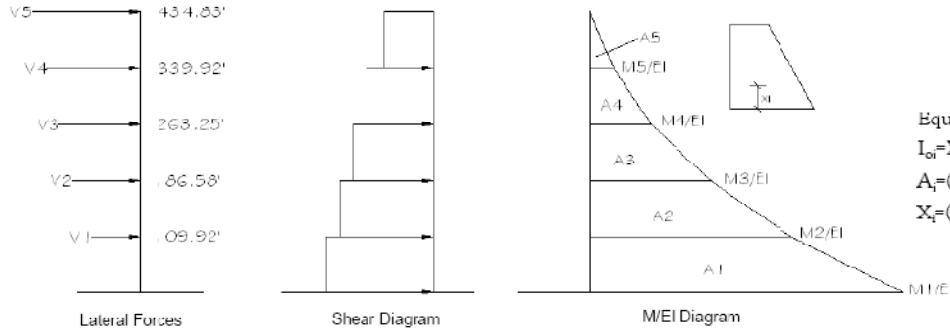


Appendix C

Classical Methods – Initial Braced Frame Member Sizes

Project AE 482
 Date 4/8/2008
 Engineer Steve Reichwein

Moment Area Method - Braced Frame Column Areas



Equations:
 $I_0 = \sum(A_c d_c^3)$
 $A_i = ((M_i + M_{i+1}) * h_i) / (2EI_0)$
 $X_i = (h_i / 3) * (M_i + 2M_{i+1}) / (M_i + M_{i+1})$

E	29000	ksi
---	-------	-----

h1	94.910	ft
h2	171.580	ft
h3	218.250	ft
h4	324.910	ft
h5	434.830	ft

V5	1354.500	kips
V4	856.200	kips
V3	388.000	kips
V2	409.900	kips
V1	150.000	kips

M5	1.543E+06	in-kips
M4	3.586E+06	in-kips
M3	5.986E+06	in-kips
M2	8.763E+06	in-kips
M1	1.296E+07	in-kips

M5/EI	53.195	in^3/I
M4/EI	123.648	in^3/I
M3/EI	206.411	in^3/I
M2/EI	302.165	in^3/I
M1/EI	446.741	in^3/I

x1	379.640	in
x2	398.931	in
x3	421.570	in
x4	431.093	in
x5	617.080	in

Target	H/400	
Δ1	2.847	in
Δ2	5.147	in
Δ3	7.448	in
Δ4	9.747	in
Δ5	13.045	in

y1	759.280	in
y2	1660.029	in
y3	2557.430	in
y4	3467.827	in
y5	4600.880	in

A5	30292.663	in^4/I
A4	62702.385	in^4/I
A3	100774.725	in^4/I
A2	144817.807	in^4/I
A1	240168.492	in^4/I

A5 x y1	2.300E+07	in^5/I
A4 x y2	1.041E+08	in^5/I
A3 x y3	2.577E+08	in^5/I
A2 x y4	5.022E+08	in^5/I
A1 x y5	1.105E+09	in^5/I

Number of Columns	4	Restisting Lateral Force Per Direction ft in^2 * Acol
d	25	
I	360000	

Acol5	22.44	in^2
Acol4	68.58	in^2
Acol3	143.53	in^2
Acol2	252.78	in^2
Acol1	424.18	in^2

Assumptions
 Torsional effects are neglected
 Gravity is neglected

Project AE 482
 Date 4/8/2008
 Engineer Steve Reichwein

Classical Work Energy Method - Concentric Braced Frame Optimization

Options: All frames consist of concentric inverted V configurations
 Bay Size = 25 feet
 Frame Force = Story Wind Load / 4
 Effects of torsion are neglected
 Braces A 36 Steel ; Columns and Girders A992

Level	Story Wind Load (Kips)	Elevation (Feet)	Floor Height	1	2	3	4	5	6	7	8	9
41.00	143.55	434.83	27.83	35.89	35.89	998.87	0.00	17.94	43.80	0.00	0.00	1.22
40.00	174.98	407.00	9.58	43.74	79.63	763.13	39.95	39.82	50.17	1.44	0.50	0.63
39.00	106.58	397.42	9.58	26.64	106.28	1018.47	70.48	53.14	66.96	3.19	0.50	0.63
38.00	99.53	387.83	9.58	24.88	131.16	1256.91	111.22	65.58	82.63	4.25	0.50	0.63
37.00	103.50	378.25	9.58	25.88	157.03	1504.88	161.50	78.52	98.94	5.25	0.50	0.63
36.00	100.88	368.67	9.58	25.22	182.25	1746.56	221.69	91.13	114.82	6.28	0.50	0.63
35.00	98.25	359.08	9.58	24.56	206.81	1981.95	291.55	103.41	130.30	7.29	0.50	0.63
34.00	95.63	349.50	9.58	23.91	230.72	2211.05	370.83	115.36	145.36	8.27	0.50	0.63
33.00	93.00	339.92	9.58	23.25	253.97	2433.87	459.27	126.98	160.01	9.23	0.50	0.63
32.00	90.38	330.33	9.58	22.59	276.56	2650.39	556.63	138.28	174.24	10.16	0.50	0.63
31.00	87.68	320.75	9.58	21.92	298.48	2860.45	662.64	149.24	188.05	11.06	0.50	0.63
30.00	85.05	311.17	9.58	21.26	319.74	3064.21	777.06	159.87	201.45	11.94	0.50	0.63
29.00	82.58	301.58	9.58	20.64	340.39	3262.05	899.63	170.19	214.46	12.79	0.50	0.63
28.00	79.95	292.00	9.58	19.99	360.38	3453.59	1030.11	180.19	227.05	13.62	0.50	0.63
27.00	77.33	282.42	9.58	19.33	379.71	3638.85	1168.26	189.85	239.23	14.42	0.50	0.63
26.00	74.70	272.83	9.58	18.68	398.38	3817.82	1313.81	199.19	250.99	15.19	0.50	0.63
25.00	72.00	263.25	9.58	18.00	416.38	3990.32	1466.52	208.19	262.33	15.94	0.50	0.63
24.00	67.95	253.67	9.58	16.99	433.37	4153.12	1626.14	216.68	273.04	16.66	0.50	0.63
23.00	65.40	244.08	9.58	16.35	449.72	4309.80	1792.26	224.86	283.34	17.33	0.50	0.63
22.00	62.78	234.50	9.58	15.69	465.41	4460.20	1964.65	232.71	293.23	17.99	0.50	0.63
21.00	60.23	224.92	9.58	15.06	480.47	4604.49	2143.06	240.23	302.71	18.62	0.50	0.63
20.00	57.68	215.33	9.58	14.42	494.89	4742.67	2327.24	247.44	311.80	19.22	0.50	0.63
19.00	55.05	205.75	9.58	13.76	508.65	4874.56	2516.95	254.33	320.47	19.80	0.50	0.63
18.00	52.58	196.17	9.58	13.14	521.79	5000.52	2711.93	260.90	328.75	20.35	0.50	0.63
17.00	50.03	186.58	9.58	12.51	534.30	5120.38	2911.95	267.15	336.63	20.87	0.50	0.63
16.00	47.48	177.00	9.58	11.87	546.17	5234.12	3116.77	273.08	344.11	21.37	0.50	0.63
15.00	44.85	167.42	9.58	11.21	557.38	5341.57	3326.13	278.69	351.17	21.85	0.50	0.63
14.00	42.30	157.83	9.58	10.58	567.96	5442.91	3539.79	283.98	357.83	22.30	0.50	0.63
13.00	39.75	148.25	9.58	9.94	577.89	5538.15	3757.51	288.95	364.09	22.72	0.50	0.63
12.00	37.13	138.67	9.58	9.28	587.18	5627.09	3979.04	293.59	369.94	23.12	0.50	0.63
11.00	34.58	129.08	9.58	8.64	595.82	5709.93	4204.12	297.91	375.39	23.49	0.50	0.63
10.00	31.95	119.50	9.58	7.99	603.81	5786.48	4432.52	301.90	380.42	23.83	0.50	0.63
9.00	29.40	109.92	9.58	7.35	611.16	5856.91	4663.98	305.58	385.05	24.15	0.50	0.63
8.00	26.85	100.33	9.58	6.71	617.87	5921.24	4898.25	308.93	389.28	24.45	0.50	0.63
7.00	24.38	90.75	9.58	6.09	623.96	5979.64	5135.10	311.98	393.12	24.71	0.50	0.63
6.00	21.83	81.17	9.58	5.46	629.42	6031.93	5374.29	314.71	396.56	24.96	0.50	0.63
5.00	19.20	71.58	9.58	4.80	634.22	6077.93	5615.56	317.11	399.58	25.18	0.50	0.63
4.00	30.83	62.00	36.00	7.71	641.93	23109.30	5858.68	320.96	978.51	25.37	0.50	1.52
3.00	9.45	26.00	10.00	2.36	644.29	6442.88	6783.05	322.14	412.55	25.68	0.50	0.64
2.00	6.60	16.00	16.00	1.65	645.94	10335.00	7040.77	322.97	524.60	25.77	0.50	0.81

- 1 — WINDF: Story wind force (kip)
 - 2 — STYSHR: Story wind shear = WINDF (I) + STYSHR (I + 1)
 - 3 — STYMOM: Story moment = STYSHR (I) x HT (I)
 - 4 — COLP: Col. axial load = COLP (I + 1) + STYMOM (I + 1) / L
 - 5 — GIRDP: Girder axial load = STYSHR (I) / 2
 - 6 — BRACEP: Brace axial load = STYSHR (I) / 2 x [brace L / (L / 2)]
 - 7 — COLP1: Col. virtual load = COLP (I + 1) + (I) x HT (I + 1) / L
 - 8 — GIRDP1: Girder virtual load = 1/2 = .5
 - 9 — BRACP1: Brace virtual load = .5 x [brace L / (L / 2)] = .707
- HT (I) = Story height
 L = Bay length (c.t.c. columns)
 brace L = Brace length

10	11	12	13	14	15
COLAR	GIRDAR	BRACAR	COLD	GIRDD	BRACED
0.00	0.00	7.31	0.00	0.00	0.08
7.57	4.46	5.62	0.02	0.05	0.06
14.98	5.15	6.50	0.02	0.05	0.07
21.74	5.73	7.22	0.02	0.06	0.07
29.11	6.27	7.90	0.02	0.06	0.08
37.32	6.75	8.51	0.02	0.07	0.09
46.10	7.19	9.06	0.03	0.07	0.09
55.39	7.59	9.57	0.03	0.08	0.10
65.10	7.97	10.04	0.03	0.08	0.10
75.20	8.32	10.48	0.03	0.09	0.11
85.62	8.64	10.88	0.03	0.09	0.11
96.32	8.94	11.27	0.03	0.09	0.12
107.27	9.22	11.62	0.03	0.10	0.12
118.43	9.49	11.96	0.03	0.10	0.12
129.77	9.74	12.28	0.04	0.10	0.13
141.26	9.98	12.58	0.04	0.10	0.13
152.87	10.20	12.86	0.04	0.11	0.13
164.57	10.41	13.12	0.04	0.11	0.14
176.26	10.60	13.36	0.04	0.11	0.14
187.99	10.79	13.59	0.04	0.11	0.14
199.74	10.96	13.81	0.04	0.11	0.14
211.49	11.12	14.02	0.04	0.12	0.14
223.21	11.28	14.21	0.04	0.12	0.15
234.90	11.42	14.39	0.05	0.12	0.15
246.53	11.56	14.56	0.05	0.12	0.15
258.09	11.69	14.72	0.05	0.12	0.15
269.56	11.80	14.87	0.05	0.12	0.15
280.93	11.92	15.01	0.05	0.12	0.16
292.17	12.02	15.15	0.05	0.12	0.16
303.28	12.12	15.27	0.05	0.13	0.16
314.23	12.20	15.38	0.05	0.13	0.16
325.02	12.29	15.48	0.05	0.13	0.16
335.63	12.36	15.58	0.06	0.13	0.16
346.04	12.43	15.66	0.06	0.13	0.16
356.25	12.49	15.74	0.06	0.13	0.16
366.24	12.54	15.81	0.06	0.13	0.16
376.01	12.59	15.87	0.06	0.13	0.16
385.52	12.67	15.92	0.07	0.13	0.17
417.33	12.69	16.25	0.07	0.13	0.17
425.97	12.71	20.64	0.11	0.13	0.21

- 10 — COLAR: Col. arca = $\sqrt{(P_i n_i)/\lambda} = \sqrt{(\text{col4}) \times (\text{col7})}$
11 — GIRDAR: Girder arca = $\sqrt{(P_i n_i)/\lambda} = \sqrt{(\text{col5}) \times (\text{col8})}$
12 — BRACAR: Brace arca = $\sqrt{(P_i n_i)/\lambda} = \sqrt{(\text{col6}) \times (\text{col9})}$
13 — COLD: Column strain = $[(\text{COLP} \times \text{HT} (I))] / [(\text{COLAR} \times E)]$
= $[(\text{col4}) \times \text{HT} (I)] / [(\text{col10}) \times E]$
14 — GIRDD: Girder strain = $(\text{GIRP} \times L / 2) / (\text{GIRDAR} \times E)$
= $[(\text{col5}) \times L / 2] / [(\text{col11}) \times E]$
15 — BRACED: Brace strain = $(\text{BRACEP} \times \text{BRACEL}) / (\text{BRACAR} \times E)$
= $[(\text{col6}) \times \text{BRACEL}] / [(\text{col12}) \times E]$

E - Young's modulus - 29.0 ksi.

16	17	18	19	20	21	22
COLRHO	SUMROC	GIRRHO	BRARHO	SUMRHO	FLDEL	TOTDEL
0.00	0.01	0.00	0.01	0.02	0.53	15.22
0.00	0.01	0.00	0.01	0.02	0.24	14.69
0.00	0.01	0.01	0.01	0.03	0.25	14.46
0.00	0.01	0.01	0.01	0.03	0.27	14.20
0.00	0.01	0.01	0.01	0.03	0.28	13.94
0.00	0.01	0.01	0.01	0.03	0.29	13.66
0.00	0.01	0.01	0.01	0.03	0.30	13.36
0.00	0.01	0.01	0.01	0.03	0.31	13.06
0.00	0.01	0.01	0.01	0.03	0.32	12.75
0.00	0.01	0.01	0.01	0.03	0.33	12.43
0.00	0.01	0.01	0.01	0.03	0.33	12.11
0.00	0.01	0.01	0.02	0.04	0.34	11.77
0.00	0.01	0.01	0.02	0.04	0.35	11.43
0.00	0.01	0.01	0.02	0.04	0.35	11.09
0.00	0.01	0.01	0.02	0.04	0.35	10.74
0.00	0.01	0.01	0.02	0.04	0.36	10.38
0.00	0.01	0.01	0.02	0.04	0.36	10.02
0.00	0.01	0.01	0.02	0.04	0.36	9.66
0.00	0.01	0.01	0.02	0.04	0.37	9.30
0.00	0.01	0.01	0.02	0.04	0.37	8.93
0.00	0.01	0.01	0.02	0.04	0.37	8.56
0.00	0.01	0.01	0.02	0.04	0.37	8.19
0.00	0.01	0.01	0.02	0.04	0.37	7.81
0.00	0.01	0.01	0.02	0.04	0.38	7.44
0.00	0.01	0.01	0.02	0.04	0.38	7.06
0.00	0.01	0.01	0.02	0.04	0.38	6.69
0.00	0.01	0.01	0.02	0.04	0.38	6.31
0.00	0.01	0.01	0.02	0.04	0.38	5.94
0.00	0.01	0.01	0.02	0.04	0.38	5.56
0.00	0.01	0.01	0.02	0.04	0.38	5.18
0.00	0.00	0.01	0.02	0.04	0.37	4.81
0.00	0.00	0.01	0.02	0.04	0.37	4.43
0.00	0.00	0.01	0.02	0.04	0.37	4.06
0.00	0.00	0.01	0.02	0.04	0.37	3.69
0.00	0.00	0.01	0.02	0.04	0.37	3.32
0.00	0.00	0.01	0.02	0.04	0.37	2.95
0.00	0.00	0.01	0.02	0.04	0.36	2.59
0.00	0.00	0.00	0.03	0.04	1.39	2.22
0.00	0.00	0.01	0.02	0.04	0.35	0.83
0.00	0.00	0.01	0.02	0.03	0.48	0.48

16 — COLRHO: Col. floor RHO = $2 \times \text{COLD} / L = 2 \times (\text{col13}) / L$
 17 — SUMROC: Sum of col. RHO — 1st story: $\text{SUMROC} = (\text{col17}) = 0$
 Above: $\text{SUMROC} (I) = \text{SUMROC} (I - 1) + \text{COLRHO} (I)$
 = $(\text{col17}) + (\text{col16})$
 18 — GIRRHO: Girder fl. RHO = $\text{GIRDD} / \text{HT} = (\text{col14}) / \text{HT}$
 19 — BRARHO: Brace fl. RHO = $\text{BRACED} \times (2 \times \text{brace } L) / (L \times \text{HT})$
 = $(\text{col15}) \times (2 \times \text{brace } L) / (L \times \text{HT})$
 20 — SUMRHO: Sum of RHOs @ FL = $\text{SUMROC} + \text{GIRRHO} + \text{BRARHO}$
 = $(\text{col17}) + (\text{col18}) + (\text{col19})$
 21 — FLDEL: Floor deflection = $\text{SUMRHO} \times \text{HT} = (\text{col20}) \times \text{HT}$
 22 — TOTDEL: Total floor deflection = $\text{FLDEL} (I) + \text{TOTDEL} (I - 1)$
 = $\text{col21} (I) + \text{col22} (I - 1)$

* Max $\Delta, \lambda = 1.0.$

23	24	25	26	27	28	29
COLAR	GIRDAR	BRACAR	C.R.	ACOL	AGIRD	ABRAC
0.00	0.00	7.31	1.17	0.00	0.00	8.56
7.57	4.46	5.62	1.17	8.87	5.22	6.58
14.98	5.15	6.50	1.17	17.54	6.04	7.60
21.74	5.73	7.22	1.17	25.46	6.70	8.45
29.11	6.27	7.90	1.17	34.08	7.34	9.24
37.32	6.75	8.51	1.17	43.69	7.90	9.96
46.10	7.19	9.06	1.17	53.98	8.42	10.61
55.39	7.59	9.57	1.17	64.85	8.89	11.20
65.10	7.97	10.04	1.17	76.23	9.33	11.76
75.20	8.32	10.48	1.17	88.04	9.74	12.27
85.62	8.64	10.88	1.17	100.25	10.11	12.74
96.32	8.94	11.27	1.17	112.78	10.47	13.19
107.27	9.22	11.62	1.17	125.59	10.80	13.61
118.43	9.49	11.96	1.17	138.66	11.11	14.00
129.77	9.74	12.28	1.17	151.94	11.41	14.37
141.26	9.98	12.58	1.17	165.39	11.68	14.72
152.87	10.20	12.86	1.17	178.99	11.95	15.05
164.57	10.41	13.12	1.17	192.69	12.19	15.36
176.26	10.60	13.36	1.17	206.37	12.41	15.64
187.99	10.79	13.59	1.17	220.11	12.63	15.91
199.74	10.96	13.81	1.17	233.86	12.83	16.17
211.49	11.12	14.02	1.17	247.62	13.02	16.41
223.21	11.28	14.21	1.17	261.35	13.20	16.64
234.90	11.42	14.39	1.17	275.03	13.37	16.85
246.53	11.56	14.56	1.17	288.65	13.53	17.05
258.09	11.69	14.72	1.17	302.18	13.68	17.24
269.56	11.80	14.87	1.17	315.62	13.82	17.42
280.93	11.92	15.01	1.17	328.92	13.95	17.58
292.17	12.02	15.15	1.17	342.09	14.07	17.73
303.28	12.12	15.27	1.17	355.09	14.19	17.87
314.23	12.20	15.38	1.17	367.92	14.29	18.01
325.02	12.29	15.48	1.17	380.55	14.39	18.13
335.63	12.36	15.58	1.17	392.97	14.47	18.24
346.04	12.43	15.66	1.17	405.16	14.55	18.34
356.25	12.49	15.74	1.17	417.11	14.62	18.43
366.24	12.54	15.81	1.17	428.81	14.69	18.51
376.01	12.59	15.87	1.17	440.24	14.74	18.58
385.52	12.67	15.92	1.17	451.38	14.83	18.64
417.33	12.69	16.25	1.17	488.63	14.86	19.03
425.97	12.71	20.64	1.17	498.74	14.88	24.17

23, 24, 25 — Repeat of columns 10, 11, 12

26 — Correction factor

27 — ACOL: Optimum column area = (col23) x (col26)

28 — AGIRD: Optimum girder area = (col24) x (col26)

29 — ABRAC: Optimum brace area = (col25) x (col26)