International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 6, Nov-Dec 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Seismic Evaluation of RCC Chimney for Zone II & V

Ahmed Raza[1], Dr. Eramma H[2]

[1]Student – M Tech (CAD Structures), Department of Studies in Civil Engineering,
[2]Professor, Department of Studies in Civil Engineering,
[1,2]University BDT College of Engineering, Davangere, Karnataka, India

ABSTRACT

Chimneys are more 'often than' not analysed structurally for loads formed by seismic & also wind. Hence, it is unsurprising to carry out the analysis to comprehend the dynamic response of 'chimney' due to upshot of earthquake and winds. On account of transformation in geometric shape of the chimney, structural analysis for instance response to earthquake and wind wavering becomes more crucial. The leading focal point of this paper is to weigh against the seismic-analysis upshots for zone II & V of a 30 m tall 'reinforced concrete chimney'. Earthquake analysis is accomplished as per IS-1893 (part 4):- 2005 & finally, the maximum values acquired in analysis for both zones are contrasted in table & also as graphs.

KEYWORDS: *Equistatic Analysis, RCC Chimney, Sesismic Zone II & V, Staad Pro*

How to cite this paper: Ahmed Raza | Dr. Eramma H "Seismic Evaluation of RCC Chimney for Zone II & V" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-6, December 2024, pp.676-690, URL: www.ijtsrd.com/papers/ijtsrd72669.pdf

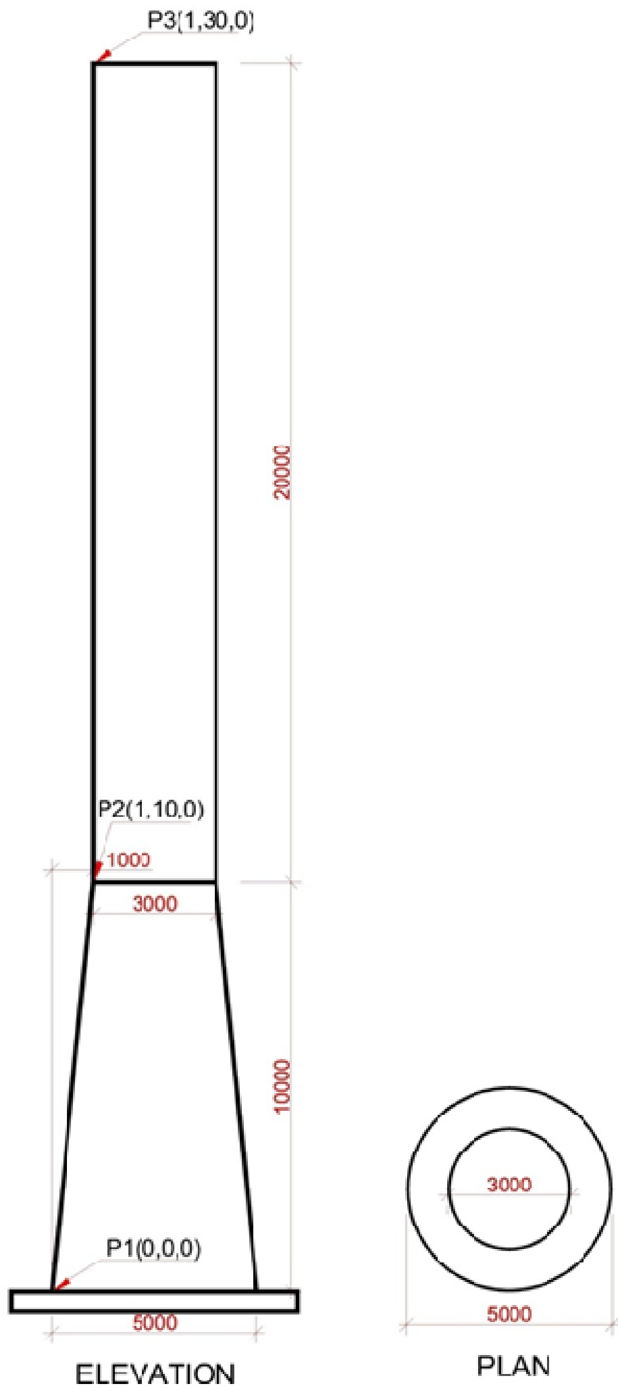
IJTSRD72669

INTRODUCTION

chimneys are 'tall & slim' structures which are employed to set free the waste or flue gases at higher space from the ground with ample 'exit velocity' so that the gases & ash (suspended particles) are disposed into the ambience over a specific spread area such a way that their concentration, upon arriving at the soil is within satisfactory values as specified by 'Pollution Control Regulatory Authorities'. In a 'coal based' power plant, flue gases from every boiler are let through a chimney, for dispersal into ambience. 'Industrial chimneys' are vertical assemblies that are constructed to diminish the impact of 'greenhouse gases' & other commerce discharges on its pressing neighbourhood's. Stone-work, bricks, concrete or even steel materials are being to build the chimney which casts out the gases produced by the industries post the production of their products. The intention is to diminish the consequence of these by-products on the surroundings and also on living things. Some reduce the level of 'pollutants' and some others diminish gas & its temperature. A 'Chimney' is a tall & slim construction via which the 'dissipated gases' are discarded into the exterior/atmosphere at a height that is at an adequate altitude by 'stack effect'. chimneys are classically upright or as much as possible upright, to guarantee that the gases are flowing efficiently, under the control of what is recognized as 'stack' or 'chimney effect'. The area within the chimney is called a flue. The tallness of chimney very much controls its capacity to transfer flue-gases to the exterior location through the 'stack effect'. The intention of any chimney is to pass on and release combustion or 'flue gases' as away as possible from the functioning area of the industry and as well as from the human habitation. The sectional sight of chimney would normally hollow & circular, from 'aerodynamic' considerations, and also tapered, from structural economy & aesthetics considerations. The chimney has to face 'gust buffeting' along the wind direction owing to dragging forces & furthermore to probable 'vortex shedding 'in the wind opposite direction. Tall RC chimney figures an imperative constituent of a major industry or a power plant. Damage or dent to chimney by reason of either wind- or earthquake may direct to shut-down of power plant or any important industry.

Objectives of the Study
1. Creating a RCC chimney using STAAD software for zone II & V.
2. Applying various loads like self-weight of the structure, temperature load, live load and earthquake load.
3. Performing the analysis of RCC chimney for zone II & V.
4. Comparing the results for zone II & V w.r.t different parameters like displacement, story drift, base shear.

DEFINING THE PROBLEM



METHODOLOGY

Step 1: Fix the Dimensions of model

To create a model for the analysis- in software dimensions are obligatory for the given prerequisites, these dimensions were being drawn derived from the prerequisites.

Step 2: Load estimates and their Combinations

Load estimates are done based on various IS codes they being 875; Part 1, 2 & 5 then 1893; 2002 part 1. The earthquake- stress on a RC.C chimney is regularly < the wind- loading stress. Normal RC.C chimneys can by and large defy earthquake with intensity up to 10 on 'MERCALLI' scale without any sober dėnts. However, in some cases where heavy mass will be fitted at the apex of this, a unique examination is obligatory. The key consequence of high heat in 'self-supported' chimneys is the alteration of the mechanical- properties of steel.

Step 3: Analysis Using STAAD Software

The created mock-up in 'STAAD' has to be analyzed after assignment of 'member's properties'. Load cases & definition of loads should be defined with awareness rooted in the computation of loads & codes. Load types will be in the order of seismic then dead then live and finally thermal load and then the combinations of these are generated for analysis.

Step 5: Analyze the mock-up in software for zone II, V.

Step 6: compare the behavior of mock-ups in different zones in terms of bending stress, lateral displacement, and lateral forces for the chimney by analyzing the models for static forces and evaluate the analysis results.

RESULTS AND DISCUSSION

Node Displacements

In STAAD.PRO, node displacements is the distance between a point's original position and its final location on a deformed

TABLE 1 Node Displacement in X, Zone II

Node Displacement		
1.2(DĻ + TEMP + ÈQX)		
Node	Zone➢II	Zone➢V
3	50.96	62.904
36	51.26	63.195
69	52.12	64.057
102	53.53	65.466
135	55.44	67.38
168	57.81	69.741
201	60.55	72.48
234	63.58	75.513
267	66.82	78.751
300	70.17	82.096
333	73.52	85.445
366	76.77	88.697
399	79.82	91.753
432	82.59	94.519
465	84.97	96.909
498	86.91	98.849
531	88.34	100.28
564	89.22	101.157
597	89.51	101.452
630	89.22	101.157
663	88.34	100.28
696	86.91	98.849
729	84.97	96.909
762	82.59	94.519
795	79.82	91.753
828	76.77	88.697
861	73.52	85.445
894	70.17	82.096
927	66.82	78.751
960	63.58	75.513
993	60.55	72.48
1026	57.81	69.741
1059	55.44	67.38
1092	53.53	65.466
1125	52.12	64.057
1158	51.26	63.195

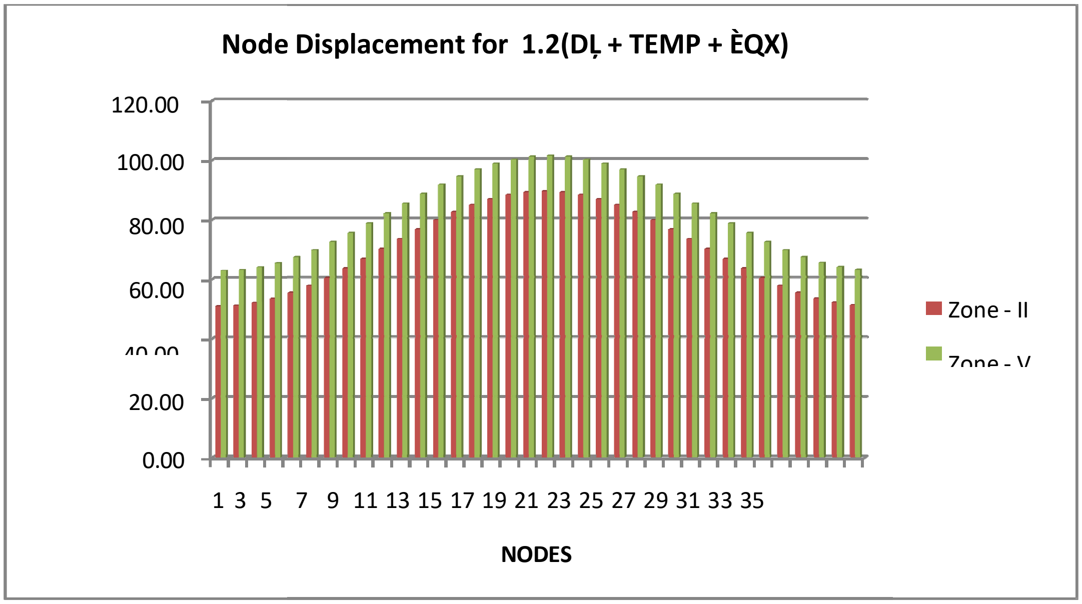


Figure 1.Node Displacement in X, Zone II

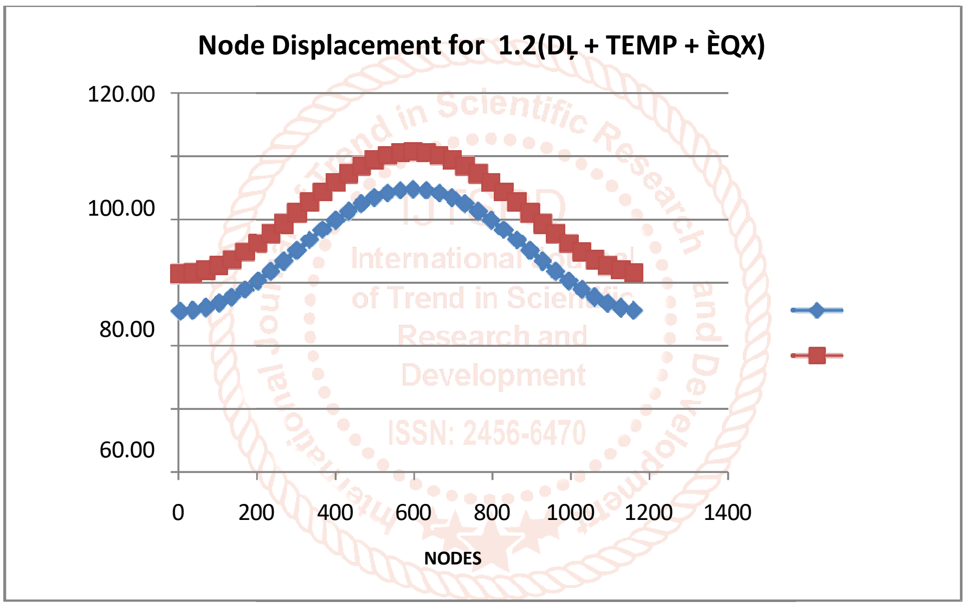


Figure 2 Node Displacement in X, Zone II

Table 2. Node Displacement in Z, Zone II

Node Displacement		
1.2(DĻ + TEMP + ÈQZ)		
Node	Zone - II	Zone - V
3	70.167	82.096
36	73.516	85.445
69	76.767	88.697
102	79.822	91.753
135	82.585	94.519
168	84.973	96.909
201	86.911	98.849
234	88.341	100.28
267	89.216	101.157
300	89.511	101.452

333	89.216	101.157
366	88.341	100.28
399	86.911	98.849
432	84.973	96.909
465	82.585	94.519
498	79.822	91.753
531	76.767	88.697
564	73.516	85.445
597	70.167	82.096
630	66.822	78.751
663	63.583	75.513
696	60.548	72.479
729	57.807	69.741
762	55.444	67.38
795	53.528	65.466
828	52.118	64.057
861	51.255	63.195
894	50.964	62.904
927	51.255	63.195
960	52.118	64.057
993	53.528	65.466
1026	55.444	67.38
1059	57.807	69.741
1092	60.548	72.48
1125	63.583	75.513
1158	66.822	78.751

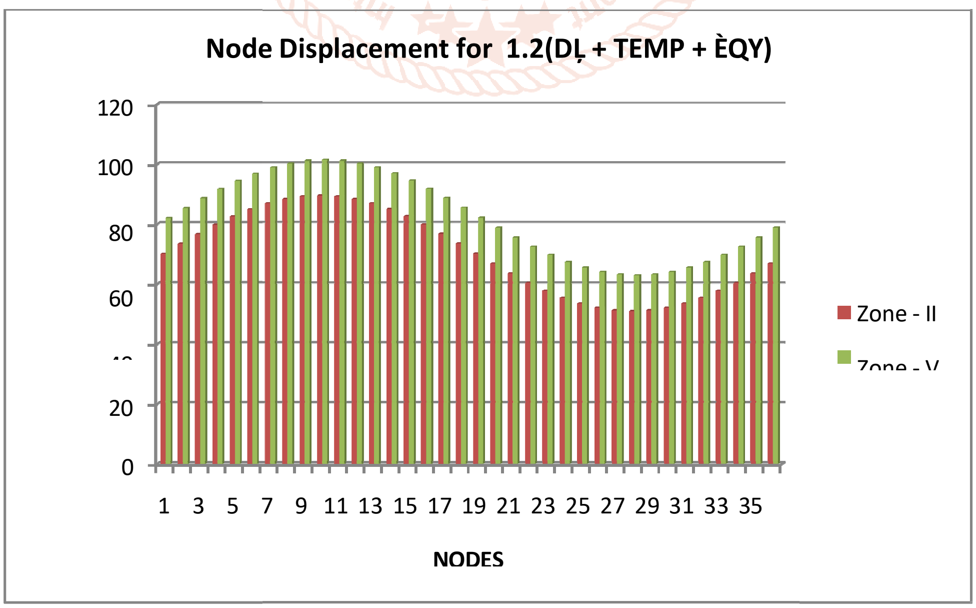


Figure 3 Node Displacement in Z, Zone II

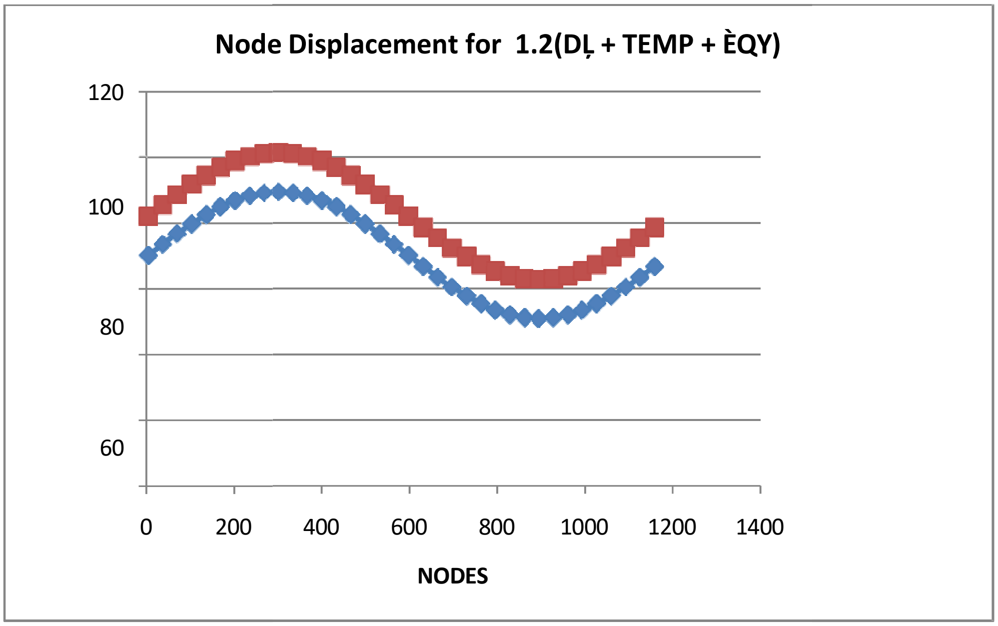


Figure 4 Node Displacement in Z, Zone II

BASE REACTION

In STAAD.PRO, the base reaction is one of the support reactions that can be displayed and extracted.

TABLE 3 Base Reaction in X

Base Reaction 1.2(DḶ + TEMP + ÈQZ)						
Node	Force-X, Zone➢ II	Moment-Y	Moment-Z	Force-X, Zone➢ V	Moment-Y	Moment-Z
1	27002.33	0.1356	2900.7948	22547.16	0.113	2405.147
34	26602.43	1.9152	2855.6856	22211.96	1.383	2367.867
67	25413.8	3.6216	2721.8772	21215.83	2.598	2257.26
100	23467.85	5.2128	2504.2572	19585.62	3.73	2077.288
133	20818.17	6.6048	2210.292	17367.03	4.715	1834.008
166	17536.17	7.9416	1850.2164	14620.81	5.677	1535.744
199	13713.62	8.9976	1436.5656	11424.83	6.435	1192.726
232	9460.207	9.7176	982.6128	7871.732	6.944	815.81
265	4897.71	10.0176	503.9868	4064.048	7.138	417.855
298	159.3984	10.2912	14.9412	113.508	7.348	10.629
331	4610.528	10.1784	-468.5376	3859.484	7.272	-392.582
364	9266.146	9.7488	-932.9556	7733.562	6.97	-780.497
397	13660.95	8.8152	-1363.6752	11387.31	6.282	-1140.808
430	17657.5	7.8684	-1749.4908	14707.24	5.616	-1464.012
463	21124.55	6.6792	-2079.8124	17585.24	4.776	-1741.079
496	23948.32	5.322	-2345.868	19927.85	3.821	-1964.482
529	26035.6	3.6264	-2540.856	21658.67	2.602	-2128.351
562	27317.43	1.8252	-2659.5216	22721.25	1.308	-2228.138
595	27749.32	0.1572	-2699.5644	23079.21	0.131	-2261.82
628	27317.57	-1.6104	-2659.5264	22721.37	-1.129	-2228.142
661	26035.7	-3.2496	-2540.6796	21658.75	-2.288	-2128.204
694	23947.83	-5.0196	-2345.8992	19927.45	-3.569	-1964.509
727	21124.59	-6.438	-2079.7536	17585.27	-4.575	-1741.03
760	17657.64	-7.632	-1749.444	14707.36	-5.419	-1463.972

793	13660.86	-8.5356	-1363.6572	11387.24	-6.049	-1140.793
826	9265.742	-9.336	-932.4936	7733.226	-6.626	-780.112
859	4610.692	-9.972	-468.7308	3859.62	-7.101	-392.743
892	159.7536	-9.996	15.156	113.805	-7.101	10.808
925	4897.556	-9.8148	503.7888	4063.919	-6.969	417.69
958	9460.568	-9.3072	983.076	7872.033	-6.602	816.196
991	13713.75	-8.7348	1436.526	11424.94	-6.215	1192.693
1024	17535.97	-7.6524	1850.3976	14620.65	-5.436	1535.895
1057	20818.24	-6.3948	2210.2428	17367.09	-4.539	1833.967
1090	23468.13	-4.8672	2504.3496	19585.86	-3.442	2077.365
1123	25413.74	-3.3612	2721.9036	21215.78	-2.38	2257.283
1156	26602.47	-1.6188	2855.7048	22211.99	-1.135	2367.884

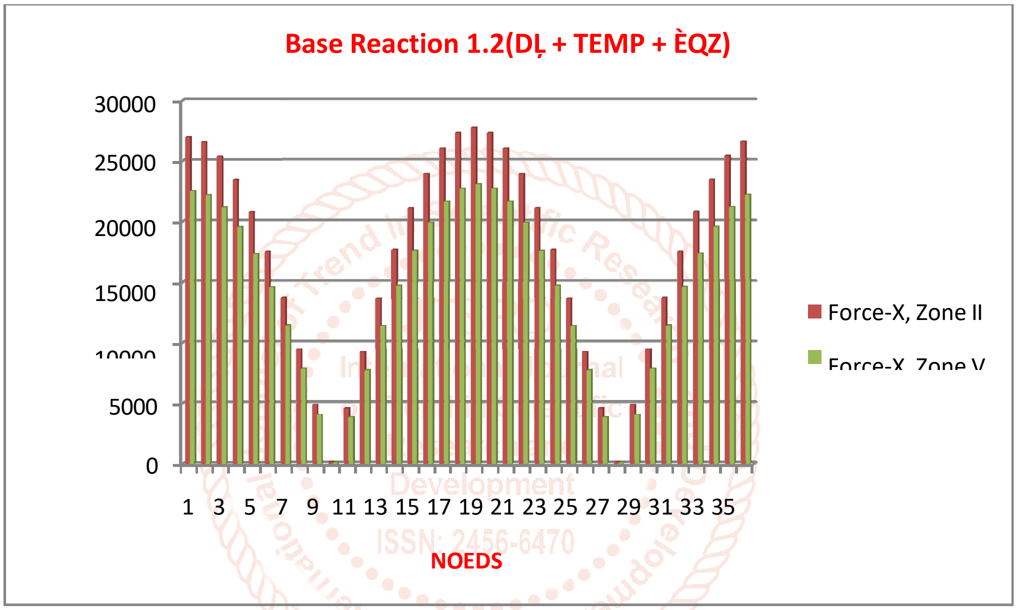


Figure 5 Base Reaction in X

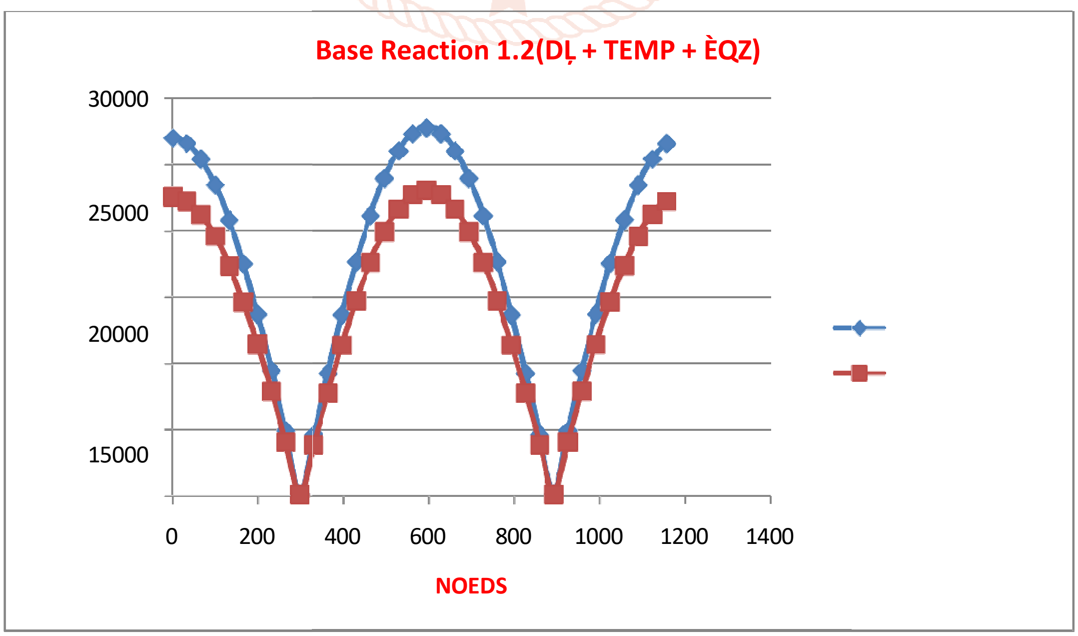


Figure 6 Base Reaction in X

SHEAR SQX

In STAAD PRO, SQX is the out-of-plane shear stress on X face at the centroid of an element.

TABLE 4 Shear SQX, 1.2(DĻ + TEMP + ÈQX)

Shear SQX		
1.2(DĻ + TEMP + ÈQX)		
SQX, kN/m2		
Plate	Zone➢ II	Zone➢ V
109	216.625	388.81
207	209.852	376.804
272	196.248	352.896
337	176.207	317.793
402	150.543	272.759
467	120.086	219.224
532	85.373	158.421
597	47.833	92.567
662	8.723	23.789
727	-31.399	-46.463
792	-70.462	-115.195
857	-107.968	-181.015
922	-142.783	-241.919
987	-173.056	-295.271
1052	-198.85	-340.435
1117	-218.791	-375.438
1182	-232.506	-399.458
1247	-239.305	-411.492
1312	-239.509	-411.695
1377	-232.352	-399.304
1442	-218.74	-375.389
1507	-198.811	-340.398
1572	-173.256	-295.472
1637	-142.474	-241.612
1702	-108.173	-181.22
1767	-70.67	-115.403
1832	-31.174	-46.239
1897	8.513	23.578
1962	48.043	92.776
2027	85.499	158.546
2092	119.885	219.021
2157	150.631	272.847
2222	176.248	317.833
2287	196.127	352.775
2352	209.789	376.741
2417	216.819	389.006

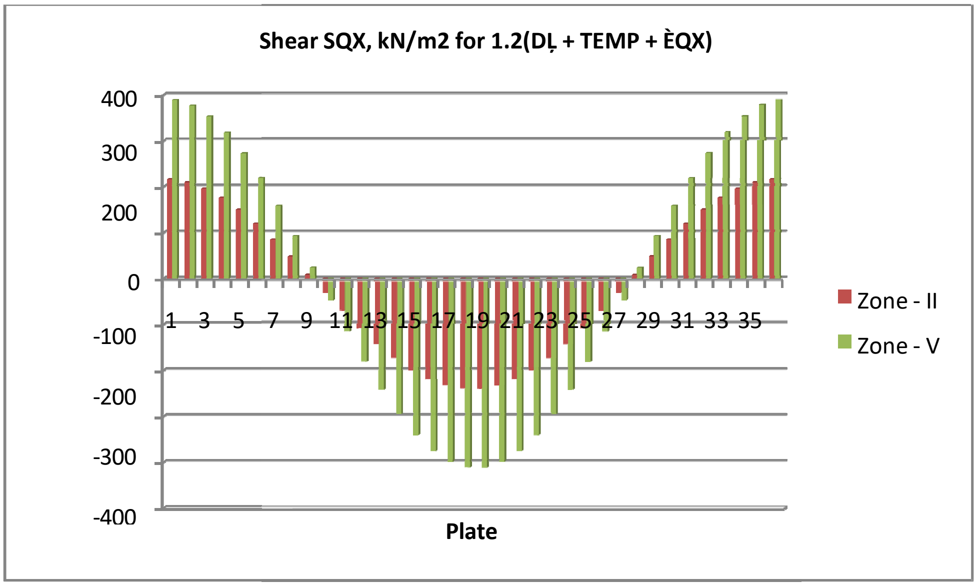
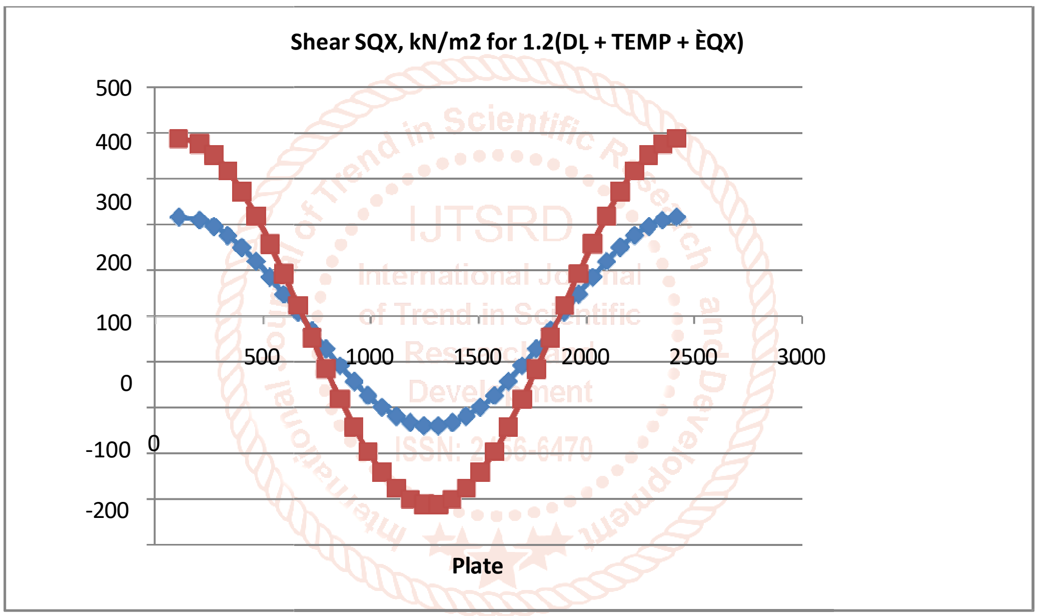


Figure 7 Shear SQX, 1.2(DĻ + TEMP + ÈQX



SHEAR SQY

In STAAD PRO, SOY is the out of plane shear stress on Y face at the centroid of an element.

TABLE 5 Shear SQY 1.2(DĻ + TEMP + ÈQX)

Shear SQY		
1.2(DĻ + TEMP + ÈQX)		
SQY,kN/m2		
Plate	Zone➢ II	Zone➢ V
109	39.082	68.639
207	37.923	66.581
272	35.689	62.581
337	32.16	56.464
402	27.792	48.772
467	22.667	39.688
532	16.499	29.036
597	10.182	17.867

662	3.459	6.045
727	-3.451	-6.035
792	-10.145	-17.826
857	-16.51	-29.047
922	-22.712	-39.733
987	-27.756	-48.734
1052	-32.181	-56.483
1117	-35.695	-62.587
1182	-37.89	-66.547
1247	-39.105	-68.661
1312	-39.2	-68.757
1377	-38.009	-66.668
1442	-35.535	-62.427
1507	-32.203	-56.506
1572	-27.804	-48.786
1637	-22.386	-39.407
1702	-16.731	-29.269
1767	-10.191	-17.876
1832	-3.393	-5.98
1897	3.391	5.974
1962	10.186	17.867
2027	16.689	29.226
2092	22.416	39.437
2157	27.795	48.773
2222	32.216	56.518
2287	35.549	62.44
2352	38.008	66.665
2417	39.2	68.756

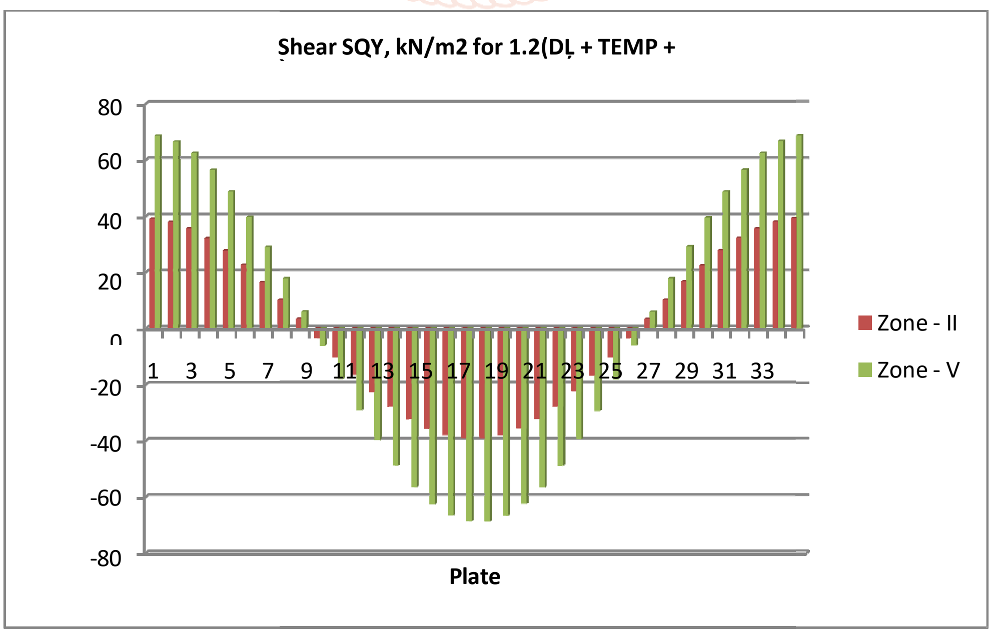


Figure 9 Shear SQY, 1.2(DḶ + TEMP + ÈQY)

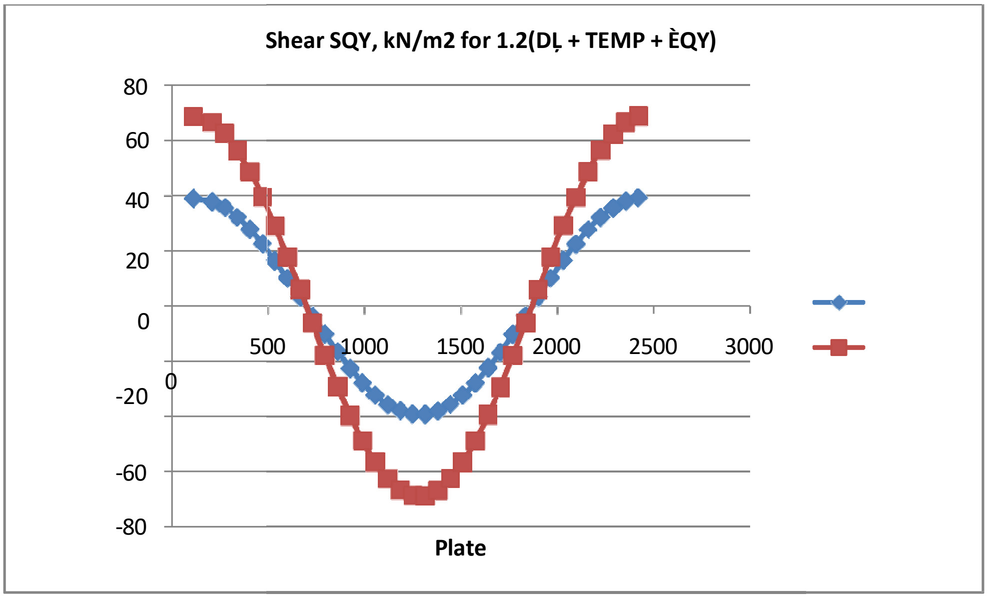


Figure 10 Shear SQY, 1.2(DĻ + TEMP + ÈQY)

MEMBRANE MXY

In STAAD PRO, the membrane stresses SX and SY are axial stresses, while the bending stresses MX and MY cause torsion and in plane shear stresses SXY and SYX

TABLE 6 Membrane MXY 1.2(DĻ + TEMP + ÈQX)

1.2(DĻ + TEMP + ÈQX)		
MXY, kNm/m		
Plate	Zone➢ II	Zone➢ V
109	0.88	1.549
207	2.606	4.59
272	4.302	7.541
337	5.815	10.21
402	7.172	12.59
467	8.339	14.616
532	9.19	16.134
597	9.806	17.207
662	10.105	17.738
727	10.094	17.726
792	9.782	17.182
857	9.226	16.17
922	8.294	14.569
987	7.182	12.599
1052	5.841	10.234
1117	4.278	7.516
1182	2.638	4.621
1247	0.883	1.551
1312	-0.897	-1.566
1377	-2.655	-4.639
1442	-4.272	-7.511
1507	-5.827	-10.222
1572	-7.181	-12.599

1637	-8.283	-14.559
1702	-9.201	-16.145
1767	-9.801	-17.202
1832	-10.113	-17.745
1897	-10.122	-17.755
1962	-9.821	-17.221
2027	-9.169	-16.112
2092	-8.327	-14.603
2157	-7.169	-12.586
2222	-5.802	-10.195
2287	-4.297	-7.535
2352	-2.62	-4.602
2417	-0.881	-1.548

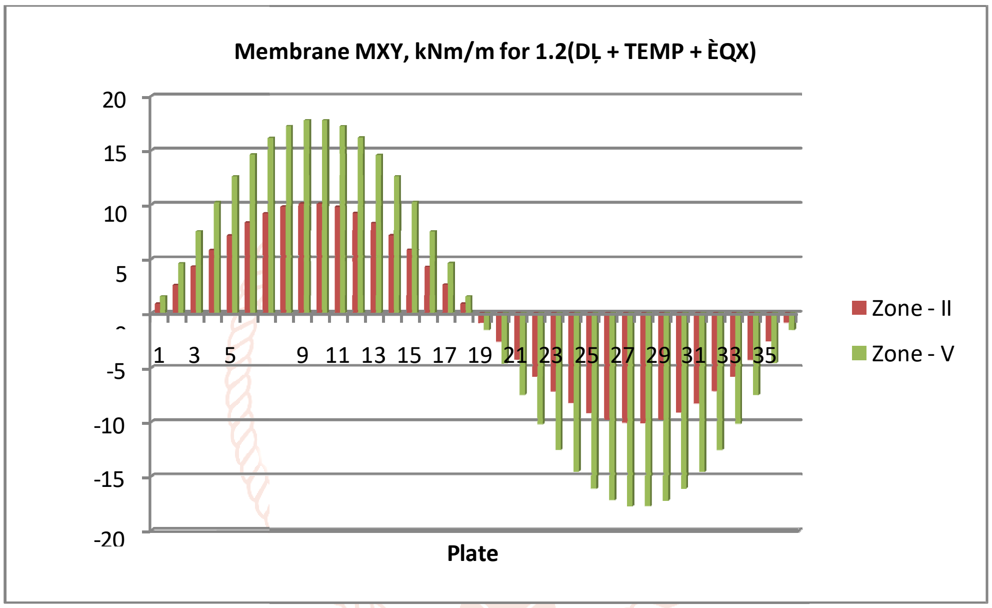


Figure 11 Membrane MXY 1.2(DĻ + TEMP + ÈQX)

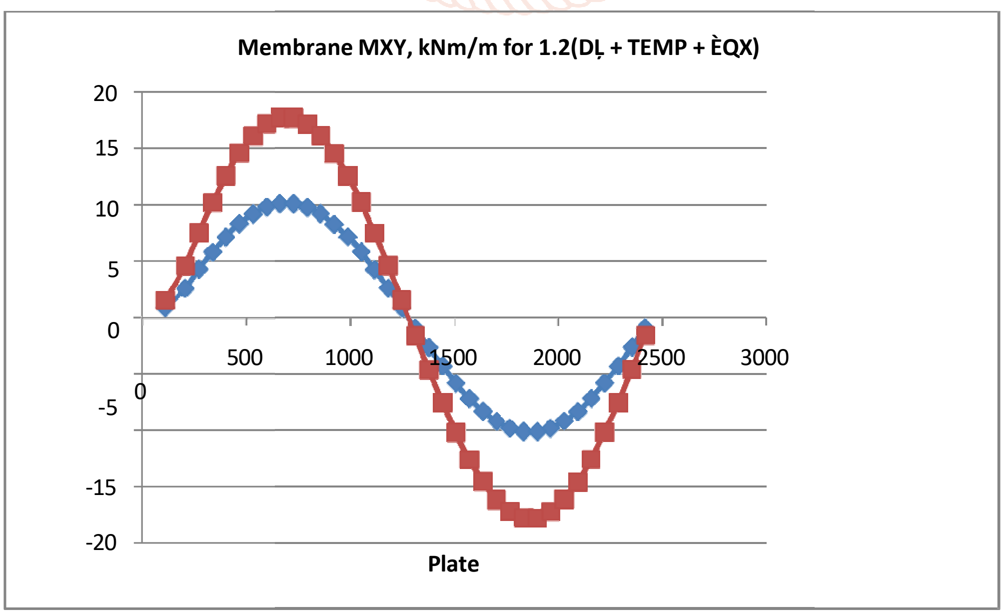


Figure 12 Membrane MXY 1.2(DĻ + TEMP + ÈQX)

TABLE 7 Membrane MXY 1.2(DḶ + TEMP + ÈQY)

1.2(DḶ + TEMP + ÈQY)		
	MXY, kNm/m	
Plate	Zone➢ II	Zone➢ V
109	10.104	17.736
207	9.78	17.18
272	9.209	16.153
337	8.306	14.581
402	7.171	12.589
467	5.847	10.241
532	4.281	7.519
597	2.63	4.612
662	0.88	1.547
727	-0.901	-1.569
792	-2.647	-4.63
857	-4.26	-7.498
922	-5.839	-10.234
987	-7.169	-12.587
1052	-8.292	-14.568
1117	-9.206	-16.15
1182	-9.789	-17.19
1247	-10.109	-17.742
1312	-10.12	-17.753
1377	-9.829	-17.229
1442	-9.179	-16.122
1507	-8.317	-14.593
1572	-7.18	-12.597
1637	-5.79	-10.185
1702	-4.292	-7.53
1767	-2.625	-4.607
1832	-0.887	-1.554
1897	0.872	1.54
1962	2.608	4.591
2027	4.317	7.556
2092	5.806	10.201
2157	7.182	12.6
2222	8.331	14.607
2287	9.188	16.131
2352	9.808	17.208
2417	10.112	17.744

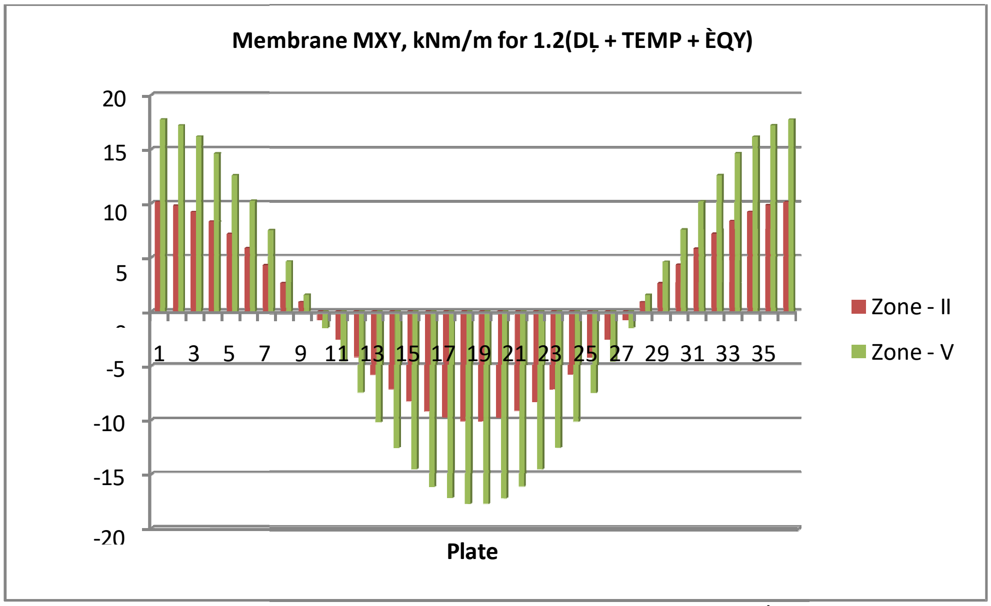


Figure 13 Membrane MXY 1.2(DḶ + TEMP + ÈQY)

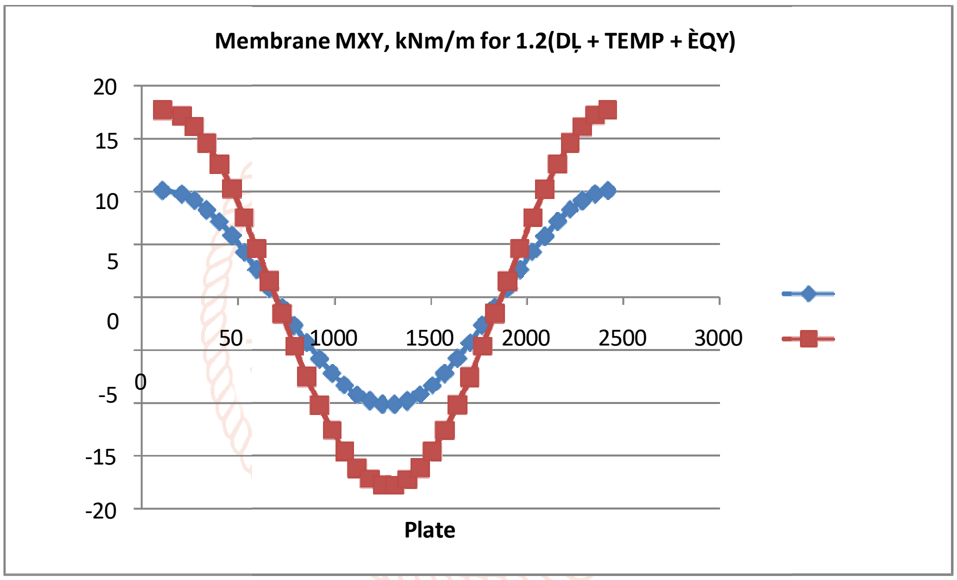


Figure 14 Membrane MXY 1.2(DḶ + TEMP + ÈQY)

CONCLUSION

Modelling attempt was done by considering the wall thickness of 600 mm initially. However, in zone 5 the displacement was crossing the permissible limit and hence 700 mm was also tired and finally 900 mm was sufficient to bring the displacement within the permissible limits.

From the above it is evident that the intensity of earthquake is governing in deciding the thickness of the chimney. Hence it is evident that the displacement is found to reduce as the wall thickness is increased. Various stresses induced due to earthquake in zone v were also within the limit when the thickness was increased to 900 mm.

Minimum grade of concrete used here is M25 as lesser grade was failing in permissible stresses

- ➢ Avg. Node Displacement
  - In X – 14.16 % increase from avg. 70.20 to avg. 82.14 mm
  - In Y – 17.44% increase avg. 70.80 to avg. 83.15 mm
- ➢ Joint Reaction at base
  - In X – 20.01 % decrease from avg. 17392.6 to avg. 14492.7 kN
  - In Y – 16.91% decrease avg. 17489.01 to avg. 14503.6 kN

REFERENCES

[1] Rajkumar. Vishwanath B Patil ‣ 2013

[2] ‘Narinder paul Singh’ & ‘Er., Mahendra Saini’ ‣ 2024

[3] ‘Yoganantham C’, ‘Helen Santhi M’ ‣2013

[4] 'Sameer Ramteke', 'Priya Gautam', 'Sanket Dongre', 'Suchita Ramteke', 'Rehan Sheikh', 'Kirti Thakare' 'Priyadarshini' ‣ 2022

[5] Shaik. Karim Saida & MVenkata. Narasaiah ‣2018

[6] Swati p&ey, Priyanka Verma, Gaurav kumar agrawal. ‣2023

[7] Kirti S Padmawar ‣2020

[8] Zeki. Karaca, Erdem. Türkel, Murat. Günaydın & SüleymanAdanur-(2015)

[9] J. L Wilson; ‣2002

[10] Yoganatham. C & Helen. Santhi M ‣2020

[11] Sudhir. K Jain, B P Singh & B K Gupta ‣2015

[12] IS; 4998(part-1);1992, 'Criteria forDesign of Reinforced Concrete Chimneys', second revision, BIS, New Delhi

[13] IS; 1893 (Part 4);2005, 'Criteria for earthquake resistant design of structures', BIS, New Delhi.

[14] IS:456(2000), Plain And Reinforced Concrete Code of Practice

[15] IS; 4998 (Part 1);: 1992, "Criteria for design of reinforced concrete chimnéys", BIS, New Delhi, 1992.

[16] ACI; 307-08: Code Requirements for Reinforced Concrete Chimnéys & Commentary, American Concrete Institute, Farmington Hills, MI48331

[17] Anurag Jain, Behnam Arya, Charles Goddard & Jon Galsworthy "Non-linear Dynamic Analysis of an Industrial Chimney's Pile foundation system for hurricane loading", eleventh Americas conference on wind engineering sanjuan, Pucrto rico, June;22-26 year 2019.

[18] BR Jayalakshmi, SV Jisha, Shivashankar, "Wind load Analysis of Tall Chimnéys with piled Raft foundation considering the Flexibility of Soil", International Journal of Advance Structural Engineering -2015, pp,.95 to115.

[19] Jeevan T Sowjanya G. V, "Soil Structure Interaction on 100m Tall Industrial Chimney under Seismic Load", International Journal of Engineering Research and Technology (IJERT), vol.,3, issue 8, Aug-2014, pp,782 to789.