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STUDY OF SEISMIC DESIGN AND ANALYSIS OF MULTISTORIED AND MULTI BAY STEEL BULILDING FRAME

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ABSTRACT
Steel is one of the most widely used material for building construction in the world .The inherent strength; toughness and high ductility of steel are characteristics that are ideal for seismic design. To utilize these advantages for seismic applications, the design engineer has to be familiar with the relevant steel design provisions and their intent given in codes. The seismic design of building frame presented in this project is based on IS 1893-2002 and IS 800 .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 IS800:2007 .The frame consists of six stories and has three bays in horizontal direction and five bays in lateral direction. The selections 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 .Finally the design of connection of an interior joint and an exterior joint of the frame have been done and the calculations have been shown. Also the design of the foundation which consists of the base plate has been done according to IS 800:2007.Relevant calculations have been shown and the figures have been drawn. The software used for analysis and design is STAAD PRO. Both during design and analysis sufficient manual calculations have been made and compared.

Key Words: STAAD PRO, G+5, ETABS, IS800:2007, IBC code.

1. 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 tectonicplates. 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. This may be explained by some of the specific features of steel structures. There are two means by which the earthquake may be resisted.

2. METHODOLOGY

The initial step is preliminary design of building frame. The procedure involved is 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

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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:

- Defining beam sections, checking deflection and resistance criteria under gravityloading.
- Following an iterative process, going through the following steps until all design criteria arefulfilled.

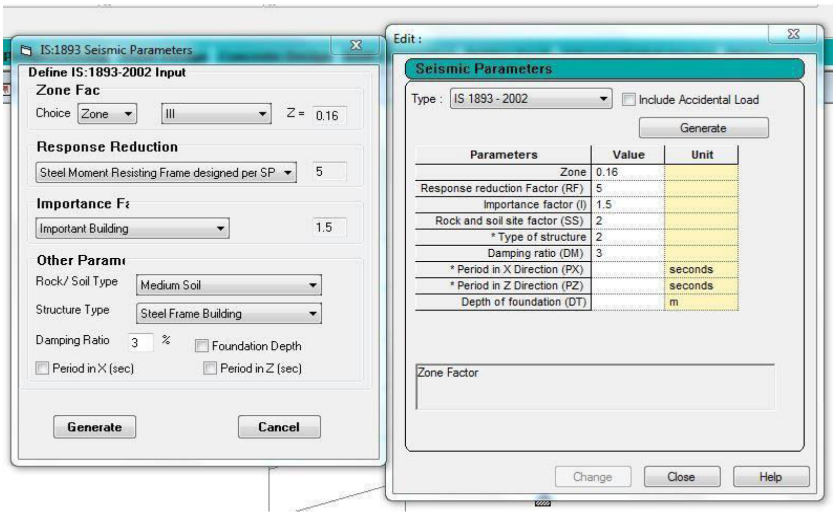
  The iterative process can make use either of lateral force method or the spectral response modal superposition method.

2.1 Problem statement

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
- Zonefactor„Z‟:0.16
- Building frame system: steel moment resisting frame designed as per SP6
- Response reduction factor:5



- Importancefactor:1.5
- Damping ratio:3%

FIG 2.1: STAAD input of seismic parameters

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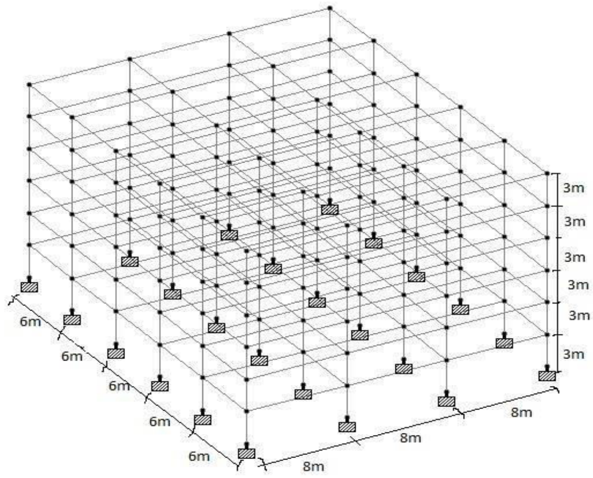

FIG 2.2: 3-dimensional view of the steel building frame

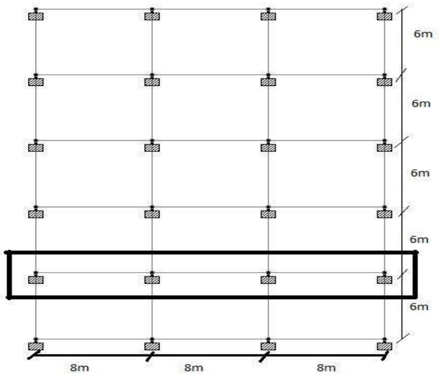

FIG 2.3: Plan ofthebuilding frame **FIG 2.4 : Elevation of thebuildingframe**

Load parameters:

dead load is taken as = 5KN/m^2 and live load is taken as 3 KN/m^2

Load Calculation

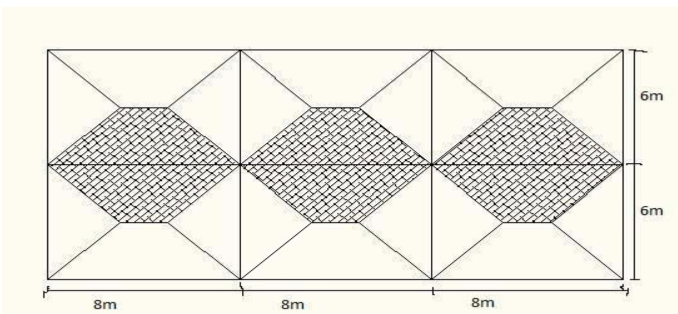

FIG 2.5 : Load distribution diagram

Load on beam along horizontal direction

1. Dead Load = $30m^2$ = 150KN
   Uniformly Distributed Load = $5KN/m^2$ = 18.75KN/m
2. Live Load = 30 3 = 90KN
   Uniformly Distributed Load = 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)

2.2 Analysis procedure

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 $V_B = A_h \times W$

After 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 results table of analysis by lateral force method is shown below.

Table 2.1: Analysis by lateral force method

Storey no.	Absolute displacement of storey D_i (m)	Design inter storey driftD_r (m)	Storey lateral force V_{tot} (KN)	Shear at storey P_{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

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Response spectrumanalysis:

In the field of seismic analysis this is one of the most popular methods. The design spectrum diagram is used to perform it.The response spectrum method uses the idealization of a multi storey shear building by a basic assumption. The assumption used is that the mass is lumped at the roof diaphragm levels and at the floor levels.

Table 2.2: Analysis by response spectrum method.

Storey no.	Absolute displacement of storey D_i (m)	Design inter storey driftD_r (m)	Storey lateral force V_{tot} (KN)	Shear at storey P_{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

2.3 DESIGN

Staad pro is used for designing all members of frame following IS 800- 2007. Common hot rolled and built-up steel members (section: I80012B50012, member 17) used for carrying axial compression, usually fail by flexural buckling. The buckling strength of these members is affected by residual stresses, initial bow and accidental eccentricities of load. To account for all these factors, the strength of members subjected to axial compression is defined by buckling class a, b, c, or d.

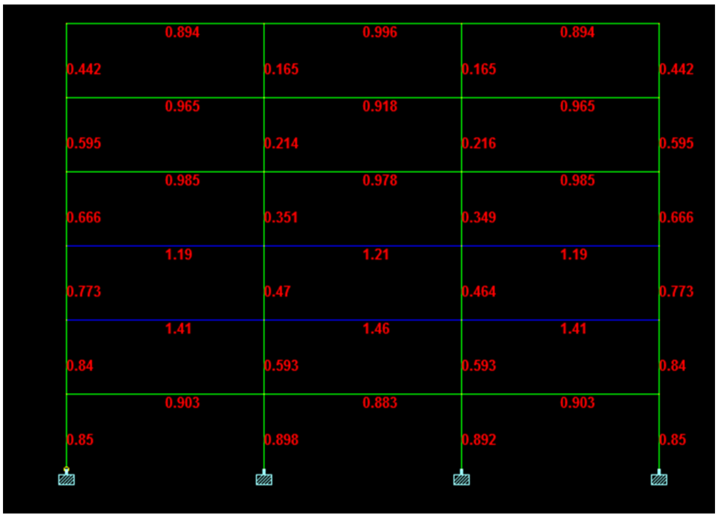

Fig 2.6: Diagram showing failed members

The design compressive strength Pd, of a member is givenby:

$P < P_d$

Where $P_d = A_e \times f_{cd}$

Where
A_e = effective sectional area as defined in 7.3.2, and

f_{cd} = design compressive stress, obtained as per 7.1.2.1.

7.1.2.1 The design compressive stress, f_{cd}, of axially loadedcompressionmembers shallbe calculated using the followingequation:

$f_{cd}= (f_y / \gamma_{mo})/(\varphi+ [\varphi^2-\lambda^2]^{0.5})=\chi f_y/ \gamma_{mo}$ where

$\varphi=0.5 [1 + \alpha (\lambda - 0.2)+ \lambda^2]$

λ= non-dimensional effective slenderness ratio

$= f_y/ f_{cc}=\sqrt{(f_y(KL/r)^2/\Pi^2 E)}$

f_{cc}=Euler buckling stress=$\Pi^2 E/(KL/r)^2$

KL/r =effective slenderness ratio or ratio of effective length, KL to appropriate radius of gyration,r

χ =stress reduction factor (see Table 8) for different buckling class, slenderness ratio and yield stress
$=1/(\varphi+ [\varphi^2-\lambda^2]^{0.5})$

Υ_{m0} =partial safety factor for material strength. α=Imperfection factor

4. RESULT:

In this chapter the results and observations of the tests conducted are presented, analyzed and discussed. Total amount of steel required in the form of connections and member sections are more for analysis and design based on response spectrum method than lateral force method.

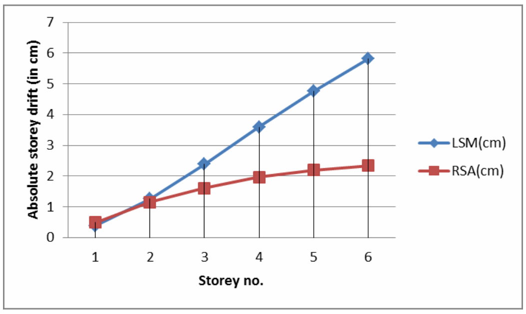

Fig 4.1: Graph of comparison of absolute storey drift

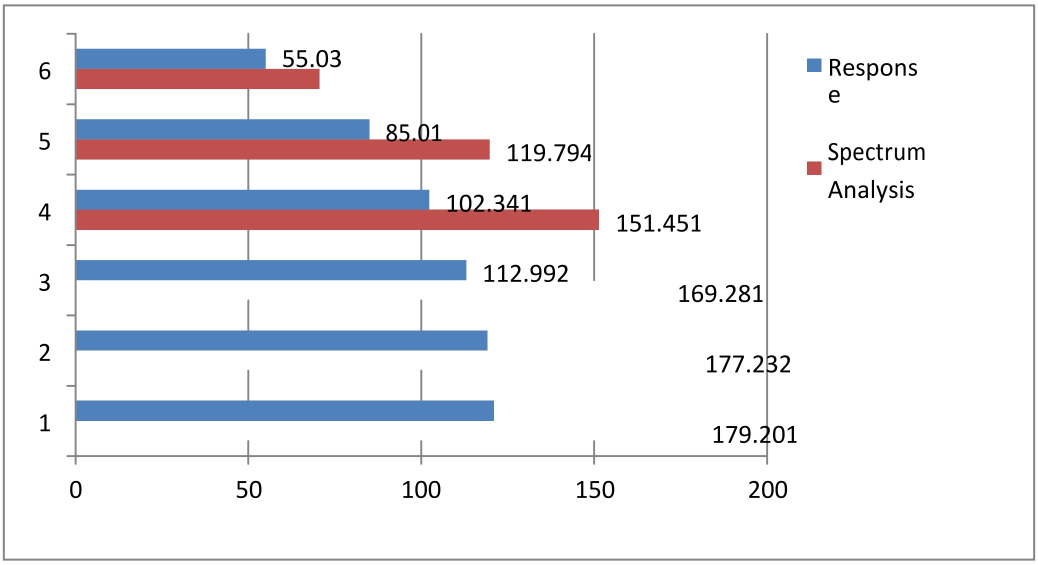

Fig 4.2: Graph of comparison of storey shear

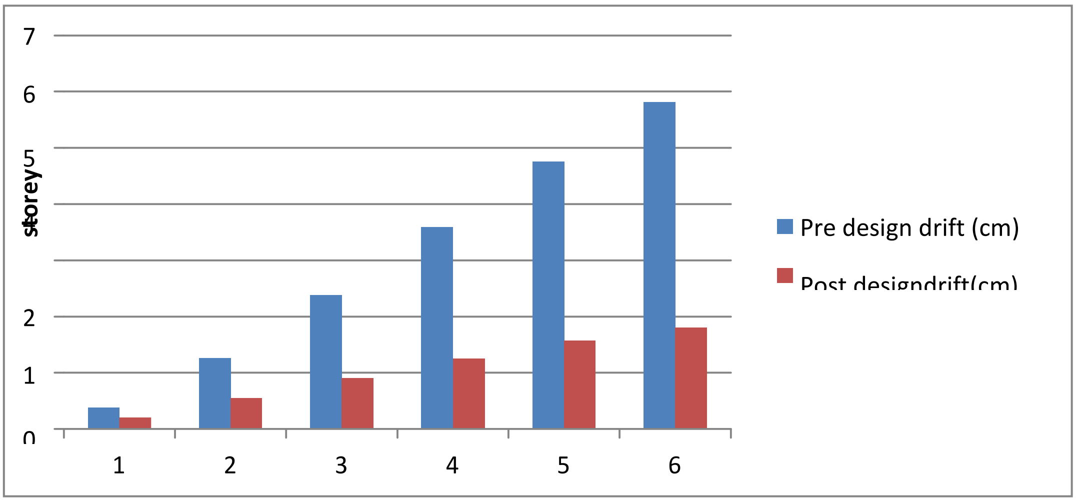

Fig 4.3: Graph of storey drift for final and initial design results

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5. CONCLUSION

The following conclusion is drawn from present work.

1. Inter storey drift was found out using lateral force method and response spectrum methodand it was found that the displacements of response spectrum method was less than that of lateral forcemethod.
2. Storey shear found by response spectrum method is less than that found by lateral force method.
3. The difference in results of response spectrum and lateral force method are attributed to certain assumptions prevalent in the lateral force method. Theyare:

a. The fundamental mode of the building makes most significant contribution to the baseshear.
b. The total building mass is considered as against the modal mass that is used in dynamic procedure. Both the assumptions are valid for low and medium rise buildings which are regular.

4. 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 forcemethod.
5. 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 is0.19s.
6. In the post design analysis the inter storey drift and base shear both have decreased significantly owing to heavier member sections leading to safe design. For example the initially used sections (eg:-**ISMB 350**) have failed and Staad Pro has redesigned and adopted higher section(eg:-**ISWB 600A)**
7. The steel take off or the cost of steel used (which is directly proportional to the amount of steel used)is less in lateral force method as compared to the response spectrum method. This is so because the response spectrum method, being dynamic in nature, is a more accurate method taking into account many more parameters like mode shape, mass participation factors to calculate the seismic vibration results. Response spectrum method is more realistic method of analysis and design of steel building frame and from the present work it is found that lateral force method leads to more cost effective of seismic design of steelframe.
8. The amount of steel required for seismic design by using lateral force method is found to be 19.73% less than that by using response spectrumanalysis
9. Because of the heavier sections used in response spectrum method the absolute displacement, storey drift are less than lateral forcemethod
10. It is found that the inter storey drift sensitivity coefficient θ does not differ much in both the methods ofanalysis
11. The values of resultant base shear in lateral force method is 49.33 % more than that of response spectrum method.

6. REFERENCES

- Subramanian N., Design of steel structures, Oxford University Press,7th edition,2011,173-209
- NegiLS,Design of Steel Structures, Tata Mc-Graw Hill Publishing Company Limited,,2nd edition,1997,
- AgarwalPankaj and Shrikhande Manish, Earthquake Resistant Design of Structures, Prentice Hall of India Limited, July 2006,251-336.
- Design Example byArcelor-Mittal.(www.arcelor-mittal.org)
- IS 800:2007, Third Revision, General Construction in Steel –Code ofPractice.
- IS 1893:2002, Fifth Revision, Criteria For Earthquake Resistant Design of Structures, Part 1 General Provisions andBuildings.