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A Wind Pressure Database from Hungary for Ventilation and Infiltration Calculations

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Introduction

Wind pressure coefficients (C_p values) are among the basic data required for ventilation and air infiltration calculations and modelling. More than two years of systematic wind tunnel testing in ETI of some of the most frequent building shapes has resulted in a database that has been provided with a handling program. This package is available from ETI, for IBM XT/AT and compatible PC's.

The CPBANK Concept

Sources of C_p values are almost exclusively, wind tunnel tests. These tests are, however, usually much too expensive to be incorporated into the budget of design of small or medium scale building projects, though some of these may require the knowledge of C_p values. Computer simulations of ventilation and air infiltration processes also use such data. There are three main approaches to provide C_p sets for these calculations:

(1) Wind tunnel testing is always workable but seldom economic.

(2) Use of existing databases - this requires quality and easy access to data.

(3) Generating parametric functions from measurement databases and using these to reproduce C_p's. Except for some rather simple cases this method is not generally workable. CPBANK follows the second approach.

CPBANK is a software package comprising a set of wind pressure coefficient (C_p) data files for a range of building shapes, fixed degrees of shielding and three types of upwind terrain. It also includes a handling program that supports easy selection of parameters, definition of distribution of points over the building envelope and a simple management of user files. CPBANK is built around a nested menu concept in which Main Menu items activate submenus.

The primary application of the produced C_p data is to supply input for air infiltration and ventilation calculations. Without any deeper knowledge of building aerodynamics

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CPBANK should only be used for building geometries included (see Figs 1,2). In most cases about 25% deviation from predefined geometric ratios may be accepted without causing substantial error. The same tolerance may be applied for the absolute dimensions of the buildings.

The C_p's in this package are all time-mean values and to calculate wind pressures the wind speed at the reference height, conventionally taken equal to the building height, has to be known.

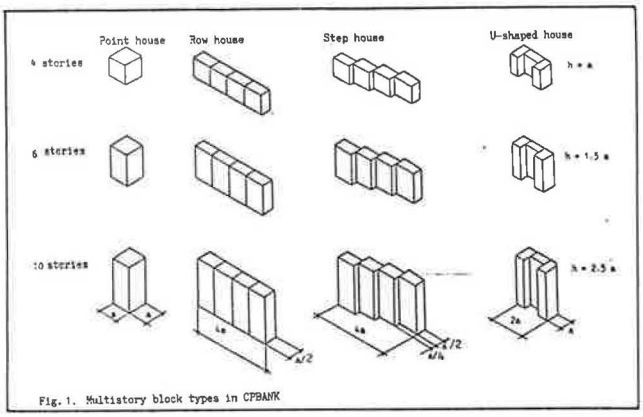

Fig. 1. Multistory block types in CPBANK

Fig. 1 Multi-story block types in CPBANK

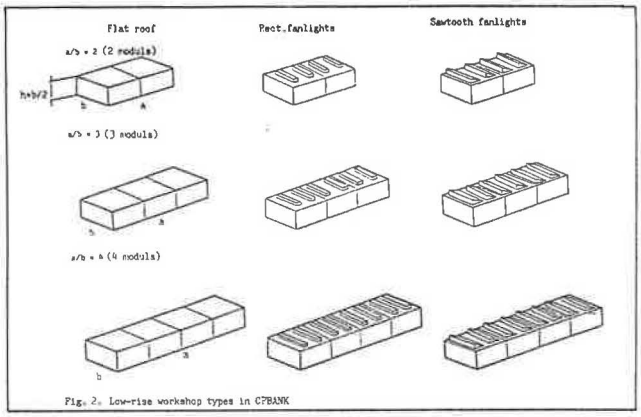

Fig. 2. Low-rise workshop types in CPBANK

Fig. 2 Low-rise workshop types in CPBANK

Air Infiltration Review

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Wind Tunnel Tests

The Wind Tunnel Laboratory of the ETI carried out hundreds of test runs to develop the C_p database. After multiple checking the measured pressure data were transformed into C_p values.

Fig. 3 shows shielding degrees used during wind tunnel testing. CPBANK offers three categories for the aerodynamic roughness of the upwind terrain. Rural terrain applies for flat, smooth, rural land with low vegetation, scattered trees, bushes or cultivated agricultural area. Suburb terrain means single family housing areas, villages and suburbs of low-rise housing. Urban terrain refers to densely built up urban area of multi-story housing.

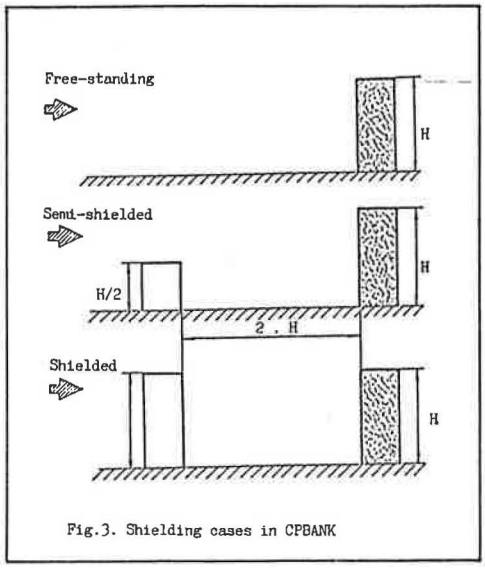


Fig.3. Shielding cases in CPBANK

Fig. 3 Shielding classes in CPBANK

The above exposure parameters may be, and usually are, dependent on the wind direction, which may be selected in 22.5 degrees increments. Zero degree wind direction coincides with the +y axis of the building coordinate system.

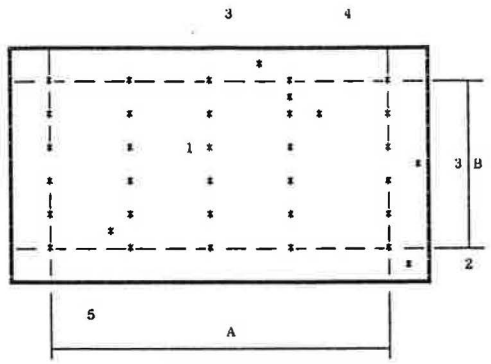
Data for Input

Two groups of data are required for input. The first comprises building data, and the second exposure data.The input of these data through the keyboard is supported by help screens, simple graphics and other tools that facilitate easy amendments and modifications. The simple file management tool and the fixed format of the user files makes it possible to create house data files by other means and pass them to CPBANK.

How CPBANK works

One group of the supplied CPBANK files contains the x,y,z coordinates of the surface points for which C_p values have been measured. These coordinates are stored in non-dimensional form, i.e., x/X_{max}, y/Y_{max}, z/Z_{max}, where the subscript '$_{max}$' refers to the total building dimension. In order to enable the location of the surface points of the given building, its coordinates must be scaled accordingly. Thus CPBANK starts with calculating scaled surface point coordinates of the defined building. Then it performs a search in the database for retrieving all data files necessary for the given task. C_p values are assigned to any defined surface point from the CPBANK files by interpolation (see Fig. 4).

Example of a building facade (roof) with the array of reference points included in CPBANK file



A,B - limits of the array of measured points

Position of the point:	CP value assigned to the point is equal to the
1 - coincidence with a measured point :	value at the measured point
2 - offside the array in a corner of facade area:	value at the corner point
3 - offside the array :	interpolated value between the nearest two measured points at the edge of the array
4 - inside the array in line with two points :	interpolated value between the two points
5 - surrounded by four array points :	value determined by triple linear interpolation

Fig. 4. How CPBANK assigns CP values to your surface points by their position relative to surface point arrays in CPBANK files.

Fig. 4 How CPBANK assigns Cp values to your surface points by their position relative to surface point arrays in CPBANK files

Structure of CPBANK Database Files

There are two types of CPBANK data files. These are: XYZ files - these contain the serial numbers and non-dimensional XYZ coordinates of the surface points where measurements were made, and C_p files - these contain 3x2 arrays of C_p data corresponding to the three roughness catagories of the upwind terrain. C_p values are tabulated according to the serial number of surface points (rows) and actually measured wind directions (columns). The second array of C_p averages are tabulated according to the serial number of surfaces (rows) and measured wind directions (columns).

C_p values for wind directions other than those tabulated are derived from the measured values by making use of symmetry to one or two axis or the center point of the actual building type.

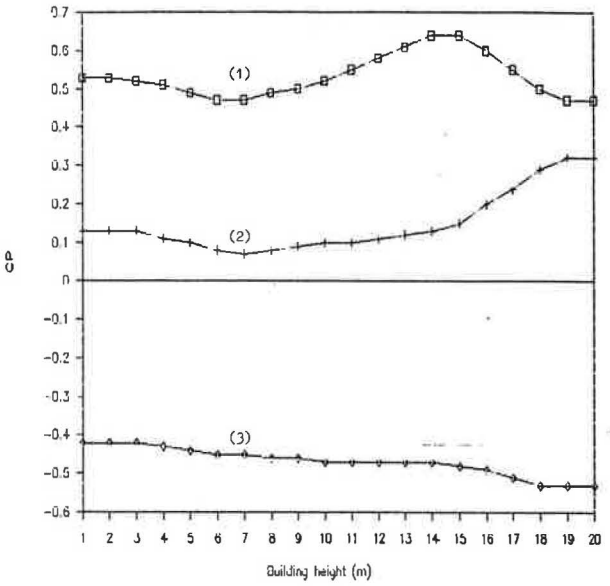


Fig.5. Vertical CP-profiles along the center line of the windward long facade (1) Free standing (2) Semi-shielded (3) shielded. Upwind terrain: Suburban. Wind direction perpendicular to facade.

Fig. 5 Vertical Cp profiles along the center oine of the windward long facade (1) Free standing (2) Semi-shielded (3). Upwind terrain: Suburban. Wind direction perpendicular to facade

Table 1 Example file of house data

Project
Example of looking up CP values for a rowhouse
1st December 1988
Building Wizard consultants Ltd, Fabuland County, Nowhereland
File name:
a:\EXAMPLE2.hus

House data:
House type : 1 Rowhouse
Nominal size : 4
Length (m) L 40.2 Width (m) L20.0 Height (m) 12.0
Your choice of Averages/Distribution : 2
Surface distribution of CP values
Number of faces of the defined building : 5
Total number of defined points : 33
Serial number of the first and last points on building faces:

Face no.	First point	Last point
1	1	3
2	4	8
3	9	14
4	15	23
5	24	33

X Y Z coordinates of points selected on the building envelop:

Point number	X (m)	Y (m)	Z (m)
1	20.0	0.0	10.0
2	1.0	0.0	1.0
3	2.0	0.0	2.0
4	0.0	1.0	1.0
.	.	.	.
.	.	.	.
.	.	.	.
30	2.0	3.0	12.0
31	4.0	7.0	12.0
32	8.0	9.8	12.0
33	2.0	8.0	12.0

Table 2 Example file of exposure data

Project:
Example of looking up CP values for a rowhouse
1st December 1988
Building Wizard Consultants Ltd, Fabuland County, Nowhereland
File name:
a:\EXAMPLE2.env

Defined environmental data
Defined wind directions : 2

Number	Wind direction	Shielding	Terrain type
1	1 0.0	2 semi shielded	1 Flat rural
2	5 90.0	1 exposed	2 Suburbian

Table 3 Example of Cp values

Project:
Example of looking up CP values for a rowhouse
1st December 1988
Building Wizard Consultants Ltd, Fabuland County, Nowhereland
File name:
a:\EXAMPLE.cpv

Your choice of Averages/Distribution :12
No. of points : 33 Wind dirs : 2
Surface distribution of CP values

Point no.	Wind direction	
	00.0	90.00
1	00.13	00.08
2	- 0.21	- 0.46
3	- 0.20	- 0.42
4	- 0.52	00.66
.	.	.
.	.	.
.	.	.
30	- 0.44	- 0.04
31	- 0.43	- 0.23
32	- 0.41	- 0.60
33	- 0.44	- 0.04

Output and User Files

All data files created by the user are stored as text files which are easy to handle by means of common word processing and spread sheet programs.

Tables 1- 3 show printouts of user files from an example run. Fig. 5 shows vertical C_p profiles along the center line of one long facade of a rowhouse type building for three cases of shielding. The upwind terrain is suburban type and the wind direction is perpendicular to the facade. C_p values in the figure were retrieved from CPBANK.

The CPBANK package is available at $1,000 U.S. from:

ETI, the Hungarian Institute for Building Science, H-1113, Budapest, David F.u.6.

Telex: 22-4285 eti h. Fax: 36-1-663-766.

For further information or inquiries please contact the author.