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Developmental Computer-Based Version of ASCE 7-95 Standard Provisions for Wind Loads

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ABSTRACT

This report includes a brief introduction to and description of the wind loading provisions of the ASCE (American Society of Civil Engineers) Standard 7-95. An interactive computer program representing those provisions was developed and tested by the authors and NIST staff. The resulting software is included in a diskette presented in this report. Instructions for the user of the program are also included. An appendix contains excerpts from a large number of calculations aimed at verifying the performance of the interactive program. Following its completion, the program was submitted for beta-testing by an ASCE-assembled team. *The program presented in this report does not reflect the results of that testing, and is not an official version of the ASCE 7-95 Standard.* A main purpose of this report is to serve the needs of professionals interested in the application of knowledge systems to the development of computer-based models of standards.

Key words: Building technology; aerodynamics; building codes; climatology; structural engineering; wind engineering.

1. INTRODUCTION

The power of desktop computers makes it practical to develop computer-based versions of standards allowing designers to use complex standards efficiently while significantly reducing the possibility of errors. Recognition of this fact led one of the authors (E. Simiu) to initiate, as a pilot project, the development of an interactive computer version of the ASCE 7-93 Standard provisions for wind loads. To keep software development costs low it was decided to use a commercial shell. The pilot project was supported by the Structures Division, Building and Fire Research Laboratory, National Institute of Standards and Technology (NIST). The support included about half of the funds needed for software development. The balance of the software development costs was covered by a "revenue-sharing" grant from the American Society of Civil Engineers (ASCE).

Upon the successful completion of the pilot project, NIST and ASCE agreed to engage in an effort to develop a similar computer version of the ASCE 7-95 Standard provisions for wind loads, which differ significantly from and are considerably more complex than those of the ASCE 7-93 Standard. One stipulation for this effort, imposed by tight NIST and ASCE budgets, was that the cost of the software should again be kept low. NIST funded the development of the present report and the attendant software. A virtually identical version of this software was reviewed by the beta-testing team. The support provided by ASCE covered the development from the software attendant to this report of a version incorporating examples and improvements requested by beta testers.

The development of the present report involved NIST[1] and M.M. Schechter Expert Systems Consultants. The report consists of a brief introduction to and description of the wind loading provisions of the ASCE Standard 7-95, a diskette containing a developmental interactive computer version of those provisions, instructions for the use of the software, and excerpts from calculations performed to verify the interactive program's performance. In developing the present report the responsibilities were divided as follows. The software and the instructions for the user were developed by M.M. Schechter Expert System Consultants under contract with NIST. NIST provided guidelines on the structure of the interactive program and assisted the software contractor in the interpretation of the Standard wind loading provisions. NIST also maintained liaison with the ASCE 7-95 Subcommittee on Wind Loads to (a) alert the Subcommittee on the existence of unclear, ambiguous, impractical or incorrect provisions in the draft Standard, and (b) inform the software contractor of the final version of those provisions as amended by the Subcommittee. This scrutiny and the numerous consequent improvements of the draft Standard were among the main motivations of the NIST effort, and helped materially in the developemnt of the final version of the Standard. Finally, NIST subjected the software to extensive verification, part of which is documented in the Appendix. The tasks described in this paragraph that did not involve writing of the software were performed by R.D. Marshall, E. Simiu, and NIST reviewers of this report.

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[1] Drs. J.L. Gross, L. Phan, and A.E. Schultz of the Structures Division, Building and Fire Research Laboratory, NIST, performed careful reviews of the calculations and offered many useful comments and suggestions.

ASCE assembled a group of professionals to perform the beta-testing of the software. With NIST assistance, ASCE drew up a list of verification tasks for the group and divided the verification tasks among its members. ASCE then evaluated the performance of these tasks. The results of the beta-testing are not reflected in this report. Therefore, *the software included in this report is not an official version of the ASCE 7-95 Standard*. The intent of this report is to serve the needs of professionals and students interested in the application of knowledge systems to the development of computer-based models of standards.

The report is organized as follows. Part I contains three sections. Section 1 consists of this introduction. Section 2 lists the main factors determining wind loads and helps to understand the rationale of the wind loading provisions of the ASCE 7-95 Standard. Section 3 presents a summary description of those provisions. Part II contains a hard copy of the instructions for the user of the interactive computer program, and a diskette containing the program software. An Appendix contains typical calculation examples from among a large number of hand calculations performed by Dr. R.D. Marshall, the authors, and reviewers of various portions of this report, to verify the performance of the computer program. The Appendix also includes some notes on the computer program.

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PART I

BRIEF INTRODUCTION TO AND DESCRIPTION OF WIND LOADING PROVISIONS OF ASCE STANDARD 7–95

2. FACTORS DETERMINING WIND LOADS

Wind loads on buildings and structures are functions of the wind flow and of the effect of that flow on the structural system or structural or nonstructural component being considered.

The wind flow depends on

(i) the basic wind speed

(ii) the mean recurrence interval of the wind speed judged to be appropriate for the design of the type of building or structure under consideration

(iii) the characteristics of the terrain surrounding the building or structure

(iv) the characteristic height above ground for the point or system being considered

(v) directional properties of the wind climate (these properties are not accounted for clearly and explicitly in the ASCE 7-95 Standard).

The effect of the wind flow on the structural system or structural or nonstructural component being considered depends upon

(vi) the aerodynamics of the building or structure

(vii) the position(s) of the area(s) acted on by the wind flow

(viii) the magnitude(s) of the area(s) of interest

(ix) the porosity of the building envelope

(x) the selection of the probability that the peak fluctuating wind load acting on a system or element will be exceeded during the wind storm considered in design

(xi) the susceptibility of the structural system under consideration to steady and time-dependent (dynamic) effects induced by the wind load.

3. BRIEF DESCRIPTION OF ANALYTICAL METHOD SPECIFIED IN ASCE 7-95 STANDARD FOR CALCULATION OF WIND LOADS

The ASCE 7-95 Standard recognizes two methods for estimating wind loads: the analytical procedure and the wind tunnel procedure. This section reviews and summarizes the wind loading provisions of the Standard pertaining to the analytical procedure. The reader should use this section, as well as the Appendix containing excerpts from calculation notes, in conjunction with the Standard itself, that is, with its provisions, figures and tables.

3.1 Calculation of Wind Loads: Basic Steps.

The analytical procedure proceeds in two steps. The first step is intended to reflect the properties of the wind flow (items (i) through (v) of sect. 2 above). The second step reflects the aerodynamic properties of the structure and dynamic properties associated with effects of the longitudinal (alongwind) wind turbulence (items (vi) through (xi) of sect. 2 above).

Step 1: Determination of Velocity Pressure.

The *velocity pressure* at elevation z, q_z, in psf is determined as follows:[2]

$$q_z = 0.6134 K_z K_{zt} V^2 I \quad (q_z \text{ in Pa, V in m/s}) \tag{1.a}$$

$$q_z = 0.00256 K_z K_{zt} V^2 I \quad (q_z \text{ in psf; V in mph}) \tag{1.b}$$

In the particular case in which q_z is evaluated at elevation h it is denoted by q_h. The Standard also uses the generic notation q to denote velocity pressure, and indicates in Table 6-1 whether in a particular instance $q=q_z$ or $q=q_h$.

The *basic wind speed* V corresponds nominally to a 50-year mean recurrence interval and is given in miles per hour[3] for most geographical locations by Fig. 6.1 of the Standard. It represents the speed from any direction at an elevation of 10 m above ground in flat open country (Exposure C, see below).

The *velocity pressure exposure coefficient* K_z reflects the dependence of the velocity pressure on terrain roughness, that is, exposure category, and height above ground. It is given in Table 6-3 of the Standard. Section 6.5.3.1 of the Standard defines in detail four exposure categories: A, B, C and D. In summary terms exposure A corresponds to terrain in large city centers; exposure B to urban and suburban areas; exposure C to flat open country; and exposure D to terrain close to a shoreline and with wind coming from over the water.

The *importance factor* I is provided in Table 6-2 of the Standard as a function of the building and structure classification given in Table 1-1. For Category II buildings/structures, that is, for most ordinary buildings/structures, I=1. For

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[2] 1 psf=47.88 Pa.

[3] 1 mph=0.44704 m/s.

Category I buildings/structures, that is, buildings/structures representing a low hazard in the event of failure (including, e.g., agricultural facilities), I=0.87. For Category III and Category IV buildings/structures, that is, buildings/structures representing a substantial hazard to human life in the event of failure (e.g., buildings where more than 300 people congregate in one area, and essential facilities such as fire stations), I=1.15. The importance factor may be interpreted as defining the mean recurrence interval of the effective velocity $I^{1/2}V$. For I>1 (I<1), that interval is larger (smaller) than 50 years.

The *topographic factor*

$$K_{zt}=(1+K_1K_2K_3)^2 \tag{2}$$

reflects the speed-up effect over hills and escarpments. The multipliers K_1, K_2 and K_3 are given in Figure 6-2 of the Standard.

Step 2: Estimation of Aerodynamic Pressures or Forces.

Aerodynamic pressures are specified in the Standard for buildings other than open buildings.[4] The aerodynamic force on an area acted upon by a uniform pressure is equal to the pressure times the area. However, the Standard has specific provisions for aerodynamic forces acting on: monoslope roofs over open buildings; chimneys, tanks, and similar structures; solid signs; open signs and lattice frameworks; and trussed towers. The calculation of aerodynamic pressures and forces as specified in the Standard is described in the sections 3.2 and 3.3.

3.2 Calculation of Aerodynamic Pressures.

The Standard specifies aerodynamic pressures used in the design of buildings. This is done separately for main wind force resisting systems and for components and cladding.

3.2.1 Main Wind Force Resisting Systems. Pressures calculated for the design of main wind force resisting systems are specified in the Standard for non-flexible buildings,[5] low-rise buildings[6] (which are a class of non-flexible buildings), flexible buildings, and arched roofs.

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[4]Open buildings are buildings having all walls at least 80% open (Section 6.2 of the Standard).

[5]Flexibility is defined in Table 6-1 of the Standard by at least one of two properties: ratio height/least horizontal dimension > 4, fundamental frequency of vibration f < 1 Hz.

[6]Low-rise buildings are defined in sect. 6.2 of the Standard as buildings that are not open, and have mean roof height not exceeding 18.29 m (60 ft) and the building's least horizontal dimension. The designer has the option of using for their design either Fig. 6-3 or Fig. 6-4.

Non-flexible Buildings. Pressures are given by the equation (Table 6-1):

$$p = qGC_p - q_h(GC_{pi}) \qquad (3)$$

The first and second term in Eq (3) represent the external and the internal pressure, respectively. In Eq (3):

$q=q_z$ for windward wall, $q=q_h$ for leeward wall and side walls, and h denotes the mean roof height

G is a gust effect factor that accounts for the fact that the wind load is not perfectly coherent throughout the surface over which it acts (G=0.8 for exposures A and B and G=0.85 for exposures C and D — sect. 6.6.1 of the Standard)

C_p=external pressure coefficient from Fig. 6-3 of the Standard

GC_{pi} is a factor proportional to the internal pressure, which depends on the degree to which the building is open (see sect. 6.2 and Table 6-4 of the Standard, which provides, among others, for the case where the degree to which a building is open may increase during a hurricane owing to breakage of windows).

Figure 6-3 of the Standard was developed from tests on flat roofs and gabled roofs. To the writers' knowledge there is no published evidence that it applies to buildings with other types of roofs.[7]

Low-rise Buildings. If Fig. 6-4 of the Standard is used (see p. 8, footnote 6), pressures are given by the equation

$$p = q_h[(GC_{pf})-(GC_{pi})] \qquad (4)$$

The factor (GC_{pf}) is proportional to the external pressure. (GC_{pi}) is defined as for Eq (3).

Flexible Buildings. Pressures are given by the equation

$$p = qG_fC_p \qquad (5)$$

While the gust effect factor G (see Eq (3)) accounts only for the imperfect spatial coherence of the wind loads, G_f accounts in addition for the dynamic amplification of the along-wind response due to the variation of the wind loading with time. The Standard iself does not specify methods for estimating G_f, and limits itself to indicating that G_f is obtained by rational analysis. A method that may be used to estimate G_f is provided in sect. C6.6 of the Commentary to the Standard.

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[7]However, according to Note 4 of Figure 6-3 of the Standard, coefficients C_p of that figure may also be used for the estimation of pressures for the calculation of main wind force resisting systems of monoslope roofs.

Arched Roofs. Pressures are given by Eq (3), where the coefficient C_p is obtained from Table 6-5 of the Standard.

Effects of Parapets. The Standard is based on the assumption that the effect of parapets on the main wind force resisting system is merely to add the load acting on the external surface of the parapets to the wind load acting on the walls up to the level of the intersection between wall and roof.

Roof Overhangs. Roofs overhangs must be designed for a positive pressure on bottom surface of windward roof overhangs corresponding to C_p=0.8 in combination with pressures indicated in Fig. 6-3 or 6-4 (sect. 6.7.2.1 of the Standard).

Torsional Effects. For buildings with mean roof height h>18.29 m (60 ft), torsional effects shall be accounted for (sect. 6.8 of the Standard).

3.2.2 Components and Cladding. The Standard provides procedures for the calculation of pressures on building components and cladding for two types of building: buildings with mean roof height h ≤ 18.29 m (60 ft) and buildings with height h > 18.29 m (60 ft). We do not address in this report the calculation of pressures on components and cladding of arched roofs. Pressures depend on the location (pressure zone) covered by the component/cladding, as indicated in the Standard. If a component/cladding covers more than one zone, the pressures are automatically calculated in the program on the basis of the weighted mean method described in the Guide to the Use of the Wind Loading Provisions of ASCE 7-88 (formerly ANSI A58.1) by K.C. Mehta, R.D. Marshall and D.C. Perry, American Society of Civil Engineers, New York, 1991.

Buildings with Height h ≤ 18.29 m (60 ft). Pressures are given by the equation

$$p = q_h[(GC_p)-(GC_{pi})] \qquad (6)$$

where q_h is calculated using Exposure C regardless of terrain, (GC_p) is given in Figs. 6-5, 6-6 and 6-7 of the Standard, and (GC_{pi}) is defined as in Eq (3). For buildings sited within Exposure B the pressures given by Eq(6) must be multiplied by the factor 0.85. The Standard contains provisions for pressures on wall components or cladding only for buildings with gabled roofs or flat roofs (Fig. 6-5A of Standard); no such provisions are available in the Standard for buildings with hipped roofs (Fig. 6-5B), stepped roofs (Fig. 6-5C), multi-span gabled roofs (Fig. 6-6), and monoslope roofs or sawtooth roofs (Fig. 6-7).

Buildings with Height h > 18.29 m (60 ft). Pressures are given by the equation

$$p = q[(GC_p)-(GC_{pi})] \qquad (7)$$

where $q=q_z$ for positive pressures and $q=q_h$ for negative pressures, the factor (GC_p) is given in Fig. 6-8 of the Standard, and (CG_{pi}) is defined as in Eq (3). If 18.29 m (60 ft)< h < 27.43 m (90 ft), Table 6-1 of the Standard stipulates: "GC_p values of Figs. 6-5, 6-6 and 6-7 shall not be used unless the height-to-width ratio does not exceed 1, q is taken as q_h, and Exposure C is used for all terrain."

Effects of Parapets. For flat, gabled, hipped and stepped roofs of buildings with $h \le 18.29$ m (60 ft), if a parapet with height of 0.91 m (3 ft) or higher is provided around the perimeter of the roof then the roof corner zones shall be treated as the roof edge zones.

Roof Overhangs. Roof overhangs must be designed for pressures determined from pressure coefficients given in Fig. 6-5B (sect. 6.7.2.2 of Standard).[8]

3.3 Calculation of Aerodynamic Forces.

The Standard contains design information on aerodynamic forces for main wind force resisting systems. For structures that are not flexible the aerodynamic forces are calculated in accordance with the formula (Table 6-1 of Standard):

$$F=q_z G C_f A_f \tag{8}$$

G is a gust effect factor that accounts for the imperfect coherence of the wind load on the surface over which it acts (G=0.8 for exposures A an B and G=0.85 for exposures C and D — sect. 6.6.1 of the Standard),

C_f is a force coefficient given in Tables 6-6 to 6-10,

A_f is an area defined in Table 6-1.

For flexible structures the following formula is specified:

$$F=q_z G_f C_f A_f, \tag{9}$$

that is, the gust effect factor G_f must be used in lieu of the factor G.

For comments on the gust effect factor G_f see text following Eq (5). The method for estimating G_f provided in Section C6.6 of the Commentary to the Standard is applicable to rectangular buildings whose horizontal cross-section is uniform with height. However, that method can also be used to obtain rough estimates of G_f for structures such as chimneys or trussed towers. If the chimney or trussed tower is tapered, then reasonable approximate results can be obtained by assuming that throughout the structure's height the cross-sectional dimensions are equal to those at two-thirds of the height of the structure. However, the fundamental frequency used as input in the program should be calculated on the basis of the

[8]If the tributary area for a component includes (a) areas outside the overhang and (b) an overhang area, depending upon the application the designer might need to calculate the average pressure over areas (a) (i.e., excluding the overhang area), and the average pressure over areas (a) and (b) (that is, including the overhang area). The program effects both calculations.

actual dimensions of the structure.[9]

[9]In implementing this approach in the computer program, the following reasonable assumptions have been made for the purpose of estimating the gust effect factor G_f. For circular structures depth = 0, width = diameter; for hexagonal and octagonal structures, depth = 0, width = diameter of circumscribed circle; for square structures: depth = width = side of square (wind normal to side), and depth = 0, width = $(2)^{1/2}$*side (wind along diagonal); trussed towers with triangular cross-section: depth=0, width = side of triangle.

PART II

INTERACTIVE COMPUTER PROGRAM

INSTRUCTIONS FOR THE USER, AND SOFTWARE

NOTE. The software is included in the diskette attached to the back cover of the report. Also included in the diskette is a file containing ten examples.

INSTRUCTIONS FOR THE USER

I. System requirements

Hardware:
Wind Load 7-95 will run on any 80386 or 80486 (SX, DX, DX2) or Pentium based computer. If you want to reduce waiting times, a 486DX2, or Pentium processor is the best. You need about 4 megabytes of disk space for the installation of the files. A display resolution of 640x480 (or better) is recommended. Your system must have a Microsoft Windows*) supported mouse.

Software:
Wind Load 7-95 runs under Microsoft Windows 3.1 or higher.

Fonts:
Files are displayed automatically in the screen font "**Terminal**" of Windows (on some original IBM computers under the name "**8514oem**").
Do not change the font you find after installation. Some printers (e.g., Hewlett Packard) however, require a recent version of the Microsoft True Type Font **MS LineDraw**. For further details on how to install this font see Section VII.

II. Installing and Starting Wind Load 7-95

1. Insert diskette in Drive A or B
2. In the Windows Program Manager select **File/Run...**
3. Type **A:Install** or **B:Install**
4. Instead of the default **Target Directory** C:\WL795 you may type another target directory. You can also install the program in an existing Program Group, by selecting the corresponding name during the installation.

The installation program creates a **Program Manager Group** "WIND LOAD 7-95" containing two icons: one for the Program, the other for this file (Read Me!). To *start* the program you only have to double click the Winestar icon.

*) Microsoft is a registered trademark and Windows is a trademark of Microsoft Corporation.

If you have an already installed older version of the program, we recommend, in order to avoid duplicating the icons, to delete first the existing ones.

After installation you should find in the directory \WL795 (the directory where you have installed the program) the following 46 files:

Text File:
- READ_ME.WRI (this file)

System Files:
- BWCC. DLL
- ESTA .ERR
- WINESTAR.DEF
- WINESTAR.EXE
- WINESTA.FON
- WINESTA.MAP

Knowledge Base:
- INITIAL.KB
- ARCH_PAR KB
- ARCHED_R KB
- BLD_FLX.KB
- CCL_STEP.KB
- CCR_HIGH.KB
- CCR_HIP.KB
- CCR_LOW.KB
- CCR_MONO.KB
- CCR_MULT.KB
- CCR_SAW.KB
- CCR_STEP.KB
- CCW_HIGH.KB
- CCW_LOW.KB
- CHIMNEY KB
- CHIMNEY1 KB
- GENERAL.KB
- GENERAL1.KB
- LOWRISE.KB
- LOWRISEB.KB
- MONO. KB
- ROOF.KB
- RESPONSE.KB
- SIGN.KB
- TOWER.KB
- TOWER1.KB
- WALLS.KB
- PICTURES.DBA

Do not use these names when saving your files. Otherwise you risk to overwrite them. However, before overwriting you will be asked if you want to do so.

III. Menu Commands

The main window has a standard Windows menu-bar at the top, and a status line at the bottom. In the middle you have the working area, where windows and dialog boxes will be presented.

The menu-bar contains the main menu commands:

File Edit Consult Window

They are pop-up menus, i.e., by clicking you open a submenu. Some of these windows appearing when using the menu commands will subsequently disappear when you click on the OK button or press Enter. Other windows remain open until you close them explicitly using their system menus. Besides the main menu commands, the consultation is directed by consultation button commands as part of the consultation dialog boxes. The dialog boxes contain also Windows system button commands, such as the command closing the box.

Some windows have scroll bars allowing to view information that exists beyond the borders of the windows. To see the whole contents of the window drag the scroll box to the bottom position of the vertical scroll bar.

The whole knowledge base of the program is incorporated in the files having the extension "KB", called knowledge bases and in the picture database file PICTURES.DBA. The current KB file is shown in the window title. Knowledge bases are divided into sections. The current section is shown in the status line.

IV. Running the program

The program is essentially self-explanatory. It is Microsoft Windows based. For this reason it would be helpful if the users of the program -- who are in fact also users of Windows -- did have some minimal exposure to Windows manuals so that they become more familiar with various Windows capabilities, options and procedures.

The interactive consultation is chiefly directed by menus. You only have to answer the questions being asked and select the appropriate options in order to obtain the desired results.

Question windows have an "Explain" button. If this button is active, you may click it to obtain supplementary information about the question posed.

Some options allow restarting the consultation with the old or new values.

If for some reason you decide to interrupt the consultation without leaving the program (option "Stop"), and do not want to wait for the next programmed restart option, you should proceed as follows:

- Select option **File/ Open...**
- Select INITIAL.KB
- Select **Consult/Begin Consultation.**

An alternative way is to select instead of "INITIAL.KB" the file "GENERAL.KB". In this case however you can only repeat your consultation with the old inputted data.

Caution:
DO NOT resume an interrupted consultation with a knowledge base other than "INITIAL.KB" or "GENERAL.KB". Use the next "Stop" option and restart in the recommended way.

Values introduced by yourself can, in general, be changed by using the option **Consult/What if - parameter changes its value** as long as you don't leave the current knowledge base. The internal name of the parameter is showed in the Status Line of the screen.

V. Archiving

A. Report of a session

Creating a report of a session:
You may wish to save a report of the session (or of a part of it).
Then:

1. Select **File/New...**
2. Select the button command **Dialog** in the dialog box.
3. In the next dialog box **"Select items to be included"** you may check one or more of the four options:
   "Pictures",
   "Question/Answers",
   "Advice"
   "Title" .
4. As a result, a second window **"Dialog untitled.log"** is displayed on the consultation screen. The selected items of dialog are written in this window simultaneously with the consultation. The Dialog window remains open until you close it by clicking on the left upper corner button.

Save the report file:
Before closing the file you will be asked if you want to save it:
"Update untitled.log before closing?".
If the answer is "Yes" you will be asked for a name.

Save a selection from the report file:

1. Select **Edit/Copy**
2. In the new Window with the title
   "Copy text from dialog to clipboard"
   select with the mouse the text to copy to the clippboard,
3. Click on **Copy,** (Selected text is now on the clipboard)
4. Choose, using the **File** menu, a file in which you want to copy the selected text : a new file selecting **File/New...** or an already existing file selecting **File/Open...**
5. Select **Edit/Paste,** after the chosen file becomes active.

This procedure can be used repeatedly, allowing saving several selected texts from the consultation report. Just keep open the window **"untitled.log".**

B. Tables

In order to facilitate archiving, you will be asked for the tables with results that have been displayed, e.g.:
"Save Table(s) in file WALLS.TXT ?"
for the pressures on wall or
"Save Table(s) in file GUST.TXT ?"

for the predictions of along-wind response.
If you answer with "Yes", the files will be created independently of the fact that you asked for a report or not. The tables are kept unaltered until a new consultation with new values takes place, when they are overwritten with new results. If you wish to avoid overwriting tables you have to store them under a different name, e.g., WALLS1.TXT and GUST1.TXT before you begin a new consultation with new input. One of the ways to do this, after finishing the consultation is as follows:

1. With the main menu option **File/Open...** select WALLS.TXT
2. The table will be displayed on the screen
3. Select **File/Save As...** and save under a new name <filename>.TXT (e.g. WALLS1.TXT) in a directory at your convenience.

C. Inserting tables or report files in other files

The tables can also be inserted in other files, using the Windows word processor **Write** and the clippboard facility of Windows in the following way, starting from the program:

1. Select **File/Open**, then select <filename>.TXT respectively <filename>.LOG
2. The table will be displayed on the screen
3. Select text to be inserted
4. Select **Edit/Copy**.

The selected table is placed on the clipboard.
You switch now the word processor and proceed as follows:

1. Select **New** or **Open** (to open an existing file),
2. Select **Character/Fonts.../Terminal** (or equivalently see section VII for details)
3. Select a small **Size** .The size number can be also written by hand if the default numbers are not small enough.
4. Select **Edit/Paste** to insert the table in this file.

D. Save a selection of the screen display:

1. Highlight the fragment you wish to copy with keyboard using *Shift+Arrows* or mouse
2. Copy the fragment to the clipboard using *Ctrl+Ins*
3. Click the button Stop
4. Choose, using the File menu, a file in which you want to copy the selected text: a new file selecting **File/New** and then **Text file...** or an already existing file selecting **File/Open...**
5. Insert with *Shift+Ins*.

Note: If you do not wish to interrupt the consultation perform only operations described in items 1. and 2. . Insertion (paste) from the clipboard as described by points 4. and 5. can be carried out after completing the consultation.

Warning:
If the output has an undesired form, it is because the selected Font is different from **Terminal** or because the size of font is too big. You can remedy this by choosing Terminal after selecting again the table text. If this font is not on your list, you should find an equivalent (see Section VII). It is also possible that a table is too wide for the selected font size and its lines appear broken. After selecting the text to be fixed, choose **Character/ Fonts.../Terminal** and a smaller **Size** .

You can proceed in a similar way using a different word processor under Windows.

VI. Printing from the Program

Print the report file while the file is on the screen:

Select **File/Print**.

Print a selection of the report file:

1. Select **Edit/Copy,**
2. In the new Window with the title
   "Copy text from dialog to clipboard"
   the text appears highlighted: deactivate highlighting by clicking
3. Select the text to copy to the clippboard
4. Click on **Copy** (Selected text is now on the clipboard)
5. Select **File/New**
6. Select **Edit/Paste**
7. Select **File/Print**

Printing Files (Tables):

1. Select **File/Open**, then select <filename>.TXT
2. The table will be displayed on the screen
3. Select **File/Print**.

Print the content of an entire screen:

1. Copy the contents of the active window onto the Clipboard
   a. Make sure that the information you want to copy is in the active window
   b. Press *Alt+Print Screen*
2. Paste into an application accepting bitmaps, e.g. **Write** (the Word Processor of Windows) as follows:
   a. Click on the icon of **Write** or on the icon **Read Me!** in the Program Manager Group ASCE 7-95
   b. Select **File/New**
   c. Select **Edit/Paste**.
3. Print by selecting **File/Print.**

<u>If this procedure doesn't work</u>, press *Shift+Print Screen* (instead of *Alt+Print Screen*).

VII. What to Do If ...

1. If instead of vertical and horizontal lines your display shows other characters, you have to change the font and perhaps also the size of the font (this can be done selecting the **Size** number or by entering a number in the size box):

   a. Select **Edit/Fonts**
   b. Select the Font **Terminal** or **8514oem** or **MS LineDraw (True Type).**

2. You have on the screen points instead of letters you need a more recent version of **MS LineDraw (True Type)** (see **3.** and **4.** below).

3. If your print output changes the vertical and horizontal lines you see on screen into other characters:

   a. Select **Edit/Fonts**

   b. Select the Font **Terminal** or **8514oem.**

   c. If your printer output is still unsatisfactory, change to the font **MS LineDraw (True Type)** using the menu command **Edit/Fonts**. Of course, you can keep **"Terminal"** for display only.

   d. If this font is not on your list:
      d1. Activate the Main Group
      d2. Activate the Control Panel
      d3. Activate the Icon Fonts (or Select **Settings/Fonts**)
      d4. Select **Add...**
      d5. In the window: "Add Fonts" select the directory... **\Windows\System** and **OK**.
      d6. From the list displayed (list on fonts installed on your hard disk) select **MS LineDraw (True Type)** if available.

4. If you wish to install the font **MS LineDraw (True Type)**:

   a. Insert the diskette in drive a: or b:
   b. Activate the Main Group
   c. Activate the Control Panel
   d. Activate the Icon Fonts (or Select **Settings/Fonts**)
   e. Select **Add...**
   f. Select Drive a: or b:.
   g. Check if **"Copy Fonts to Windows Directory"** is crossed.
   h. Click on **Select All.**
   i. **OK.**

5. If the tables are correctly displayed on the screen, but when trying to print the files, a Windows error message is flashed:

This means that your Display Driver is not completely compatible with the Windows operating system. (Test by printing a text written in **Write** with the font Terminal or 8514oem). You need an updated display driver for your video board.

Three other solutions can also fix this problem:

a. For printing use the Microsoft True Type Font **MS LineDraw.**
To install it see point **3** and **4.**

b.Change your System Settings using the Windows Setup program and install an original Microsoft driver in the following way:

b1. Exit Windows.
b2. From the DOS prompt change to the Windows directory from the hard disk where Windows is installed with the command **cd\ windows** (press return).
b3. Type **setup** (press return).
b4. You will see the list "System Information" with your current Windows configuration:
Select with the arrow the option **Display: .....**
and press return.
b5. A new menu with display configurations is flashed.
b6. Select a new Microsoft display driver compatible with the monitor, i.e with a resolution not higher than supported (e.g.,a VGA with appropriate resolution)
b7. If Windows doesn't start, it means that you have to chose a lower resolution. Call the setup program again and repeat the procedure.

c. Go to DOS Prompt. Any existing *.TXT file can be displayed and printed with the usual DOS commands "type" and "print," respectively. You can also use the DOS editor "EDIT" for the same purpose.

Caution: Do not call text files containing tables directly from File Manager using the "Note Pad". Changing the files called in this manner can damage them.

APPENDIX

CALCULATION NOTES, AND NOTES ON THE COMPUTER PROGRAM

CALCULATION NOTES, AND NOTES ON THE COMPUTER PROGRAM

This Appendix contains excerpts from a large number of calculations performed for the purpose of testing the interactive computer program. We suggest that the reader perform these calculations independently by using the provisions of the ASCE Standard 7-95. The reader can then check the results of his/her hand calculations against the results yielded by the interactive computer program. The material included in this Appendix is intended to help the reader trace the source of errors in his/her calculations, in the event that such errors occur. This exercise should help the reader gain familiarity with the use of the ASCE Standard 7-95 provisions for wind loads. Since the reader is expected to use the Standard, notes and figures included therein are not reproduced in this Appendix. We also include in this section a few notes on the computer program. Occasional small differences between hand calculation and computer program results are due to round-off errors and are usually on the order of 0.1%. Examples A.1, A.5, A.7, A.18, and A.20 to A.24 were kindly supplied by Dr. R.D. Marshall.

A.1 Building (Mean Roof Height $h \leq 18.29$ m (60 ft))

Wind and Building Characteristics:

V=44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building dimension normal to ridge line: 12.19 m (40 ft)
Building dimension parallel to ridge line: 18.29 m (60 ft)
Eave height: 2.44 m (8 ft)
Gabled roof with slope $\theta=20°$
No openings in walls (i.e., building is not partially enclosed, see Section 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
No overhangs
Fundamental frequency larger than 1 Hz.

Importance factor: 1.00 (Table 6-2 of Standard)
Mean roof height: h=3.55 m (i.e., $h=8+(40/4)\tan(20°)=11.64$ ft)
$K_h=0.85$ (Table 6-3 of Standard)
$K_{zt}=1$ (no topographic effects)
$q_h=1041.87$ Pa ($q_h=(0.00256)(0.85)(1.0)(100)^2(1.0)=21.76$ psf — see Eq (1)
$GC_{pi}=\pm0.18$ (Table 6-4 of Standard)
Internal pressure=187.69 Pa ($(21.76)(\pm0.18)=\pm3.92$ psf).

A1.1 <u>Main Wind Force Resisting System</u>

WALLS (see Eq (3) of this report, and Table 6-1 and Fig. 6-3 of Standard)

Wind Normal to Ridge (L/B=40/60=0.67):

(see Fig. 6-3 of Standard; L and B are, respectively, horizontal dimension of building parallel and normal to wind direction).

From Fig. 6-3 of Standard:

Windward Wall: C_p= 0.8
Leeward Wall: C_p=-0.5
Side Wall: C_p=-0.7

From Section 6.6.1 of Standard:

G=0.85

(see definition following Eq (3) of this report).

Windward Wall:
External pressure: 708.63 Pa [(21.76)(0.85)(0.8)=14.80 psf]
Net pressure: 896.32 Pa [14.80-(-3.92)=18.72 psf] (neg. int. press.)
520.94 Pa [14.80-(3.92) =10.88 psf] (pos. int. press.)

Leeward Wall:
External pressure: 442.89 Pa [(21.76)(0.85)(-0.5)=-9.25 psf]
Net pressure: -255.20 Pa [-9.25-(-3.92)=-5.33 psf] (neg. int. press.)
-630.58 Pa [-9.25-(3.92)=-13.17 psf] (pos. int. press.)

Side Wall:
External pressure: -620.05 Pa [(21.76)(0.85)(-0.7)=-12.95 psf]
Net pressure: -423.36 Pa [-12.95-(-3.92)=-9.03 psf] (neg. int. press.)
-791.40 Pa [-12.95-(3.92)=-16.87 psf] (pos. int. press.)

Wind Parallel to Ridge (L/B=60/40=1.5):

Windward Wall: Same as above (up to eave level)

Leeward Wall:
External pressure: -354.31 Pa [(21.76)(0.85)(-0.4)=-7.40 psf]
Net pressure: -166.62 Pa [-7.40-(-3.92)=-3.48 psf] (neg. int. pressure)
-542.00 Pa [-7.40-(3.92)=-11.32 psf] (pos. int. pressure)

Side Wall: Same as above.

ROOF (see Eq 3 of this report, and Table 6-1 and Fig. 6-3 of Standard)

Wind Normal to Ridge:

h/L=11.64/40=0.291

Windward Slope (C_p values obtained by linear interpolation from Fig. 6-3 of Standard between values for h/L=0.25 and h/L=0.5):

C_p=-0.3+(-0.1)(0.291-0.25)/(0.5-0.25)=-0.316
C_p=(0.2)(0.5-0.291)/(0.5-0.25)=0.167

Leeward Slope:

C_p=-0.6

Windward Slope:
External pressure=-279.62 Pa [(21.76)(0.85)(-0.316)=-5.84 psf]
Net pressure: -91.93 Pa [-5.84-(-3.92)=-1.92 psf] (neg. int. press.)
-467.31 Pa [-5.84-(3.92) =-9.76 psf] (pos. int. press.)

External pressure: 147.95 Pa [(21.76)(0.85)(0.167)=3.09 psf]
Net pressure: 335.64 Pa [3.09-(-3.92)=7.01 psf] (neg. int. press.)
-39.74 Pa [3.09-(3.92)=-0.83 psf] (pos. int. press.)

Leeward Slope:
External pressure: -531.47 Pa [(21.76)(0.85)(-0.6)=-11.10 psf]
Net pressure: -343.78 Pa [-11.10-(-3.92)=- 7.18 psf] (neg. int. pressure)
-719.16 Pa [-11.10 -(3.92)=-15.02 psf] (pos. int. pressure)

Wind Parallel to Ridge:

h/L=11.64/60=0.194

Horizontal Distance From Windward Edge:

0-h/2: 0-1.77 m (0-5.82 ft)
C_p=-0.9; Ext. press.=-797.73 Pa [(21.76)(0.85)(-0.9)=-16.65 psf]

h/2-h: 1.77-3.55 m (5.82-11.64 ft)
C_p=-0.9; Ext. press.=-797.73 Pa (-16.65 psf)

h-2h: 3.55-7.10 m (11.64-23.28 ft)
C_p=-0.5; Ext. press.=-443.18 Pa [(21.76)(0.85)(-0.5)=-9.25 psf]

>2h: >7.10 m (>23.28 ft)
C_p=-0.3; Ext. press.=-265.73 Pa [(21.76)(0.85)(-0.3)=-5.55 psf]

0-h/2: Net press.=-609.52 Pa [-16.65-(-3.92)=-12.73 psf] (neg. int. press.)
=-984.90 Pa [-16.65-(3.92) =-20.57 psf] (pos. int. press.)

h/2-h: **Same as above**

h-2h: Net press.=-255.20 Pa [-9.25-(-3.92)=-5.33 psf] (neg. int. press.)
=-630.58 Pa [-9.25-(3.92)=-13.17 psf] (pos. int. press.)

>2h: Net press.= -78.04 Pa [-5.55-(-3.92)=-1.63 psf] (neg. int. press.)
=-453.43 Pa [-5.55-(3.32) =-9.47 psf] (pos. int. press.)

A.1.2 Components and Cladding

Recall that pressures depend on location of component or cladding, and on its area (sections 2 and 3.2.2 and Eq (6) of this report, and Fig. 6-5 of Standard).

WALLS

See Fig. 6-5 of Standard. In the calculations that follow the component is assumed to be located in two pressure zones, with respective areas as follows:

Zone 4: A=3.72 m^2 (40 sq ft)
Zone 5: A=0.93 m^2 (10 sq ft)
Total area of component: 4.65 m^2 (50 sq ft)

As was pointed out in Section 3.2.2 of this report, if a component is located in more than one zone, the pressure on the component is calculated by the weighting mean method, which is used below.

External pressure coefficients (based on total 3.72 m^2 (50 sq ft) area)[10]
Zone 4: GC_p=0.877 and -0.977
Zone 5: GC_p=0.877 and -1.153

Zone 4: Neg. external press.=-1018.89 Pa [(21.76)(-0.978)=-21.28 psf]
Net press.= -831.20 Pa [-21.28-(-3.92)=-17.36 psf] (neg. int. press.)
=-1206.58 Pa [-21.28-(3.92) =-25.20 psf] (pos. int. press.)

Pos. external press.=913.55 Pa [(21.76)(0.877)=19.08 psf]
Net press.= 1101.24 Pa [19.08-(-3.92)= 23.00 psf] (neg. int. press.)
= 725.86 Pa [19.08-(3.92) = 15.16 psf] (pos. int. press.)

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[10]The value GC_p=0.877 is obtained by interpolation as follows. For A=10 ft^2, GC_p=1.0; for A=500 ft^2, GC_p=0.7 (Fig. 6-5 of Standard). From these two points it is possible to obtain the values a and b of the line $a\ell n(A)+b = GC_p$. The results are $a=\{-0.3/[\ell n(500)-\ell n(10)]\}$, $b=1+\{0.3[\ell n(10)]/[\ell n(500)-\ell n(10)]\}$, so that for A=50 ft^2, GC_p=0.877.

Zone 5: Neg. external press.=-1200.35 Pa [(21.76)(-1.152)=-25.07 psf]
Net press.=-1012.66 Pa [-25.07-(-3.92)=-21.15 psf]
(neg. int. press.)
=-1388.04 Pa [-25.07-(3.92) =-28.99 psf]
(pos. int. press.)

Pos. ext. press.=913.55 Pa [(21.76)(0.877)=19.08 psf]
(same as for zone 4)
Net press.= 1101.25 Pa [19.08-(-3.92)= 23.00 psf]
(neg. int. press.)
= 725.86 Pa [19.08-(3.92) = 15.16 psf]
(pos. int. press.)

Average neg. press.: -1242.96 Pa [(40)(-25.20)+(10)(-28.99)]/50=-25.96 psf]
Average pos. press.: 1101.24 Pa [(40)(23.00)+(10)(23.00)]/50 = 23.00 psf]

For the sake of comparison, the reader should obtain computer program outputs[11].

A2 Building in Exposure B (Mean Roof Height $h \leq 18.29$ (60 ft)), Components and Cladding

We consider the same building as in Example A.1, but assume that the terrain corresponds to exposure B. The pressures on components and cladding are calculated as follows. Pressures are first calculated exactly as in Example A.1, by assuming Exposure C. The results so obtained are multiplied by the reduction factor 0.85 (see Note 11, Fig. 6-5 of Standard). For example, for the component described in Example A.1.2, the pressures are -1056.72 Pa [(0.85)(-25.96)=-22.07 psf] and 936.06 Pa [(0.85)(23.00)=19.55 psf].

A.3 Partially Enclosed Building

We consider the same building as in Example A.1, except that the walls and roof have openings specified as follows:

First long wall: A_o=10.31 m^2 (111 sq ft); second long wall: 0.93 m^2 (10 sq ft); first short wall: 1.86 m^2 (20 sq ft); second short wall: 1.86 m^2 (20 sq ft); roof: 4.65 m^2 (50 sq ft) (order of walls is immaterial).

The total area of openings in the building envelope not including the opening A_o is A_{oi}=9.29 m^2 (10+20+20+50=100 sq ft). The gross area of the wall with opening A_o is A_g=44.59 m^2 (60x8=480 sq ft). The gross area of the building envelope not including the area of the wall with opening A_o is A_{gi}=368.38 m^2 (3965.2 sq ft)

[11]To print a record of a session or part thereof, after starting the session the user should click "Stop," "File," "New," "Dialog," "Questions/Answers and Advice," "Consult," "Continue Consultation." Before end of session click "Stop," "File," Print." To print a file (e.g., file CC_WALLS.TXT), when asked "Save Tables in file CC_WALLS.TXT?" answer yes, click "Stop" and "Open," enter CC_WALLS.TXT in highlighted space underneath "File Name," and click "OK," then "File" and "Print." For more details see instructions for the user.

(this includes the gable wall ends).

It can be verified that this building is partially enclosed (see sect. 6.2 of Standard). The internal pressure coefficients (GC_{pi}) are therefore +0.8 and −0.3 (Table 6-4 of Standard). If, instead of A_o=10.31 m^2 (111 sq ft), we had assumed A_o=10.13 m^2 (109 sq ft), it can be verified that the conditions for a building to be partially enclosed would not have been met (see sect. 6.2 of Standard), and the pressure coefficients would have been the same as for the building of Example A.1, that is, ±0.18.

A.4 Building With Parapet (Mean Roof Height h≤18.29 m (60 ft))

Wind and Building Characteristics:

V=44.7 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building plan dimensions: 15.24 m x 15.24 m (50 ft x 50 ft)
Eave height: 6.1 m (20 ft)
Flat roof
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not located in a hurricane-prone region
No overhangs
Fundamental frequency greater than 1 Hz
Parapets: 1.52 m (5 ft) high.

Mean Wind Force Resisting System:
Parapets are ssumed to have no effect other than adding to the wind force acting on the walls the force due to external pressures acting on the parapets.

Components and Cladding:
Roof component, assumed in this example to have a 0.93 m^2 (10 sq ft) area in zone 3.

Mean roof height 6.1 m (h=20 ft).
K_h=0.9 (Table 6-3 of Standard).
Importance factor I=1.0 (Table 6-2 of Standard).
q_h= 1103.16 Pa (23.04 psf) (see Eq. 1 of this report).
(GC_p)=−1.8 (Fig. 6-5B of Standard; in accordance with note 6, for buildings with roof slopes θ<10 degrees, if a parapet with height equal to or larger than 0.91 m (3 ft) is provided, zone 3 (corner zone) shall be treated as zone 2 (edge zone)).
Internal pressure coefficient (GC_{pi})=±0.18 (Table 6-4 of Standard, building not open, not partially enclosed, and not sited in hurricane-prone region)

Negative pressures (see Eq (6) of this report):
-1785.93 Pa [(23.04)(-1.8+0.18)= 37.3 psf] (neg. int. press.)
-2184.30 Pa [(23.04)(-1.8-0.18)=-45.62 psf] (pos. int. press.)

A.5 Building With Roof Overhangs (Mean Roof Height h≤18.29 m (60 ft)

Wind and Building Characteristics:

V=44.7 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building dimension parallel to ridge: 30.48 m (100 ft)
Building dimension normal to ridge: 15.24 m (50 ft)
Eave height: 6.1 m (20 ft)
Gable roof with slope θ=20°
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
Fundamental frequency larger than 1 Hz
Overhangs: 1.22 m (4 ft).

Mean roof height h=7.48 m [20+(50/4)tan(20°)=24.55 ft]
K_h=0.936 (Table 6-3 of Standard)
q_h=1147.21 Pa (23.96 psf) (Eq (1) of this report).
Internal pressure coefficient (GC_{pi})=±0.18 (Table 6-4 of Standard, building not open, not partially enclosed, and not sited in hurricane-prone region)

Roof component no. 1 is assumed to have 1.86 m^2 (20 sq ft) area in zone 1:

(GC_p)=-0.870 and 0.440 (Fig. 6-5B of Standard)

Net pressures based on negative external pressures:
-791.46 Pa [(23.96)[(-0.870-(-0.18)]=-16.53 psf] (neg. int. press.)
-1204.67 Pa [(23.96)[(-0.870-(0.18)]= -25.16 psf] (pos. int. press.)

Net pressures based on positive external pressures:
711.5 Pa [(23.96)[0.440-(-0.18)]=14.86 psf] (neg. int. press.)
298.3 Pa [(23.96)[0.440-(0.18)]= 6.23 psf] (pos. int. press.)

Roof component no. 2 is assumed to have 3.72 m^2 (40 sq ft) area, of which 1.86 m^2 (20 sq ft) in zone 1 and 1.86 m^2 (20 sq ft) in zone 2. For a similar set of calculations, see Section A.1.2 in this Appendix.

Zone 1: (GC_p)=-0.840 and 0.380 (based on the 3.72 m^2 (40 sq ft) area of the entire component — see Fig. 6-5B of Standard)
Zone 2: (GC_p)=-1.679 and 0.380 (based on the 3.72 m^2 (40 sq ft) area of the entire component)

Calculated net pressures assuming entire component extends over one zone only:

Zone 1: −756.98 Pa (−15.81 psf) and −1170.19 Pa (−24.44 psf); 642.55 Pa (13.42 psf) and 229.35 Pa (4.79 psf)
Zone 2: −1719.84 Pa (−35.92 psf) and −2132.57 Pa (−44.54 psf); 642.55 Pa (13.42 psf) and 229.35 Pa (4.79 psf)

Weighted net pressures:
For negative internal pressures:
−1238.66 Pa {[(20)(−15.81)+(20)(−35.92)]/40=−25.87 psf]}
642.55 Pa (13.42 psf)
For positive internal pressures:
−1651.38 Pa {[(20)(−24.44)+(20)(−44.54)]/40=−34.49 psf]
229.35 Pa (4.79 psf)

Roof component no. 3 is assumed to have 3.72 m^2 (40 sq ft) total area. It is further assumed that a 2.23 m^2 (24 sq ft) portion of the component is not an overhang area; and that, of this portion, a 1.86 m^2 (20 sq ft) area is in zone 1 and a 0.37 m^2 (4 sq ft) area is in zone 2. The balance of the area of component 3, that is, a 1.49 m^2 (16 sq ft) portion is assumed to be an overhang area belonging to zone 2.

First set of calculations (only area over zone 1 and zone 2 not including the overhang (i.e., only 2.23 m^2 (24 sq ft) area) is considered):

External pressure coefficients based on the total 2.23 m^2 (24 sq ft) area:
Zone 1: (GC_p)=−0.862 and 0.424
Zone 2: (GC_p)=−1.834 and 0.424

Net pressures:
Zone 1: −782.36 Pa {(23.96)[−0.862−(−0.18)]=−16.34 psf} and
−1195.56 Pa {(23.96)[−0.862−(0.18)]=−24.97 psf}

692.82 Pa {(23.96)[0.424−(−0.18)]=14.47 psf}
280.10 Pa {(23.96)[0.424−(0.18)] = 5.85 psf}

Zone 2: −1897.48 Pa {(23.96)[−1.834−(−0.18)]=−39.63 psf}
−2310.69 Pa {(23.96)[−1.834−(0.18)] =−48.26 psf}

692.82 Pa {(23.96)[0.424−(−0.18)]=14.47 psf}
280.10 Pa {(23.96)[0.424−(0.18)] = 5.85 psf}

Weighted net pressures:
For negative internal pressures:
−968.13 Pa {[(20)(−16.34)+(4)(−39.63)]/24=−20.22 psf}
692.82 Pa (14.47 psf)
For positive internal pressure:
−1381.34 Pa {[(20)(−24.97)+(4)(−48.26)]/24=−28.85 psf}
280.10 Pa (5.85 psf)

Second set of calculations (based on the total 3.72 m^2 (40 sq ft) area, that is, overhang area is also considered):

External pressure coefficients:
Zone 1: $(GC_p)=-0.840$
Zone 2: $(GC_p)=-1.679$
Overhang: $(GC_p)=-2.200$ (independent of area, see Fig. 6-5B of Standard)

Net pressures:
Zone 1: −756.98 Pa {(23.96)[−0.840−(−0.18)=−15.81 psf}
−1170.19 Pa {(23.96)[−0.840−(0.18)= −24.44 psf}

Zone 2: −1719.85 Pa {(23.96)[−1.679−(−0.18)=−35.92 psf}
−2132.58 Pa {(23.96)[−1.679−(0.18)= −44.54 psf}

Overhang: −2523.75 Pa [(23.96)(−2.2)=52.71 psf] (not affected by internal pressures)

Weighted net pressures:

For negative internal pressures:
−1559.93 Pa {[(20)(−15.81)+(4)(−35.92)+(16)(−52.71)]/40=−32.58 psf}
For positive internal pressures:
−1807.95 Pa {[(20)(−24.44)+(4)(−44.54)+(16)(−52.71)]/40=−37.76 psf}

Roof component no. 4 — assumed total area 9.29 m^2 (100 sq ft). A 3.34 m^2 (36 sq ft) portion of the component is not an overhang area. Of this portion 2.32 m^2 (25 sq ft) are in zone 1, 0.929 m^2 (10 sq ft) in zone 2, and 0.093 m^2 (1 sq ft) in zone 3. A 5.95 m^2 (64 sq ft) portion of the component is an overhang area, of which 3.72 m^2 (40 sq ft) are in zone 2 and 2.23 m^2 (24 sq ft) in zone 3.

First set of calculations (based on area over zone 1, and zones 2 and 3 not including overhang, that is, based on 3.34 m^2 (36 sq ft) area):

External pressure coefficients [based on the total 3.34 m^2 (36 sq ft area)]
Zone 1: $(GC_p)=-0.844$ and 0.389
Zone 2: $(GC_p)=-1.711$ and 0.389
Zone 3: $(GC_p)=-1.711$ and 0.389

Net pressures (calculation is left as an exercise for the reader):

Zone 1:	−761.77 Pa (−15.91 psf)	and	−1174.98 Pa	(−24.54 psf)
	652.60 Pa (13.63 psf)	and	239.88 Pa	(5.01 psf)
Zone 2:	−1756.24 Pa (−36.68 psf)	and	−2169.44 Pa	(−45.31 psf)
	652.60 Pa (13.63 psf)	and	239.88 Pa	(5.01 psf)
Zone 3:	−1756.24 Pa (−36.68 psf)	and	−2169.44 Pa	(−45.31 psf)
	652.60 Pa (13.63 psf)	and	239.88 Pa	(5.01 psf)

Weighted net pressures:

For negative internal pressure:
−1065.81 Pa {[(25)(−15.91)+(10)(−36.68)+(1)(−36.68)]/36=−22.26 psf}
652.60 Pa (13.63 psf)

For positive internal pressure:
-1479.01 Pa {[(25)(-24.54)+(10)(-45.31)+(1)(-45.31)]/36=-30.89 psf}
239.88 Pa (5.01 psf)

Second set of calculations [based on total 9.29 m^2 (100 sq ft area)]:
External pressure coefficients:
Zone 1: $(GC_p)=-0.8$ and 0.3
Zone 2: $(GC_p)=-1.4$ and 0.3
Zone 3: $(GC_p)=-1.4$ and 0.3
Overhang, zone 2: $(GC_p)=-2.2$
Overhang, zone 3: $(GC_p)=-2.5$

Net pressures (calculation is left as an exercise for the reader):
Zone 1: -711.50 Pa (-14.86 psf) and -1124.22 Pa (-23.48 psf)
Zone 2: -1399.53 Pa (-29.23 psf) and -1812.74 Pa (-37.86 psf)
Zone 3: -1399.53 Pa (-29.23 psf) and -1812.74 Pa (-37.86 psf)
Overhang, zone 2: -2523.75 Pa (-52.71 psf)
Overhang, zone 3: -2868.12 Pa (-59.90 psf)

Weighted net pressures:
For negative internal pressure:
-2029.63 Pa {[(25)(-14.86)+(10+1)(-29.23)+(40)(-52.71)+(24)(-59.9)]/100 =-42.39 psf}
For positive internal pressure:
-2178.06 Pa {[(25)(-23.48)+(10+1)(-37.86)+(40)(-52.71)+(24)(-59.9)]/100 =-45.49 psf}

A.6 <u>Building With Parapet (Mean Roof Height 18.29 m) (h>60 ft)</u>

Wind and Building Characteristics:

V=100 mph (44.70 m/s)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building plan dimensions: 15.24 m x 15.24 m (50 ft x 50 ft)
Eave height: 28.96 m (95 ft)
Flat roof
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No overhangs
Fundamental frequency larger than 1 Hz
Parapets: 1.52 m (5 ft) high.

Main Wind Force Resisting System:
Parapets are assumed to have no effect on the main wind force resisting system other than adding the wind force acting on them to the wind force acting on the walls.

Components and Cladding

Mean roof height h=28.96 m (95 ft)

K_h=1.25 (Table 6-3 of Standard)

q_h=1532.16 Pa (32.00 psf) (Eq. 1 of this report).

Roof component 1, assumed to have area 0.93 m^2 (10 sq ft) in zone 1. (GC_p)=-1.4 (Fig. 6-8 of Standard). Pressures are 1868.24 Pa {32[-1.4-(-0.18)]=-39.04 psf} and 2420.81 Pa {32[-1.4-(0.18)]=-50.56 psf}.

Roof component 2, assumed to have area 0.93 m^2 (10 sq ft) in zone 2. (GC_p)=-2.3 (Fig. 6-8 of Standard). Pressures are -3248.18 Pa {32[-2.3-(-0.18)]=-67.84 psf} and 3799.76 Pa {32[-2.3-(0.18)]=-79.36 psf}.

Roof component 3 is assumed to have total area 0.93 m^2 (10 sq ft) of which 0.186 m^2 (2 sq ft) in zone 1, 0.278 m^2 (3 sq ft) in zone 2 and 0.465 m^2 (5 sq ft) in zone 3. (GC_p)=-1.4 for zone 1, -2.3 for zone 2, and -2.3 for zone 3 (Fig. 6-8 of Standard, including note 7, which states that if a parapet with height equal to or larger than 0.91 m (3 ft) is provided, zone 3 is treated like zone 2). Pressures calculated for the area in zone 1 are:

-1869.24 Pa {32[-1.4-(-0.18)]=-39.04 psf}
-2420.8 Pa {[32{-1.4-(0.18)]=-50.56 psf}

and for the areas in zones 2, 3:

-3248.18 Pa {32[-2.3-(-0.18)]=-67.84 psf}
-3799.76 Pa {32[-2.3-(0.18)]=-79.36 psf}.

The pressures acting on the component are obtained by taking the weighted average of the pressures over the areas of the component within zones 1, 2 and 3, the weights consisting of the respective areas, that is,

-2972.39 Pa {[(-39.04)(2)+(-67.84)(3)+(-67.84)(5)]/(2+3+5)=-62.08 psf)
-3523.97 Pa {[(-50.56)(2)+(-79.36)(3)+(-79.36)(5)]/(2+3+5)=-73.60 psf}.

A.7 Building (Mean Roof Height 18.29 m (60 ft)<h<27.43 m (90 ft) and Height-to-Width Ratio <1), Components and Cladding

Building Characteristics: **plan dimensions**: 27.43 m x 27.43 m (90 ft x 90 ft); **eave height: 24.38 m (80 ft); flat roof. Other characteristics as in Example A6.**

Since 18.28 m (60 ft)<h<27.43 m (90 ft) and the height-to-width ratio does not exceed 1, we use Fig. 6-5, rather than Fig. 6-8 of the Standard (see text following Eq (7) of this report).

Roof component, is assumed to be in zone 2 and to have area= 0.093 m^2 (10 sq ft). **The external pressure coefficients** (GC_p) are -1.8 and 0.3. (Fig. 6-5B of the Standard). Had the plan dimensions been 80 ft x 80 ft, (GG_p) would have been -2.3 (Table 6-8 of the Standard).

A.8 <u>Low-rise Building</u>

Wind and Building Characteristics:

V=44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building dimension parallel to ridge: 30.48 m (100 ft)
Building dimension normal to ridge: 15.24 m (50 ft)
Eave height: 6.096 m (20 ft)
Gable roof with slope θ=20°
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
No overhangs
Fundamental frequency larger than 1 Hz.

Importance factor: 1.00
Mean roof height: h=7.48 m [20+(50/4)tan(20°)=24.55 ft]
K_h=0.936 (Table 6-3 of Standard)
K_{zt}=1
q_h=1147.21 Pa [(0.00256)(0.936)(1.00)(100)^2(1.00) =23.96 psf] (see Eq. 1 of this report)
Internal pressure= 206.36 Pa [(23.96)(±0.18) = ±4.31 psf] (see Table 6-4 of Standard).

Main Wind Force Resisting System (based on Fig. 6-4 of Standard) (1 psf=47.88 Pa)

LOAD CASE A (see Fig. 6-4 of the Standard and Fig. C6-2 of Commentary to the Standard)

Building Surface	GC_{pf}	$GC_{pf}-GC_{pi}$ (neg. int. press.)	Net p/47.88* (neg. int. press.)	$GC_{pf}-GC_{pi}$ (pos. int. press.)	Net p/47.88* (pos. int. press.)
1	0.53	0.71	17.01	0.35	8.39
2	−0.69	−0.51	−12.22	−0.87	−20.85
3	−0.48	−0.30	−7.19	−0.66	−15.81
4	−0.43	−0.25	−5.99	−0.61	−14.62
1E	0.80	0.98	23.48	0.62	14.86
2E	−1.07	−0.89	−21.32	−1.25	−29.95
3E	−0.69	−0.51	−12.22	−0.87	−20.85
4E	−0.64	−0.46	−11.02	−0.82	−19.65

*p=pressure in Pa

LOAD CASE A ROTATED (see Fig. 6-4 of the Standard and Fig. C6-2 of Commentary to the Standard)

Building Surface	GC_{pf}	$GC_{pf}-GC_{pi}$ (neg. int. press.)	Net p/47.88* (neg. int. press.)	$GC_{pf}-GC_{pi}$ (pos. int. press.)	Net p/47.88* (pos. int. press.)
1	0.40	0.58	13.90	0.22	5.27
2**	-0.69	-0.51	-12.22	-0.87	-20.85
3	-0.37	-0.19	-4.55	-0.55	-13.18
4	-0.29	-0.11	-2.64	-0.47	-11.26
1E	0.61	0.79	18.93	0.43	10.30
2E	-1.07	-0.89	-21.32	-1.25	-29.95
3E	-0.53	-0.35	- 8.39	-0.71	-17.01
4E	-0.43	-0.25	- 5.99	-0.61	-14.62

*p=pressure in Pa
** See Note 4, Figure 6-4 of Standard.

LOAD CASE B (same values as for CASE B ROTATED, see Fig. 6-4 of the Standard and Fig. C6-2 of Commentary to the Standard)

Building Surface	GC_{pf}	$GC_{pf}-GC_{pi}$ (neg. int. press.)	Net p/47.88* (neg. int. press.)	$GC_{pf}-GC_{pi}$ (pos. int. press.)	Net p/47.88* (pos. int. press.)
1	-0.45	0.27	-6.47	-0.63	-15.09
2	-0.69	-0.51	-12.22	-0.87	-20.85
3	-0.37	-0.19	-4.55	-0.55	-13.18
4	-0.45	-0.27	-6.47	-0.63	-15.09
5	0.40	0.58	13.90	0.22	5.27
6	-0.29	-0.11	-2.64	-0.47	-11.26
1E	-0.48	-0.30	-7.19	-0.66	-15.81
2E	-1.07	-0.89	-21.32	-1.25	-29.95
3E	-0.53	-0.35	-8.39	-0.71	-17.01
4E	-0.48	-0.30	-7.19	-0.66	-15.81
5E	0.61	0.79	18.93	0.43	10.30
6E	-0.43	-0.25	-5.99	-0.61	-14.62

A.9 Hipped Roof

Wind and Building Characteristics:

V=44.7 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open; building dimension parallel to ridge: 18.29 m (60 ft)
Building dimension normal to ridge: 12.19 m (40 ft)
Eave height: 2.44 m (8 ft)
Hipped roof with slopes θ=20°
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
Fundamental frequency larger than 1 Hz.

q_h=1041.87 Pa (21.76 psf)
Internal pressures: ±187.69 Pa (±3.92 psf)

Assumed area of component: 0.93 m^2 (10 sq ft), zone 2; use Eq (6) of this report (taken from Table 6-1 of Standard). Use Fig. 6-5B of Standard.

A.9.1. No Overhangs. External pressure coefficients: (CG_p)=-2.1 and 0.5. External pressures: -2188.13 Pa (-45.7 psf) and 520.93 Pa (10.88 psf). Design pressures: -2375.33 Pa (-49.61 psf) and 708.62 Pa (14.8 psf).

A.9.2 Overhangs (1.22 m (4 ft)). External pressure coefficients: (CG_p)=-2.2 and 0.5. External pressures: -2292.02 Pa (-47.87 psf) and 520.93 Pa (10.88 psf). Design pressures: -2479.71 Pa (-51.79 psf) and 708.62 Pa (14.8 psf).

A.10 One-stepped Roofs

Wind and Building Characteristics:

V=44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building dimension parallel to roof steps: 30.48 m (100 ft)
Building dimension normal to roof steps: 17.24 m (50 ft)
Height of upper roof level: 9.14 m (30 ft)
Height of lower roof level: 4.57 m (15 ft)
Width of upper roof level: 7.62 m (25 ft)
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
No overhangs
Fundamental frequency larger than 1 Hz.

h=9.14 m (30 ft)
q_h=1201.31 Pa [(0.00256)(0.98)$(100)^2$(1)=25.09 psf]
Internal pressure ±216.42 Pa [(25.09)(±0.18)=±4.52 psf].
Width of edge strips: 1.52 m (5 ft) (see Note 12 of Fig. 6-5 of Standard)

Use Fig. 6-5C and Note 9, Fig. 6-5 of Standard.

Component No.1: assumed to be on lower roof, with area 0.93 m^2 (10 sq ft), in cross-hatched zone of Fig. 6-5C of the Standard, zone 1 (middle part of strip). Positive pressure: (GC_p)=1 (Note 9 of Fig. 6-5, and Fig. 6-5 of Standard), so p=1417.73 Pa [25.09(1)+4.52=29.61 psf]. Negative pressure: (GC_p)=-1 (Note 9 of Fig. 6-5, and bottom left plot of Fig. 6-5B), so negative design pressure is p=-1417.73 Pa [25.09(-1)-4.52=-29.61 psf].

Component No.2: assumed to be on lower roof, with area 0.93 m^2 (10 sq ft), in cross-hatched zone of Fig. 6-5C of the Standard, zone 2 (end part of strip). Positive pressure: (GC_p)=1 (Note 9 of Fig. 6-5, and Fig. 6-5 of Standard), so p=1417.73 Pa [25.09(1)+4.52=29.61 psf]. Negative pressure: (GC_p)=-1.8 (Note 9 of Fig. 6-5, and bottom left plot of Fig. 6-5B), so negative design pressure is p =-2378.68 Pa [25.09(-1.8)-4.52=-49.68 psf].

Component No.3: assumed to be on lower roof or upper roof, with area 0.93 m^2 (10 sq ft), in zone 3. Negative pressure: (GC_p)=-2.8 (Note 9 of Fig. 6-5, and bottom left plot of Fig. 6-5B), so negative design pressure is p=-3580 Pa [25.09(-2.8)-4.52=-74.77 psf].

Component No.4: assumed to be on lower roof or upper roof, with area 0.93 m^2 [10 sq ft] of which 1.52 m^2 (5 sq ft) in zone 2 and 1.52 m^2 (5 sq ft) in zone 3. Negative design pressure is p=-2979.57 Pa {[(-49.68)(5)+(-74.77)(5)]/10=-62.23 psf}.

A.11 Two-stepped Roof

Input same as for Example A.10, except for building dimensions, which are as follows. Building dimension parallel to roof steps: 30.48 m (100 ft); building dimension normal to roof steps: 27.43 m (90 ft); height of upper roof level: 9.14 m (30 ft); height of lower roof level: 4.57 m (15 ft); width of upper left roof level: 9.14 m (30 ft); width of lower roof level: 9.14 m (30 ft).

Component No. 1: area 0.93 m^2 (10 sq ft), lower roof, zone 2. Negative design pressure: -2378.68 Pa [(25.09)(-1.8-0.18)=-49.68 psf] (Fig. 6-5C of Standard).

A.12 Multi-span Gabled Roof

Wind and Building Characteristics:

V= 44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building dimension parallel to ridge line: 30.48 m (100 ft)
Building dimension normal to ridge line: 17.24 m (50 ft)
Width of one gabled roof span: 8.62 m (25 ft)
Eave height: 6.10 m (20 ft)
Roof slopes θ=20°
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
No overhangs
Fundamental frequency larger than 1 Hz.

Mean roof height h=6.79 m [20+(25/4)tan(20°)=22.27 ft]
K_z=0.9182
q_h=1125.66 Pa (23.51 psf).

See Fig. 6-6 of Standard.

Component No. 1: assumed to have 0.93 m^2 (10 sq ft) area in zone 1. Pressures: – 2003.78 Pa [(–1.6–0.18)(23.51)=–41.85 psf] and 878.12 Pa [(0.6+0.18)(23.51)= 18.34 psf].

A.13 Monoslope Roof

Wind and Building Characteristics:

V=44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building dimension parallel to ridge line: 30.48 m (100 ft)
Building dimension normal to ridge line: 6.1 m (20 ft)
Eave height: 6.1 m (20 ft)
Roof slope θ=20°
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
No overhangs
Fundamental frequency larger than 1 Hz.

Mean roof height h=7.21 m (20+(20/2)tan(20°)=23.64 ft)
K_z=0.9291
q_h=1139.07 Pa (23.79 psf).

See Fig. 6–7A of Standard.

Component No. 1: assumed to have 0.93 m^2 (10 sq ft) area in zone 2. Negative design pressure: –2027.73 Pa [(–1.6–0.18)(23.79)=–42.35 psf].

A.14 Sawtooth Roof

Wind and Building Characteristics:

V=44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Building dimension parallel to ridge line: 15.24 m (50 ft)
Building dimension normal to ridge line: 12.19 m (40 ft)
Eave height: 3.05 m (10 ft)
Roof slope θ=20°
Width of one roof span: 3.05 m (10 ft)
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane–prone region
No parapets
No overhangs
Fundamental frequency larger than 1 Hz.

Mean roof height h=3.60 m [10+(5/2)tan(20°)=11.82 ft]
K_z=0.85
q_h=1041.87 Pa (21.76 psf).

See Fig. 6–7B of Standard.

Component No. 1: assumed to have 0.93 m^2 (10 sq ft) area in zone 3, Span A (see Fig. 6–7B of Standard). Negative design pressure: –4459.06 Pa [(–4.1–0.18)(21.76) =–93.13 psf].

Component No. 2: assumed to have 0.93 m^2 (10 sq ft) area in zone 3, Spans B, C, D (see Fig. 6–7B of Standard). Negative design pressure: –2896.26 Pa [(–2.6–0.18)(21.76)=–60.49 psf].

A.15 Tall Flexible Building, Main Wind Force Resisting System

For the building of Example 9 included in the diskette attached to this report, we reproduce excerpts from results obtained by hand calculations (for notations, see sect. C6.6 of Commentary to ASCE 7-95 Standard) Q^2=0.5883; $\bar{V}_{\bar{z}}$ = 26.769 m/s (87.826 ft/s); N_1=1.354; R_n=0.111; R_b=0.555; R_h=0.1465; R_d=0.2445; R^2=0.584; G=1.056; K=0.502; maximum acceleration at 182.88 m (600 ft) elevation: 0.2377 m/s^2 (0.78 ft/s^2).

A.16 Arched Roof, Main Wind Force Resisting System

Wind and Building Characteristics:

V=44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building not open
Dimension parallel to arch axis: 30.48 m (100 ft)
Dimension normal to arch axis: 15.24 m (50 ft)
Spring-line slope θ=20°
Eave height: 6.096 m (20 ft)
Rise-to-span ratio: r=0.09
Mean roof height: 6.77 m (22.2 ft)
No openings in walls (i.e., building is not partially enclosed, see sect. 6.2 of Standard)
Building not in a hurricane-prone region
No parapets
No overhangs
Fundamental frequency larger than 1 Hz.

K_h=0.918
q_h=1125.19 Pa ((0.00256)(0.918)(100^2)= 23.5 psf)
Internal pressure: ±202.53 Pa ((±0.18)(23.5)=±4.23 psf).

See Table 6-5 of Standard.

Pressures, Wind Normal to Axis:

Windward Quarter: −1063.42 Pa [(23.5)(0.85)(−0.9)−4.23=−22.21 psf]
−667.93 Pa [(23.5)(0.85)(−0.9)+4.23=−13.75 psf]

Center half: C_p=−0.7−r=−0.79

−958.08 Pa [(23.5)(0.85)(−0.79)−4.23=−20.01 psf]
−553.02 Pa [(23.5)(0.85)(−0.79)+4.23=−11.55 psf]

Leeward quarter: −680.86 Pa [(23.5)(0.85)(−0.5)−4.23=−14.22 psf]
−257.79 Pa [(23.5)(0.85)(−0.5)+4.23=− 5.76 psf]

Pressures, Wind Parallel to Axis:

Windward Quarter (see note 3 of Table 6-5 of Standard)

$h/L=22.2/100=0.222$

0-h (i.e., 0-6.77 m (0-22.2 ft)): $C_p=-0.9$, pressures identical to those for windward quarter)

h-2h (i.e., 6.77 m (22.2 ft)-13.53 m (44.4 ft)): $C_p=-0.5$ (p=-679.9 Pa (-14.2 psf) and p=-275.8 Pa (-5.76 psf)

>2h (i.e., > 13.53 m (44.4 ft)): $C_p=-0.3$, p=-489.34 Pa (-10.22 psf) and p=-84.27 Pa (-1.76 psf).

A.17 Monoslope Roof over Open Building

Wind and Structure Characteristics:

V=44.70 m/s (100 mph)
Exposure C
Building classification: category II
Building not situated on or near hills or escarpments
Building open
Roof dimension parallel to wind direction: L= 15.24 m (50 ft)
Building dimension normal to wind direction: B= 30.48 m (100 ft)
Roof slope $\theta=20°$
Maximum height of roof from ground: 11.92 m (39.1 ft).

See Tables 6-1 and 6-6 of Standard.[12]

z=11.92 m (39.1 ft)
$K_z=1.035$
$q_h=1268.35$ Pa [$(0.00256)(1.035(100^2)=26.49$ psf]
Area of roof: $A_f=494.33\ m^2$ [(100)[50/cos(20°)]=5320.9 sq ft].

[12]Table 6-1 of the Standard specifies the use of pressures q_z at heights z, rather than the use of a single pressure q_h at the mean roof height h. Since pressures increase with height, the use of a single pressure q_h in conjunction with the total area of the roof would underestimate the total force based on pressures q_z multiplied by the respective tributary areas. To avoid such underestimation, the force acting on the roof may be based on the pressure calculated at the top of the roof, used in conjunction with the total area of the roof. This conservative approach is used in this section and in the computer program. Note that the program can be used to calculate forces on horizontal strips of the roof. These forces could then be added up to yield the total force on the roof.

For wind deviating 10° from horizontal:

$F=q_zGC_fA_f=293\ 078$ N [(26.49)(0.85)(0.55)(5320.9)=65.89 kips]

For wind deviating −10° from horizontal:

$F=q_zGC_fA_f=639\ 622$ N [(26.49)(0.85)(1.2)(5320.9)=143.8 kips]

Location of center of presssure, X/L:

For wind deviating 10° from horizontal: X/L=0.3
For wind deviating −10° from horizontal: X/L=0.45.

A.18 Tank

Wind and Structure Characteristics: V= 44.70 m/s (100 mph); exposure C; structure classification: category I (I=0.87); tank not situated on or near hills or escarpments; height of tank: h=18.29 m (60 ft); surface roughness: rough (see Note 3, Table 6–7 of Standard); diameter: D= 6.1 m (20 ft).

(1 ft=0.3048 m; 1 psf=47.88 Pa; 1 lb/ft=14.59 N/m)

$q_z=1066.29K_z$ Pa [$(0.00256)(K_z)(V^2)I=(0.00256)(100^2)(0.87)K_z=22.27\ K_z$ psf]; h/D=60/20=3; $C_f=0.7+(1/3)(0.8-0.7)=0.733$; G=0.85; $A_f=6.1$ m^2/m (20 ft^2/ft) of height.

$F=q_zGC_fA_f=(0.85)(0.733)A_fq_z$

z/0.3048 (z in m)	K_z	$q_z/47.88$ (q_z in Pa)	F/14.59 (F in N/m)
0–15	0.85	18.93	235.9
20	0.90	20.04	249.7
25	0.94	20.94	260.8
30	0.98	21.83	271.9
40	1.04	23.16	288.6
50	1.09	24.27	302.4
60	1.13	25.17	313.6

A.19 Chimney

Wind and Structure Characteristics:

$V=44.7$ m/s (100 mph)
Exposure C
Structure classification: category I ($I=0.87$)
Chimney not situated on or near hills or escarpments
Height of chimney: $h=24.38$ m (80 ft)
Shape in plan: square
Side of square: 4.57 m (15 ft)
Fundamental frequency, oscillations normal to side of square: 0.2 Hz;
Fundamental frequency, oscillations along diagonal: 0.1 Hz
Damping ratio: 0.015.

See Table 6-7 of Standard.

$h/D=80/15=0.33$

$C_f=1.372$ normal to side of square
$C_f=1.072$ along diagonal

$q_h=1290.37$ Pa $[(0.00256)(1.21)(100^2)(0.87)=26.95$ psf$]$

Force at top of chimney per unit length:

$F=q_hG_fC_fA_f=8084.62$ N/m $[(26.95)(1.372)(15)G_f=554.6\ G_f$ lb/ft$]$ (for direction normal to side of square; use value of G_f corresponding to this direction)

$F=q_hG_fC_fA_f=8942.79$ N/m $[(26.95)(1.072)(15)(2)^{1/2}G_f=612.8\ G_f$ lb/ft$]$ (for diagonal direction; use value of G_f corresponding to diagonal direction)

The calculation of the gust response factors is left to the reader as an exercise. It is performed automatically by the computer program. Note that the computer program also has the capability for calculating wind loads on hexagonal and octagonal chimneys and similar structures, and on tapered chimneys.

A.20 Solid Sign Above Ground Level

Wind and Structure Characteristics: 44.70 m/s (V=100 mph); exposure C; structure classification: category I (I=0.87); sign not situated on or near hills or escarpments; ratio of openings to gross area: 0 (see Note 1, Table 6-8 of Standard); distance from ground to bottom edge of sign: 3.05 m (10 ft); height above ground of top edge of sign: 9.14m (30 ft); width of sign: N=0.61 m (2 ft).

Larger dimension of sign: M=6.05 m (30-10=20 ft); M/N=20/2=10; C_f=1.3 (Table 6-8 of Standard); q_z=1066.29 Pa ($0.00256K_zV^2I=22.27K_z$ psf).

(1 ft=0.3048 m; 1 psf=47.88 Pa; 1 lb/ft=14.59 N/m)

$F=q_zGC_fA_f=2.21q_z$

z/0.3048 (z in m)	K_z	q_z/47.88 (q_z in Pa)	F/14.59 (F in N/m)
0-15	0.85	18.93	41.8
20	0.90	20.04	44.3
25	0.94	20.94	46.3
30	0.98	21.83	48.2

NOTE. The force F is proportional to the gust effect factor G if the sign is not flexible (Table 6-1 of Standard). If the sign is flexible, the forces obtained as shown above should be multiplied by the ratio G_f/G, where G_f is a gust effect factor that accounts for the structure's flexibility and should be obtained by rational analysis (Table 6-1 of Standard). Neither the Standard nor the program offers guidance on the calculation of G_f for this case. Depending upon the specific example at hand, the user may consider adapting for this case the method for calculating the gust effect factor given in Section C6.6 of the Commentary to the Standard.

A.21 Solid Sign at Ground Level

Wind and Structure Characteristics: 44.70 m/s (V=100 mph); exposure C; structure classification: category I (I=0.87); sign not situated on or near hills or escarpments; ratio of openings to gross area: 0 (see Note 1, Table 6-8 of Standard); height of sign: 12.19 m (H=40 ft); width of sign: W= 1.52 m (5 ft).

Ratio ν=H/W=40/5=8; C_f=1.4 (Table 6-8 of Standard); q_z=1066.29 Pa [$0.00256K_zV^2I=22.27K_z$ psf].

(1 ft=0.3048 m; 1 psf=47.88 Pa; 1 lb/ft=14.59 N/m)

$F=q_zGC_fA_f=(0.85)(1.4)(5.0)q_z=5.95q_z$

$z/0.3048$ (z in m)	K_z	$q_z/47.88$ (q_z in Pa)	$F/14.59$ (F in N/m)
0–15	0.85	18.93	112.6
20	0.90	20.04	119.3
25	0.94	20.94	124.6
30	0.98	21.83	129.9
40	1.04	23.16	137.8

NOTE. The force F is proportional to the gust effect factor G if the sign is not flexible (Table 6-1 of Standard). If the sign is flexible, the forces obtained as shown above should be multiplied by the ratio G_f/G, where G_f is a gust effect factor that accounts for the structure's flexibility and should be obtained by rational analysis (Table 6-1 of Standard). Neither the Standard nor the program offers guidance for the calculation of G_f in this case. Depending upon the specific example at hand, the user may consider adapting for this case the method for calculating the gust effect factor given in Section C6.6 of the Commentary to the Standard.

A.22 Open Sign With Flat-sided Members

Wind and Structure Characteristics: 44.70 m/s (V=100 mph); exposure C; structure classification: category I (I=0.87); sign not situated on or near hills or escarpments; ratio of solid area to gross area: ϵ=0.5 (see Note 4, Table 6-9 of Standard); heigth above ground of bottom of sign: 3.05 m (10 ft); height above ground of top of sign: 12.19 m (40 ft); width of sign: 3.05 m (10 ft); members are flat-sided.

q_z=1066.29K_z Pa [0.00256K_zV^2I=22.27K_z psf]; C_f=1.6 (Table 6-9 of Standard); A_f (per unit height)=(10)(0.50)= 1.52 m^2/m (5 sq ft/ft).

(1 ft=0.3048 m; 1 psf=47.88 Pa; 1 lb/ft=14.59 N/m)

$F=q_zGC_fA_f=(0.85)(1.6)(5.0)q_z=6.8q_z$

$z/0.3048$ (z in m)	K_z	$q_z/47.88$ (q_z in Pa)	$F/14.59$ (F in N/m)
0–15	0.85	18.93	128.73
20	0.90	20.04	136.31
25	0.94	20.94	142.36
30	0.98	21.83	148.42
40	1.04	23.16	157.51

NOTE. The force F is proportional to the gust effect factor G if the sign is not flexible (Table 6-1 of Standard). If the sign is flexible, the forces obtained as shown above should be multiplied by the ratio G_f/G, where G_f is a gust effect factor that accounts for the structure's flexibility and should be obtained by rational analysis (Table 6-1 of Standard). Neither the Standard nor the program offers guidance for the calculation of G_f in this case. Depending upon the specific example at hand, the user may consider adapting for this case the method for calculating the gust effect factor given in Section C6.6 of the Commentary to the Standard.

A.23 Open Sign With Rounded Members

Wind and Structure Characteristics: V=44.7 m/s (100 mph); exposure C; structure classification: category I (I=0.87); sign not situated on or near hills or escarpments; ratio of solid area to gross area: ϵ=0.5 (see Note 4, Table 6-9 of Standard); heigth above ground of bottom of sign: 3.05 m (10 ft); height above ground of top of sign: 12.19 m (40 ft); width of sign: 3.048 m (10 ft); members are rounded with diameter D= 0.3048 m (1 ft).

$q_z=1066.29K_z$ Pa ($0.00256K_zV^2I=22.27K_z$ psf)

To obtain force coefficient C_f from Table 6-9 of Standard, estimate typical q_z for sign: typical q_z=1043.78 Pa (21.8 psf); $D(q_z)^{1/2}=(1)(21.8)^{1/2}$; C_f=1.1 (Table 6-9 of Standard); A_f (per unit height)=(10)(0.50)=1.52 m^2/m (5 sq ft/ft).

$F=q_zGC_fA_f=(0.85)(1.1)(5.0)q_z=4.68q_z$

(1 ft=0.3048 m; 1 psf=47.88 Pa; 1 lb/ft=14.59 N/m)

z/0.3048 (z in m)	K_z	q_z/47.88 (q_z in Pa)	F/14.59 (F in N/m)
0-15	0.85	18.93	88.6
20	0.90	20.04	93.8
30	0.98	21.83	102.6
40	1.04	23.16	108.4

NOTE. The force F is proportional to the gust effect factor G if the sign is not flexible (Table 6-1 of Standard). If the sign is flexible, the forces obtained as shown above should be multiplied by the ratio G_f/G, where G_f is a gust effect factor that accounts for the structure's flexibility and should be obtained by rational analysis (Table 6-1 of Standard). Neither the Standard nor the program offers guidance for the calculation of G_f in this case. Depending upon the specific example at hand, the user may consider adapting for this case the method for calculating the gust effect factor given in Section C6.6 of the Commentary to the Standard.

A.24 Trussed Tower

Wind and Structure Characteristics: $V=44.7$ m/s (100 mph); exposure C; structure classification: category I ($I=0.87$); tower not situated on or near hills or escarpments; ratio of solid area to gross area of a tower face: $\epsilon=0.5$ (see Note 7, Table 6-10 of Standard); square cross-section; width: 3.05 m (10 ft); height 30.48 m (100 ft); flat-sided members.

$q_z=1066.29K_z$ Pa ($0.00256K_zV^2I=22.27K_z$ psf)

$A_f=0.15$ m^2/m [(0.05)(10)(1)=0.5 sq ft/ft]

$C_f=4.0\epsilon^2-5.9\epsilon+4.0=3.715$

$q_zC_fA_f=(22.27)(3.715)(0.5)K_z=41.37G_fK_z$

(1 ft=0.3048 m; 1 psf=47.88 Pa; 1 lb/ft=14.59 N/m)

$F=q_zG_fC_fA_f$ (for flexible towers; for non-flexible towers G_f is replaced by G)

z/0.3048 (z in m)	K_z	q_z/47.88 (q_z in Pa)	F/14.59 (F in N/m)
0-15	0.85	35.16	86.85
20	0.90	37.23	91.96
30	0.98	40.54	100.13
40	1.04	43.02	106.26
50	1.09	45.09	111.37
60	1.13	46.75	115.47
70	1.17	48.40	119.55
80	1.21	50.06	123.65
90	0.24	51.30	126.71
100	1.26	52.13	128.76

The calculation of the gust effect factor G_f is left to the reader as an exercise. A rough estimate of G_f is provided automatically by the computer program.

A.25 Topographic Factor K_{zt}

Consider a building located at a distance $x=22.86$ m (75 ft) upwind of a two-dimensional ridge with height $H=11.43$ m (37.5 ft) and characteristic horizontal dimension $L_h=45.72$ (150 ft). Calculate topographic factor at $z=7.62$ m (25 ft) elevation and at 9.14 m ($z=30$ ft) elevation. See Figure 6-2 of Standard.

K_1 multiplier

$H/L_h=37.5/150=0.25$; $K_1=0.36$

K_2 multiplier

$x/L_h=75/150=0.5$; $K_2=0.67$ (recall that building is sited upwind, rather than downwind, of crest)

K_3 multiplier

$z/L_h=25/150=0.167$; $K_3=0.74-(0.74-0.55)(0.067)/(0.10)=0.6127$

$z/L_h=30/150=0.20$; $K_3=0.55$

$z=7.62$ m (25 ft): $K_{zt}=(1+K_1K_2K_3)^2=1.317$

$z=9.14$ m (30 ft): $K_{zt}=(1+K_1K_2K_3)^2=1.283$.