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STATISTICAL TREATMENT OF PEAK GUSTS
ON CLADDING

by

W. A. Dalgliesh

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ANALYSE STATISTIQUE DES PRESSIONS DYNAMIQUES DE POINTE SUR LES PANNEAUX DE REVETEMENT

SOMMAIRE

Les méthodes statistiques de prédiction des effets dynamiques du vent sur la structure des immeubles de grande hauteur sont de plus en plus reconnues. Il est possible d'utiliser des méthodes semblables pour les surcharges de vent sur les panneaux de revêtement à condition de tenir compte de certaines différences telles que le degré d'exposition, les dimensions et les caractéristiques dynamiques des éléments en cause. Les pressions et les suctions du vent enregistrées à plusieurs endroits sur un immeuble de grande hauteur durant une période de grands vents sont utilisées pour prédire les efforts dynamiques de pointe sur les fenêtres et les panneaux de revêtement. L'article examine la méthode de prédire les effets dynamiques de pointe fondée sur le processus aléatoire. Les pressions dynamiques de pointe telles que mesurées sont comparées aux valeurs calculées par la méthode usuelle du coefficient de majoration pour la pointe de rafale et à celles obtenues par une méthode plus détaillée des effets de la vitesse de pointe instantanée. Il apparaît que cette dernière méthode doit être préférée, parce qu'elle est plus conforme au phénomène de pression dynamique de pointe. Cependant, il faudra une expérimentation plus poussée et des relevés additionnels avant d'en arriver à établir de façon complètement satisfaisante les valeurs admissibles aux calculs.

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STATISTICAL TREATMENT OF PEAK GUSTS ON CLADDING^a

By W. Alan Dalglish,¹ A. M. ASCE

INTRODUCTION

From a practical point of view, the best measure of wind depends on meteorological records, often mean wind speed averaged over a few minutes or an hour. For cladding design, however, the mean speed is not adequate. Instead, gust effects must be determined, i.e., the maximum pressure or suction that can reasonably be expected to occur during the expected lifetime of the cladding.

Translation from mean wind speed to mean pressure is a relatively straightforward procedure involving mean pressure coefficients derived from model tests in a wind tunnel. A more difficult problem arises in the determination of wind turbulence effects. Anemometer records show random fluctuations about the mean speed and, similarly, records of pressure measured on cladding indicate a continual random variation. One solution to this problem is to relate the mean wind speed to the maximum gust registered within a given time by a fast-response anemometer. This relation, a wind gust factor, is used to convert the mean speed to a gust speed for use in design (6,7).

The latter solution is inadequate for structural design of tall, slender buildings. The response of such structures to wind turbulence is so unlike the response of anemometers that gust factors derived from them are completely unsuitable for predicting design loads. Thanks to nearly 10 yr of research, wind gust effects on the structural frame of tall buildings can now be estimated by means of gust loading factor methods (4,8,9). The gust loading factor is based on the statistical characteristics of wind turbulence, the mean wind speed profile, and the size and dynamic properties of the structure.

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In principle, one would not expect the simple wind gust factor approach to be entirely suitable for cladding design, although so far there has not been the same clear indication of inadequacy in practical situations. Most wind damage affects roofing or cladding and, although it is usually difficult to fix the responsibility for damage on the design pressures used, improved understanding of cladding loads and better methods of design are obviously worth pursuing.

Despite the research already done, information on measured gust pressures on cladding is relatively hard to find. The purpose of this paper is two-fold, therefore: (1) To present a summary of statistical information derived from actual pressure measurements on a tall building; and (2) to analyze the implications of this information with regard to a gust effect factor suitable for cladding design.

FIELD MEASUREMENTS

The Division of Building Research of the National Research Council of Canada started a program of wind pressure measurements on tall buildings in 1962 to check available information used in wind load design. One of the main applications for the full-scale data was the checking of the validity of wind tunnel testing techniques (2); full-scale measurements are now examined directly to provide insight into the nature of gust action over localized areas of one tall building.

A 45-story office tower in Montreal (Fig. 1) was instrumented in September, 1968 with six pressure transducers on each of two mechanical equipment floors. Each transducer measures the difference in air pressure between a measuring and a reference port by means of a steel diaphragm, the deflection of which causes a proportional voltage in a strain gage bridge circuit. The measuring ports were connected by short plastic tubes to the outside air through 1/8-in. holes in the spandrel panels; and all 12 reference ports were connected by long plastic tubes to a common central location on the 40th floor.

A plan view of the locations of the 1/8-in. holes, the same for both levels, is given in Fig. 2. Locations on the upper mechanical floor (545 ft above the street) are designated as shown in Fig. 2 with a one prefixed to indicate the level (e.g., 1W1 and 1W2) and those on the lower mechanical floor (195 ft above the street) are designated as belonging to level 2.

The signals from each of the 12 transducers were transmitted to a digital data acquisition system located on the upper mechanical floor. Wind direction and speed signals were transmitted from a wind vane and anemometer on an existing mast on the roof. Fourteen channels of information were scanned every 1/2 sec and recorded digitally on computer-compatible magnetic tape.

Half-hour records were initiated automatically when the wind speed reached a preset limit, and after 10 months of operation more than 30 hr of records with mean speeds (at the 800-ft level) ranging from 30 fps to 80 fps were collected. The present study is based on 20 or so hours, representing winds from the five wind directions shown in Fig. 2. Typical recorded time histories are shown in Fig. 3 for three locations on the upper level, 1W3 (windward), 1N2 (sidewall, glancing wind) and 1E1 (leeward).

Definition of Terms.—Pressures are summarized in terms of mean and rms (rms about the mean value) pressure coefficients. Peak pressures are

plotted as histograms, or observed probability distributions, of a reduced random variable to be defined in this section. Unless otherwise noted, all pressure coefficients are based on the mean dynamic pressure of the wind

FIG. 1.—SOUTH-EAST ELEVATION OF 45-STORY OFFICE BUILDING, MONTREAL, INSTRUMENTED AT 195 FT AND 545 FT FOR WIND PRESSURE MEASUREMENTS

measured at the 800-ft level as follows:

$$C_{--} = \frac{p}{\frac{1}{2} \rho V^2} \dots \dots \dots (1)$$

in which p = wind pressure, in pounds per square foot; ρ = density of air, in slugs per cubic foot; and V = mean wind speed at 800 ft, averaged over 3-1/3 min, 10 min, or 30 min as indicated, in feet per second.

The mean pressure coefficient, C_{mean} , represents the net pressure difference across the exterior wall and is related to the external and internal pres-

sure coefficients as follows:

$$C_{\text{mean}} = C_{\text{ext}} - C_{\text{int}} \dots \dots \dots (2)$$

The rms pressure coefficient, C_{rms} , refers to the rms value of either a 10-min or a 30-min record. Maximum peaks of speed, pressure, or suction are considered to be random variables that can be conveniently expressed in

FIG. 2.—PLAN LAYOUT OF CLADDING POSITIONS FOR WIND PRESSURE MEASUREMENTS SHOWING DIRECTIONS OF RECORDED HIGH WINDS

FIG. 3.—TYPICAL WIND PRESSURES ON CLADDING

terms of the number of standard deviations by which they exceed the mean value as follows:

$$x = \frac{\text{maximum peak} - \text{mean}}{\text{rms value}} \dots \dots \dots (3)$$

In the reduced form given in Eq. 3 the maximum peaks observed from all the records are plotted as probability distributions and compared with the

TABLE 1.—MEAN PRESSURE COEFFICIENTS, C_{mean} AND CORRELATION INDICES

Cladding position	Wind direction β , in degrees									
	25		30		35		40		45	
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1E1	-0.12	(0.40) ^a	-0.26	(0.85)	-0.19	(0.64)	-0.19	(0.58)	-0.14	(0.66)
1N2	0.19	(0.45)	0.14	(0.66)	0.28	(0.72)	0.29	(0.78)	0.38	(0.76)
1W1	0.38	(0.67)	0.40	(0.92)	0.36	(0.53)	0.29	(0.61)	0.12	(0.24)
1W2	0.43	(0.67)	0.37	(0.86)	0.34	(0.64)	0.30	(0.81)	0.22	(0.58)
1W3	0.36	(0.66)	0.26	(0.76)	0.22	(0.52)	0.18	(0.74)	0.14	(0.32)
1W4	0.34	(0.64)	0.23	(0.66)	0.18	(0.50)	0.16	(0.67)	0.11	(0.24)
2E1	-0.21	(0.86)	-0.25	(0.85)	-0.32	(0.61)	-0.28	(0.41)	-0.28	(0.71)
2N2	0.13	(0.64)	0.16	(0.49)	0.10	(0.3)	0.18	(0.3)	— ^b	
2W1	0.14	(0.69)	0.18	(0.67)	0.16	(0.2)	—		—	
2W2	0.16	(0.71)	0.19	(0.67)	0.17	(0.2)	0.10	(0.2)	—	
2W3	0.15	(0.55)	0.16	(0.66)	0.15	(0.2)	0.08	(0.2)	—	
2W4	0.10	(0.11)	0.10	(0.35)	— ^b		—		—	

^a Correlation index shown in parentheses.^b No value available—correlation index less than 0.2.TABLE 2.—RMS PRESSURE COEFFICIENTS, C_{rms}

Cladding position	10-MIN RECORDS				30-MIN RECORDS			
	Wind Direction β , in degrees							
	30		40		30		40	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1E1	0.05	(0.62) ^a	0.03	(0.36)	0.05	(0.60)	0.05	(0.53)
1N2	0.07	(0.69)	0.07	(0.42)	0.07	(0.65)	0.10	(0.65)
1W1	0.14	(0.65)	0.16	(0.53)	0.14	(0.62)	0.19	(0.72)
1W2	0.13	(0.63)	0.07	(0.33)	0.13	(0.63)	0.12	(0.51)
1W3	0.11	(0.65)	0.08	(0.65)	0.11	(0.68)	0.10	(0.54)
1W4	0.09	(0.67)	0.07	(0.73)	0.10	(0.71)	0.09	(0.58)
2E1	0.13	(0.58)	0.16	(0.63)	0.13	(0.57)	0.19	(0.88)
2N2	0.07	(0.76)	0.06	(0.68)	0.07	(0.77)	0.07	(0.82)
2W1	0.13	(0.74)	0.12	(0.55)	0.13	(0.75)	0.15	(0.80)
2W2	0.13	(0.76)	0.08	(0.56)	0.12	(0.77)	0.11	(0.72)
2W3	0.12	(0.77)	0.07	(0.66)	0.11	(0.78)	0.09	(0.62)
2W4	0.10	(0.81)	0.06	(0.62)	0.09	(0.87)	0.07	(0.53)

^a Correlation index.

TABLE 3.—FLUCTUATION RATES AND MODES OF PROBABILITY DISTRIBUTIONS OF PEAK PRESSURES (REDUCED VARIATE, EQ. 3)

Cladding position (1)	Fluctuation Rates per second		Modes	
	ν_c (2)	ν_p (3)	10-min records (4)	30-min records (5)
1E1	0.05	0.19	2.9	3.4
1N2	0.18	0.38	3.6	3.6
1W1	0.13	0.34	3.4	4.1
1W2	0.10	0.30	3.4	3.5
1W3	0.08	0.25	2.9	3.1
1W4	0.07	0.23	2.6	2.9
2E1	0.12	0.29	4.4	5.6
2N2	0.13	0.34	3.8	3.9
2W1	0.12	0.32	3.9	4.4
2W2	0.08	0.26	3.6	4.1
2W3	0.07	0.26	3.4	4.2
2W4	0.10	0.27	3.6	3.6
Wind speed	0.19	0.43	2.6	2.9

FIG. 4.—MAXIMUM PEAK PRESSURES FOR POSITION 1W2, HISTOGRAMS AND THEORETICAL PROBABILITY DENSITY

FIG. 5.—MAXIMUM PEAK PRESSURES FOR POSITION 1E1, HISTOGRAMS, AND THEORETICAL PROBABILITY DENSITY

theoretical distribution defined by Davenport (3) for a stationary, Gaussian process:

$$f(x, \nu, T) = x \nu T \exp \left[-\frac{x^2}{2} - \nu T \exp \left(-\frac{x^2}{2} \right) \right] \dots \dots \dots (4)$$

in which $f(x, \nu, T) dx$ = probability that the value of the maximum peak will lie between x and $x + dx$; ν = average effective fluctuation rate per second; and T = length of the record considered, in seconds.

Finally, for cladding design the peak pressure at a point is required and is represented by the peak pressure coefficient, C_{peak} , as follows:

$$|C_{\text{peak}}| = |C_{\text{mean}}| + g |C_{\text{rms}}| \dots \dots \dots (5)$$

The peak factor, g , can be considered a particular value of x , the reduced variate defined in Eq. 3. More will be said about the selection of g in a later section. The absolute value symbols show that the addition for the peak increases the absolute value of the panel pressure, whether it is positive or negative.

SUMMARY OF EXPERIMENTAL RESULTS

Mean and rms pressure coefficients derived by linear regression of cladding pressures versus the corresponding velocity pressure at 800 ft are pre-

FIG. 6.—MAXIMUM PEAK PRESSURES FOR POSITIONS (a) 1N2 AND (b) 2N2; HISTOGRAMS AND THEORETICAL PROBABILITY DENSITY

FIG. 7.—MAXIMUM PEAK PRESSURES FOR POSITION 2W2; HISTOGRAMS AND THEORETICAL PROBABILITY DENSITY

sented in summary form in Tables 1 and 2. Mean pressure coefficients are given in Table 1 for five wind directions. Each wind direction is the central value for a 5° interval containing from 30 to 60 individual 3-1/3-min averages (200 sec). Each value is accompanied by its correlation index, r^2 , which indicates what fraction of the variance in pressure could be attributed to variance in the reference dynamic pressure at 800 ft.

Rms pressure coefficients based on 10-min or 30-min averaging times are given in Table 2 for two wind directions, $\beta = 30^\circ$ and $\beta = 40^\circ$, in which β is the angle measured to the north of the normal to the west wall.

Fluctuation Rates.—The theoretical expression (assuming a stationary Gaussian random process) for the probability distribution of maximum peaks is shown in Eq. 4 to be determined by the length of the process, in seconds, T , and the average fluctuation rate, ν . For pressure fluctuations on cladding ν is a random variable, i.e., the numerical value of ν differs somewhat from record to record in a random fashion. Nevertheless, the fluctuation rate still provides useful information for the checking and improvement of theoretical

FIG. 8.—WIND RECORD SHOWING OCCASIONAL BURSTS OF INTENSE TURBULENCE ON THE LEEWARD WALL

methods for predicting peak pressures. The theoretical interpretation of ν is that it represents the average number of crossings of the zero (mean) value with positive slope (referred to as plus crossings) per second. For narrow-band random processes the plus crossing rate and the number of peaks per second are essentially the same; but for the wide-band process (one containing energy contributions from a wide range of frequencies) represented by gust pressures on cladding the actual number of peaks was found to be about twice or three times the number of zero crossings. This is indicated by the comparison of the plus crossing rate, ν_c and the peak rate, ν_p . The average values found for each of these rates, along with the modes of the probability distributions of the extreme peaks, are given in Table 3. Because of deviations from strict stationarity of the mean value, the observed plus crossing rate tends to increase with decreasing lengths of record. Shorter records might be selected, for example, to obtain a closer approximation to stationarity. In any case, the peak rate, ν_p , is clearly an upper bound for the effective fluctuation rate ν , no matter what length of record is used.

Distributions of Peak Maxima.—Figs. 4 through 7 are probability distributions from three cladding positions on level 1 and two on level 2. Two curves defined in Eq. 4 are superimposed on the observed distributions, that on the left based on ν_c and that on the right based on ν_p . Figs. 4, 5, and 7 show the same data partitioned into (a) 30-min records and (b) 10-min records. As expected, the distributions are shifted to the right when longer records are chosen, indicating that the expected maximum pressure or suction increases as a function of storm duration.

FIG. 9.—MAXIMUM PEAK WIND SPEED AT 800 FT, HISTOGRAMS AND THEORETICAL PROBABILITY DENSITY

The observed distributions are in good agreement with theory for cladding positions on the upper mechanical floor. On the lower level, however, they tend to be more widely scattered and centered at higher peak values than the theoretical curves, with the greatest discrepancies occurring for position 2E1 (not shown). A possible explanation is suggested by some of the records of measured pressure differences versus time for position 2E1 (see Fig. 8). They appear to consist of periods of low turbulence, alternating with periods of high turbulence during which the high peaks occur. The rms pressure is thus not stationary, as required by the theory. The intermittent bursts of tur-

bulence may be related to random shifts in position of some strong vertically oriented vortex just behind the building.

Fig. 9 shows almost the opposite discrepancy for wind speed; the observed distributions are centered at lower peak values and the scatter appears slightly less than suggested by theory. Preliminary studies seem to verify the assumptions of a stationary Gaussian process and thus have not yet suggested an explanation, but the investigation will be continued.

GUST EFFECT FACTOR FOR CLADDING DESIGN

The 1970 edition of the National Building Code of Canada makes use of a gust effect factor, which can be calculated either by a simple method based on judgement and a wind gust factor, or by a detailed method (5). In the simple method the gust effect factor, C_g , is given as 2.0 for structural design and 2.5 for cladding design. The detailed method is a modification of the gust loading factor method proposed by Davenport (4).

The experimental results summarized in the last section provide an opportunity to assess the two methods by comparing calculated and measured

TABLE 4.—EXPOSURE PARAMETERS FOR COMPUTING DESIGN WIND LOADS ON BUILDINGS

Terrain type (1)	k (2)	α (3)	k_z (4)	Z_z , in feet (5)
Open	0.005	0.14	1.0	30
Medium	0.015	0.25	0.6	60
City	0.05	0.36	0.4	100
Simple method		0.10	1.0	30

pressures for the 12 cladding positions. Application of the gust effect factor to cladding design is demonstrated by

$$\frac{p}{q_{30}} = C_e C_g C_{ext} - C_e C_{int} \dots \dots \dots (6)$$

in which p = equivalent static design pressure for cladding; q_{30} = reference design pressure appropriate for 30-ft height in open terrain, supplied as climate design data (1); C_e , $C_{e_{1/2}}$ = exposure factors; and C_{ext} , C_{int} are as in Eq. 2.

Exposure Factor.—Both the simple method and the detailed method require an exposure factor for converting from the reference design pressure at 30 ft in open terrain to the appropriate reference pressure at the building:

$$C_e = k_z \left(\frac{h}{Z_z} \right)^{2\alpha} \dots \dots \dots (7)$$

in which C_e = exposure factor for height h (called $C_{e_{1/2}}$ and evaluated at mid-height of structure for use with internal pressure coefficient); k_z = constant

of proportionality; h = height of structure or height to element being designed; Z_z = a base height, in feet and α = power law exponent for velocity profile.

Table 4 lists the suggested parameters for the simple method and for three categories of terrain roughness for the detailed method. Terrain roughness to the west of the 45-story building was estimated to be between medium and city; interpolated values for k_z , Z_z and α of 0.5, 80 ft, and 0.3 were used, therefore, for calculations by the detailed method.

Gust Effect Factor for Detailed Method.—For a relatively small, rigid cladding panel the dynamic properties have negligible influence and the gust effect factor reduces to

$$C_g = 1 + g \cdot 4.9 \sqrt{k} \left(\frac{30}{h} \right)^\alpha \dots \dots \dots (8)$$

The measured cladding pressures presented herein are essentially independent of dynamic properties of the cladding through which the pressure taps passed. Thus Eq. 8 is appropriate for analysis of the data. Suggested values for the surface roughness coefficient, k , for the three terrain categories are given in Table 4. The interpolated value used for calculating gust effect factors by the detailed method was 0.03.

The linear relation between C_{rms} and C_{ext} , which is required for Eqs. 5, 6, and 8, is shown in Fig. 10 to hold reasonably well for the upper level. The deviations for the lower level are probably due to poor correlation in the evaluation of C_{mean} ; the two points farthest from the regression line, cladding positions 2N2 and 2W4, have correlation indices of only 0.49 and 0.35, respectively (see Table 1).

Peak Factor.—The central factor in the relation between mean and maximum peak pressures or suctions is seen to be the peak factor, g . As shown in Figs. 3 to 6, the number of rms values by which the maximum peak exceeds the mean is a random variable described by a probability distribution. The choice of g , therefore, affects the overall probability of exceeding the design cladding pressure. In structural response evaluation the gust factor is often selected to correspond to the average maximum peak value. The probability that this quantity may be exceeded is about 0.43 and this same probability level is reasonable to be used in cladding design.

As the observed distributions generally had a larger spread than the corresponding theoretical distributions, the observed peak factors, g_i , (with probabilities of exceedance 0.43 for each of the 12 cladding positions) were in fact about 5 % larger than the observed averages of the maximum peaks in each case. In comparing measured and calculated peak pressures the larger values of g_i (having exceedance probabilities 0.43) were used to define measured peaks and the average of all 12 g_i , or 4.5, was used for calculations by the detailed method.

Comparison of Measured and Calculated Pressures.—A practical comparison of the detailed method with the simple method must include the influence of the exposure factor; it is not the same for both. Comparison of measured and calculated pressures in Table 5 is given in terms of C_{peak} times C_e , or the peak cladding pressure divided by the mean velocity pressure at a height of 30 ft in open terrain.

The mean pressure coefficients used were those determined from the measured pressures; thus, any differences between measured and calculated values are due solely to differences in C_g , the gust effect factor, and C_e , the

TABLE 5.—COMPARISON OF MEASURED AND CALCULATED PEAK CLADDING PRESSURES (BASED ON MEAN WIND AT 30 FT IN OPEN TERRAIN)

Cladding position (1)	Measured			Calculated	
	g_i (2)	C_{peak} (3)	$C_{peak} C_e$ (4)	Detailed method, $C_{peak} C_e$ (5)	Simple method, $C_{peak} C_e$ (6)
1E1	3.9	-0.45	-0.90	-1.00	-1.14
1N2	4.2	0.44	0.88	1.07	1.12
1W1	3.2	0.86	1.71	2.41	2.58
1W2	3.5	0.83	1.65	2.26	2.41
1W3	4.7	0.78	1.55	1.69	1.79
1W4	4.2	0.65	1.29	1.53	1.62
2E1	6.6	-1.11	-2.21	-1.47	-1.98
2N2	4.6	0.48	0.96	1.12	1.50
2W1	4.2	0.73	1.45	1.25	1.67
2W2	4.3	0.71	1.41	1.31	1.75
2W3	4.6	0.66	1.31	1.12	1.50
2W4	4.7	0.52	1.04	0.74	0.99

FIG. 10.—LINEAR RELATION BETWEEN C_{rms} AND C_{ext} FOR 30° WIND DIRECTION

exposure factor. On the upper level the detailed method averaged 23 % higher and the simple method 32 % higher than the measured values. On the lower level the detailed method averaged 15 % lower and the simple method 19 % higher than the measured values.

Differences would be reduced by almost half for the detailed method if the average g_i for the respective levels (4.0 for the upper and 4.9 for the lower) were used instead of the grand average, 4.5. Position 2E1, in particular, contributes to a higher g for the lower level, but if a distinction were made in the time series between periods of relative calm and periods of high turbulence, g would come down and the rms value would go up.

The terms of Eq. 8 multiplied by g can be described collectively as the coefficient of variation of the fluctuating cladding pressure (rms value/mean value), or more concisely as the intensity of pressure turbulence. For this important quantity the detailed method, as applied, gave an under-estimate for the lower level and an over-estimate for the upper level.

CONCLUSIONS

Calculation of a gust effect factor for cladding design hinges on the estimation of two important quantities: intensity of pressure turbulence, and peak factor. The intensity of pressure turbulence is the more difficult quantity to estimate, although present results also indicate some variation in the peak factor from one position to another.

The detailed gust effect factor method recognizes the importance of the two quantities and provides some improvement over the simpler and more conservative wind gust factor method, but neither method can yet be considered entirely adequate. A major difficulty is the evaluation of the turbulence generated by structures in the immediate vicinity of the building to be designed.

The latter point raises an interesting question: if other buildings cause significantly increased levels of turbulence (from wake interaction), to what extent should future changes in the surroundings be considered in design? Perhaps consideration should be given to specifying one or more standard exposures, with representative configurations for surrounding buildings.

In view of the need for detailed information on turbulence intensities in city environments, efforts should be increased to gather climatic data at typical building sites. Admittedly this is no easy task. To make the best possible use of field data, which are expensive and time-consuming to collect and interpret, close cooperation should be maintained among meteorologists, wind tunnel experts, and those doing measurements on full-scale buildings.

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APPENDIX II.—NOTATION

The following symbols are used in this paper:

- $C_e, C_e^{1/2}$ = exposure factors;
 C_{ext} = external pressure coefficient at a point;
 C_{int} = internal pressure coefficient at a point;
 C_{mean} = mean (time-averaged) pressure coefficient at a point;
 C_{peak} = peak pressure coefficient at a point;
 C_{rms} = rms pressure coefficient at a point;
 $f(x, v, T) dx$ = probability that value of maximum peak will lie between x and $x + dx$;
 g, g_i = peak factor;
 h = height of structure or height of element being designed;
 k = surface roughness coefficient;
 k_z = proportionality constant;
 p = pressure difference across exterior wall, in pounds per square foot;

- q_{30} = reference design wind pressure appropriate for 30-ft height in open terrain;
- r^2 = correlation index;
- T = length of record, in seconds;
- V = mean wind speed at 800 ft, averaged over 200 sec, 10 min or 30 min as indicated, in feet per second;
- x = reduced variate representing excess of peak of random function over mean value;
- Z_z = base height, in feet;
- α = power law exponent for velocity profile;
- β = wind direction measured as angle, in degrees, north of a perpendicular to west wall;
- ν = average effective fluctuation rate per second;
- ν_c = average fluctuation rate indicated by number of crossings of mean value with positive slope;
- ν_p = average fluctuation rate indicated by number of peaks; and
- ρ = density of air, in slugs per cubic foot.

8356 STATISTICAL TREATMENT OF PEAK GUSTS ON CLADDING

KEY WORDS: aerodynamics; buildings; field testing; gust loads; random processes; structural engineering; walls; wind pressure

ABSTRACT: Design methods based on a statistical approach to the prediction of dynamic effects of wind on frameworks of tall buildings are steadily gaining acceptance. Similar concepts can be applied to wind loads on cladding, although there are important differences such as exposure, size, and dynamic properties of the elements considered. Wind pressures and suctions at several points on a tall building recorded during strong winds are used to study the problem of predicting peak gust loads on windows and cladding elements. The statistical approach to the prediction of peak gusts, based on random process theory, is investigated. Measured peak pressures are compared to values calculated by a simple wind gust factor method and by a more detailed gust effect factor method. It is concluded that the gust effect factor method is preferable because it promotes a better understanding of peak pressures, but further field data and experimentation are needed before entirely satisfactory design estimates can be made.

REFERENCE: Dalglish, W. Alan, "Statistical Treatment of Peak Gusts on Cladding," Journal of the Structural Division, ASCE, Vol. 97, No. ST9, Proc. Paper 8356, September, 1971, pp. 2173-2187.

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