KaderColumn PROGRAM VERSION 1.0

1. Introduction:

Column cross-sections are generally symmetric about both axes. Tied columns are usually more practical than spiral columns because of their lower construction cost as far as the structure is build far from earthquake zones. Failure in columns could occur due to failure of material (e.g. crushing of concrete) or instability of the column (e.g. buckling). Short columns fail due to material failure while slender or long columns could fail due to instability.

The basic requirement for strength design of column may be expressed as follow:

$\phi\, Pn \geq Pu$ and $\phi\, Mn \geq Mu$

and $\phi\, Vn \geq Vu$ (out of scope in this version)

Where *Pu* and *Mu* are the factored applied axial load and bending moment, *Pn* and *Mn* are the nominal capacity of the column cross-section, and ϕ is the strength reduction factor varies from 0.65 to 0.9 depending on the rebar tensile strain value.

In general, the applied loads on the column consists of axial load and bending moment. The bending moment has two components (M_x and M_y around principle axes *X* and Y, respectively). KaderColumn program deals with the case of columns subjected to either axial load only or axial load and bending moment applied about the maximum principle axis.

The effect of axial load on the behavior of a column cross-section can be studied using the Column Interaction Diagram (M-P curve).

2. KaderColumn Program:

KaderColumn program version 1 deals with reinforced concrete tied short columns. It designs columns subjected to up to eleven cases of loading consisted of axial load and bending moment applied about the maximum principle axis. The program constructs the column strength interaction diagram (Bending moment-Axial load curve) from the input data of the cross-section and check if all input cases of loading being within the design curve.

If the input data of the cross-section is not sufficient the program increases them starting from the Min. ρ to the cross-sectional dimensions unit all input cases of loading being within the design curve. The program suggests an arrangement of ties and draws them.

3. Features:

The features of KaderColumn program are as follow:

1- It is very simple and short.
2- It calculates and draws the column strength interaction diagram for a reinforced concrete tied short column which has a rectangular (with rebars at two sides only or at all four sides), square or circular section and subjected to axial load and bending moment about the max. principle axis of its cross-section..
3- Up to eleven cases of loads (axial load and bending moment) are allowed. The program checks all these cases to be within the column interaction diagram.

4- It designs the section and draws it with a suitable arrangement of ties.
5- The user can modify the section dimensions, the min. and max. percentage of reinforcement and some other parameters to get the reasonable section from his point of view.
6- The user can save and open the input data file that can be saved by the program.
7- The program uses the ultimate strength method for design and follows the appropriate ACI 318-02 Code requirements.

4. Input Data:

KaderColumn program lets the user input and change most of the parameters which affect the design to get the recommended section details from his point of view. When the program starts the user will see initial data as a guide to help him for input his data. The following are summary of the input data.

4.1 Number of Load Cases:

Input the number of load cases applied on the column. The Number of load cases must be integer between 1 and 11.

4.2 Axial load Pu:

Input the factored axial load values equal to the number of load cases in kips units.

4.3 Bending Moment Mu:

Input the factored bending moment values equal to the number of load cases in ft.kips units. The values of Mu must be positive or zero.

4.4 Section Type:

Choose by clicking mouse on one of the four types of sections.

1- Rec. 4 Sides: Rectangular section with rebars distributed on the four sides.
2- Rec. 2 Sides: Rectangular section with rebars distributed on two sides only.
3- Circular: Circular section, tied not spiral column.
4- Square: Square section with rebars uniformly distributed on the four sides.

4.5 Min. b

For section type 1 or 2, input the minimum width of the rectangular section.
For section type 3, input the minimum diameter of the circular section.
For section type 4, input the minimum dimension of the square section.
Input Min. b must be 8 or bigger and in inch units.

4.6 Min. t

For section type 1 or 2 only, input the minimum height of the rectangular section in inch units. Input Min. t must be 8 or bigger and greater than Min. b.

4.7 Max. t/b

For section type 1 or 2 only, input the maximum height over width ratio for the rectangular section. Input Max. t/b must be grater than 1.

4.8 Cover

Input the clear cover to tie; the distance from the section face to the outer tie face in inch units. Input cover must be between 1 and 3.

4.9 f’c

Input the characteristic strength of concrete in ksi units. Input f’c must be between 2.5 and 12.

4.10 fy

Input the yield strength of reinforcement in ksi units. Input fy must be between 40 and 80.

4.11 Min. ρ

Input the percentage of the reinforcement, the ratio of rebar's cross-sectional area to the column cross-sectional area . Input Min. ρ must be between 0.01 and 0.05.

4.12 Max. ρ

Input the percentage of the reinforcement, the ratio of rebar's cross-sectional area to the column cross-sectional area. Input Max. ρ must be between (Min. ρ +0.01) and 0.08.

4.13 Min

Input the minimum rebar diameter. Input Min # must be 4, 5, 6, 7, 8, 9, 11, 14 or 18 and less than or equal to Max. #.

4.14 Max

Input the minimum rebar diameter. Input Max # must be 4, 5, 6, 7, 8, 9, 11, 14 or 18 and greater than or equal to Min. #.

4.15 Tie Dia.

Input the tie diameter. Input Tie Dia. # must be 3, 4, 5, or 6.

4.16 Es

Input the modulus of elasticity of steel in ksi units. Input Es must be greater than 0.

5. Output Data:

KaderColumn program creates an output text file contains 21 calculated points on the column interaction diagram for the nominal capacity and the design curves. The nominal capacity curve is constructed by using the 21 pairs of *Mu* (the factored ultimate bending moment) and *Pu* (the factored ultimate axial load) that the column cross-section can carries. The design curve is constructed by using the 21 pairs of ϕ*Mu* and ϕ*Pu,* where ϕ is the strength reduction factor which is equal to 0.65 for tied column subjected to pure axial compression load or big axial compression load and bending moment less than the balanced bending moment (the rebar tensile strain is less than 0.002) and equal to 0.9 for tied column where the rebar tensile strain is greater than 0.005. For rebar yield strength equal to 40 ksi and rebar tensile strain between 0.002 and 0.005, ϕ varies linearly from 0.65 to 0.9.

The 21 calculated points of the nominal capacity curve (*Mn* - *Pn* curve) are described as follows:

- Point (1): At pure axial compression load *Pn pure*, and *Mn* = 0; (0, *Pn pure*)
- Point (2): At *Pn max* (=0.8 of *Pn pure)*, and *Mn* = 0; (0, 0.8 *Pn pure*)
- Point (3): At *Pn max* and the corresponding *Mn*; (*Mn*, 0.8 *Pn pure*)
- Point (4): At rebar tensile strain = 0 calculate the corresponding *M* and *P*; (*Mn* and *Pn)*
- Point (5): At rebar tensile strain = 0.25 of rebar yield strain; (*Mn*, *Pn*)
- Point (6): At rebar tensile strain = 0.5 of rebar yield strain; (*Mn*, *Pn*)
- Point (7): At rebar tensile strain= 0.75 of rebar yield strain; (*Mn*, *Pn*)
- Point (8): At rebar tensile strain = rebar yield strain (balanced section); (*Mn*, *Pn*)

- Points from (9) to (20): From rebar tensile strain = 1.25 rebar yield strain up to rebar tensile strain = 4.0 of rebar yield strain; tensile strain increment = 0.25 of rebar yield strain; (*Mn*, *Pn*)
- Point (21): Pure axial tension *Pn ten* and *Mn* = 0; (0, *Pn ten*)

The 21 calculated points of the design curve (ϕ*Mn* - ϕ*Pn* curve) is the same as those of the nominal curve except for calculation of ϕ at each point and multiply the calculated *Mn* and *Pn* at this point by the corresponding ϕ .