Reliability based calibration of partial factors for the future evolution of EN 1990 for wind actions

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Workshop summary

In Delft on 17-18 February 2015 the JCSS and CEN/TC250/WG7 organised a workshop on the reliability based calibration of partial factors for the future evolution of EN 1990 for wind actions.

Under CEN rules, TC 250/WG 7 is preparing a new proposal for the partial factors for the revision of EN 1990.

The JCSS workshop was a starting point for discussion among experts involved in different fields. In the reliability based calibration of partial factors background documentation is needed on statistical characteristics of climatic loads, also possible 'hidden' conservatisms in climatic load models should be quantified. However, also other possible short comings or white spots in the code can be addressed.

In the workshop the Alan Davenport Wind Loading Chain as the model for the wind load was accepted as the working principle. Within this chain proper modeling of the parameters with corresponding uncertainties was considered to be necessary.

Basic discussion was the question which physical phenomenon causes the extreme wind speeds. Often only synoptic storms are seen as the principal cause of extreme wind speeds. The study of thunderstorm loading of structures is a topic of recent research in Italy. Engineering methods (e.g. Eurocode EN 1991-1-4) are still mostly referred to stationary phenomena at the synoptic scale, with velocity profiles in equilibrium with the atmospheric boundary layer. Thunderstorms are non-stationary phenomena at the mesoscale with different velocity profiles. Measurements carried out by J. Solari in how ports (near the sea) in Italy show that the design wind velocity is frequently associated with thunderstorms.

Extreme value distributions are used for extreme wind speed or wind pressure. Gumbel, Weibull, Generalized Pareto and Three Parameter Lognormal distributions were mentioned in the workshop. The influence of the choice for this distribution function on the probability of failure and the required partial factor is very significant. It was agreed that in literature for the wind pressure (not for the wind speed) often a Gumbel distribution is taken. M. Holicky however, based on the skewness of the wind speed, proposed a 3 parameter Lognormal distribution. Using this distribution, the derived partial factors are significantly smaller than in the case of the Gumbel distribution.

With respect to climate change a small decreasing trend in annual extremes in Denmark was observed.

In the workshop it was observed that very little data is available for the modelling of possible hidden conservatisms in the modeling of the terrain roughness and the wind velocity profile. It is therefore difficult to assign distribution functions to that parameter in the wind loading chain.
It was discussed that experience gained from a large number of wind tunnel tests for different building geometries learns that :
- The Eurocode 1 m² pressure coefficients often underestimate the wind action measured in the wind tunnel. An underestimation of 20% was mentioned by S.O. Hansen.
- The Eurocode 10 m² pressure coefficients often overestimate the wind action measured in the wind tunnel. An overestimation of more than 20% was mentioned by S.O. Hansen.
- The Eurocode global wind action often overestimates the wind action measured in the wind tunnel. Often the overestimation is of an order of at least 40% was mentioned by S.O. Hansen but this value was questioned since in some countries this is already taken into account by using a factor describing the (lack of) correlation between wind and leeward pressures.

For the determination of the pressure coefficients a Gumbel distribution was proposed based on wind tunnel measurements. For the probabilistic model it was concluded that 1 m^2 and 10 m^2 areas on different locations of the building should be observed (windward, leeward, corners) together with the global modeling of the wind load on the building. For the 10 m^2 areas S.O. Hansen advises to use the average value of 4 closely located pressure taps.

For semi-probabilistic engineering design often a 0.78 (N. Cooke) or a 0.95 (Dutch guideline) fractile in the distribution of pressure coefficients is used. This may be conservative or not and this choice depends on the full probabilistic model of the wind loading chain with all relevant stochastic variables.

The model uncertainty associated with the use of the wind loading chain, the use of extreme wind speeds from anemometers at 10 m height, the use of pressure coefficients from wind tunnel measurements and the uncertainty in the translation of wind load to load effects is difficult to estimate. It was discussed to apply a sensitivity study.

A separate discussion took place about the vortex models in the Eurocode. Very often from measurements in practice they appear to significantly over- or underestimate the reality. This should be addressed in the re-evaluation of these chapters in EN 1991-1-4.

Several methods for the calibration of the partial factors were proposed:

1. Level 1 probabilistic calculation with standard alpha factor α=-0.7 for the wind load
2. Level 2 or 3 probabilistic calculations with simplified modeling of the strength based on $R_d=S_d=\gamma_S*S_{char}$ and S_{char} from EN 1991-1-4 with a coefficient of variation for R of 0.1 or 0.15
3. Codecal calculations in which also different load combinations are observed.
4. Using annual target reliability values or life-time target reliability values.

Here is a need for more insight in the consequences and a harmonization of view.

Conclusions and future work

- Further study will be done to investigate the applicability of the 3-parameter lognormal distribution for the annual extreme wind speeds. This distribution is the governing distribution for the partial factor. Data from the Netherlands (R. Steenbergen), from Denmark (J. Sorensen) and from Italy (P. Formichi) will be send to M. Holicky who will investigate that data to come jointly to a conclusion which distribution function to use.
- In a first analysis directionality effects in the wind speed are not taken into account.
- For the pressure coefficients values from the TNO wind tunnel and from Danish wind tunnels can be used. Different locations on buildings should be taken into consideration. Hidden safeties can be avoided through accurately using and interpreting of wind tunnel data. Front- and backside correlations should be taken into account.
- For the model uncertainties assumptions should be made and sensitivity studies should be carried out.
- With respect to the reliability methods, it is proposed to first use the above mentioned methods 1) and 2) for a life-time target reliability value. Later we can expand the probabilistic calculations to also load combinations.
- Through more advanced measuring and careful examination of the data, the extreme wind speeds from thunderstorms should be separated from the extreme wind speeds from synoptic storms since the velocity profile is completely different as well as other (statistical) properties. This is a long-term goal.