Structural-Safety

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Alert

SCOSS ALERT
Wind Adjacent to Tall Buildings

December 2015

WHO SHOULD READ THIS ALERT?

This Alert is aimed at those who design or commission temporary structures that are subject to wind loading and adjacent to tall buildings. Such temporary structures may be particularly prone to adverse wind effects by virtue of their relative position.

ALERT

Reports to CROSS have raised concerns about the design of temporary works to resist wind loading in urban environments. Temporary works have suffered local wind damage, and it is suspected that is, in part, because wind loads have not been determined correctly. Although reports relate to urban environments, temporary structures adjacent to tall buildings in exposed location may also be adversely affected.

The current UK Code of Practice for wind actions (BS EN 1991-1-4) addresses wind loading on buildings but only gives limited guidance on the effect of wind flow on nearby structures. Guidance on a small number of scenarios is given in the UK National Annex to BS EN 1991-1-4 (with further background information in PD 6688-1-4). Clause NA.2.27 addresses a particular case of funnelling (where flow is forced into a smaller volume and so is accelerated). An enhancement in pressure coefficients is given where the walls of two buildings face each other and the gap between them is less than a given value. Designers should always be mindful of the potential for funnelling, where air is forced into a narrow gap. The increase in wind velocity will increase the dynamic pressure and raise pressures on the surfaces of the gap.

The flow around buildings is complex and three-dimensional. However, it is possible to understand some of the underlying principles to assist in deciding when specialist advice is required. A desk study by a specialist can often provide a good indication of the significant issues.

Consider a rectangular building normal to the wind direction. The building obstructs the free flow of air, creating positive pressure on the windward face. This air flows down the face of the building due to the variation of oncoming wind speed (and pressure) with height. In effect the building acts like a scoop, collecting air from higher levels and delivering this to ground level. This is commonly referred to as a downdraft.

The winds brought down to ground on the centreline of the building re-circulate, counter-intuitively reversing the direction of the wind near ground level. Winds brought down to ground away from the centreline of the building accelerate around the upwind corners of the building; the down-drafted air is drawn to the negative pressure in the wake of the building. If a structure (temporary or permanent) is located directly in front of a building, in the corner zones or in the separated flow region downstream from the corners, it is possible that it will experience wind pressures far in excess of those for which it was designed (if considered in isolation to its surroundings). This effect is illustrated in Figure 1.

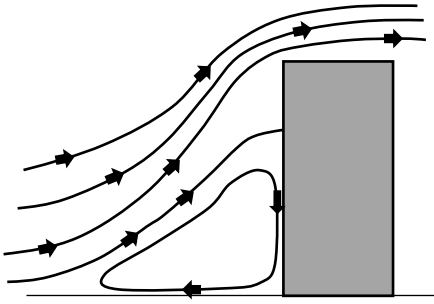

Figure 1: Flow on the centreline of a building (side elevation).

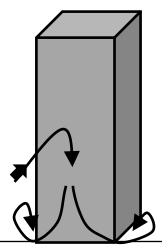

Figure 2: Flow on the around the corners (front view).

Some design guidance is given in reference [4] on surface winds near isolated high-rise buildings, based on the work of Maruta [5]. This is a purely empirical method so is only valid over the range of parameters to which the model was fitted. A method is also given in Annex A.4 of BS EN 1991-1-4, and provides a first approximation for the peak velocity pressure on structures surrounding a single tall building. However, many urban environments are far more complex, with many adjacent tall structures. A conservative approach is to use the height of the tallest building as the reference height to calculate the dynamic wind pressure used near ground level. To indicate the significance of the effect, the wind pressure at ground level could be more than doubled by the blockage effects of an 80m tall building[1].

Guidance is given in BS EN 1991-1-4 and the UK National Annex on the high local pressures that arise on the edges of walls and roofs. Designers should recognise that wind loading is transient, cyclic and likely to be turbulent. Therefore, connections (e.g. for cladding, sign boards, fencing, etc.) in these zones should be sufficiently robust to resist fatigue.

Careful consideration should be given to the selection of probability and seasonal factors when determining wind loads in accordance with EN1991-1-4. Recommendations on return periods depending on the duration of the works are given in EN1991-1-6. Particular care should be taken before adopting seasonal factors, as this requires strict control and certainty over the period of installation of the temporary structure.

Designers of temporary structures should consider how the environment around a temporary structure will change during the construction process. Different stages in the construction of a tall building may introduce blockage effects that alter or funnel wind flow, and give the critical design case for wind loading (e.g. with the addition of cladding). Advice should be sought in critical and complex situations, where a competent wind engineer may be able to help identify the main wind-related issues or suggest quantitative studies (e.g. wind tunnel or otherwise) where necessary.

Although this Alert was prompted by concerns regarding the design of temporary structures around tall buildings, it should be noted that wind around tall buildings can lead to unpleasant (and sometimes dangerous) conditions for pedestrians. Information to assist designers, planners, developers and building control officers in dealing with the wind environment around buildings is given in BRE Digest 520. The contents of this digest are also relevant to the design of temporary structures around tall buildings.

REFERENCES

[1] BS EN 1991-1-4: 2005. Eurocode 1 – Actions on structures. Part 1-4: General actions – Wind actions (Incorporating corrigenda July 2009 and January 2010).

[2] UK National Annex to Eurocode 1 – Actions on structures. Part 1-4: General actions – Wind actions (+AMD A1: 2010).

[3] PD 6688-1-4: 2009: Published Document. Background information to the National Annex to BS EN 1991-1-4 and additional guidance.

[4] Cook, N.J. The designer's guide to wind loading of building structures. Part 2. Static Structures (ISBN 0-408-00871-7).

[5] Maruta, E. The study of high winds regions around tall buildings. PhD thesis. Tokyo, Nihon University, 1984.

[6] Blackmore, P. Wind microclimate around buildings. Building Research Digest (BRE) 520, 2011.

[7] BS EN 1991-1-6: 2005. Eurocode 1 – Actions on Structures. Part 1-6: General actions – Actions during execution.

FOOTNOTE:

The advice of the Building Research Establishment and the UK Wind Engineering Society in the preparation of this Alert is gratefully acknowledged.

[1] This example is indicative only. Designers should determine the appropriate wind pressure for the particular site under consideration, either using the conservative approach suggested, or by more detailed methods of assessment.