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EXAMINE THE IMPACT OF WIND AND EARTHQUAKE FORCES ON A SELF-SUPPORTING STEEL CHIMNEY

Pragati Paswan*1, Abhisekh Mishra*2

*1,2Dept., Of Civil Engineering, Institute Of Engineering And Technology Lucknow, India.

ABSTRACT

This paper explores the design and structural performance of self-supported steel chimneys under two different design codes: the European code (EN 1993-3-2) and the Indian code (IS:6533-1989). These towering structures are crucial for releasing harmful gases at high altitudes to minimize environmental impact. The study focuses on a 90-meter steel chimney and conducts seismic and wind analyses using the SAP2000 software, considering seismic zone III conditions and a basic wind speed of 47 meters per second. Shear force and Maximum Base Moment are calculated to assess structural integrity. By comparing the outcomes of designs under these two codes, the research aims to provide insights into the efficiency and safety of self-supported steel chimneys, contributing to advancements in structural engineering and environmental protection.

I. INTRODUCTION

Self-supporting steel chimneys are essential engineering structures employed in a myriad of industrial applications, serving as conduits for the safe release of gases, particulates, and by products generated during various industrial processes. These towering vertical structures are meticulously designed to withstand environmental forces, providing a crucial link between the industrial processes on the ground and the surrounding atmosphere. Understanding the structural behaviour of self-supporting steel chimneys is paramount, as they must endure the effects of wind, seismic activity, and other dynamic loads while maintaining their integrity and functionality.

This paper delves into a comprehensive study and analysis of self-supporting steel chimneys, with a specific focus on two critical parameters: shear force and bending moment. These parameters are fundamental in assessing the structural performance of chimneys, as they directly influence their stability, safety, and overall functionality. In essence, shear force and bending moment represent the internal forces and moments that act on the chimney's structure, influencing its behaviour under various loads and environmental conditions.

Our investigation aims to provide a deeper understanding of the complexities associated with self-supporting steel chimneys, particularly when subjected to dynamic forces. By examining the behaviour of these structures under different operational scenarios, we seek to unravel the intricacies of how shear force and bending moment impact their stability and structural integrity. This analysis is vital not only for ensuring the safety of these industrial components but also for advancing the field of structural engineering and contributing to the development of more robust and efficient chimney designs.

Throughout this paper, we will explore the theoretical foundations of shear force and bending moment and then apply this knowledge to real-world scenarios, utilizing structural analysis tools and techniques. By conducting a systematic and rigorous investigation, we aim to provide engineers, researchers, and practitioners with valuable insights into the design, analysis, and safety considerations of self-supporting steel chimneys. Ultimately, our findings will contribute to the development of best practices in the engineering of these vital structures, enhancing their reliability, sustainability, and overall performance in industrial applications.

II. LOAD COMBINATIONS

According to the specifications outlined in IS: 6533 (Part 2), the design of the stack should take into account the following load factors:

a) Load case 1 = Dead load + wind load (along X direction) + Imposed load
b) Load case 2 = Dead load + wind load (along Y direction) + Imposed load
c) Load case 3 = Dead load + Imposed load + earthquake load

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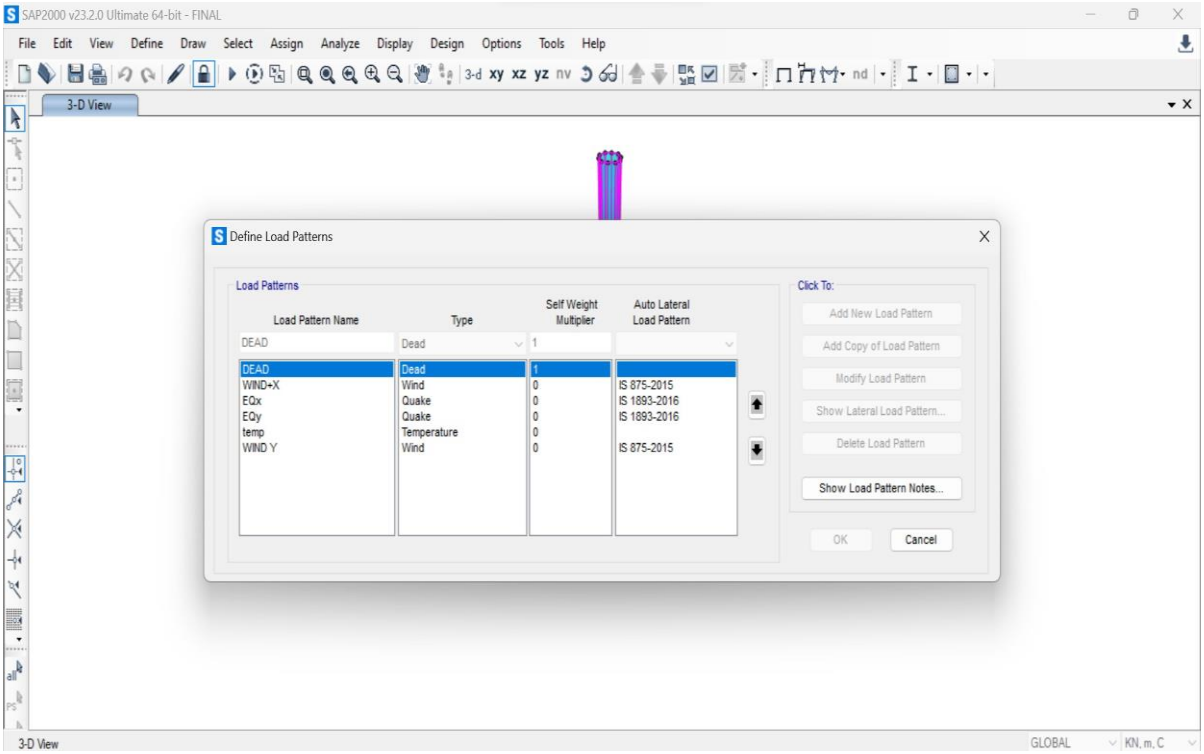
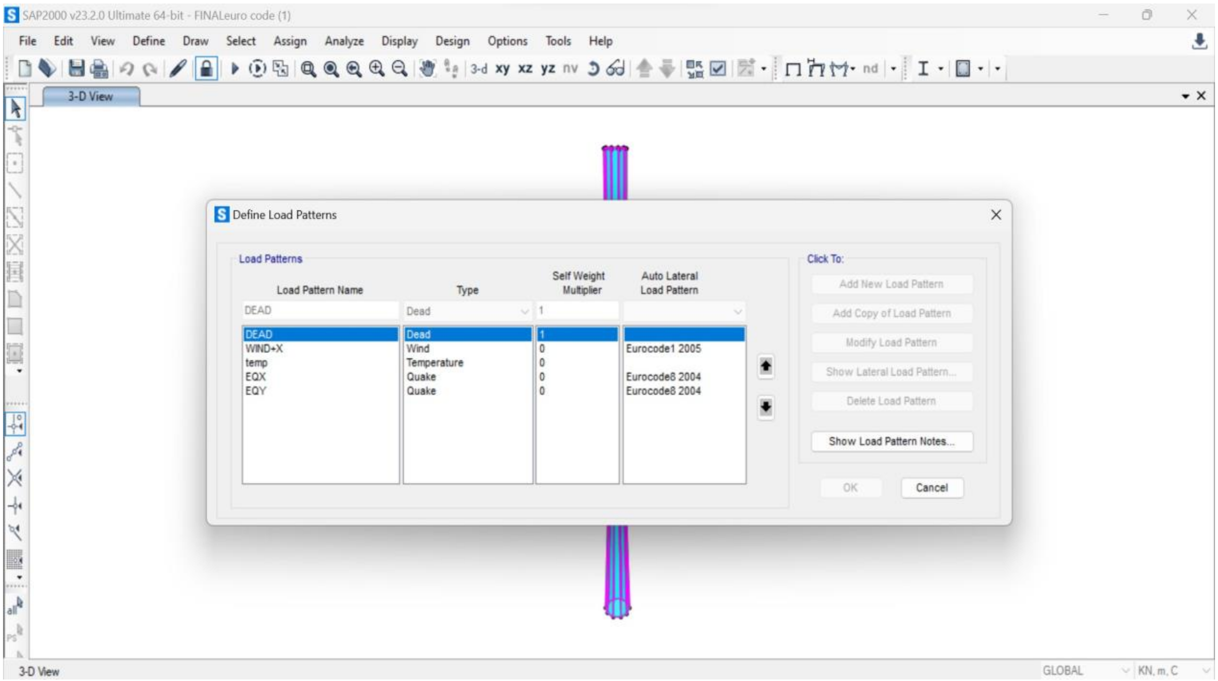


According to the specifications outlined in EN 1990 and EN 1998-1 the design of the stack should take into account the following load factors:

a) Load case 1 = Dead load + wind load+ Imposed load

b) Load case 2 = Dead load + Earthquake load (along X direction) + Earthquake load (along Y direction)



III. MOMENT DEMAND DUE TO LOAD SEISMIC

Seismic moment demand refers to the twisting forces exerted on structures during earthquakes. This parameter is measured in terms of magnitude and direction, and is incorporated into structural design codes, along with other loads. To achieve this, they typically incorporate a safety margin into their designs, thereby enhancing earthquake resistance and maintaining structural integrity. The maximum moment at the base of steel chimney due to seismic demand in accordance with IS code and Eurocode is tabulated in Table 1.

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Table 1: Maximum moment at the base of steel chimney due to seismic demand.

Load Combination Action	Code Definition	Maximum base moment
1.5 [DL+EQX]	IS code	-6.980E-06
1.0[DL]+1.0[EQY] +0.3[EQX]	Eurocode	-1.995E-07

The table illustrates that the IS code yields the highest moment demand, while the Eurocode produces the lowest moment demand.

IV. SHEAR DEMAND DUE TO SEISMIC LOAD

The assessment of seismic shear demand is an essential factor in evaluating the lateral or horizontal forces exerted on a building or structure during an earthquake. This parameter quantifies the shear forces acting in parallel to the ground and plays a vital role in the design of structural elements to effectively withstand these forces during seismic events. The calculation of shear demand resulting from seismic activity, as per the specifications outlined in the IS code and Eurocode, is also conducted. The findings are presented in a tabular format in Table 2.

Table 2: Maximum shear at the base of steel chimney due to seismic demand

Load Combination Action	Code Definition	Maximum Shear (KN)
1.5 [DL+EQX]	IS code	-7.697
1.0[DL]+1.0[EQY] +0.3[EQX]	Eurocode	-66.164

It can be seen that the shear demand according to Eurocode is significantly higher than that given in the IS code.

V. MOMENT DEMAND DUE TO WIND LOAD

The moment demand resulting from wind load pertains to the rotational forces exerted on a structure by wind. In the context of design codes and load combinations, various factors such as wind speed and direction are taken into account. The evaluation of the moment demands caused by wind load, as calculated using the IS code and Eurocode, is conducted by utilizing the load combinations specified in these standards. A comparison of the maximum demand is made by plotting the demand moment profile along the height of the reinforced concrete chimney. The resulting moments from the wind loads applied to the steel chimney are tabulated in a table for the purpose of comparing the specifications outlined in the aforementioned codes.

Table 3: Moment due to wind load on steel chimney

Load Combination Action	Code Definition	Maximum Base Moment
1.5(DL+WL)	IS code	-5498859.82
1.0DL+1.0WL	Eurocode	-28664.4652

The table illustrates that adherence to IS code specifications leads to higher moment demands, while compliance with Eurocode results in comparatively lower moment demands.

VI. SHEAR DEMAND DUE TO WIND LOAD

The shear demand resulting from wind load pertains to the horizontal or lateral forces exerted on a structure due to wind pressure. It signifies the inclination of a building or structure to undergo lateral displacement or movement as a consequence of wind influence. Design codes and standards offer recommendations for the computation and mitigation of shear demands induced by wind loads, taking into account variables such as wind velocity, building configuration, and exposure. The calculation of shear demand resulting from wind load is also conducted, and the resulting shear distribution along the height of the reinforced chimney is presented in tabular form in Table 4.

Table 4: Shear due to wind load at base of steel chimney

Load Combination Action	Code Definition	Maximum Shear
1.5(DL+WL)	IS code	-87.3
1.0DL+1.0WL	Eurocode	-78.064

The table clearly demonstrates that the shear caused by wind-induced loads, as calculated in accordance with the IS code, yields the highest shear demand. Conversely, when calculated using the Eurocode, the shear demand due to wind action is found to be the lowest.

VII. CONCLUSION

A comparative study was conducted to analyse a self-supporting steel chimney, utilizing both Indian standards (IS code) and European Norms (EN). The steel chimney was modelled using SAP 2000 Software. The analytical investigation presented in this paper yielded several specific and general conclusions. The IS code yields the highest seismic moment demand, while the Eurocode produces the lowest moment demand. The seismic shear demand according to Eurocode is significantly higher than that given in the IS code. IS code specifications leads to higher moment demands, while compliance with Eurocode results in comparatively lower moment demands. In conclusion, it can be said that the self-supporting steel chimney designed according to both code is safe but Indian code safer and economical as compare to European code.

VIII. REFERENCE

[1] L. Wang, Z. Wang, N. Huang, X. Y. Fan, and Z. hua Zhang, "Comparative analysis of cross-wind load code for high structures with circular sections," Structures, vol. 43, pp. 1177–1186, Sep. 2022, doi: 10.1016/j.istruc.2022.07.008.

[2] B. Prathyusha Yadav, S. Anitha Reddy, J. Ganesh Yadav, and C. Venkata Siva Rama Prasad, "Estimation of seismic and wind loads for design of a 100 m self-supported industrial RCC chimney," in Materials Today: Proceedings, Elsevier Ltd, 2020, pp. 1562–1567. doi: 10.1016/j.matpr.2020.09.406.

[3] M. M. Khan, A. Kumar, and R. Assistant, "CFD SIMULATION OF WIND EFFECTS ON INDUSTRIAL RCC CHIMNEY," CFD Simulation of Wind Effects on Industrial RCC Chimney. International Journal of Civil Engineering and Technology, vol. 8, no. 1, pp. 1008–1020, 2017, [Online]. Available: http://www.iaeme.com/IJCIET/index.asp1008http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=1http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=1

[4] J. Králik, "DETERMINISTIC AND PROBABILITY ANALYSIS OF THE STEEL CHIMNEY UNDER WIND LOADS," 2011.

[5] M. Pavan Kumar, P. M. Raju, N. V. Babu, and K. Roopesh, "RIC STUDY ON LATERA NCE OF STEEL CHIMNE," International Journal of Civil E, vol. 8, no. 7, 2017, [Online]. Available: http://www.iaeme.com/IJCIEhttp://http://wwhttp://www.iaeme.com/IJCIEwww.iaeme.com/ijciet/issues.asp?JType=IJCIET&VT

[6] Rajkumar and Vishwanath. B. Patil, "Analysis of Self-Supporting Chimney," International Journal of Innovative Technology and Exploring Engineering, 2013.

[7] G. Murali, B. Mohan, P. Sitara, and P. Jayasree, "Response of Mild Steel chimney Under Wind Loads," International Journal of Engineering Research and Applications (IJERA) www.ijera.com, vol. 2, pp. 490–498, [Online]. Available: www.ijera.com

[8] M. Bhavan, B. Shah, and Z. Marg, "Indian Standard CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF STEEL CHIMNEY PART 2 STRUCTURAL ASPECT (First Revision) BUREAU OF INDIAN STANDARDS," 1998.

[9] M. B. Bureau of Indian Standards, Design Loads (Other than Earthquake) for Buildings and Structures-Code of Practice Part 3 Wind Loads (Third Revision). 2015. [Online]. Available: www.standardsbis.in

[10] N. Europeenne and E. Norm, "EN 1993-3-2: Eurocode 3: Design of steel structures - Part 3-2: Towers, masts and chimneys – Chimneys," 2006.

[11] S. Rahman, A. K. Jain, S. D. Bharti, and T. K. Datta, "Comparison of international wind codes for across wind response of concrete chimneys," Journal of Wind Engineering and Industrial Aerodynamics, vol. 207, Dec. 2020, doi: 10.1016/j.jweia.2020.104401.

[12] R. B. D and A. Professor, "Analysis of Cantilever Steel Chimney As Per Indian Standards," 2015. [Online]. Available: www.ijera.com

[13] M. Bhatt and S. Vasanwala, "Comparison of Ultimate Capacities of RC Chimney Sections under Wind Loading," Trends in Sciences, vol. 19, no. 1, Jan. 2022, doi: 10.48048/tis.2022.1722.

[14] K. R. C. Reddy, O. R. Jaiswal, and P. N. Godbole, “Wind and Earthquake Analysis of Tall RC Chimneys,” 2011.

[15] R. Sarkar, D. Shrimal, and S. Goyal, “Seismic analysis of a 275 m tall RCC multi-flue chimney: A comparison of IS code provisions and numerical approaches,” in Advances in Structural Engineering: Dynamics, Volume Two, Springer India, 2015, pp. 1015–1025. doi: 10.1007/978-81-322-2193-7_80.

[16] H. F. Fasel, F. Meng, E. Shams, and A. Gross, “CFD analysis for solar chimney power plants,” Solar Energy, vol. 98, pp. 12–22, Dec. 2013, doi: 10.1016/j.solener.2013.08.029.