GUST FACTORS FOR EXTERNAL AND INTERNAL PRESSURES ON LOW-RISE BUILDINGS

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Notation

b	= panel width
C_H, C_V, C_M	= load effect coefficients of H, V and M
d	= building depth
h	= eaves height
H,V,M	= total horizontal, vertical and overturning load effect
p_i	= internal pressure
p_1-p_{16}	= magnitude of equivalent pressure blocks on load sensing panels
q	= free-stream dynamic pressure
R_G	= gust factor ratio
u,v,w	= components of wind velocity
σ	= standard deviation

Superscript Notation

$\bar{X}$	= mean value of X
$\hat{X}$	= peak value of X

Introduction

The details of studies of wind effects on third scale model houses have been reported elsewhere (1,2). In this paper, the interaction of peaks of wind loads and peaks of horizontal, vertical and overturning movement forces on the model houses is discussed.

Experimental Data

The characteristics of the wind used in this paper is shown in Table 1. The mean free stream dynamic pressure was 48 Pa, while the peak value was 173 Pa.

The dimensions of the test house are shown in Figure 1, while Figure 2 shows the mean values of the pressure coefficients around the building. Also shown in Figure 2 is the pressure coefficients calculated by using AS 1170 Part 2-1983. The peak values of the pressure coefficients are shown in Table 2.

The total wind loads acting on a model house, denoted by H, V and M, are shown in Figure 1(b). Reference (2) shows that at each instant the influence of the 16 pressures shown can be integrated to produce the required total load effect and from these normalized load effect coefficient, C_H, C_V and C_M, can be calculated.

However, the interaction between internal and external pressures plays an important role in determining peak load effects. Again, reference (2) shows how cases for six different internal pressures can be obtained by assuming openings at various parts of the structure. The characteristics of the internal pressure coefficients, C_{pi}, for the six cases are shown in Table 3.

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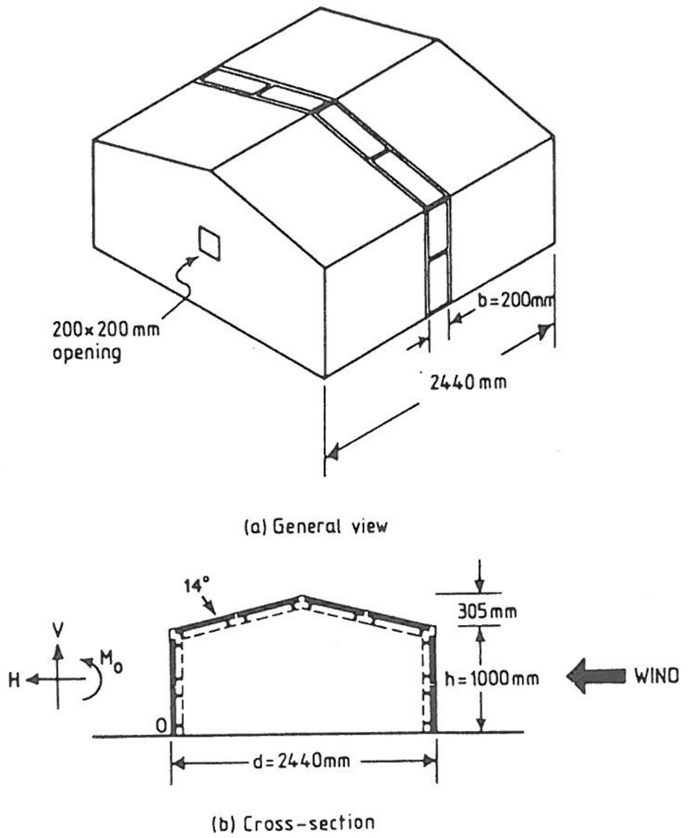

Figure 1 Details of a typical instrumented model house.

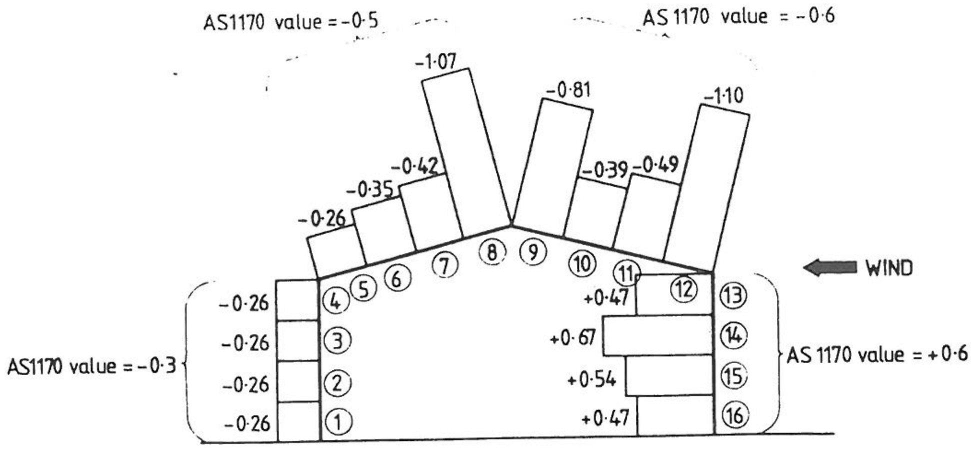

Figure 2 Mean pressure coefficients

TABLE 1
CHARACTERISTICS OF THE REFERENCE WIND

Parameter	Value
θ (^{o})	21.0
$\bar{u}$ (ms^{-1})	8.7
$\hat{u}$ (ms^{-1})	17.0
$\sigma_u/\bar{u}$	0.21
$\sigma_v/\bar{u}$	0.18
$\sigma_w/\bar{u}$	0.06
$\bar{q}$ (Pa)	48.0
$\hat{q}$ (Pa)	173.0
$\sigma_q/\bar{q}$	0.45

TABLE 2
CHARACTERISTICS OF EXTERNAL PRESSURES

Panel pressure (Fig.3)	C_p		
	Mean	Peak*	σ
p_1	-0.26	-0.97	0.13
p_2	-0.26	-1.13	0.14
p_3	-0.26	-1.08	0.13
p_4	-0.26	-0.91	0.13
p_5	-0.26	-0.84	0.12
p_6	-0.35	-0.98	0.14
p_7	-0.42	-1.24	0.17
p_8	-1.07	-3.06	0.42
p_9	-0.81	-2.29	0.29
p_{10}	-0.39	-1.28	0.14
p_{11}	-0.49	-2.05	0.22
p_{12}	-1.10	-4.14	0.42
p_{13}	0.47	2.75	0.28
p_{14}	0.67	3.30	0.36
p_{15}	0.54	2.86	0.30
p_{16}	0.47	2.65	0.28

*For peak values in the same direction as the mean

TABLE 3
CHARACTERISTICS OF INTERNAL PRESSURES

Opening type	C_{pi}		
	mean	peak*	σ
None	0.00	0.00	0.00
Windward	0.54	2.86	0.30
Side wall	-0.12	-1.72	0.17
Leeward	-0.26	-1.13	0.14
Ridge	-0.94	-2.62	0.35
Through	0.14	1.29	0.16

*For peak values in the same direction as the mean

Gust Factor Ratio

In typical wind tunnel measurements, point pressure measurements are usually not made simultaneously at all locations. Hence peak load effects cannot be evaluated through direct integration. One indirect method used is to compute the mean load effect from these measurements and then to apply a suitable gust factor to obtain a peak. Often the estimate of a load gust factor is related to a wind gust factor obtained from a filtered measurement of the free-stream dynamic pressure. This wind gust factor, denoted by G_{qo} is defined by

$$G_{qo} = \hat{q}_o/\bar{q}$$

where $\hat{q}_o$ is usually taken as the peak 1-5 second free-stream dynamic pressure, and $\bar{q}$ the mean free-stream dynamic pressure. For the experimental example considered, $\hat{q}_o$ may be approximated by the peak measured in the wind data shown in Table 1. Thus the gust factor of the free-stream dynamic pressure is G_{qo} = 173/48 = 3.6.

This gust factor may then be used to define a gust factor ratio R_G for the load effects H, V and M as follows:

$$R_G(H) = (\hat{H}/\bar{H})/G_{qo}$$

$$R_G(V) = (\hat{V}/\bar{V})/G_{qo}$$

$$R_G(M) = (\hat{M}/\bar{M})/G_{qo}$$

where $\hat{H}$, $\hat{V}$ and $\hat{M}$ denote peak values for the data, and $\bar{H}$, $\bar{V}$ and $\bar{M}$ are mean values.

The measured gust factor ratios for H, V and M are given in Tables 4, 5 and 6.

Discussion

It can be seen from Tables 4, 5 and 6 that where the effect of internal pressure is considered, the gust ratio factor is close to 1, which suggests that in this case the gust factor method is reasonably valid. However, where internal pressure effects are eliminated, the gust ratio factor drops to around 0.8 which is probably due to the non-coincidence of peaks at different localities on the structure.

References

1. Leicester, R.H., and Hawkins, B.T., 'Measurement of Wind Loads with One-Third Scale Model Structures', Proceedings of Diamond Jubilee Conference, Institution of Engineers, Australia, Perth, May 1979.

2. Leicester, R.H., and Hawkins, B.T., 'Large Models of Low Rise Buildings Loaded by the Natural Wind', Proceedings of Sixth International Wind Engineering Conference, Surfers Paradise, Australia, March 1983.

TABLE 4
CHARACTERISTICS OF HORIZONTAL FORCE H

Opening type	C_H			$R_G(H)$
	mean	Maximum possible	σ	
All	0.74	3.01	0.34	1.12

TABLE 5
CHARACTERISTICS OF VERTICAL FORCE V

Opening type	C_V			$R_G(V)$
	Mean	Maximum possible	σ	
None	0.61	1.70	0.22	0.77
Windward	1.14	4.26	0.48	1.02
Side wall	0.49	1.89	0.23	1.05
Leeward	0.35	1.34	0.17	1.07
Ridge	-0.33	*	0.15	-
Through	0.75	2.66	0.32	0.99

* No positive uplift

TABLE 6
CHARACTERISTICS OF OVERTURNING MOMENT M

Opening type	C_M			$R_G(M)$
	Mean	Maximum possible	σ	
None	0.71	2.14	0.26	0.83
Windward	1.16	4.32	0.49	1.02
Side wall	0.61	2.22	0.25	1.01
Leeward	0.48	1.82	0.22	1.05
Ridge	-0.10	0.39	0.09	-
Through	0.82	2.93	0.35	0.99