Fundusze Europejskie
Wiedza Edukacja Rozwój

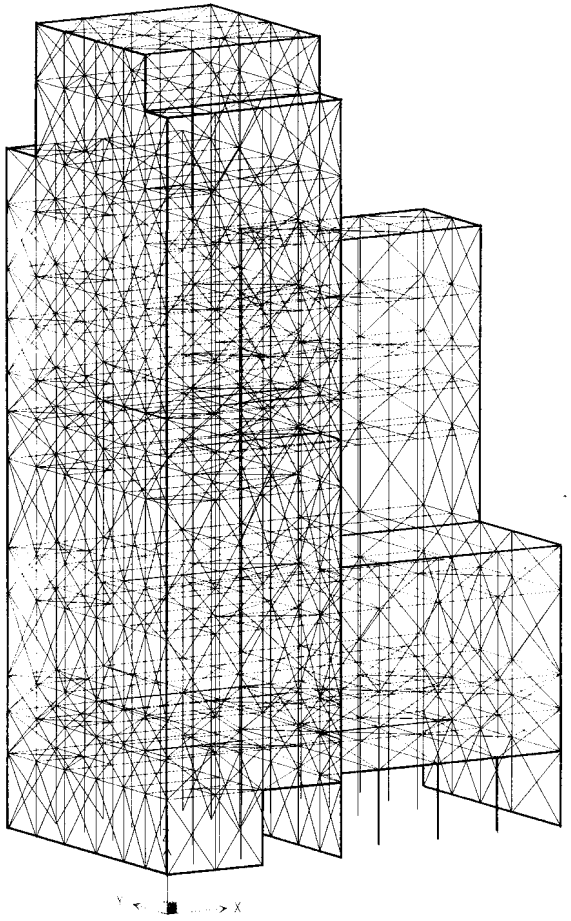
Unia Europejska
Europejski Fundusz Społeczny

STUDY CASE OF SERVICEABILITY LIMIT STATE OF AN EXISTING STRUCTURE. RANDOM MODELLING OF WIND LOAD

The reloading tower, of the total height 82 m, is designed in the Northern Port location in Gdańsk, Poland. Because of the technological regime (work of the bucket hoist) the horizontal deflection of the upper deck cannot be greater than $u_0 = 3.0$ cm. For this reason the structure was designed of a very high stiffness, the main design criterion was of not exceeding the horizontal displacement u of the upper deck.

Fundusze Europejskie
Wiedza Edukacja Rozwój

Unia Europejska
Europejski Fundusz Społeczny

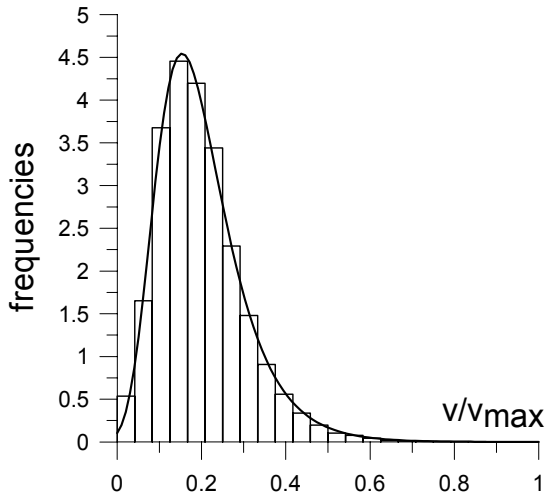


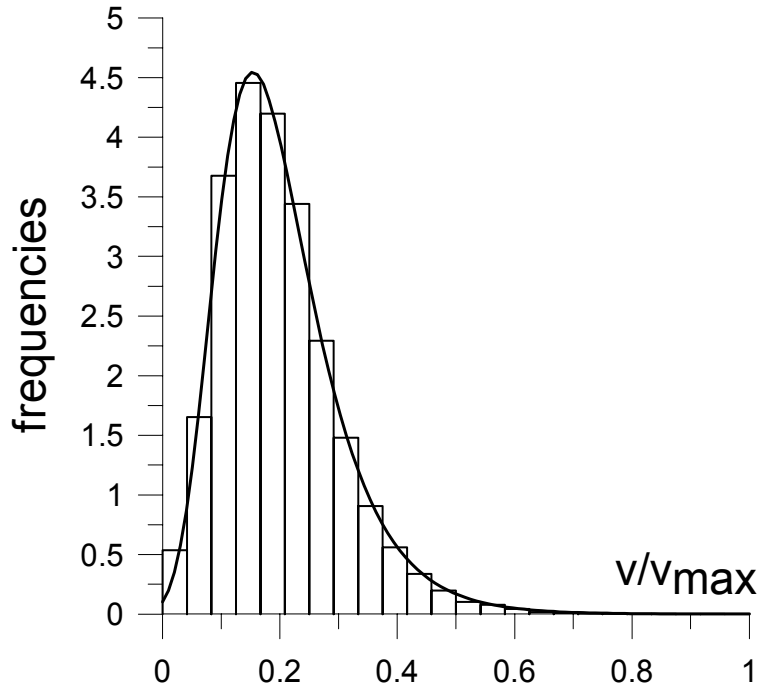
Structural model of the tower

„Zintegrowany Program Rozwoju Politechniki Gdańskiej”
POWR.03.05.00-00-Z044/17

Random model of the wind load was established on the basis of the measurements of the wind velocity, received on courtesy of the Polish Meteorological and Hydrological Institute. Statistical analysis of the frequencies of wind velocity from the years 1990 - 99 proved that the wind velocity can be described by Gumbel distribution of the parameters: $u = 0.15$, $a = 12.4$. The distribution of the wind pressure was taken by the transformation $Y = cX^2$ of the wind velocity.

Assumptions were made to describe the dead load by a Gaussian variable, service and technological loads by uniform variables. Linear structural analysis (SAP 2000) brought about the horizontal displacement u. The serviceability limit state of the structure was defined in the form of the variable $RES(\omega) = u_0 / u(\omega)$.





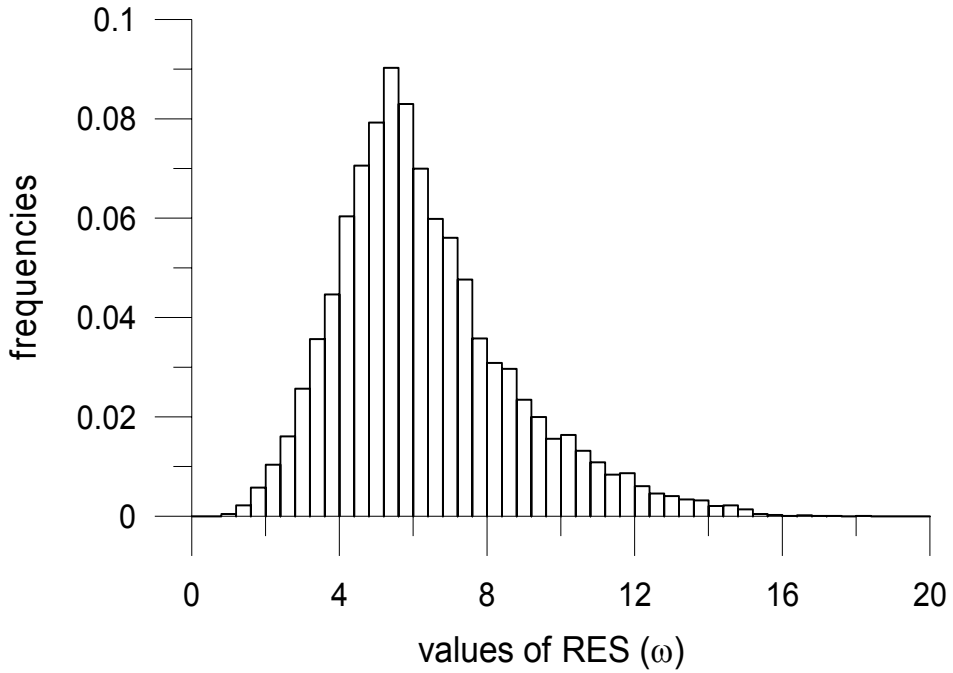
The Gumbel probability density function

and the histogram of the mean wind velocity for the Northern Port, Gdańsk

In the formula above the symbol ω denotes an elementary event.

Simulation of four random variables was performed, 10000 realizations of the problem were done. Probability distribution of the serviceability limit state was estimated by a histogram of the variable *RES* (ω). The characteristics of this histogram are:

- mean value $\mu = 6.312$
- standard deviation $\sigma = 2.407$
- probability of SLS $p_f = \mathrm{P}(\mathrm{RES}(\omega) < 1.0) = 0.0002$
- reliability $R = 1 - p_f = 0.9998$



Histogram of the random variable *RES*(ω), i.e. histogram of structural SLS

The simulation - based analysis leads to the conclusion that the structure fulfils the required stiffness conditions. The exceeding of the allowable displacement is an event of a very low probability, in the time of performance the most frequent deflections are supposed to be much less than u_0 . It is worth noting that standard - based procedure, with constant, characteristic values of loads results in the displacement $u = 4.56$ cm, much greater than it is allowed, so in this case the conclusion would be of an insufficient stiffness of the structure.