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A Work Paper on - Design of Earthquake Resistance Tall Structure with Lateral Force Method & Response Spectrum Analysis (Stadd. Pro)

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Abstract: *The design of a building requires a detailed analysis to the building on which the structure is based. But somewhere it is not possible to do manual calculations which is why the need for editing tools was met. Built on several power tools, one of which was widely used by Stadd. Pro, which allows the processing of a structure preference to its construction. For high- rise buildings it is possible to use Stadd. Pro for consolidation and its integration as well as structural analysis and design-based design. Steel is the most widely used building materials in the world. In order to take advantage of these seismic resources, a design engineer must be familiar with the design features of the metal and the purpose for which they are coded. The basic formation of the building framework presented for this project is based on IS 1893- 2002 and IS 800 such as IS 800: 2007. The building contains six stories and has three biscuits on the straight side and five bays on the back side.*

Keywords: *FEM, ANSYS 15.0, Modal hammer, Accelerometer, FFT Analyzer, Pulse software, Instron, Tensile Strength etc.*

1. Introduction

Seismic analysis is likely to be a groundbreaking factor that analyzes the structure and that is the calculation of the building's response to earthquakes. it is part of the architectural approach, seismic engineering or structural testing and design in regions where earthquakes are prevalent.

The most important earthquakes are at the extremities of the earth's crust. These plates are usually at least partially aligned but are prevented from doing so by collision until the pressure between the plates below the epicenter point is so high that the movement occurs suddenly. this is usually an earthquake. Earthquakes cause waves inside the earth that fill the earth, causing movement in the foundations of buildings. The significance of the waves decreases with the space from the epicenter. Therefore, there is a planet region with a high or low earthquake risk, calculating its proximity to the tectonic plate border. Beside from the major earthquakes that occur along the boundaries of the tectonic plate, some have their origins within the innocent pairs. Called ‘intra plates’ earthquakes, these forces are small, but they can still destroy within the area known as the epicenter.

The following earthquake vibration parameters follows Seismic zone: 3

- Zone factor ‘Z’: 0.16
- Structure frame : steel moment performing frame designed as per IS 456:2000
- Calculation reduction factor : 5
- Importance factor : 1.5
- Damping ratio: 3%.

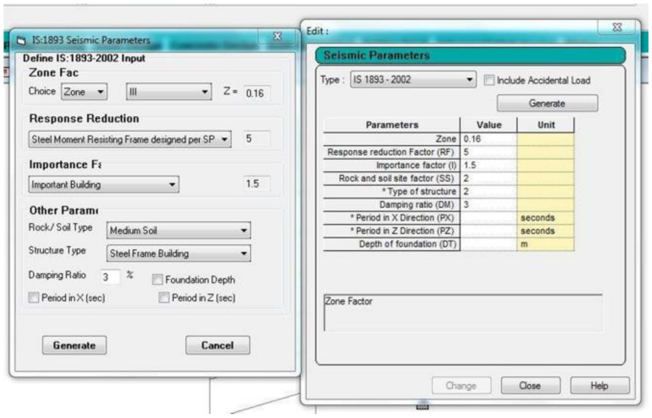

Figure 1: Stadd pro. Input of seismic parameter

2. Literature Review

Literature reviews corresponding to the earthquake analysis of the multistorey structure were controlled. the target was to understand the strength of the various structural properties of different seismic zones. it has been noted that the majority of researchers, scholars and consultants have been active in the field of earthquakes, geography, the importance of seismic analysis, modern design methods, building methods, and so on.

[MVK. Satish et.al (2019)] evaluated and designed the G + 3 hospital building and the design of its land acquisition structure was studied using STAAD. NSP), this study recommends the use of standard NSP instead of the original NSP mode because it provides a better result when comparing building structures.

[Dr. Ashokkumar et.al (2018)] designed the G + 3 hospital building using a stand-alone stand at STAAD.Pro the efficiency of the analysis using software in addition to the written method was analyzed and a comparative analysis was performed.

[B. Gireesh (2016)] A study of the structure and earthquake of the G + 7 building was studied using the Stadd.Pro software. During this study planning was funded by the following general Indian codes: IS 1893 (Part 1) - 2007, in base shear planning. IS 1893: 2002 in terms of seismic resistance which identified various analytical methods supporting the local Zone, high building value and building value. After starting the project a heavy load, live load, air load, snow load and earthquake load was placed for further analysis.

[Mahesh et.al (2017)] This study focused on structural analysis within the effect of air load on a sloping surface with software Stadd.Pro. air conditioning was supported by India's standard code IS 875 part- III. Studies have shown that because height increases arrival time, shear strength and shared displacement all show a direct relationship with the higher value. It has therefore been concluded that zone IV is the most important because the rates of bending, shear strength and joint migration were the highest in the IV zone and the minimum within Zone I.

[D. Ramya et.al, (2015)] compared the planning and over-analysis of the multi-storey G + 10 structure with STAAD. Pro and other software's. the critical wind speed of this study was assumed to be 33.0 m / s so the shear strength and curvature above each part of the structure were calculated for a different combination of loads. This study shows that STAAD.Pro is flexible in comparison to ETABS software in terms of architecture.

[Bandipati Anup et al., (2014)] This paper discusses by examining and planning a multi- storey structure [G + 5 (3-dimensional frame)] adopting STAAD Pro. The process used in STAAD.Pro is a custom method. Initially they need 2-D frames created and tested for physical calculations. The exact result must be proven. We inspected and constructed a building with G + 5 [2-D Frame] structures instantly in all possible load combinations. The work is completed with many other 2-Dimensional and 3-Dimensional frames under different load combinations.

3. Formulation & Load Calculation

The parameters to be used for this section are determined initially using two checks: Moment Resistance check and Deflection criteria.

Checks the deflection limit of Beam in x motion. Selecting the Beam category: Total Dead load + Live load =51 KN/m = gravity load. Now the code specifies maximum deflection limit as

1/ 300 where, l is the effective length of the section.

$$\text{So, } \frac{1}{300} = \frac{Pl4}{384EI}$$

$$I_{\text{Required}} = \frac{300Pl}{384}$$

$$= \frac{300X51X83}{384X2.1X1}$$

$$= 9714.3\text{cm}^4$$

So section selected is ISMB 350
Izz=13630cm4 Area 66.7cm^2
Depth of section= 350 mm Breadth of flange =140 mm
Thickness of flange=14.2 mm
Thickness of Web=8.1 mm
Definition of Column Sections checking the 'weak beam strong column criteria'
Mc : moment of column
Mg : moment of beam
$\Sigma Mc = Mc1 + Mc2$
$\Sigma Mg = Mg1 + Mg2$
$\Sigma Mc \geq 1.2\ \Sigma Mg$ (as per IS 800:2007)
$\Sigma fyc \times \Sigma Zcolumn > 1.2\ \Sigma fyb \times Zbeam$

So,
2 X 250 X Zreq. = 1.2 X 250 X 1094.8 X 1000
Zreq. =656.88 cm^3

So, therefore the selection of section is: I80012B50012.
There for calculation of the moment using the shown equations & the section of all columns is found to be: I80012B50012
Check compression & buckling at ground floor level with under gravity loading.
Formated loaded area = 8 X 6=48m^2.
Floor weight is taken as 5Kn/m^2, all included.
Groundfloor=48 X 5 = 240KN/storey
Gwalss=(8+6) X 3=42 KN/storey
Gframe=18.5 KN/storey

Q=3 KN/m2 X 48=144 KN
1.35 X G +1.5 X Q =1.35 X 300.5 + 1.5 X 144=622 KN/storey

Compression in column for basement level: 6 X 622=3732 KN.
Approx. buckling length should=3.0 m (equal to each storey height)
Now calculation for the column section of 180012B50012
Sectional area=387 cm^2 And IZZ=494454 cm^4
Rzz = 35.744 cm
λ =.48
χ =.85
Fcd= χ fy/γmo =.85 X 250/1.1=193.18 N/mm^2
Pd= Fcd X A=193.18 X 38700=7476.136KN.>3732 KN
Where; Fcd is calculated as design compressive stress. Where; Pd is is calculated as design compressive strength.

Calculation of seismic mass
For the steel structure frame considered, the seismic calculation of mass in terms of joint weight & for the member weight of the steel frame:

Dead load is = 5KN/m^2, Live load is = 3KN/m^2
Area load calculated for each beam is 30m2, & there are 3 beams in each storey. Therefore total DL +LL for per each storey is calculated to be:
= 3 X 30 X (5 + 3) =720KN

Nodal loads apply as 144KN on both interior nodes & a nodal load apply as 72KN on the exterior nodes.
Thus the total nodal load are contribution for the seismic mass calculation is:
=144 X 2 + 72 X 2 = 432KN

Weight of wall (Dead Load) is also contributes as for the seismic mass. Weight of the wall (Dead Load) is 3KN/m.
Thus total wall weight per storey is calculated as:
= 3×24 =72KN
So far; there for total seismic mass for calculation as per storey is given by

= 720+432+72 = 1224KN

4. Design Analysis

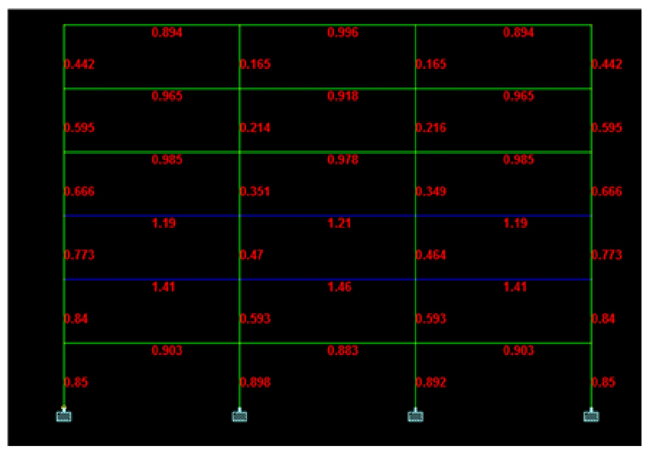

Figure 2: Diagram showing failed members

Table 1: Table of members failed and modified sections (by lateral force method)

S. no.	Failed member no:	Failed section	Critical condition	Staad design section (passed)
1	1	ISMB350	IS 6.2	ISWB500
2	3,8,11,1,15	ISMB350	IS 6.2	ISLB550
3	10,12,17	ISMB350	IS 7.1.2	ISWB600
4	13	ISMB350	IS 6.2	ISHB450A
5	4,5,6,7,9,16,18	ISMB350	IS 7.1.2	ISWB600A
6	2	ISMB350	IS 6.2	ISHB450

Table 2: Table of members failed and new modified sections(by response spectrum analysis)

Sl no.	Failed member no:	Failed section	Critical condition	Staad design section (passed)
1	1,13	I80012B50012	IS 7.1.2	I80012B50016
2	2,14	I80012B50012	IS 7.1.2	I0012B55012
3	3,15	I80012B50012	IS 7.1.2	ISWB550
4	7,8,9,40,42	ISMB350	IS 6.2	I100012B50012
5	21	I80012B50012	IS 7.1.2	I100012B50012
6	27	I80012B50012	IS 7.1.2	ISWB600A

Connection Design:

Considering node 16, a connection is built between the components ISWB600A and I80012B50012 as described below

The connection of the heating plate to the column piles is eliminated using a full entry weld, the positive pressure can also be, Pb = 150Mpa and weld size
't'=10mm

$$\text{Length of the weld required: } = \sqrt{\frac{6\,X\,M}{t\,X\,Pb}} = \sqrt{\frac{6\,X\,278.682\,X\,1000\,X\,1000}{10\,X\,150}} = 1055\text{mm}$$

$$\text{Max. bending stress in the weld } P_b = \frac{M\,X\,y}{I} = \frac{6\,X\,M}{t\,X\,d2} = \frac{6\,X\,278.682\,X\,300\,X\,1000000}{850\,X\,300X300X30}$$

$$= 21.85\text{Mpa}$$

$$\text{Shear stress at weld} = \frac{W}{d\,X\,t} = \frac{120\,X\,1000}{10\,X\,1294} = 9.27\text{Mpa}$$

Final condition: $Pe = \sqrt{Pb2 + 3Ps2} = \sqrt{21.85^2 + 3\ X\ 9.27^2} = 27.114\text{Mpa} < 225\text{Mpa}$

Design is OK (so assumed steel plate of 824×850 mm is welded to the flanges of the column)

Connection Of Beam To The Steel-Plate

Consider 2 angle sections of ISA 100×100×8 and 20mm dia close tolerance turned bolts

$$n = \sqrt{\frac{6\,X\,M}{m\,X\,p\,X\,R}}\ \text{(no. of bolts required)} = \sqrt{\frac{6\,X\,278.682}{4\,X\,0.06\,X\,108.915}} = 7.997 \approx 8\text{ bolts}$$

R = bolt value (area × σtf)
m= 4 lines, M= 278.682KN, W=120KN
After calculation n= 7.997 ≈ 8 no.s bolts per line

Check for stresses:

$$\sigma\text{ tf cal} = \frac{6\,M}{m\,X\,p\,X\,n2\,X\,Ab} = \frac{6\,X\,278.682\,X\,100}{4\,X\,6\,X\,(8X8)X\frac{\pi}{4}X\,(21.5)2} = 299.8\text{ Mpa}$$

$$\text{Shear stress on each bolt} = \frac{W}{m\,X\,n\,X\,Ab} = \frac{120\,X\,(10)3}{32X\frac{\pi}{4}X\,(21.5)2} = 1.03\text{Mpa}$$

Permissible combined shear and tensile stress :

$$\frac{\tau vf\ cal}{\tau vf} + \frac{\sigma vf\ cal}{\sigma vf} \leq 1.4$$

$$= \frac{299.8}{300} + \frac{1.03}{100}$$

$$1.00963 \leq 1.4\ \text{(OK)}$$

Unstiffened Seat Connection:

Assume 2 angle sections ISA 150×115×8

$$\text{Strength of bolts in single shear} = \frac{300}{1000} X \frac{\pi}{4} X\ (21.5)^2 = 108.9\text{KN}$$

$$\text{Strength of bolts in bearing 12mm plate} = \frac{300}{1000} X\ 21.5\ X\ 12 = 77.4\text{KN}$$

$$\text{No. of bolts} = \frac{120}{77.4} = 1.55 \approx 2$$

$$\text{Bearing length a} = \frac{R}{tw\,X\,\sigma p} - h2\sqrt{3} = \frac{120X\,(10)3}{11.8\,X\,187.5} - 46.05\,X\,\sqrt{3} = -25.52\ \text{(negative)}$$

$$\text{But bearing length a} \geq \frac{R}{2\,X\,tw\,X\,\sigma p} = \frac{120X\,(10)3}{11.8\,X\,187.5} = 27.11\text{mm}$$

5. Result and Discussion

Table 3: Comparison analysis of the absolute storey drift in both methods: (table 6.1)

Storey no.	Storey height	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

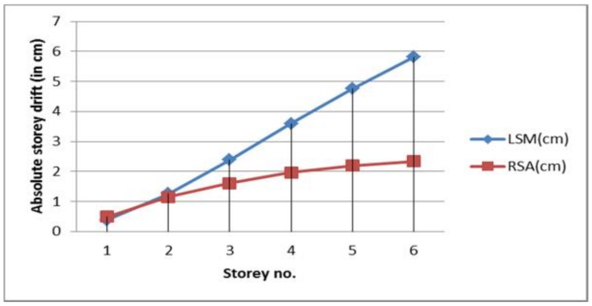

Figure 3: Graph of comparison no of absolute storey drift

Table 4: Comparison analysis of the storey shear: (using both LSM and RSA)

Storey no.	Storey height	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

It is found that the extreme shear difference of these methods is approximately 29.73% somewhere in each yard.

Table 5: Drift: By Lateral Force Method

Storey no.	Pre design drift (cm)	lesign drift(cm)	Difference in %
1	0.3869	0.2056	46.85
2	1.2595	0.5472	56.55
3	2.3837	0.9052	68.11
4	3.5892	1.2561	65
5	4.7566	1.5729	66.93
6	5.8123	1.8012	69.05

It is evident that the variability in design and pre-delivery variations is approximately 62.08% in the individual retail space.
The total amount of metal required within the type of connection with the parts of the members is more than the analysis and support style of the support system used rather than the dynamic strength method.

5. Conclusion

1. Inter-storey Drift was identified using the power team method and response method and it was found that the downside of the response system is not only visual but also a lateral force method.
2. The shear obtained by the physical means of the method is smaller than that obtained by the lateral force method.
3. As seen within the above results the values obtained according to the force analysis are smaller than those of the lateral force method. this is very common because the duration of the main mode with a powerful analysis is 0.62803 is greater than the 0.33 s estimate of the lateral force method.
4. The analysis also shows that the basic modal weight is 85.33% of the seismic weight. The second modal is 8.13% of the total seismic mass m so the time frame is 0.19s.
5. within the design analysis submitted the inter storey Drift and base shear are both significantly reduced due to the heavy component parts leading to safe construction. For example the previously used categories (eg: ISMB 350) failed and Stead Pro reset and accepted the higher category (eg: ISWB 600 A)

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