SEISMIC ANALYSIS & DESIGN OF STEAM TURBINE GENERATOR FLOOR IN THERMAL POWER PLANTS

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ABSTRACT

In this paper the attempt has been made to carry out the static analysis and the seismic analysis of the steam turbine generator structure with the understanding concepts of fabrication of steel for structural assembly. A detail study has been done for the planning & modeling of industrial structure including various parameters such as methodology adopted in actual practice for construction, analysis and design for the turbine generator floor, various components of the assembly, loading on the structure using criteria as per the codal provisions, design parameters as per prevailing standards, method of analysis and detailing. The analysis has been done on the basis of Indian codes, some criteria such as deflection criteria, d/t ratio criteria, minimum thickness criteria has been taken based on draft code (IS 800) with the provisions have used based on the current industries practices. The results are then studied including forces, member stresses, deflection & the sections used at site in the industrial training executed at Thermal Power Station Khaparkheda.

Keywords: Seismic analysis, Seismic zones, Structural steel fabrication, critical load combinations.

1. INTRODUCTION

Structural Steel is a common building material used throughout the construction industry. Its primary purpose is to form a skeleton for the structure, essentially the part of the structure that holds everything up and together. By using the available ISMB steel sections the desired design requirements cannot be met, especially for the highly loaded structures, as the moment of inertia and cross sectional area play major role, thus the use of BUILT UP I-SECTIONS by structural steel, made up with the process of fabrication are necessary. Fabrication process is carried out for the production of main & auxiliary columns, tie & floor beams, formation of crane girders, bracings & the trusses etc. Columns are formed by suitable arrangement of web, flanges, stiffeners & the base plates. Fabrication includes the connection between various members. So from review of literature it aims to analyze the following points:-

- An analytical investigation of the P-Δ effects in medium height steel moment resisting frames to selected earthquake motions is reported.
- Under earthquake excitations, base shears are lower for the more flexible frames. As a result, a more economical design may be possible if the effect of connection flexibility is considered in the analysis.

- The approach is based on an analytical model that captures the possibility of connection fracture and the subsequent loss of strength and stiffness.

Principal objectives in undertaking this paper are:

1. Development of innovative sustainable construction material is needed due to increasing infrastructure needs.
2. Relational case study executed in thermal power plant at Khaparkheda.
3. Modeling and Analysis of whole assembly is with STAAD.Pro.
4. To understand the concepts of seismic analysis and it's all relative combinations for finding the critical values of displacements, stresses and the beam end forces.

2. DETAILS OF THE STRUCTURE:-

1. Type of structure :- Industrial building of steam turbine generator located at thermal power station khaparkheda.
2. Total area :- 5523 sq.m
3. Turbine area :- 504 sq.m
4. Service bay area :- 714 sq.m
5. Storey height :- 8.5 m per floor
6. Earthquake zone :- II (zone factor 0.10) ; Category :- II ; Class :- A
7. Type of soil :- Type II (medium soil)
8. Importance factor :- 1.5
9. Building frame system :- Steel moment resisting frame design as per SP 6 i.e R= 5.0
10. Loads applied on structure :-
    a. Gantry b. Brick load c. Dead load
    d. Earthquake load e. Roof Pressure
    e. Live load:- 1. For all floors= 5KN/m^2 & 2. For upper roofs=2.5 KN/m^2

3. ROLLED STEEL SECTIONS ARE GIVEN IN TABLE 1 :-

1	Beams	I section	ISMB 600 with cover plate width as 600mm and the thickness of 24 mm	Steel
2	Beams	I section	ISMB 300 on top of the roof	Steel
3	Bracings	Channel section	ISMC 300 face to face and the spacing of 0.3 m	Steel
4	Truss	Channel section	ISMC 300 face to face and the spacing of 0.3 m	Steel

4. DEAD LOAD CALCULATIONS ON FLOORS ARE GIVEN IN TABLE 2:-

1	Floor load on 47.0 m	In B-C bay grid 1-7	-2.5 kN/m^2
2	Floor load on 39.0 m	Only self weight no other load act	-2.5 kN/m^2
3	Floor load on 36.0 m	In B-C bay grid 1-12	-5 kN/m^2
4	Floor load on 31.75 m	In B-C bay grid 1-12	-5 kN/m^2
5	Floor load on 27.0 m	In B-C bay grid 1-6	-5 kN/m^2
6	Floor load on 24.0 m	In B-C bay grid 1-12	-5 kN/m^2
		In C- D- E- bay grid 9-10-11	-5 kN/m^2
7	Floor load on 17.0 m	In A-B bay grid 4-9 pressure intensity	-3.3 kN/m^2
		In C- D- E- bay grid 9-10-11	-5 kN/m^2
8	Floor load on 12.0 m	Only self weight no other load act	-5 kN/m^2
9	Floor load on 8.5 m	In C- D- E- bay grid 9-10-11	-5 kN/m^2
		In A-B bay grid 4-9 pressure intensity	-1.6563 kN/m^2
10	Floor load on 3.5 m	In A-B bay grid 8-10	-5 kN/m^2
11	Brick mesonry	On floor 8.5, 17, 24	-36 kN/m
12	Brick mesonry	On floor 31.75-47	-48 kN/m
13	Brick mesonry	On floor 24 to 36	-18.8 kN/m
14	Gantry	On A- B bay grid 1-12	Fy -2500kN Mx1250kNm

5. SEISMIC ANALYSIS: - Load combinations for seismic calculations as per IS 1893:2002:-

1. SEISMIC X **2.** SEISMIC Z **3.** DEAD LOAD **4.** LIVE LOAD
5. 1.5 DL + 1.5 LL **6.** 1.2 DL + 1.2 LL **7.** 1.2 DL + 1.2 LL + 1.2 EQX
8. 1.2 DL + 1.2 LL + 1.2 EQZ **9.** 1.2 DL + 1.2 LL - 1.2 EQX
10. 1.2 DL + 1.2 LL - 1.2 EQZ **11.** 1.5 DL **12.** 1.5 DL + 1.5 EQX
13. 1.5 DL + 1.5 EQZ **14.** 1.5 DL - 1.5 EQX **15.** 1.5 DL - 1.5 EQZ
16. 0.9 DL + 1.5 EQX **17.** 0.9 DL + 1.5 EQZ **18.** 0.9 DL - 1.5 EQX
19. 0.9 DL - 1.5 EQZ

CRITICAL LOAD COMBINATIONS:-

In case of Seismic Calculations :- case no. 12. (1.5DL +1.5EQX)

RESULTS :- CRITICAL END FORCES & STRESSES 12) 1.5 DL+ 1.5EQX :-

Sr	Sections	Moment of resistance	Max Bending moments	Max Axial force	Max Shear Force	Max Axial stress	Max Bending stress	Max shear stress
1	ISMB 600 with cover plate of 600mm & thickness 24mm	kN-m	kN-m	kN	kN	N/mm^2	N/mm^2	N/mm^2
A	8.5m level beam 2	1893	2082	5251	1366	67.03	49.18	22.36
B	8.5m level beam 6	1893	1557.97	12718	886.27	58.49	40.68	14.21
E	17m level beam 6	1893	1983.91	8240.5	488.15	37.93	66.39	28.49
F	17m level beam 7	1893	2040.58	3467.4	533.58	15.44	66.26	28.96
H	24m level beam 5	1893	2078.75	2566.1	504.36	11.88	27.673	10.26
I	24m level beam 6	1893	1936.40	2621.7	416.05	29.10	24.178	14.21
J	31.75m level beam 2	1893	2085.73	107.35	795.91	3.007	62.82	18.57
K	31.75m level beam 8	1893	1875.04	1214.6	144.45	5.43	54.499	17.73
2	ISMB 300 ON TOP OF ROOFS	94.64	-	-	-	-	-	-
A	ISMB 300 from a side no 5	94.64	42.243	59.177	10.437	10.51	240.17	1.282
B	ISMB 300 from c side no 5	94.64	47.573	69.281	11.432	12.30	195.05	1.028
3	ISMC 300 WITH SPACING 0.3 M	69.99	-	-	-	-	-	-
A	a row brace at 8.5 as secondary beam	69.99	88.912	1791.2	25.489	196.2	14.22	1.289
B	cross brace a row 8.5	69.99	46.984	2443.4	14.65	267.6	2.02	0.18
C	c row at 47 m slab as secondary beam	69.99	48.103	224.69	19.565	24.61	45.72	14.13
4	BUILT UP I COLUMN	Lcc = 31968	(for 11 m column)	-	-	-	-	-
A	Column a 1	31968	8845.99	772.52	1077.3	3.57	173.29	4.98
B	Column a 6	31968	9864.13	1613.1	1335.4	7.768	193.24	6.183

C	Column b 6	31968	11738.68	5165.7	1371.5	23.91	229.96	6.35
E	Column d 10	31968	14344.38	5345.5	2362.7	24.74	281.01	10.93
F	Column e 9	31968	1354.92	268.93	7269.0	1.245	142.40	6.273

6. COMBINED PERMISSIBLE AXIAL & BENDING COMPRESSIVE STRESSES:-

Cross Sectional Area Ax same Ax & Ay because of double I prismatic	216000.00 mm^2
Radius of Gyration rz & ry is same (mm)	421.00 mm
Axial Load Fx	7936600.50 N =7936 kN
Major Axis Moment Mz	9516236800.00= 9516 kN-m
Minor Axis Moment My	97141496.00 = 97.14 kN-m
Shear Along Major Axis Fz	60105.11 N = 60.10 kN
Shear Along Minor Axis Fy	1240151.50 N = 1240.15 kN
Effective Length Lez & Ley	9549.98 mm
Section Modulus About Major Axis - Tension Edge Stz	51044492.00 mm^3
Section Modulus About Minor Axis - Tension Edge S_{ty}	51102088.00 mm^3
Lez / rz = 9549.98/421.00	22.68...< 180 so safe
Allowable Slenderness Ratio	180
Actual Tensile Stress ft = Fx / Anet	36.74 N/ mm^2
Allowable Tensile Stress ft_allowable =0.60fy	150 N/ mm^2
Actual Bending Tensile Stress - Major Axis ftz =Mz / Stz	186.43 N/ mm^2
Allowable Bending Tensile Stress –Major Axis ftz_allowable =0.66fy	165 N/ mm^2

Actual Bending Tensile Stress - Minor Axis fty =My / Sty	1.90 N/ mm^2
Allowable Bending Tensile Stress- Minor axis fty_allowable =0.66fy	165 N/ mm^2
Interaction ratio =ft / ft_allowable + ftz / ftz_allowable + fty / fty_allowable	1.39... safe in LSM i.e We consider FOS=1.5

7. DISCUSSION

1. From seismic analysis the observations for critical load combinations is given by the case no 12. 1.5 DL + 1.5 EQX.
2. The values of Moment of resistance for all beams, truss & bracings are exceeding the actual Bending moment values given by the Staad.pro thus it is safe in permissible bending criteria.
3. Load carrying capacity of the prismatic built up double I section is found out to be satisfactory by checking combined permissible axial & bending stress values.
4. Axial stresses, Bending stresses, Shear stresses & the deflection criteria are found to be safe within the permissible limits.
5. The structural steel assembly can be erected easily for the upcoming loads as compared to the RCC structures.
6. Horizontal or vertical thrust can be converted to any side of the structure so as to help in load diversions.
7. For future strengthening of any structure steel is more accessible by providing the stub columns, flange bracings etc.

8. CONCLUSIONS

1. On the site fabrications in the case study gives added inputs to design process.
2. Precautions to be taken in fabrication and erection can be well understood on the site.
3. Higher resistance to the seismic forces occurred in the flexible frame structure by steel fabrication.
4. Analysis and design as grids result is lower beam sizes.
5. The value of combined permissible axial & bending stress ratio as comes out to be safe thus no need of providing the flange bracings or stub columns etc.
6. The load carrying capacity of prismatic built up double I sections are provided on higher sides thus for future expansions this can be utilized.
7. The sectional properties for ISMB 900 section are not in database and design parameters of Staad.pro 2007 so by using the section as ISMB 600 with cover plate of 600 X 24 mm on both sides resist the permissible stresses and the respective bending moments in beam sections.

REFERANCES

1. Mahendrakumar. 2009. Elastic buckling of i-beam flanges subjected to a linearly varying stress distribution. *Journal of Constructional Steel Research*. Vol-63, pp: 1373-1383.
2. John L. Gross. 1998. A connection model for the seismic analysis of welded steel moment frames. *Journal of Constructional Steel Research*. Vol-20, pp: 390-397.
3. Chang-Ho Park. 1997. Effect of gravity load on seismic response of steel-framed structures. *Journal of Constructional Steel Research*. Vol-19, pp: 439-451.
4. M. Fragiacomo. 2004. Seismic response of steel frames under repeated earthquake ground motions. *Journal of Constructional Steel Research*. Vol-26, pp: 2021-2035.
5. Luca Martinelli. 1998. The seismic behavior of steel moment-resisting frames with stiffening braces. *Journal of Constructional Steel Research*. Vol-12, pp: 1045-1062.
6. Egor P. Popov.1993. Developments in seismic structural analysis and design. *Journal of Constructional Steel Research*. Vol-17, pp: 187-197.
7. J. A. Tjondro. 1992. Seismic *p*-δ effects in mesium height moment resisting steel frames. *Journal of Elsevier Research*. Vol-14, pp: 75-90.
8. J. Shen. 2000. Seismic performance of steel moment frames with reduced beam sections. *Journal of Elsevier Research*. Vol-22, pp: 968-983.
9. Yuhshi Fukumoto. 1996. New constructional steels and structural stability. *Journal of Elsevier Research*. Vol-18, pp: 789-791.
10. J. Lindner.1997. Design of steel beams and beam columns. *Journal of Elsevier Research*. Vol-19, pp: 378-364.
11. W. S. King. 2005. A modified stiffness method for plastic analysis of steel frames. *Journal of Elsevier Research*. Vol-19, pp: 1009-1018.