Specification of design wind loads in India

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Abstract: Codes in current use in India for specifying design wind loads for structures are analysed, and shown to be inconsistent with available data on extremes. Thus, it is found that while the National Building Code specifies the highest wind loads on the east coast and western Gujarat, the observed extreme winds are highest in the eastern Gangetic valley. As the consequences of under-specification can be serious, a careful re-examination of the code seems called for. It is argued that although the available data on extremes may not be complete, they provide a more rational basis for formulating a building code; as wind loads become more important in construction engineering a serious effort at generating and analysing the required meteorological data seems highly worthwhile. However, procedures followed elsewhere for predicting extreme winds and the nature of gusts need to be validated for the country. In addition there is also a need to study certain meteorological phenomena peculiar to the Indian subcontinent like the duststorms and the nor'westers of north India.

Keywords. Design wind loads; National Building Code; extreme winds; risk analysis; wind engineering; wind energy.

1. Introduction

Wind loads and response to wind are important design parameters for many structures including bridges, high rise buildings, tall towers etc.; it is nowadays essential to ensure that such structures can survive the high winds and gusts likely to be encountered. This paper considers how these winds may be specified for India. Many countries including the US, the UK, Australia etc. have in recent years reframed their respective national codes for wind and gust loads. The major reason for the change is that while the older versions were deterministic, the new codes are probabilistic, and make use of the statistics of extreme winds and risk analysis. No such exercise has been carried out for India so far. As of now, the National Building Code of India (NBC 1970) and the Indian Standards (IS 1965) provide maps of the country specifying 'design wind pressure' in various zones. There is however some analysis of extreme winds in India based on data from meteorological observatories (Sharma & Sehgal 1968; Ayyar & Goyal 1972; Mani & Mooley 1983). We describe these data in §2, and present a critical review in §3; some tentative suggestions for rewriting the code are made in §4.

2. Survey of data

2.1 NBC specifications

The NBC provides two wind pressure maps reproduced from IS (1965) for the country. These specify a basic wind pressure which (after conversion to SI units by us) may be
written as

$$p = 0.76 V^2 \text{ Pa, } V \text{ in m/s;}$$

(1)

the pressures are stated to be "the maximum ever likely to occur in the respective areas under fully exposed conditions". One map includes "short duration winds", defined as those "which last only for a few minutes, generally less than 5 minutes"; the other excludes such winds. It appears, from the notes accompanying these maps, that the wind speeds expected during cyclones have played a major role in the formulation of the specifications.

The actual (static) load on any structure is then determined in terms of the basic pressure $p$, taking into account factors such as the geometry of the building. Corrections for heights exceeding 30 m are also provided in the notes.

2.2 Extreme winds

A second (and more satisfactory) approach would be to utilize extreme value statistics (e.g., Gumbel 1958) to specify wind speeds that are likely to be exceeded with stated probabilities in different parts of the country. Some analysis of data on such extreme winds (i.e., maximum wind speed during a year) in India is presented by Sharma & Sehgal (1968), Ayyar & Goyal (1972) and Mani & Mooley (1983); they provide contours of extreme wind speeds corresponding to different specified "return periods".

This "return period" is defined as follows. If the probability of experiencing an extreme wind speed higher than $v$ in any one year is $1/T$ (i.e., if $P(V > v) = 1/T$), then $T$ is called the return period for the wind speed $v$. The probability of interest to the designer is that of encountering at least one extreme of specified value in the period $T$; this probability is

$$1 - (1 - 1/T)^T, \rightarrow 1 - e^{-T} \text{ as } T \rightarrow \infty.$$

(2)

For a given risk of exceedence during the life of a structure, the return period required can be worked out.

Contours of extreme wind speeds obtained by Ayyar & Goyal and Mani & Mooley are based on data on annual peak gust wind speeds from Dines pressure tube anemographs from 24 and 18 stations respectively spread over the country. The basic wind speeds used in the analysis are obtained from anemometers at different heights above ground; no corrections were applied for height, terrain or exposure. The data have been fitted to a Fisher-Tippett Type I distribution, which gives, for the probability that the extreme wind speed $V$ is less than $v$, the value

$$P(V < v) = \exp[-\exp(-(v-\mu)/\sigma)],$$

(3)

where $\mu$ is a location parameter and $\sigma > 0$, a scale parameter. On the other hand Sharma & Sehgal analysed similar data from only 7 stations in north India. They have corrected their anemometer readings for variations in height and fitted their data to the same distribution (which they call the Gumbel distribution).

Figure 1 shows the 100 year return period contours of Ayyar & Goyal superposed over the Nsc map which includes short duration winds. It will be noticed that, according to Ayyar & Goyal, the highest winds are experienced not along the east coast as indicated by Nsc, but in the eastern Gangetic valley. They suggest in explanation that "the short-period squally winds associated with the thunderstorms and the duststorms