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A Review on Seismic Analysis of RC Chimney with Fixed and Flexible Base Soil Conditions in Different Seismic Zones

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ABSTRACT- Chimneys are usually designed for loads produced by seismic effect and wind. So, it is inevitable to analyses the dynamic response of chimney due to effect of earthquake and wind loads. On account of changes in geometry of the chimney, structural analysis such as response to earthquake becomes more critical. The prime focus of this paper is to conduct the seismic analysis of a reinforced concrete chimney. The main purpose is to study the effect of various parameters like different seismic zones, various soil conditions of the chimney on the seismic performance of the structure

KEYWORDS – RCC Chimney, Seismic analysis, Linear Static Analysis, ETABS Software, Response Spectrum Analysis, Base Shear.

I. INTRODUCTION

A chimney is a structure that provides ventilation for hot flue gases or smoke from boiler, stove or fireplace the outside atmosphere. Chimneys are typically vertical or possible to vertical, to ensure that the gases flow smoothly, drawing air into the combustion. So chimneys are constructed as much as taller. The height of a chimney influences its ability to transfer flue gases to the external environment. Industrial chimneys are commonly referred to as flue gas stacks and are generally external structures. They are generally located adjacent to a steam generating boiler or industrial furnace and the gases are carried to them with ductwork. [6]

Construction of such tall chimneys needs the better understanding of loads acting on them and of the structural behavior, so that with the help of modern construction equipment and technique such as slip form, reinforced concrete, the most favored material for chimney construction, could be used efficiently. The proper design and construction of such chimneys will create self standing structures to resist wind load and other forces acting on them. It is a common practice to consider the effects of wind and earthquake separately in the design. [4]

II. LITERATURE REVIEW

K. R. C. Reddy, O. R. Jaiswal & P. N. Godbole (2011) [1] Discusses about wind and earthquake analysis of tall reinforced concrete chimney. In this paper two reinforced concrete chimneys are analyzed for wind and earth quake loads. Earth quake analysis is done as per IS 1893 (part 4): 2005 and wind analysis is done as per IS 4998 (part 1): 1992. The combination of along & across wind loads of chimney is done as per ACI 307-98 code. Finally they computed the governing load for design of chimneys.

B.R. Jayalekshmi1, Ansu Thomas & R. Shivashankar (2014) [2] Discusses about a 275m tall industrial chimney with annular raft foundation was idealized by finite elements and subjected to El Centro earthquake motion to study the effect of openings in the structure and the soil flexibility. The aim of this paper was to propose the need for an accurate evaluation of the soil structure interaction forces which govern the structural response. In this paper, a three-dimensional soil-structure interaction (SSI) was numerically simulated using finite element method. The transient dynamic analysis was carried out using LS-DYNA software. The radial and tangential bending moments of annular raft foundation obtained from this SSI analysis had been compared with those obtained from conventional method according to the Indian standard code of practice, IS 11089:1984.

Yoganatham .C & Helen Santhi .M (2013) [3] The analysis and design of chimneys are normally governed by wind or earthquake load. In this paper modal analysis of a RCC chimney in a cement factory is carried out using the FEM software package ANSYS. The effects changes in the dimensions of the chimney on the modal

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parameters such as fundamental frequency, displacement etc are evaluated. The displacement of chimney is found to decrease with increase in all geometric parameter ratios.

M.G. Shaikh Mie & H.A.M.I. Khan [4] The present paper discuses governing loads acting on reinforced concrete tall chimney. The main focus is to compare the wind analysis result with that due to seismic one. Wind analysis is done for along wind by peak factor method as well as by gust factor method and for across wind by simplified method as well as by random response method. The results obtain in above cases are compared. The seismic analysis is performed using response spectrum method. Finally, the maximum value obtained in wind analysis and seismic analyses are then compared for deciding the design value. The effect of wind forces is quite significant as compared to earthquake forces over 220m height RCC chimney. The geometry of chimney has to be so chosen that deflection of chimney at the top is within permissible limits.

J.L.Wilson (2003) [5] This paper presents results of recent experimental tests which indicate that reinforced concrete chimneys possess some ductility when subjected to cyclic loads. Based on these tests an inelastic procedure has been established for assessing the performance of reinforced concrete chimneys subject to severe earthquake ground shaking. This procedure has been used to analyses a number of chimneys, develop design recommendations and establish appropriate ductility factors. Tall reinforced concrete chimneys being highly tuned, profiled cantilevers respond in a complex manner to earthquake excitation, with the response dominated by higher mode effects, in both the elastic and inelastic range.

K.Anil Pradeep & C.V. Sivarama Prasad (2014) [6] In his experiment he described that industrial chimneys are generally intended to support critical loads produced by seismic activity. So it is essential to evaluate the dynamic response of chimney to seismic activity and wind loads. As per draft code the deflection at the free end of the chimney should be well within the permissible limit. The effect of wind force for 55m/s wind speed is quite significant as compared with the earthquake forces in zone II and III. Moment due to earthquake in zone III is almost equal to the combined moment due to wind speed of 55m/s.

Sudhir K. Jain, B. P. Singh & B. K. Gupta (1990) [7] Ten tall chimneys were considered for a parametric study by the researchers. Dynamic analysis of these chimneys was carried out by finite element method to study the implications of I.S. Code provisions for a fixed seismic design spectrum. Response in the first six modes was combined by the square root of sum of squares. The design spectrum was taken same as in IS: 1893-1984. They found that the design seismic force specified by the Indian code was very much on the lower side. Ten chimneys with height ranging from 107.5m to 336.2m had been analyzed by the finite element method and the results compared with those from expressions recommended in the I.S. code expression. For time period is found to be quite accurate and gives a value which was a little on the higher side (up to 13 percent).The code tends to overestimate the base shear to the extent of 45 to 70%. This was due to an unusually large factor, Cv, included in the base shear expression which needs to be revised. Base moment by I.S. code was 2 to 13% more than the actual base moment which was quite satisfactory. This happened because factor Cv, had not been included in the base moment expression. The method of shear distribution with height given in the code was quite accurate.

Rajib Sarkar, Devendra Shrimal & Sudhanshu Goyal (2015) [8] In this paper, a RCC multi-flue chimney of 275 m height has been considered for study. Design forces in the chimney were obtained in accordance with the stipulated recommendations of IS 1893 (Part 4) 2005 for based on equivalent static lateral force method. Then dynamic response spectrum modal analyses were carried out for calculating the seismic forces developed in the chimney. The results from the response spectrum method were compared with the values obtained from the codal procedures for different base conditions viz. fixed base, circular raft resting on soil and annular raft resting on piles. Though base moment and shear for fixed base conditions are higher with IS code procedure, the moment and shear at higher elevations of the chimney are critical with detail dynamic analysis. Detail dynamic analysis with time history yields critical values of design moment and shear for foundation types of raft on soil and annular raft on piles.

Ganesh Kumar & T Shruthi (2014) [9] A study of three dimensional 200m chimney structure models with different slenderness ratio, with different raft thickness of annular raft and resting on three types of soils ranging from vary soft to stiff has been carried out by researchers. The structure was subjected to acceleration time history of Bhuj earthquake ground motion. The soil was idealized as an elastic model and the prescribed ground motion was used for SSI analysis. The variation of natural frequency, deflection of raft and structural response for various parameters like tangential and radial moments of annular raft on different types of soil were studied. The time history analysis of the soil-structure model was carried out using the general FEM software SAP 2000 for ground motions BHUJ. After analysis they concluded with that natural frequency decreases with increase in soil flexibility and percentage decrease in natural frequency decreases with increasing soil flexibility. Most of the design codes assume linear displacement in the annular raft, but in reality SSI plays a major role and displacement will always be more under the chimney shield.

Zeki Karaca, ErdemTürkel, Murat Günaydın & SüleymanAdanur (2015) [10] An industrial RC chimney with a total height of 75m was selected for the dynamic analysis before and after FRP strengthening. Three-dimensional finite element models of the chimney before and after FRP composites strengthening were developed in ANSYS (ANSYS, 2008). This software has the ability to make linear, nonlinear, static and dynamic analysis of 3D structures. Then, linear transient analyses of the chimney were carried out by using 1992 Erzincan Earthquake ground motion record. After that, body of chimney was strengthened with FRP composite, and dynamic analyses were performed. Finally, dynamic responses of chimney before and after FRP strengthening, such as displacements and maximum–minimum principal stresses, were compared. The results deducted from their study can be summarized as For both analyses, the horizontal displacement values increased along the height of the chimney from bottom to top. For both analyses, maximum and minimum principal stresses occurred at the zone of opening and at the base of the chimney, respectively. Also, they found that FRP strengthening was effective on the dynamic response of industrial RC chimneys.

III. CONCLUSION

It is thus concluded that seismic response of tall chimneys is influenced greatly by soil supporting its base and nature of earthquake excitation's striking the base. Ignoring any one of them, can significantly affect the performance of chimney during earthquake and lead to devastating effects. Most of the researchers did analysis on RCC Chimney under seismic loading. Most of them used STADD and SAP2000 software for modeling and analysis of chimney, but still there is a lack of study on structural behavior and performance of RCC Chimney, So now it is necessary to find out seismic behavior of RCC Chimney by linear static analysis using ETABS software and check and compare the effect of various parameters like different seismic zones, various soil conditions of the chimney on the seismic performance of the structure.

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