Eurocode UK National Annex Implementation

PD 6688 1991-1-4:2015

This Published Document came to effect on 31 December 2015. The newly introduced Annex B covers the along wind gust response of self-supported lattice towers. Annex B provides a method to resolve the incompatibility between the methods used in BS EN 1993-3-1:2006 for calculating the along-wind gust response and the wind model used in the UK national Annex to BS EN 1991-1-4.

The method proposed revolves around calculating a gust response factor G_{EN} that is similar to the basic gust response factor G_B used in BS 8100-1:1986. The method of calculating the gust response factor is similar to the method shown in Section C.5.6 General theory of derivation of gust factors in BS8100-2:1986.

Two aerodynamic admittances J_a and J_p are required to be calculated and it requires integration or double integration through the tower height of non-dimensional coefficients γ_z.

For a self-supported tower, the response consists of:

- Tower members (legs and bracings) axial loads (compression and tension).
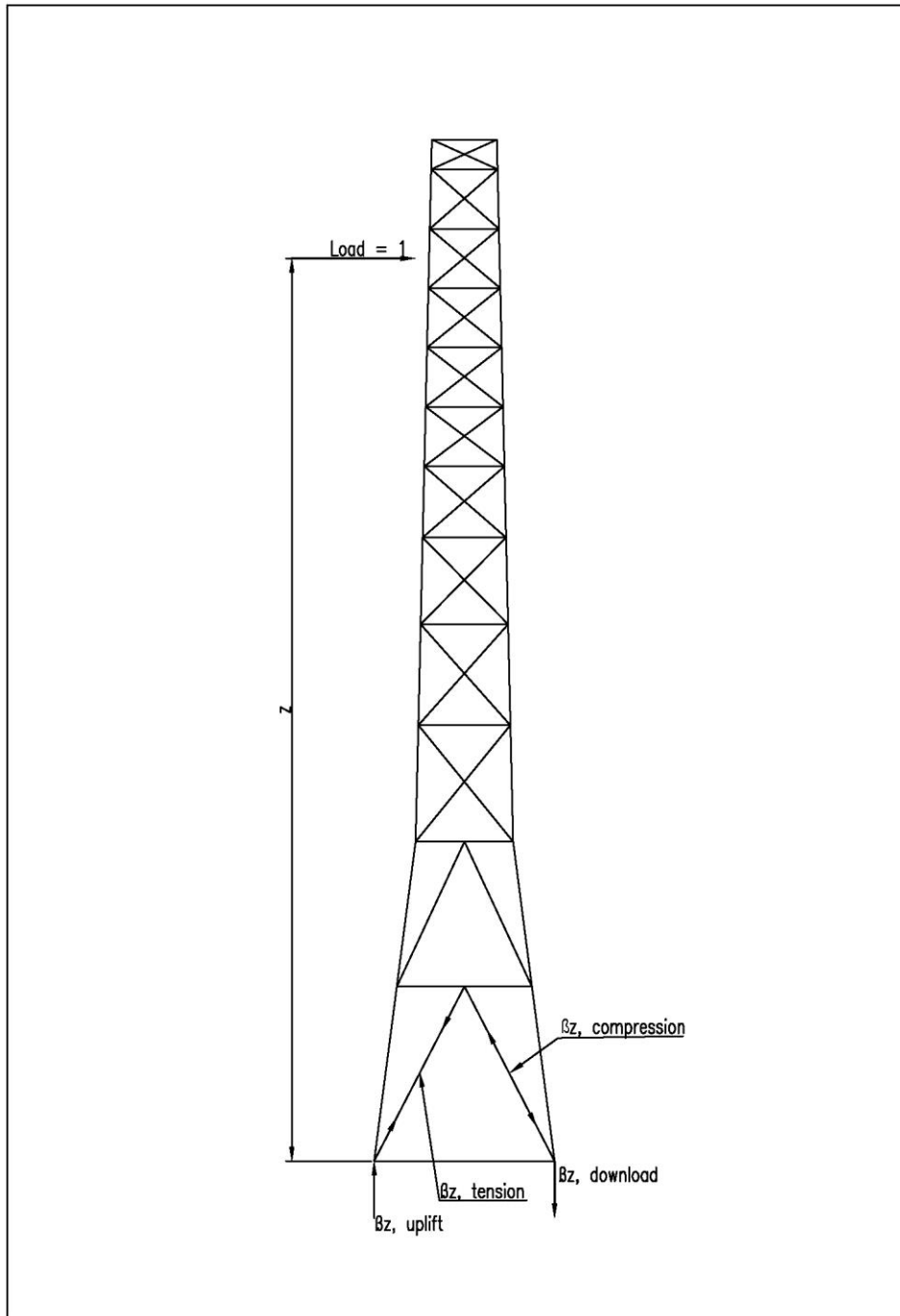- Individual leg base reaction loads
- Global tower foundation loads

Gust response factors G_{EN} are required to be calculated for the tower response.

The non-dimensional coefficients γ_z, include β_z, structural influence factors at height z.

This information sheet presents how DE Tower analysis software calculates the influence factors. The worked examples in the Published Document looked at global bending moment and shear at tower base or at a height above tower base. This method works well if self-supported towers are modelled as cantilevers and individual tower member loads are calculated from the bending moment and shear loads. In practice, self-supported towers are modelled as 3-D spatial trusses, and axial loads are calculated for each tower members.

DE Tower Software Information Sheet

In implementing the Published Document, DE Tower analysis software calculates structural influence factors for each tower member (leg or bracing) and each foundation response (maximum individual leg uplift, download and shear and global foundation loads).

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DE Tower Software Information Sheet

In addition to all the analysis load combinations required by the BS EN 1991-1-4 and BS EN 1993-3-1:2006, a large number of additional influence factor load cases are required to be run with the finite element model.

For each of the tower panel throughout the height of the tower, a unit load is applied and all relevant responses. Since the software uses 12 wind directions (30° increments) for triangular towers and 8 wind directions (45° increments), the unit load has to be applied for each wind direction, too.

The total number of additional load runs is equal to number of panels multiplied by the number of wind directions.

We recently analyzed an 89-m tall self-supported tower used as a meteorological tower for a wind farm. The tower is very narrow and it has 88 panels. The tower is triangular and the software by default uses 12 wind directions. 1056 additional influence line load cases (88 panels times 12 wind directions) were required.

The procedure for calculating the maximum compression loads for a particular panel is, as follows.

Step 1: Run all strength (ultimate) load combinations for dead load only and dead load with wind for all wind directions. The wind loads are mean wind loads in accordance with EN 1993-3-1.

Step 2: Run all additional influence factor load cases.

Step 3: For each panel, search for the members that have the maximum compression and tension loads. For example, for a three-legged tower, identify the most loaded leg in compression and tension out of all three leg members in the panel. Record the wind directions that yielded the maximum response, tension and compression.

Step 4: For each response at each panel, calculate gust response factors G_{EN}, using influence factors load runs obtained at Step 2, for the particular wind direction that yielded the maximum response.

Step 5: For each maximum response, subtract the corresponding dead load only response. Apply the gust response factors G_{EN}, calculated at Step 4 to the maximum response that came from the mean wind loads to obtain a fluctuating wind response. A height escalation factor is applied, similar to BS B100-1:1986.

Few comments about the foundation load responses. In practice, for individual reaction loads under each leg, maximum uplift, down load and shear load are calculated. For each maximum response, in each direction, the corresponding other direction responses are calculated. DE Tower analysis software calculates gust response factors for both the maximum response and the corresponding responses. For example, for the maximum uplift, it calculates the gust response factors for the corresponding shear loads. Same approach is applied for global foundation loads.

 A quick word about another type of response, tower displacements. BS 8100-1:1986 applies gust response factors to displacements. The Eurocodes, EN 1991-1-4 and EN 1993-3-1 use a different approach. The wind pressures used for serviceability load combinations are q_p, peak wind pressures as opposed to mean wind pressures used for the strength (ultimate) load combinations. Since peak wind loads are used, there is no further need for gust response factors.

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