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RESPONSE SPECTRUM OF WIND FORCE

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ABSTRACT

This paper presents the classical elastic response spectra of a single-degree-of-freedom system (SDOF) which is obtained from the measured data of the force caused by a wind named Bora [1].

The experimental measurements of wind action were performed on the SDOF consisting of a smooth steel bar clamped in a fixed metal base with a steel sphere placed on top. An accelerometer with a resolution of 10^{-5} second was installed in a lee of the steel sphere. The time resolution varies from 0.01 to 0.00001 second. The measurements were carried out in such a way that the horizontal acceleration of the metal sphere centre was measured in the direction of the wind acceleration. The acceleration records of the SDOF have been translated into the wind force using standard dynamics methods [2].

The measured data made possible the construction of the elastic response spectrum of the undamped SDOF for each particular incitement. The non-dimensional shape of the response spectrum r(T) for the observed wind named Bora was constructed by a non-dimensional comparison based on the envelopes of the averaging values. A scale of the spectrum is taken so that the spectrum force of the unit value of 1(N) is associated to the period T=1(s). The non-dimensional response spectrum, shown in Fig. 1, can be very well approximated by the functions:

$$\begin{aligned} r(T) &= e^{-\log T}, \quad 0 < T < 1(s) \\ r(T) &= 1, \quad 1(s) < T < 4(s) \end{aligned} \tag{1}$$

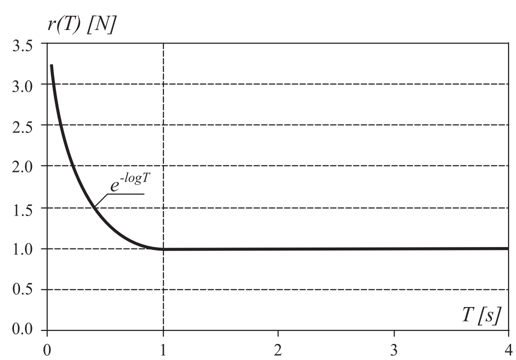

Fig. 1. Non-dimensional response spectra

It can be observed from the presented results that the ordinate of elastic response spectra increases with decreasing natural period of the SDOF.

The paper also presents a practical method for determining the elastic response spectrum for a particular SDOF [3] and a newly specified location, based on the known data of the average wind velocity.

The corresponding response spectrum for a particular location can be constructed by a transformation based on the measured data of the average wind velocity $V(T_w)$ (km/h), where T_w is the averaging period in seconds. A scale of non-dimensional spectra can be obtained from these two data according to the expression [1]:

$$m(T_w)=\left[\frac{V_{(Tw)}^2}{95^2}\right]\frac{1}{a_0(T_w)} \quad [m^0] \tag{2}$$

where $a_0(T_w)$ is a constant component of the wind force which is defined by an approximated analytical expression [1]:

$$a_0(T_w)=\left[\frac{20}{413}(\ln T_w)^2-\frac{10}{51}\ln T_w+1\right]e^{-0.20\ln T_w} \tag{3}$$

The ordinate of the response spectrum for a particular location can be obtained in the form of the product of a non-dimensional response spectra ordinate r(T) and the corresponding scale $m(T_w)$ according to the following expression:

$$R(T)=r(T)\,m(T_w) \tag{4}$$

The ordinates of the response spectra presented by expressions (4) represent the value of the wind force which will appear on a particular location for a given condition of the wind action, on the SDOF with the same geometry of the experimental sample used in this paper.

The sum of the products of all the coefficients c_i and the referent areas $A_{ref,i}$ subjected to the wind of the sample described in this paper, congruent to the condition in EC 1 part 2-4 [3] is $\Sigma c_i A_{ref,i}=0.20(dm^2)$. The ratio of the geometric relation between the arbitrary SDOF and experimental SDOF can be established according to the expression:

$$a=\frac{\sum_i c_i A_{ref,i}}{0.20} \quad (dm^0) \tag{5}$$

The response spectrum for a particular SDOF and corresponding wind defined by the averaging velocity can be represented as:

$$R_e(T)=a\ r(T)\,m(T_w) \tag{6}$$

Elastic response spectrum can be used for the calculation of the wind effect on the structure by the modal response spectrum analysis.

REFERENCES

[1] A. Mihanović, Ž. Nikolić and P. Marović, "Waves properties of wind actions on structure", *Int. J. Engineering Modelling*, Vol. **19**, (2006). (in print)

[2] J.L. Humar, *Dynamics of Structures*, Prentice Hall, New Jersey, 1990.

[3] European Committee for Standardization, Eurocode 1. Basis of design and actions on structures – Part 2-4: Actions on structures – Wind actions. ENV 1991-2-4, Brussels, 1995.