Analyze Example

Input Data – Output Pages 1 to 4

These pages contain the input data as described above under DESIGN, except for the group load data. The column is analyzed and the yield nominal (yield) strength of the column section is determined.

Nominal Strength Values – Output Pages 5 & 6

The angle of the resultant nominal moment varies from 90 degrees (Transverse) to 0 degrees (Longitudinal) in 15 degree increments. The nominal axial load P varies from 0.8Po TO -0.1Po in increments of 0.1Po (Po = Nominal Axial load Strength).

The last page in this section is a plot of the nominal moments.

```
HP-UX A.09.03      Tue Jul 25 09:50:42 PDT 1995

DIRECTORY: /user/tsbcl/projects/test
INPUT FILE: adelines.yield

0...|....1....|....2....|....3....|....4....|....5....|....6....|....7....|....8

4' X 8' RECTANGULAR WITH FILLETS ANALYZE     VERSION  1    12.09.83
         3
         2
         3        30
         4
         0       1.0       6.0         1     44.00      3.50       .00
      3250  29000000     .0030     60000
     96.00     48.00      9.00      9.00
     20.49     24.00                          1.56

0...|....1....|....2....|....3....|....4....|....5....|....6....|....7....|....8
```

```
TITLE 4' X 8' RECTANGULAR WITH FILLETS ANALYZE  7/25/1995  09:50:39 PAGE  1


*****************************************************************
*                YIELD PROGRAM - VERSION 1.01    10.11.90       *
*****************************************************************


COLUMN TYPE                    =  3  (RECTANGULAR W/FILLETS)
CONCRETE LOOPS                 =  1
TOTAL NO. OF CONCRETE COORD.   =  8
STEEL REBAR PATTERN            =  2  (INTERSECTING LOOPS)
NUMBER OF STEEL REBAR LOOPS    =  3
TOTAL NO. OF STEEL REBARS      = 30
PLOT TYPE                      =  4  (MNY VS. MNX)
DESIGN TYPE                    =  0  (ANALYSIS)
PERCENT STEEL LIMITS           =     (1.00 % MIN.  6.00 % MAX.)


**********************
* MATERIAL PROPERTIES *
*********************************************************************

ULTIMATE CONCRETE COMPRESSIVE STRESS - FC =     3250. (PSI)
YOUNG'S MODULUS FOR CONCRETE         - EC =  3249500. (PSI)
YOUNG'S MODULUS FOR STEEL BARS       - ES = 29000000. (PSI)
ULTIMATE CONCRETE COMPRESSIVE STRAIN - EO =      .003 (IN PER IN)
YIELDING STRESS FOR STEEL BARS       - FY =    60000. (PSI)
```

TITLE 4' X 8' RECTANGULAR WITH FILLETS ANALYZE 7/25/1995 09:50:39 PAGE 2

RECTANGULAR CROSS-SECTION (WITH FILLETS)

HX	HY	FX	FY
96.00	48.00	9.00	9.00

CONCRETE COORDINATES (INCHES)

COORD	X	Y
1	48.00	15.00
2	39.00	24.00
3	-39.00	24.00
4	-48.00	15.00
5	-48.00	-15.00
6	-39.00	-24.00
7	39.00	-24.00
8	48.00	-15.00

TITLE 4' X 8' RECTANGULAR WITH FILLETS ANALYZE 7/25/1995 09:50:39 PAGE 3

INTERSECTING LOOP PATTERN

RADIUS	SPACING	AREA
20.49	24.00	1.56

STEEL REBAR COORDINATES (INCHES)

COORD	X	Y
1	-12.00	16.61
2	12.00	-16.61
3	-18.74	19.80
4	18.74	-19.80
5	-26.18	20.37
6	26.18	-20.37
7	-33.33	18.24
8	33.33	-18.24
9	-39.24	13.70
10	39.24	-13.70
11	-43.13	7.33
12	43.13	-7.33
13	-44.49	.00
14	44.49	.00
15	-43.13	-7.33
16	43.13	7.33
17	-39.24	-13.70
18	39.24	13.70
19	-33.33	-18.24
20	33.33	18.24
21	-26.18	-20.37
22	26.18	20.37
23	-18.74	-19.80
24	18.74	19.80
25	12.00	16.61
26	-12.00	-16.61
27	4.24	20.05
28	-4.24	-20.05
29	-4.24	20.05
30	4.24	-20.05

THE MAIN LONGITUDINAL STEEL IS ASSUMED TO BE # 11 BARS.

```
TITLE 4' X 8' RECTANGULAR WITH FILLETS ANALYZE  7/25/1995  09:50:39 PAGE  4


 *************************
 * INITIAL REFERENCE DATA *
 ***************************************************************************

 TOTAL AREA OF THE SECTION                AG =     30.88 FT**2
 NOMINAL AXIAL LOAD STRENGTH              PO =  14960.79 KIPS
 TOTAL REINFORCEMENT AREA                AST =     46.80 IN**2
 PERCENT STEEL                             =      1.05 %

 GROSS MOMENT OF INERTIA ABOUT Y-AXIS   IYC =    154.81 FT**4
 GROSS MOMENT OF INERTIA ABOUT X-AXIS   IXC =     39.19 FT**4

 STEEL MOMENT OF INERTIA ABOUT Y-AXIS   IYS =    2.0159 FT**4
 STEEL MOMENT OF INERTIA ABOUT X-AXIS   IXS =     .6197 FT**4
```

TITLE 4' X 8' RECTANGULAR WITH FILLETS ANALYZE 7/25/1995 09:50:39 PAGE 5

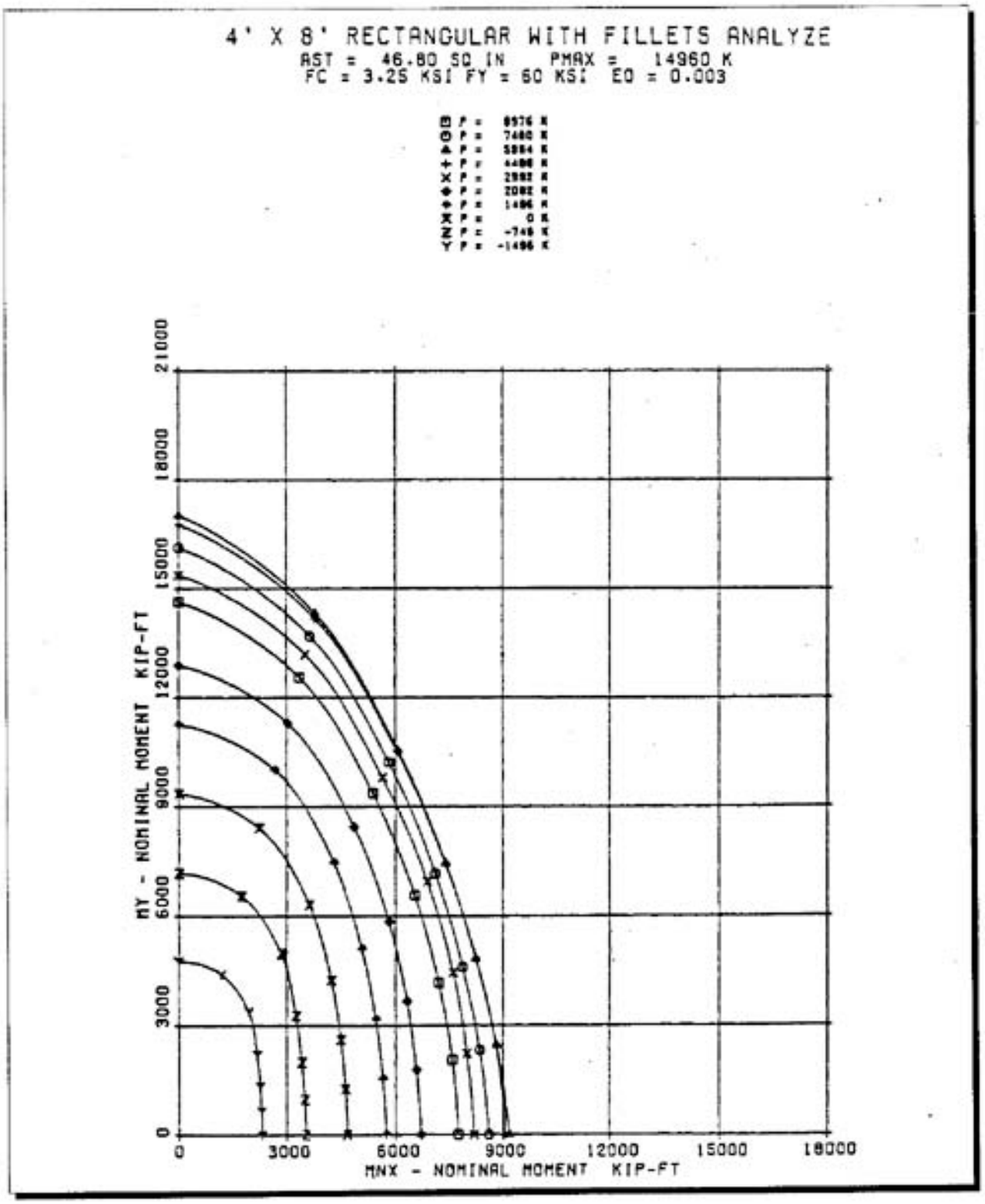
```
*************************************************************
* NOMINAL STRENGTH VALUES  (KIP-FT)     AST =  46.80 SQ IN *
*************************************************************
```

ANGLE	TRANS MNY	LONG MNX	COMB. MN	AXIAL PN	P-BALANCE (APPROX)
90.0	14630.	0.	14630.	8976.	5534
	16130.	0.	16130.	7479.	
	17020.	0.	17020.	5984.	
	16764.	0.	16764.	4490.	
	15369.	0.	15369.	2993.	
	12886.	0.	12886.	1497.	
	11249.	0.	11249.	749.	
	9348.	0.	9348.	1.	
	7177.	0.	7177.	-747.	
	4758.	0.	4758.	-1495.	
75.0	12563.	3360.	13004.	8975.	5459
	13690.	3658.	14171.	7479.	
	14317.	3797.	14812.	5986.	
	14177.	3791.	14675.	4490.	
	13188.	3529.	13652.	2994.	
	11306.	3026.	11704.	1498.	
	10015.	2681.	10368.	750.	
	8411.	2252.	8707.	1.	
	6554.	1754.	6785.	-747.	
	4412.	1181.	4567.	-1495.	
60.0	9365.	5384.	10802.	8975.	5309
	10220.	5814.	11758.	7479.	
	10554.	6064.	12172.	5986.	
	10530.	6026.	12133.	4487.	
	9798.	5642.	11306.	2994.	
	8444.	4869.	9748.	1498.	
	7464.	4305.	8617.	749.	
	6307.	3638.	7281.	1.	
	4967.	2866.	5735.	-747.	
	3385.	1953.	3908.	-1495.	

TITLE 4' X 8' RECTANGULAR WITH FILLETS ANALYZE 7/25/1995 09:50:39 PAGE 6

```
*************************************************************
* NOMINAL STRENGTH VALUES  (KIP-FT)     AST =  46.80 SQ IN *
*************************************************************
```

ANGLE	TRANS MNY	LONG MNX	COMB MN	AXIAL PN	P-BALANCE (APPROX)
45.0	6559.	6519.	9247.	8978.	5237
	7159.	7089.	10074.	7481.	
	7447.	7374.	10480.	5983.	
	7431.	7361.	10460.	4488.	
	6936.	6870.	9763.	2991.	
	5846.	5817.	8247.	1495.	
	5102.	5076.	7197.	747.	
	4239.	4231.	5989.	1.	
	3266.	3259.	4614.	-747.	
	2194.	2189.	3099.	-1495.	
30.0	4174.	7180.	8305.	8978.	5160
	4606.	7845.	9097.	7482.	
	4827.	8219.	9532.	5983.	
	4831.	8227.	9541.	4488.	
	4450.	7577.	8787.	2991.	
	3664.	6306.	7293.	1495.	
	3171.	5457.	6311.	747.	
	2609.	4492.	5195.	-1.	
	1989.	3423.	3958.	-749.	
	1335.	2274.	2637.	-1495.	
15.0	2046.	7554.	7826.	8978.	5236
	2313.	8331.	8646.	7480.	
	2445.	8807.	9140.	5984.	
	2445.	8799.	9132.	4488.	
	2215.	7970.	8272.	2991.	
	1777.	6558.	6795.	1495.	
	1530.	5647.	5851.	747.	
	1251.	4623.	4790.	-1.	
	972.	3500.	3633.	-747.	
	643.	2313.	2401.	-1496.	
.0	0.	7719.	7719.	8976.	5459
	0.	8589.	8589.	7479.	
	0.	9188.	9188.	5983.	
	0.	9060.	9060.	4490.	
	0.	8171.	8171.	2993.	
	0.	6686.	6686.	1497.	
	0.	5742.	5742.	749.	
	0.	4675.	4675.	1.	
	0.	3538.	3538.	-747.	
	0.	2329.	2329.	-1495.	


4' X 8' RECTANGULAR WITH FILLETS ANALYZE
AST = 46.80 SQ IN PMAX = 14960 K
FC = 3.25 KSI FY = 60 KSI EO = 0.003
P = 8576 K
P = 7480 K
P = 5984 K
P = 4488 K
P = 2992 K
P = 2092 K
P = 1496 K
P = 0 K
P = -748 K
P = -1496 K
MY - NOMINAL MOMENT KIP-FT
MNX - NOMINAL MOMENT KIP-FT
0
3000
6000
9000
12000
15000
18000
21000

Input Data Format (XEDIT)

General Data

Header – (A40,14X,I1)

Columns	Entry	Variable
1 - 40	Project Title	HEAD
55	Version (enter 1)	IVERS

Column Type – (I10)

Columns	Entry	Variable
1 - 10	Column Type (1,2,3,4,6,8,9)	ICON

Column Data – (2I10)

This line required for manual input (type = 1) only.

Columns	Entry	Variable
1 - 10	Number of Concrete Boundary Loops	NSLOOP
11 - 20	Total Number of Concrete Coordinates	NNODE

Rebar Type – (I10)

Columns	Entry	Variable
1 - 10	Rebar Type (1,2,3,4,5)	IREBAR

Rebar Data – (2I10)

Columns	Entry	Variable
1 - 10	Number of Steel Loops or Rows	NSLOOP
11 - 20	Total Number of Steel Rebars	NBAR

Plot Type – (I10)

Columns	Entry	Variable
1 - 10	Plot Type (0 to 4)	IPLOT

Problem Type, Steel Limits, Spiral Reinforcement (I10,2F10.0,I10,3F10.0)

Columns	Entry	Variable	Units
1 - 10	Problem Type	IPROB	
11 - 20	Minimum Percent Longitudinal Steel	RMIN	%
21 - 30	Maximum Percent Longitudinal Steel	RMAX	%
31 - 40	Number of Columns in Bent	NC	
41 - 50	Out to Out Diameter of Spiral	DSO	In
51 - 60	Distance from Top Plastic Hinge to Center of Gravity of Superstructure	CGS	Ft
61 - 70	Center to Center Spacing of Columns	CSP	Ft

Material Properties – (4F10.0)

Columns	Entry	Variable	Units
1 - 10	ULT Concrete Compressive Stress	FC	Psi
11 - 20	Young's Modulus for Steel Rebars	ES	Psi
21 - 30	ULT Concrete Compressive Strain	EO	In/In
31 - 40	Yielding Stress for Steel Rebars	FS	Psi

Column Dimensions

Concrete Coordinates – Manual Input (type = 1) (2F10.0,I10)

Note: Repeat this series of lines for each separate concrete boundary loop.

1st line (2F10.0,I10)

Columns	Entry	Variable	Units
1 - 10	X-Coordinate	X(I)	In
11 - 20	Y-Coordinate	Y(I)	In
21 - 30	Number of Coordinates this Loop	LNODE(NLOOP)	

I = 1 to LNODE(NLOOP)
One line for each remaining coordinate (2F10.0).
Do not repeat the number of coordinates in the loop.

Column Dimensions (Types 2,3,4,6,8,9) – (4F10.0)

Columns	Entry	Variable	Units
1 - 10	X-Width	BX	In
11 - 20	Y-Thick	HY	In
21 - 30	X-Fillet	FX	In
31 - 40	Y-Fillet	FY	In

Rebar Layouts

Steel Coordinates – Manual Input (Type = 1) (2F10.0,20X,F10.0,I10)

Note: Repeat this series of lines for each separate steel loop.

1st Line (2F10.0,20X,F10.0,I10)

Columns	Entry	Variable	Units
1 - 10	X-Coordinate	XS(I)	In
11 - 20	Y-Coordinate	YS(I)	In
41 - 50	Area of Steel	AS(I)	Sq In
51 - 60	Number of Coordinates this Loop	LSNODE(NSLOOP)	

I = 1 to LSNODE(NSLOOP)
One line for each remaining rebar coordinate (2F10.0)
Do not repeat the number of coordinates in the loop.

Rebar Layout

Intersecting Loops (Type 2) - (2F10.0,20X,1F10.0)
Semicircular Ends (Type 3) - (2F10.0,20X,1F10.0)
Concenric Loops (Type 4) - (1F10.0,30X,1F10.0,I10)

Note: For concentric loops (type 4) the number of lines in this section is equal to the "Total Number of Loops".
I = 1 to NSLOOP

Columns	Entry	Variable	Units
1 - 10	Loop Radius	RS(I)	In
11 - 20	Loop Spacing	SPACE	In
21 - 30	Area of Each Bar	AS(I)	Sq In
31 - 40	Number of Bars in this Loop	LSNODE(I)	

Rebar Layouts – Rows (Type 5) - (5F10.0,I10)

Note: The number of lines in this section is equal to the "Total Number of Rows". I = 1 to NSLOOP

Columns	Entry	Variable	Units
1 - 10	X-Coordinate Start Row	X1(I)	In
11 - 20	Y-Coordinate Start Row	Y1(I)	In
21 - 30	X-Coordinate End Row	X2(I)	In
31 - 40	Y-Coordinate End Row	Y2(I)	In
41 - 50	Area of Each Bar	AS(I)	In
51 - 60	Number of Bars in this Row	LSNODE(I)	

Load Data – Units Kips & Feet – (11 Lines)

Note: You may repeat this section (11 lines) for up to 10 different loadings.

Header – (3A8,A6,7X,A3,4X,A6)

Columns	Entry	Variable Name
1 - 30	Load Name	LOADNO(I)
38 - 40	Create a Footing File? (Yes/No)	PRNT
45 - 50	Footing Type (SPREAD/PILE)	FTYPE

Data – (2F5.0,10X,2F10.0,2I5,F10.0)

Columns	Entry	Variable	Units
1 - 5	Effective Length Factor Transverse	Ky	
6 - 10	Effective Length Factor Longitudinal	Kx	
21 - 30	Percent Live Load Impact	PERI	%
31 - 40	Column Length	ZLEN	Ft
41 - 45	Tie = 1, Spiral = 0 (Confinement)	ITIE	
46 - 50	Top = 1, Bottom = 0 (Load Connection)	ITOP	
51 - 60	Seismic Ductility and Risk Factor	Z	

Column End Conditions (61X,4I1)

Columns	Entry	Variable
62	Top Transverse	Topy
63	Top Longitudinal	Topx
64	Bottom Transverse	Boty
65	Bottom Longitudinal	Botx

Service Loads – 3(F7.0,F8.0,4F7.0,4F6.0)

1 st Line	My	Transverse Moment
2 nd Line	Mx	Longitudinal Moment
3 rd Line	N	Axial Load

		Variable Name Line Number		
Columns	Entry	1	2	3
1 - 7	Dead Load	DLT	DLL	DLN
8 - 15	PS (Pre Stress)	PST	PSL	PSN
16 - 22	Live Load + Impact (My Max)	HTT	HTL	HTN
23 - 29	Live Load + Impact (Mx Max)	HLT	HLL	HLN
30 - 36	Live Load + Impact (N Max)	HAT	HAL	HAN
37 - 43	W (Wind)	WT	WL	WN
44 - 49	WL (Wind on Live Load)	WLT	WLL	WLN
50 - 55	LF (Longitudinal Force)	LFT	LFL	LFN
56 - 61	CF (Centrifugal Force)	HCFT	HCFL	HCFN
62 - 67	T (Temperature)	TT	TL	TN

P-Loads – 3(15X,3F7.0,19X,F6.0)

1 st Line	PMy	Transvers Moment
2 nd Line	PMx	Longitudinal Moment
3 rd Line	PN	Axial Load

Columns	Entry	1	2	3
16 - 22	Live Load + Impact (PMy Max)	PTT	PTL	PTN
24 - 29	Live Load + Impact (PMx Max)	PLT	PLL	PLN
30 - 36	Live Load + Impact (PN Max)	PAT	PAL	PAN
56 - 61	CF (Centrifugal Force)	PCFT	PCFL	PCFN

Unreduced Seismic & Arbitrary Loads – 3(6F10.0)

1st Line	My	Transverse Moment
2nd Line	Mx	Longitudinal Moment
3rd Line	N	Axial Load

		Variable Name Line Number		
Columns	**Entry**	**1**	**2**	**3**
1 - 10	Unreduced Seismic Case 1 Max Trans	EQTT	EQTL	EQTN
11 - 20	Unreduced Seismic Case 2 Max Long	EQLT	EQLL	EQLN
21 - 30	Arbitrary Service AL-1	MYS1	MXS1	PS1
31 - 40	Arbitrary Service AL-2	MYS2	MXS2	PS2
41 - 50	Arbitrary Factored AL-1	MYF1	MXF1	PF1
51 - 60	Arbitrary Factored AL-2	MYF2	MXF2	PF2

Appendix A – Slenderness Effects

The YIELD program calculates the critical buckling load and moment magnification factor based on the unbraced AASHTO design procedure, as described in article 8.16.5 of the CALTRANS *Bridge Design Practice* Manual.

Moment Magnification

The method is based on the moment magnifer concept in which the moments computed by an ordinary frame analysis are multiplied by a moment magnifier. This magnifier, (&), is a function of the factored axial load, (Pu), and the critical buckling load, (Pc), for the column:

$$Mc = \& \, M2 \qquad (8\text{-}40)$$

$$\& = \frac{Cm}{1 - Pu/Pc} \geq 1.0 \qquad (8\text{-}41)$$

Where: Cm = 1.0 for an unbraced frame.
Mc = Design moment
M2 = Larger end moment

Critical Buckling Load – Pc

The effective length factor (k), the unbraced column length (Lu) and the column stiffness parameter (EI), are used to caluclate the critical buckling load (Pc):

$$Pc = \frac{Pi**2 \, EI}{(k \, Lu)**2} \qquad (8\text{-}42)$$

The program determines the effective length factor (k) by using equations (C) and (D) from the ACI commentary (1):

for Ga < 2:

$$k = \frac{20 - Ga}{20} \sqrt{1 + Ga} \qquad (Eq. C)$$

for Ga > 2:

$$k = .9 \times \sqrt{1 + Ga} \qquad \text{(Eq. D)}$$

where (Ga) is the average of the (G) values at the two ends of the column and (G) is:

$$G = \frac{\text{Sum EI/Lc}}{\text{Sum EI/L}} \quad \begin{array}{l}\text{Column} \\ \text{Members in plane at one end of column}\end{array}$$

The (G) values are determined by using the moment distribution factors at the top and bottom of the column.

For members hinged at one end and fixed at the other the effective length factor (k) is taken as 2.1.

Stiffness Parameter – EI

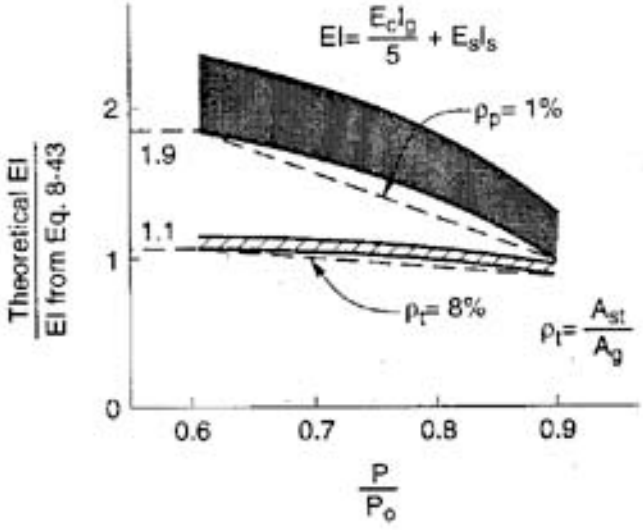
The AASHTO procedure approximates stiffness variations due to cracking, creep, and the nonlinearity of the concrete stress-strain curve. Creep due to sustained loads tends to reduce the effective value of EI. This is taken into account by dividing EI by (1 + Bd) where Bd is the ratio of dead load moment to total load moment.

$$EI = (Ec\ Ig / 5 + Es\ Is) / (1 + Bd) \qquad (8\text{-}43)$$

Based on information from the ACI Commentary (1), the YIELD program makes a further modification to the stiffness parameter, (EI), depending on the percent steel and the axial load load ratio, (P/Po) (see Figure 1). Most CALTRANS bridge columns have an axial load ratio, (P/Po), less than 0.6. For steel ratios of 1 to 8 percent with axial load ratios, (P/Po), less than 0.6, the theoretical (EI) varies from 1.9 to 1.1 times greater than that calculated by the AASHTO equation (8-44). For 1 to 8 percent steel with (P/Po) equal to 0.9 the theoretical and calculated (EI) are about the same. Straight line interpolation is used for steel ratios and axial load ratios that fall between these boundaries, as shown in Figure 1. The net effect is to increase the column stiffness, EI, and thus reduce the amount of moment magnification.

The effects of slenderness are neglected by the program, when the slenderness ratio, (kL/r), is less than 22 (8.16.5.2.5). When (kl/r) is greater than 100, the YIELD program warns the user to either redesign the column with a larger cross section or perform a special second order analysis (8.16.5.2.6).

The program neglects moment magnification for Group VII seismic loads. By definition the plastic moment is the capacity of the column and the moment cannot be magnified.



Equation of Flexural Stiffness vs. Theoretical Values
Figure 1

Notations

Bd = Ratio of maximum dead load moment to maximum total loadmoment, always positive (8.16.5.2.7)

Ec = Modulus of elasticity of concrete (8.7.1)

EI = Flexural stiffness of compression member (8.16.5.2.7)

Es = Modulus of elasticity of reinforcement (8.7.2)

Ig = Moment of inertia of gross concrete section about centroidal axis, neglecting reinforcement

Is = Moment of inertia of reinforcement about centroidal axis of member cross section

k = Effective length factor for compression members (8.16.5.2.3)

Lu = Unsupported length of compression member (8.16.5.2.1)

Mc = Moment for design of compression member (8.16.5.2.7)

M2 = Larger end moment on compression member (8.16.5.2.4)

Pc = Critical load (8.16.5.2.7)

Po = Nominal axial load strength of a section at zero eccentricity (8.16.4.2.1)

Pu = Factored axial load at given eccentricity

& = Moment magnifier (8.16.5.2.9)

&b = Moment magnifer for members braced against sidesway

&s = Moment magnifer for members not braced against sidesway

References

1. ACI Committee 318, "Commentary on Building Code Requirements for Reinforced Concrete (ACI 318-83)," American Concrete Institute, 1983