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REVIEW ON NATURAL DRAFT HYPERBOLIC COOLING TOWERS

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Abstract – *Natural draft hyperbolic cooling towers are doubly curved thin shell concrete structures that contribute to protection of environment and to efficient power generation. These structures are beneficial for cooling the thermal power plants by minimizing the need of water and thus avoiding thermal pollution of water bodies. Natural draft hyperbolic Cooling towers are important structures of thermal power plants, providing cooling across a broad range of applications. They are the structures which liberates heat to the atmosphere by the process known as evaporation , and are widely used in industries such as power plants, oil refining, steel mills, chemical processing and for manufacturing processes.*

Key Words: Hyperbolic cooling tower, Seismic effect, Wind effect, Stiffening ring, Cooling process

1. INTRODUCTION

Natural Draft hyperbolic cooling towers are widely used in most of the electric power generation units, chemical and manufacturing industries as a part of cooling the waste heat. From the structural point of view hyperbolic cooling towers are high rise reinforced concrete structures in the form of doubly curved thin walled shells of complex geometry and so is their analysis and design.

Natural draft hyperbolic cooling towers were subjected to self-weight, seismic load and wind load. Wind act as the main loading in natural draught cooling towers in the absence of seismic loads. The static and dynamic response of these towers are interesting and challenging for any structural engineer in view of their appearance.

Natural draft hyperbolic cooling tower structures may appear different in design and size, and they all function to liberate heat extracted from a process or building system through evaporation of water. Cooling towers are engineered and designed based on wind load in the absence of earthquake load. From the engineers point of view they are thin shelled large cylindrical reinforced concrete structures. These structures primarily resist the applied forces on the shell and bending action plays the secondary role in these structures.

The hyperbolic natural draft tower are environmental friendly and are extremely dependable for cooling process and have higher efficiency in view of its thermal performance. The air flow through this tower is produced by the difference in heat densities between the heated air inside the stack and the relatively cool ambient air outside the tower.

2. LITERATURE REVIEW

Qian-Qian Yu et.al (2016) studied about the resistance of large natural draft hyperbolic cooling towers towards the ground vibration. The study was conducted using shaking table on a 1/55 scaled reinforced concrete super-large cooling tower. Dynamic responses corresponding to seismic actions were measured and analysed. It was found that at strong earthquakes the columns of the tower collapse first followed by the tower leading to complete collapse of the structure. The research finally proposed a new earthquake resistant design for the cooling tower.

Hongkui Ji et.al (2014) conducted a study on prediction of ground motion due to the collapse of a large scale natural draft hyperbolic cooling tower under strong earthquakes. The ground motion owing to the collapse of a large scale cooling tower under strong earthquakes was appropriately predicted using a comprehensive approach. It was concluded that the site characteristics can significantly affect the collapse-induced ground vibrations. It was also concluded that tower situated in a typical hard experience moderate ground vibrations.

Feng Lin et.al (2013) conducted a study based on a 235m natural draft hyperbolic cooling tower due to the accidental load like seismic and strong wind. A reliable approach was presented in this study for the prediction of the ground vibration due to the collapse of a 235 m high cooling tower, which can be caused by various accidental loads such as explosion or strong wind. A parametric study was conducted on considering different collapse profiles, soil characteristics as well as the arrangements of an isolation trench. It was observed that collapse due to severe ground vibration occurred in the base of the cooling tower. The study concluded that the vibration increased rapidly with the increase in height of cooling tower.

S T Ke et.al (2012) introduced a methodology for analysis of static wind loads on large cooling towers. Based on the study conducted he introduced a new method called Consistent coupling method (CCM) for analyzing wind induced responses and corresponding wind load. The research introduced a new method in calculating the background and resonant components.

El Ansary et.al (2011) examined the optimum shape and design suitable for a natural draft hyperbolic cooling tower. The Study was to formulate a tool that is applicable of achieving an optimum shape and design of hyperbolic cooling towers by coupling non-linear finite element model. Based on it a genetic algorithm optimization technique was developed.

Rafat Al-Waked (2010) conducted a study on crosswinds effect on the performance efficiency of natural draft hyperbolic cooling towers. A three-dimensional model was used to determine the effect of crosswinds on cooling tower performance surrounded by other building structures. The proper understanding of standalone natural draft cooling towers was done. It was considered to be an efficient approach in determining the physics of the airflow in and around the tower. The model was considered to be a vital tool in obtaining qualitative results that can be implemented into parametric studies before being applied to the full-scale structures.

Norton (2006) conducted a study on effect of asymmetric imperfections on the earthquake response of hyperbolic cooling tower. The study was conducted using a linear computer program to evaluate several towers. The result revealed that the bending stresses due to imperfections can be a part of the conventional membrane stresses.

Saeid Sabouri Ghomi (2006) analysed effect of stiffening rings on buckling stability of natural draft hyperbolic cooling tower structures. It was noted that on point of costs and structural stability of the cooling towers, engineers could add stiffening rings. The study stated that in order to achieve maximum buckling stability, a proper knowledge of important design parameters is unavoidable. Additional stiffeners were found to increase the buckling resistance of hyperbolic shell.

Robert N. Meroney (2006) conducted a study on computational fluid dynamics prediction of cooling tower. It was stated that leakage of small water droplets from natural draft cooling tower installations can contain water treatment chemicals that can cause adverse effects on cooling tower shell surfaces. The study based on computational fluid dynamics (CFD) concluded that plume rise, surface concentrations of chemicals should be taken proper consideration for the efficient working of the structure.

Hyuk Chun Noh(2005) compared the ultimate strength of large scale reinforced concrete thin shell structures. The comparison was made between strength of large scale reinforced concrete natural draft hyperbolic cooling tower shell and natural draft hyperbolic parabolic (HP) saddle shell. It was concluded that the local yielding of reinforcement in meridional direction occurs hyperbolic cooling tower shell and tension crack failure occurs prior to local yielding in natural draft hyperbolic parabolic shells..

Zingoniet.al (2005) conducted study on damage, deterioration and long term performance of cooling tower shells .It also explains the issues of response to short-term loading and immediate causes. The study also focussed on durability and long-term performance efficiency on design of towers right from the outset. The study end with the prediction of appropriate numerical models was also done.

A B Kulkarni et.al (2005) conducted analysis of natural draft hyperbolic cooling tower using equivalent plate concept. The finite element software was used towards a practical application by considering the issues related to natural draft hyperbolic cooling towers. The main study utilises the finite element software developed to replace column supports of the tower by equivalent shell elements

Harte et.al (2002) conducted a study on natural draft hyperbolic cooling towers as a part of an efficient and cleaner energy generating method. It outlines the design and construction of natural draft hyperbolic cooling towers. The combined action of wind and thermal effects was studied to ensure durability and safety of the structure. It concluded that the natural frequency decreases with height leading to increased dynamic action.

A M Nasir et.al (2002) investigated the dynamics of axis symmetric natural draft hyperbolic shell structures in order to study the influence of shell height, wall thickness and curvature on free vibration and dynamic response. It was stated that increase in height increases period of vibration. Increase in curvature leads to decrease in fundamental modal period first and then it is increased.

Gupta et.al (1996) formulated seismic analysis and design of natural draft hyperbolic cooling towers. This study presents methods of seismic analysis. It was stated that the response spectrum method of analysis is more significant. A method based on boundary condition and inelastic action of response spectra for various earthquake zones was presented.

Alavandi bhimaraddi (1991) conducted a study on free vibration response of column supported, ring stiffened natural draft hyperbolic cooling tower. The tower was modelled using an isoparametric quadrilateral shell elements, and the rings and columns was modelled using an isoparametric three-dimensional curved beam element. The study revealed that the use of stiffening rings contribute to high vibration efficiency.

3. CONCLUSIONS

From the literatures it is find out that, many researchers conducted studies on behaviour of natural draft hyperbolic cooling towers. They are subjected to buckling and collapse failure. Researchers used different approaches to evaluate buckling and dynamic behaviour mostly analytical, experimental and numerical. Cooling tower shells were subjected to a relatively severe environment over their lifetime. The tower is subjected to the physical loads produced by wind, temperature, and moisture acting on concrete which may still be drying and hardening. The studies conducted on natural draft cooling towers proved that a properly designed tower with proper wind breakers can resist all the forces and failures. A good natural draft cooling tower should be designed to be safe for its entire life time irrespective of any accidental damage.

REFERENCES

[1] Qian-QianYu et.al, "Collapse resistant performance of super-large cooling towers subjected to seismic actions," Engineering Structures 108 (2016) Published by Elsevier Science Ltd, pp .77-89

[2] Hongkui Ji**, "**Prediction of ground motion due to the collapse of large-scale cooling tower under strong earthquakes", Soil Dynamics and Earthquake engineering, 65 (2014) ,pp .43-54.

[3] Feng Lin et.al(2013), "prediction of ground vibration due to the collapse of a 235 m high cooling tower under accidental loads", Soil Dynamics and Earthquake engineering ,65 (2013) pp .43-54.

[4] El Ansary, "Optimum Shape and Design of Cooling Towers", World Academy of Science, Engineering and Technology, 2011, pp 12-21

[5] Bamu and Zingoni, "Damage, deterioration and the long-term structural performance of cooling tower shells", Engineering Structures, 2005, pp. 1794–1800.

[6] Meroney, "CFD prediction of cooling tower drift,Journal of Wind", Journal of Engineering and Industrial Aerodynamics, 2006, pp. 463-490.

[7] S. Sabouri-Ghomi, "Effect of stiffening rings on buckling stability of R.C. hyperbolic cooling towers", Thin Walled Structures2006, pp. 152-158.

[8] A. W. Rafat, and B.Masud, "Cross winds effect on performance of natural draft wet cooling towers", Journal of Thermal Sciences, 2010, pp. 218-224.

[9] H. C. Noh, "Ultimate strength of large scale reinforced concrete thin shell structures", Thin-Walled Structures, 2005, pp.1418–1443.

[10] S.T. Ke, Y.J. Ge, L. Zhao, and Y. Tamura, "A new methodology for analysis of static wind loads on super large cooling towers", Journal of Wind Engineering, 2012 pp. 30–39.

[11] Shailesh S. Angalekar, Dr. A. B. Kulkarni, "Analysis of natural draft hyperbolic cooling tower by finite element method using equivalent plate method", International Journal of Engineering Research and Applications, pp.144-148.

[12] R L Norton, "Study on the effect of asymmetric imperfection of the earthquake response of hyperbolic cooling tower", 2006.

[13] Gupta**, "**Seismic analysis and design of cooling towers", ASCE journal1996.

[14] Alavandi bhimaraddi**,** "study on free-vibration response of column supported, ring-stiffened cooling tower", Engineering Structures, 2016, pp 77-89

[15] D P Thambiratnam, D Butler, P Austin, "Dynamics of axis symmetric shells", Thin Walled Structures,2002, pp 665-690.