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MULTISTORIED AND MULTI BAY STEEL BUILDING FRAME BY USING SEISMIC DESIGN

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Abstract: The aim of the present work is to analyze a multistory and multi bay (G+5) moment resisting building frame for earthquake forces following IS 1893 and then design it as per IS 800:2007 .The frame consists of six story‟s and has three bays in horizontal direction and five bays in lateral direction. The selection of arbitrary sections have been done following a standard procedure. The two methods that have been used for analysis are Equivalent static load method and Response Spectrum method .A comparative study of the results obtained from both these methods have been made in terms of story displacement ,inter story drift and base shear . The frame has also been further checked for P- analysis and required correction in moments have been done following IBC code .Then the steel moment resisting frame has been designed following IS-800:2007 based on these methods of analysis. In the process of design the section has undergone numerous iterations till all the criteria mentioned in the IS 800 have been satisfied. The designed frame was again analyzed and results were compared in terms of sections used. The cost efficiency of both the methods have been compared.

Keywords*: Base Shear, Story Displacement, Story Drift, IS 800-2007, Response Spectrum Method*

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I.INTRODUCTION:

Seismic Analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent. The most important earthquakes are located close to the borders of the main tectonic plates which cover the surface of the globe. These plates tend to move relative to one another but are prevented by doing so by friction until the stresses between plates under the epicenter point become so high that a move suddenly takes place. This is an earthquake. The local shock generates waves in the ground which propagate over the earth‟s surface, creating movement at the bases of structures. The importance of waves reduces with the distance from the epicenter. Therefore, there exists region of the world with more or less high seismic risk, depending on their proximity to the boundaries of the main tectonic plates Besides the major earthquakes which take place at tectonic plate boundaries, others have their origin at the interior of the plates at fault lines. Called „intra plates‟ earthquakes, these less energy, but can still be destructive in the vicinity of the epicenter The action applied to a structure by an earthquake is a ground movement with horizontal and vertical components. The horizontal movement is the most specific feature of earthquake action because of its strength and because structures are generally better designed to resist gravity than horizontal forces. The vertical component of the earthquake is usually about 50% of the horizontal component, except in the vicinity of the epicenter where it can be of the same order. Steel structures are good at resisting earthquakes because of the property of ductility. Experience shows that steel structures subjected to earthquakes behave well. Global failures and huge numbers of casualties are mostly associated with structures made from other materials. Dynamic wind analysis of tall buildings involves the study of the wind-induced behaviour of structures under varying wind conditions. This analysis is critical for understanding the structural performance and safety of tall buildings, as they are more susceptible to dynamic forces caused by wind.

II.OBJECTIVE

The primary objective of this thesis is to perform a comparative seismic analysis of a multistoried and multi-bay steel building frame using both the **Lateral Force Method (LFM)** and the **Response Spectrum Method (RSM)** as per IS 1893 (Part 1):2016 are as follows:

- To determine and compare the inter-storey drift obtained by the Lateral Force Method and Response Spectrum Method, and to analyze the reasons for the observed variations in displacement values.
- To compare the storey shear and base shear values derived from both methods and examine the implications of overestimation or underestimation in simplified static analysis.
- To evaluate the effect of post-design optimization on structural safety by comparing initial and revised member sections

III.METHODOLOGY AND MODELLING APPROACH

The initial step is preliminary design of building frame. The procedure involved are selection of sections of members of the frame. Since the dynamic action effects are a function of member stiffness, the process unavoidably involves much iteration. The example considered here involves a building in which seismic resistance is provide by moment resisting frames (MRF), in both x and y directions. Moment resisting frames (MRF) are known to be flexible structures. Thus their design is often governed by the need to satisfy deformation criteria under service earthquake loading, or limitation of P-Δ effects under design earthquake loading.

For this reason rigid connections are preferred. The Preliminary design consists of following steps:

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Defining beam sections, checking deflection and resistance criteria under gravity loading.

Following an iterative process, going through the following steps until all design criteria are fulfilled.

The iterative process can make use either of lateral force method or the spectral response modal superposition method.

1. Selection of Beam Sections.
2. Definition of Column Sections checking the „weak beam strong column criteria‟.
3. Check compression /buckling at ground floor level under gravity loading.
4. Calculation of seismic mass.
5. Static analysis of one plane frame under lateral loads.
6. Static analysis under gravity loading.
7. Stability check using P-Δ effects (parameter ϴ) in the seismic loading situation.
8. Deflection check under earthquake loading.
9. For Response spectrum analysis step 5 is replaced by response spectrum analysis of one plane frame to evaluate earthquake action effects

3.2 Modelling

The structure consisting of six stories with three bays in horizontal direction and six bays in lateral direction is taken and analyzed it by both equivalent static method and response spectrum analysis and designed.

The storey height is 3 meters and the horizontal spacing between bays is 8 meters and lateral spacing of bays is 6 meters

The seismic parameters of building site are as follows

- Seismic zone: 3
- Zone factor „Z‟: 0.16
- Building frame system: steel moment resisting frame designed as per SP 6
- Response reduction factor: 5
- Importance factor:1.5
- Damping ratio: 3%

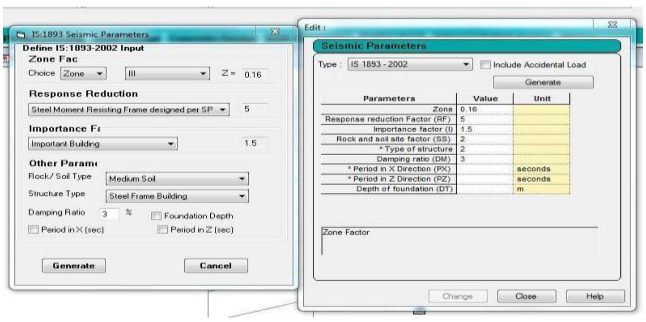

FIG 3.1 : STAAD input of seismic parameters

LOAD PARAMETERS:

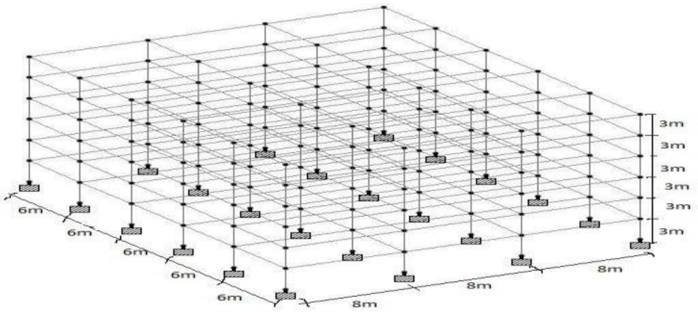

FIG 3.2 : 3-dimensional view of the steel building frame

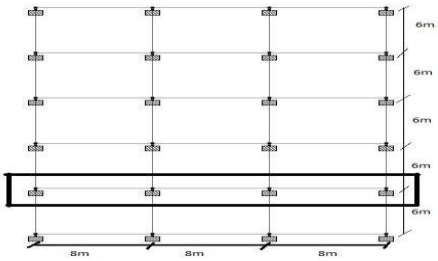

FIG 3.3: Plan of the building frame

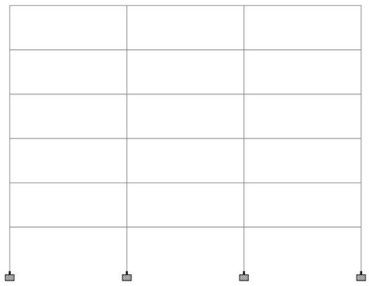

FIG 3.4 : Elevation of the building frame

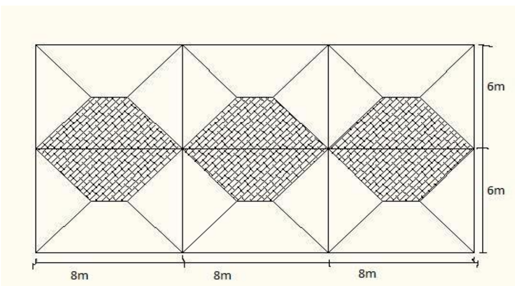

FIG 3.5 : Load distribution diagram

dead load is taken as = 5KN/m² and live load is taken as 3 KN/m²

Load Calculation

Load on beam along horizontal direction

1. Dead Load	=	$30m^2 \times$	=	150KN
Uniformly Distributed Load	=		=	18.75KN/m
2. Live Load	=	150/8	=	
Uniformly Distributed Load	=	30×3	=	90KN
		90/8		11.75KN/m

Load combinations as per IS1893-2002 :

- 1.7(DL+LL)
- 1.7(DL+EQ)
- 1.7(DL-EQ)
- 1.3(DL+LL+EQ)
- 1.3(DL+LL-EQ)

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IV.ANALYSIS

4.1LATERAL FORCE METHOD:

The seismic load of each floor is calculated at its full dead load and imposed load. The weight of columns and walls in any storey should be appropriately divided to the floors above and below the storey. Buildings designed for the storage purposes are likely to have large percentages of service load present at the time of the earthquake. The imposed load on the roof is not considered. In the equivalent static method which accounts for the dynamics of the buildings in approximate manner, the design seismic base shear is determined by VB=Ah × WAfter obtaining the seismic forces acting at different levels, the forces and moments in different members can be obtained by using any standard computer program for various load combinations specified in the code. The structure must also be designed to resist the overturning effects caused by seismic forces. And also storey drifts, member forces and moment due to P- delta effect must be determined. IS 1893 stipulates that the storey drift in any storey due to the minimum specified lateral loads , with a partial load factor of 1.0 should not exceed 0.004 times the storey height.

Table 4.1 : Analysis by lateral force method

Storey o.	Absolute isplaceetof toreyD$_i$ (m)	Design inter torey drift D$_r$ m)	Storey lateral orce V$_{tot}$ (KN)	Shear at storey $_{tot}$ (KN)
1	0.003869	0.003869	1.969	179.201
2	0.012595	0.008726	7.951	177.232
3	0.023837	0.011242	17.83	169.281
4	0.035892	0.012055	31.657	151.451
5	0.047566	0.011674	49.212	119.794
6	0.058123	0.010557	70.582	70.582

4.2RESPONSE SPECTRUM ANALYSIS:

Storey no.	Absolut displacment of storey D$_i$ (m)	Designintr storey drift D$_r$ m)	Storey lateral orce V$_{tot}$ (KN)	Shear at storey $_{tot}$ (KN)
1	0.00491	0.00491	1.877	120.981
2	0.0115	0.0066	6.112	119.104
3	0.0161	0.0046	10.651	112.992
4	0.0196	0.0035	17.331	102.341
5	0.0219	0.0023	29.98	85.01
6	0.0234	0.0015	55.03	55.03

Table 4.2:Analysis by response spectrum method.

Response is obtained by using different modal combination methods such as square-root-of-sum- of-squares method(SRSS)or the complete quadratic method (CQC) which are used when natural periods of the different modes are well separated (when they differ by 10% of the lower frequency and the damping ratio does not exceed 5%.The CQC is a method which can account for modal coupling methods suggested by IS 1893.

4.3P-Δ ANALYSIS:

The P-Δ effect refers to the additional moment produced by the vertical loads and the lateral deflection of the column or other elements of the building resting lateral forces.

Table 4.3: Correction for P-Δ effect (lateral force method)

Storey no:	Absolute displace hent of the torey D$_i$ m)	Design inter storey rift D$_r$(m)	Storey lateral forces	Shear t storey V$_{tot}$(K N)	Total cumulat ve gravity oad at storey P$_{tot}$ (KN)	Storey height: H$_i$(m)	Inter storey rift sensitivi y oefficie t: (θ)
1	0.003869	0.00389	1.969	179.20	7344	3	0.05285
2	0.012595	0.00876	7.951	177.23	6120	3	**0.10043**
3	0.023837	0.01122	17.83	169.28	4896	3	**0.10838**
4	0.035892	0.01205	31.657	151.45	3672	3	0.09742
5	0.047566	0.01164	49.212	119.79	2448	3	0.07951
6	0.058123	0.01057	70.582	70.582	1224	3	0.06102

Table 4.6: Correction for P-Δ effect, (response spectrum analysis)

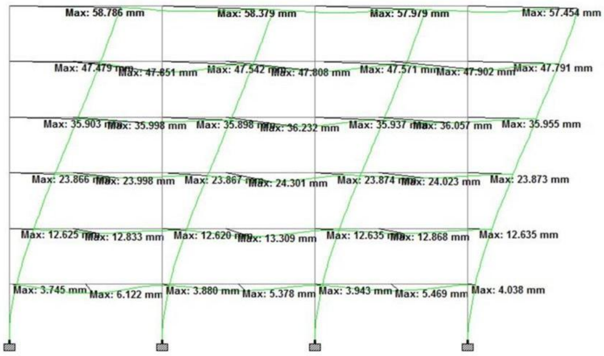
Storey no:	Absolute displacem nt of the torey D$_i$ m)	Design inter storey rift D$_r$(m)	Storey lateral forces	Shear t storey V$_{tot}$(K N)	Total cumulati e gravity oad at torey P$_{tot}$ (KN)	Storey height: H$_i$(m)	Inter storey rift sensitivi y oefficien (θ)
1	0.00491	0.0049	1.877	120.98	7344	3	0.09935

2	0.0115	0.0066	6.112	119.10	6120	3	**0.11304**
3	0.0161	0.0046	10.651	112.99	4896	3	0.06644
4	0.0196	0.0035	17.331	102.34	3672	3	0.04186
5	0.0219	0.0023	29.98	85.01	2448	3	0.02207
6	0.0234	0.0015	55.03	55.03	1224	3	0.01112

V.RESULT AND DISCCUSSION

5.1 RESULTS OF LATERAL FORCE METHOD:

Maximum bending moment, shear force etc. are obtained for load combination 1.7(EQ+DL)



FIG(5.1) Displacement diagram for load combination 1.7(EQ+DL)

The inter storey drift as seen from above diagram is within the limits of deflection of the code i.e. it is within .004 of storey height= 0.004X3000= 12mm.

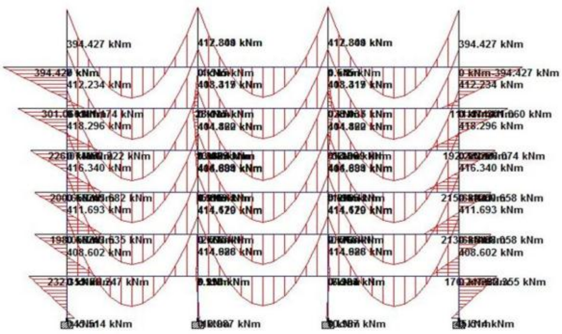
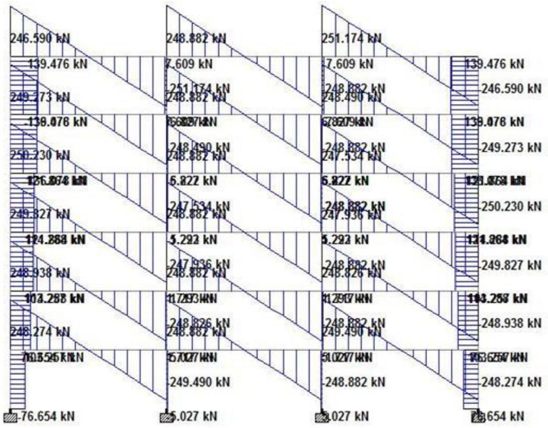


FIG (5.2) Bending moment diagram for load combination 1.7(EQ+DL)

5.2 RESULTS OF RESPONSE SPECTRUM ANALYSIS:

Maximum bending moment, shear force etc. are obtained for load combination 1.3(DL+LL+EQ)

Fig(5.3) Bending moment diagram for load combination 1.3(DL+LL+EQ)

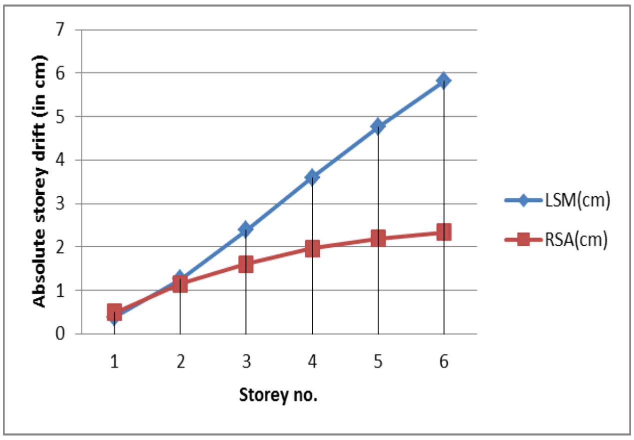


Fig(5.4) shear force diag.in X-axis shear force diag. in Y-axis Load combination is same in both cases-Load case 1.3(DL+LL+EQ).

5.3 Comparison of absolute storey drift in both methods:

Table 5.1 absolute storey drift in both methods

Storey no.	Storey eight	LSM(cm)	RSA(cm)
1	3	0.3869	0.491
2	6	1.2595	1.15
3	9	2.3837	1.61
4	12	3.5892	1.96
5	15	4.7566	2.19
6	18	5.8123	2.34



Fig(5.5) Graph of comparison of absolute storey drift

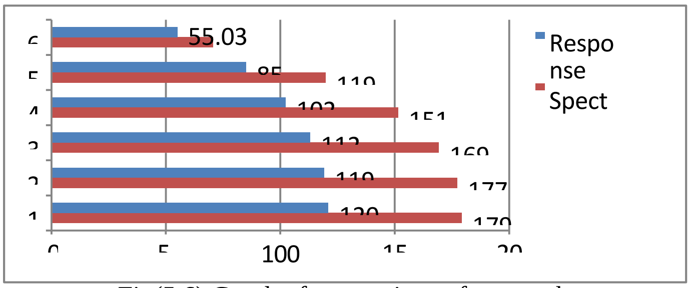
Table(5.2) Comparison of storey shear: (using both LSM and RSA)

Sstorey no.	Storey eight	LSM (KN)	RSA (KN)	Difference in %
1	3	179.201	120.981	28.91
2	6	177.232	119.104	32.79

3	9	169.281	112.992	33.25
4	12	151.451	102.341	32.42
5	15	119.794	85.01	28.99
6	18	70.582	55.03	22.033

Storey no.Storey height LSM (KN)RSA (KN)Difference in %

It is found that the difference storey shear by both these methods are about 29.73 %at an average per storey.



Fig(5.6) Graph of comparison of storey shear

VI.CONCLUSION

1. Inter storey drift was found out using lateral force method and response spectrum method and it was found that the displacements of response spectrum method was less than that of lateral force method.
2. Storey shear found by response spectrum method is less than that found by lateral force method.
3. As observed in the above results the values obtained by following dynamic analysis are smaller than those of lateral force method. This is so because the first mode period by dynamic analysis is 0.62803 is greater than the estimated 0.33 s of lateral force method.
4. The analysis also shows that the first modal mass is 85.33% of total seismic mass. The second modal mass is 8.13% of the total seismic mass m and the time period is 0.19s.

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