Temporary fixing of metal decking

BCSA agreed a programme of work with the Building Research Establishment (BRE) in 2019 to carry out a series of dynamic wind tests on steel decking sheets, followed by a series of wind tunnel tests for both high-rise and portal frame type structures. The aim of this project was (i) to determine the possible loads taken by the individual fixings connecting the decking to the steelwork during the temporary fixed construction stage, and (ii) to propose a simplified methodology based on BS EN 1991-1-4 for the design of such fixings. Recommendations are given at the end of this document for practical construction in the UK.

a) High-rise building model b) Low-rise building model

Fig. 1. View of a test specimen with the decking installed

Programme of experimental testing

Wind uplift testing of metal decking sheets

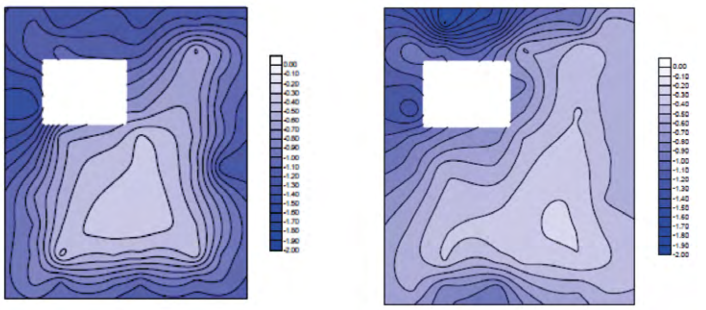
Five dynamic wind uplift tests on steel decking sheets with different fixings configurations and dynamic tests on edge trims were carried out using BRE's BREWULF system (BRE Realtime Wind Uniform Load Follower). The nail fixings used to secure the decking sheets were representative of existing industry practices.

The results showed that a notable number of the fixings failed in decking sheets fitted using temporary gas fired or cartridge fired nails at a wind pressure of about 1.6 kN/m², while decking sheets fitted using permanent fixings achieved a wind pressure in excess of 3.2 kN/m². It was also found that the resistance of the fixings under combined uplift and shear loads could be lower than expected. This focussed attention on the wind pressure coefficients used in the wind uplift calculations. Current best practice is to use the pressure coefficients given in BS EN 1991-1-4 for canopy roof structures. A wind tunnel assessment was then carried out, developing improved application specific pressure coefficients.

Wind tunnel assessment of wind loads on decking of steel-framed buildings

The purpose of this wind tunnel assessment was to carry out 1:150 scaled modelling to measure the net wind pressure coefficients acting on the decking in a range of steel-framed building configurations, see Fig. 1. The results from this wind tunnel study indicated that the codified pressure coefficients (canopy roof model adopted in Eurocode 1, part 1-4) commonly used for steel decking were conservative when compared with the measured pressure coefficients.

Figure 2 shows the worst case measured peak net uplift pressure coefficients, $c_{p,net}$, for the two building configurations. The largest uplifts are associated with the darker areas. The greatest uplift loads occur everywhere around the edges of the buildings. The presence of a core may exacerbate these uplift forces, as can be seen by the concentrations of the contours which are particularly obvious on the low-rise building (1st floor level, see Fig. 2b), but can also be seen on the high-rise building plots, as evidenced by the lighter regions, see Fig. 2a. Away from the core in the centre of the floorplates are large regions of relatively small $c_{p,net}$. The concentrations of the contours shown in Fig. 2 give an indication as to where zoning of the $c_{p,net}$ values might be appropriate for codification purposes.



a) High-rise building model floor level 14 b) Low-rise building model floor level 1

Fig. 2. Worst-case peak net uplift pressure coefficients

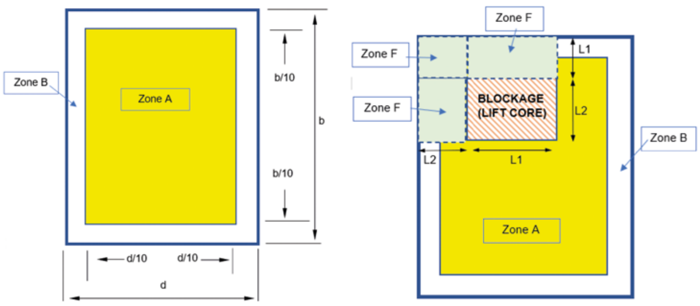
Simplified methodology for wind loads on steel decking

Based on the findings of the research, the BRE developed a simplified methodology for determining the peak velocity pressure and the wind pressures on steel decking in unclad steel-framed structures. The methodology is based on BS EN 1991-1-4 and the UK National Annex, and includes the measured pressure coefficients for low-rise and high-rise buildings of 15, 10 and five storeys tall, see Table 1. Figure 3 defines the pressure coefficient zones: Zone A (central zone), Zone B (edge zone) and Zone F for the highly loaded region around the core or other area of significant blockage. The extent of Zone F is considered to depend on the plan dimensions of the blockage. From analysis of the wind tunnel data it is taken that Zone F should extend around the blockage for a distance equal to the plan dimensions of the blockage.

By using the measured pressure coefficients, the wind uplift pressures are reduced and consequently this leads to a reduction in the number or strength of the temporary fixings. However, application of this design model shows that current 'standard' fixing arrangements are generally suitable for the Midlands and South-Central regions only, with most projects outside of these areas requiring heavy-duty/permanent fasteners to discrete zones of the floorplate.

Zone	Low-rise (1 storey)	High-rise (5 storeys)	High-rise (10 storeys)	High-rise (15 storeys)
A (central)	-0.25	-0.25	-0.25	-0.25
B (edge)	-0.90	-0.70	-0.85	-0.85
F (blockage)	-1.45	-1.00	-1.15	-1.25

Table 1. Net pressure coefficients to be used in the design of the temporary fixings of steel sheets in high-rise unclad steel frame buildings



a) Case with no significant blockage

b) Case with blockage near to the edge zone B

Fig. 3. Loading zones for the case without significant blockage and with blockage based on the specific measurements from the wind tunnel study

The extent and magnitude of Zone F shown in Fig. 3 is based on the position of the core in the wind tunnel study. In practice the core could be in different locations on the floorplate. The characteristic lengths $L1$ and $L2$ of Zone F are equal to the dimensions of the area of blockage. These lengths are independent of the approaching wind direction and apply to the windward faces around the blockage.

From discussions with BCSA and using engineering judgement based on the wind tunnel study results, the BRE suggested that where the core or other blockage is away from the edge zone areas then there will not be a Zone F, i.e. Zone F will only occur where the increased suction area around the core interacts with the increased suction in the edge zones. Figure 4 shows the suggested generic engineering rule for accounting for the increased suction around cores or other areas of significant blockage. It is expected that this rule will apply to any rectangular plan shape building. The width of edge Zone B in Fig. 4 is as defined in Table 7.6 of BS EN 1991-1-4 and is b/10, where b is the cross-wind breadth of the building. The extent of Zone B around the core is equal to the dimensions of the core as shown in Fig. 4. The width of Zone F shown in Case B of Fig. 3 is variable and will depend on the position of the core with respect to the edge Zone B. The maximum extent of Zone F will be $L1$ + d/10.

Interim recommendations for temporary fixings of metal decking

Further developments will be completed to provide a more comprehensive solution for the design and/or specification of temporary fixings for metal decking. However, the following guidance is considered sufficiently conservative to ensure most temporary decking installations are completed safely. A more detailed approach may be completed using the BRE Simplified Approach, see report P117212-1002 (issue 3).

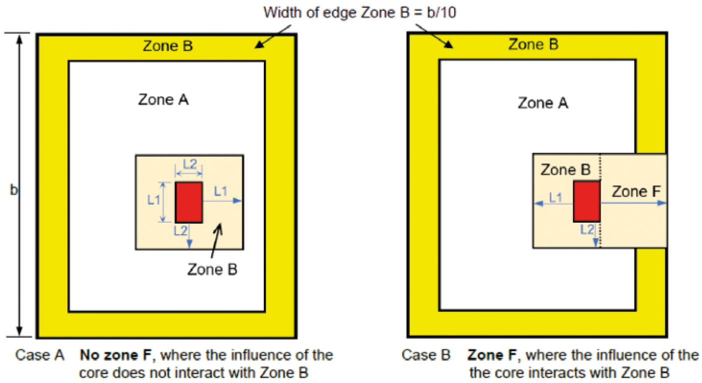


Fig. 4. Suggested generic rule for determining the extent of the increased suction around an area of significant blockage (the red rectangle)

The following simplified guidance are given for designs in Wind Zones 1, 2, and 3, see Fig. 5, according to BS EN 1991-1-4 and the UK National Annex:

- Zones to be identified in accordance with Section 3 of this document.
- Wind Zone A: X-U15 or similar, existing fixing centres (300/333 mm and 600/666 mm), corresponding to 1.07 fixings/m², usual practice.
- Wind Zone B:
  - Pairs of X-U15 fasteners or similar arranged as per current practice, i.e. 2 no. per 300/333 mm at end supports, 1 no. per 300/333 mm at intermediate supports, or
  - Single X-ENP-19 fasteners at 600/666 mm centres.
- Wind Zone F:
  - Single X-ENP-19 fasteners arranged as per current practice.
  - Else, requires project specific review.

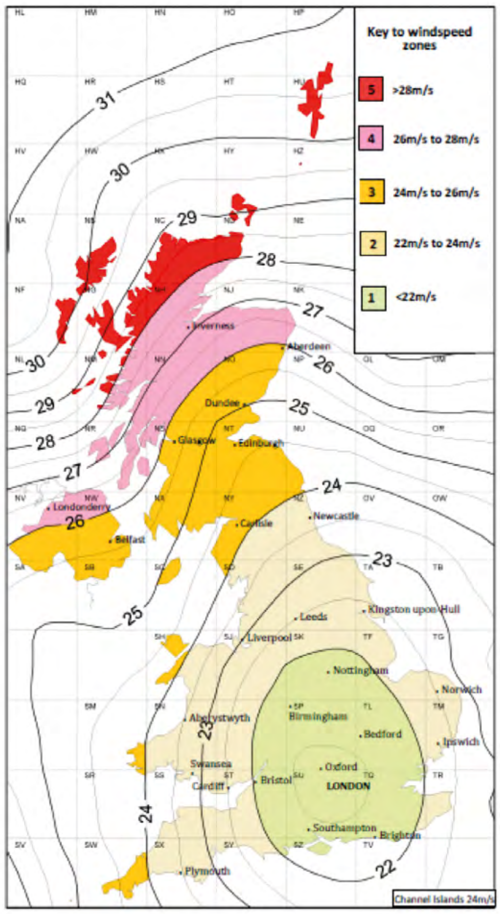


Fig. 5. Simplified zonal map of fundamental basic wind velocity (map drawn by BRE)