บทที่ 4
ผลการวิจัย

4.1 รายละเอียดของโปรแกรมและข้อจำกัดของการใช้งาน.

4.1.1 เป็นโปรแกรมที่ใช้งานภายใต้โปรแกรม Excel Version 7.

4.1.2 ใช้กับคอมพิวเตอร์รุ่น Intel Pentium 75 ขึ้นไป ram 16 bit.

4.1.3 เป็นโปรแกรมที่ใช้งานภายใต้ Windows 95.

4.1.4 การทำงานเป็น worksheet ที่มีหลายๆ sheet ทำงานสัมพันธ์กันภายใต้โปรแกรม Excel Version 7.

4.2 ขั้นตอนการใช้โปรแกรม Interaction diagram.

เมื่อพิจารณาจากโปรแกรม ผู้ใช้จะต้องใส่ข้อมูลในsheet "Input"ดังตัวอย่างข้างต้น

ขั้นที่1 คือ การใส่ค่าข้อมูลเบื้องต้น (สังเกตจากเครื่องหมาย *) หมายถึง มีการใส่ข้อมูลเพียงครั้งเดียวต่อโจทย์หนึ่งข้อซึ่งได้แก่ ค่า *fc'= ,*fy= ,*b= , *h= ,*β1= , *Ast= ,*As1= ,*As2= ,*As3= ,*As4= ,*d1= ,*d2= ,*di= ,*l=

ขั้นที่2 คือ การใส่ค่าข้อมูลที่มีการแปรผัน (สังเกตจากเครื่องหมาย ***) หมายถึงให้มีการใส่ค่าตามความต้องการของผู้ใช้โปรแกรม ได้แก่ค่า ***Puc=, ***c1=, ***c2=, ***c3=, ***c4=, ***c5=, ***c6=, ***c7=, ***c8=, ***c9=, ***c10=,

หมายเหตุ

- การใส่ค่าใน ***Puc ควรใส่ค่าที่ใกล้เคียงกับค่า Puo ให้มากที่สุด
- การใส่ค่า ***c แต่ละตัว ต้องเรียงจากมากไปหาน้อยเท่านั้น
- การใส่ค่า ***c10 (tension)นั้นต้องทำให้ Pu(lb) มีค่าใกล้เคียง 0 ให้มากที่สุด

4.3 ตัวอย่างการใช้โปรแกรม Interaction diagram.และการวิเคราะห์โจทย์

ตัวอย่างที่1 Analysis of a Short Rectangular Tied Column.

A short tied column is reinforced with three No.9 bars on each of the two faces parallel to the axis of bending. Calculate

(a) concentric design load Puo

(b) load Pub and e_b corresponding to balanced failure condition

(c) Pu if e=14 in.

(d) Pu if e=10 in.

Given:

fc' = 4,000 psi

fy = 60,000 psi

b = 12 in.

h = 20 in.

d1 = 2.5 in.

d2 = 17.5 in.

Solution (by hand.)

Trial 1: c = 10 in. , Pu = 100,000 lb

Output: c_{bal} = 10.3571 in.

P_{bal} = 244,290.0002 lb

M_{bal} =3,244,009.017 in.-lb

e_{bal} = 13.2793

Puo = 647,136.000 lb

Pu = 235,620.000 lb

Mu = 3,232,320.000 in.-lb

e = 13.7184

Trial 2: c = 9.8 in., Pu = 230,000 lb

Output: Pu = 230,764.800 lb

Mu = 3,224,624.508 in.-lb

e = 13.9736

Trial 3: c = 9.78in.

Output: Pu = 230,279.280 lb

Mu = 3,223,809.562 in.-lb

e = 13.9996

13.9996 in. ≈ 14 in., say; O.K. Therefore, 230,279 lb. for e = 14 in.

(d) Since e= 10 in. is < e_b, failure will be in compression. There is no need to reinput Pu, which is used to calculate ϕ since for compression failure ϕ = 0.70. ϕ = 0.70 was used in the previous computation and is still in storage

Trial 1: c = 11 in. , Pu = 230,000 lb

Output: Pu = 277,936.9091 lb

Mu =3,123,109.882 in.-lb

e = 11.2368

Trial 2: c = 11.5 in

Output: Pu = 302,712.2609 lb

Mu = 3,033,640.119 in.-lb

e = 10.0215

Trial 3: c = 11.51 in.

Output: Pu = 303,196.5689 lb

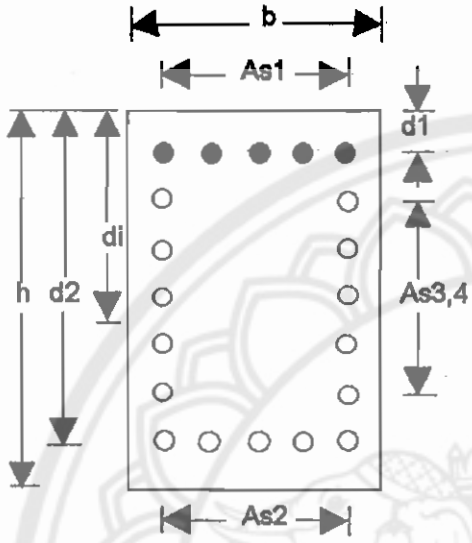
Mu = 3,031,882.098 in.-lb

e = 9.9997

e ≈ 10 in. Conclude that Pu = 303,197 lb.

INPUT

INTERACTION OF TIED COLUMN



Input Data

* fc' =	4000.00	psi
* fy =	60000.00	psi
* b =	12.00	in.
* h =	20.00	in.
* B1=	0.850	
* Ast =	6.00	in.^2
* As1=	3.00	in.^2
* As2 =	3.00	in.^2
* As3 =	0.00	in.^2
* As4 =	0.00	in.^2
* d1=	2.50	in.
* d2=	17.50	in.
* di =	0.00	in.
* l =	2.00	faces
***Puc =	100000.00	lb.

TRUE	com	tension	Pu (lb),com	Pu (lb),ten	
control	23.5294	10.3571	647136.00	244290.00	
***c1=	11.0000	10.0000	277936.91	235620.00	
***c2=	11.5000	9.8000	302712.26	230764.80	
***c3=	11.5100	9.7800	303196.57	230279.28	
***c4=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c5=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c6=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c7=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c8=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c9=	0.0000	0.0000	#DIV/0!	#DIV/0!	96000.00
***c10=	0.0000	0.0000	#DIV/0!	#DIV/0!	
control	10.3571		244290.00	0.00	

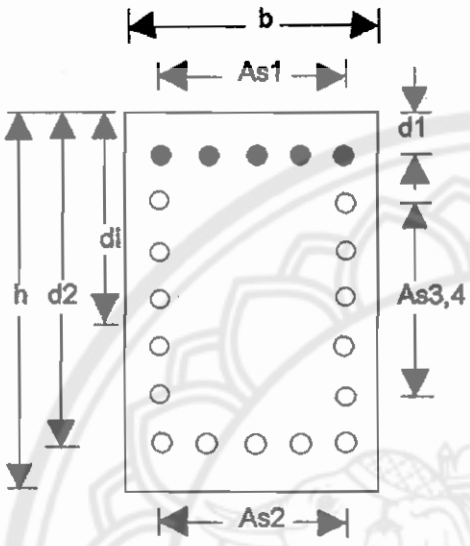
OUTPUT

OUTPUT 0F INTERACTION DIAGRAM

		Mu (In.-lb)	Pu (lb)	e
c0=	23.529412	0	647136	0.0000
c1=	11.0000	3123110	277937	11.2368
c2=	11.5000	3033640	302712	10.0215
c3=	11.5100	3031882	303197	9.9997
c4=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c5=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c6=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c7=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c8=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c9=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c10=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
Cbal=	10.3571	3244009	244290	13.2793
c11=	10.0000	3232320	235620	13.7184
c12=	9.8000	3224625	230765	13.9736
c13=	9.7800	3223810	230279	13.9996
c14=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c15=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c16=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c17=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c18=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c19=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c20=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!

INPUT

INTERACTION OF TIED COLUMN



Input Data

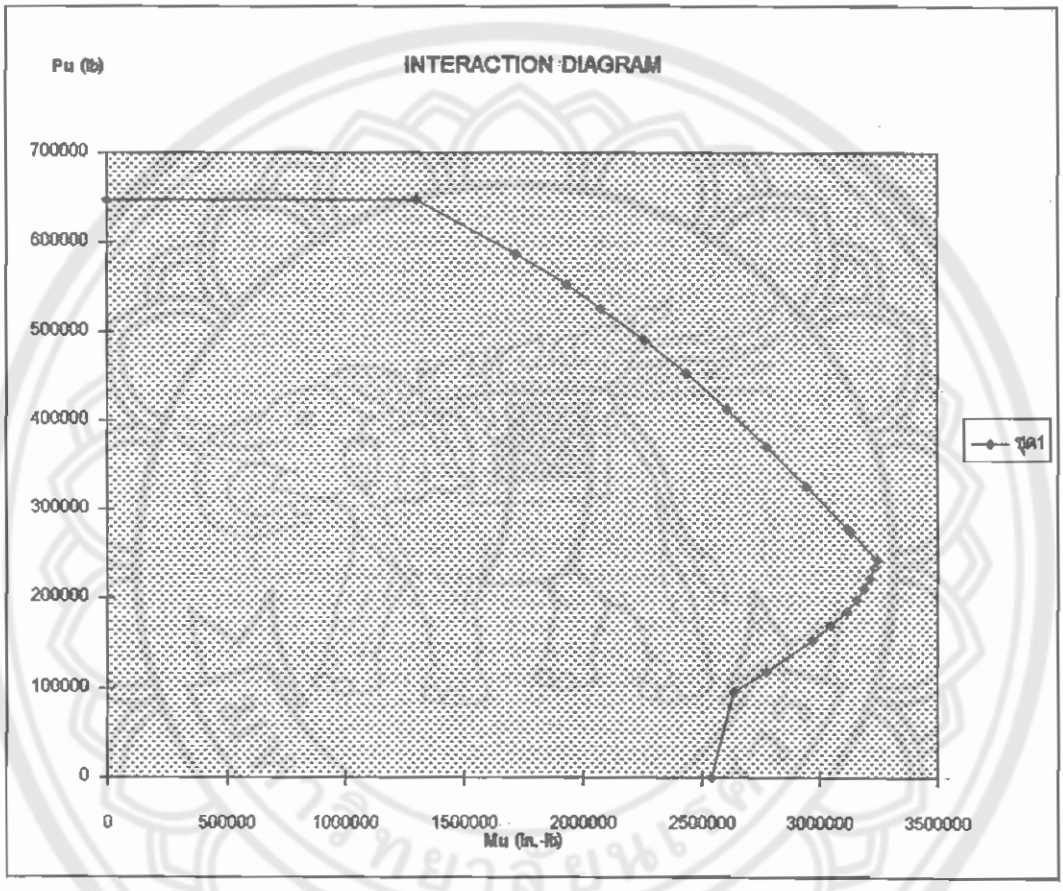
* fc' =	4000.00	psi
* fy =	60000.00	psi
* b =	12.00	in.
* h =	20.00	in.
* B1=	0.850	
* Ast =	6.00	in.^2
* As1=	3.00	in.^2
* As2 =	3.00	in.^2
* As3 =	0.00	in.^2
* As4 =	0.00	in.^2
* d1=	2.50	in.
* d2=	17.50	in.
* di =	0.00	in.
* l =	2.00	faces
***Puc =	647136.00	lb.

TRUE	com	tension	Pu (lb),com	Pu (lb),ten	
control	23.5294	10.3571	647136.00	244290.00	
***c1=	20.8470	10.0000	647134.38	235620.00	
***c2=	19.0000	9.5000	587387.68	223482.00	
***c3=	18.0000	9.0000	553763.00	211344.00	
***c4=	17.0000	8.5000	526178.47	199206.00	
***c5=	16.0000	8.0000	490147.88	186674.25	
***c6=	15.0000	7.5000	452550.00	170730.00	
***c7=	14.0000	7.0000	413049.00	154242.00	
***c8=	13.0000	6.0000	371205.69	119091.00	
***c9=	12.0000	5.3983	326434.50	95999.16	96000.00
***c10=	11.0000	3.4354	277936.91	4.91	
control	10.3571		244290.00	0.00	

OUTPUT 0F INTERACTION DIAGRAM

		Mu (in.-lb)	Pu (lb)	e
c0=	23.529412	0	647136	0.0000
c1=	20.8470	1301951	647134	2.0119
c2=	19.0000	1724717	587388	2.9362
c3=	18.0000	1933812	553763	3.4921
c4=	17.0000	2076972	526178	3.9473
c5=	16.0000	2262842	490148	4.6167
c6=	15.0000	2439833	452550	5.3913
c7=	14.0000	2610462	413049	6.3200
c8=	13.0000	2778024	371206	7.4838
c9=	12.0000	2946910	326435	9.0276
c10=	11.0000	3123110	277937	11.2368
Cbal=	10.3571	3244009	244290	13.2793
c11=	10.0000	3232320	235620	13.7184
c12=	9.5000	3211534	223482	14.3704
c13=	9.0000	3185589	211344	15.0730
c14=	8.5000	3154485	199206	15.8353
c15=	8.0000	3115270	186674	16.6883
c16=	7.5000	3045302	170730	17.8369
c17=	7.0000	2966097	154242	19.2302
c18=	6.0000	2775900	119091	23.3091
c19=	5.3983	2636953	95999	27.4685
c20=	3.4354	2541547	5	517428.5901

INTERACTION



ตัวอย่างที่2 Analysis of Column Controlled by Tension Failure; Stress in Compression Steel Less Than Yield Strength.

A short rectangular reinforced concrete column is 12 in.x 15 in. and is reinforced with three No. 9 bars on each of the two faces parallel to the axis of bending. Calculate the ultimate design load Pu=ϕPn if the eccentricity e= 12 in.

Given:

fc' = 4,000 psi

fy = 60,000 psi

d1 = 2.5 in.

Solution (by hand.)

Trial 1: c = 10 in. , Pu = 150,000 lb

Output: c_{bal} = 7.3980 in.

P_{bal} = 167,412.8572 lb

M_{bal} =1,981,382.662 in.-lb

e_{bal} = 11.8353

Puo= 532,896.000 lb

Pu = 315,945.000 lb

Mu = 1,611,645.000 in.-lb

e = 5.1010

Trial 2: c = 6.5 in.

Output: Pu = 137,084.7692 lb

Mu = 1,904,002.921 in.-lb

e = 13.8892

Trial 3: c = 7.2 in.

Output: Pu = 160,909.700 lb

Mu= 1,966,667.668 in.-lb

e = 12.2222

Trial 4: c = 7.3 in.

Output: Pu = 164,206.3069 lb

Mu = 1,974,259.617 in.-lb

e = 12.0230

Trial 5: c = 7.31 in.

Output: Pu = 164,534.6599 lb

Mu = 1,975,000.925 in.-lb

e = 12.0036

Conclude that Pu = 164,535 lb for e = 12 in., Pu = 164,535 lb $< \phi$Pnb;

Therefore, failure will be in tension, or alternatively, c = 7.31 in. $< c_b$.

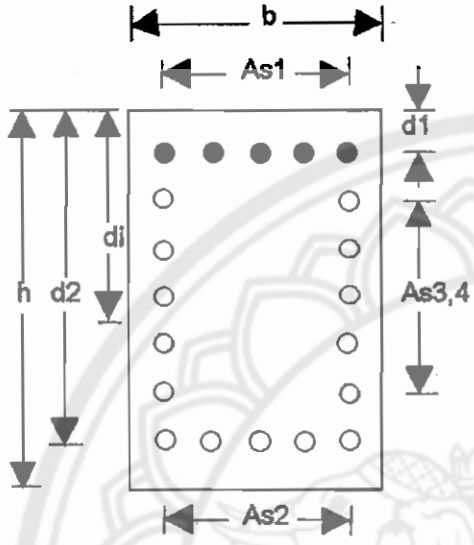
4.5098 in. $\approx$ 4.50 in.,say; O.K.

Pu = 372,247 lb > 365,000 lb

Therefore, adopt 15 in.x 15 in. section with two No.9 bars on each face.

INPUT

INTERACTION OF TIED COLUMN



Input Data

* fc' =	4000.00	psi
* fy =	60000.00	psi
* b =	12.00	in.
* h =	15.00	in.
* B1=	0.850	
* Ast =	6.00	in.^2
* As1=	3.00	in.^2
* As2 =	3.00	in.^2
* As3 =	0.00	in.^2
* As4 =	0.00	in.^2
* d1=	2.50	in.
* d2=	12.50	in.
* di =	0.00	in.
* I =	2.00	faces
***Puc =	150000.00	lb.

TRUE	com	tension	Pu (lb),com	Pu (lb),ten	
control	17.6471	7.3980	532896.00	167412.86	
***c1=	10.0000	6.5000	315945.00	137084.77	
***c2=	0.0000	7.2000	#DIV/0!	160909.70	
***c3=	0.0000	7.3000	#DIV/0!	164206.31	
***c4=	0.0000	7.3100	#DIV/0!	164534.66	
***c5=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c6=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c7=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c8=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c9=	0.0000	0.0000	#DIV/0!	#DIV/0!	72000.00
***c10=	0.0000	0.0000	#DIV/0!	#DIV/0!	
control	7.3980		167412.86	0.00	

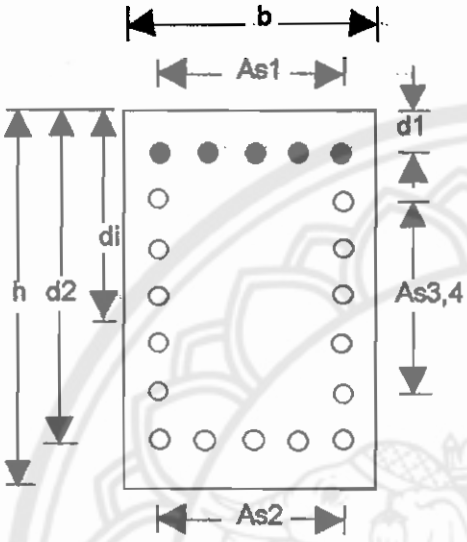
OUTPUT

OUTPUT 0F INTERACTION DIAGRAM

		Mu (In.-lb)	Pu (lb)	e
c0=	17.647059	0	532896	0.0000
c1=	10.0000	1611645	315945	5.1010
c2=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c3=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c4=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c5=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c6=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c7=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c8=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c9=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c10=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
Cbal=	7.3980	1981383	167413	11.8353
c11=	6.5000	1904003	137085	13.8892
c12=	7.2000	1966668	160910	12.2222
c13=	7.3000	1974260	164206	12.0230
c14=	7.3100	1975001	164535	12.0036
c15=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c16=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c17=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c18=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c19=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c20=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!

INPUT

INTERACTION OF TIED COLUMN



Input Data

* fc' =	4000.00	psi
* fy =	60000.00	psi
* b =	12.00	in.
* h =	15.00	in.
* B1=	0.850	
* Ast =	6.00	in.^2
* As1=	3.00	in.^2
* As2 =	3.00	in.^2
* As3 =	0.00	in.^2
* As4 =	0.00	in.^2
* d1=	2.50	in.
* d2=	12.50	in.
* di =	0.00	in.
* l =	2.00	faces
***Puc =	150000.00	lb.

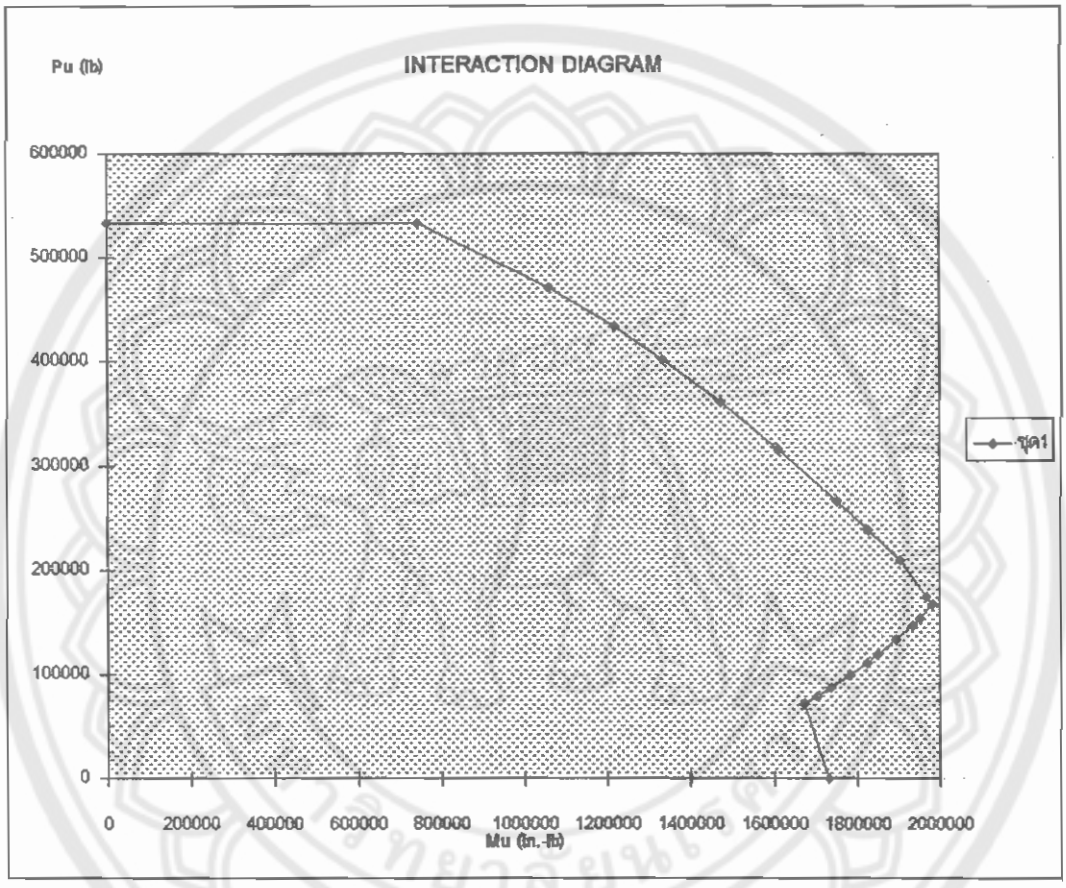
TRUE	com	tension	Pu (lb),com	Pu (lb),ten	
control	17.6471	7.3980	532896.00	167412.86	
***c1=	15.7837	7.0000	532894.69	154242.00	
***c2=	14.0000	6.8000	471159.00	147467.68	
***c3=	13.0000	6.4000	434334.92	133559.21	
***c4=	12.0000	6.0000	402559.50	119091.00	
***c5=	11.0000	5.8000	360982.36	111610.80	
***c6=	10.0000	5.5000	315945.00	100032.55	
***c7=	9.0000	5.2000	266294.00	87958.66	
***c8=	8.5000	5.0000	239229.53	79590.00	
***c9=	8.0000	4.8244	209905.50	72002.15	72000.00
***c10=	7.5000	3.4354	174930.00	4.91	
control	7.3980		167412.86	0.00	

OUTPUT

OUTPUT 0F INTERACTION DIAGRAM

		Mu (in.-lb)	Pu (lb)	e
c0=	17.647059	0	532896	0.0000
c1=	15.7837	743391	532895	1.3950
c2=	14.0000	1058914	471159	2.2475
c3=	13.0000	1218152	434335	2.8046
c4=	12.0000	1331511	402560	3.3076
c5=	11.0000	1473245	360982	4.0812
c6=	10.0000	1611645	315945	5.1010
c7=	9.0000	1752479	266294	6.5810
c8=	8.5000	1826352	239230	7.6343
c9=	8.0000	1902428	209906	9.0633
c10=	7.5000	1967477	174930	11.2472
Cbal=	7.3980	1981383	167413	11.8353
c11=	7.0000	1950492	154242	12.6457
c12=	6.8000	1932958	147468	13.1077
c13=	6.4000	1893615	133559	14.1781
c14=	6.0000	1848172	119091	15.5190
c15=	5.8000	1822982	111611	16.3334
c16=	5.5000	1781859	100033	17.8128
c17=	5.2000	1736402	87959	19.7411
c18=	5.0000	1703468	79590	21.4030
c19=	4.8244	1672670	72002	23.2308
c20=	3.4354	1731534	5	352519.7556

INTERACTION



ตัวอย่างที่3 Design of Column with Large Eccentricity; Initial Tension Failure

A tied reinforced concrete column is subjected to a service axial force due to dead load =65000 lb. and a service axial force due to live load = 125000 lb. Eccentricity to the plastic and geometric centroid is e= 16 in.

Design the longitudinal and lateral reinforcement for this column , assuming a nonslender column with a total reinforcement ratio between 2 and 3 %

Given:

f_c' = 4,000 psi

f_y = 60,000 psi

Solution (by hand.)

Calculate the factored external load and moment.

$P_u = 1.4D + 1.7L = 1.4X65{,}000 + 1.7x125{,}000 = 303{,}500$ lb

$P_u e = 303{,}500x16 = 4{,}856{,}000$ in.-lb

Assume a section 20 in. x 20 in. and a total reinforcement ratio of 3 %

Assume that $\rho = \rho' = A_s/bd = 0.015$ and d1= 2.5 in.

$A_s = A_s' = 0.015x20(20-2.5) = 5.25$ in.^{2}

Try five No.9 bars =5.00 in.^{2} on each face (3,225 mm.^{2})

$\rho = 5.00/(20x17.5) = 0.0143$

Trial 1: c = 9 in.

Output: c_{bal} = 10.3571 in.

P_{bal} = 407,150.0003 lb

M_{bal}=5,406,681.696 in.-lb

e_{bal} = 13.2793

Puo= 1,078,560.000 lb

Pu = 352,239.9999 lb

Mu = 5,309,314.500 in.-lb

e = 15.0730

Trial 2: c = 8.5 in.

Output: Pu = 332,010.0001 lb

Mu = 5,257,475.125 in.-lb

e = 15.8353

Trial 3: c = 8.4 in.

Output: Pu = 327,964.000 lb

Mu = 5,246,075.520 in.-lb

e = 15.9959

15.9959 in.≈ 16.00 in., say; O.K.

Pu = 327,964 lb > 303,500 lb

Therefore, adopt section 20 in.x 20 in.with five No.9 bars on each face

ϕPnb>Pu. Therefore, tension failure.

ตัวอย่างที่4 Design of Column with Small Eccentricity; Initial Compression Failure.

A nonslender column is subjected to a factored Pu= 365000 lb (1620 kN) and a factored Mu= 1,640,000 in.-lb (185 kN.-m) . Assume that the gross reinforcement ratio ρg= 1.5 to 2 %and that the effective cover to the center of the longitudinal steel is d1= 2.5 in. (63.5 mm.) .Design the column section and the necessary longitudinal and transverse reinforcement.

Given:

fc' = 4,500 psi (31.03 MPa), normalweight concrete

fy = 60,000 psi (414 MPa)

Solution (by hand.)

Calculation of factored design loads

Pu = 365000 lb , e= 1640000/365000 = 4.5 in.(144 mm.)

Assume a 15 in.x 15 in. (d =12.5 in.) section

Assume a reinforcement ratio $\rho = \rho' = 0.01$

$As = As' = 0.01 \times 15 \times 15 = 4.5$ in.^{2}

Provide two No.9 bars on each side.

$As = As' = 2.0$ in.^{2} (1290 mm.^{2})

Solution

Trial 1: c = 9 in.

Output: c_{bal} = 7.3980 in.

P_{bal}= 236,409.442 lb

M_{bal}=1,886,822.310 in.-lb

e_{bal}= 7.9812

Puo= 607,782 lb

Pu = 329,484.8958 lb

Mu = 1,759,515.689 in.-lb

e = 5.3402

Trial 2: c = 10 in.

Output: Pu = 379,535.6250 lb

Mu = 1,663,749.610 in.-lb

e = 4.3836

Trial 3: c = 9.8 in.

Output: Pu = 369,801.6697 lb

Mu = 1,683,708.722 in.-lb

e = 4.5530

Trial 4: c = 9.85 in.

Output: Pu = 372,246.9878 lb

Mu= 1,678,762.307 in.-lb

e = 4.5098

ϕPnb<Pu. Therefore, compression failure.

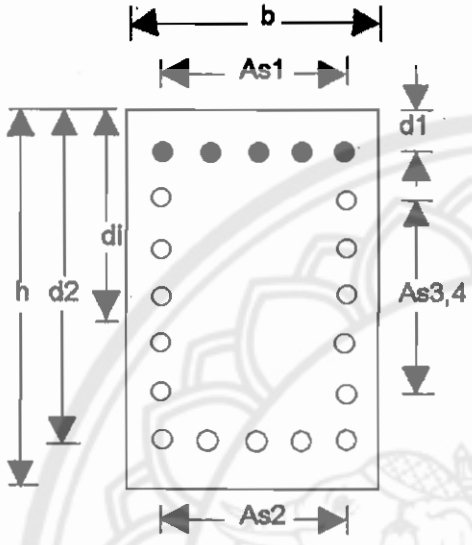
4.5098 in. $\approx$ 4.50 in.,say; O.K.

Pu = 372,247 lb > 365,000 lb

Therefore, adopt 15 in.x 15 in. section with two No.9 bars on each face.

INPUT

INTERACTION OF TIED COLUMN



Input Data

* fc' =	4500.00	psi
* fy =	60000.00	psi
* b =	15.00	in.
* h =	15.00	in.
* B1=	0.825	
* Ast =	4.00	in.^2
* As1=	2.00	in.^2
* As2 =	2.00	in.^2
* As3 =	0.00	in.^2
* As4 =	0.00	in.^2
* d1=	2.50	in.
* d2=	12.50	in.
* di =	0.00	in.
* l =	2.00	faces
***Puc =	365000.00	lb.

TRUE	com	tension	Pu (lb),com	Pu (lb),ten	
control	18.1818	7.3980	607782.00	236409.44	
***c1=	9.0000	0.0000	329484.90	#DIV/0!	
***c2=	10.0000	0.0000	379535.63	#DIV/0!	
***c3=	9.8000	0.0000	369801.67	#DIV/0!	
***c4=	9.8500	0.0000	372246.99	#DIV/0!	
***c5=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c6=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c7=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c8=	0.0000	0.0000	#DIV/0!	#DIV/0!	
***c9=	0.0000	0.0000	#DIV/0!	#DIV/0!	101250.00
***c10=	0.0000	0.0000	#DIV/0!	#DIV/0!	
control	7.3980		236409.44	0.00	

OUTPUT 0F INTERACTION DIAGRAM

		Mu (in.-lb)	Pu (lb)	e
c0=	18.181818	0	607782	0.0000
c1=	9.0000	1759516	329485	5.3402
c2=	10.0000	1663750	379536	4.3836
c3=	9.8000	1683709	369802	4.5530
c4=	9.8500	1678762	372247	4.5098
c5=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c6=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c7=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c8=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c9=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c10=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
Cbal=	7.3980	1886822	236409	7.9812
c11=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c12=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c13=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c14=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c15=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c16=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c17=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c18=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c19=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!
c20=	0.0000	#DIV/0!	#DIV/0!	#DIV/0!

ตัวอย่างที่5 Construction of a load-Moment Design Strength Interaction Diagram for a Rectangular Column (ρ = 1-8%)

Construct a load-moment design strength interaction diagram for a rectangular column having the following properties(Two faces)

Given:

fc' = 6,000 psi

fy = 60,000 psi

b = 12 in.

h = 14in.

d1 = 3 in.

As = As' = 1-8 %(bh) $in.^2$

Solution

Given: As = As' = 0.84 $in.^2$(1%Ag)

Trial 1: (In compression zone)

c = 15.1035 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.4 ,6.2 ,6, 5.6 ,5.2 , 4.8 , 4.4 , 4 , 3.9467 , 1.9943 in.

Given: As = As' = 1.68 $in.^2$(2%Ag)

Trial 2: (In compression zone)

c = 15.2513 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.4 ,6.2 ,6, 5.6 ,5.2 , 4.8 , 4.6, 4.5 ,4.4719 , 2.7159 in.

Given: As = As' = 2.52 $in.^2$(3%Ag)

Trial 3: (In compression zone)

c = 15.3812 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.4 ,6.2 ,6, 5.6 ,5.3, 5.2 , 5.1, 5 , 4.8745 , 3.2317 in.

Given: As = As' = 3.36 $in.^2$(4%Ag)

Trial 4: (In compression zone)

c = 15.4966 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.4 ,6.2 ,6, 5.8 ,5.6 , 5.5 , 5.4 , 5.3 , 5.2049 , 3.6424 in.

Given: As = As' = 4.20 $in.^2$(5%Ag)

Trial 5: (In compression zone)

c = 15.60 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.4 ,6.2 ,6, 5.9 ,5.8 , 5.7 , 5.6 , 5.5 , 5.4864, 3.9867 in.

Given: As = As' = 5.04 $in.^2$(6%Ag)

Trial 6: (In compression zone)

c = 15.6933 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.5 ,6.4 ,6.3, 6.2 ,6.1 , 6 , 5.9 , 5.8, 5.7322 , 4.2844 in.

Given: As = As' = 5.88 $in.^2$(7%Ag)

Trial 7: (In compression zone)

c = 15.7780 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.5 ,6.48 ,6.45, 6.4 ,6.3 , 6.2 , 6.1 , 6 , 5.9506 , 4.5473 in.

Given: As = As' = 6.72 $in.^2$(8%Ag)

Trial 8: (In compression zone)

c = 15.8554 in. , Pu = 200,000 lb

c = 15 ,14 ,13 , 12 ,11 , 10 , 9 , 8 , 7 in.

(In tension zone)

c = 6.5 ,6.48 ,6.45, 6.4, 6.35 ,6.3 , 6.25 , 6.2 , 6.1472,4.783 in.

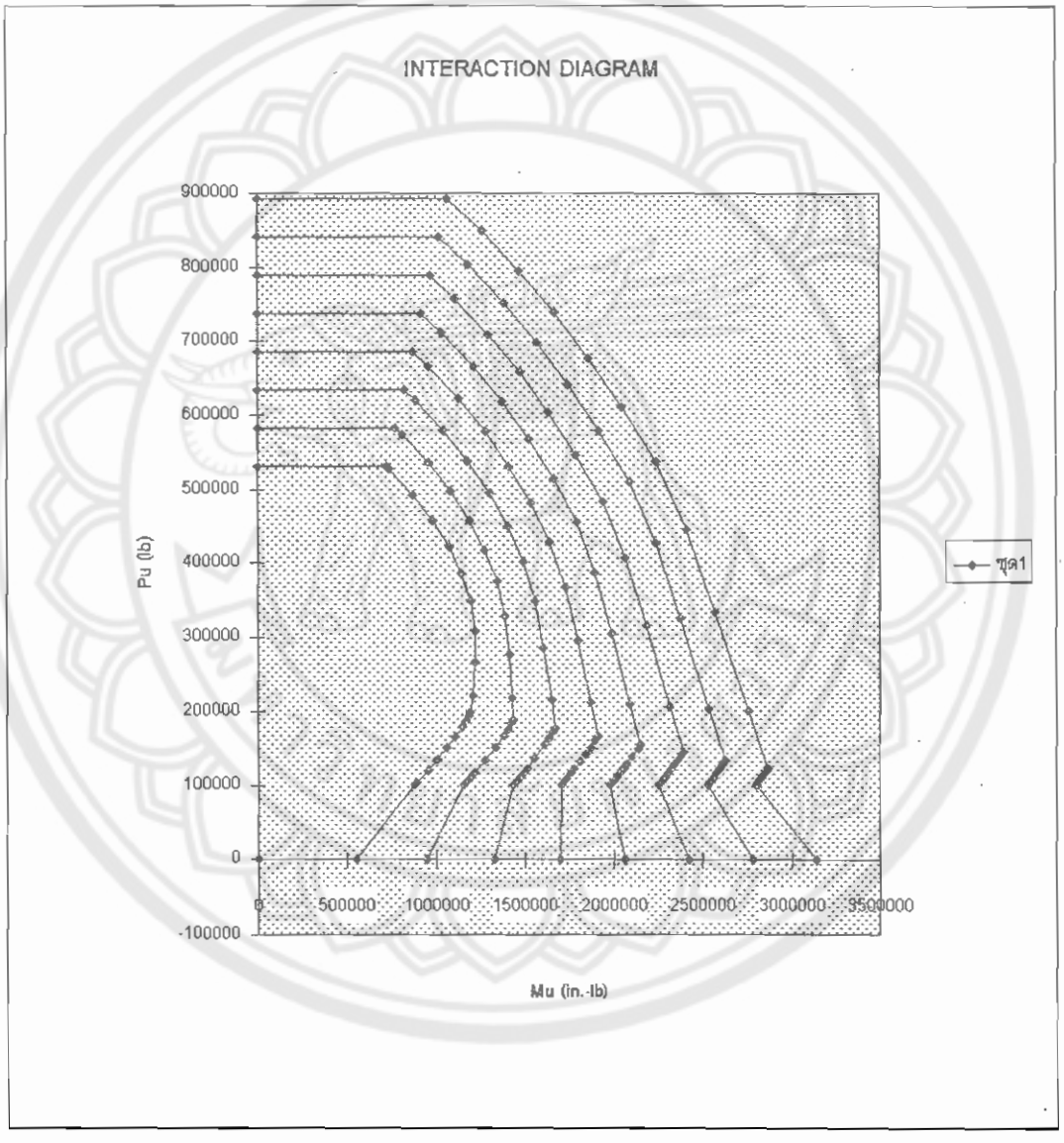
Output: c_{bal} = 6.5102 in.

P_{bal} = 198,476.60 lb

M_{bal} =1,193,005.74 in.-lb

e_{bal} = 6.0108

Puo = 531,457.92 lb


INTERACTION DIAGRAM
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
-100000
Pu (lb)
0
500000
1000000
1500000
2000000
2500000
3000000
3500000
Mu (in.-lb)
ชุด1

ตัวอย่างที่6 Construction of a load-Moment Design Strength Interaction Diagram for a Rectangular Column

Construct a load-moment design strength interaction diagram for a rectangular column having the following properties(Four faces)

Given:

fc' = 4,000 psi

fy = 60,000 psi

b = 20 in.

h = 20 in.

d1 = 3 in.

d2 = 17 in.

di = 13.5 in.

As1 = As2 = 4 $in.^2$

As3 = As4 = 1 $in.^2$

Solution

Trial 1: (In compression zone)

c = 20.9030 in. , Pu =1,078,560 lb

c = 20 ,19 ,18 , 16 ,14 , 12 , 10 , 9 , 8 in.

(In tension zone)

c = 7.7 ,7.6,7.5, 7.4 ,7.3 , 7.2 , 7.1 , 7 , 6.9837 , 4.4772 in.

Output: c_{bal} = 7.9898 in.

P_{bal} = 213,880 lb

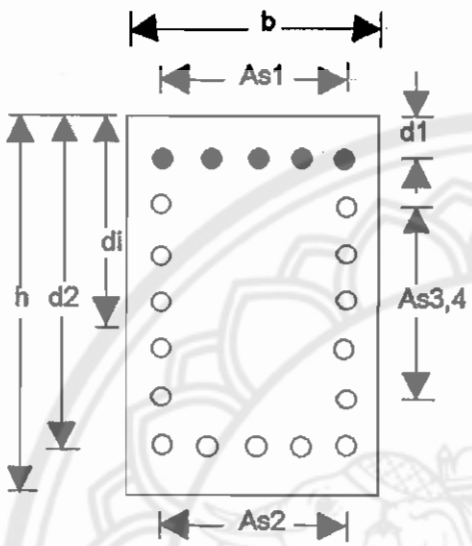
M_{bal} =4,603,258 in.-lb

e_{bal} = 21.5226

Puo =1,078,560 lb

INPUT

INTERACTION OF TIED COLUMN



Input Data

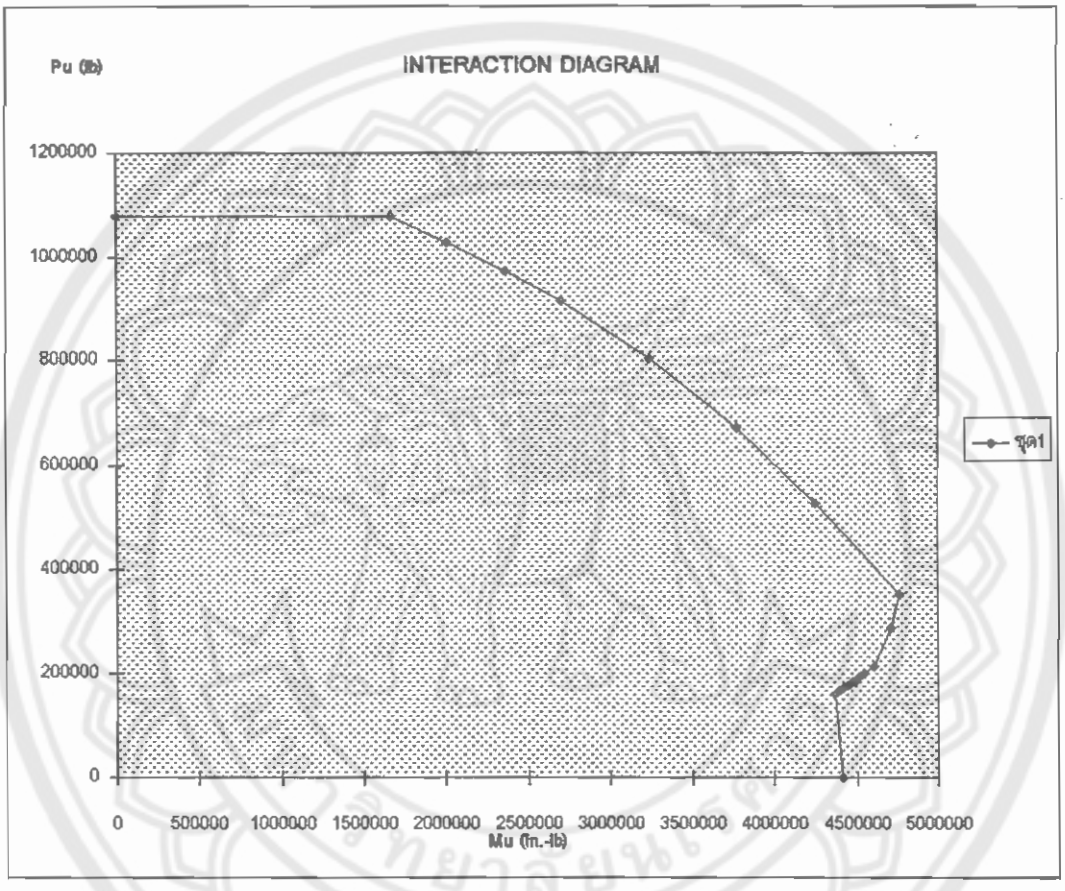
* fc' =	4000.00	psi
* fy =	60000.00	psi
* b =	20.00	in.
* h =	20.00	in.
* B1=	0.850	
* Ast =	10.00	in.^2
* As1=	4.00	in.^2
* As2 =	4.00	in.^2
* As3 =	1.00	in.^2
* As4 =	1.00	in.^2
* d1=	3.00	in.
* d2=	17.00	in.
* di =	13.50	in.
* I =	4.00	faces
***Puc =	1078560.00	lb.

TRUE	com	tension	Pu (lb),com	Pu (lb),ten	
control	23.5294	7.9898	1078560.00	213880.48	
***c1=	20.9030	7.7000	1078556.93	198712.91	
***c2=	20.0000	7.6000	1029525.00	193418.11	
***c3=	19.0000	7.5000	973840.00	188090.00	
***c4=	18.0000	7.4000	916463.33	182727.24	
***c5=	16.0000	7.3000	804886.25	177328.41	
***c6=	14.0000	7.2000	672310.00	171892.00	
***c7=	12.0000	7.1000	527275.00	166416.42	
***c8=	10.0000	7.0000	352450.00	160900.00	
***c9=	9.0000	6.9837	288120.00	159996.83	160000.00
***c10=	8.0000	4.4772	214672.50	0.64	
control	7.9898		213880.48	0.00	

OUTPUT 0F INTERACTION DIAGRAM

		Mu (in.-lb)	Pu (lb)	e
c0=	23.529412	0	1078560	0.0000
c1=	20.9030	1667318	1078557	1.5459
c2=	20.0000	2012133	1029525	1.9544
c3=	19.0000	2369587	973840	2.4332
c4=	18.0000	2702810	916463	2.9492
c5=	16.0000	3237538	804886	4.0224
c6=	14.0000	3770277	672310	5.6079
c7=	12.0000	4252196	527275	8.0645
c8=	10.0000	4761015	352450	13.5083
c9=	9.0000	4707875	288120	16.3400
c10=	8.0000	4604479	214673	21.4489
Cbal=	7.9898	4603258	213880	21.5226
c11=	7.7000	4540095	198713	22.8475
c12=	7.6000	4517203	193418	23.3546
c13=	7.5000	4493733	188090	23.8914
c14=	7.4000	4469677	182727	24.4609
c15=	7.3000	4445025	177328	25.0666
c16=	7.2000	4419765	171892	25.7125
c17=	7.1000	4393888	166416	26.4030
c18=	7.0000	4367381	160900	27.1434
c19=	6.9837	4362999	159997	27.2693
c20=	4.4772	4413544	1	6933259.0247

INTERACTION



ตัวอย่างที่7 Construction of a load-Moment Design Strength Interaction Diagram for a Rectangular Column

Construct a load-moment design strength interaction diagram for a rectangular column having the following properties(Four faces)

Given:

fc' = 6,000 psi

fy = 60,000 psi

b = 20 in.

h = 20 in.

d1 = 3 in.

d2 = 17 in.

di = 11.75 in.

As1 = As2 = 4 $in.^2$

As3 = As4 = 3 $in.^2$

Solution

Trial 1: (In compression zone)

c = 20.6625 in. , Pu =1,572,816 lb

c = 20 ,19 ,18 , 16 ,14 , 12 , 10 , 9 , 8 in.

(In tension zone)

c = 6.9541 , 5.3801 in.

Output: c_{bal} = 6.9541 in.

P_{bal} = 126,274 lb

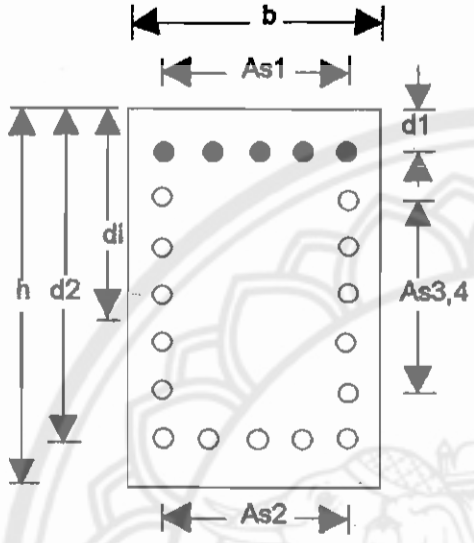
M_{bal} =5,459,704 in.-lb

e_{bal} = 43.2370

Puo =1,572,816 lb

INPUT

INTERACTION OF TIED COLUMN



Input Data

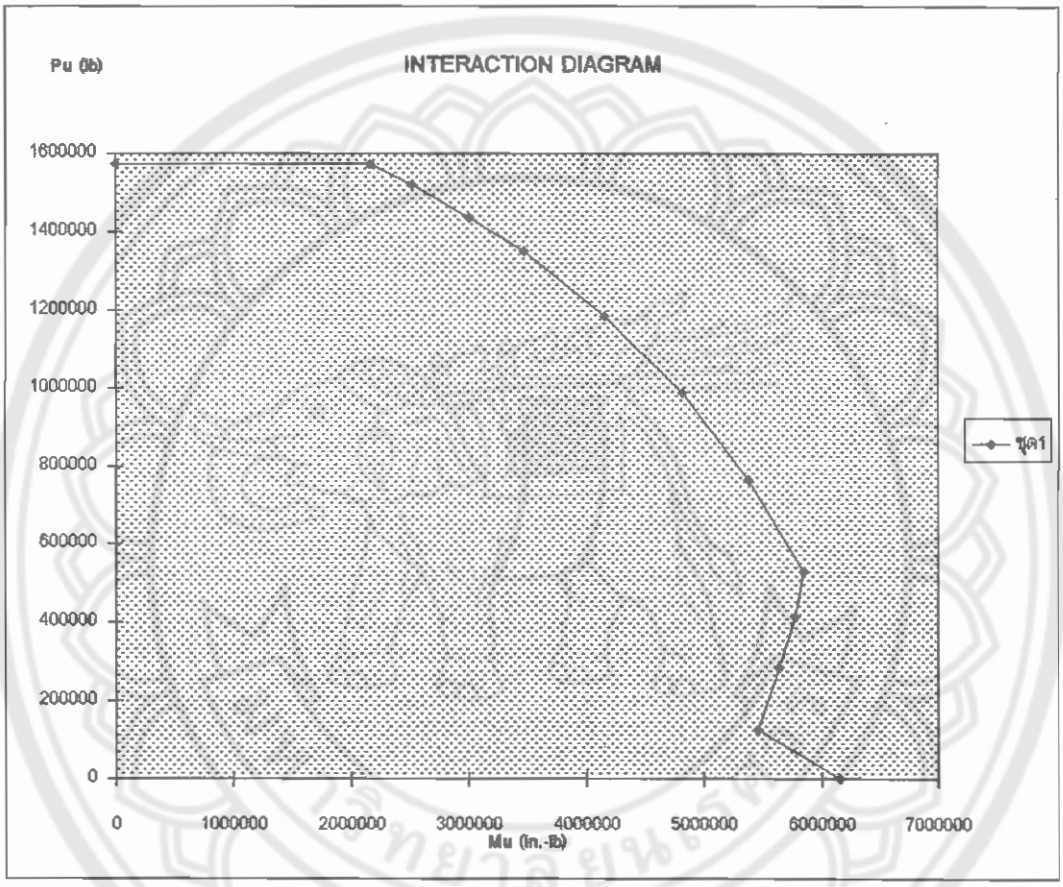
* fc' =	6000.00	psi
* fy =	60000.00	psi
* b =	20.00	in.
* h =	20.00	in.
* B1=	0.850	
* Ast =	14.00	in.^2
* As1=	4.00	in.^2
* As2 =	4.00	in.^2
* As3 =	3.00	in.^2
* As4 =	3.00	in.^2
* d1=	3.00	in.
* d2=	17.00	in.
* di =	11.75	in.
* l =	4.00	faces
***Puc =	1572816.00	lb.

FALSE	com	tension	Pu (lb),com	Pu (lb),ten	
control	23.5294	6.9541	1572816.00	126273.85	
***c1=	20.6625	6.9541	1572816.60	126276.88	
***c2=	20.0000	6.9541	1519087.50	126276.88	
***c3=	19.0000	6.9541	1436201.05	126276.88	
***c4=	18.0000	6.9541	1350848.33	126276.88	
***c5=	16.0000	6.9541	1185174.38	126276.88	
***c6=	14.0000	6.9541	988485.00	126276.88	
***c7=	12.0000	6.9541	766692.50	126276.88	
***c8=	10.0000	6.9541	528675.00	126276.88	
***c9=	9.0000	6.9540	414680.00	126267.66	**126273.85**
***c10=	8.0000	5.3801	284208.75	5.61	
control	6.9541		126273.85	0.00	

OUTPUT 0F INTERACTION DIAGRAM

		Mu (in.-lb)	Pu (lb)	e
c0=	23.529412	0	1572816	0.0000
c1=	20.6625	2163343	1572817	1.3755
c2=	20.0000	2514632	1519088	1.6554
c3=	19.0000	3009726	1436201	2.0956
c4=	18.0000	3463907	1350848	2.5642
c5=	16.0000	4157574	1185174	3.5080
c6=	14.0000	4817279	988485	4.8734
c7=	12.0000	5379275	766693	7.0162
c8=	10.0000	5853619	528675	11.0722
c9=	9.0000	5781074	414680	13.9410
c10=	8.0000	5645964	284209	19.8656
Cbal=	6.9541	5459704	126274	43.2370
c11=	6.9541	5459708	126277	43.2360
c12=	6.9541	5459708	126277	43.2360
c13=	6.9541	5459708	126277	43.2360
c14=	6.9541	5459708	126277	43.2360
c15=	6.9541	5459708	126277	43.2360
c16=	6.9541	5459708	126277	43.2360
c17=	6.9541	5459708	126277	43.2360
c18=	6.9541	5459708	126277	43.2360
c19=	6.9540	5459675	126268	43.2389
c20=	5.3801	6158555	6	1097974.5202

INTERACTION



ตัวอย่างที่8 Construction of a load-Moment Design Strength Interaction Diagram for a Rectangular Column

Construct a load-moment design strength interaction diagram for a rectangular column having the following properties(Four faces)

Given:

fc' = 6,000 psi

fy = 60,000 psi

b = 20 in.

h = 20 in.

d1 = 3 in.

d2 = 17 in.

di = 12.33 in.

As1 = As2 = 4 $in.^2$

As3 = As4 = 4 $in.^2$

Solution

Trial 1: (In compression zone)

c = 21.4775 in. , Pu =1,634,304 lb

c = 20 ,19 ,18 , 16 ,14 , 12 , 10 , 9 , 8 in.

(In tension zone)

c = 7.2973 , 6.5556 in.

Output: c_{bal} = 7.2973 in.

P_{bal} = 55,024 lb

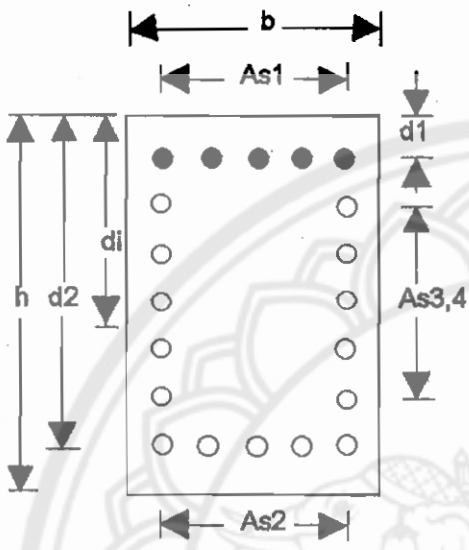
M_{bal} =5,867,684 in.-lb

e_{bal} = 106.6382

Puo =1,634,304 lb

INPUT

INTERACTION OF TIED COLUMN



Input Data

* fc' =	6000.00	psi
* fy =	60000.00	psi
* b =	20.00	in.
* h =	20.00	in.
* B1=	0.825	
* Ast =	16.00	in.^2
* As1=	4.00	in.^2
* As2 =	4.00	in.^2
* As3 =	4.00	in.^2
* As4 =	4.00	in.^2
* d1=	3.00	in.
* d2=	17.00	in.
* di =	12.33	in.
* l =	4.00	faces
***Puc =	1634304.00	lb.

FALSE	com	tension	Pu (lb),com	Pu (lb),ten	
control	24.2424	7.2973	1634304.00	55024.24	
***c1=	21.4775	7.2973	1634300.16	55024.24	
***c2=	20.0000	7.2973	1512361.20	55024.24	
***c3=	19.0000	7.2973	1426749.95	55024.24	
***c4=	18.0000	7.2973	1338171.33	55024.24	
***c5=	16.0000	7.2973	1164166.50	55024.24	
***c6=	14.0000	7.2973	955746.00	55024.24	
***c7=	12.0000	7.2973	745682.00	55024.24	
***c8=	10.0000	7.2973	461252.40	55024.24	
***c9=	9.0000	7.2973	330001.00	55024.24	**55024.24**
***c10=	8.0000	6.5556	177513.00	0.52	
control	7.2973		55024.24	0.00	

OUTPUT 0F INTERACTION DIAGRAM

		Mu (In.-lb)	Pu (lb)	e
c0=	24.242424	0	1634304	0.0000
c1=	21.4775	1846494	1634300	1.1298
c2=	20.0000	2613100	1512361	1.7278
c3=	19.0000	3084803	1426750	2.1621
c4=	18.0000	3520478	1338171	2.6308
c5=	16.0000	4193211	1164167	3.6019
c6=	14.0000	4856805	955746	5.0817
c7=	12.0000	5387400	745682	7.2248
c8=	10.0000	5977205	461252	12.9586
c9=	9.0000	5966142	330001	18.0792
c10=	8.0000	5913512	177513	33.3131
Cbal=	7.2973	5867684	55024	106.6382
c11=	7.2973	5867684	55024	106.6382
c12=	7.2973	5867684	55024	106.6382
c13=	7.2973	5867684	55024	106.6382
c14=	7.2973	5867684	55024	106.6382
c15=	7.2973	5867684	55024	106.6382
c16=	7.2973	5867684	55024	106.6382
c17=	7.2973	5867684	55024	106.6382
c18=	7.2973	5867684	55024	106.6382
c19=	7.2973	5867684	55024	106.6382
c20=	6.5556	7201432	1	13739131.1711

INTERACTION