ABSTRACT

WIND INDUCED VIBRATION OF CONCRETE CHIMNEY

One of the major causes of the failure of tall concrete chimneys is the shedding of vortices, which may cause severe oscillation under certain conditions. The vortex induced vibration is a complex phenomenon involving many crucial factors such as lock-in, aeroelastic effects, location of chimneys, characteristics of the wind flow etc. Vortex induced vibration is the subset of wind induced vibration, which is proven disastrous for concrete chimneys. Therefore, the vortex induced vibration of chimneys has attracted the attention of researchers in the past, and research is continuing on the subject. Despite considerable work has been done in the literature on the subject, there appear to be a number of gap areas where further research is desired. With this background in view, our study is undertaken.

The research presented in the thesis "*Wind Induced Vibration Of Concrete Chimney*" is a comprehensive study of the vortex induced vibration (VIV) of a chimney, focusing on four different aspects. The first aspect critically evaluates the existing Wake-oscillator models for the VIV of the chimney. To investigate the effect of linearization fused in the existing models, an iterative procedure to account for the nonlinearities arising from the aeroelastic effect is incorporated in the analysis. The comparison of linearized and proposed nonlinear model to find responses of three tapered chimneys (120m, 210m, and 360m) emphasizes the evaluation of the existing models. The response and reliability analysis of tall chimneys under vortex induced force is performed in the second part of the study. A power spectral density function is used to express the vortex induced force, which is assumed to be perfectly correlated over the top one-third height of the chimney. The aeroelastic effect in the VIV is taken into account in the analysis. The responses are obtained using both Modal and Direct Spectral Analysis. To examine the effects of the parameters, the responses of the same three chimneys are obtained under a set of parametric variations. The chimney responses are also compared to those obtained from international wind codes. The random vortex force reliability analysis of the chimney is also performed using the crossing analysis technique used by Vanmark.

The third portion of the work involves an exhaustive comparison of five international codes ACI 307-08, CICIND, National Building Code of Canada, 2015, IS 4998:2015, AS/NZ

1170.2:2011, Euro code method-I and Euro code method-II on the VIV of chimneys. The study explains how various code formulae were created, emphasizing their mathematical foundation. The same three chimneys are examined, and the responses obtained by various codes are compared to demonstrate their differences and similarities. The comparison includes deterministic and random variants of the equivalent static load analysis for the chimneys' VIV. In the final section of the study, three passive control devices, Tuned Mass Damper (TMD), Multi-Tuned Mass Damper (MTMD), and Tuned Mass Inerter System (TMIS), are presented to suppress the undesirable vibration of chimneys caused by VIV. The frequency domain spectral analysis is used to reduce the response, i.e., the top displacement of the chimneys. The analysis includes a Genetic Algorithm-based optimization technique to optimize the optimal tuning frequency and damping of the passive dampers. The same three chimneys are used in the example problems, and a parametric study is carried out to investigate the effectiveness of three control devices for chimneys of varying heights.

The results of the thesis indicate that tall chimneys are vulnerable to vortex induced failure. More stringent mitigation measures are needed to avoid such failures of chimneys by performing advanced analytical techniques, updating code provisions and devising state-of-the-art response control techniques.