

6.It is suggested to relay on response spectrum method even in asymmetric multi-storeyed buildings for seismic analysis and design.

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