DESIGN CRITERIA

คอนกรีตเสริมเหล็ก $f_c' = 210$ ksc $\qquad f_c = 0.375 \times 210 = 78.75$ ksc

SR24

$f_y = 2400$ ksc

$f_s = 0.5 \times 2400 = 1200$ ksc

$E_s = 2.04 \times 10^6$ ksc

$E_c = 15210\sqrt{210}$ ksc

$n = 9.25$

$$k = \frac{1}{1 + \frac{1200}{9.25 \times 78.75}} = 0.377$$

$$j = 1 - \frac{0.377}{3} = 0.874$$

$$R = \frac{1}{2} \times 78.75 \times 0.377 \times 0.874$$

$= 12.98$ ksc

$f_{sj} = 1048$ ksc

$v_c = 0.292\sqrt{210} = 4.23$ ksc

SD30

$f_y = 3000$ ksc

$f_s = 0.5 \times 3000 = 1500$ ksc

$E_s = 2.04 \times 10^6$ ksc

$E_c = 15210\sqrt{210}$ ksc

$n = 9.25$

$$k = \frac{1}{1 + \frac{1500}{9.25 \times 78.75}} = 0.327$$

$$j = 1 - \frac{0.327}{3} = 0.891$$

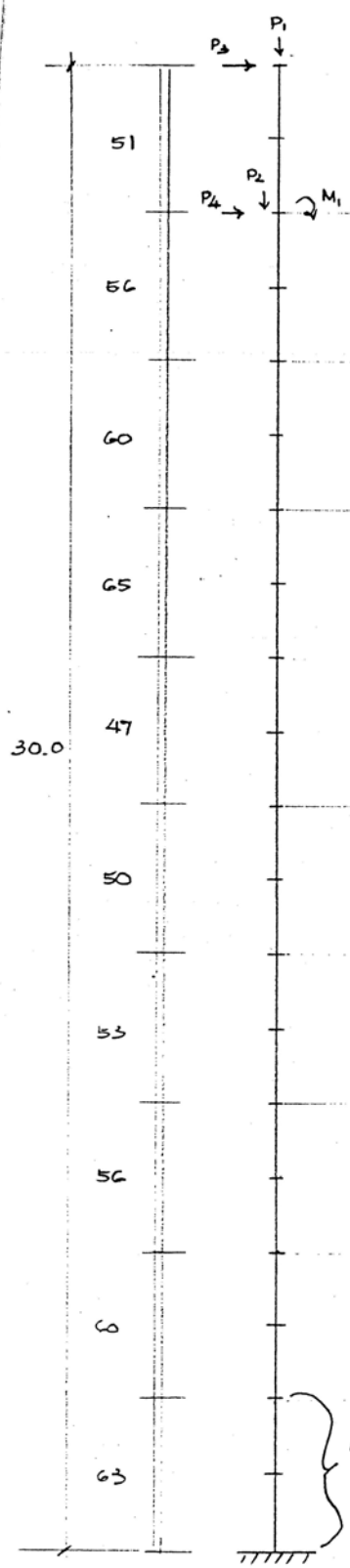
$$R = \frac{1}{2} \times 78.75 \times 0.327 \times 0.891$$

$= 11.47$ ksc

$f_{sj} = 1337$ ksc

$v_c = 0.292\sqrt{210} = 4.23$ ksc

เหล็กรูปพรรณ $\qquad f_y = 2520$ ksc



D (m)	A (m^2)	I (m^4)	↓
0.42	0.01538	3.203×10^{-4}	365+600
0.46	0.01689	4.240×10^{-4}	400+600
0.50	0.01840	5.479×10^{-4}	435+600
0.54	0.01991	6.940×10^{-4}	470+600
0.58	0.02141	8.639×10^{-4}	505+600
0.62	0.02292	1.059×10^{-3}	540+600
0.66	0.02443	1.283×10^{-3}	580+600
0.70	0.02594	1.535×10^{-3}	615+600
0.74	0.02744	1.819×10^{-3}	650+600
0.78	0.02895	2.135×10^{-3}	685+600
0.80	0.03930	3.961×10^{-3}	

$KL/r > 200$

$P_1 = (25 \times 3 \times 2 \times 3) + 300 + 250 = 1000$ kg

$P_2 = 600$ kg

$P_3 = 120 \times \frac{3 \times 2}{2} = 360$ kg

$P_4 = 850$ kg

$M_1 = 250$ kg.m

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==============================================================================
    MICROFEAP-P1
PROJECT  : ANTENNA POLE
AUTHORITY:
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     ****************************
     *                          *
     *  COMBINATION             *
     *                          *
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STRESS COMBINATION (2D-FRAME SYSTEM)
LOAD FACTOR : 1/1

ELEM	MA HINGE	SECTION (M)	AXIAL F. (KG)	SHEAR (KG)	MOMENT (KG-M)
1	1	0.00	-1.2845D+04	2.8930D+03	-5.8370D+04
		1.50	-1.2845D+04	2.7985D+03	-5.4101D+04
2	1	0.00	-1.1560D+04	2.7985D+03	-5.4101D+04
		1.50	-1.1560D+04	2.7040D+03	-4.9975D+04
3	2	0.00	-1.1560D+04	2.7040D+03	-4.9975D+04
		1.50	-1.1560D+04	2.6140D+03	-4.5986D+04
4	2	0.00	-1.0310D+04	2.6142D+03	-4.5986D+04
		1.50	-1.0310D+04	2.5242D+03	-4.2133D+04
5	3	0.00	-1.0310D+04	2.5243D+03	-4.2133D+04
		1.50	-1.0310D+04	2.4403D+03	-3.8410D+04
6	3	0.00	-9.0950D+03	2.4399D+03	-3.8410D+04
		1.50	-9.0950D+03	2.3559D+03	-3.4813D+04
7	4	0.00	-9.0950D+03	2.3557D+03	-3.4813D+04
		1.50	-9.0950D+03	2.2762D+03	-3.1339D+04
8	4	0.00	-7.9150D+03	2.2766D+03	-3.1339D+04
		1.50	-7.9150D+03	2.1971D+03	-2.7983D+04
9	5	0.00	-7.9150D+03	2.1966D+03	-2.7984D+04
		1.50	-7.9150D+03	2.1216D+03	-2.4744D+04
10	5	0.00	-6.7750D+03	2.1218D+03	-2.4744D+04
		1.50	-6.7750D+03	2.0468D+03	-2.1618D+04
11	6	0.00	-6.7750D+03	2.0483D+03	-2.1618D+04
		1.50	-6.7750D+03	1.9778D+03	-1.8599D+04
12	6	0.00	-5.6700D+03	1.9766D+03	-1.8600D+04
		1.50	-5.6700D+03	1.9061D+03	-1.5687D+04

STRESS COMBINATION (2D-FRAME SYSTEM)
LOAD FACTOR : 1/1

ELEM	MA HINGE	SECTION (M)	AXIAL F. (KG)	SHEAR (KG)	MOMENT (KG-M)

STRESS COMBINATION (2D-FRAME SYSTEM)
LOAD FACTOR : 1/1

ELEM	MA HINGE	SECTION (M)	AXIAL F. (KG)	SHEAR (KG)	MOMENT (KG-M)
13	7	0.00	-5.6700D+03	1.9061D+03	-1.5688D+04
		1.50	-5.6700D+03	1.8086D+03	-1.2902D+04
14	7	0.00	-4.6000D+03	1.8086D+03	-1.2901D+04
		1.50	-4.6000D+03	1.7111D+03	-1.0264D+04
15	8	0.00	-4.6000D+03	1.7112D+03	-1.0263D+04
		1.50	-4.6000D+03	1.6212D+03	-7.7638D+03
16	8	0.00	-3.5650D+03	1.6208D+03	-7.7635D+03
		1.50	-3.5650D+03	1.5308D+03	-5.4010D+03
17	9	0.00	-3.5650D+03	1.5321D+03	-5.4013D+03
		1.50	-3.5650D+03	1.4481D+03	-3.1661D+03
18	9	0.00	-2.5650D+03	1.4461D+03	-3.1664D+03
		1.50	-2.5650D+03	1.3621D+03	-1.0598D+03
19	10	0.00	-1.9650D+03	5.1281D+02	-1.3092D+03
		1.50	-1.9650D+03	4.3631D+02	-5.9741D+02
20	10	0.00	-1.0000D+03	4.3744D+02	-5.9755D+02
		1.50	-1.0000D+03	3.6094D+02	2.1875D-01

COMBINATION

DISPLACEMENT COMBINATION (2D-FRAME SYSTEM)
LOAD FACTOR : 1/1

NODE	1-DISP (M)	2-DISP (M)	3-DISP (Rad)
1	0.0000D+00	0.0000D+00	0.0000D+00
2	1.4286D-03	-3.1693D-05	-1.8810D-03
3	5.5729D-03	-6.0215D-05	-3.6216D-03
4	1.2438D-02	-9.0306D-05	-5.5053D-03
5	2.2012D-02	-1.1714D-04	-7.2350D-03
6	3.4291D-02	-1.4553D-04	-9.1084D-03
7	4.9252D-02	-1.7058D-04	-1.0812D-02
8	6.6874D-02	-1.9717D-04	-1.2652D-02
9	8.7114D-02	-2.2031D-04	-1.4303D-02
10	1.0993D-01	-2.4498D-04	-1.6081D-02
11	1.3525D-01	-2.6609D-04	-1.7644D-02
12	1.6299D-01	-2.8870D-04	-1.9306D-02
13	1.9304D-01	-3.0761D-04	-2.0722D-02
14	2.2527D-01	-3.2795D-04	-2.2192D-02
15	2.5948D-01	-3.4446D-04	-2.3383D-02
16	2.9548D-01	-3.6231D-04	-2.4557D-02
17	3.3299D-01	-3.7615D-04	-2.5413D-02
18	3.7170D-01	-3.9123D-04	-2.6133D-02
19	4.1121D-01	-4.0208D-04	-2.6487D-02
20	4.5112D-01	-4.1120D-04	-2.6698D-02
21	4.9123D-01	-4.1585D-04	-2.6762D-02

COMBINATION

STRESS COMBINATION <2D-FRAME SYSTEM>
LOAD FACTOR : 1/0

ELEM	MA HINGE	SECTION (M)	AXIAL F. (KG)	SHEAR (KG)	MOMENT (KG-M)
1	1	0.00	-1.2845D+04	6.1035D-05	2.4999D+02
		1.50	-1.2845D+04	6.1035D-05	2.4999D+02
2	1	0.00	-1.1560D+04	2.4414D-04	2.4999D+02
		1.50	-1.1560D+04	2.4414D-04	2.4999D+02
3	2	0.00	-1.1560D+04	0.0000D+00	2.4999D+02
		1.50	-1.1560D+04	0.0000D+00	2.4999D+02
4	2	0.00	-1.0310D+04	-2.4414D-04	2.4999D+02
		1.50	-1.0310D+04	-2.4414D-04	2.4999D+02
5	3	0.00	-1.0310D+04	-4.8828D-04	2.4999D+02
		1.50	-1.0310D+04	-4.8828D-04	2.4999D+02
6	3	0.00	-9.0950D+03	4.8828D-04	2.4999D+02
		1.50	-9.0950D+03	4.8828D-04	2.4999D+02
7	4	0.00	-9.0950D+03	-3.4180D-03	2.4999D+02
		1.50	-9.0950D+03	-3.4180D-03	2.4999D+02
8	4	0.00	-7.9150D+03	2.9297D-03	2.4999D+02
		1.50	-7.9150D+03	2.9297D-03	2.4999D+02
9	5	0.00	-7.9150D+03	2.4414D-03	2.4999D+02
		1.50	-7.9150D+03	2.4414D-03	2.4999D+02
10	5	0.00	-6.7750D+03	4.8828D-04	2.4999D+02
		1.50	-6.7750D+03	4.8828D-04	2.4999D+02
11	6	0.00	-6.7750D+03	3.9063D-03	2.4999D+02
		1.50	-6.7750D+03	3.9063D-03	2.4999D+02
12	6	0.00	-5.6700D+03	-4.8828D-03	2.4999D+02
		1.50	-5.6700D+03	-4.8828D-03	2.4999D+02

STRESS COMBINATION (2D-FRAME SYSTEM)
LOAD FACTOR : 1/0

ELEM	HA HINGE	SECTION (M)	AXIAL F. (KG)	SHEAR (KG)	MOMENT (KG-M)

STRESS COMBINATION (2D-FRAME SYSTEM)
LOAD FACTOR : 1/0

ELEM	HA HINGE	SECTION (M)	AXIAL F. (KG)	SHEAR (KG)	MOMENT (KG-M)
13	7	0.00	-5.6700D+03	-1.4648D-03	2.4999D+02
		1.50	-5.6700D+03	-1.4648D-03	2.4999D+02
14	7	0.00	-4.6000D+03	1.9531D-03	2.4999D+02
		1.50	-4.6000D+03	1.9531D-03	2.5000D+02
15	8	0.00	-4.6000D+03	-2.4414D-03	2.4999D+02
		1.50	-4.6000D+03	-2.4414D-03	2.4999D+02
16	8	0.00	-3.5650D+03	-2.9297D-03	2.4999D+02
		1.50	-3.5650D+03	-2.9297D-03	2.5000D+02
17	9	0.00	-3.5650D+03	0.0000D+00	2.5000D+02
		1.50	-3.5650D+03	0.0000D+00	2.5000D+02
18	9	0.00	-2.5650D+03	1.9531D-03	2.5000D+02
		1.50	-2.5650D+03	1.9531D-03	2.4999D+02
19	10	0.00	-1.9650D+03	3.4180D-03	-6.1035D-03
		1.50	-1.9650D+03	3.4180D-03	2.9297D-03
20	10	0.00	-1.0000D+03	2.9297D-03	-2.6855D-03
		1.50	-1.0000D+03	2.9297D-03	1.4648D-03

COMBINATION

DISPLACEMENT COMBINATION (2D-FRAME SYSTEM)
LOAD FACTOR : 1/0

NODE	1-DISP (M)	2-DISP (M)	3-DISP (Rad)
1	0.0000D+00	0.0000D+00	0.0000D+00
2	-6.2727D-06	-3.1693D-05	8.3636D-06
3	-2.5091D-05	-6.0215D-05	1.6727D-05
4	-5.7544D-05	-9.0306D-05	2.6544D-05
5	-1.0472D-04	-1.1714D-04	3.6360D-05
6	-1.6799D-04	-1.4553D-04	4.7993D-05
7	-2.4870D-04	-1.7058D-04	5.9626D-05
8	-3.4858D-04	-1.9717D-04	7.3544D-05
9	-4.6933D-04	-2.2031D-04	8.7461D-05
10	-6.1317D-04	-2.4498D-04	1.0432D-04
11	-7.8230D-04	-2.6609D-04	1.2118D-04
12	-9.7958D-04	-2.8870D-04	1.4185D-04
13	-1.2079D-03	-3.0761D-04	1.6252D-04
14	-1.4709D-03	-3.2795D-04	1.8825D-04
15	-1.7726D-03	-3.4446D-04	2.1398D-04
16	-2.1180D-03	-3.6231D-04	2.4657D-04
17	-2.5123D-03	-3.7615D-04	2.7915D-04
18	-2.9626D-03	-3.9123D-04	3.2127D-04
19	-3.4761D-03	-4.0208D-04	3.6338D-04
20	-4.0212D-03	-4.1120D-04	3.6338D-04
21	-4.5663D-03	-4.1585D-04	3.6338D-04

TENNA POLE

$P = 12845$ kg

$M = 58370$ kg.m

try 12 mm thk

$$KL/r = \frac{2 \times 30}{\sqrt{3.961 \times 10^{-3} / 0.03930}} = 189$$

$$C_c = \sqrt{\frac{2\pi^2 \times 2.1 \times 10^6}{2520}} = 128.2$$

$$f_a = \frac{12845}{289.5} = 44.4 \text{ ksc}$$

$$F_a = \frac{12\pi^2\, 2.1 \times 10^6}{23\,(189)^2} = 302.7 \text{ ksc}$$

$$\frac{f_a}{F_a} = \frac{44.4}{302.7} = 0.147$$

< 0.15

$$f_b = \frac{58370 \times 100 \times 40}{396100} = 589.4 \text{ ksc}$$

$$F_b = 0.6 \times 2520 = 1512 \text{ ksc}$$

$$\frac{44.4}{302.7 \times 1.33} + \frac{589.4}{1512 \times 1.33} = 0.4$$

< 1

Ok 12 mm thk HOT DIP GALVANIZED

$P = 6775$ kg

$M = 24744$ kg.m

try 12 mm thk

$$KL/r = \frac{2 \times 15}{\sqrt{8.639 \times 10^{-4} / 0.02141}} = 149.3$$

$C_c = 128.2$

$$f_a = \frac{6775}{214.1} = 31.6 \text{ ksc}$$

$$F_a = \frac{12\pi^2\, 2.1 \times 10^6}{23\,(149.3)^2} = 485.1 \text{ ksc}$$

$$\frac{f_a}{F_a} = \frac{31.6}{485.1} = 0.07$$

< 0.15

$$f_b = \frac{24744 \times 100 \times 29}{86590} = 830.6 \text{ ksc}$$

$F_b = 1512$ ksc

$$\frac{31.6}{485.1 \times 1.33} + \frac{830.6}{1512 \times 1.33} = 0.46$$

< 1

Ok 12 mm thk HOT DIP GALVANIZED

T 1

$P = 9095$ kg

$M = 34813$ kg.m

$$T, C = \frac{9095}{1.33 \times 8} \pm \frac{34813}{1.33(0.65 + 2 \times 0.31)}$$

$$= 21465, -19756 \text{ kg}$$

Ø 22 mm thk ℞

$$f_s = \frac{21465}{2.2 \times 12.2} = 800 \text{ ksc}$$

Ø ¢ 25 mm BOLT

$$f_s = \frac{21465}{3 \times 2 \times 4.91} = 729 \text{ ksc}$$

JOINT 2

$P = 4600$ kg.

$M = 12901$ kg.m

$$T, C = \frac{4600}{1.33 \times 6} \pm \frac{12901}{1.33 \times 0.5}$$

$$= 19976, -18824 \text{ kg}$$

Ø 22 mm thk ℞

$$f_s = \frac{19976}{2.2 \times 9.7} = 936 \text{ ksc}$$

Ø ¢ 25 mm BOLT

$$f_s = \frac{19976}{3 \times 2 \times 4.91} = 678 \text{ ksc}$$

NCHOR BOLT

USE ¢38mm ANCHOR BOLT

$M = 58370$ b.m

$$f_1 = \frac{58370 \times 100 \times 52.5}{3955983} = 77.5 \text{ ksc}$$

$$f_2 = \frac{58370 \times 100 \times 40}{3955983} = 59.0 \text{ ksc}$$

$$P = \frac{77.5 + 59.0}{2} \times 12.5 \times 18.16 = 15493 \text{ b}$$

$$f_b = \frac{15493}{1.33 \times 11.34} = 1027 \text{ ksc}$$

ใช้ 16-¢38mm ANCHOR BOLTS

NTING

$P = 50$ lb

$w = 20$ lb/m

$M = 20 \times \frac{1.8^2}{2} + 50 \times 1.5 = 107$ lb.m

$T = C = \frac{107}{1.25} = 86$ lb.

Use L 50×50×4 mm (3.06 kg/m)

$A_T = \frac{86}{1500} = 0.06$ cm²

$f_{s_c} = 1200 - 0.0341 \left(\frac{180}{1.53}\right)^2 = 728$ ksc

$A_{sc} = \frac{86}{728} = 0.12$ cm²

$V = (20 \times 1.8 + 50)\,2 + 50 = 222$ lb.

$f_s = 1200 - 0.0341 \left(\frac{150}{1.53}\right)^2 = 872$ ksc

$A_s = \frac{222}{872} = 0.25$ cm²

$V_T = 222 \times \frac{2.34}{1.5} = 346$ lb

$A = \frac{346}{1500} = 0.23$ cm²

∴ Use L 50×50×4 mm (3.06 kg/m)

$P = 222$ lb

$w = 50$ lb/m

$M = 50 \times \frac{0.85^2}{2} + 222 \times 0.85 = 207$ lb.m

$T = C = \frac{207}{1.25} = 166$ lb

Use [50×25×5 mm (3.86 kg/m)

$A_T = \frac{166}{1500} = 0.11$ cm²

$f_{sc} = 1200 - 0.0341 \left(\frac{85}{0.71}\right)^2 = 711$ ksc

$A_{sc} = \frac{166}{711} = 0.23$ cm²

$V = 50 \times 0.85 + 222 = 265$ lb

$V_T = 265 \times \frac{1.75}{1.5} = 309$ lb

$A = \frac{309}{1500} = 0.21$ cm²

∴ Use [50×25×5 mm (3.86 kg/m)

RKING PLATFORM

$$\omega = 100 \times 0.6 = 60 \text{ kg/m}$$

$$P = 100 \text{ kg}$$

$$M^{+} = 60 \times \frac{1^2}{8} + 100 \times \frac{1}{4} = 32.5 \text{ kg.m}$$

$$S = \frac{32.5}{15} = 2.17 \text{ cm}^3$$

$$S_{9mm} = \frac{30 \times 0.9^3}{12 \times 0.45} = 4.05 \text{ cm}^3$$

$$\omega = 20 + 60 \times 0.4 = 44 \text{ kg/m}$$

$$P = 50 \text{ kg}$$

$$M^{-} = 44 \times \frac{0.6^2}{2} + 100 \times 0.6 = 68 \text{ kg.m}$$

$$S = \frac{68}{15} = 4.5 \text{ cm}^3$$

Ng L 60×60×5 mm

$$\Delta = \frac{44 \times 0.6^4}{8 \times 2.01 \times 19.6} + \frac{100 \times 0.6^3}{3 \times 2.01 \times 19.6} = 0.2 \text{ cm}$$

TING

P = 12845 kg.

M = 58370 kg.m

$$P = \frac{12845 + 14000}{4} \pm \frac{58370 \times 1}{4 \times 1}$$

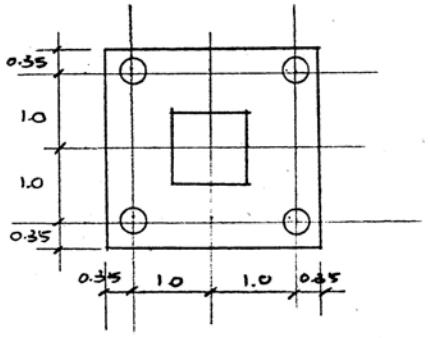
$= 6711 \pm 14593$ kg

$= 21304 , -7882$ kg.

ใช้เสาเข็ม ¢ 0.35 m รับน้ำหนักปลอดภัยได้

ไม่น้อยกว่า 30 ตัน/ต้น

เลือกฐานรากขนาด 2.7 × 2.7 × 0.8 m



$M_1 = 2 \times 21304 (1.0 - 0.6) = 17043$ kg.m

$M_2 = 2 \times 7882 (1.0 - 0.6) = 6306$,

$A_{s_1} = \frac{17043}{1337 \times 0.7} = 18.2$ cm²

$A_{s_2} = 6.7$ cm² 15 # 16 mm

ที่ระดับฐาน

$$A = \frac{\pi}{4}(0.8^2 - 0.776^2) + 8(0.012 \times 0.1)$$

$$= 0.03930 \quad m^2$$

$$I = \frac{\pi}{64}(0.8^4 - 0.776^4) +$$

$$4(1 \times 10^{-6} + 1.2 \times 10^{-3} \times 0.45^2) +$$

$$4(1 \times 10^{-6} + 1.2 \times 10^{-3} \times 0.375^2)$$

$$= 3.9613 \times 10^{-3} \quad m^4$$