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- (f) Except as prohibited elsewhere in this Agreement, this Agreement shall be binding upon and inure to the benefit of the personal and legal representatives, permitted successors, and permitted assigns of the parties hereto.

- (g) All notices, demands, consents or requests that may be or are required to be given by any party to another party shall be in writing. All notices, demands, consents or requests given by the parties hereto shall be sent either by U.S. certified mail, postage prepaid or by an overnight international delivery service, addressed to the respective parties. Notices, demands, consents or requests served as set forth herein shall be deemed sufficiently served or given at the time of receipt thereof.
- (h) The various rights, options, elections, powers, and remedies of a party or parties to this Agreement shall be construed as cumulative and no one of them exclusive of any others or of any other legal or equitable remedy that said party or parties might otherwise have in the event of breach or default in the terms hereof. The exercise of one right or remedy by a party or parties shall not in any way impair its rights to any other right or remedy until all obligations imposed on a party or parties have been fully performed.
- (i) No waiver by Customer, PCA or Dealer (if any) of any breach, provision, or default by the other shall be deemed a waiver of any other breach, provision or default.
- (j) The parties hereto, and each of them, agree that the terms of this Agreement shall be given a neutral interpretation and any ambiguity or uncertainty herein should not be construed against any party hereto.
- (k) If any provision of this Agreement or portion thereof is held to be unenforceable or invalid by any court or competent jurisdiction, such decision shall not have the effect of invalidating or voiding the remainder of this Agreement, it being the intent and agreement of the parties that this Agreement shall be deemed amended by modifying such provision to the extent necessary to render it enforceable and valid while preserving its intent or, if such modification is not possible, by substituting therefor another provision that is enforceable and valid so as to materially effectuate the parties' intent.

Except as set forth herein, this Agreement may be modified or amended only by a written instrument signed by a duly authorized representative of PCA and Customer.

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Chapter 1

Introduction

Terms

The following terms are used throughout this manual. A brief explanation is given to help familiarize you with them.

Windows	refers to the Microsoft Windows environment version 3.1 or higher.
[]	indicates metric equivalent
Click on	means to position the cursor on top of a designated item or location and press and release the left-mouse button (unless instructed to use the right-mouse button).
Double-click on	means to position the cursor on top of a designated item or location and press and release the left-mouse button twice in quick succession.

Conventions

To help you locate and interpret information easily, the pcaColumn manual adheres to the following text format.

<i>Italic</i>	indicates a glossary item, or emphasizes a given word or phrase.
Bold	indicates the name of a menu or a menu item command such as File or Save.
Mono-space	indicates something you should enter with the keyboard. For example “c:*.txt”.
KEY + KEY	indicates a key combination. The plus sign indicates that you should press and hold the first key while pressing the second key, then release both keys. For example, “ALT + F” indicates that you should press the “ALT” key and hold it while you press the “F” key. then release both keys.

System requirements

To use pcaColumn, a personal computer running Microsoft Windows 98 or later is required. pcaColumn needs less than 10 MB of disk space to install.

Program Capacity

- 500 reinforcing bars within a section.
- 500 exterior points that define the geometric outline of the cross section (pcaSection module).
- 500 interior points that define an opening in the cross section (pcaSection module).
- 4000 factored load entries, each consisting of an axial load, a moment about the x-axis, and a moment about the y-axis.
- 50 service load entries, each consisting of dead, live, wind and earthquake axial loads, moments at column top about the x and y axes, and moments at column bottom about the x and y axes.
- 20 load combinations.

Installing pcaColumn

1. If you have the installation disk please insert it into the CD drive and proceed to step 2. If you do not have the installation disk but downloaded the installation file from our website, please run the file and proceed to step 3.
2. If the installation does not start automatically after inserting the installation disk to the CD drive then please run the file `install.exe` from the installation disk and proceed to step 3. If the installation starts automatically then please follow the instructions on the screen. You may be asked which product you want to install if you received `pcaColumn` together with other software from `pcaStructurePoint`.
3. The installation process starts by displaying the following window (Figure 1-1). Please read all the information. Then press the NEXT button. This will continue the installation process by installing license manager, an evaluation license, and the application software.

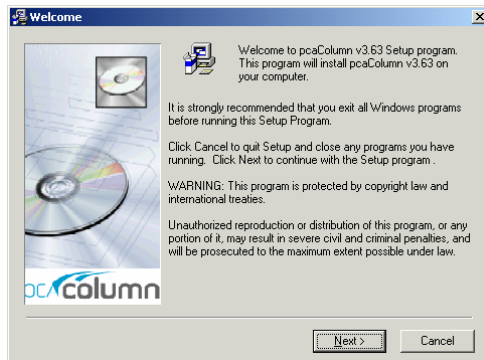


Figure 1-1. Beginning of the installation

4. The first step of the application installation process is to review the software license agreement as shown in Figure 1-2. Please read all the information carefully. Press the I AGREE button to confirm that you have read and agreed with it. This will continue the installation. If you do not agree with the license agreement press the I DO NOT AGREE button. This will stop the installation.



Figure 1-2. License agreement

5. If you continue the installation then please read the latest information of the software included in the readme file (Figure 1-3). Having read all the information press the NEXT button.

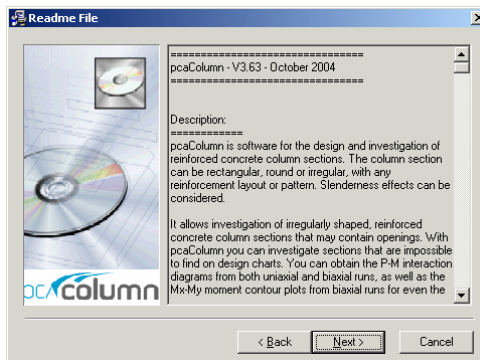


Figure 1-3. Readme file

6. In the next step please provide the user's name and company. Press next when you are ready to proceed.

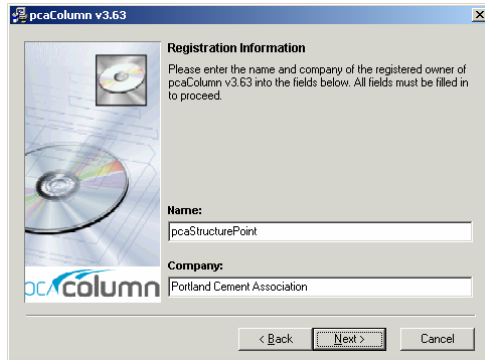


Figure 1-4. Registration information

7. The next setup is to decide the directory where pcaColumn is to be installed as shown in Figure 1-5. The default directory is C:\Program Files\PCA\pcaColumn. You may press the BROWSE button to locate the directory. If the directory does not exist, the setup program will create it. Press the NEXT button to go to the next step.

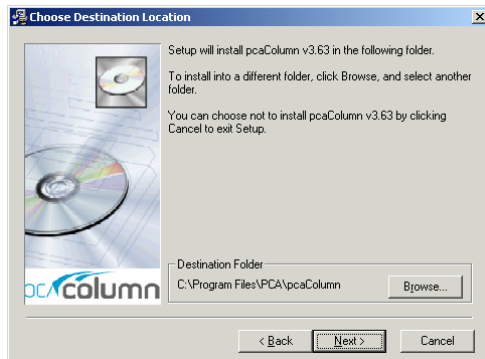


Figure 1-5. Choose Destination Location

8. The next step is to enter the group name as shown in Figure 1-6. Windows will use this name in the Start/Programs menu. Press the NEXT button to go to the next step.

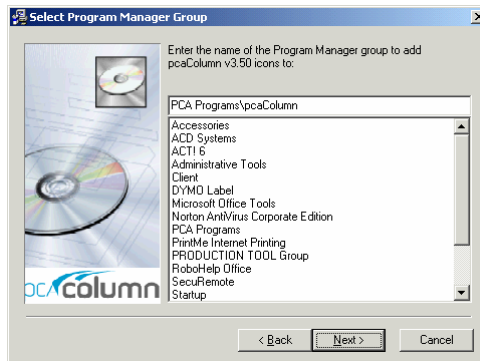


Figure 1-6. Select Program Manager Group

9. After all the previous steps are completed, press the NEXT button as shown in Figure 1-7 to start the installation.

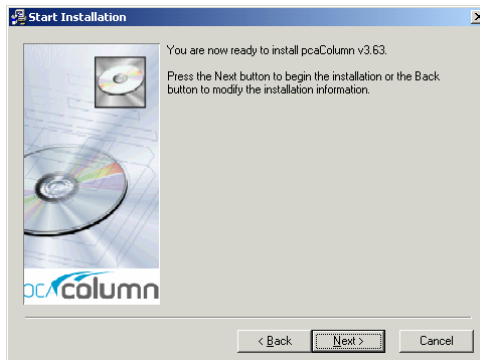


Figure 1-7. Start Installation

10. During the installation a window as in Fig. 1-8 shows the progress as files are copied to your hard drive.

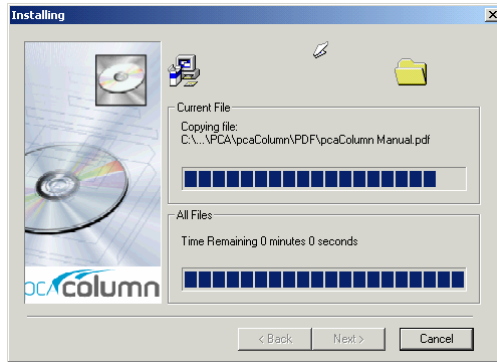


Figure 1-8. Installation progress

11. After the installation is completed, a dialog box similar to Figure 1-9 is shown. Press the FINISH button to finish the installation.

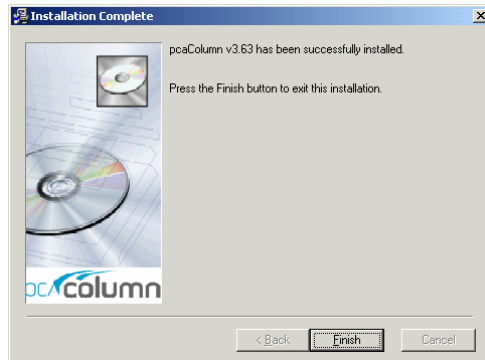


Figure 1-9. Installation Complete

Purchasing and Licensing Process

Licensing Model

By default, each pcaStructurePoint software application comes in an Evaluation mode. This means that initially our products can be used for a limited time of 15 days. If the user decides to purchase the software license, and completes the purchase, pcaStructurePoint will provide a License Code. By entering this code, user will activate the software license. Once the software license is activated the application will no longer have restrictions limiting the time of operation.

Evaluation Mode

This is the default mode of the license. In this licensing scheme, users are granted limited rights to use our full-featured software. The only visible difference between the evaluation version and the licensed version is an additional start-up dialog box as shown in Figure 1-10. It gives a choice of buying the software, entering the activation code or running the application in the evaluation mode by pressing the EVALUATE button. Evaluation mode is available for a limited time only. By default, pcaStructurePoint software applications come with 15 days. That means, from the day of installation, a user can evaluate the software for the next 15 days. After this time, user will either obtain a License, or uninstall the application.

Note: Any tampering with system clock or evaluation license file will render the software useless.

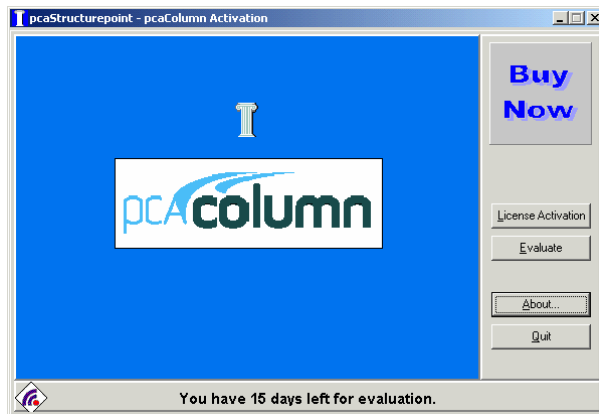


Figure 1-10. Start-up Dialog Box

How to Purchase

You may purchase the license on-line at www.pcaStructurePoint.com or by calling our Sales Department at 847-972-9042. To buy on-line you may press BUY NOW button, which will run your default web browser and open the product web page where you will be able to complete the transaction.

Licensing Activation

After the purchase is completed, pcaStructurePoint will generate a unique Activation Code based on the product ID and the locking code, which is derived from the unique hardware-id of the user's computer. Each License is associated

with the particular PC in which user has installed the pcaStructurePoint software. This implies that the activation-code will not work on any other PC. You can transfer the license to another PC by contacting pcaStructurePoint for the transfer procedures.

To activate the license press the LICENSE ACTIVATION button in the start-up dialog box. This will bring a window as in Figure 1-11, which shows three license activation methods.

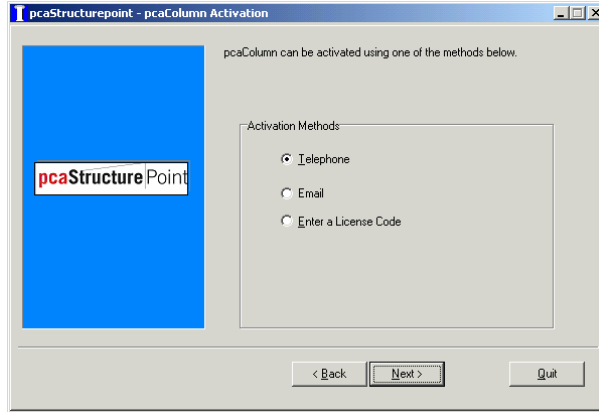


Figure 1-11. License activation methods

If you have already received the license code you may choose ENTER LICENCE CODE and then press the NEXT button. A window (Figure 1-12) will pop up where you will be able to type in the license code. However, in order to avoid mistyping we advise to use copy and paste feature instead of typing the code.

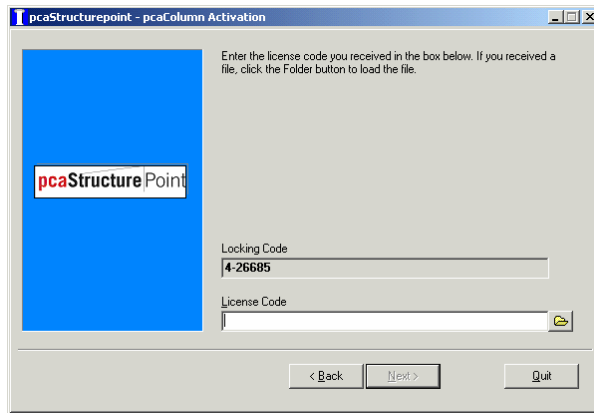



Figure 1-12. Enter license code

The license code can also be extracted from a file. To do that press the BROWSE button  and open the file in which the license code is stored using the open window (Figure 1-13).

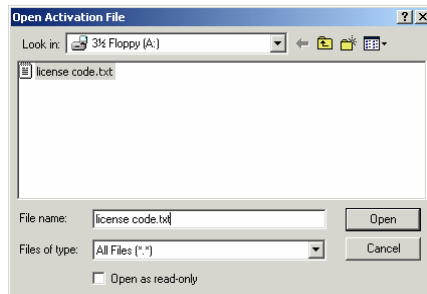


Figure 1-13. Open activation file

If the entered code is correct the license will be activated and window as in Figure 1-14 will show. When you press the FINISH button the license activation will be completed.

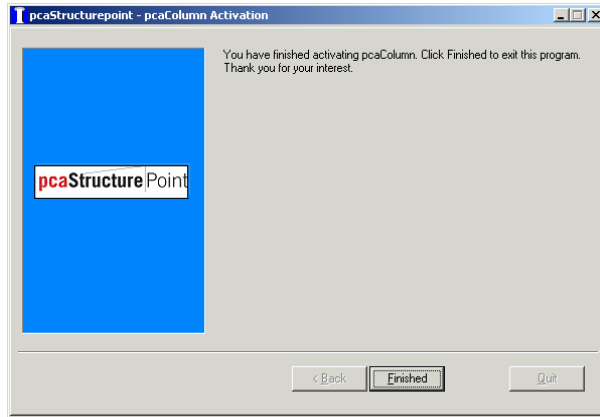


Figure 1-14. Activation completion

If you do not have the license code you may chose either TELEPHONE or E-MAIL method, whichever is more convenient for you. Please note that for E-MAIL method you need to have the Internet connection and a default mailer configured in your system.

Activation by Phone

If the telephone method was chosen to activate the license the following screen appears (Figure 1-15). It shows the product ID and the Locking Code.

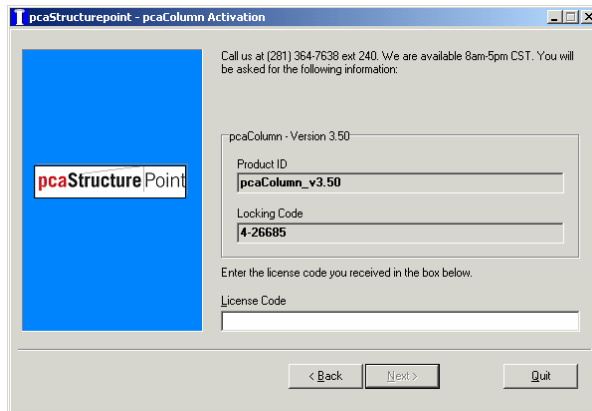


Figure 1-15. Activation by phone

This information is needed when you make a phone call at 847-966-4357 (HELP) to obtain the license. You will be asked to provide information about yourself in order to verify that you have purchased the license.

Activation by E-mail

If the e-mail method was chosen to activate the license a screen (Figure 1-16) will show prompting you to provide information about yourself. When you type in all the information press the SEND E-MAIL button and it will be automatically e-mailed to us together with the product ID and the Locking Code. After the information is verified the license code will be generated and e-mailed back to you.

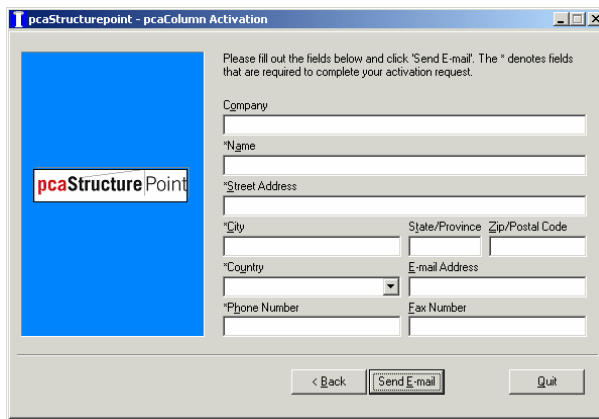


Figure 1-16. Activation by e-mail

After you receive it you may enter it by pressing the LICENSE ACTIVATION button in the start up dialog box (Figure 1-10) and choosing ENTER LICENSE CODE option. . If the entered code is correct, the license will be activated and window as in Figure 1-14 will show. When you press the FINISH button the license activation will be completed.

Chapter 2

Method of Solution

pcaColumn enables the user to compute the capacity of (investigate) or design reinforced concrete column sections. The section under consideration may be subject to a combination of loadings consisting of combined axial loads and uniaxial or biaxial moments.

In pcaColumn, the section may be rectangular or circular with any reinforcement layout. Material properties for the concrete and reinforcing steel are user-controlled. The applied loading consists of tensile or compressive axial loads acting alone or combined with uniaxial or biaxial bending.

At the user's option, the program may investigate the slenderness effects on a column using the approximate method described in the design code. If applicable, the program computes the magnification factors to be applied to the moment(s).

With the pcaSection module, pcaColumn can investigate irregularly-shaped sections. An irregular section is defined as a closed polygon and may even contain an opening (hollow section).

pcaColumn conforms to the provisions of the following design specifications: *Building Code Requirements for Structural Concrete* (ACI 318-02), published by the American Concrete Institute, Farmington Hills, MI.

Design of Concrete Structures (A23.3-94), published by the Canadian Standards Association, Ontario, Canada

A – Definitions and Assumptions

1. The analysis of the reinforced concrete section conforms to the provisions of the Strength Design Theory.
 - a) All conditions of strength satisfy the applicable conditions of equilibrium and strain compatibility.
 - b) Strain in the concrete and in the reinforcement is directly proportional to the distance from the neutral axis.
 - c) The maximum usable (ultimate) strain at the extreme concrete compression fiber is assumed equal to 0.003 (0.0035 for CSA) unless otherwise specified by the user.
 - d) A uniform rectangular concrete stress block is used. For ACI code, the maximum uniform concrete compressive stress, f_c , is $0.85f'_c$ and the block depth is β_1c , where c is the distance from the extreme compression fiber to the neutral axis and β_1 , is described in item 4 below. Both f_c and β_1 may be modified by the user. For CSA, f_c is taken as:

$$f_c = (0.85 - 0.0025f'_c)f'_c \geq 0.67f'_c, \text{ where } f'_c \text{ is in MPa}$$

- e) Concrete displaced by the reinforcement in compression is deducted from the compression block.

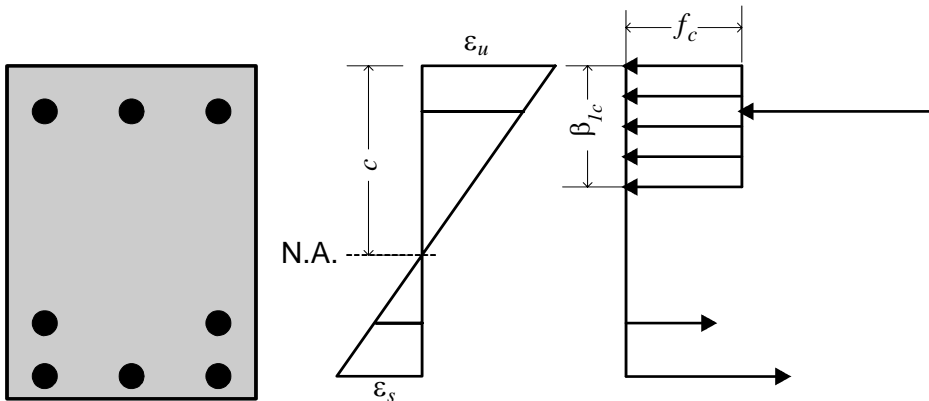


Figure 2- 1. Analysis of Reinforced Section

- f) For the reinforcing steel, the elastic-plastic stress-strain distribution is used. Stress in the reinforcing steel below the yield strength, f_y , is directly proportional to the strain. For strains greater than that corresponding to the yield strength, the reinforcement stress remains constant and equal to f_y .
- g) Tensile strength of concrete is neglected.

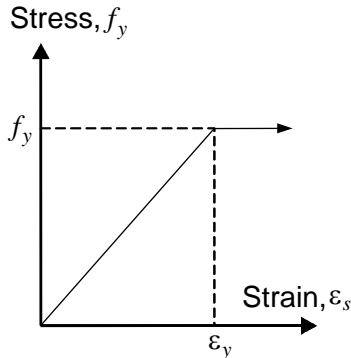


Figure 2-2. Elastic-Plastic Stress-Strain Reinforcement Curve

2. The modulus of elasticity of concrete, E_c , is computed as follows (unless otherwise specified by the user):

$$E_c = 57,000\sqrt{f'_c}, \text{ where } f'_c \text{ and } E_c \text{ are in psi,}$$

$$E_c = 4,700\sqrt{f'_c}, \text{ where } f'_c \text{ and } E_c \text{ are in MPa.}$$

For the CSA standard, $E_c = 3,518\sqrt{f'_c} + 7,355$, where f'_c and E_c are in MPa.

3. The modulus of elasticity of reinforcing steel, E_s , is taken as 29,000 ksi (200,000 MPa) unless otherwise specified by the user.
4. The ratio of the concrete compression block depth to the distance between the extreme compression fiber and the neutral axis, β_1 , is computed as follows (unless otherwise specified by the user):

$$0.65 \leq \beta_1 = 1.05 - 0.05f'_c \leq 0.85, \text{ where } f'_c \text{ is in ksi,}$$

$0.65 \leq \beta_1 = 1.0643 - 0.007143 f'_c \leq 0.85$, where f'_c is in MPa.

For CSA: $\beta_1 = 0.97 - 0.0025 f'_c \geq 0.67$, where f'_c is in MPa.

5. Stress in the reinforcement is computed based on the strain at the centroid of each reinforcing bar.
6. All moments are referenced to the geometric centroid of the gross concrete section (neglecting the reinforcement).
7. For the ACI code, the nominal (unreduced) strength of the section is first computed on the basis of the strength of materials. This is then reduced to the design strength using the capacity reduction factors.

The following reduction factors are used for the ACI code:

ϕ_a is the reduction factor for pure axial compression,

ϕ_b is the reduction factor for tension-controlled failure,

ϕ_c is the reduction factor for compression-controlled failure.

Compression-controlled failure and tension-controlled failure are defined in clauses 10.3.3 and 10.3.4 respectively. Reduction factor, ϕ , is assumed to vary linearly with the tensile strain in the extreme tension steel for failure cases falling between the limits of the compression-controlled and the tension-controlled cases.

For the CSA standard, the following factors are used:

ϕ_a is the reduction factor for pure axial compression,

ϕ_s is the material resistance factor for steel,

ϕ_c is the material resistance factor for concrete.

8. If the reinforcement ratio falls below the code-specified minimum of 1%, the program has two options: consider the section as *Structural* or *Architectural*. For *Architectural*, the maximum concrete stress, f_c , is multiplied by the reinforcement ratio. This produces the same effect as reducing the concrete area to achieve a reinforcement ratio of 1%. For *Structural*, the specified concrete stress is used.
9. Under the Design option, the reinforcement ratio cannot be less than 0.5%. Under the Investigation option, any value can be used for the reinforcement ratio.

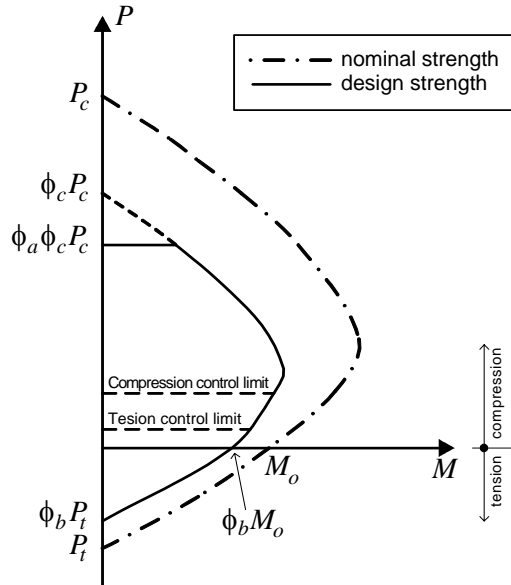


Figure 2-3. Reduction factors for Flexure and Axial Loads per ACI code

B – Sign Convention

1. Looking at the section in plan, the positive x-axis points to the right and the positive y-axis points up.
2. Positive axial loads are compressive and negative axial loads are tensile.
3. The right-hand rule is used to determine the compression and tension faces of the section. A positive moment about the x-axis, M_x , produces tension at the top face of the section and compression at the bottom face. A positive moment about the y-axis, M_y , produces tension at the left face of the section and compression at the right face.

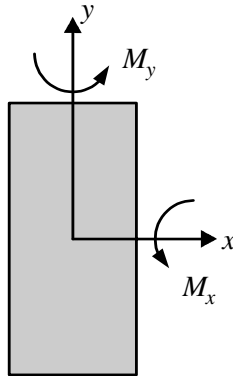


Figure 2-4. *pcaColumn's positive local coordinate system*

4. If service loads are input, moments at the upper (top) and lower (bottom) ends of the column are needed. Top and bottom moments of opposite signs produce single curvature bending. Top and bottom moments of the same sign produce double curvature bending.

In the global coordinate system, the section at the upper end of the column coincides with *pcaColumn's* local coordinate system where positive moments about the y-axis produce tension on the left side of the section. However, the global coordinate system produces an opposite effect on the section at the lower end of the column where positive moments about the y-axis produce tension on the right side of the section. Since *pcaColumn* assumes the reinforcement pattern to be constant throughout the column height, the program internally changes the sign of the service moments at the lower end to convert from the global coordinate system to the local.

5. For uniaxial runs, the factored moments considered always produce positive bending on the section as described in item 3 above. This is valid for the cases when the section is symmetrical about the run axis. If the column bends in double curvature and the section is not symmetrical, a biaxial investigation run is recommended.

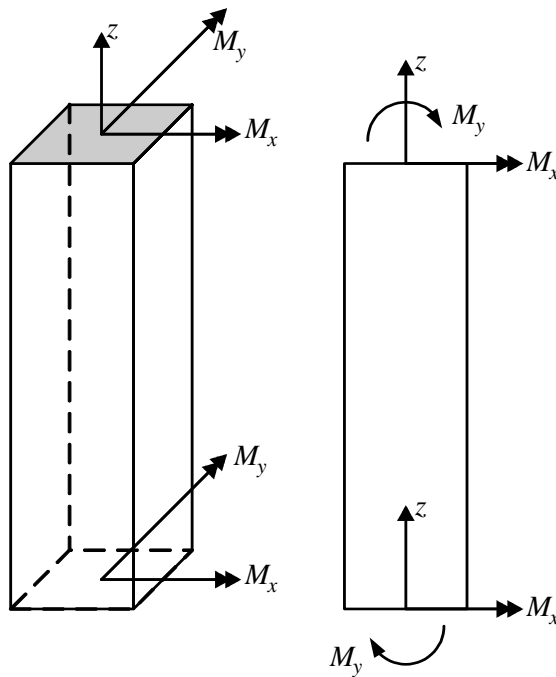
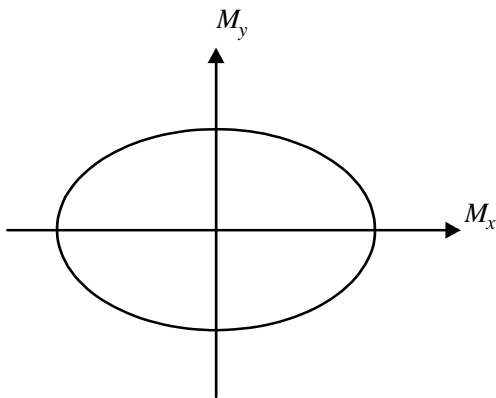
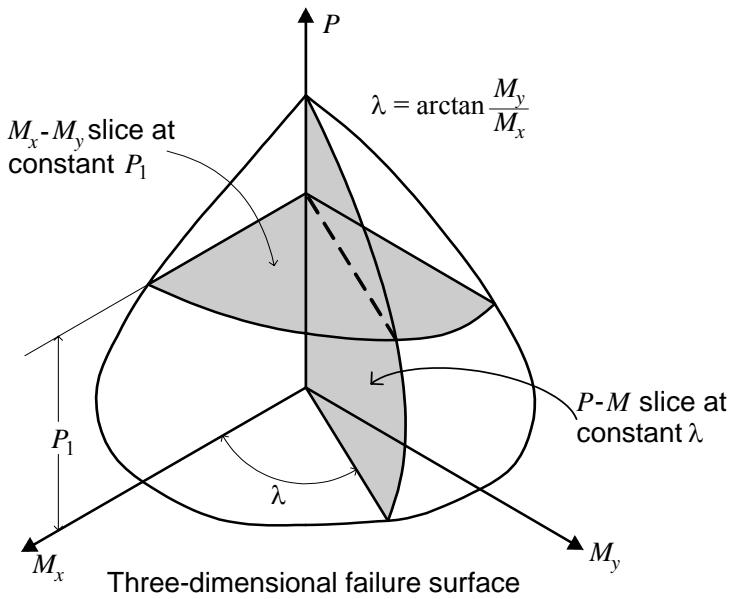


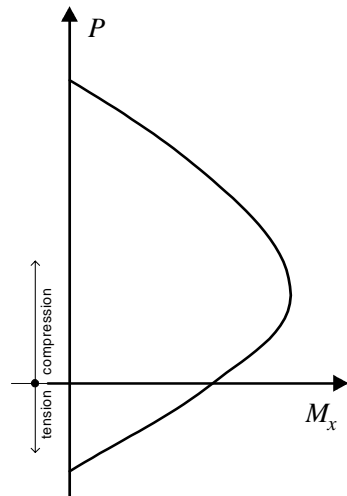
Figure 2-5. *pcaColumn's positive global system*

C – Section Investigation

1. The computations performed when investigating a section depend on the selected load mode:
 - a) Factored loads - for the axial load of each load point, the moment capacity and the ratio of design-to-applied moment are computed. For a biaxial run, the computed M_x and M_y moment capacities are at the same angle as that produced by the applied M_x and M_y moments.
 - b) Service loads - the program computes the factored loads using the input load combinations. If slenderness effects are to be checked and the column is found to be slender, the applied moments are magnified according to Procedures E and F. For each factored load, the same computations described in (a) above are performed.



(a) Moment slice at constant load



(b) P-M slice at constant angle

Figure 2-6. Interaction Surface for Combined Load and Biaxial Bending

- c) Control points - for several key points on the interaction diagram, the axial load, corresponding moment capacity and the corresponding neutral axis depth are computed. The key points are: pure compression, maximum compression, point where steel stress is zero, point where steel stress is $0.5 f_y$, balanced point, pure flexure and pure tension. For ACI code, an additional control point is introduced where maximum steel strain is equal to 0.005 (tension control limit).
 - d) Axial loads – for each input axial load, the moment capacity and the corresponding neutral axis depth are computed.
2. The program also computes the interaction diagram (uniaxial runs) or the three-dimensional failure surface (biaxial runs) of the input section. The values of pure compressive axial load capacity and pure tensile axial load capacity are computed. These two values set the range within which the moment capacities are computed. A predetermined number of axial load values (within this range) are computed.
- a) For uniaxial runs, the moment capacity about the selected axis only is computed. The moment capacity about the orthogonal axis is ignored. To compute the moment capacity at a certain level of axial load, the neutral axis angle is held constant, parallel to the selected axis. The neutral axis depth is adjusted to arrive at the desired axial load capacity. This is done for all the predetermined values of axial load.
 - b) For biaxial runs, the same predetermined values of axial load are utilized. For each level of axial load, the section is rotated in 10-degree increments from 0 degrees to 360 degrees and the M_x and M_y moment capacities are computed. Thus for each level of axial load, an M_x - M_y contour is developed. Repeating this for the entire range of axial loads, the three-dimensional failure surface is computed.

D – Section Design

1. Based on the specified minimum, maximum and increment specified for the section and the reinforcing bars, the program selects the smallest section with the least amount of reinforcement for which the load-moment capacity exceeds the applied loads. If service loads are input, they are factored using the input load combinations. Depending on the design criteria the user selects, the least amount of reinforcement the program searches for means either the smallest number of bars or the smallest steel area.

2. The program starts the design by trying the smallest section (minimum dimensions) and the least amount of reinforcing bars. The program verifies that the ratio of provided reinforcement is always within the specified minimum and maximum ratios. Furthermore, the bar spacing is always kept greater than or equal to the larger of 1.5 times the bar diameter or 1.5 in. [40 mm] (unless otherwise specified by the user).
3. A section fails the design if, for the design axial load, the ratio of design-to-applied moment is less than 1.0 (unless otherwise specified in the Design Criteria box).
4. Once a section passes the design, its capacity is computed and the computations explained in Procedure C above are performed.

E – Moment Magnification (Slenderness Effects) for Non-Sway Columns

1. If properties of framing members are input, pcaColumn computes the non-sway condition effective length factor, k_b , as the smaller of:

$$0.7 + 0.05(\psi_A + \psi_B)$$

$$0.7 + 0.05\psi_{\min}$$

Where ψ is the ratio of $\Sigma(EI/L)$ of columns to $\Sigma(EI/L)$ of beams in a plane at one end of the column, ψ_A and ψ_B are the values of ψ at the upper end and the lower end of the column, respectively, and ψ_{\min} is the smaller of ψ_A and ψ_B .

The value of k_b must always be between 0.5 and 1.0. The moment of inertia used in computing ψ is the gross moment of inertia multiplied by the cracked section coefficients (specified in the Slenderness Factors box).

2. The smaller and larger factored column end moments M_1 and M_2 , respectively, are computed. M_1 is positive if the column is bent in single curvature and is negative if the column is bent in double curvature. M_2 is always positive.
3. For the ACI code, slenderness effects will be considered if

$$\frac{k_b l_u}{r} \geq 34 - 12 \frac{M_1}{M_2} .$$

For the CSA standard

$$\frac{k_b l_u}{r} \geq \frac{25 - 10 \frac{M_1}{M_2}}{\sqrt{\frac{P_f}{f'_c A_g}}} ,$$

where l_u is the unsupported column length and $r = \sqrt{\frac{I_g}{A}}$ is the radius of gyration. The ratio M_1 / M_2 is always greater than or equal to -0.5.

4. If the ratio $k_b l_u / r$ exceeds 100, slenderness effects using this approximate procedure cannot be applied. A more exact method must be used. In this case, the procedure is aborted and a message is issued.
5. The factor C_m is computed as:

$$C_m = 0.6 + 0.4 \frac{M_1}{M_2} \geq 0.4 .$$

6. The factor β_d is computed as the ratio of maximum factored axial dead load to the total factored axial load for the load combination under consideration.
7. The quantity $(0.2E_c I_g + E_s I_{se})$ is determined; where E_c is the modulus of elasticity of concrete, E_s is the modulus elasticity of steel, I_g is the gross moment of inertia of the concrete section, and I_{se} is the moment of inertia of reinforcement. The product EI is computed as:

$$EI = \frac{0.2E_c I_g + E_s I_{se}}{1 + \beta_d} .$$

8. The critical buckling load, P_c , is computed as:

$$P_c = \frac{\pi^2 EI}{(k_b l)^2} .$$

9. The non-sway moment magnification factor, δ_b , is computed as:

$$\delta_{ns} = \frac{C_m}{1 - \frac{P_u}{\phi_k P_c}} \geq 1.0,$$

where the stiffness reduction factor, ϕ_k , is taken as 0.75 (may be modified using the Slenderness Factors box) and P_u is the factored axial load for the load combination under consideration.

10. The moment due to minimum eccentricity, e_{min} , is computed as:

$$M_{min} = P_u e_{min}, \text{ where}$$

$$e_{min} = 0.6 + 0.03 h, \text{ with } h \text{ in in,}$$

$$e_{min} = 15 + 0.03 h, \text{ with } h \text{ in mm,}$$

and h is the section dimension (diameter for circular sections) in the direction being considered.

11. The magnified moment, M_c is the larger of $\delta_{ns} M_2$ or $\delta_{ns} M_{min}$.

F – Moment Magnification (Slenderness Effects) for Sway Columns

1. If properties of framing members are input, pcaColumn computes the sway condition effective length factor, k_s , using the following simplified equations:

$$\text{if both ends are restrained and } \psi_m < 2, k_s = 0.05(20 - \psi_m)\sqrt{1 + \psi_m} \geq 1.0,$$

$$\text{if both ends are restrained and } \psi_m \geq 2, k_s = 0.9\sqrt{1 + \psi_m} \geq 1.0,$$

$$\text{if the upper end is hinged, } k_s = 2 + 0.3\psi_B,$$

$$\text{if the lower end is hinged, } k_s = 2 + 0.3\psi_A,$$

$$\text{if both ends are hinged, } k_s = 30.$$

Where ψ is the ratio of $\Sigma(EI/L)$ of columns to $\Sigma(EI/L)$ of beams in a plane at one end of the column, ψ_A and ψ_B are the values of ψ at the upper end and the lower end of the column, respectively, and ψ_m is the average of ψ_A and ψ_B .

An end is determined to be hinged if its ψ is very large. This happens in the case where $\Sigma(EI/L)$ of beams is too small (or zero) relative to the $\Sigma(EI/L)$ of columns at that end. In this case, the program outputs 999.9 for the value of ψ . The moment of inertia used in computing ψ is the gross moment of inertia multiplied by the cracked section coefficients (specified in the Slenderness Factors box).

2. The smaller and larger factored non-sway column end moments M_{1b} and M_{2b} , respectively, are computed. These are factored moments due to dead and live loads. M_{1b} is positive if the column is bent in single curvature and is negative if the column is bent in double curvature. M_{2b} is always positive.
3. The smaller and larger factored sway column end moments M_{1s} and M_{2s} , respectively, are computed. These are factored moments due to lateral loads (wind and earthquake). M_{1s} is positive if the column is bent in single curvature and is negative if the column is bent in double curvature. M_{2s} is always positive.
4. For the ACI code, slenderness effects will be considered if $k_s I_u / r \geq 22.0$. For the CSA standard, all sway columns are designed for slenderness effects.
5. If the ratio $k_s I_u / r$ exceeds 100, slenderness effects using this approximate procedure cannot be applied. A more exact method must be used. In this case, the procedure is aborted and a message is issued.
6. The quantity $(0.2E_c I_g + E_s I_{se})$ is determined; where E_c is the modulus of elasticity of concrete, E_s is the modulus elasticity of steel, I_g is the gross moment of inertia of the concrete section, and I_{se} is the moment of inertia of reinforcement. The product EI is computed as:

$$EI = 0.2E_c I_g + E_s I_{se}.$$

7. The critical buckling load, P_c , is computed as:

$$P_c = \frac{\pi^2 EI}{(k_s I_u)^2}.$$

8. The sway moment magnification factor, δ_s , is computed as:

$$\delta_s = \frac{1.0}{1 - \frac{\Sigma P_u}{\phi_k \Sigma P_c}} \geq 1.0,$$

where the stiffness reduction factor, ψ_k , is taken as 0.75.

ΣP_u is taken as the factored axial load for the load combination under consideration times the ratio $\Sigma P_u / P_u$.

ΣP_c is taken as the critical buckling load for the load combination under consideration times the ratio $\Sigma P_c / P_c$.

ϕ_k and the ratios $\Sigma P_u / P_u$ and $\Sigma P_c / P_c$ may be modified using the Slenderness Factors box.

9. If $\frac{l_u}{r} \leq 35 / \sqrt{\frac{P_u}{f_c' A_g}}$, the magnified moment is computed as:

$$M_{1c} = M_{1b} + \delta_s M_{1s},$$

$$M_{2c} = M_{2b} + \delta_s M_{2s}.$$

10. If $\frac{l_u}{r} > 35 / \sqrt{\frac{P_u}{f_c' A_g}}$, the braced moment magnification factor, δ_b , is computed

according to steps 1 through 9 as described in Procedure E above. In step 7, however, β_d is computed for the load combination under consideration. The magnified moment is computed as:

$$M_{1c} = \delta_b (M_{1b} + \delta_s M_{1s}),$$

$$M_{2c} = \delta_b (M_{2b} + \delta_s M_{2s}).$$

G – Output notation

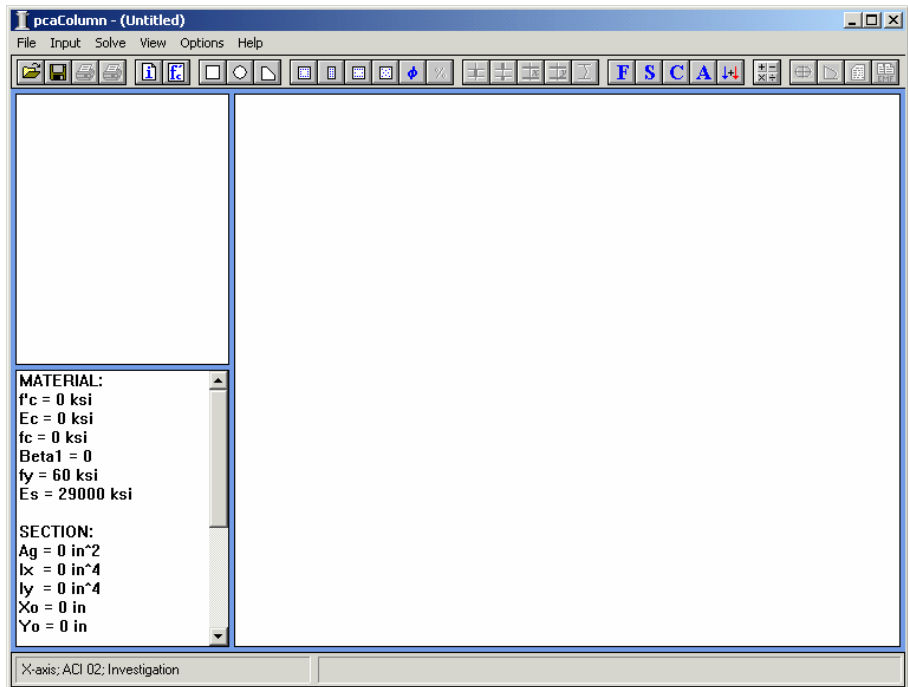
The following table explains some of the notations used in the output of the program:

<u>Notation</u>	<u>ACI Code</u>	<u>CSA Standard</u>
P_u	Ultimate factored axial load (P_u)	Factored axial load (P_f)
M_u	Ultimate factored moment (M_u)	Factored moment (M_f)
fM_n	Moment capacity (ψM_n)	Factored moment of resistance (M_r)

Chapter 3

The *pcaColumn* Window

Most windows have certain elements in common, such as a title bar and menus. Not all windows, however, have every element. To learn more about how to use window elements, refer to your Microsoft Windows manual. The following is a list of the *pcaColumn* window components.



Control-Menu Box:

The Control-menu box is located in the upper-left corner of the window and includes commands for sizing, moving, enlarging, restoring, and closing the window, as well as switching to other applications. To access the Control-menu

box using the mouse, click the left mouse button on the box; using the keyboard, press ALT+ - (hyphen).

Title Bar:

The Title bar displays the name of the application (pcaColumn in this case), along with the name of the current data file in use. If the data have not been saved into a file, the word Untitled is displayed in the Title bar.

Menu Bar:

The Menu bar is located directly below the Title bar. It lists the available menus. A menu contains a list of commands or actions you can execute.

Tool Bar:

The Tool bar is located directly below the Menu bar. It contains a collection of buttons (or icons) that provide a shortcut to accessing the menu commands. The Tool bar buttons can only be accessed using the mouse.

Information Bar:

The Information bar is located on the left side of the pcaColumn window. The top part displays the column cross section. The bottom part is a list of selected input data echo.

Graphics Area:

The Graphics area covers most of the window. This is where the interaction diagram is shown.

Status Bar:

The Status bar is located along the bottom of the window. It displays important information such as units, design code, cursor position, and helpful messages.

Using the Menus

To access a menu item using the mouse, point to the menu item and click the left-mouse button. Each menu item can also be selected with the keyboard by simultaneously pressing the ALT key and the underlined letter of the menu you want to open. For example, to open the **F**ile menu, press ALT + F.

To close a menu without selecting a command, point to any blank area on the screen and click the left-mouse button, or press ESC.

To choose a command from a selected menu, point to that command and click the left-mouse button, or use the UP and DOWN ARROW keys until you reach the command and press ENTER.

Menu Conventions

The following menu conventions are used in pcaColumn.

Menu convention	Meaning
Dimmed (or not visible) command.	The command is not available at the current time.
An ellipsis (...) following a command.	When the command is selected, a dialog box will appear, requesting data input or listing options to select from.
A check mark (✓) next to a command.	The command is in effect. When the check mark is removed (by selecting the command), the command is no longer in effect.

Using a Dialog Box

A dialog box is displayed to request information or to supply you with information. An ellipsis (...) after a menu command indicates a dialog box will appear when that command is elected. For example, if you choose the **Open** command from the **File** menu, the OPEN dialog box appears. In this dialog box, specify the name of the file you want to open.

Command Button:

The Command button (or Push button) is labeled to do exactly what it says. The OK and CANCEL buttons are common command buttons. A command button followed by an ellipsis (...) opens another dialog box. The currently selected button has a darker border than other buttons. You can choose the selected button by pressing ENTER.

Option Button:

The Option button (or Radio button) is one of a group of related options in which you can select only one. When an option is selected, the selected option button contains a black dot. To select an option with the mouse, click the mouse button on

the option you want, or using the keyboard, press TAB to move to the group of options you want and use the arrow keys to select the option button.

Check Box:

The Check box is an option that can be turned on or off. Unlike option buttons, you can turn on as many check boxes as you want, even if they are in a group. When a check box is turned on, an “X” appears in the box. If you are using a mouse, click a blank check box to select it or click a selected check box to clear it. If you are using a keyboard, press TAB to move to the check box. Press the SPACEBAR to select the box. Press the SPACEBAR again to clear the selection.

Text Box:

The Text box is where data or information is entered. When you move into an empty text box, an insertion point (flashing vertical bar) appears. The text you type starts at the insertion point. If the box already contains text, it is selected and any text typed replaces it. You can also delete the existing text by pressing DEL or BACKSPACE.

List Box:

A List box displays a list of choices. If there are more choices than can fit in the box, scroll bars are provided so you can move quickly through the list. To select an item from a list box, click the scroll arrows until the item you want to select appears in the list box, then click on that item. If you are using the keyboard, use the arrow keys to scroll to the item you want.

Drop-Down List:

A Drop-down list appears initially as a rectangular box with the current selection marked. To see a list of available choices, click the arrow at the right of the box or press ALT + DOWN ARROW to open the box. You can now select another item by scrolling as you do with a list box.

Working with a List Box

A list box displays a list of choices or items. If there are more choices than can fit in the box, scroll bars are provided. The scroll bar is usually located to the right (vertical scroll bar) or at the bottom (horizontal scroll bar) of a list box.

To select a single item from a list box:

- Click the scroll arrows until the item you want to select appears in the list box. Click the item.
- Using the keyboard, use the UP or DOWN arrow key to scroll to the item you want.

To select multiple sequential items in a list:

- Click the first item you want to select and then drag the cursor to the last item you want to select. Alternatively, click on the last item you want to select. Both items, and all items in between, are selected. To cancel the selections, release the SHIFT key and click any item.
- Using the keyboard, use the UP ARROW or DOWN ARROW key to move the cursor to the first item you want to select. Press and hold down the SHIFT key. Continue to press the arrow key repeatedly until all the items you want are selected. To cancel the selections, release the SHIFT key and press one of the arrow keys.

To select multiple non-sequential items in a list:

- Press and hold down the CTRL key, and click each item you want to select. To cancel a selection, press and hold down the CTRL key, and click the item again. There are no keyboard equivalents for this procedure.

File Menu

The **File** menu is used for working with data files, printing results, and exiting the program.

New (CTRL+N)

Clears any input data and returns the data to the default values so that a new data file may be input.

Open (CTRL+O)

Opens an existing pcaColumn data file.

Save (CTRL+S)

Saves the changes you have made to the current data file under that same filename.

Save As

Names or renames a data file.

Import (CTRL+I)

Reads geometry, reinforcement or loads data from an ASCII (Text) file.

Revert

Discards any changes to the data and returns to the last version of saved data. This option will only be available if the file has been modified since the last file save.

Print Results

Displays Print dialog box and prints the results in the text form to the selected printer.

Print Screen

Displays Print dialog box and prints the results similarly as they appear on the screen.

Recent Data File List

Provides quick access to up to four previously open data files.

Exit

Quits the pcaColumn program. If you have made any changes to your data and have not saved them, pcaColumn will prompt you whether you want to save or abandon any changes you have made before you exit.

Input Menu

The Input menu includes commands used to input the data needed to define a problem.

General Information

Input labels to identify the input and select from several options that control the run.

Material Properties

Input the material properties for concrete and reinforcement.

Section

Rectangular: Input the dimensions of a rectangular section.

Circular: Input the dimension of a circular section.

Irregular: Execute `pcaSection` to define an irregularly shaped section. See Chapter 6.

Reinforcement

All Sides Equal: Input a reinforcement pattern in which all the bars are of one size, and the number of bars is the same on all four sides of a rectangular layout or are equally spaced for a circular layout. *Available for rectangular and circular sections.*

Equal Spacing: Input a reinforcement pattern in which all bars are of one size and are uniformly spaced on all four sides of a rectangular layout. *Available for rectangular sections only.*

Sides Different: Input a reinforcement pattern in which each one of the four sides of a rectangular section has a certain number of bars and a certain bar size. *Available for rectangular sections only.*

Irregular Pattern: Input a reinforcement pattern in such a way that bars of any size can be placed anywhere within the column section.

Confinement: Input confinement-related data such as the capacity reduction factors and the size of ties associated with the longitudinal bar size.

Design Criteria: Input parameters that govern the design of the section such as column type, minimum and maximum reinforcement ratio, bar selection criterion, minimum clear spacing, and design/required ratio.

Slenderness

Design Column: Input data needed for slenderness related to the column being considered.

Column Above/Below: Input data needed for slenderness related to the columns above and below the design column.

X-Beams: Input data needed for slenderness related to beams perpendicular to the x-axis framing into the design column.

Y-Beams: Input data needed for slenderness related to beams perpendicular to the y-axis framing into the design column.

Factors: Input factors that affect slenderness calculations.

Loads

Factored: Input factored axial loads and moments. *This command is available for non-slender columns only.*

Service: Input service-level (dead, live, wind and earthquake) axial loads and moments about the active axis. Moments are input at the top and at the bottom of the column. *This command must be used for slender columns.*

Control Points: If chosen, the program will compute key points on the interaction diagram. In addition, the splice regions are shown on the interaction diagram. *This option is available for short (non-slender) columns under the investigation option only.*

Axial Loads: Input a group of axial loads with an initial value, a final value, and an increment. *This command is available for uniaxial short (non-slender) columns only.*

Load Combinations: Input the load factors and combinations used to combine the service loads.

Flip/Rotate Section

Flip an unsymmetrical section about an axis or rotate an irregular section (created in `pcaSection`).

Solve Menu

The **Solve** menu contains commands used to perform the design or investigation, trace through the design process, and send the output to a text file.

Execute (F5)

Executes the solver.

Design Trace

Toggles trace-through-a-design On and Off.

Results File

Toggles output-to-results-file On and Off.

View Menu

The View menu commands used to customize the display screen to suit your viewing needs, view the interaction diagram at a given angle, view the contour for a given axial load, superimpose an interaction diagram or a contour from another run, and view the results file.

Redraw

Redraws the displayed diagram or contour and clear any superimposed curves.

Copy Diagram to Clipboard (CTRL+C)

Copies the displayed diagram or contour to clipboard so that in can be pasted in other applications.

Information Bar

Shows or hides the Information bar.

Tool Bar

Shows or hides the Tool bar.

Status bar

Shows or hides the Status bar.

Grid

Shows or hides the grid.

Mx-My Diagram

View a contour of the failure surface sliced at a constant axial load.

P-M Diagram

View an interaction diagram sliced at a constant (M_x , M_y) angle.

Superimpose

Superimpose a diagram from a previously saved run over the current diagram.

Results (F6)

View the results file after a successful run has been performed with the **Solve | Results File** option ON.

Options

The **Options** menu contains commands used to view or change pcaColumn's default settings and reinforcing bar database.

Startup defaults

View or Edit application startup default settings.

Rebar database

View or Edit reinforcing bar database.

Help Menu

Contents and Index

Lists all the available help topics about the program.

Using Help

Provides help on using the Microsoft Windows help system.

About

Displays copyright information and the version number of the program.

Chapter 4

Operating the Program

This chapter is divided into sections that follow the order in which commands and options appear in the program.

Creating a New Data File

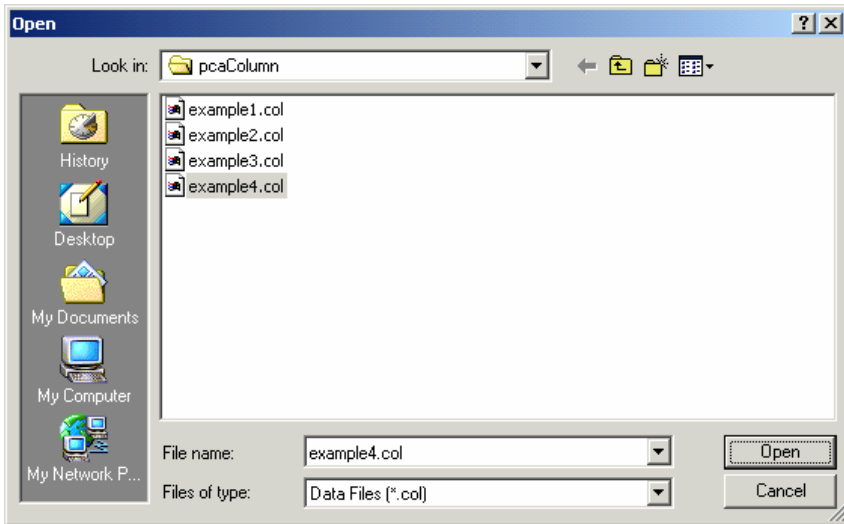
When pcaColumn is first loaded, the program is ready to obtain input for a new file. The data will not have a filename associated with it, therefore, Untitled appears in the Title bar.

- Select **File | New**. This clears the screen and returns to the default settings of the program. If existing data have been changed prior to selecting the **New** command, pcaColumn asks if you want to save the data. At any time after starting a new file, use the **File | Save As** command to give the file a name.

Opening an Existing Data File

You can open pcaColumn data files that were previously saved to disk. pcaColumn reads files that have been saved in binary format (with COL extension).

- Select **File | Open**. A dialog box appears.
- All files with the COL extension contained in the current drive and directory are displayed in the File Name list box.
- To open a file that exists in another drive or directory, select the drive or directory you want from the Drives drop-down list or the Directories list box respectively.
- From the File Name list box, select the file to be opened, or simply type its name in the text box.
- Choose the OK button.



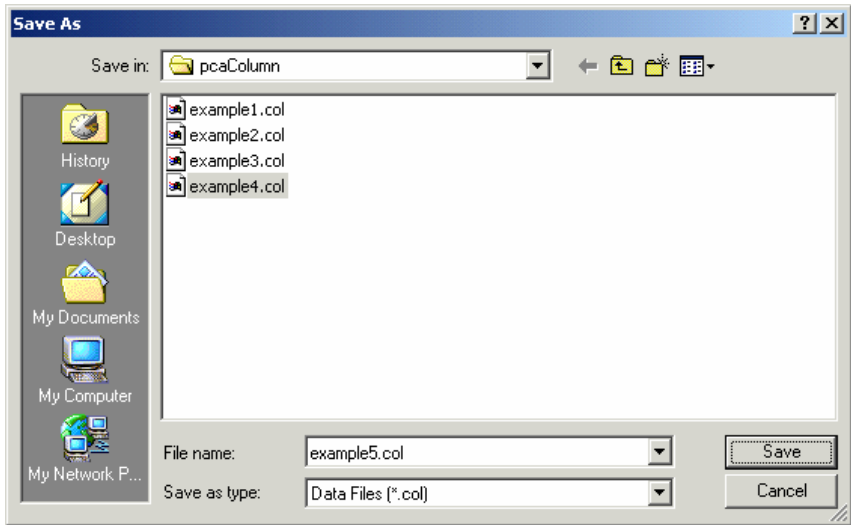
Saving the Data

To save the data with the same filename:

At anytime while editing a data file that has previously been saved under a filename, choose **File | Save** to save the changes under the same file name. Selecting the **File | Save** command before giving the data file a name displays the Save As dialog box.

To give the data a new or different filename:

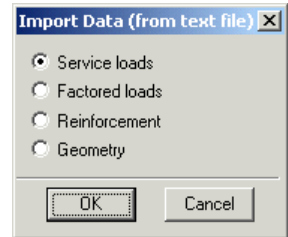
- Select **File | Save As**. A dialog box appears.
- All files with COL extension contained in the current drive and directory are displayed in the File Name list box.
- To save the file to a drive or directory other than the default, select a different drive from the Drives drop-down list or a different directory from the Directories list box.
- In the File Name text box, type a new filename. If no file extension is specified, .COL will be appended to the specified filename.
- Choose the OK button.



Importing Data

Geometry, reinforcement or load data may be imported from a text file. The import file must be saved in pure ASCII (text) format.

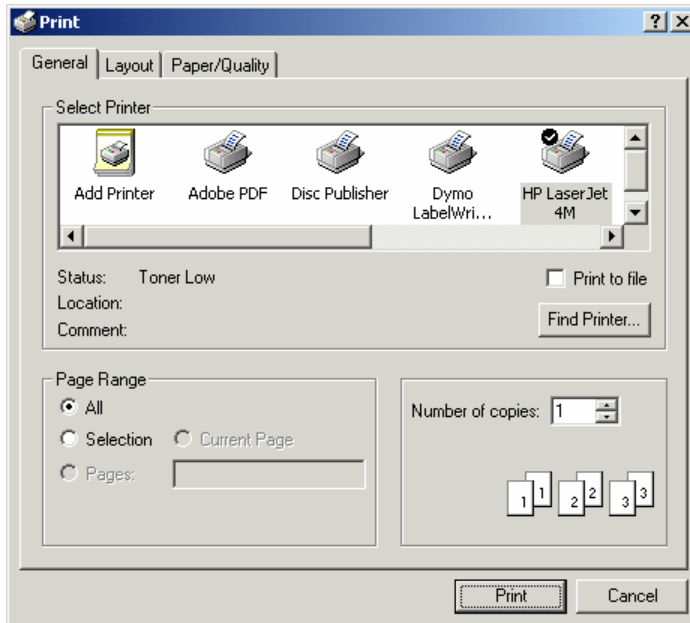
- Select **File | Import**. A dialog box appears.
- Select the type of data you want to import: Service Loads, Factored Loads, Reinforcement or Geometry.
- Choose the OK button. The Open Import file box is displayed.
- All files with the TXT extension contained in the current drive and directory are displayed in the File Name list box.
- To open a file that exists in another drive or directory, select the drive or directory you want from the Drives drop-down list or the Directories list box respectively.
- From the File Name list box, select the file to be opened, or simply type its name in the text box.
- Choose the OK button.



Printing the Results

Once a successful run has been performed you may print the displayed diagram using **File | Print Screen** command. if the **Solve | Results File** option was selected you may print the results file using **File | Print Results** . pcaColumn sends the printout to the printer selected in the Print dialog box.

- Select **File | Print Results** or **File | Print Screen**. A dialog box appears.



- Select the printer to send the results to.
- Use Print dialog controls to set up the printer options.
- Choose the OK button to start the printing or choose the Cancel to terminate the print job.

General Information

The General Information command allows you to define or change options that will affect the rest of the input.

- Select **Input | General Information**. A dialog box appears.
- Enter the project, column, and engineer labels.
- Select the units of measure, English or Metric.
- Select the axis about which the column capacity is to be computed: X-axis, Y-axis, or Biaxial.
- Select the design code to conform to: ACI 318-02 or CSA A23.3-94.
- Choose a run option: Investigation or Design.
- Specify whether slenderness effects are to be considered or not.
- Choose the OK button.

Material Properties

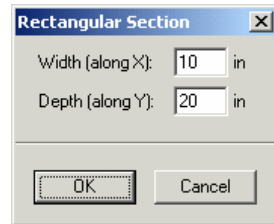
- Select **Input | Material Properties**. A dialog box appears.
- Enter the concrete compressive strength, f'_c . The modulus of elasticity, E_c ; the constant stress intensity, f_c , at the maximum usable strain used to calculate the force on concrete; the factor used to determine the depth of the stress block, $\beta(1)$; and the maximum usable strain at the extreme concrete compression fiber, are automatically computed and displayed. Modify any of the values if different that computed.

- For the reinforcing steel, enter the yield strength, f_y , and the modulus of elasticity, E_s .
- Choose the OK button.

Section / Rectangular

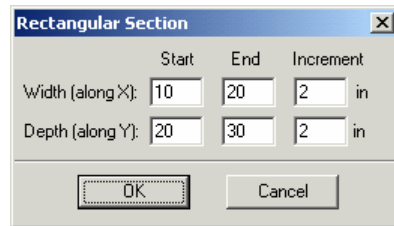
Inputting for the Investigation Option:

- Select **Input | Section | Rectangular**. A dialog box appears.
- Enter the width and depth of the rectangular section. Note that width is measured along the x-axis and depth is measured along the y-axis.
- Choose the OK button.



Inputting for the Design Option:

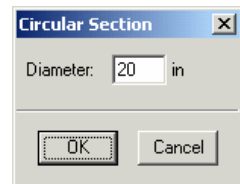
- Select **Input | Section | Rectangular**. A dialog box appears.
- Enter the starting and ending values for each dimension (width and depth) along with an increment for each dimension. Note that the starting and ending values may be the same (in which case the increment must be zero).
- Choose the OK button.



Section / Circular

Inputting for the Investigation Option:

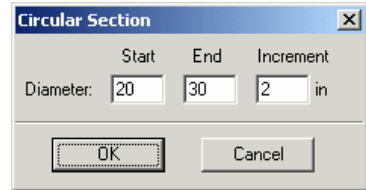
- Select **Input | Section | Circular**. A dialog box appears.
- Enter the diameter of the column section.
- Choose the OK button.



Inputting for the Design Option:

- Select **Input | Section | Circular**. A dialog box appears.

- Enter the starting and ending values the diameter along with an increment. Note that the starting and ending values may be the same (in which case the increment must be zero).
- Choose the OK button.

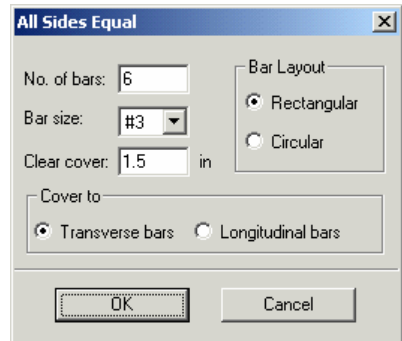


Reinforcement / All Sides Equal

The **Input | Reinforcement | All Sides Equal** command allows you to enter the total number of bars in the column section. The program attempts to divide the bars equally between the four sides of a rectangular layout then equally space them on each side. Corner bars are associated with the top and bottom sides, and if the total number of bars is not a multiple of four, the top and bottom sides get the extra bars. For a circular layout, the program attempts to equally space the bars.

Inputting for the Investigation Option:

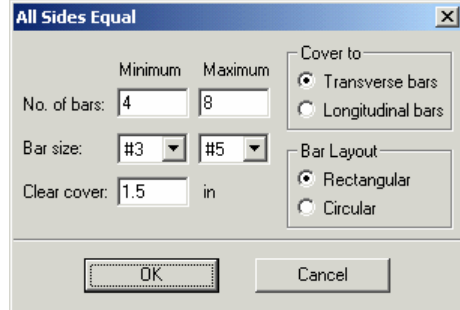
- Select **Input | Reinforcement | All Sides Equal**. A dialog box appears.
- Enter the total number of bars in the section (must be at least 4 and must be a multiple of 2 for a rectangular layout).
- Select the bar size.
- Enter the clear cover and specify whether it is to the transverse (ties) or to the longitudinal bars.
- Select a bar layout, Circular or Rectangular. The default is Circular for a circular section and Rectangular for a rectangular section.
- Choose the OK button.



Inputting for the Design Option

- Select **Input | Reinforcement | All Sides Equal**. A dialog box appears.

- Enter the minimum and maximum total number of bars in the section (must be at least 4 and must be a multiple of 4 for a rectangular layout).
- Select the minimum and maximum bar sizes along with the clear cover.
- Enter the clear cover and specify whether it is to the transverse (ties) or to the longitudinal bars.
- Select a bar layout, Circular or Rectangular. The default is Circular for a circular section and Rectangular for a rectangular section.

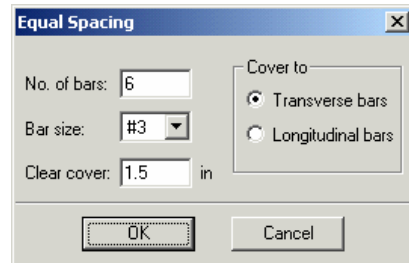


Reinforcement / Equal Spacing

The **Input | Reinforcement | Equal Spacing** command allows you to enter the total number of bars in the column section. The program attempts to place the bars equally spaced on all four sides of a rectangular layout. Corner bars are associated with the top and bottom sides and if the total number of bars is not a multiple of 4, the top and bottom sides will get the extra bars.

Inputting for the Investigation Option:

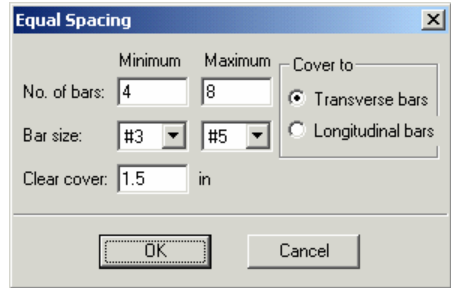
- Select Input | Reinforcement | Equal Spacing. A dialog box appears.
- Enter the total number of bars in the section (*must be at least 4 and a multiple of 2*).
- Select the bar size.
- Enter the clear cover and specify whether it is to the transverse (ties) or to the longitudinal bars.
- Choose the OK button.



Inputting for the Design Option:

- Select Input | Reinforcement | Equal Spacing. A dialog box appears.

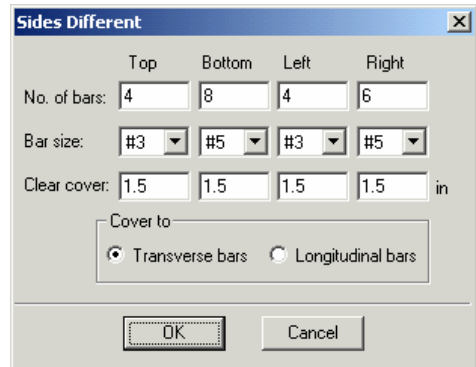
- Enter the minimum and maximum total number of bars in the section (*must be a multiple of 4*).
- Select the minimum and maximum bar sizes.
- Enter the clear cover and specify whether it is to the transverse (ties) or to the longitudinal bars.
- Choose the OK button.



Reinforcement / Sides Different

Inputting for the Investigation Option:

- Select **Input | Reinforcement | Sides Different**. A dialog box appears.
- Enter the number of bars to be placed on each of the top, bottom, left and right sides of the rectangular section. *Note that corner bars are associated with the top and bottom sides.*
- Select the bar size and enter the clear cover for each of the top, bottom, left and right sides of the section.
- Specify whether the clear cover entered is to the transverse (ties) or to the longitudinal bars.
- Choose the OK button.



Inputting for the Design Option:

- Select **Input | Reinforcement | Sides Different**. A dialog box appears.
- In the Top and Bottom group, enter the minimum and maximum total number of bars to be placed on the top and bottom sides, along with the bar size and the clear cover. *The number of bars must be greater than 4 and a multiple of 2. Corner bars are associated with the top and bottom sides.*

- Select the minimum and maximum bar size and enter the clear cover.
- Repeat the steps above for the Left and Right sides.
- Specify whether the clear cover entered is to the transverse (ties) or to the longitudinal bars.
- Choose the OK button.

Reinforcement / Irregular Pattern

The **Input | Reinforcement | Irregular Pattern** command allows you to specify any number of bars (up to 500) to be placed anywhere within the column section. Each bar may have any cross-sectional area. *This command is available with the Investigation option only.*

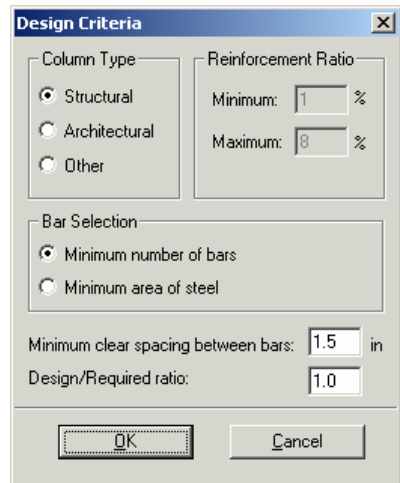
- Select **Input | Reinforcement | Irregular Pattern**. If the section is irregular, The pcaSection window, where the section reinforcement may be graphically input, is displayed. Otherwise, a dialog box appears.
- Enter the bar area, along with its x- and y-coordinates.
- Choose the Insert button. The data are added to the list box.
- Repeat the steps above for each entry.
- To edit an entry, select it from the list box, modify its values in the text boxes, and choose the Modify button. To change the area for several bars at once, select those bars from the list box, enter the new area in the Area text box, and choose Modify.

No.	Area	X	Y
1	0.31	-7.8125	17.8125
2	0.31	7.8125	17.8125
3	0.31	-7.8125	-17.8125
4	0.31	7.8125	-17.8125

- To delete a bar entry, select it from the list box and choose the Delete button.
- Choose the OK button.

Reinforcement / Design Criteria

- Select **Input | Reinforcement | Design Criteria**. A dialog box appears. *This command is available with the Design option only.*
- Specify whether the column is to be considered Structural (default), Architectural, or Other. Notice that the minimum and maximum reinforcement ratios change depending on the selection.
- Choose whether bar selection is to be based on minimum number of bars (default) or on minimum area of steel.
- To modify the limiting reinforcement ratios, choose **Other**. Enter the minimum and maximum reinforcement ratios in the corresponding text boxes.
- Enter the minimum clear bar spacing and the design-to-required ratio.
- Choose the OK button.



Reinforcement / Confinement

- Select Input | Reinforcement | Confinement. A dialog box appears.
- Select the type of bar confinement: Tied (default), Spiral, or Other. The capacity reduction factors change depending on the selection.
- To modify the capacity reduction factors, choose Other for confinement type.

For the ACI code:

Phi(a) is the reduction factor for pure axial compression,

Phi(b) is the reduction factor flexure and axial tension,

Phi(c) is the reduction factor for combined flexure and axial compression.

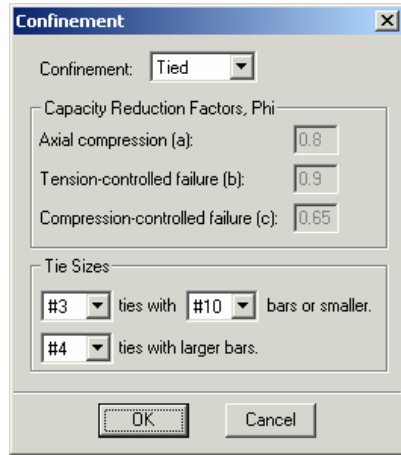
For the CSA code:

Phi(a) is the reduction factor for pure axial compression,

Phi(s) is the material resistance factor for steel,

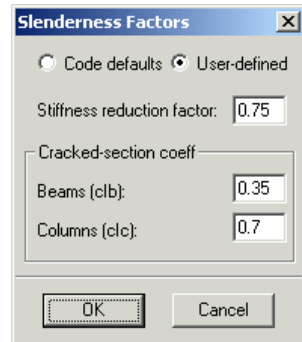
Phi(c) is the material resistance factor for concrete.

- Specify the tie size associated with the particular longitudinal bar sizes. The code requirements are used as defaults.
- Choose the OK button.



Slenderness / Factors

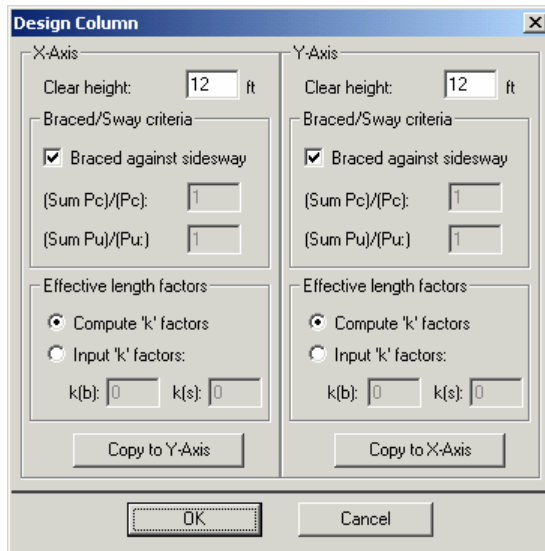
- Select **Input | Slenderness | Factors**. A dialog box appears. *Note: this command is available for slender columns only.*
- The default values, per the design code, for the stiffness reduction factor (used to compute the moment magnification factors) and the cracked section coefficients for beams and columns are displayed. To modify these values, select the User-defined option and enter your values.
- Choose the OK button.



Slenderness / Design Column

- Select **Input | Slenderness | Design Column**. A dialog box appears. The x-axis or y-axis data groups may be disabled depending on the active run axis. *Note: this command is available for slender columns only.*
- Enter the clear column height in the corresponding text box.

- Specify whether the column is braced against sidesway or not by selecting or clearing the Braced Against Sidesway option.
- For an unbraced column, enter the ratio of the sum of the critical load of all story columns to the critical load of the column under consideration, $(\sum P_c)/P_c$. Also, enter the ratio of the sum of the factored axial load of all story columns to the factored axial load of the column under consideration, $(\sum P_u)/P_u$.
- In the Effective Length Factors group, specify whether the k factor(s) are to be user-input or computed by the program, by selecting the corresponding option.
- If you chose Input k Factors, enter the effective length factors for braced and sway conditions, K_b and K_s , respectively.
- Repeat the steps above for each active axis.
- Choose the OK button.



Slenderness / Columns Above and Below

- Select **Input | Slenderness | Columns Above/Below**. A dialog box appears. Note: this command is available for slender columns only for which the Compute k Factors option is selected in the Design Column dialog box.

The dialog box is titled "Columns Above and Below". It is divided into two columns: "Column Above" and "Column Below".

Column Above:

- No column specified
- Height (c/c): 15 ft
- Width (along X): 30 in
- Depth (along Y): 30 in
- Concrete, f_c : 4 ksi
- Ec: 3605 ksi
- Copy to Column Below

Column Below:

- No column specified
- Height (c/c): 15 ft
- Width (along X): 30 in
- Depth (along Y): 30 in
- Concrete, f_c : 4 ksi
- Ec: 3605 ksi
- Copy to Column Above

At the bottom of the dialog are "OK" and "Cancel" buttons.

- In the Column Above group, specify whether or not a column above the design column exists, by selecting or clearing the No column specified option.
- If a column above exists; enter the center-to-center height, the width (along the x-axis), the depth (along the y-axis), the concrete compressive strength, and the concrete modulus of elasticity of the column above in the corresponding text boxes. For circular sections, enter zero for the Depth and input the section diameter in the Width box. If zero is entered for both Width and Depth, the dimensions of the design column will be automatically used.
- Repeat the same for the column below or, if the column above and the column below are the same, choose the Copy to Column Below button.
- Choose the OK button.

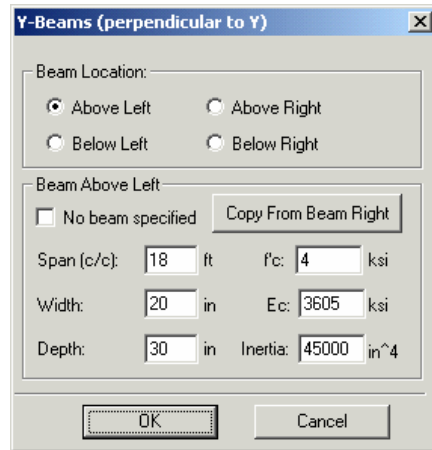
Slenderness / X-Beams

- Select **Input | Slenderness | X-Beams**. A dialog box appears. Beams defined using this command span perpendicular to the x-axis. *Note: this command is available for slender columns only for which the Compute k Factors option is selected in the Design Column dialog box and the run axis is biaxial or uniaxial x-axis.*
- From the Beam Location group, choose the appropriate option. The data group below updates depending on the selection.
- For the selected beam, specify whether or not a beam exists, by selecting or clearing the No Beam Specified option.
- If a beam exists; enter the center-to-center span length, width, depth, concrete compressive strength, concrete modulus of elasticity, and moment of inertia (if different than computed) of the beam.
- Repeat the steps above for the beams above right, below left, and below right.
- Choose the OK button.

Slenderness / Y-Beams

- Select **Input | Slenderness | Y-Beams**. A dialog box appears. Beams defined using this command span perpendicular to the y-axis. *Note: this command is available for slender columns only for which the Compute k Factors option is selected in the Design Column dialog box and the run axis is biaxial or uniaxial y-axis.*
- From the Beam Location group, choose the appropriate option. The data group below updates depending on the selection.
- For the selected beam, specify whether or not a beam exists, by selecting or clearing the No Beam Specified option.

- If a beam exists; enter the center-to-center span length, width, depth, concrete compressive strength, concrete modulus of elasticity, and moment of inertia (if different than computed) of the beam.
- Repeat the steps above for the beams above right, below left, and below right.
- Choose the OK button.



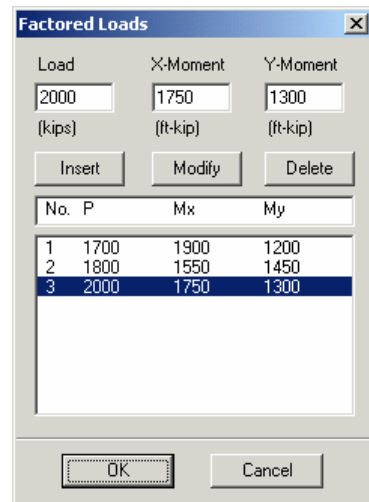
The dialog box titled "Y-Beams (perpendicular to Y)" contains the following fields and controls:

- Beam Location:** Four radio buttons: "Above Left" (selected), "Above Right", "Below Left", and "Below Right".
- Beam Above Left:** A checkbox "No beam specified" and a button "Copy From Beam Right".
- Span (c/c):** Input field with value "18" and unit "ft".
- f'c:** Input field with value "4" and unit "ksi".
- Width:** Input field with value "20" and unit "in".
- Ec:** Input field with value "3605" and unit "ksi".
- Depth:** Input field with value "30" and unit "in".
- Inertia:** Input field with value "45000" and unit "in⁴".
- Buttons: "OK" and "Cancel".

Loads / Factored

Whether designing or investigating a short (non-slender) column, factored loads consisting of applied axial loads and moments about the active axis may be input.

- Select **Input | Loads | Factored**. A dialog box appears.
- Enter the factored axial load in the Load text box.
- Depending on the active axis, enter the factored moment about the x-axis, the factored moment about the y-axis, or both.
- Choose the Insert button. The data are added to the list box.
- Repeat the steps above for each factored load entry.
- To edit an entry, select it from the list box, modify its values in the text boxes, and choose the Modify button.
- To delete an entry, choose it from the list box and choose the Delete button.
- Choose the OK button.



The dialog box titled "Factored Loads" contains the following fields and controls:

- Load:** Input field with value "2000" and unit "(kips)".
- X-Moment:** Input field with value "1750" and unit "(ft-kip)".
- Y-Moment:** Input field with value "1300" and unit "(ft-kip)".
- Buttons: "Insert", "Modify", and "Delete".
- List Box:** A table with columns "No.", "P", "Mx", and "My".

No.	P	Mx	My
1	1700	1900	1200
2	1800	1550	1450
3	2000	1750	1300

Buttons: "OK" and "Cancel".

Loads / Service

When designing or investigating a short or slender column, service level loads consisting of dead, live, and lateral (wind and earthquake) axial loads and moments at both column ends about the active axis may be input. These loads are then factored and combined based on the load combinations.

- Select **Input | Loads | Service**. A dialog box appears.

	Axial Load (kips)	X-Moments (ft-kips)		Y-Moments (ft-kips)		
		@ Top	@ Bot	@ Top	@ Bot	
Dead:	230	2	2	1	1	Insert
Live:	173	108	-100	50	46	Modify
Wind:	6	84	-70	15	-11	Delete
E.Q.:	0	0	0	0	0	

No. [P, Mxt, Mxb, Myt, Myb] for each case

```

1 D [230, 2, 2, 1, 1]; L [173, 108, -100, 50, 46]; W [6, 84, -70, 15, -11]; E [0, 0, 0, 0]
2 D [250, 3, 3, 2, 2]; L [150, 90, -85, 35, -43]; W [8, 92, -75, 18, -16]; E [0, 0, 0, 0]
3 D [230, 3, 3, 2, 2]; L [160, 87, -83, 56, -43]; W [7, 86, -72, 5, -4]; E [0, 0, 0, 0]
    
```

OK Cancel

- For each of the load cases: dead, live, wind and earthquake, enter the axial load and the applicable moment (about x or y) at the column top and bottom.
- Choose the Insert button. The data are added to the list box.
- Repeat the steps above for each entry.
- To edit an entry, select it from the list box, modify its values in the text boxes, and choose the Modify button.
- To delete an entry, choose it from the list box and choose the Delete button.
- Choose the OK button.

Load / Control Points

A non-slender column may be investigated without inputting any loads. The capacity of the section is computed along with other important information. *This command is not available for slender columns or under the Design option.*

- Select **Input | Loads | Control Points**.

In the output file, key points on the interaction diagram are listed. For each point, the axial load and bending moment capacities, along with the corresponding neutral axis depth, are listed.

For a biaxial run, these points are listed for bending about positive and negative X and Y axes.

For a uniaxial runs, the bar-splice regions are indicated on the interaction diagram.

Loads / Axial Loads

When investigating a short column (uniaxial runs only), grouped factored applied axial loads may be input. The corresponding moment capacity for each load is computed and output. *This command is not available under the Design option, for biaxial runs, or if the column is slender.*

- Select **Input | Loads | Axial Loads**. A dialog box appears.
- To input a range of axial loads, enter the initial, final and increment values in the corresponding text boxes. To input a discrete (single) axial load, enter its value in the Initial text box, and enter zero in the Final and Increment text boxes.
- Choose the Insert button. The data are added to the list box.
- Repeat the steps above for each axial load entry you may have.
- To edit an entry, select it from the list box, modify its values in the text boxes, and choose the Modify button.
- To delete an entry, choose it from the list

No.	Initial	Final	Inc
1	120	180	10
2	80	150	10
3	95	125	5

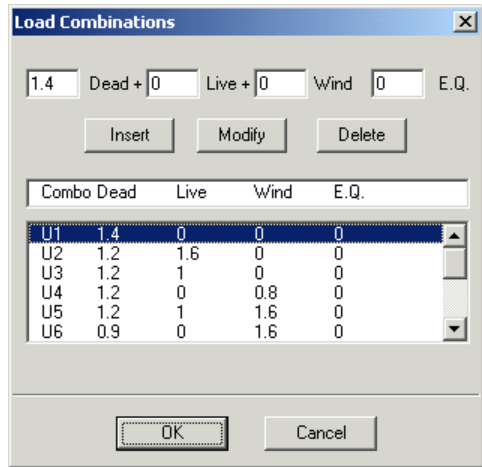
box and choose the Delete button.

- Choose the OK button.

Loads / Load Combinations

pcaColumn allows you to specify up to fifteen load combinations. The service load input under the load cases (dead, live, wind, and earthquake) are combined based on these combinations. A minimum of one combination must be input.

- Select **Input | Loads | Load Combinations**. A dialog box appears. For a new file, the default combinations per the selected code are shown in the list box.
- To add a new combination, enter the load factors or multipliers for each load case, Dead, Live, Wind, and Earthquake.
- Choose the Insert button. The data are added to the list box.
- Repeat the steps above for each load combination. Up to eight combinations may be defined.
- To edit an entry, select it from the list box, modify its values in the text boxes, and choose the Modify button.
- To delete an entry, choose it from the list box and choose the Delete button.
- Choose OK when done.

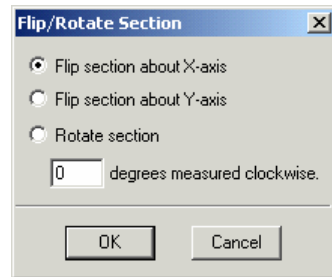


Flipping / Rotating the Section

This command is available for Irregular sections and for sections with Sides Different or Irregular reinforcement.

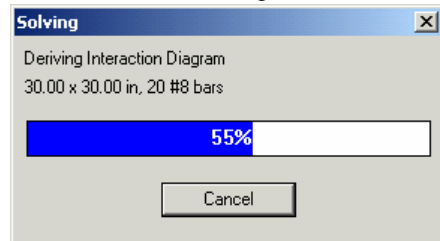
- Select **Input | Flip/Rotate Section**. A dialog box appears.

- Select one of the options: Flip section about x-axis, Flip section about y-axis, or Rotate section. The last option is available for irregular sections only.
- If Rotate section is selected, enter the angle of rotation (clockwise is positive).
- Choose the OK button.



Executing a Run

- Select **Solve | Results File**. This is an option that may be turned ON or OFF by choosing it again. With this option ON, an output file will be created while the program is solving. The output file is a text file that contains an echo of the input along with slenderness calculation output, load combinations, and the critical points on the interaction diagram.
- Select **Solve | Design Trace** (*design option only*). This is an option that may be turned ON or OFF by choosing it again. With this option ON, if designing a column section, the program will pause at each cross section and reinforcement layout it tries, and display the cross section with its bars in the Information bar.
- Select **Solve | Execute**. If more data are needed to solve the problem, an error box appears and you will be prompted for the required data. If all the needed data are input, the solver portion of pcaColumn will start executing. The Solving box appears with a progress indicator. Click Cancel to terminate the solution process.



After a successful run, the interaction diagram or the contour plot is displayed in the Graphics area of the window.

Viewing the Results

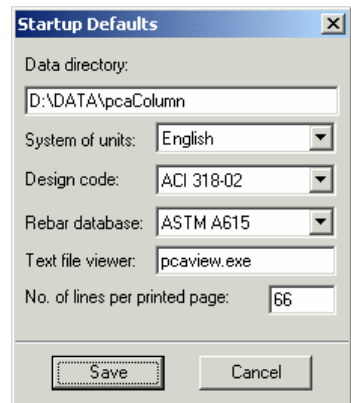
Once a successful run has been performed with the Execute | Results File option ON, you may view the results file.

- Select **View | Results**. pcaColumn executes the pcaView program, an applet that enables viewing of text-based files.
- Use the scroll bars or the cursor keys to navigate through the file.
- Select **Exit** to quit pcaView and return to pcaColumn.

Changing the Startup Defaults

You can change some default settings that pcaColumn uses when it is started or when the **File | New** command is executed.

- Select **Options | Startup Defaults**. A dialog box appears.
- Enter the full path of the directory to which pcaColumn defaults when opening a data file.
- Select the system of units, design code, and rebar database to be used as defaults whenever a new file is started.
- Enter the name of the program to be used by pcaColumn when viewing results. By default, pcaColumn uses pcaView.
- Enter the number of lines per page to be used in formatting the results file.
- Choose the **Save** button to save these options in the PCAPROGS.INI file.



Changing the Rebar Database

- Select **Options | Rebar Database**. A dialog box appears.

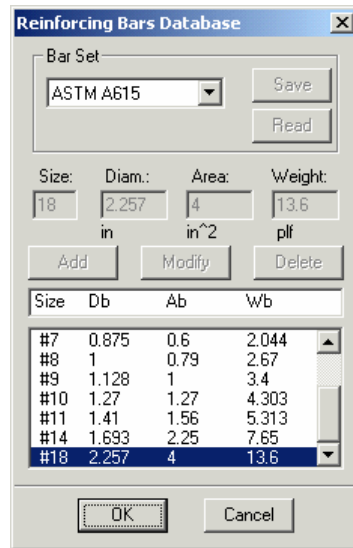
To select a different set:

- From the Bar Set drop-down list, select the set to be used.
- Choose the **OK** button.

To create or modify a user-defined set

- From the Bar Set drop-down list, select **User-defined**. The **Add**, **Delete** and **Modify** buttons are enabled.

- To edit an entry, select it from the list box, modify its values, and choose the Modify button.
- To delete an entry, select it from the list box and choose the Delete button.
- To add an entry, enter the bar size, diameter, area and unit weight in the corresponding text box, and choose the Add button. The data are added to the list box.
- A user-defined set may be saved to disk for use in other files. To do so, choose the Save button after inputting the bars. To retrieve a saved set, choose the Read button. Rebar database is saved to the PCACOL.BAR file.
- Choose the OK button.



Superimposing Diagrams

After executing a run and selecting the **File | Save** command, the program saves the diagram data in a separate file that has the same filename as the input file, with an IAD extension. This file may be later read by the program and two diagrams (of different files) may be superimposed for the purpose of comparison. Note that the run option (uniaxial or biaxial) of the two files must be the same

- Select **View | Superimpose**. The open dialog box appears.
- All files with the IAD extension contained in the current drive and directory are displayed in the File Name list box. To open a file that exists in another drive or directory, select the drive or directory you want from the Drives drop-down list or the Directories list box respectively.
- From the File Name list box, select the file to be opened, or simply type its name in the text box.

- Choose the OK button. If the data is successfully read, the diagram from the IAD file (shown dotted) is superimposed over the currently displayed diagram.
- To clear any superimposed diagrams, select the **View | Redraw** command.

Viewing the Diagram

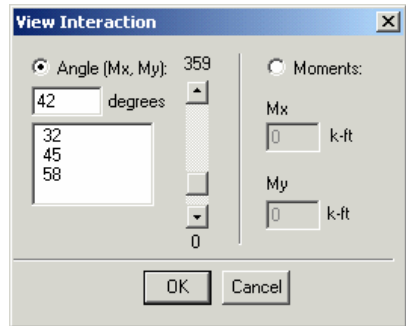
For a uniaxial run, the program computes and displays the P-M interaction diagram. For a biaxial run, the program computes the three-dimensional failure surface (P, M_x, M_y). The failure surface can be viewed in one of two ways:

- P-M interaction diagram (vertical slice at an angle measured from M_x)
- M_x-M_y contour curve (horizontal slice at a constant axial load).

Whenever the mouse cursor moves over the Graph area, the axial load, moment, and eccentricity are displayed in the Status bar.

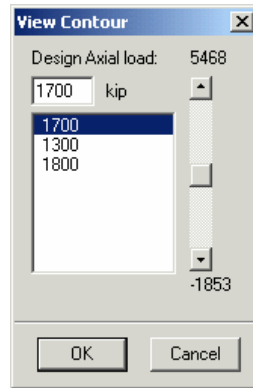
Viewing the Interaction Diagram

- Select **View | Interaction**. A dialog box appears.
- Specify whether you want to enter an angle or the values of the moments that produce a view angle by selecting either the Angle or Moments option, respectively.
- If the Angle option was selected, select an angle from the list, use the scroll bar to pick an angle, or simply enter the value in the text box.
- If the Moments option was selected, enter the values of M_x and M_y which produce a view angle. The value of that view angle is computed and shown in the Angle text box.
- Choose the OK button.



Viewing the Contour

- Select **View | Contour**. A dialog box appears.
- Select an axial load from the list, use the scroll bar to pick a load, or simply enter the value in the text box.
- Choose the OK button.



Chapter 5

Examples

Example 1 – Design of a Short Column

Determine the size and reinforcement of a column section to carry the following factored loads:

$$P_u = 1,700 \text{ kips}, M_{ux} = 1,900 \text{ ft-kips}, M_{uy} = 1,200 \text{ ft-kips}.$$

The column section is rectangular, limited in width to 32 in but the depth could be as large as 48 in. The reinforcing bars are equally distributed on all four sides and the reinforcement ratio should be limited to 3%. Use 6-ksi concrete and 60-ksi reinforcing steel.

1. From the **File** menu, choose **New**. Any input data is cleared and the default values are restored.
2. From the **Input** menu, choose **General Information**.
 - Input the project header.
 - Select English units and ACI 318-02 code.
 - Select Biaxial for run axis, Design for run option and No for slenderness.
 - Choose Ok.
3. From the **Input** menu, choose **Material Properties**.
 - Input 6 for the concrete strength. Other properties are computed and will be accepted.
 - Choose Ok.

General Information

Labels

Project: PCACOL Manual, Biaxial

Column: Ex_1 Engineer: PCA

Units

English Metric

Design Code

ACI 318-02 CSA A23.3-94

Run Axis

About X-Axis About Y-Axis Biaxial

Run Option

Investigation Design

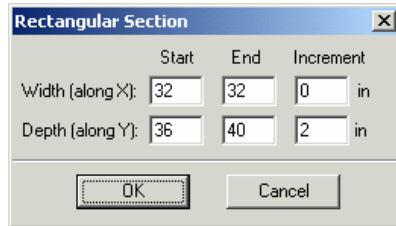
Consider slenderness? Yes No

OK Cancel



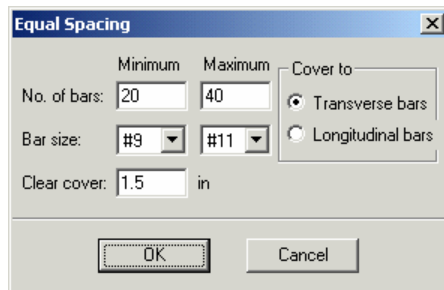
4. From the **Input** menu, choose **Section | Rectangular**.

- For the section Width, input 32, 32 and 0 under Start, End and Increment.
- For the section Depth, input 36, 48 and 2 under Start, End and Increment.
- Choose Ok.



5. From the **Input** menu, choose **Reinforcement | Equal Spacing**.

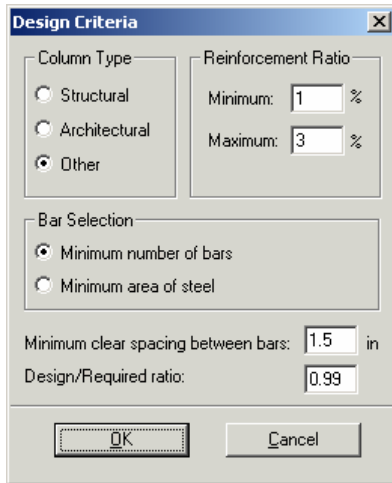
- Input 20-#9 bars for minimum and 40-#11 bars for maximum.
- Input 1.5 in for the cover and select Transverse bars.
- Choose Ok.



6. From the **Input** menu, choose **Reinforcement | Design Criteria**.

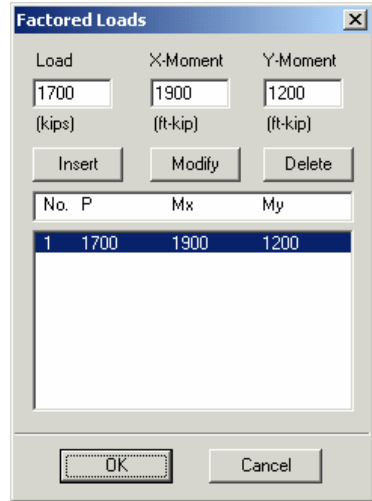
- Under Column Type, select Other.
- Input 3 for Maximum Reinforcement Ratio.

- Choose Ok.



The Design Criteria dialog box contains the following settings:

- Column Type: Other
- Reinforcement Ratio:
 - Minimum: 1 %
 - Maximum: 3 %
- Bar Selection:
 - Minimum number of bars
 - Minimum area of steel
- Minimum clear spacing between bars: 1.5 in
- Design/Required ratio: 0.99



The Factored Loads dialog box contains the following settings:

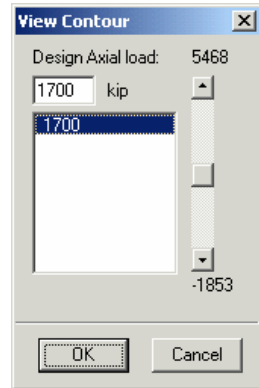
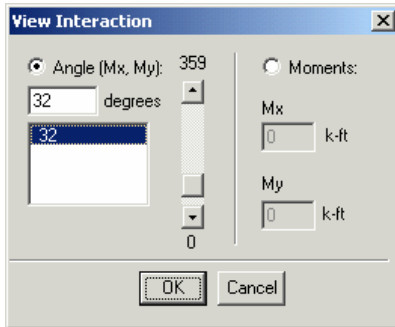
- Load: 1700 (kips)
- X-Moment: 1900 (ft-kip)
- Y-Moment: 1200 (ft-kip)

Buttons: Insert, Modify, Delete

No.	P	Mx	My
1	1700	1900	1200

Buttons: OK, Cancel

- From the **Input** menu, choose **Loads | Factored**.
 - Input 1700, 1900 and 1200 for the Load, X-Moment and Y-Moment, respectively.
 - Choose Insert to add the entry to the list box.
 - Choose Ok.
- From the **Solve** menu, choose **Execute**.
 - The solver of the program is started and, upon completion, displays the selected section that passes the design (32x38 with 22-#11 bars).
 - The Mx-My contour at zero-axial load is displayed in the Graphics area.
- From the **View** menu, choose **Interaction**.
 - The Angle list displays the Mx-My angle for the input moment(s). Choose 32 from the list.
 - Choose Ok. The PM interaction diagram (at 32-deg Mx-My angle) is displayed in the Graphics area. The load point is indicated on the diagram.



10. From the **View** menu, choose **Contour**.
 - The Design Axial Load list displays the value(s) of any input load(s). Choose 1700 from the list.
 - Choose Ok. The Mx-My contour at P = 1700 kips is displayed in the Graphics area. The load point is indicated on the diagram.
11. From the **View** menu, choose **Results**.
 - Page through the results file.
 - Choose **Exit** to quit the pcaView program and get back to pcaColumn.
12. From the **File** menu, choose **Print Results**.
 - Select the printer to send the text results to.
 - Choose Ok.
13. From the **File** menu, choose **Print Screen**.
 - Select the printer to send the graphical results to.
 - Choose Ok.

General Information:

```

=====
File Name: C:\Program Files\PCA\pcaColumn\Examples\Example1.col
Project:  PCACOL Manual, Biaxial
Column:   Ex_1                               Engineer: PCA
Code:     ACI 318-02                          Units: English

Run Option: Design                            Slenderness: Not considered
Run Axis:   Biaxial                           Column Type: User-defined
  
```

Material Properties:

```

=====
f'c   = 6 ksi           fy   = 60 ksi
Ec    = 4415.21 ksi    Es   = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.75
  
```

Section:

```

=====
Rectangular: Width = 32 in           Depth = 40 in

Gross section area, Ag = 1280 in^2
Ix = 170667 in^4                   Iy = 109227 in^4
Xo = 0 in                           Yo = 0 in
  
```

Reinforcement:

```

=====
Rebar Database: ASTM A615
Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)
-----
# 3    0.38    0.11 # 4    0.50    0.20 # 5    0.63    0.31
# 6    0.75    0.44 # 7    0.88    0.60 # 8    1.00    0.79
# 9    1.13    1.00 # 10   1.27    1.27 # 11   1.41    1.56
# 14   1.69    2.25 # 18   2.26    4.00
  
```

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
 phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Rectangular
 Pattern: Equal Bar Spacing (Cover to transverse reinforcement)
 Total steel area, As = 34.32 in^2 at 2.68%
 22 #11 Cover = 1.5 in

Factored Loads and Moments with Corresponding Capacities: (see user's manual for notation)

```

=====

```

No.	Pu kip	Mux k-ft	Muy k-ft	fMnx k-ft	fMny k-ft	fMn/Mu
1	1700.0	1900.0	1200.0	1927.6	1217.5	1.015

*** Program completed as requested! ***

Example 2 – Capacity of a Non-Sway Column

Check the capacity of an interior column, located on the third floor of a braced frame. The frame has 5 bays (24 ft on centers) and 6 floors (14 ft floor-to-floor height).

All interior columns are 18x18 and all exterior columns are 16x16. All interior columns of the third floor have 8-#10 bars with 1.5 in cover. All beams are 48x12 and support a 6-in slab. The moment of inertia of the T-section is 13,823 in⁴. Use 4-ksi concrete and 60-ksi steel for all beams and columns.

The service load values for the column under consideration are as follows:

	<u>Dead</u>	<u>Live</u>
P (kip)	230	173
Top M_x (kip-ft)	2	108
Bottom M_x (kip-ft)	2	-100

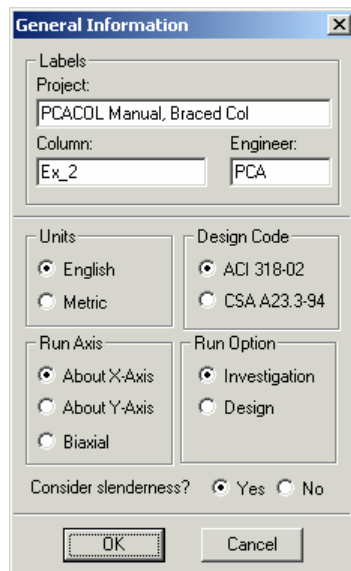
The column is to be checked for the following load combination:

$$U1 = 1.4 D$$

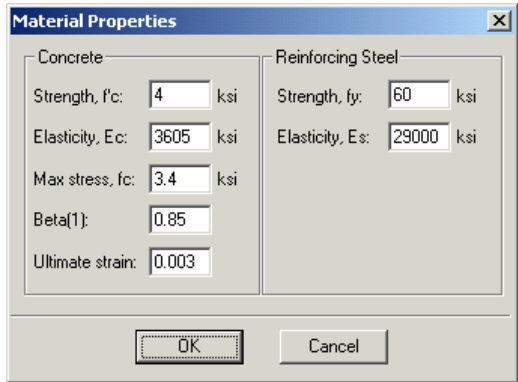
$$U2 = 1.2 D + 1.6 L$$

$$U3 = 1.2 D + 1.0 L$$

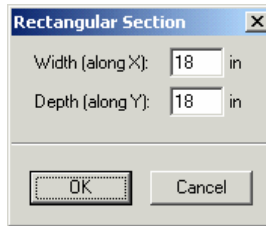
- From the **File** menu, choose **New**. Any input data is cleared and the default values are restored.
- From the **Input** menu, choose **General Information**.
 - Input the project header.
 - Select English units and ACI 318-02 code.
 - Select About X for run axis, Investigation for run option and Yes for slenderness.
 - Choose Ok.



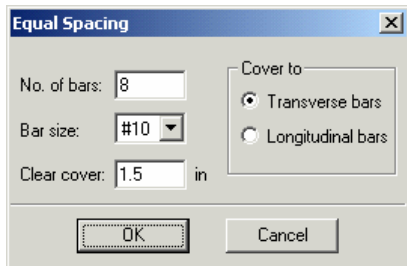
3. From the **Input** menu, choose **Material Properties**.
 - Input 4 for the concrete strength. Other properties are computed and will be accepted.
 - Choose Ok.



4. From the **Input** menu, choose **Section | Rectangular**.
 - Input 18 and 18 for the section width and depth.
 - Choose Ok.



5. From the **Input** menu, choose **Reinforcement | Equal Spacing**.
 - Input 8-#10 bars and 1.5 in for the cover and select Transverse bars.
 - Choose Ok.



6. From the **Input** menu, choose **Slenderness | Design Column**.
 - Input 13 for the column clear height.
 - Check the Braced against sidesway option and select Compute 'k' factors.
 - Choose Ok.

7. From the **Input** menu, choose **Slenderness | Columns Above/Below**.
 - Clear the No column specified option.
 - Input 14 for the column height (center-to-center) and leave the other data as is.
 - Choose Copy to Column Below.
 - Choose Ok.

8. From the **Input** menu, choose **Slenderness | X-Beams**.
 - Choose Above Left.
 - Clear the No beam specified option.
 - Input 24 for the span (center-to-center).

- Input 48 and 12 for the width and depth, respectively.
- Input 13823 for the moment of inertia.
- Leave the other data as is.
- Choose Above Right and click on Copy From Beam Left.
- Choose Below Left and click on Copy From Beam Above.
- Choose Below Right and click on Copy From Beam Above.
- Choose Ok.

9. From the **Input** menu, choose **Loads | Service**.

- Input 230, 2.0 and 2.0 for the dead Load, X-Moment and Y-Moment, respectively.
- Input 173, 108 and -100 for the live Load, X-Moment and Y-Moment, respectively.
- Choose Insert to add the entry to the list box.
- Choose Ok.

	Axial Load (kips)	X-Moments (ft-kips)		Y-Moments (ft-kips)	
		@ Top	@ Bot	@ Top	@ Bot
Dead:	230	2	2	0	0
Live:	173	108	-100	0	0
Wind:	0	0	0	0	0
E.Q.:	0	0	0	0	0

No. [P, Mxt, Mxb, Myt, Myb] for each case

1 D | 230, 2, 2, 0, 0; L | 173, 108, -100, 0, 0; W | 0, 0, 0, 0, 0; E | 0, 0, 0, 0, 0

10. From the **Input** menu, choose **Loads | Load Combinations**.

- If the list displays thirteen combinations, leave the first three as they are. Select combinations four through thirteen and click Delete. Only the first three combinations need to be considered.
- Choose Ok.

Combo	Dead	Live	Wind	E.Q.
U1	1.4	0	0	0
U2	1.2	1.6	0	0
U3	1.2	1	0	0

11. From the **Solve** menu, choose **Execute**.

- The solver of the program is started and, upon completion, displays the interaction diagram of the section with the load point plotted within the diagram.

12. From the **View** menu, choose **Results**.

- Page through the results file.
- Choose Exit to quit the pcaView program and get back to pcaColumn.

13. From the **File** menu, choose **Print Results**.

- Select the printer to send the text results to.
- Choose Ok.

14. From the **File** menu, choose **Print Screen**.

- Select the printer to send the graphical results to.
- Choose Ok.

General Information:

```

=====
File Name: C:\Program Files\PCA\pcaColumn\Examples\Example2.col
Project: PCACOL Manual, Braced Col
Column: Ex_2                               Engineer: PCA
Code: ACI 318-02                           Units: English

Run Option: Investigation                    Slenderness: Considered
Run Axis: X-axis                            Column Type: Structural
  
```

Material Properties:

```

=====
f'c = 4 ksi                               fy = 60 ksi
Ec = 3605 ksi                             Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.85
  
```

Section:

```

=====
Rectangular: Width = 18 in                Depth = 18 in

Gross section area, Ag = 324 in^2
Ix = 8748 in^4                             Iy = 8748 in^4
Xo = 0 in                                   Yo = 0 in
  
```

Reinforcement:

```

=====
Rebar Database: ASTM A615
Size Diam (in) Area (in^2)              Size Diam (in) Area (in^2)
-----
# 3    0.38    0.11 # 4    0.50    0.20 # 5    0.63    0.31
# 6    0.75    0.44 # 7    0.88    0.60 # 8    1.00    0.79
# 9    1.13    1.00 # 10   1.27    1.27 # 11   1.41    1.56
# 14   1.69    2.25 # 18   2.26    4.00
  
```

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
 phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Rectangular
 Pattern: Equal Bar Spacing (Cover to transverse reinforcement)
 Total steel area, As = 10.16 in^2 at 3.14%
 8 #10 Cover = 1.5 in

Slenderness:

```

=====
Sway Criteria:
-----
  
```

X-axis: Braced column.

Column Axis	Height ft	Width in	Depth in	I in^4	f'c ksi	Ec ksi
Design X	13	18	18	8748	4	3605
Above X	14	0	0	8748	4	3605
Below X	14	0	0	8748	4	3605

X-Beams Location	Length ft	Width in	Depth in	I in^4	f'c ksi	Ec ksi
Above Left	24	48	12	13823	4	3605
Above Right	24	48	12	13823	4	3605
Below Left	24	48	12	13823	4	3605
Below Right	24	48	12	13823	4	3605

Effective Length Factors:

Axis	Psi(top)	Psi(bot)	k(Braced)	k(Sway)	klu/r
X	2.170	2.170	0.917	(N/A)	27.53

Moment Magnification Factors:

Stiffness reduction factor, phi(K) = 0.75
 Cracked-section coefficients: cI(beams) = 0.35; cI(columns) = 0.7

$0.2 * E_c * I_g + E_s * I_{se} \text{ (X-axis)} = 1.56e+007 \text{ kip-in}^2$

X-axis Ld/Comb	Pc(kip)	Braced			Sway	
		Betad	Cm	Delta	Pc(kip)	Delta
1 U1	3766	1.000	0.000	1.000	*	N/A
U2	5023	0.499	0.960	1.125		N/A
U3	4664	0.615	0.954	1.094		N/A

* Slenderness need not be considered.

Load Combinations:

U1 = 1.400*Dead + 0.000*Live + 0.000*Wind + 0.000*EarthQuake
 U2 = 1.200*Dead + 1.600*Live + 0.000*Wind + 0.000*EarthQuake
 U3 = 1.200*Dead + 1.000*Live + 0.000*Wind + 0.000*EarthQuake

Service Loads:

No.	Load Case	Axial Load kip	Mx @ Top k-ft	Mx @ Bot k-ft	My @ Top k-ft	My @ Bot k-ft
1	Dead	230.0	2.0	2.0	0.0	0.0
	Live	173.0	108.0	-100.0	0.0	0.0
	Wind	0.0	0.0	0.0	0.0	0.0
	E.Q.	0.0	0.0	0.0	0.0	0.0

Factored Loads and Moments with Corresponding Capacities: (see user's manual for notation)

NOTE: Each loading combination includes the following cases:

First line - at column top
 Second line - at column bottom

No.	Load Combo	Pu kip	Mux k-ft	fMnx k-ft	fMn/Mu
1	1 U1	322.0	2.8	283.2	101.154
2		322.0	-2.8	-283.2	101.154
3	1 U2	552.8	197.1	231.8	1.176
4		552.8	177.3	231.8	1.308
5	1 U3	449.0	120.8	256.5	2.123
6		449.0	106.8	256.5	2.402

*** Program completed as requested! ***

Example 3 – Capacity of a Sway Column

Check the capacity of an interior column, located on the third floor of a sway (unbraced) frame. The frame has 5 bays (24 ft on centers) and 6 floors (14 ft floor to-floor height).

All interior columns are 18x18 and all exterior columns are 16x16. All interior columns of the third floor have 8-#10 bars with 1.5 in cover. All exterior columns of the third floor have 8-#8 bars. All beams are 48x12 and support a 6-in slab. The moment of inertia of the T-section is 13,823 in⁴. Use 4-ksi concrete and 60-ksi steel for all beams and columns.

In addition to the gravity load analysis, a lateral load analysis due to wind was performed. The service load values for the column under consideration are as follows:

	<u>Dead</u>	<u>Live</u>	<u>Wind</u>	<u>Earthquake</u>
P (kip)	230	173	6	0
Top M_x (kip-ft)	2	108	84	0
Bottom M_x (kip-ft)	2	-100	-70	0

The column is to be checked for the following load combinations:

$$U1 = 1.4 D$$

$$U2 = 1.2 D + 1.6 L$$

$$U3 = 1.2 D + 1.0 L$$

$$U4 = 1.2 D + 0.8 W$$

$$U5 = 1.2 D + 1.0 L + 1.6 W$$

$$U6 = 0.9 D + 1.6 W$$

$$U7 = 1.2 D - 0.8 W$$

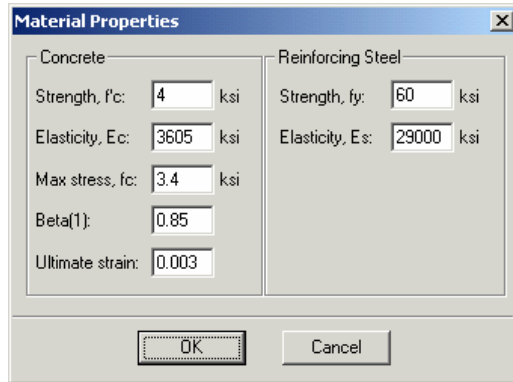
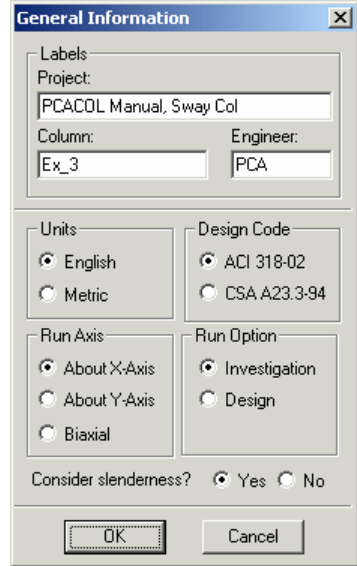
$$U8 = 1.2 D + 1.0 L - 1.6 W$$

$$U9 = 0.9 D - 1.6 W$$

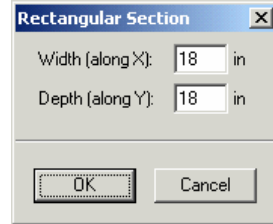
Based on preliminary computations, P_c for interior columns is 2,466 kips and P_c for exterior columns is 1,120 kips. With 2 exterior columns and 4 interior columns, $\Sigma P_c = 2 \times 1,120 + 4 \times 2,466 = 12,104$ kips. For the column under consideration, the ratio $\Sigma P_c / P_c = 12,104 / 2,466 = 4.91$.

Theoretically, the ratio $\Sigma P_u / P_c$ would be different for each combination. Since the program allows for one ratio only, the most conservative one (the ratio due to the fifth load combination) will be used. For combination U5, the total factored gravity loads on the floor is $\Sigma P_u = 2,268$ kips and the factored load on the column is $P_u = 459$ kips. For the column under consideration, the ratio $\Sigma P_u / P_c = 2,268/459 = 4.94$.

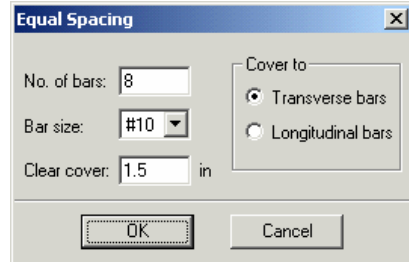
1. From the **File** menu, choose **New**. Any input data is cleared and the default values are restored.
2. From the **Input** menu, choose **General Information**.
 - Input the project header.
 - Select English units and ACI 318-02 code.
 - Select About X for run axis, Investigation for run option and Yes for slenderness.
 - Choose Ok.
3. From the **Input** menu, pick **Material Properties**.
 - Input 4 for the concrete strength. Other properties are computed and will be accepted.
 - Choose Ok.



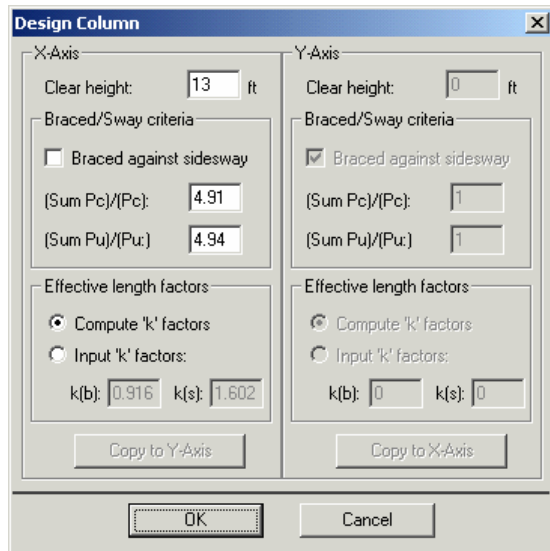
4. From the **Input** menu, pick **Section | Rectangular**.
 - Input 18 and 18 for the section width and depth.
 - Choose Ok.



5. From the **Input** menu, choose **Reinforcement | Equal Spacing**.
 - Input 8-#10 bars and 1.5 in for the cover and select Transverse bars.
 - Choose Ok.



6. From the **Input** menu, choose **Slenderness | Design Column**.
 - Input 13 for the column clear height.
 - Clear the Braced against sidesway option and input 4.91 and 4.94 for the Sum Pc/Pc and Sum Pu/Pu, respectively.
 - Select Compute 'k' factors
 - Choose Ok.



7. From the **Input** menu, choose **Slenderness | Columns Above/Below**.
 - Clear the No column specified option.
 - Input 14 for the column height (center-to-center) and leave the other data as is.

- Choose Copy to Column Below.
- Choose Ok.

8. From the **Input** menu, choose **Slenderness | X-Beams**.

- Choose Above Left.
- Clear the No beam specified option.
- Input 24 for the span (center-to-center).
- Input 48 and 12 for the width and depth, respectively.
- Input 13823 for the moment of inertia.
- Leave the other data as is.
- Choose Above Right and click on Copy From Beam Left.
- Choose Below Left and click on Copy From Beam Above.
- Choose Below Right and click on Copy From Beam Above.
- Choose Ok.

9. From the **Input** menu, choose **Loads | Service**.
 - Input 230, 2.0 and 2.0 for the Dead Load, X-Moment and Y-Moment, respectively.
 - Input 173, 108 and -100 for the Live Load, X-Moment and Y-Moment, respectively.
 - Input 6, 84 and -70 for the Wind Load, X-Moment and Y-Moment, respectively.
 - Choose Insert to add the entry to the list box.
 - Choose Ok.

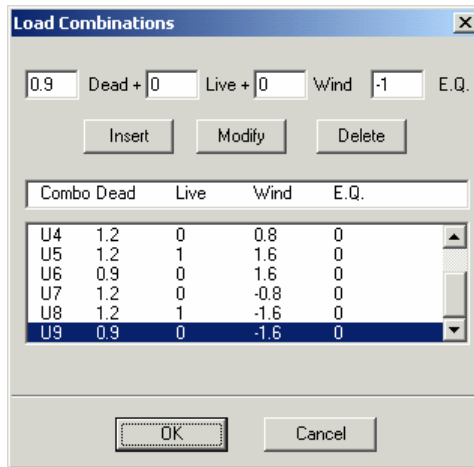
	Axial Load (kips)	X-Moments (ft-kips)		Y-Moments (ft-kips)		
		@ Top	@ Bot	@ Top	@ Bot	
Dead:	230	2	2	0	0	Insert Modify Delete
Live:	173	108	-100	0	0	
Wind:	6	84	-70	0	0	
E.Q.:	0	0	0	0	0	

No. [P, Mxt, Mxb, Myt, Myb] for each case

1 D [230, 2, 2, 0, 0]; L [173, 108, -100, 0, 0]; W [6, 84, -70, 0, 0]; E [0, 0, 0, 0, 0]

OK Cancel

10. From the **Input** menu, choose **Loads | Load Combinations**.
 - If the list displays thirteen combinations, leave the first nine as they are. Select combinations ten through thirteen and click Delete. Only the first nine combinations need to be considered.
 - Choose Ok.



11. From the **Solve** menu, choose **Execute**.
 - The solver of the program is started and, upon completion, displays the interaction diagram of the section with the load points plotted within the diagram. Note that point 2 falls just outside the interaction diagram indicating inadequate capacity of this section.
12. From the **View** menu, choose **Results**.
 - Page through the results file.
 - Choose Exit to quit the pcaView program and get back to pcaColumn.
13. From the **File** menu, choose **Print Results**.
 - Select the printer to send the text results to.
 - Choose Ok.
14. From the **File** menu, choose **Print Screen**.
 - Select the printer to send the graphical results to.
 - Choose Ok.

General Information:

```

=====
File Name: C:\Program Files\PCA\pcaColumn\Examples\Example3.col
Project: PCACOL Manual, Sway Col
Column: Ex_3                               Engineer: PCA
Code:   ACI 318-02                          Units: English

Run Option: Investigation                    Slenderness: Considered
Run Axis:   X-axis                          Column Type: Structural
  
```

Material Properties:

```

=====
f'c = 4 ksi                               fy = 60 ksi
Ec = 3605 ksi                             Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.85
  
```

Section:

```

=====
Rectangular: Width = 18 in                Depth = 18 in

Gross section area, Ag = 324 in^2
Ix = 8748 in^4                            Iy = 8748 in^4
Xo = 0 in                                  Yo = 0 in
  
```

Reinforcement:

```

=====
Rebar Database: ASTM A615
Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)
-----
# 3    0.38    0.11 # 4    0.50    0.20 # 5    0.63    0.31
# 6    0.75    0.44 # 7    0.88    0.60 # 8    1.00    0.79
# 9    1.13    1.00 # 10   1.27    1.27 # 11   1.41    1.56
# 14   1.69    2.25 # 18   2.26    4.00
  
```

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
 phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Rectangular
 Pattern: Equal Bar Spacing (Cover to transverse reinforcement)
 Total steel area, As = 10.16 in^2 at 3.14%
 8 #10 Cover = 1.5 in

Slenderness:

```

=====
Sway Criteria:
-----
X-axis: Unbraced column. Sum of Pc = 4.91*Pc   Sum of Pu = 4.94*Pu

Column Axis      Height      Width      Depth      I          f'c        Ec
                  ft          in         in         in^4       ksi        ksi
-----
Design X         13         18         18         8748       4          3605
Above X          14         0          0          8748       4          3605
Below X          14         0          0          8748       4          3605

X-Beams          Length      Width      Depth      I          f'c        Ec
Location         ft          in         in         in^4       ksi        ksi
-----
Above Left       24         48         12         13823      4          3605
Above Right      24         48         12         13823      4          3605
Below Left       24         48         12         13823      4          3605
Below Right      24         48         12         13823      4          3605
  
```

Effective Length Factors:

Axis	Psi(top)	Psi(bot)	k(Braced)	k(Sway)	klu/r
X	2.170	2.170	0.917	1.602	48.11

Moment Magnification Factors:

Stiffness reduction factor, phi(K) = 0.75
 Cracked-section coefficients: cI(beams) = 0.35; cI(columns) = 0.7

0.2*Ec*Ig + Es*Ise (X-axis) = 1.56e+007 kip-in^2

X-axis Ld/Comb	Pc(kip)	Braced			Sway	
		Betad	Cm	Delta	Pc(kip)	Delta
1 U1	3766	1.000	0.400	1.000	2466	1.212
U2	5023	0.499	0.960	1.125	2466	1.430
U3	4664	0.615	0.954	1.094	2466	1.323
U4	3798	0.983	0.908	1.007	2466	1.180
U5	4702	0.602	0.942	1.083	2466	1.332
U6	3851	0.956	0.924	1.000	2466	1.134
U7	3766	1.000	0.960	1.063	2466	1.173
U8	4626	0.628	0.840	1.000	2466	1.314
U9	3766	1.000	0.943	1.014	2466	1.120

Load Combinations:

U1 = 1.400*Dead + 0.000*Live + 0.000*Wind + 0.000*EarthQuake
 U2 = 1.200*Dead + 1.600*Live + 0.000*Wind + 0.000*EarthQuake
 U3 = 1.200*Dead + 1.000*Live + 0.000*Wind + 0.000*EarthQuake
 U4 = 1.200*Dead + 0.000*Live + 0.800*Wind + 0.000*EarthQuake
 U5 = 1.200*Dead + 1.000*Live + 1.600*Wind + 0.000*EarthQuake
 U6 = 0.900*Dead + 0.000*Live + 1.600*Wind + 0.000*EarthQuake
 U7 = 1.200*Dead + 0.000*Live - 0.800*Wind + 0.000*EarthQuake
 U8 = 1.200*Dead + 1.000*Live - 1.600*Wind + 0.000*EarthQuake
 U9 = 0.900*Dead + 0.000*Live - 1.600*Wind + 0.000*EarthQuake

Service Loads:

No.	Case	Axial Load kip	Mx @ Top k-ft	Mx @ Bot k-ft	My @ Top k-ft	My @ Bot k-ft
1	Dead	230.0	2.0	2.0	0.0	0.0
	Live	173.0	108.0	-100.0	0.0	0.0
	Wind	6.0	84.0	-70.0	0.0	0.0
	E.Q.	0.0	0.0	0.0	0.0	0.0

Factored Loads and Moments with Corresponding Capacities: (see user's manual for notation)

NOTE: Each loading combination includes the following cases:
 First line - at column top
 Second line - at column bottom

No.	Combo	Load kip	Pu kip	Mux k-ft	fMnx k-ft	fMn/Mu
1	1 U1	322.0	322.0	2.8	283.2	101.154
2		322.0	322.0	-2.8	-283.2	101.154

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3	1	U2	552.8	175.2	231.8	1.323
4			552.8	157.6	231.8	1.471
5	1	U3	449.0	110.4	256.5	2.323
6			449.0	97.6	256.5	2.628
7	1	U4	280.8	81.7	302.4	3.700
8			280.8	63.7	302.4	4.747
9	1	U5	458.6	289.5	254.3	0.879#
10			458.6	246.8	254.3	1.030
11	1	U6	216.6	154.1	324.0	2.102
12			216.6	125.2	324.0	2.589
13	1	U7	271.2	-76.4	-307.9	4.029
14			271.2	-68.1	-307.9	4.522
15	1	U8	439.4	-66.2	-258.6	3.906
16			439.4	-49.6	-258.6	5.216

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 Example3

17	1	U9	197.4	-148.8	-328.7	2.209
18			197.4	-127.3	-328.7	2.582

#- Column section cannot resist applied loads

*** Program completed as requested! ***

Chapter 6

The pcaSection Module

pcaSection is an add-on module to the pcaColumn program. It enables the user to investigate irregularly shaped reinforced concrete sections subject to a combination of loadings. pcaSection considers a polygonal section reinforced with bars located at any location. The section may contain one opening. In addition, pcaSection allows easy modification of a circular section by converting it into an approximate polygon.

pcaSection is accessed from within pcaColumn. Once pcaColumn is started, you can activate pcaSection by selecting the **Section | Irregular** command from the **Input** menu. This starts pcaSection, minimizes and locks the pcaColumn window and maximizes the pcaSection window. The section geometry may then be defined by drawing it on the screen or by inputting the coordinates of the polygon nodes. Once the section definition is complete, return to pcaColumn by selecting **Save and Exit** from the **Main** menu.

Once the irregular section is defined, its reinforcement is input using pcaSection as well. This is done by selecting the **Reinforcement | Irregular** command from the **Input** menu of pcaColumn. The section reinforcement may also be defined graphically.

Main Menu

Drawing Area

Set the limits for the drawing area and control the grid and snap settings.

Save and Exit

Accept the input and/or modifications made in `pcaSection` and return to `pcaColumn`.

Exit without Saving

Discard the input and/or modifications made in `pcaSection` and return to `pcaColumn`.

Edit Menu

Section

Toggles the input/editing session to the section.

Opening

Toggles the input/editing session to the section opening.

Reinforcement

Toggles the input/editing session to the section reinforcement.

Add

Switches to the Add mode to graphically insert section or opening nodes or reinforcing bars.

Delete

Switches to the Delete mode to graphically delete section or opening nodes or reinforcing bars.

Move

Switches to the Move mode to graphically move section or opening nodes or reinforcing bars.

Modify

Allows manual editing of the section or opening node coordinates or the reinforcing bar area and coordinates.

View Menu

Zoom

Magnifies or reduces the graphical image.

Pan

Translates or moves the graphical image.

Redraw

Redraws the displayed section and resets the Zoom and Pan actions.

Grid

Shows or hides the grid.

Snap

Toggles the Snap On and Off. With the Snap On, the cursor snaps (sticks) to exact locations.

Labels

Shows or hides the internal numbering of section (or opening) nodes and bars.

Status bar

Shows or hides the Status bar.

Help Menu

Index

Lists all the available help topics about the program.

About

Displays copyright information and the version number of the program.

Defining the Drawing Area

- Select **Main | Drawing Area**. A dialog box appears. This step is not needed the first time pcaSection is started using pcaColumn's **Section | Irregular** command. The box is automatically displayed.
- Input the limits (minimum and maximum) of the area within which the section is to be drawn in both directions.
- Input the interval (step) for the grid system. The grid is used as a guideline when drawing.
- Select or clear the Show Grid option to show or hide the grid.
- Input the interval (step) for the snap. The snap settings may be different than the grid settings and may be different in each direction (x and y).
- Select or clear the Snap On option to activate or disable the Snap.
- Choose the OK button.

Drawing Area

Limits

	X	Y	
Minimum:	-50	-50	in
Maximum:	50	50	in

Grid

	X	Y	
Step:	10	10	in

Show Grid

Snap

	X	Y	
Step:	5	5	in

Snap On

OK Cancel

Graphical Editing of the Section or Opening

In pcaSection, the section (or opening) must be a closed polygon. It is defined by inputting the nodes at each corner or vertex of the polygon. No two segments (sides) may overlap or cross and no two nodes may coincide. An opening must lie completely within the section.

The coordinates that correspond to the cursor location are always displayed in the Status bar. To force the cursor to “stick” to exact locations, turn the Snap option on. The program will snap to locations whose coordinates are multiples of the snap steps.

To add section or opening nodes:

- Switch the input session to Section (or Opening) by selecting **Edit | Section** (or **Edit | Opening**).

- Switch the input mode to Add by selecting **Edit | Add**.
- If you are editing a section (or opening), you must first click on an existing node. Once this is done, you can insert subsequent nodes.
- Adding a node is done by moving the cursor to a desired location within the Graphics area and clicking the left-mouse button.
- After inserting a node, a line extending from the last added node follows the cursor. Click at another location to insert subsequent nodes. A line connecting the two nodes is drawn.
- To end the drawing, click the right-mouse button or press the ESC key. The first and last nodes are connected to close the section. Also note that while in the Add mode, moving the cursor outside the Graphics area ends the drawing.

To delete section or opening nodes:

- Switch the input session to Section (or Opening) by selecting **Edit | Section** (or **Edit | Opening**).
- Switch the input mode to Delete by selecting **Edit | Delete**.
- Marquee select the node (or nodes) to be deleted. This is done by moving the cursor to one location, pressing the left-mouse button and while holding the button down, moving to another location. While moving, a dotted rectangle (called the marquee) is drawn. Releasing the left-mouse button end the marquee. All nodes that are enclosed with the marquee are deleted and the section (or opening) is redrawn. To cancel a marquee action while holding down the left-mouse button, press the ESC key or click the right-mouse button. Also, leaving the Graphics area cancels the marquee operation.

To move section or opening nodes:

- Switch the input session to Section (or Opening) by selecting **Edit | Section** (or **Edit | Opening**).
- Switch the input mode to Move by selecting **Edit | Move**.
- Place the cursor over the node to be moved then press and hold the left-mouse button. As long as the button is held down, moving the cursor moves the selected node to the cursor location. Once the node is at the new desired location, release the mouse button. To cancel a move action while holding down the left-mouse button, press the ESC key or click the right-mouse button. Also, leaving the Graphics area cancels the move operation.

Graphical Editing of the Reinforcement

In *pcaSection*, the reinforcing bars may be located anywhere. The only restriction imposed in the program is that no two bars may overlap. The coordinates that correspond to the cursor location are always displayed in the Status bar. To force the cursor to “stick” to exact locations, turn the Snap option on. The program will snap to locations whose coordinates are multiples of the snap steps. While in the Reinforcement session, you cannot switch to the Section or Opening sessions without returning to *pcaColumn*. Therefore, the **Edit | Reinforcement** command will have a check mark to its left. You use the command to specify the bar size or area and the number of bars to be added.

To add one single bar at a time:

- Switch the input mode to Add by selecting **Edit | Add**.
- Select **Reinforcement** from the **Edit** menu. A dialog box appears.
- In the Number of bars box, input 1.
- Choose the Size option and select the size of the bar or choose the Area option and input the bar area in the edit box.
- Choose the OK button.
- In the Graphics area, point to the desired location and click. A bar is inserted.
- Repeat the step above to insert more bars.



To generate multiple bars:

- Switch the input mode to Add by selecting **Edit | Add**. The command must have a check mark left of it.
- Select **Reinforcement** from the **Edit** menu. A dialog box appears.
- Input the number of bars to be generated (should be greater than 1).
- Choose the Size option and select the size of the bar or choose the Area option and input the bar area in the edit box.
- Choose the OK button.

- In the Graphics area, click at a location (let us call it point A), move the cursor to another location and click (let us call it Point B). The specified number of equally-spaced bars is added, along the line connecting the points A and B. For subsequent generations, point B becomes A and you only need to click at the second point (B) to generate more bars.
- To end the multiple bar generation or move to another location (without adding bars), click the right-mouse button or press the ESC key. Also note that while in the multiple bar generation of the Add mode, moving the cursor outside the Graphics area aborts the generation.

To delete bars:

- Switch the input mode to Delete by selecting **Edit | Delete**.
- Marquee select the bar(s) to be deleted. This is done by moving the cursor to one location, pressing the left-mouse button and while holding the button down, moving to another location. While moving, a dotted rectangle (called the marquee) is drawn. Releasing the left-mouse button end the marquee. All bars that are enclosed with the marquee are deleted. To cancel a marquee action while holding down the left-mouse button, press the ESC key or click the right-mouse button. Also, leaving the Graphics area cancels the marquee operation.

To move a bar:

- Switch the input mode to Move by selecting **Edit | Move**.
- Place the cursor over the bar to be moved then press and hold the left-mouse button. As long as the button is held down, moving the cursor moves the selected bar with it. Once the bar is at the new desired location, release the mouse button. To cancel a move action while holding down the left-mouse button, press the ESC key or click the right-mouse button. Also, leaving the Graphics area cancels the move operation.

Manual Editing of the Section or Opening

- Switch the input session to Section (or Opening) by selecting **Edit | Section** (or **Edit | Opening**).
- Select **Edit | Modify**. A dialog box appears. If you have already defined a section (or opening), the coordinates of its nodes are shown in the list.
- To add a node, enter its x and y coordinates and choose the Insert button. The entry is inserted in the list box following the selected entry.
- To edit an entry, select it from the list box, modify its values in the text boxes, and choose the Modify button.
- To delete an entry, choose it from the list box and choose the Delete button.
- Choose the OK button.

No.	X	Y
1	6	0
2	24	0
3	24	24
4	30	24
5	30	36
6	0	36
7	0	24
8	6	24

Manual Editing of the Reinforcement

- Select **Edit | Modify**. A dialog box appears.
- To add a bar, enter its area, x-coordinate and y-coordinate and choose the Insert button. The entry is inserted in the list box following the selected entry.
- To edit an entry, select it from the list box, modify its values in the text boxes, and choose the Modify button. You can change the area of a group of bars by selecting them from the list, enter the new area and choose Modify.
- To delete an entry, choose it from the list box and choose the Delete button.
- Choose the OK button.

No.	Area	X	Y
12	0.79	21	21
13	0.79	21	15
14	0.79	21	9
15	0.79	21	3
16	0.79	3	27
17	0.79	15	27
18	0.79	27	27
19	0.79	15	3

Zooming and Panning the Image

Zooming is the enlargement or reduction of the graphical image. Panning is the translation or movement of the image.

Zooming:

- Select View | Zoom.
- To enlarge the view (zoom-in): using the left-mouse button, click anywhere within the Graphics area. Click again for further magnification.
- To reduce the view (zoom-out): using the right-mouse button, click anywhere within the Graphics area. Click again for further reduction.
- To reset the Zoom and return to the default, select View | Redraw.

Panning:

- Select View | Pan.
- Place the cursor over the Graphics area. Press the left-mouse button and, while still holding the button, move the cursor in the direction you wish to pan. A line showing the amount and direction of panning is drawn.
- Release the mouse button. The view is panned and the image is redrawn.
- To reset the Pan and return to the default, select **View | Redraw**.

Keyboard shortcuts:

The following keyboard assignments are always active:

<u>Key combination</u>	<u>Action</u>
Ctrl + Page Up	Zoom-in
Ctrl + Page Down	Zoom-out
Ctrl + Cursor key	Pan
Enter	Reset zoom/pan (Redraw)

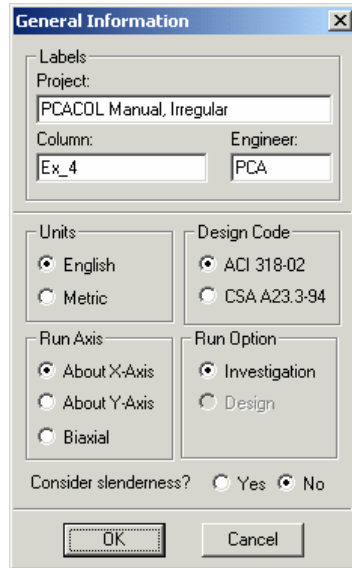
Example 4 -Capacity of an Irregular Section

This example uses the pcaSection module.

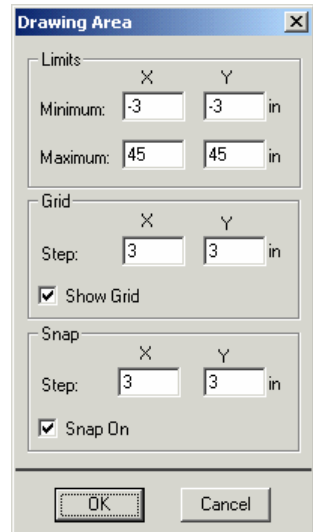
Obtain the interaction diagram of a T-shaped section which contains a rectangular opening. The capacity is to be computed about the x-axis. The section is reinforced with 19-#8 bars, spaced 6 in. apart. The distance between the center of each edge bar to the face of the section is 3 in. Use 6-ksi concrete and 60-ksi reinforcing steel.

Note: when instructed to move to a location (15, 25), move the cursor until the cells in the Status bar show “x=15” and “y=25”.

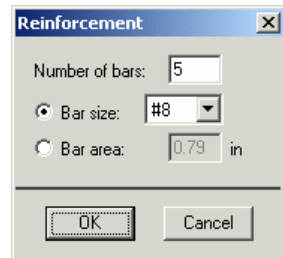
1. From the **File** menu, choose **New**. Any input data is cleared and the default values are restored.
2. From the **Input** menu, choose **General Information**.
 - Select English units and ACI 318-02 code.
 - Select About X for run axis, Investigation for run option and No for slenderness.
 - Choose Ok.
3. From the **Input** menu, choose **Material Properties**.
 - Input 6 for the concrete strength. Other properties are computed and will be accepted.
 - Choose Ok.



4. From the **Input** menu, choose **Section | Irregular**. The pcaSection module is loaded, its window occupies the desktop, and the Drawing Area box appears.
 - Input -3 and -3 for the minimum X and Y, respectively.
 - Input 45 and 45 for the maximum X and Y, respectively.
 - Input 3 and 3 for X and Y grid step, respectively and check the Show Grid option.
 - Input 3 and 3 for X and Y snap step, respectively and check the Snap On option.
 - Choose Ok.
5. The default input session is Section and the default input mode is Add (the **Edit | Section** and **Edit | Add** options are checked).
 - In the Graphics area, move the cursor to the location (6, 0) and click the left mouse button. A node is inserted.
 - Move to (24, 0) and click the left mouse button.
 - Move to (24, 24) and click the left mouse button.
 - Move to (30, 24) and click the left mouse button.
 - Move to (30, 36) and click the left mouse button.
 - Move to (0, 36) and click the left mouse button.
 - Move to (0, 24) and click the left mouse button.
 - Move to (6, 24) and click the left mouse button.
 - Click the right-mouse button to end drawing the section.
6. To define the opening nodes, switch the input session to Opening by selecting **Edit | Opening**. The input mode should still be Add (the **Edit | Opening** and **Edit | Add** options are now checked).

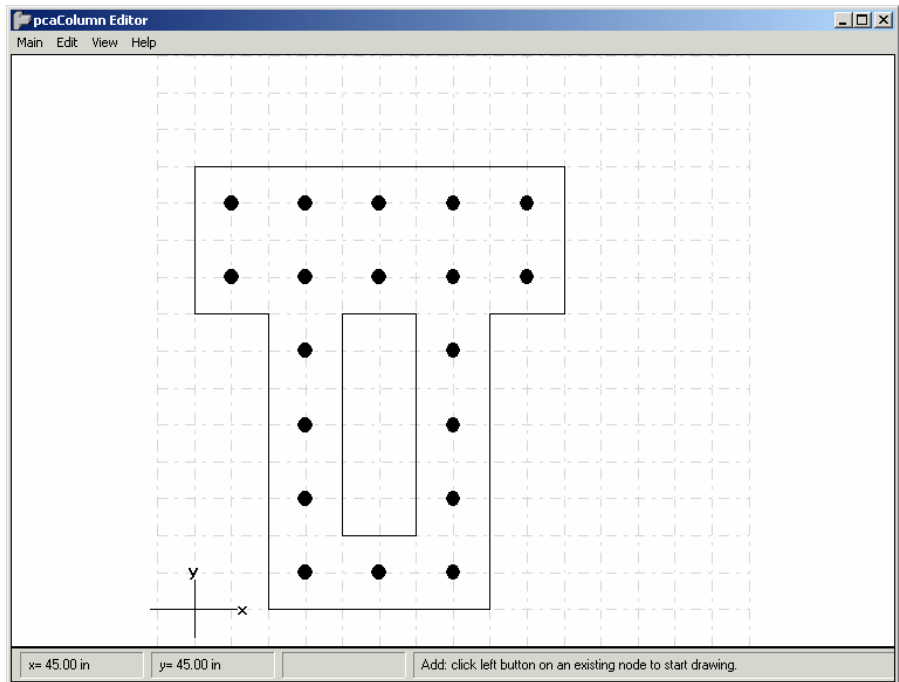
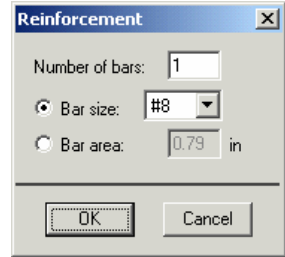


- In the Graphics area, move the cursor to the location (12, 6) and click the left mouse button. A node is inserted.
 - Move to (18, 6) and click the left mouse button.
 - Move to (18, 24) and click the left mouse button.
 - Move to (12, 24) and click the left mouse button.
 - Click the right-mouse button to end drawing the opening.
7. From the **Main** menu, choose **Save and Exit**. You are returned to pcaColumn and the section is shown in the Information bar.
 8. From the **Input** menu, choose **Reinforcement | Irregular**. The pcaSection module is loaded, its window occupies the desktop.
 9. The default input session is Reinforcement and the default input mode is Add (the **Edit | Reinforcement** and **Edit | Add** options are checked).
 10. Define some bars using multiple bar generation:
 - From the Edit menu, choose Reinforcement. Input 5 for the Number of bars and select #8 from the Size list. Choose Ok.
 - Move the cursor to the location (3, 33) and click the left mouse button.
 - Move to (27, 33) and click the left mouse button. Five equally-spaced bars are generated between the two locations.
 - Click the right-mouse button to end.
 - Move the cursor to the location (9, 27) and click the left mouse button.
 - Move to (9, 3) and click the left mouse button. Five equally-spaced bars are generated between the two locations.
 - Click the right-mouse button to end.
 - Move the cursor to the location (21, 27) and click the left mouse button.
 - Move to (21, 3) and click the left mouse button. Five equally-spaced bars are generated between the two locations.
 - Click the right-mouse button to end.



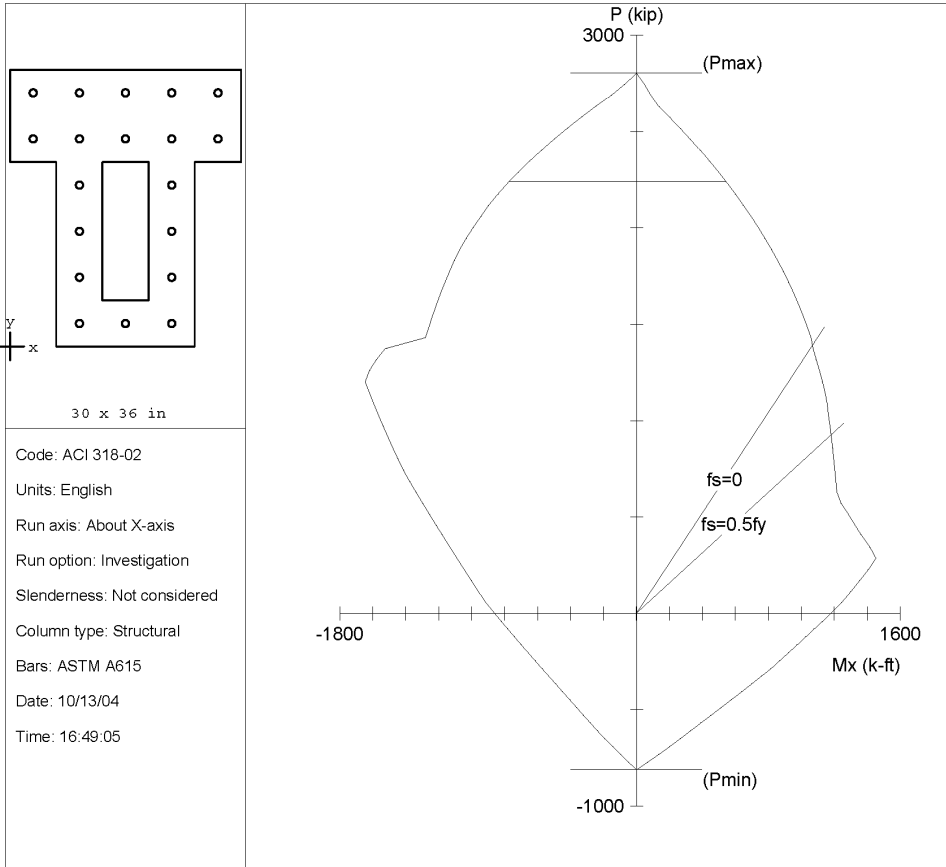
11. Define the remaining bars using single bar placement:

- From the Edit menu, choose Reinforcement. Input 1 for the Number of bars and select #8 from the Size list. Choose Ok.
- Move the cursor to the location (3, 27) and click the left mouse button. A bar is inserted.
- Move to (15, 27) and click the left mouse button. Another bar is inserted.
- Move to (27, 27) and click the left mouse button. Another bar is inserted.
- Move to (15, 3) and click the left mouse button. Another bar is inserted.



12. From the **Main** menu, choose **Save and Exit**. You are returned to pcaColumn and the section is shown in the Information bar.
13. From the **Input** menu, choose **Loads | Control Points**.
14. From the **Solve** menu, choose **Execute**.

- The solver of the program is started and, upon completion, displays the interaction diagram of the section.
15. From the **View** menu, choose **Results**.
 - Page through the results file.
 - Choose Exit to quit the pcaView program and get back to pcaColumn.
 16. From the **File** menu, choose **Print Results**.
 - Select the printer to send the text results to.
 - Choose Ok.
 17. From the **File** menu, choose **Print Screen**.
 - Select the printer to send the graphical results to.
 - Choose Ok.



Code: ACI 318-02
 Units: English
 Run axis: About X-axis
 Run option: Investigation
 Slenderness: Not considered
 Column type: Structural
 Bars: ASTM A615
 Date: 10/13/04
 Time: 16:49:05

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File: C:\Program Files\PCA\pcaColumn\Examples\Example4.col			
Project: PCACOL Manual, Irregular			
Column: Ex_4		Engineer: PCA	
f _c = 6 ksi	f _y = 60 ksi	Ag = 684 in ²	19 #8 bars
E _c = 4415 ksi	E _s = 29000 ksi	As = 15.01 in ²	Rho = 2.19%
f _c = 5.1 ksi	f _c = 5.1 ksi	Xo = 15.00 in	I _x = 82404 in ⁴
e _u = 0.003 in/in		Yo = 21.00 in	I _y = 38340 in ⁴
Beta1 = 0.75		Clear spacing = 5.00 in	Clear cover = N/A
Confinement: Tied	phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65		

General Information:

```

=====
File Name: C:\Program Files\PCA\pcaColumn\Examples\Example4.col
Project: PCACOL Manual, Irregular
Column: Ex_4                               Engineer: PCA
Code: ACI 318-02                           Units: English

Run Option: Investigation                   Slenderness: Not considered
Run Axis: X-axis                           Column Type: Structural
    
```

Material Properties:

```

=====
f'c = 6 ksi                               fy = 60 ksi
Ec = 4415.21 ksi                          Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.75
    
```

Section:

```

=====
Exterior Points
  No.   X (in)   Y (in)   No.   X (in)   Y (in)   No.   X (in)   Y (in)
-----
   1     6.0     0.0     2     24.0    0.0     3     24.0    24.0
   4    30.0    24.0     5     30.0    36.0     6      0.0    36.0
   7     0.0    24.0     8      6.0    24.0

Interior Points
  No.   X (in)   Y (in)   No.   X (in)   Y (in)   No.   X (in)   Y (in)
-----
   1    12.0     6.0     2     18.0     6.0     3     18.0    24.0
   4    12.0    24.0
    
```

```

Gross section area, Ag = 684 in^2
Ix = 82404 in^4           Iy = 38340 in^4
Xo = 15 in                Yo = 21 in
    
```

Reinforcement:

```

=====
Rebar Database: ASTM A615
Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)   Size Diam (in) Area (in^2)
-----
# 3    0.38    0.11 # 4    0.50    0.20 # 5    0.63    0.31
# 6    0.75    0.44 # 7    0.88    0.60 # 8    1.00    0.79
# 9    1.13    1.00 # 10   1.27    1.27 # 11   1.41    1.56
# 14   1.69    2.25 # 18   2.26    4.00
    
```

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
 phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Pattern: Irregular

Total steel area, As = 15.01 in^2 at 2.19%

```

Area in^2   X (in)   Y (in)   Area in^2   X (in)   Y (in)   Area in^2   X (in)   Y (in)
-----
  0.79      3.0     33.0     0.79      9.0     33.0     0.79      15.0    33.0
  0.79     21.0    33.0     0.79     27.0    33.0     0.79      9.0     27.0
  0.79      9.0     21.0     0.79      9.0     15.0     0.79      9.0      9.0
  0.79      9.0      3.0     0.79     21.0    27.0     0.79     21.0    21.0
  0.79     21.0    15.0     0.79     21.0     9.0     0.79     21.0     3.0
  0.79      3.0     27.0     0.79     15.0    27.0     0.79     27.0    27.0
  0.79     15.0      3.0
    
```

Control Points:
 =====

Bending about	Axial Load P kip	X-Moment k-ft	Y-Moment k-ft	N.A. depth in
X @ Pure compression	2803.1	-0	0	106.33
@ Max compression	2242.5	539	0	43.06
@ fs = 0.0	1387.9	1065	0	33.00
@ fs = 0.5*fy	925.1	1180	-0	24.54
@ Balanced point	598.8	1217	0	19.53
@ Tension Control	281.9	1454	-0	12.38
@ Pure bending	0.0	1178	0	8.18
@ Pure tension	-810.5	0	0	0.00

*** Program completed as requested! ***

Appendix

Conversion Factors - English to SI

To convert from	To	Multiply by
in.	m (1000 mm)	0.025400
ft	m	0.304800
lb	N (0.001 kN)	4.448222
kip (1000 lbs)	kN	4.448222
plf (lb/ft)	N/m	14.593904
psi (lb/in. ²)	kPa	6.894757
ksi (kips/in. ²)	MPa	6.894757
psf (lb/ft ²)	N/m ² (Pa)	47.88026
pcf (lb/ft ³)	kg/m ³	16.018460
ft-kips	kN • m	1.355818

Conversion Factors - SI to English.

To convert from	To	Multiply by
m (1000 mm)	in	39.37008
m	ft	3.28084
N (0.001 kN)	lb	0.224809
kN	kip (1000 lbs)	0.224809
kN/m	plf (lb/ft)	68.52601
MPa	psi (lb/in. ²)	145.0377
MPa	ksi (kips/in. ²)	0.145038
kN/m ² (kPa)	psf (lb/ft ²)	20.88555
kg/m ³	pcf (lb/ft ³)	0.062428
kN • m	ft-kips	0.737562

Contact Information

Web Site: <http://www.pcaStructurePoint.com>

E-mail: info@pcaStructurePoint.com
support@pcaStructurePoint.com

Ordering: pcaStructurePoint
Attn: Customer Service
5420 Old Orchard Road
Skokie, IL 60077
USA

Phone: (847) 972-9042

Fax: (847) 972-9043

Technical Support: pcaStructurePoint
5420 Old Orchard Road
Skokie, IL 60077
USA

Phone: (847) 966-HELP / (847) 966-4357

Fax: (847) 581-0644

Bug Report Form

To help us improve our products please fax, mail or e-mail questions to:

pcaStructurePoint
 5420 Old Orchard Road
 Skokie, IL 60077
 Fax: (847) 581-0644
 E-mail: support@pcaStructurePoint.com

Program Name		Company Name	
Program Version		Tester's Name	
Program Release		Phone	
Operating System		Fax	
CPU / Memory		E-mail	
Network		Input File	
Bug No.		Output File	
Date		Screen Shot File	
Bug Priority Category			

<p>Problem Title <i>Please enter a brief, one-line description of the problem.</i></p>
<p>Summary Information <i>Restate the problem title and/or include more descriptive summary information.</i></p>
<p>Error Messages <i>If the problem causes any error messages, please list the exact error messages that you are receiving.</i></p>
<p>Steps to Reproduce <i>If the problem is reproducible, please list the steps required to cause it. If the problem is not reproducible (only happened once, or occasionally for no apparent reason), please describe the circumstances in which it occurred and the symptoms observed.</i></p>
<p>Results <i>Describe your results and how they differed from what you expected.</i></p>
<p>Workaround <i>If there is a workaround for the problem, please describe it in detail.</i></p>
<p>Documentation & Notes <i>Document any additional information that might be useful in resolving the problem.</i></p>

