WIND PRESSURE LOAD ON AN INDUSTRIAL BUILDING

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Summary

Deflector shield panels in front of the top-lit-louver were designed for the roof of a low-rise industrial building to improve natural ventilation. Both wind pressure loads acting on the deflector shields for structural calculations, and pressure data in the vicinity of the window rows for ventilation calculations were needed.

A wind tunnel test, modelling suburbian surroundings by turbulent boundary layer flow and simulating several wind directions and building group configurations, was carried out on models of the buildings scaled at 1:200. Mean, RMS and peak pressure coefficients were determined and presented for the structural and ventilation design.

1. Introduction

The operations of natural ventilation systems are exposed to wind effects. In industrial buildings, where the inside technological heat sources are significant, the use of natural ventilation has proved to be economical and effective.

The natural ventilation network of a typical low-rise industrial building comprises the following sections:

(i) fresh air inlet, through the windows on the side-wall façades;

(ii) inside space, through which the fresh air flows and picks up effluents and excess heat;

(iii) contaminated air outlet, in most cases through the windows of the top-lit-louver.

The governing pressure difference of the natural ventilation derives from two effects:

(i) stack effect caused by temperature differences;

(ii) wind effects acting on the side walls in the vicinity of the inlets and outlets.

In order to guarantee the maximum wind pressure difference between the inlet and outlet areas, deflector shield panels in front of the top-lit-louver were proposed and designed. The perpendicular flat plate positioned before the window row, in case of wind, presumably causes high suction in the shaft between the panel and the side wall of the top-lit-louver.

Structural and ventilation engineers needed information on wind pres-

0167-6105/86/$03.50

sure loads acting on the deflector panels and pressure data in the vicinity of the ground floor and the top window rows. Since the proposed type of industrial buildings can be built together, simulations of several building configurations were also needed (single, two and three buildings built together).

2. Experimental method

2.1. Wind data

The presumed site, the surroundings of the buildings was suburbian. The wind speed to be taken into account was the design wind speed (1-min gust) determined from the Hungarian Code of Practice for Meteorological Loads [1].

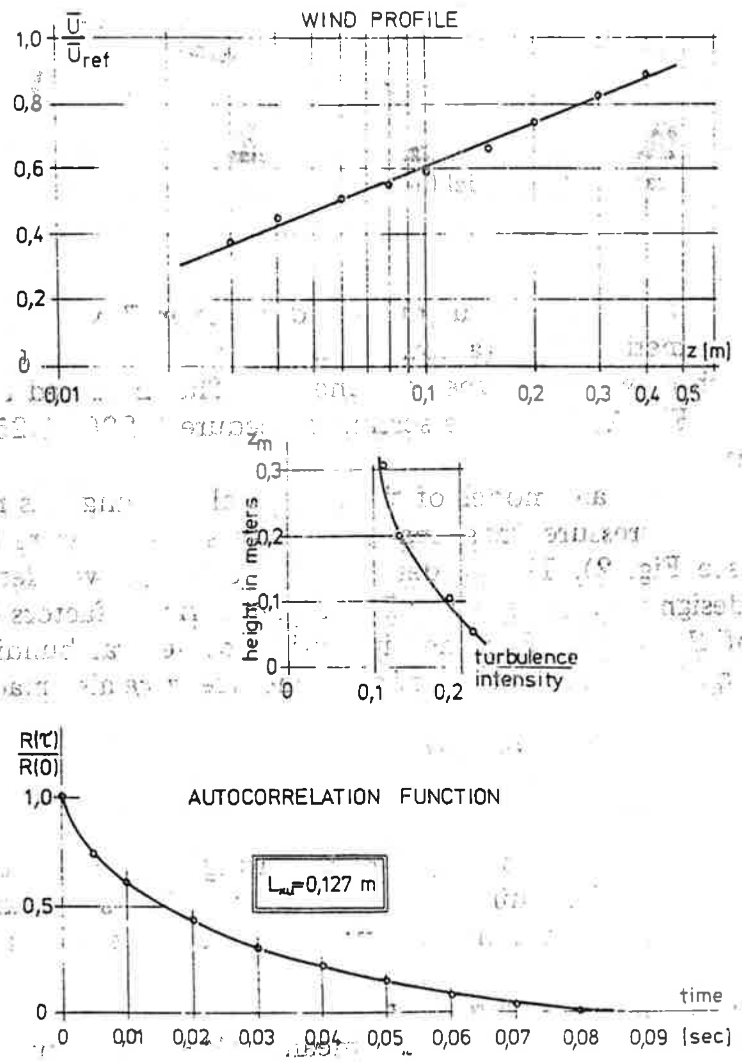


Fig. 1. Characteristics of the model boundary layer.

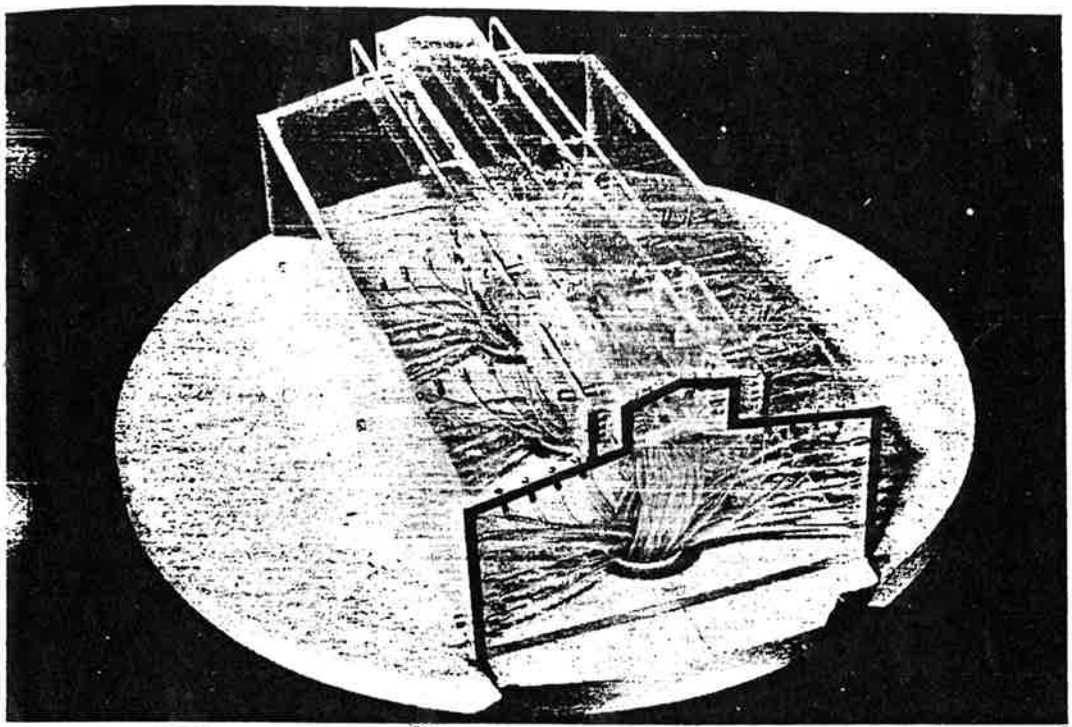


Fig. 2. Photograph of the model building.

2.2. Model data

The model wind (turbulent boundary layer flow) was generated by the Counihan method [2] (a row of elliptic vortex generators, a barrier and a 6 m fetch of wooden cube roughnesses). The measured flow properties are shown in Fig. 1. From the scaling procedure 1:200—1:250 geometric scale was derived.

The 1:200 scale model of the industrial building was made of plexiglass plates. The pressure taps, made in three sections, were 0.5 mm diameter holes (see Fig. 2). The model velocity to be set was determined from the actual design wind speed using ESDU transforming factors [3] and a velocity scale of S_u = 1/3. For the simulation of several building configurations two wooden dummy models of the same size were also made.

2.3. Experimental equipment

Wind tunnel

The dimensions of the new recirculating type wind tunnel of the Hungarian Institute for Building Science are as follows: working section width, 2.2 m; height, 1.4 m; length, 9 m; maximum air velocity available, 20 m s^{-1}.

Boundary layer measurement

The velocity measurements (mean, RMS, peak, autocorrelation) were made with a DISA 55M hot-wire system and a LYREC tape recorder for time delay.

Pressure measurement

The method of dynamic pressure measurement (restrictor method) was the same as described in refs. 4 and 5. Equipment: Scanivalve pressure scanner assembled together with Setra-237 transducer. Data evaluation was made with a MODI-82 microcomputer.

3. Results

There were 12 measured variations (setup): 3 wind directions (perpendicular to the side wall, parallel with, and inclined 45°) and 4 configurations (single building; measured and behind a dummy building; before a dummy; and measured between two dummy buildings).

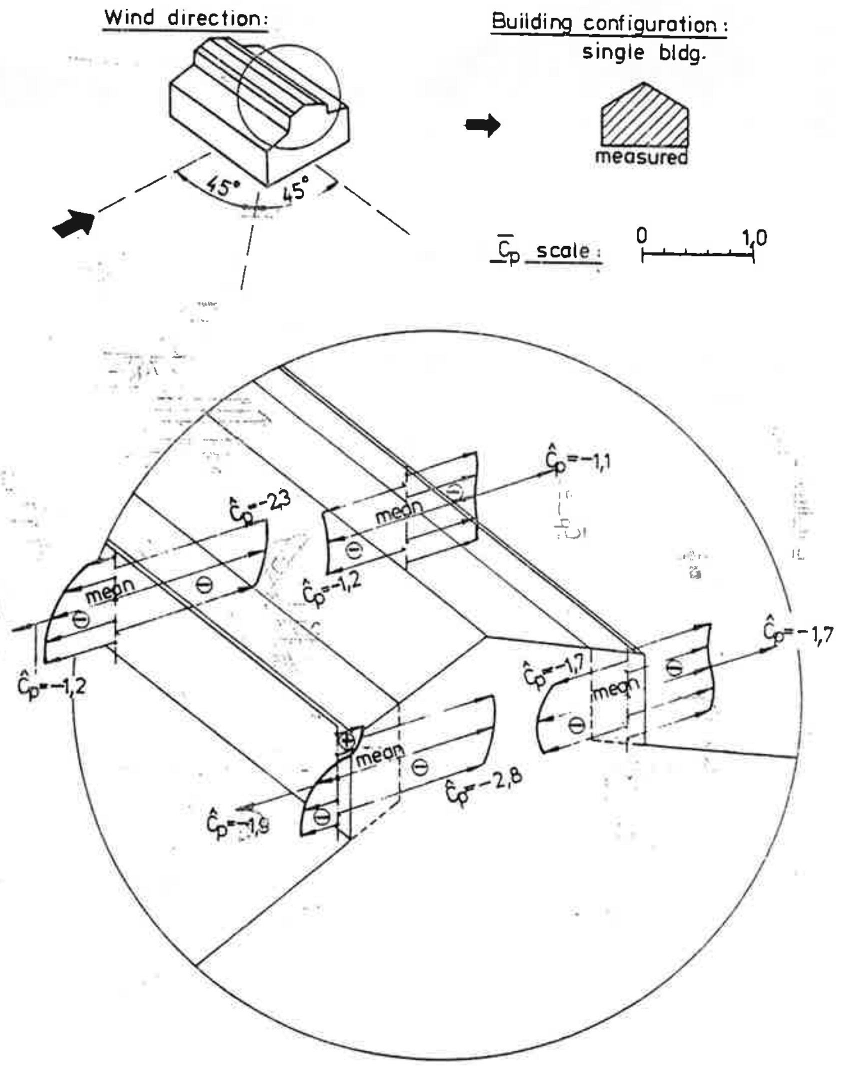


Fig. 3. Wind pressure coefficients on the deflector shield panels.

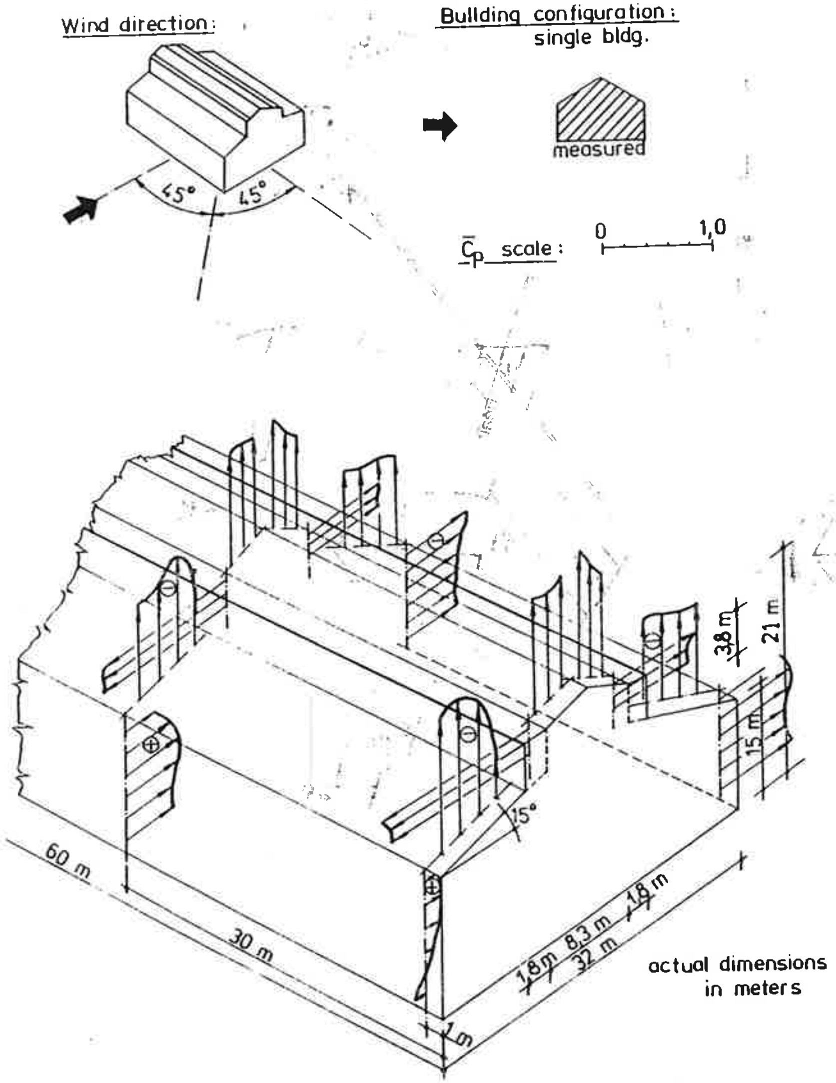


Fig. 4. Wind pressure coefficients on the building façades.

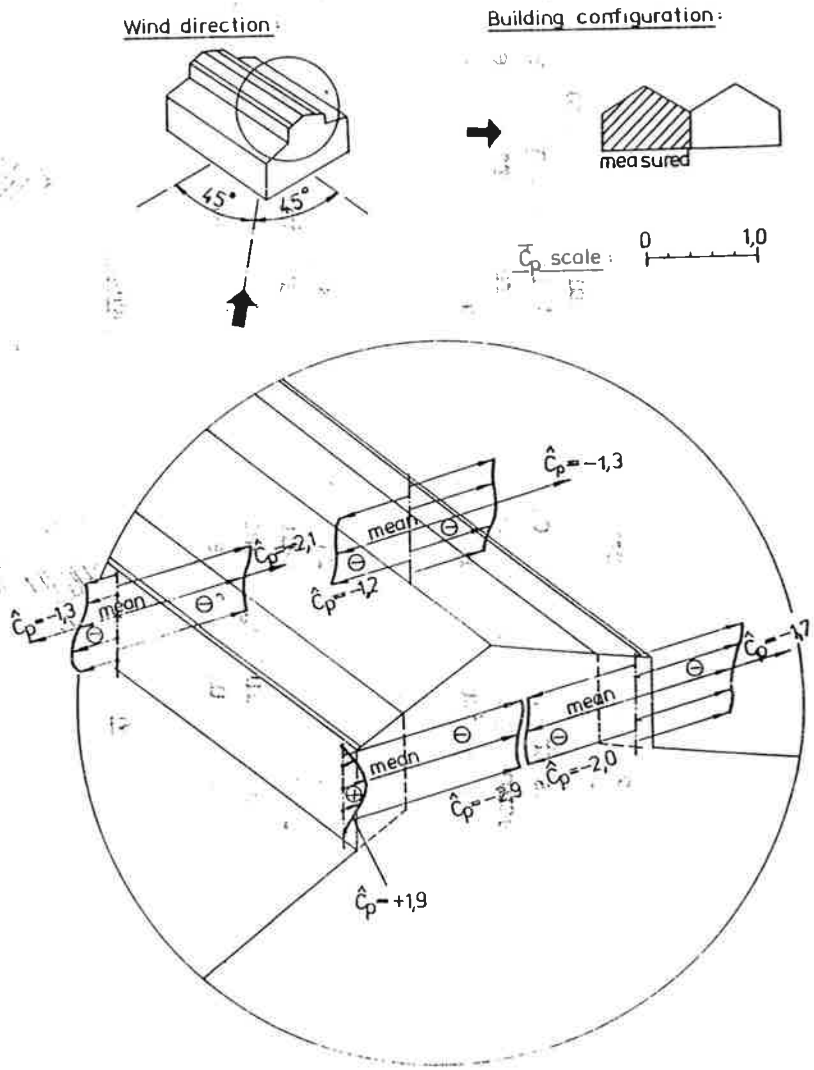


Fig. 5. Wind pressure coefficients on the deflector shield panels.

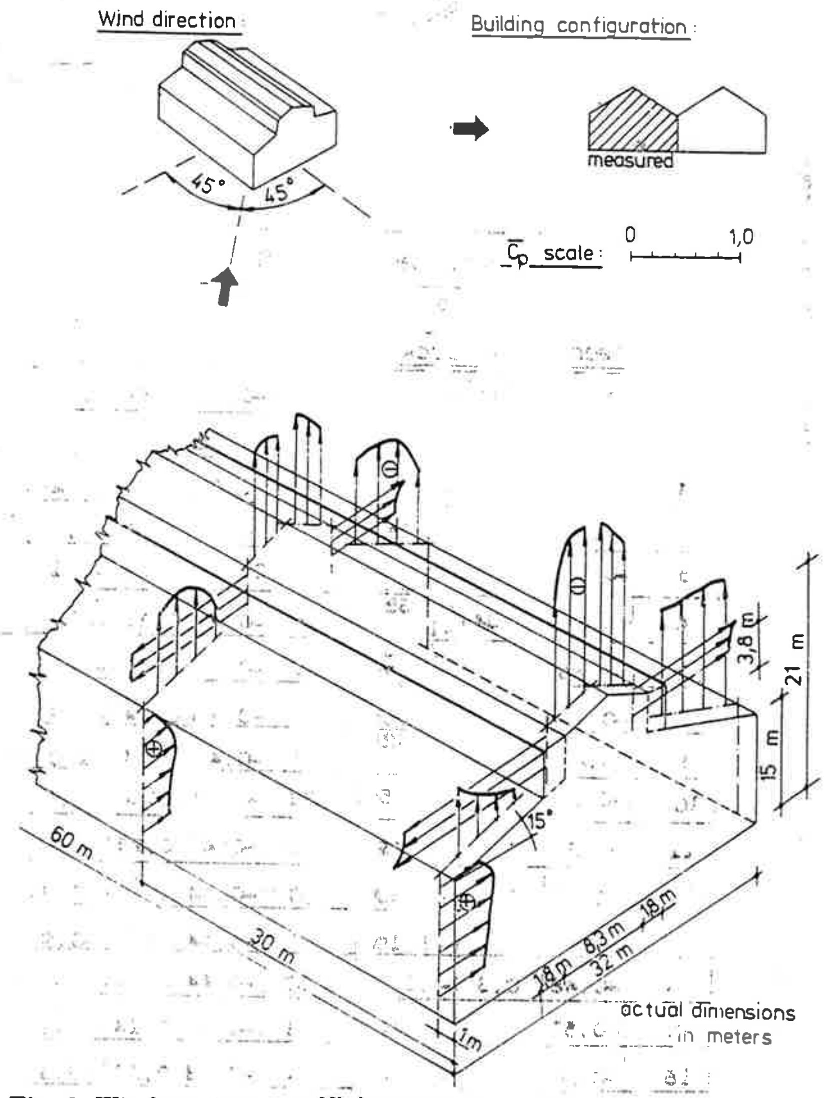


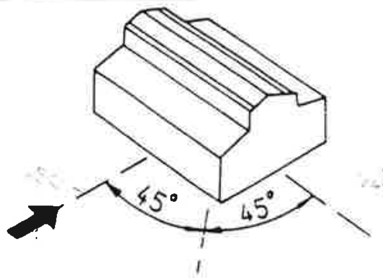
Fig. 6. Wind pressure coefficients on the building façades.

The pressure coefficients were calculated from the measured pressures (mean, RMS, peak) related to the dynamic head ($\rho/2\overline{U}^2$) at the height of the middle axis of the deflector shield panel. Figures 3—7 show examples from the results.

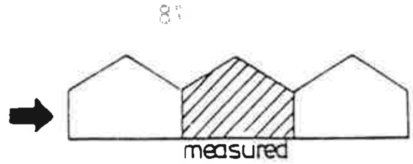
The C_p values (mean, RMS, peak) on the two sides of the panels could be used for dynamic structural calculations, and the $\overline{C}_p$ values (mean) on the side walls (windows) of the building and on the window rows of the top-lit-louver could be used for the calculations of natural ventilation.

References

Wind direction:



Building configuration:



Measured section: middle							
meas. points	$\bar{C}_p$ mean	C_p rms	$\hat{C}_p$ peak	meas. points	$\bar{C}_p$ mean	C_p rms	$\hat{C}_p$ peak
1	−0,64	0,32	−1,42	19	−0,76	0,37	−1,65
2	−0,64	0,33	−1,37	20	−0,62	0,3	−1,47
3	−0,54	0,32	−1,38	21	−0,57	0,26	−1,24
4	−0,32	0,31	−1,15	22	−0,46	0,25	−1,1
5	−0,46	0,37	+0,55 −1,19	23	−0,46	0,25	−1,1
6	−0,48	0,34	+0,55 −1,2	24	−0,45	0,24	−1,1
7	−0,48	0,34	+0,46 −1,37	25	−0,45	0,26	−1,0
8	−0,46	0,39	+0,5 −1,28	26	−0,46	0,24	−0,95
9	−0,46	0,41	+0,92 −1,3	27	−0,46	0,25	−1,0
10	−0,55	0,3	−1,35	28	−0,45	0,24	−1,0
11	−0,5	0,28	−1,19	29	−0,44	0,26	−1,0
12	−0,46	0,3	−1,19	30	−0,44	0,26	−0,92
13	−0,48	0,3	−1,19	31	−0,44	0,26	−0,92
14	−0,48	0,3	−1,1	32	−0,44	0,24	−0,9
15	−0,53	0,31	−1,25	33	−0,46	0,24	−0,9
16	−0,52	0,31	−1,32	34	−0,48	0,25	−0,9
17	−0,52	0,32	−1,35	35	−0,48	0,27	−1,0
18	−0,59	0,31	−1,19	36	−0,52	0,3	−1,1

Distribution of the measured points:

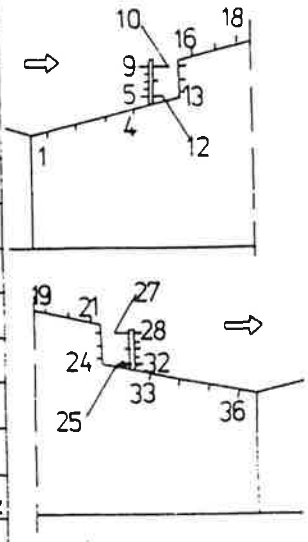


Fig. 7. Tabulated wind pressure coefficients.

2 J. Counihan, An improved method of simulating of the boundary layer in a wind tunnel, Atmos. Environ., 3 (1969)197—214.
3 ESDU, Engineering Sciences Data Unit, 1979, Item No. 72026.
4 H.P. Irvin, K.R. Cooper and R. Girard, Correction of distortion effects caused by tubing systems in measurements of fluctuating pressures, National Research Council of Canada, Rep.
5 D. Surry and T. Stathopoulos, An experimental approach to the economical measurement of spatially averaged wind loads, J. Ind. Aerodyn., 2 (1977) 78.