SPECTRAL CHARACTERISTICS AND EXTREME VALUE ANALYSIS FOR WINDS IN INDIA AND CODAL PROVISIONS

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CERTIFICATE

This is to certify that the thesis entitled, "*SPECTRAL CHARACTERISTICS AND EXTREME VALUE ANALYSIS FOR WINDS IN INDIA AND CODAL PROVISIONS*" being submitted by **Mr. Ved Raj Sharma** to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy in Civil Engineering, is a record of bonafide research work carried out by him. He has worked under our supervision and guidance and has fulfilled the requirements for the submission of this thesis, which to the best of our knowledge has reached the requisite standard.

This thesis or any part thereof has not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Randomness of wind loading on civil engineering structures was given due attention commencing from mid sixties mainly due to the work of A.G. Davenport. It was subsequently incorporated in codal provisions in the form of gust factor/gust effect factor/gust response factor. In the Indian sub-continent no attention was paid towards wind measurements determining randomness of wind loading. The revised wind loading code of India, (IS:875 (Part 3), 1987) is based on peak wind approach like its predecessor. However, Gust Factor Method has also been incorporated as an alternate for flexible structures. Gust spectra and other related terms used in Gust Factor Method are not based on measurements pertaining to Indian wind climate and its structure. These have been mainly derived from 1983 version of Australian Wind Loading Standard. The mean wind speed required in Gust Factor Method, has been recommended to be determined from basic wind speed (peak wind) by approximate conversion factor. The present study has been undertaken with an objective of better understanding of wind behaviour in India, wind-structure interaction, selection of appropriate model for predicting extreme winds and critical appraisal of revised wind loading code of India.

The spectral characteristics of mean winds recorded with three cup generator anemometer have been obtained. The Graphical Method has been presented for converting wind velocity records in time domain to frequency domain. The spectra has also been obtained with Discrete Fourier Transform Method. The results obtained from the two methods corroborate. The highest spectral peak obtained is for a period of 24 hours and the peak second in rank corresponds

to a time period of twelve hours. The spectra obtained has been compared with those presented by other investigators.

Field measurements pertaining to atmospheric turbulence were carried out and along-wind spectra obtained experimentally. The gust spectra has been obtained in different frequency ranges upto a maximum of 10 Hz. Energy contents in low frequency range have been found to be dominant. A spectral hump has also been found consistently in the frequency range of 0.3 Hz to 0.6 Hz. Based on the spectral ordinates obtained, analytical models have been suggested for predicting spectra in different forms. The predicted spectra has been compared with those obtained from spectral expressions put forward by other investigators alongwith the measured spectra. In addition, other turbulence parameters, turbulence intensity, velocity gust factor and peak factor have been computed and compared with those reported in the literature.

For the purpose of understanding wind-structure interaction, a vertical cantilever structure was erected in the field. The measurements of atmospheric turbulence and the corresponding response of the structure have been carried out. The spectrum for atmospheric turbulence and the corresponding response spectrum for strain of the structure have been obtained. The correlation between gust spectra and the corresponding response spectra has been investigated.

Basic wind speed map of India incorporated in revised wind loading code is based on probabilistic analysis of peak winds by Extreme Value Type I distribution. Other investigators have preferred Extreme Value Type-I/Extreme

Value Type-II distribution without suitability of either of these having been tested. In the present study suitability of Extreme Value Type-I/Extreme Value Type-II distribution has been critically assessed with "Probability Plot Correlation Coefficient" method and extreme winds predicted accordingly. It has been found that at majority of the stations the peak wind data is more appropriately fitted by Extreme Value Type-II distribution. Similarly statistical analysis of mean wind data yields that Extreme Value Type II distribution is more appropriate at majority of the stations. On comparison of predicted extreme mean wind speeds with those incorporated in code it has been found that the values obtained from code are over estimated. Further, velocity gust factors have been computed and compared with those incorporated in the said code.

The provisions of revised wind loading code of India have been discussed and compared with those of American, British and Canadian Codes. A simple parameter-by-parameter comparison of provisions of four codes is not feasible as parameters have not been defined in identical manner in each of these codes. As an alternative, comparison among the codes has been made in two ways. One is a qualitative comparison of various terms and factors used for determining wind loads. Secondly, quantitative comparison of wind loads computed on typical structures; a low rise building, two tall buildings, and a lattice tower, has been made. The qualitative and quantitative comparisons highlight significant differences in the provisions of the codes.

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