PRESSURE DISTRIBUTIONS ON BUILDINGS IN ATMOSPHERIC SHEAR FLOWS

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NCLATURE

	mean pressure coefficient--defined in text
ean	
s	fluctuating pressure coefficient--defined in text
x	peak-maximum pressure coefficient--defined in text
n	peak-minimum pressure coefficient--defined in text
	building height
	instantaneous fluctuating pressure on a structure
	ambient static pressure of approach wind
	mean velocity
	building width
	horizontal coordinate
	vertical coordinate
	density of ambient air

TRODUCTION

A program designed to determine the surface
ssures on building models immersed in a simulated
spheric flow is discussed. The research is part
larger research program on wind effects on struc-
es within the Fluid Mechanics and Wind Engineering
ram at Colorado State University supported by the
onal Science Foundation. A series of flat-roofed
angular buildings is being studied in wind-tunnel
ndary layers modeling four typical neutral atmo-
ric flow conditions. The object of this program
to determine the effect of atmospheric-flow
ables and building shape parameters on the pres-
distributions--both mean and instantaneous.

CTIVES

This program is designed to provide a detailed
estigation of the pressure distribution on the
es and roof of a series of flat-roofed rectangular
dings immersed in a simulated atmospheric flow.
measurements are being conducted in the industrial
odynamics wind tunnel, Colorado State University.
s tunnel has a 6x6 ft cross section and a test
ion 60 ft long. Detailed justification for wind-
nel modeling of wind loads on structures is avail-
in the literature (1,2,3). Four flow conditions
e been selected to provide variation from a smooth
form rural exposure to an urban exposure.

The flow variables which are being considered
the exponent of the power-law profile, the rough-
s height, integral scales of the turbulence of the
roach flow in both the longitudinal and transverse
ections and the variations of turbulent intensity
n height. Building shape parameters under investi-
ion include the ratio of lengths of adjacent sides,
ratio of a designated side dimension to the height
the building, and the ratio of a designated side
relevant flow parameter (i.e. longitudinal
egral scale or roughness length). A listing of
es under investigation is given in Table 1.

The characteristics of the surface pressure
tributions which are being measured include local pressure coefficients, correlations between the instantaneous pressure fluctuations at selected locations on the face of a building, distribution of pressure coefficients across a given face as a function of wind direction and other wind parameters, and the spectral properties of the pressure fluctuations. This study will provide basic information about the nature of surface pressures and isolate relevant building and flow parameters which significantly influence surface pressures distributions.

a/b \ h/a	1	2	3	4
1	10,10	5,5	2.5,2.5	1.25,1.25
½	10,20	5,10	2.5,5	1.25,2.5
¼	10,40	5,20	2.5,10	1.25,5

h building height, 10 in.
a width of small side in in.
b width of large side in in.

Table entries are in the form a,b

Table 1 Model building dimensions

EXPERIMENTAL METHODS

Data Acquisition

All pressure data is being taken using a digital data-acquisition system described by Peterka (4). Data is taken for 272 tap locations on a building for 11 wind directions from 0 to 90 deg based upon a fixed side as a reference. One of the models is shown in Figure 1. The layout of pressure-tap locations on a typical side is shown in Figure 2. Instantaneous pressure records are digitized on-line at a sample rate of 250 samples per second. All data is then stored on magnetic tape for reduction to pressure-coefficient form and for further analysis.

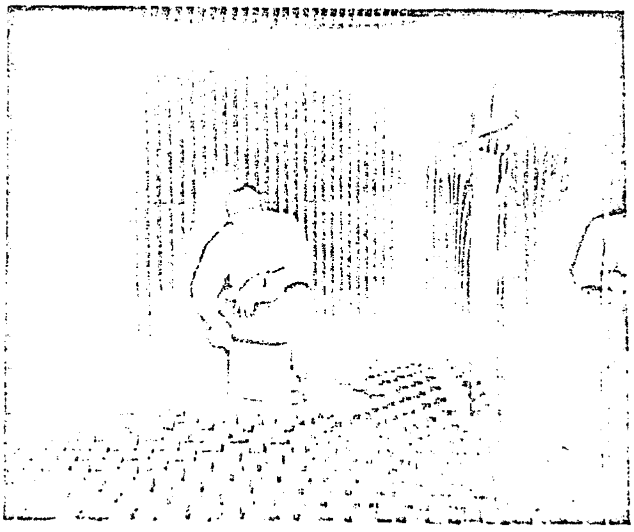

Fig. 1 Model building

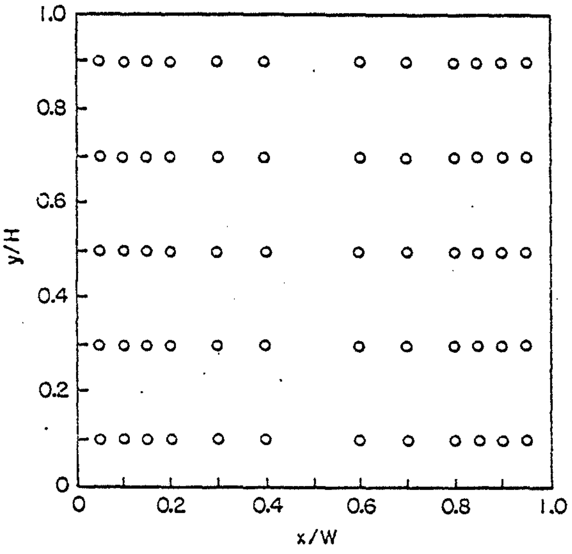

Fig. 2 Pressure-tap locations

Data Reduction

Most data reduction is carried out on the Colorado State University CDC 6400 computer. The initial data records are reduced to four separate pressure coefficients. The first is the mean pressure coefficient

$$C_{p_{mean}} = \frac{(p - p_\infty)_{mean}}{\rho U^2/2} . \qquad (1)$$

It represents the mean of the instantaneous pressure difference between the pressure tap location on the side of the building and the static pressure in the wind tunnel above the model. The magnitude of the fluctuating pressure is obtained from the rms pressure coefficient

$$C_{p_{rms}} = \frac{[(p - p_\infty) - (p - p_\infty)_{mean}]_{rms}}{\rho U^2/2} . \qquad (2)$$

The numerator is the root-mean-square of the instantaneous pressure fluctuation about its mean.

If the pressure fluctuations followed a Gaussian probability distribution, no additional data would be required to predict the frequency with which any given pressure level would be observed. Peterka and Cermak (5) showed that the probability distribution of negative pressure fluctuations in regions of separated flow does not follow a Gaussian distribution function. The distribution is skewed such that the probability of large negative pressures is substantially higher than would be predicted from a Gaussian distribution. This fact means that additional information is required in order to determine the extreme values of pressures which may be expected to occur during a given interval. The following peak-minimum and peak-maximum pressure coefficients are used to express these extreme values:

$$C_{p_{min}} = \frac{(p - p_\infty)_{min}}{\rho U^2/2} \quad \text{and} \quad C_{p_{max}} = \frac{(p - p_\infty)_{max}}{\rho U^2/2} . \qquad (3)$$

The maximum and minimum values of $(p-p_\infty)$ are determined by searching all data values recorded for a particular tap location.

All pressure-coefficient data is stored on digital tape for rapid access in further analysis. Several automated plotting routines have been developed which are capable of generating contour plots as that shown in Figure 3 or rectilinear plots of pressure variation along a side at a given level. In addition the mean pressure-coefficient data can be read directly from a tape and used in the calculations of mean forces and moments acting on the model buildings.

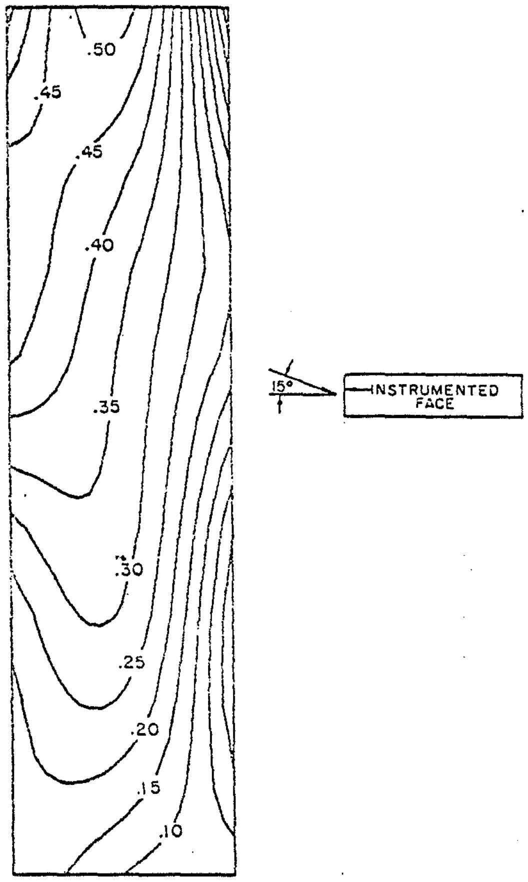

Fig. 3 Contours of mean pressure coefficient

Spectral analysis is accomplished using Fast Fourier Transform techniques. Figure 4 is a power spectrum obtained by processing a single record consisting of 524,000 data points taken at 1000 samples per second. The small peak at 200 to 300 Hz does not represent energy content at these frequencies, but an aliasing of energy above the 500 Hz resolution limit of the sampling frequency. Since the aliasing occurs at a position where the spectral amplitude is 5 orders of magnitude below the maximum, it is a minimal effect on the interpretation of the spectrum.

CURRENT STATUS

Initial pressure-coefficient measurements have been completed for 23 building/boundary layer combinations. Extensive flow measurements have been completed for 3 of the boundary layers. Analysis of this data is in progress. Within the next few months, measurements with the fourth boundary layer and detailed correlation measurements at selected locations will be completed.

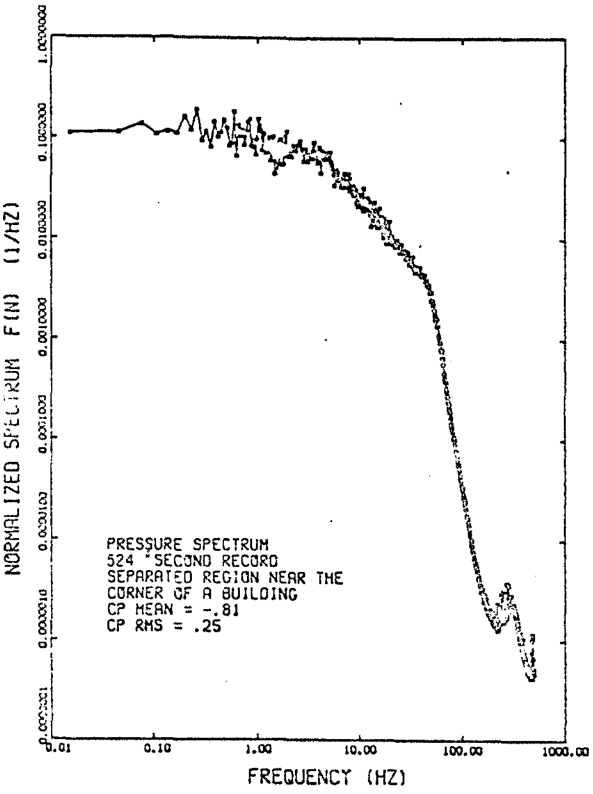

Fig. 4 Pressure power spectrum

ACKNOWLEDGMENTS

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