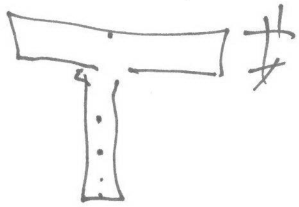
Structural Checksheet Response

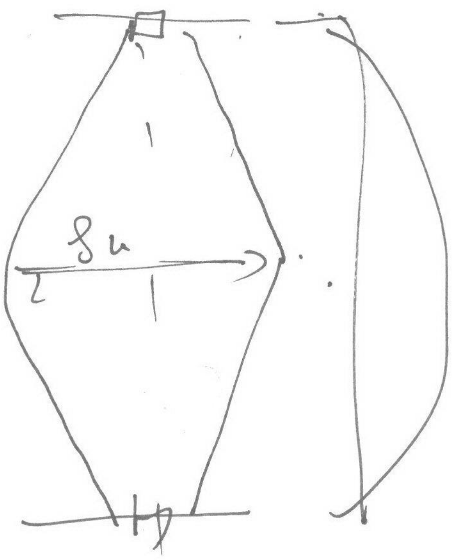
Permit #: 14-211482-STR-01-CO **Date: 11-21-2014**

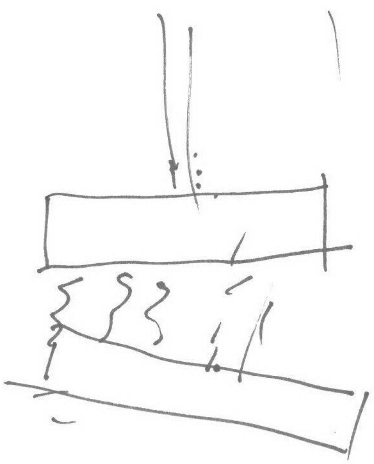
Customer name and phone number: ____________________

Note: *Please number each change in the '#' column. Use as many lines as necessary to describe your changes. Indicate which reviewer's checksheet you are responding to and the item your change addresses. If the item is not in response to a checksheet, write* ***customer*** *in the last column.*

#	Description of changes, revisions, additions, etc.	Checksheet and item #
1.	See revised general notes for updated special inspection.	STR-1 Item #1
2.	See revised general notes for updated list of deferred submittals.	STR-1 Item #2
3.	PT tendon layout has been revised. See revised calculations and drawings.	STR-1 Item #3
4.	The displacement is 0.41" in the orginal calculation. It is the Joint Loads and Enforced Displacements (BLC 3 EQ) table. For the revise permit (see sheet C-12A) the displacement is 0.55".	STR-1 Item #4
5.	See revised PT printouts. Additional information was included.	STR-1 Item #5
6.	All drift values are in inches. See revised sheet L-11A for updated max drift at each level as well as the individual story driftes.	STR-1 Item #6
7.	The reasoning for the "holes" in the H shape core on sheet L72 was to demonstrate that the entire flange was not require to resist the compressive force caused by the overturning moment. A simplified shape was used in the revised submittal. See sheet L-72A.	STR-1 Item #7
8.	The ½" differential settlement is between two adjacent columns. See attached calculations for the static settlement calculations as well as the settlement cause by liquefaction at the maximum considered earthquake. See sheets DS1 to DS	STR-1 Item #8
9.	Additional drag struts ((4) #5 each end of wall) have been added. See revised calculation L-23A	STR-1 Item #9







DCI ENGINEERS

Structural Calculations

For:

Block 8L

60 NW Davis

Portland, OR 98209

Structural Calculations Package

Revised Calculations

STRUCTURAL REGISTERED PROFESSIONAL ENGINEER
74858PE
OREGON
MARCH 23, 2011
SHIRLEY CHALUPA
EXPIRES: 12-31-2015

Prepared For:

Ankrom Moisan Architects, Inc.

6820 SW Macadam Ave, Ste 100

Portland, OR 98104

9-Dec-14

Job Number: 14031-0013

400 SW 6th Avenue, Suite 605 Portland, OR 97204 Phone: (503) 242.2448 Fax: (503) 242.2449

Seattle Spokane Everett Portland San Diego Austin

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Design Narrative

Project: Block 8L

General Building Information:

Block 8L is new construction consisting of 5 levels of heavy timber over 1 level of post-tensioned slab and concrete columns. The building was not designed as a podium. Each of the upper floors is framed with glu-lam beams and columns. The floors are 3x decking with 3" of concrete topping. Each floor was analyzed a semi-rigid diaphragm. The timber framed levels bear on a PT- slab. The columns align with the concrete columns below, or are supported on PT transfer beams. The lateral system is composed of specially reinforced concrete shear walls. The typical columns and exterior walls are supported on spread footings. The concrete shear walls are supported on mat foundations. The foundation system is supported on GeoPiers (designed by others).

Lateral Force Resisting System:

The LFRS is comprised of special concrete shear walls and semi-rigid diaphragms. The floors were analysis as semi-rigid due to the L-shaped floor plan and thin concrete topping to better capture the actual floor performance. A linear dynamic analysis performed using Etabs. The design base shear were scaled to 85% of the ELF base shear. Due to the horizontal irregularity type #2 the building was designed with a rho of 1.3. In addition to a rho if 1.3 a 25% increase in the diaphragm and chord loads was required per ASCE 7 section 12.3.3.4. The shear walls bear on individual mat foundations sitting on geopiers. The geopiers (designed by others) were used to resist both tension and compression.

DCI ENGINEERS

Project # : 14031-0013	Page # :
Project Name: Block 8L	
Engineer : MDP	Date : 9/11/2014
Subject : Table of Contents	

Design Criteria:

Codes OSSC 2014
ASCE 7-010

Design Criteria See Attached Sheet

Table of Contents:

DCI ENGINEERS

Project Block 8L	Project No.	Sheet No.
Subject Design Criteria	Date	By

Seismic Criteria (Per Soils Report)

$S_S = 0.981$
$S_1 = 0.421$
Site Class D
$F_a = 1.108$
$F_v = 1.579$
$S_{DS} = 0.724$
$S_{D1} = 0.443$

see lateral calcs for more seismic loading

Wind

V = 120mph
Exp B
$C_{pi} = \pm 0.18$ (Enclosed)
$K_{zt} = 1.0$

Z4 = 20.4psf
Z5 = 38.3psf
Z3 = 15psf
Z2 = 35.3psf
Z1 = 46.7psf

Dead Loads

Roof → see attached
Typ Flr = 55psf → see sheet L3+L4 for detail break downs

Live Load

Roof = 20psf or 100 @ gathering area
Floor = 40psf – Res.
50 + 15psf → office

Snow Load

$P_f = 25psf$
$P_g = 20psf$
$I = 1.0$
$C_e = B$
$C_t = 1.0$

Scan

Structural Calculations

For:

Block 8L

60 NW Davis

Portland, OR 98209

Structural Calculations Package

Revised Settlement Calculations

STRUCTURAL
REGISTERED PROFESSIONAL
ENGINEER
74858PE
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MARCH 23, 2011
SHIRLEY CHALUPA
EXPIRES: 12-31-2015

Prepared For:

Ankrom Moisan Architects, Inc.

6820 SW Macadam Ave, Ste 100

Portland, OR 98104

12-Dec-14

Job Number: 14031-0013

400 SW 6th Avenue, Suite 605 Portland, OR 97204 Phone: (503) 242.2448 Fax: (503) 242.2449

Seattle Spokane Everett Portland San Diego Austin

Structural Checksheet Response

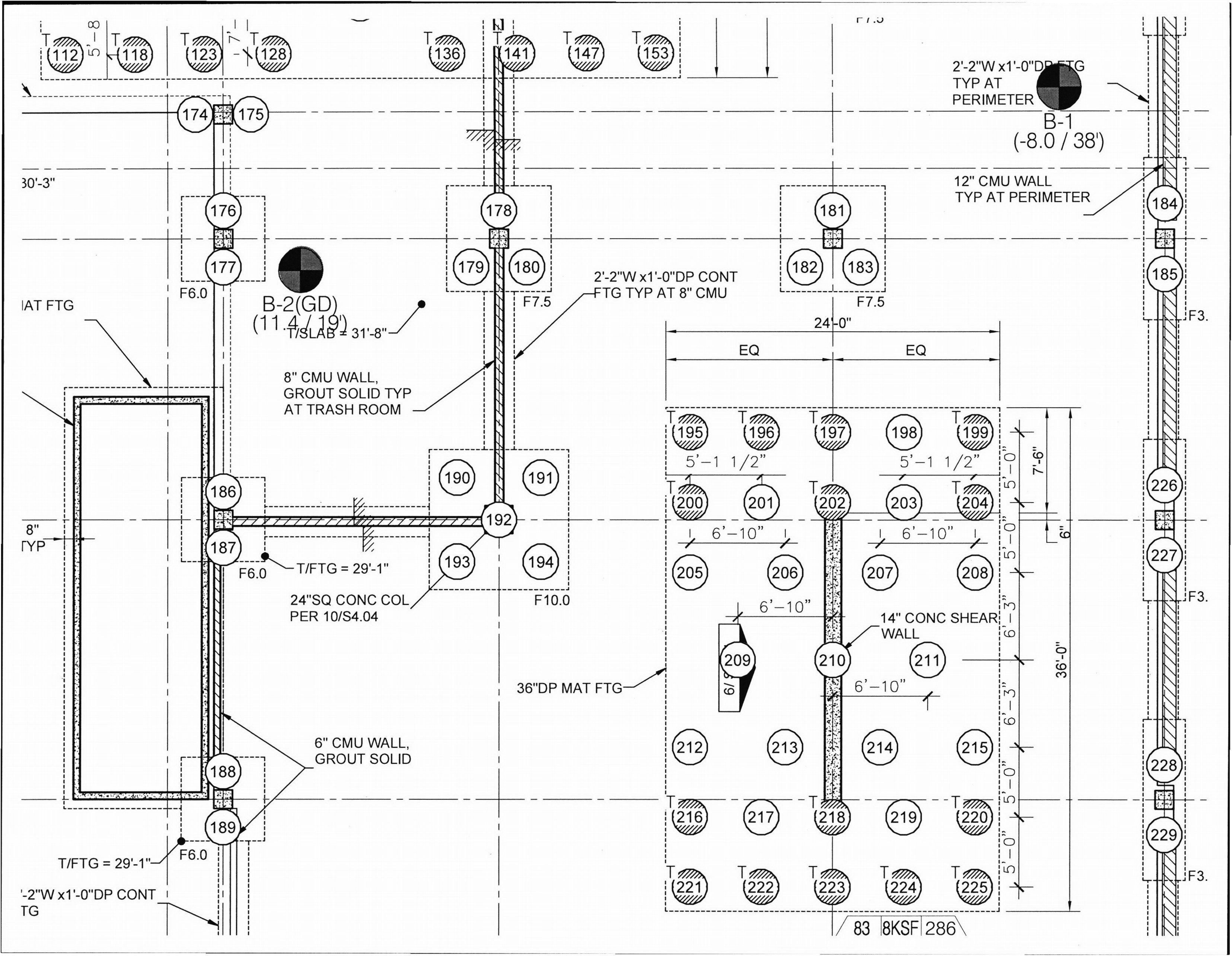
Permit #: **14-211482-GRD-01-CO** **Date:** 12/12/2014

Customer name and phone number: Mike Poulos (DCI) 503-242-2448

Note: *Please number each change in the '#' column. Use as many lines as necessary to describe your changes. Indicate which reviewer's checksheet you are responding to and the item your change addresses. If the item is not in response to a checksheet, write* **customer** *in the last column.*

#	Description of changes, revisions, additions, etc.	Checksheet and item #
1	See attached revised calculations	1

(for office use only)



2'-2"W x1'-0"DP FTG
TYP AT
PERIMETER
B-1
(-8.0 / 38')
12" CMU WALL
TYP AT PERIMETER
30'-3"
F6.0
F7.5
F7.5
F3.
MAT FTG
B-2(GD)
(11.4 / 19')
T/SLAB = 31'-8"
2'-2"W x1'-0"DP CONT
FTG TYP AT 8" CMU
24'-0"
EQ
EQ
8" CMU WALL,
GROUT SOLID TYP
AT TRASH ROOM
5'-1 1/2"
5'-1 1/2"
7'-6"
5'-0"
6'-10"
6'-10"
6"
8"
TYP
T/FTG = 29'-1"
F6.0
24"SQ CONC COL
PER 10/S4.04
F10.0
6'-10"
14" CONC SHEAR
WALL
36"DP MAT FTG
6'-10"
36'-0"
6'-3"
6'-3"
5'-0"
5'-0"
5'-0"
6" CMU WALL,
GROUT SOLID
T/FTG = 29'-1"
F6.0
2'-2"W x1'-0"DP CONT
FTG
83
8KSF
286

DCI ENGINEERS

Project No.	Sheet No. 1
Project: Block 8L	Date
Subject: Displacement Calcs - ASCE 41-13	By

1. Loading: DL = 120psf ⇒ 100psf slab, 15psf part., 5psf misc.
LL = 50psf
SL = 0psf

$Q_G = 1.1(Q_D + Q_L + Q_S)$ ASCE 41-13 eq (7-1) pg 93

$Q_D = DL = 120psf$
$Q_S = SL = 0$
$Q_L = = 30psf$ ⇒ this is the reduced LL

$A_{tt} = 20' \times 25' = 500$
$K_{LL} = 4$
$Q_L = L\left(0.25 + \frac{15}{\sqrt{K_{LL} A_{TT}}}\right)$
$= 50(0.25 + .335)$
$Q_L = 29.25$ ⇒ use 30psf

$Q_G = 1.1(120 + 30 + 0) = \underline{165psf}$

Deformation controlled 7.5.2.1.1. $Q_{UD} = Q_G + Q_E$ (moments)

Q_E = moment or shear from differential settlement (static + Liq.)

Force Controlled 7.5.2.1.2. $Q_{UF} = Q_G \pm \frac{Q_E}{C_1 C_2 J}$ (shear)

$J = 2.0$ (per ASCE 41)
$C_1 = 1.0$ } conservative, 1.0 is min
$C_2 = 1.0$ } possible (Eq 7-22 + 23)

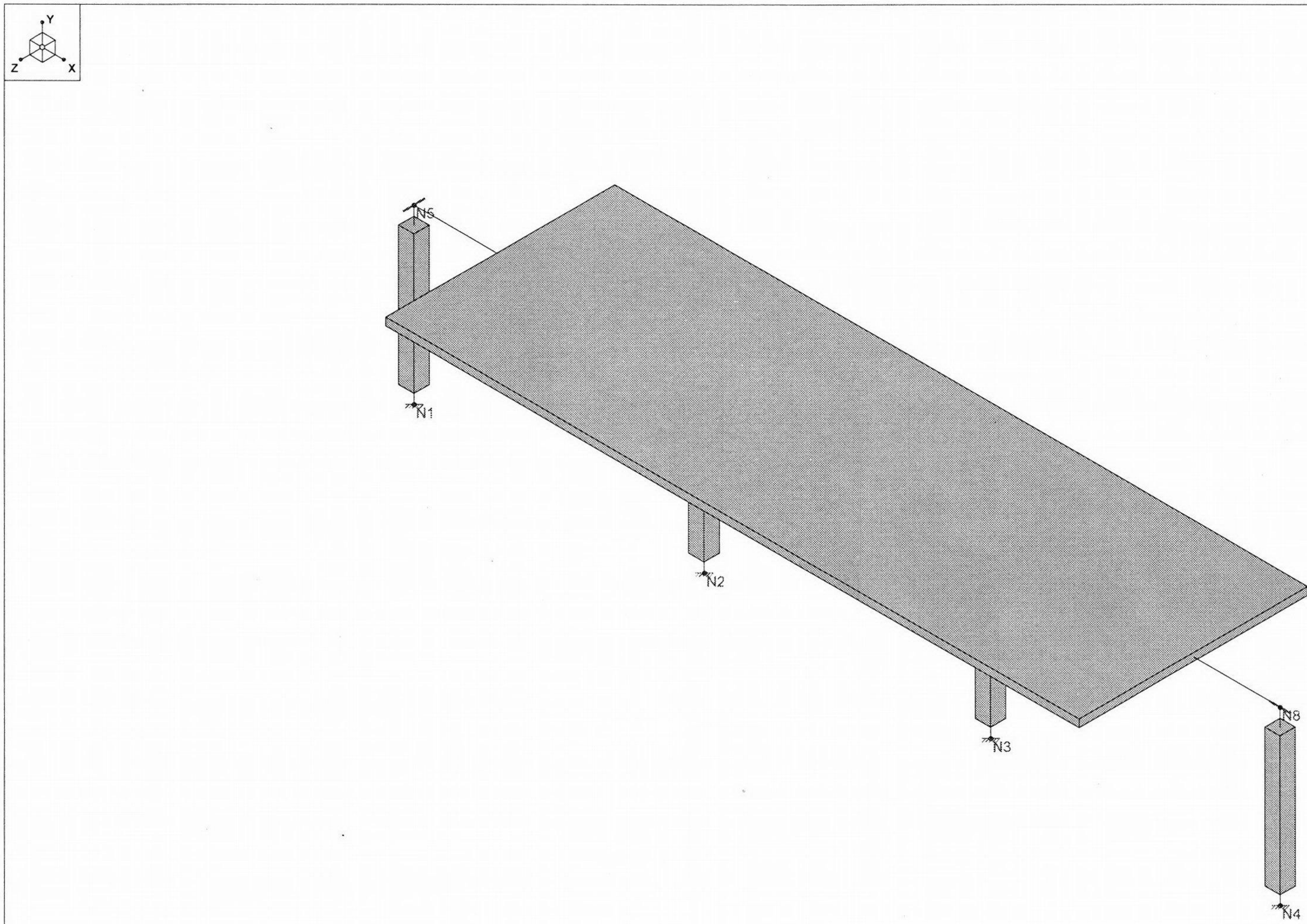
ENGINEERS	Project No.	Sheet No. 2
Project		Date
Subject		By

2. Modeling → using Risa 3D

Slab → will be full column Trib Width
→ 20' or 25'-4" depending on direction
→ $F_c' = 1.5(5000psi) = 7500psi$ per Table 10-I
→ $F_y' = 1.25(60ksi) = 75ksi$
→ cracked properties ⇒ $\beta_{eff} : 0.5$
↳ see section 10.4.4.2.1

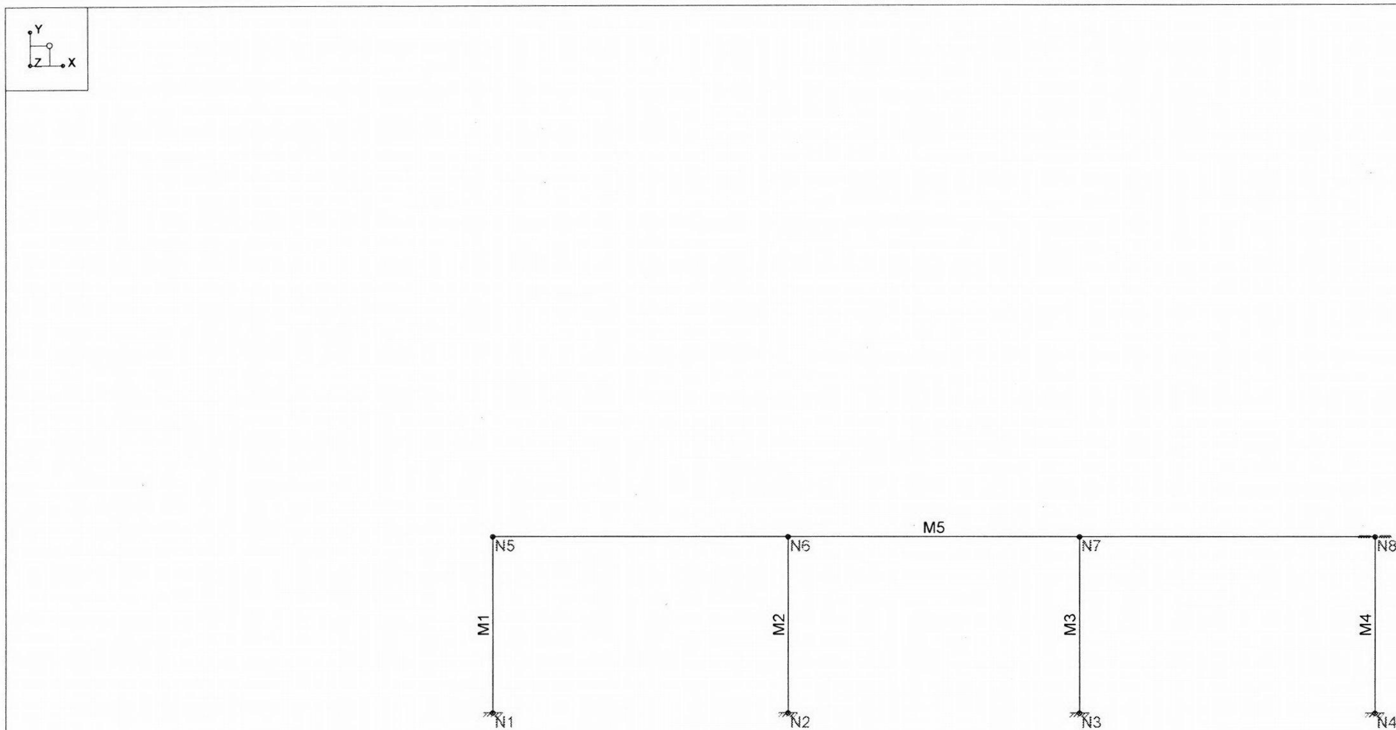
→ column to slab connection is fixed

Columns → Fixed-Fixed Condition
→ Cracked properties ⇒ $0.7I_g$ per ACI 318-11 10.10.4.1



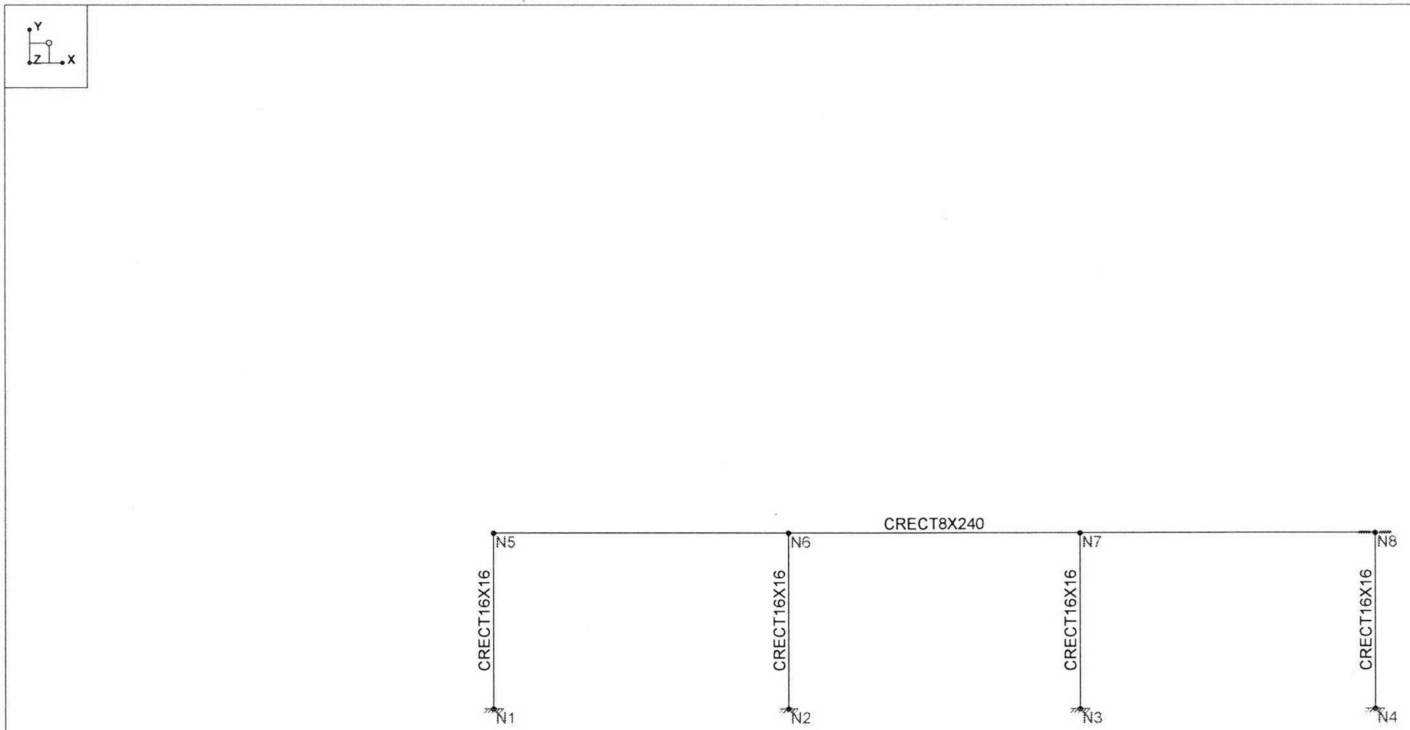
SK - 1

Dec 11, 2014 at 3:27 PM



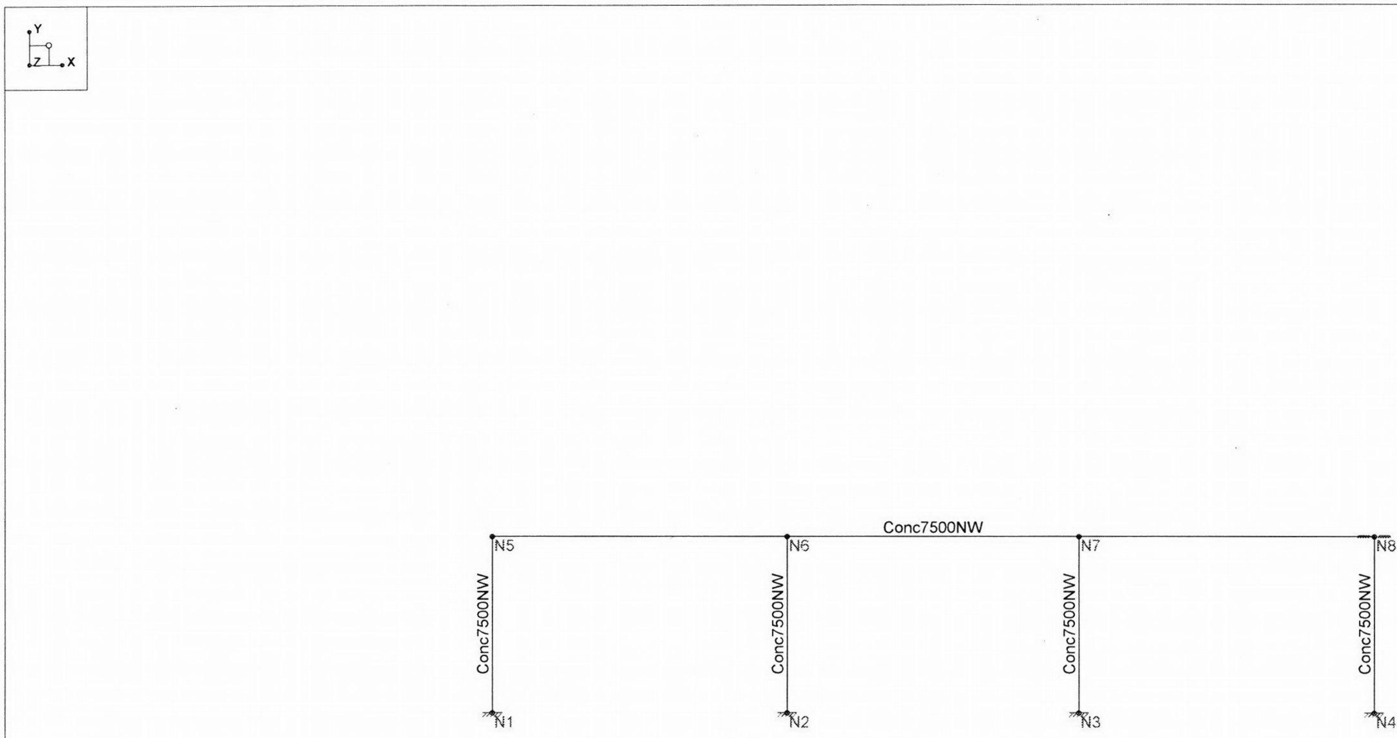
Loads: BLC 2, QE

		SK - 2
		Dec 11, 2014 at 3:28 PM



Loads: BLC 2, QE

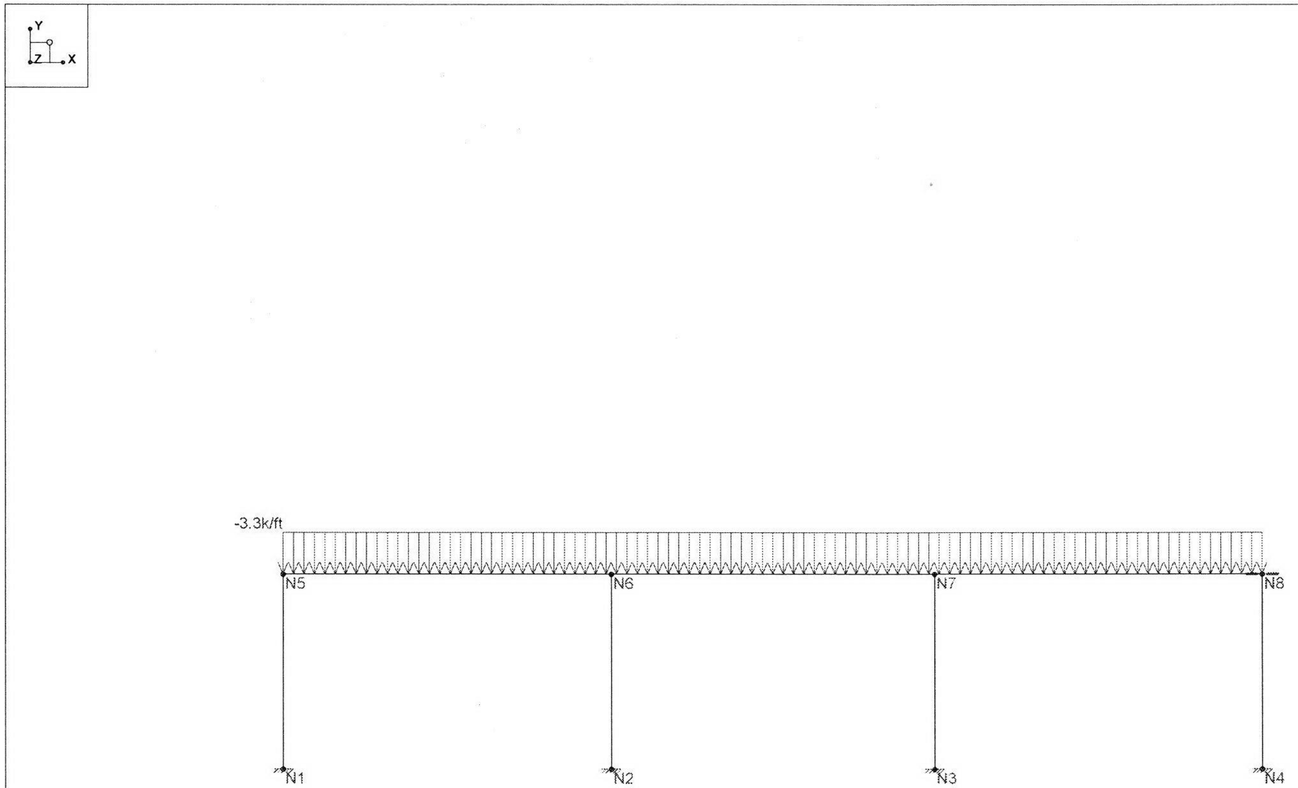
		SK - 3
		Dec 11, 2014 at 3:29 PM



Loads: BLC 2, QE

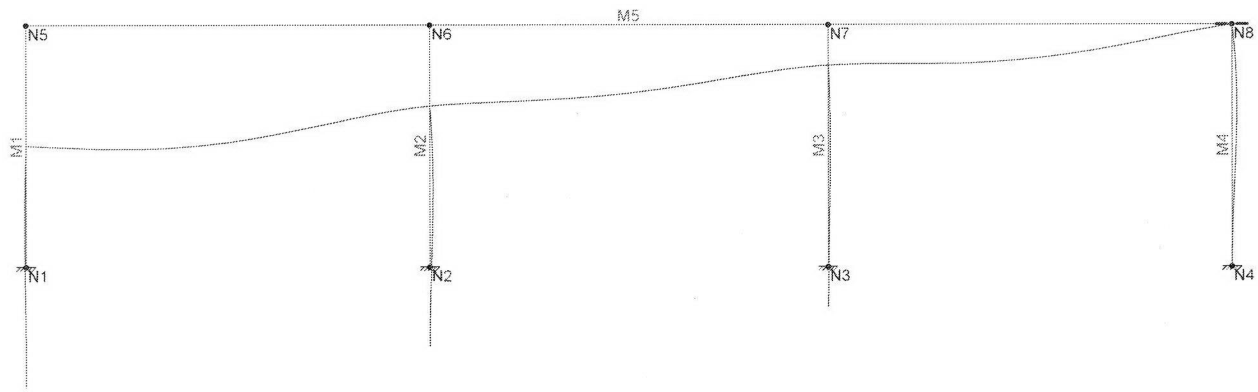
SK - 4

Dec 11, 2014 at 3:30 PM



Loads: BLC 1, Qd
Results for LC 1, Qud (no static)

		SK - 6
		Dec 11, 2014 at 3:35 PM



Results for LC 1, Qud (no static)

SK - 22

Dec 12, 2014 at 9:40 AM

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E...	Density[k/ft...	Yield[ksi]	Ry	Fu[ksi]	Rt
1	A36 Gr.36	29000	11154	.3	.65	.49	36	1.5	58	1.2
2	A572 Gr.50	29000	11154	.3	.65	.49	50	1.1	65	1.1
3	A992	29000	11154	.3	.65	.49	50	1.1	65	1.1
4	A500 Gr.B RND	29000	11154	.3	.65	.49	42	1.4	58	1.3
5	A500 Gr.B Rect	29000	11154	.3	.65	.49	46	1.4	58	1.3
6	A53 Gr.B	29000	11154	.3	.65	.49	35	1.6	60	1.2
7	75 KSI	29000	11154	.3	.65	.49	75	1.5	65	1.2

Concrete Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E...	Density[k/ft...	f'c[ksi]	Lambda	Flex Steel[...	Shear Stee...
1	Conc3000NW	3156	1372	.15	.6	.145	3	1	60	60
2	Conc3500NW	3409	1482	.15	.6	.145	3.5	1	60	60
3	Conc7500NW	4935	1584	.15	.6	.145	7.5	1	60	60
4	Conc3000LW	2085	907	.15	.6	.11	3	.75	60	60
5	Conc3500LW	2252	979	.15	.6	.11	3.5	.75	60	60
6	Conc4000LW	2408	1047	.15	.6	.11	4	.75	60	60

Concrete Beam Design Parameters

	Label	Shape	Length[ft]	B-eff Left[in]	B-eff Right[in]	Slab Thi...	Slab Thi...	Icr Factor	Flexural ...	Shear L...
1	M5	CRECT8X2...	75.666					.5	Use Des...	Use Des...

Concrete Column Design Parameters

	Label	Shape	Length[ft]	Lu-yy[ft]	Lu-zz[ft]	Cm-yy	Cm-zz	Kyy	Kzz	y sway	z sway	Icr Fac...	Flexur...	Shear ...
1	M1	16" Column	15									.7	Use D...	Use D...
2	M2	16" Column	15									.7	Use D...	Use D...
3	M3	16" Column	15									.7	Use D...	Use D...
4	M4	16" Column	15									.7	Use D...	Use D...

Joint Loads and Enforced Displacements (BLC 2 : QE)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft, k*s^2*ft)]
1	N1	D	Y	-3
2	N2	D	Y	-2
3	N3	D	Y	-1
4	N4	D	Y	0

Joint Loads and Enforced Displacements (BLC 3 : Static N1)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft, k*s^2*ft)]
1	N1	D	Y	-.61

Joint Loads and Enforced Displacements (BLC 4 : Static N2)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft, k*s^2*ft)]
1	N2	D	Y	-.61

Joint Loads and Enforced Displacements (BLC 5 : Static N3)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft, k*s^2*ft)]
1	N3	D	Y	-.61

Joint Loads and Enforced Displacements (BLC 6 : Static N4)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft, k*s^2*ft)]
1	N4	D	Y	-.61

Member Distributed Loads (BLC 1 : Qd)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-3.3	-3.3	0	0

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribut...	Area(M...	Surface...
1	Qd	None						1		
2	QE	None				4				
3	Static N1	None				1				
4	Static N2	None				1				
5	Static N3	None				1				
6	Static N4	None				1				

Load Combinations

	Description	Sol...	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Qud (no static)	Yes	Y		1	1	2	1												
2	Quf (no static)	Yes	Y		1	1	2	.5												
3	Gravity only	Yes	Y		1	1														
4	Qud (static at N1)	Yes	Y		1	1	2	1	3	1										
5	Qud (static at N2)	Yes	Y		1	1	2	1	4	1										
6	Qud (static at N3)	Yes	Y		1	1	2	1	5	1										
7	Qud (static at N4)	Yes	Y		1	1	2	1	6	1										
8	Quf (static at N1)	Yes	Y		1	1	2	.5	3	1										
9	Quf (static at N2)	Yes	Y		1	1	2	.5	4	1										
10	Quf(static at N3)	Yes	Y		1	1	2	.5	5	1										
11	Quf(static at N4)	Yes	Y		1	1	2	.5	6	1										
12	Gravity only (Static N1)	Yes	Y		1	1	3	1												
13	Gravity only (Static N2)	Yes	Y		1	1	4	1												
14	Gravity only (Static N3)	Yes	Y		1	1	5	1												
15	Gravity only (Static N4)	Yes	Y		1	1	6	1												

Member Section Forces

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
1	1	M1	1	33.899	-4.575	0	0	0	-22.681
2			2	33.899	-4.575	0	0	0	-5.526
3			3	33.899	-4.575	0	0	0	11.63
4			4	33.899	-4.575	0	0	0	28.785
5			5	33.899	-4.575	0	0	0	45.94
6	1	M2	1	87.9	10.345	0	0	0	51.141

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
7			2	87.9	10.345	0	0	0	12.347
8			3	87.9	10.345	0	0	0	-26.447
9			4	87.9	10.345	0	0	0	-65.242
10			5	87.9	10.345	0	0	0	-104.036
11	1	M3	1	85.824	6.31	0	0	0	31.189
12			2	85.824	6.31	0	0	0	7.527
13			3	85.824	6.31	0	0	0	-16.135
14			4	85.824	6.31	0	0	0	-39.796
15			5	85.824	6.31	0	0	0	-63.458
16	1	M4	1	42.075	15.898	0	0	0	78.679
17			2	42.075	15.898	0	0	0	19.06
18			3	42.075	15.898	0	0	0	-40.559
19			4	42.075	15.898	0	0	0	-100.178
20			5	42.075	15.898	0	0	0	-159.796
21	1	M5	1	4.575	33.875	0	0	0	45.94
22			2	4.575	-28.55	0	0	0	-4.401
23			3	-5.771	-3.02	0	0	0	-77.667
24			4	-12.081	20.413	0	0	0	-44.455
25			5	-12.081	-42.011	0	0	0	159.796
26	2	M1	1	35.922	-7.392	0	0	0	-36.559
27			2	35.922	-7.392	0	0	0	-8.838
28			3	35.922	-7.392	0	0	0	18.882
29			4	35.922	-7.392	0	0	0	46.603
30			5	35.922	-7.392	0	0	0	74.323
31	2	M2	1	87.416	6.191	0	0	0	30.641
32			2	87.416	6.191	0	0	0	7.423
33			3	87.416	6.191	0	0	0	-15.794
34			4	87.416	6.191	0	0	0	-39.012
35			5	87.416	6.191	0	0	0	-62.23
36	2	M3	1	86.379	2.149	0	0	0	10.633
37			2	86.379	2.149	0	0	0	2.574
38			3	86.379	2.149	0	0	0	-5.486
39			4	86.379	2.149	0	0	0	-13.545
40			5	86.379	2.149	0	0	0	-21.604
41	2	M4	1	39.981	13.066	0	0	0	64.664
42			2	39.981	13.066	0	0	0	15.665
43			3	39.981	13.066	0	0	0	-33.334
44			4	39.981	13.066	0	0	0	-82.334
45			5	39.981	13.066	0	0	0	-131.333
46	2	M5	1	7.392	35.903	0	0	0	74.323
47			2	7.392	-26.522	0	0	0	-14.383
48			3	1.201	-1.515	0	0	0	-77.672
49			4	-.948	22.446	0	0	0	-34.467
50			5	-.948	-39.978	0	0	0	131.333
51	3	M1	1	37.931	-10.21	0	0	0	-50.437
52			2	37.931	-10.21	0	0	0	-12.151
53			3	37.931	-10.21	0	0	0	26.134
54			4	37.931	-10.21	0	0	0	64.42
55			5	37.931	-10.21	0	0	0	102.706
56	3	M2	1	86.909	2.038	0	0	0	10.141
57			2	86.909	2.038	0	0	0	2.5
58			3	86.909	2.038	0	0	0	-5.142

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
59			4	86.909	2.038	0	0	0	-12.783
60			5	86.909	2.038	0	0	0	-20.425
61	3	M3	1	86.913	-2.012	0	0	0	-9.923
62			2	86.913	-2.012	0	0	0	-2.38
63			3	86.913	-2.012	0	0	0	5.164
64			4	86.913	-2.012	0	0	0	12.707
65			5	86.913	-2.012	0	0	0	20.251
66	3	M4	1	37.945	10.235	0	0	0	50.65
67			2	37.945	10.235	0	0	0	12.27
68			3	37.945	10.235	0	0	0	-26.11
69			4	37.945	10.235	0	0	0	-64.489
70			5	37.945	10.235	0	0	0	-102.869
71	3	M5	1	10.21	37.931	0	0	0	102.706
72			2	10.21	-24.493	0	0	0	-24.365
73			3	8.173	-.009	0	0	0	-77.677
74			4	10.184	24.479	0	0	0	-24.477
75			5	10.184	-37.946	0	0	0	102.869
76	4	M1	1	30.486	-.585	0	0	0	-2.986
77			2	30.486	-.585	0	0	0	-.794
78			3	30.486	-.585	0	0	0	1.398
79			4	30.486	-.585	0	0	0	3.59
80			5	30.486	-.585	0	0	0	5.782
81	4	M2	1	92.349	12.946	0	0	0	63.973
82			2	92.349	12.946	0	0	0	15.426
83			3	92.349	12.946	0	0	0	-33.122
84			4	92.349	12.946	0	0	0	-81.669
85			5	92.349	12.946	0	0	0	-130.217
86	4	M3	1	84.602	5.887	0	0	0	29.078
87			2	84.602	5.887	0	0	0	7.001
88			3	84.602	5.887	0	0	0	-15.076
89			4	84.602	5.887	0	0	0	-37.152
90			5	84.602	5.887	0	0	0	-59.229
91	4	M4	1	42.261	15.989	0	0	0	79.129
92			2	42.261	15.989	0	0	0	19.169
93			3	42.261	15.989	0	0	0	-40.791
94			4	42.261	15.989	0	0	0	-100.751
95			5	42.261	15.989	0	0	0	-160.71
96	4	M5	1	.584	30.481	0	0	0	5.782
97			2	.584	-31.943	0	0	0	19.634
98			3	-12.363	-1.948	0	0	0	-71.455
99			4	-18.25	20.26	0	0	0	-46.435
100			5	-18.25	-42.164	0	0	0	160.71
101	5	M1	1	38.359	-9.208	0	0	0	-45.578
102			2	38.359	-9.208	0	0	0	-11.049
103			3	38.359	-9.208	0	0	0	23.48
104			4	38.359	-9.208	0	0	0	58.009
105			5	38.359	-9.208	0	0	0	92.538
106	5	M2	1	78.406	10.63	0	0	0	52.566
107			2	78.406	10.63	0	0	0	12.705
108			3	78.406	10.63	0	0	0	-27.157
109			4	78.406	10.63	0	0	0	-67.018
110			5	78.406	10.63	0	0	0	-106.879

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
111	5	M3	1	92.086	9.62	0	0	0	47.575
112			2	92.086	9.62	0	0	0	11.499
113			3	92.086	9.62	0	0	0	-24.577
114			4	92.086	9.62	0	0	0	-60.653
115			5	92.086	9.62	0	0	0	-96.73
116	5	M4	1	40.846	15.169	0	0	0	75.072
117			2	40.846	15.169	0	0	0	18.186
118			3	40.846	15.169	0	0	0	-38.699
119			4	40.846	15.169	0	0	0	-95.585
120			5	40.846	15.169	0	0	0	-152.47
121	5	M5	1	9.208	38.341	0	0	0	92.538
122			2	9.208	-24.084	0	0	0	-42.28
123			3	-1.422	-8.071	0	0	0	-83.873
124			4	-11.043	21.637	0	0	0	-28.64
125			5	-11.043	-40.788	0	0	0	152.47
126	6	M1	1	32.67	-3.842	0	0	0	-19.041
127			2	32.67	-3.842	0	0	0	-4.633
128			3	32.67	-3.842	0	0	0	9.775
129			4	32.67	-3.842	0	0	0	24.184
130			5	32.67	-3.842	0	0	0	38.592
131	6	M2	1	94.202	7.041	0	0	0	34.807
132			2	94.202	7.041	0	0	0	8.403
133			3	94.202	7.041	0	0	0	-18.001
134			4	94.202	7.041	0	0	0	-44.405
135			5	94.202	7.041	0	0	0	-70.809
136	6	M3	1	76.269	6.033	0	0	0	29.827
137			2	76.269	6.033	0	0	0	7.204
138			3	76.269	6.033	0	0	0	-15.419
139			4	76.269	6.033	0	0	0	-38.042
140			5	76.269	6.033	0	0	0	-60.665
141	6	M4	1	46.557	20.538	0	0	0	101.64
142			2	46.557	20.538	0	0	0	24.622
143			3	46.557	20.538	0	0	0	-52.395
144			4	46.557	20.538	0	0	0	-129.413
145			5	46.557	20.538	0	0	0	-206.431
146	6	M5	1	3.842	32.65	0	0	0	38.592
147			2	3.842	-29.775	0	0	0	11.427
148			3	-3.199	2.029	0	0	0	-83.886
149			4	-9.232	15.946	0	0	0	-82.332
150			5	-9.232	-46.479	0	0	0	206.431
151	7	M1	1	34.052	-4.664	0	0	0	-23.119
152			2	34.052	-4.664	0	0	0	-5.627
153			3	34.052	-4.664	0	0	0	11.865
154			4	34.052	-4.664	0	0	0	29.357
155			5	34.052	-4.664	0	0	0	46.849
156	7	M2	1	86.674	10.764	0	0	0	53.22
157			2	86.674	10.764	0	0	0	12.855
158			3	86.674	10.764	0	0	0	-27.509
159			4	86.674	10.764	0	0	0	-67.874
160			5	86.674	10.764	0	0	0	-108.238
161	7	M3	1	90.337	3.699	0	0	0	18.275
162			2	90.337	3.699	0	0	0	4.404

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
163			3	90.337	3.699	0	0	0	-9.467
164			4	90.337	3.699	0	0	0	-23.338
165			5	90.337	3.699	0	0	0	-37.209
166	7	M4	1	38.634	11.897	0	0	0	58.874
167			2	38.634	11.897	0	0	0	14.262
168			3	38.634	11.897	0	0	0	-30.35
169			4	38.634	11.897	0	0	0	-74.962
170			5	38.634	11.897	0	0	0	-119.574
171	7	M5	1	4.664	34.028	0	0	0	46.849
172			2	4.664	-28.397	0	0	0	-6.387
173			3	-6.1	-4.09	0	0	0	-71.455
174			4	-9.799	23.811	0	0	0	-20.414
175			5	-9.799	-38.614	0	0	0	119.574
176	8	M1	1	32.529	-3.402	0	0	0	-16.864
177			2	32.529	-3.402	0	0	0	-4.107
178			3	32.529	-3.402	0	0	0	8.651
179			4	32.529	-3.402	0	0	0	21.408
180			5	32.529	-3.402	0	0	0	34.165
181	8	M2	1	91.863	8.792	0	0	0	43.473
182			2	91.863	8.792	0	0	0	10.502
183			3	91.863	8.792	0	0	0	-22.469
184			4	91.863	8.792	0	0	0	-55.44
185			5	91.863	8.792	0	0	0	-88.411
186	8	M3	1	85.155	1.726	0	0	0	8.522
187			2	85.155	1.726	0	0	0	2.048
188			3	85.155	1.726	0	0	0	-4.427
189			4	85.155	1.726	0	0	0	-10.901
190			5	85.155	1.726	0	0	0	-17.375
191	8	M4	1	40.15	13.157	0	0	0	65.114
192			2	40.15	13.157	0	0	0	15.774
193			3	40.15	13.157	0	0	0	-33.566
194			4	40.15	13.157	0	0	0	-82.907
195			5	40.15	13.157	0	0	0	-132.247
196	8	M5	1	3.402	32.509	0	0	0	34.165
197			2	3.402	-29.915	0	0	0	9.652
198			3	-5.391	-.442	0	0	0	-71.46
199			4	-7.117	22.293	0	0	0	-36.447
200			5	-7.117	-40.131	0	0	0	132.247
201	9	M1	1	40.361	-12.025	0	0	0	-59.456
202			2	40.361	-12.025	0	0	0	-14.362
203			3	40.361	-12.025	0	0	0	30.733
204			4	40.361	-12.025	0	0	0	75.827
205			5	40.361	-12.025	0	0	0	120.921
206	9	M2	1	77.954	6.476	0	0	0	32.066
207			2	77.954	6.476	0	0	0	7.781
208			3	77.954	6.476	0	0	0	-16.504
209			4	77.954	6.476	0	0	0	-40.789
210			5	77.954	6.476	0	0	0	-65.074
211	9	M3	1	92.627	5.46	0	0	0	27.02
212			2	92.627	5.46	0	0	0	6.546
213			3	92.627	5.46	0	0	0	-13.928
214			4	92.627	5.46	0	0	0	-34.402

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
215			5	92.627	5.46	0	0	0	-54.876
216	9	M4	1	38.755	12.338	0	0	0	61.057
217			2	38.755	12.338	0	0	0	14.791
218			3	38.755	12.338	0	0	0	-31.475
219			4	38.755	12.338	0	0	0	-77.741
220			5	38.755	12.338	0	0	0	-124.007
221	9	M5	1	12.025	40.369	0	0	0	120.921
222			2	12.025	-22.056	0	0	0	-52.262
223			3	5.55	-6.566	0	0	0	-83.878
224			4	.09	23.669	0	0	0	-18.651
225			5	.09	-38.755	0	0	0	124.007
226	10	M1	1	34.695	-6.66	0	0	0	-32.919
227			2	34.695	-6.66	0	0	0	-7.946
228			3	34.695	-6.66	0	0	0	17.028
229			4	34.695	-6.66	0	0	0	42.001
230			5	34.695	-6.66	0	0	0	66.975
231	10	M2	1	93.687	2.887	0	0	0	14.306
232			2	93.687	2.887	0	0	0	3.479
233			3	93.687	2.887	0	0	0	-7.348
234			4	93.687	2.887	0	0	0	-18.176
235			5	93.687	2.887	0	0	0	-29.003
236	10	M3	1	76.881	1.872	0	0	0	9.271
237			2	76.881	1.872	0	0	0	2.25
238			3	76.881	1.872	0	0	0	-4.77
239			4	76.881	1.872	0	0	0	-11.79
240			5	76.881	1.872	0	0	0	-18.811
241	10	M4	1	44.435	17.706	0	0	0	87.626
242			2	44.435	17.706	0	0	0	21.228
243			3	44.435	17.706	0	0	0	-45.171
244			4	44.435	17.706	0	0	0	-111.57
245			5	44.435	17.706	0	0	0	-177.968
246	10	M5	1	6.66	34.678	0	0	0	66.975
247			2	6.66	-27.747	0	0	0	1.446
248			3	3.773	3.535	0	0	0	-83.891
249			4	1.9	17.978	0	0	0	-72.344
250			5	1.9	-44.446	0	0	0	177.968
251	11	M1	1	36.075	-7.482	0	0	0	-36.997
252			2	36.075	-7.482	0	0	0	-8.94
253			3	36.075	-7.482	0	0	0	19.117
254			4	36.075	-7.482	0	0	0	47.175
255			5	36.075	-7.482	0	0	0	75.232
256	11	M2	1	86.191	6.61	0	0	0	32.72
257			2	86.191	6.61	0	0	0	7.932
258			3	86.191	6.61	0	0	0	-16.857
259			4	86.191	6.61	0	0	0	-41.645
260			5	86.191	6.61	0	0	0	-66.433
261	11	M3	1	90.85	-.462	0	0	0	-2.281
262			2	90.85	-.462	0	0	0	-.549
263			3	90.85	-.462	0	0	0	1.182
264			4	90.85	-.462	0	0	0	2.914
265			5	90.85	-.462	0	0	0	4.645
266	11	M4	1	36.582	9.065	0	0	0	44.86

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
267			2	36.582	9.065	0	0	0	10.867
268			3	36.582	9.065	0	0	0	-23.125
269			4	36.582	9.065	0	0	0	-57.117
270			5	36.582	9.065	0	0	0	-91.11
271	11	M5	1	7.482	36.056	0	0	0	75.232
272			2	7.482	-26.369	0	0	0	-16.369
273			3	.872	-2.585	0	0	0	-71.46
274			4	1.334	25.843	0	0	0	-10.425
275			5	1.334	-36.581	0	0	0	91.11
276	12	M1	1	34.557	-6.219	0	0	0	-30.742
277			2	34.557	-6.219	0	0	0	-7.419
278			3	34.557	-6.219	0	0	0	15.903
279			4	34.557	-6.219	0	0	0	39.225
280			5	34.557	-6.219	0	0	0	62.548
281	12	M2	1	91.355	4.639	0	0	0	22.973
282			2	91.355	4.639	0	0	0	5.578
283			3	91.355	4.639	0	0	0	-11.816
284			4	91.355	4.639	0	0	0	-29.211
285			5	91.355	4.639	0	0	0	-46.606
286	12	M3	1	85.687	-2.434	0	0	0	-12.034
287			2	85.687	-2.434	0	0	0	-2.906
288			3	85.687	-2.434	0	0	0	6.223
289			4	85.687	-2.434	0	0	0	15.351
290			5	85.687	-2.434	0	0	0	24.48
291	12	M4	1	38.098	10.326	0	0	0	51.1
292			2	38.098	10.326	0	0	0	12.379
293			3	38.098	10.326	0	0	0	-26.342
294			4	38.098	10.326	0	0	0	-65.063
295			5	38.098	10.326	0	0	0	-103.783
296	12	M5	1	6.219	34.537	0	0	0	62.548
297			2	6.219	-27.887	0	0	0	-.33
298			3	1.581	1.063	0	0	0	-71.465
299			4	4.015	24.326	0	0	0	-26.458
300			5	4.015	-38.099	0	0	0	103.783
301	13	M1	1	42.349	-14.843	0	0	0	-73.335
302			2	42.349	-14.843	0	0	0	-17.675
303			3	42.349	-14.843	0	0	0	37.985
304			4	42.349	-14.843	0	0	0	93.645
305			5	42.349	-14.843	0	0	0	149.305
306	13	M2	1	77.48	2.322	0	0	0	11.566
307			2	77.48	2.322	0	0	0	2.858
308			3	77.48	2.322	0	0	0	-5.851
309			4	77.48	2.322	0	0	0	-14.56
310			5	77.48	2.322	0	0	0	-23.268
311	13	M3	1	93.147	1.299	0	0	0	6.464
312			2	93.147	1.299	0	0	0	1.592
313			3	93.147	1.299	0	0	0	-3.279
314			4	93.147	1.299	0	0	0	-8.15
315			5	93.147	1.299	0	0	0	-13.021
316	13	M4	1	36.722	9.506	0	0	0	47.042
317			2	36.722	9.506	0	0	0	11.396
318			3	36.722	9.506	0	0	0	-24.25

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
319			4	36.722	9.506	0	0	0	-59.896
320			5	36.722	9.506	0	0	0	-95.543
321	13	M5	1	14.843	42.397	0	0	0	149.305
322			2	14.843	-20.028	0	0	0	-62.245
323			3	12.521	-5.061	0	0	0	-83.883
324			4	11.223	25.702	0	0	0	-8.662
325			5	11.223	-36.722	0	0	0	95.543
326	14	M1	1	36.705	-9.477	0	0	0	-46.797
327			2	36.705	-9.477	0	0	0	-11.258
328			3	36.705	-9.477	0	0	0	24.28
329			4	36.705	-9.477	0	0	0	59.818
330			5	36.705	-9.477	0	0	0	95.357
331	14	M2	1	93.149	-1.266	0	0	0	-6.194
332			2	93.149	-1.266	0	0	0	-1.445
333			3	93.149	-1.266	0	0	0	3.304
334			4	93.149	-1.266	0	0	0	8.054
335			5	93.149	-1.266	0	0	0	12.803
336	14	M3	1	77.472	-2.289	0	0	0	-11.286
337			2	77.472	-2.289	0	0	0	-2.703
338			3	77.472	-2.289	0	0	0	5.879
339			4	77.472	-2.289	0	0	0	14.461
340			5	77.472	-2.289	0	0	0	23.044
341	14	M4	1	42.371	14.874	0	0	0	73.612
342			2	42.371	14.874	0	0	0	17.833
343			3	42.371	14.874	0	0	0	-37.947
344			4	42.371	14.874	0	0	0	-93.726
345			5	42.371	14.874	0	0	0	-149.505
346	14	M5	1	9.477	36.706	0	0	0	95.357
347			2	9.477	-25.719	0	0	0	-8.536
348			3	10.744	5.04	0	0	0	-83.896
349			4	13.033	20.011	0	0	0	-62.355
350			5	13.033	-42.413	0	0	0	149.505
351	15	M1	1	38.084	-10.299	0	0	0	-50.875
352			2	38.084	-10.299	0	0	0	-12.253
353			3	38.084	-10.299	0	0	0	26.37
354			4	38.084	-10.299	0	0	0	64.992
355			5	38.084	-10.299	0	0	0	103.615
356	15	M2	1	85.686	2.457	0	0	0	12.22
357			2	85.686	2.457	0	0	0	3.008
358			3	85.686	2.457	0	0	0	-6.204
359			4	85.686	2.457	0	0	0	-15.416
360			5	85.686	2.457	0	0	0	-24.628
361	15	M3	1	91.341	-4.622	0	0	0	-22.837
362			2	91.341	-4.622	0	0	0	-5.503
363			3	91.341	-4.622	0	0	0	11.831
364			4	91.341	-4.622	0	0	0	29.166
365			5	91.341	-4.622	0	0	0	46.5
366	15	M4	1	34.588	6.233	0	0	0	30.844
367			2	34.588	6.233	0	0	0	7.472
368			3	34.588	6.233	0	0	0	-15.9
369			4	34.588	6.233	0	0	0	-39.272
370			5	34.588	6.233	0	0	0	-62.645

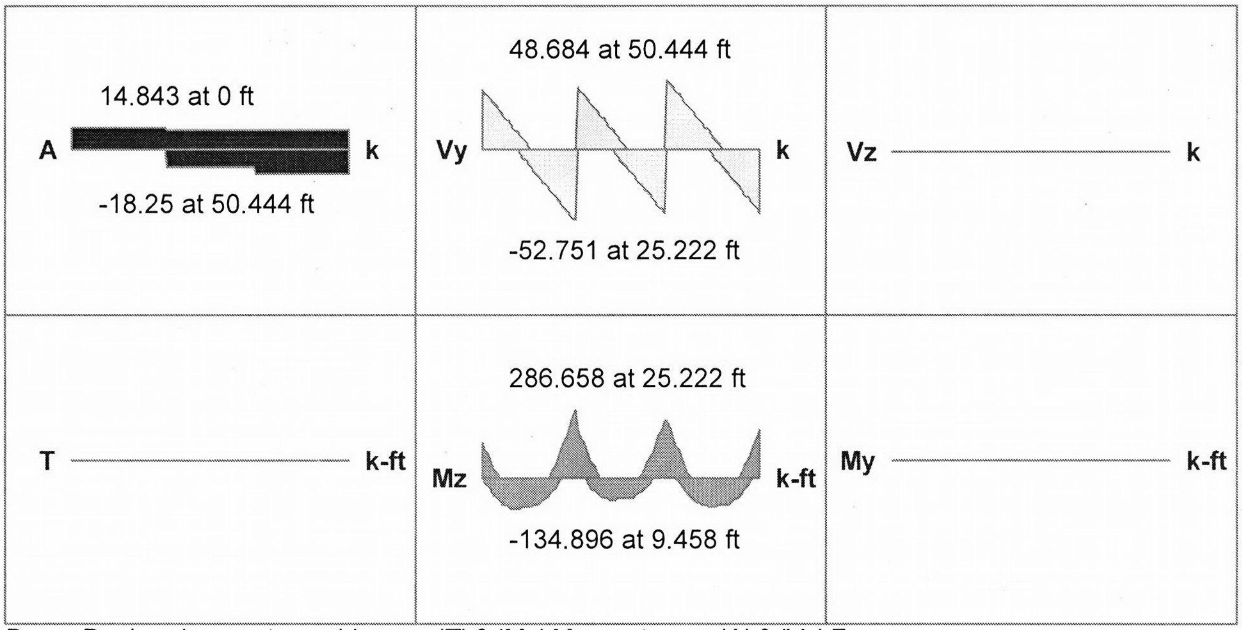
Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
371	15	M5	1	10.3	38.084	0	0	0	103.615
372			2	10.3	-24.34	0	0	0	-26.351
373			3	7.844	-1.08	0	0	0	-71.465
374			4	12.466	27.876	0	0	0	-.435
375			5	12.466	-34.548	0	0	0	62.645

Beam: *M5*

Shape:	**CRECT8X240**	Concrete Stress Block:	**Rectangular**
Material:	**Conc7500NW**	Cracked Sections Used:	**Yes**
Length:	**75.666 ft**	Cracked 'I' Factor:	**0.5**
I Joint:	**N5**	Effective 'I':	**5120 in^4**
J Joint:	**N8**		

Code Check:
Report Based On 97 Sections



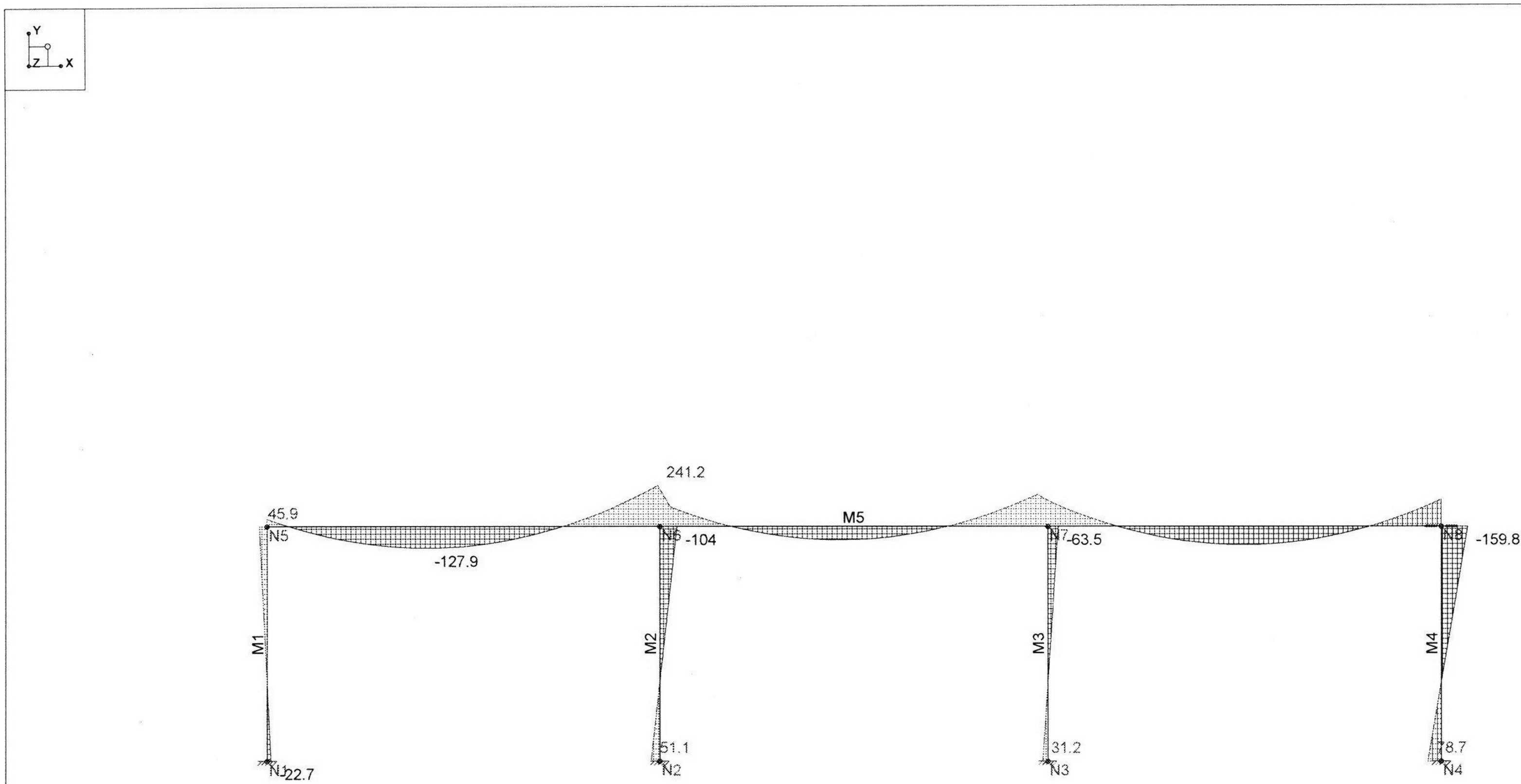
Beam Design does not consider any 'T' & 'My' Moments, nor 'A' & 'Vz' Forces.

ACI 318-11 Code Check

Top Bending Check	**0.916**	Bot Bending Check	**0.706**	Shear Check	**0.283 (y)**
Location	**24.434 ft**	Location	**9.458 ft**	Location	**24.434 ft**
Gov Muz Top	**246.105 k-ft**	Gov Muz Bot	**-134.896 k-ft**	Gov Vuy	**50.15 k**
phi*Mnz Top	**268.805 k-ft**	phi*Mnz Bot	**191.111 k-ft**	phi*Vny	**177.319 k**
Tension Bar Fy	**60 ksi**	Concrete Weight	**.145 k/ft^3**		
Shear Bar Fy	**60 ksi**	λ	**1**		
F'c	**7.5 ksi**	E_Concrete	**4935 ksi**		
Flex. Rebar Set	**ASTM A615**	Min 1 Bar Dia Spac.	**No**		
Shear Rebar Set	**ASTM A615**	Threshold Torsion	**40.228 k-ft**		

Span Information

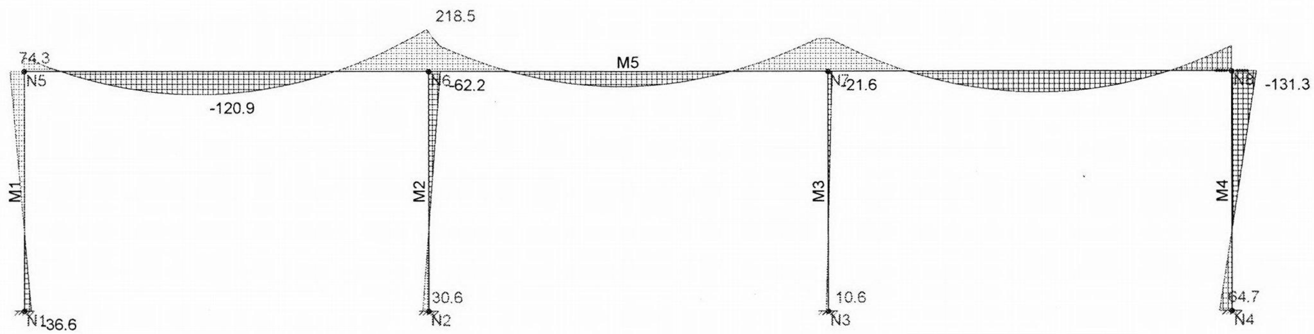
Span	Span Length (ft)	I-Face Dist. (in)	J-Face Dist. (in)
1	**0 - 25.3**	**8**	**8**
2	**25.3 - 50.3**	**8**	**8**
3	**50.3 - 75.7**	**8**	**8**



Results for LC 1, Qud (no static)
Member z Bending Moments (k-ft)

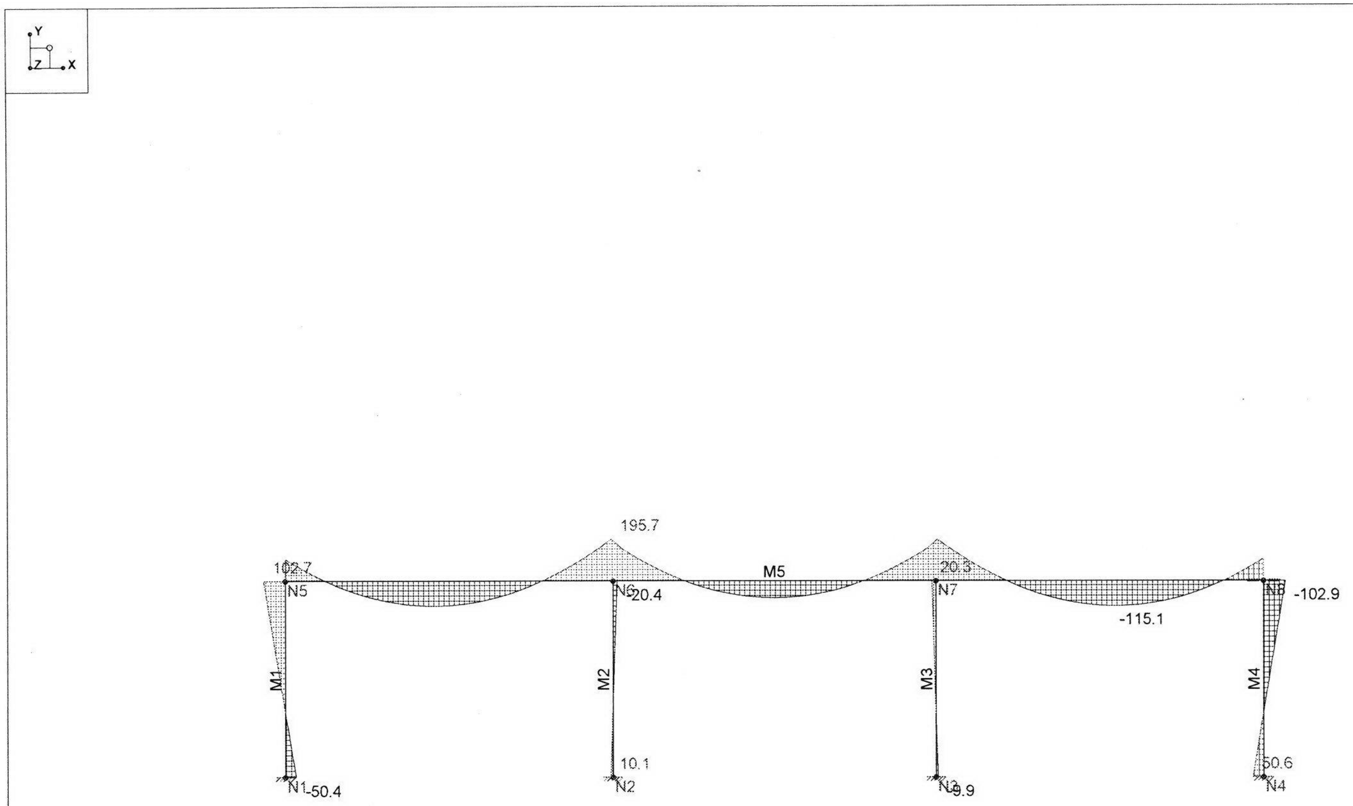
SK - 8

Dec 12, 2014 at 9:23 AM



Results for LC 2, Quf (no static)
Member z Bending Moments (k-ft)

		SK - 9
		Dec 12, 2014 at 9:24 AM
		Column Vert. Disp. 20ft bays static+eq.r3d

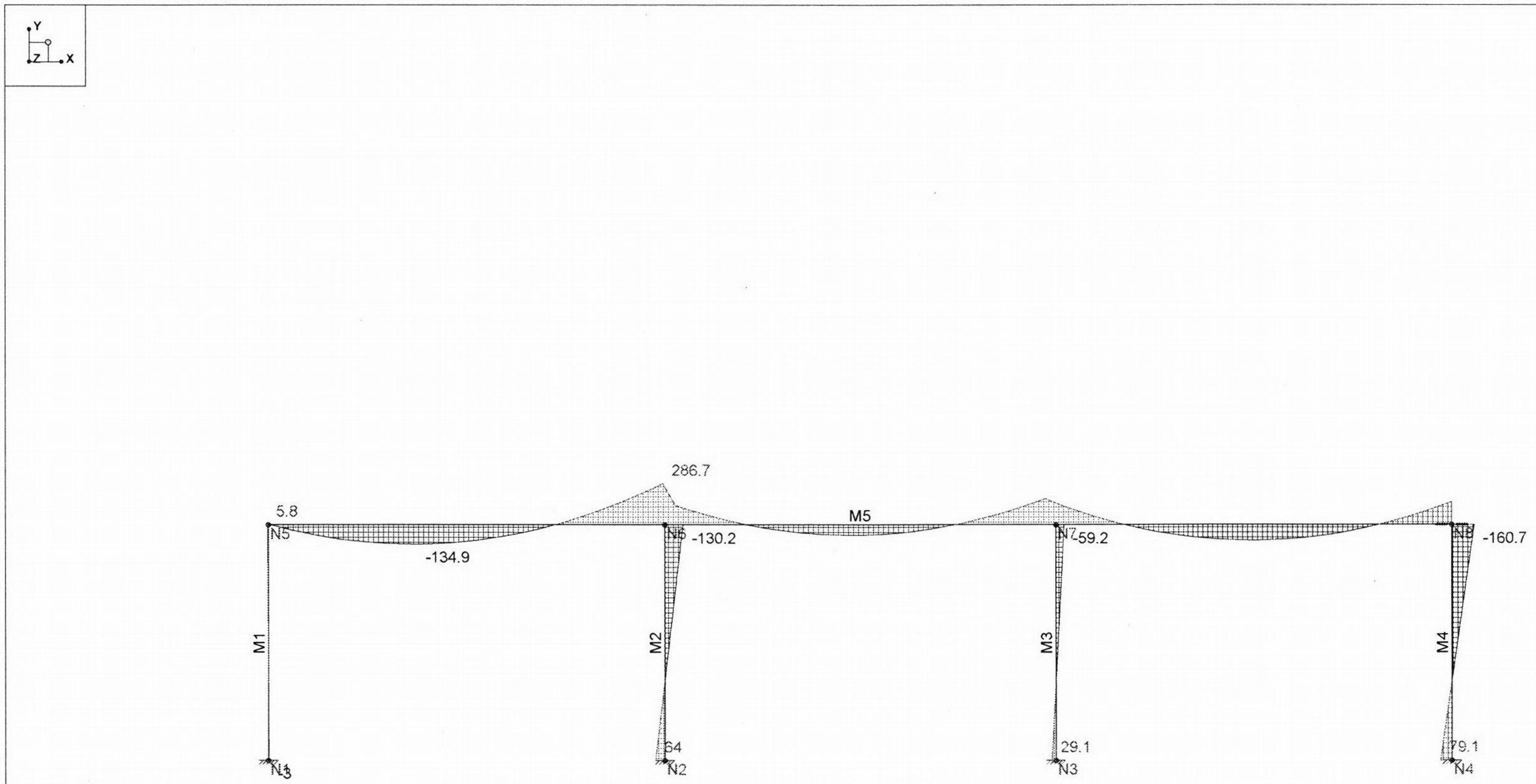


Results for LC 3, Gravity only
Member z Bending Moments (k-ft)

SK - 7

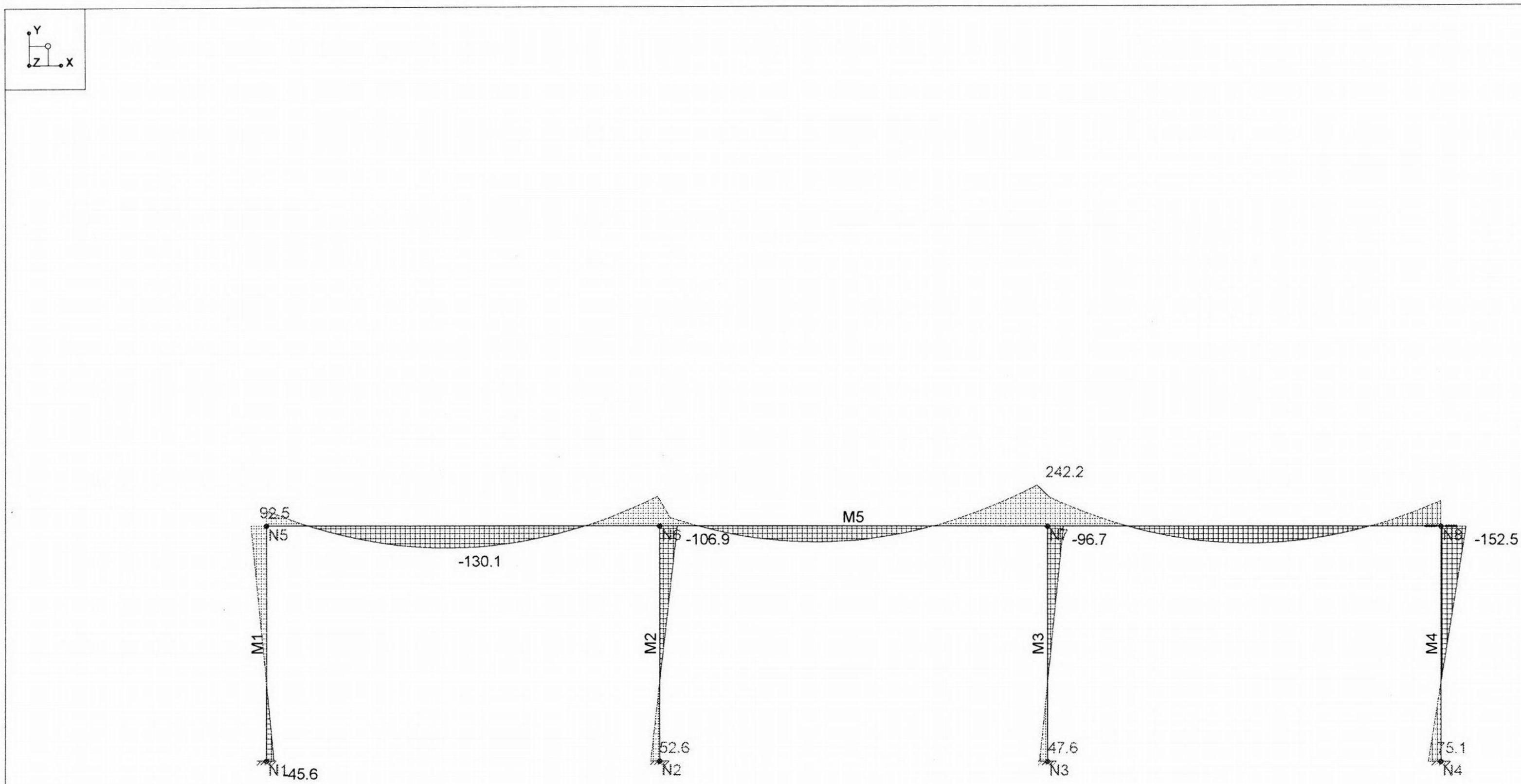
Dec 12, 2014 at 9:22 AM

Column Vert. Disp. 20ft bays static+eq.r3d



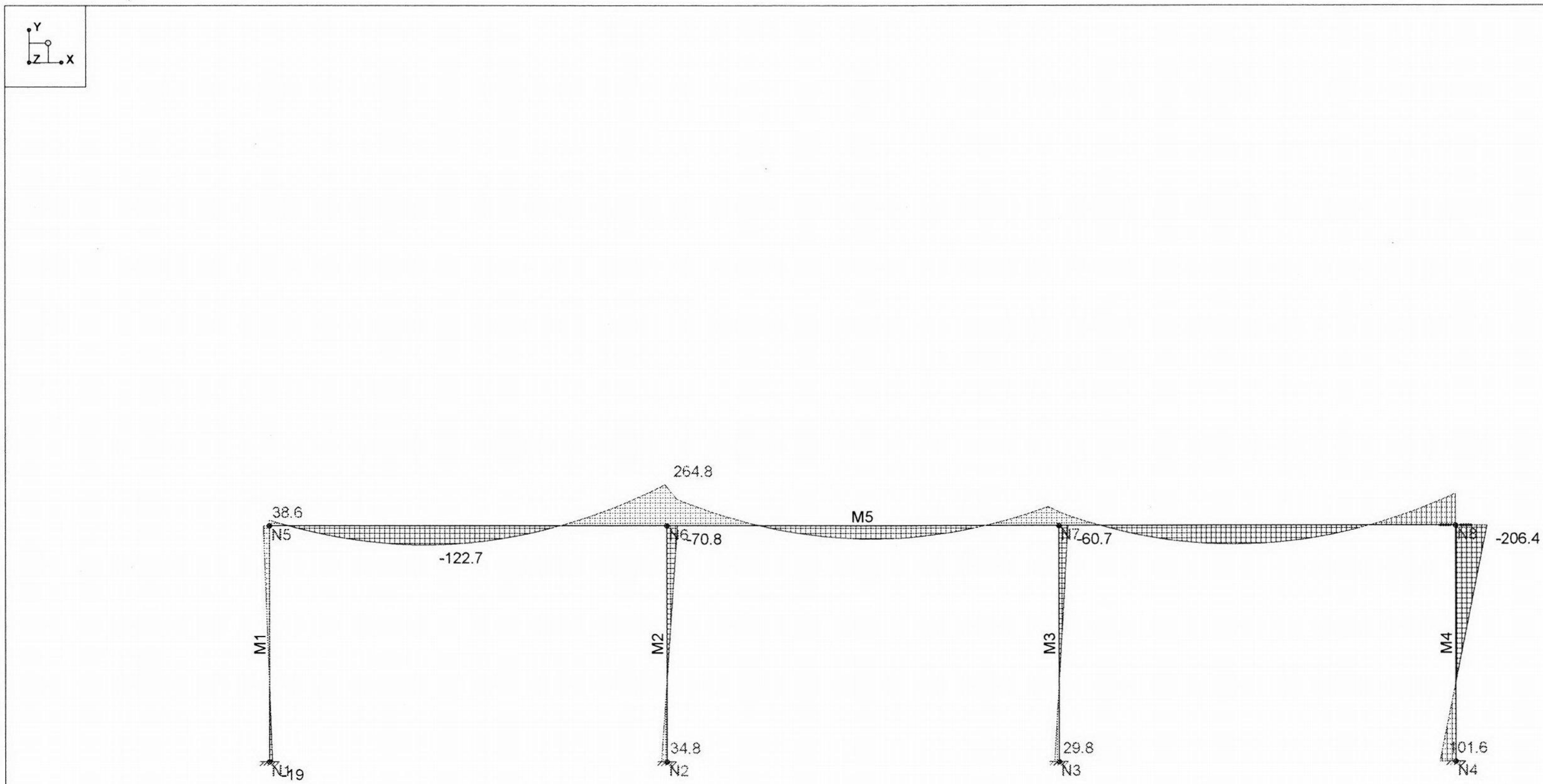
Results for LC 4, Qud (static at N1)
Member z Bending Moments (k-ft)

		SK - 10
		Dec 12, 2014 at 9:25 AM
		Column Vert. Disp. 20ft bays static+eq.r3d



Results for LC 5, Qud (static at N2)
Member z Bending Moments (k-ft)

		SK - 11
		Dec 12, 2014 at 9:26 AM
		Column Vert. Disp. 20ft bays static+eq.r3d

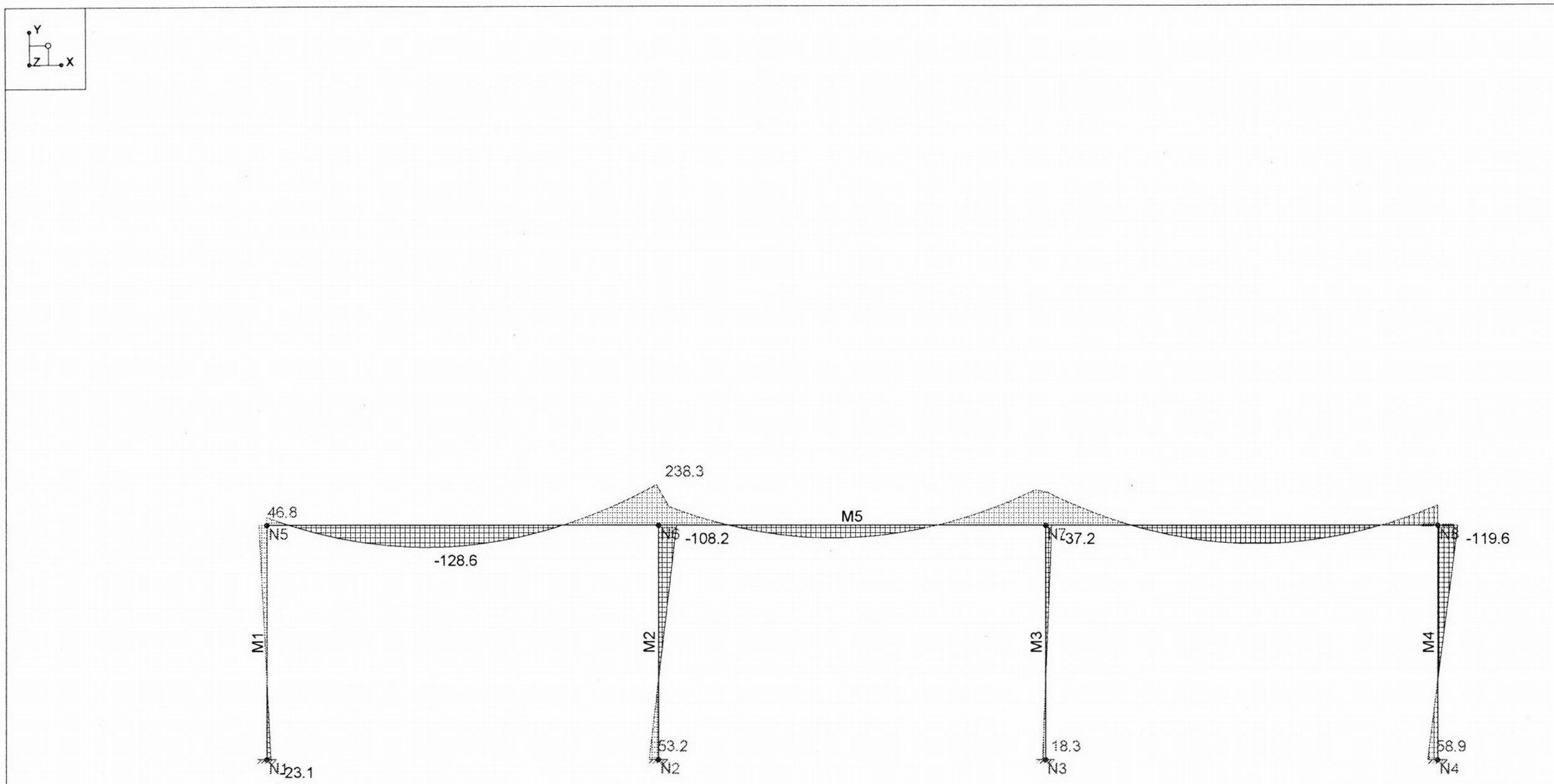


Results for LC 6, Qud (static at N3)
Member z Bending Moments (k-ft)

SK - 12

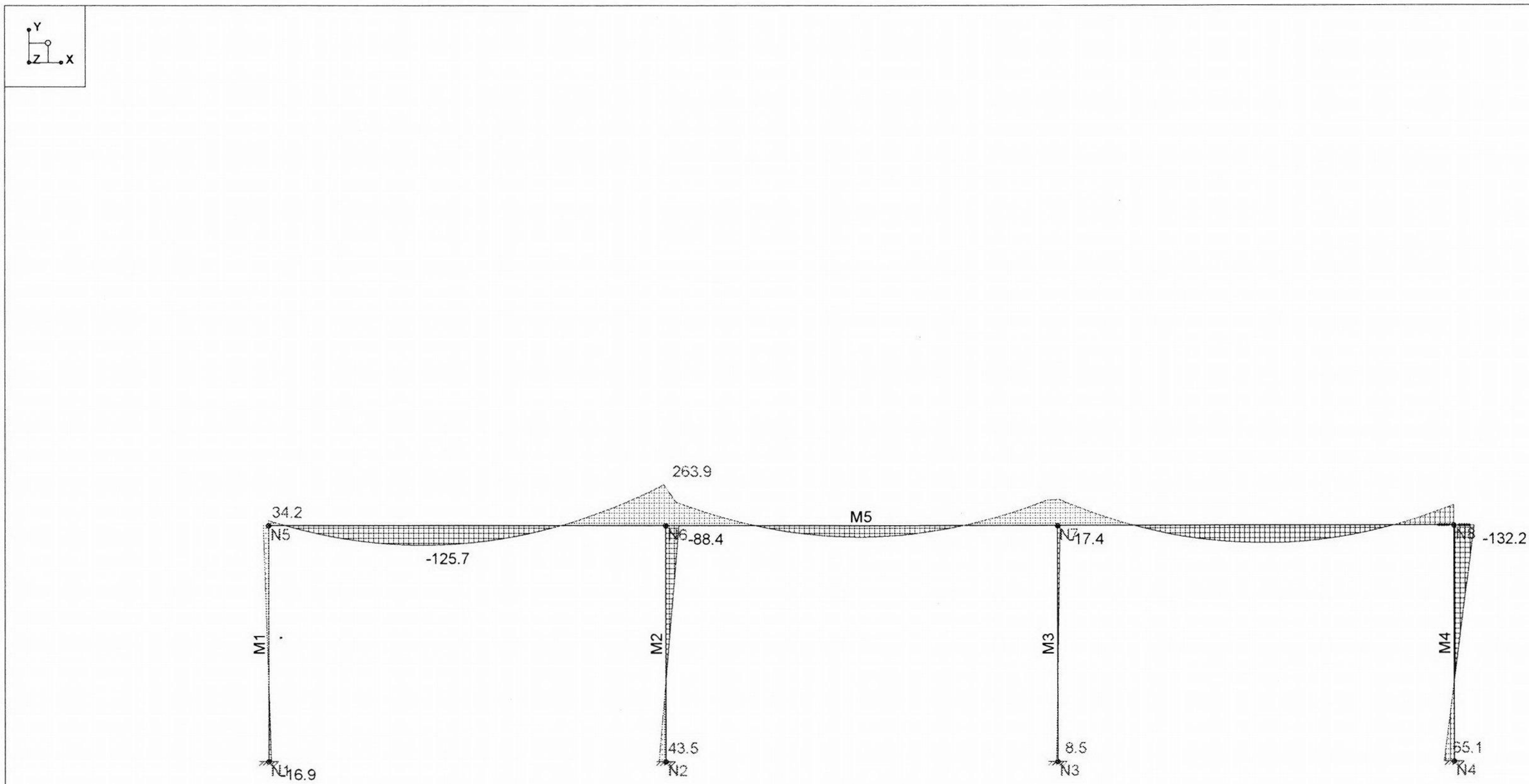
Dec 12, 2014 at 9:31 AM

Column Vert. Disp. 20ft bays static+eq.r3d



Results for LC 7, Qud (static at N4)
Member z Bending Moments (k-ft)

		SK - 13
		Dec 12, 2014 at 9:32 AM
		Column Vert. Disp. 20ft bays static+eq.r3d

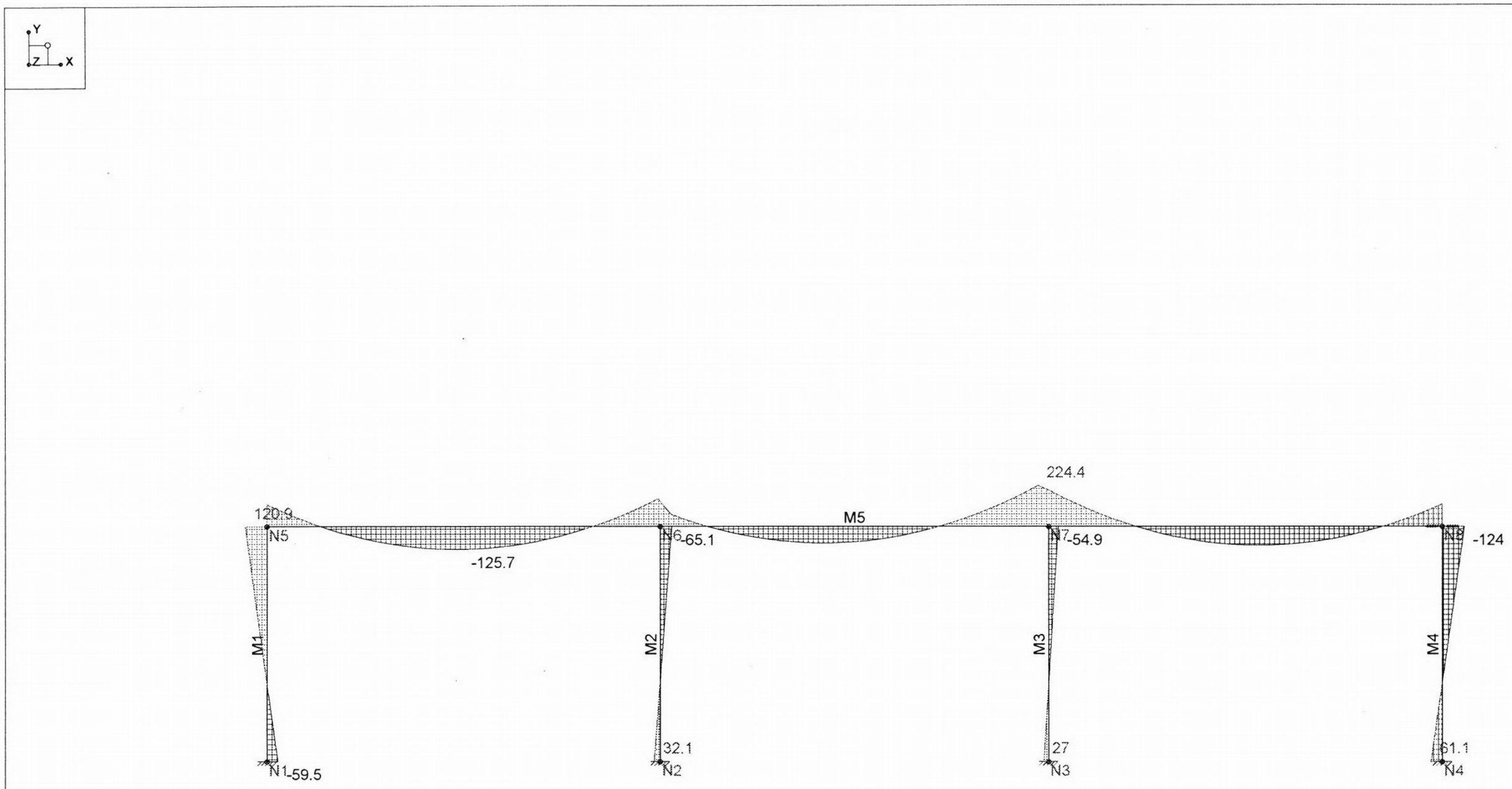


Results for LC 8, Quf (static at N1)
Member z Bending Moments (k-ft)

SK - 14

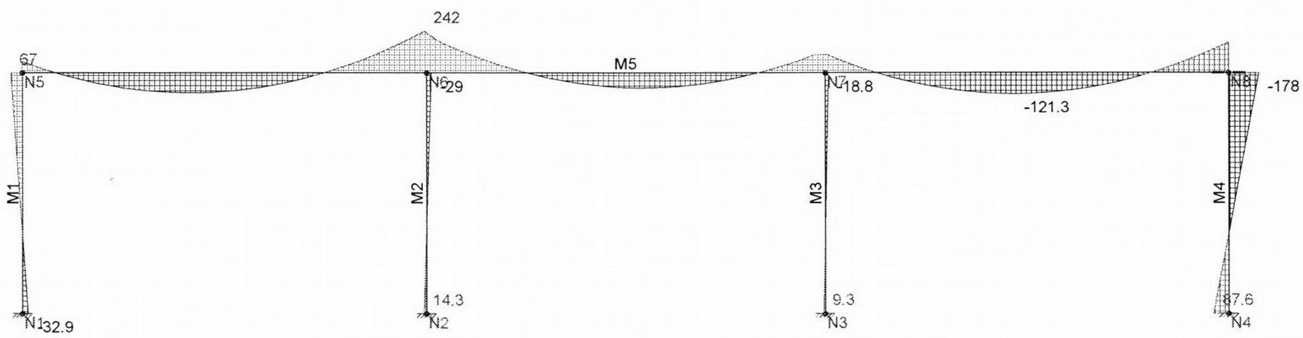
Dec 12, 2014 at 9:33 AM

Column Vert. Disp. 20ft bays static+eq.r3d



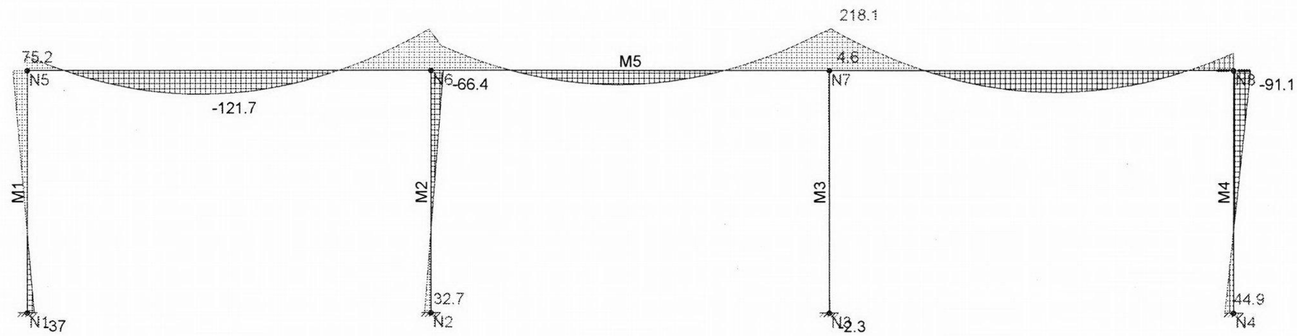
Results for LC 9, Quf (static at N2)
Member z Bending Moments (k-ft)

		SK - 15
		Dec 12, 2014 at 9:33 AM
		Column Vert. Disp. 20ft bays static+eq.r3d



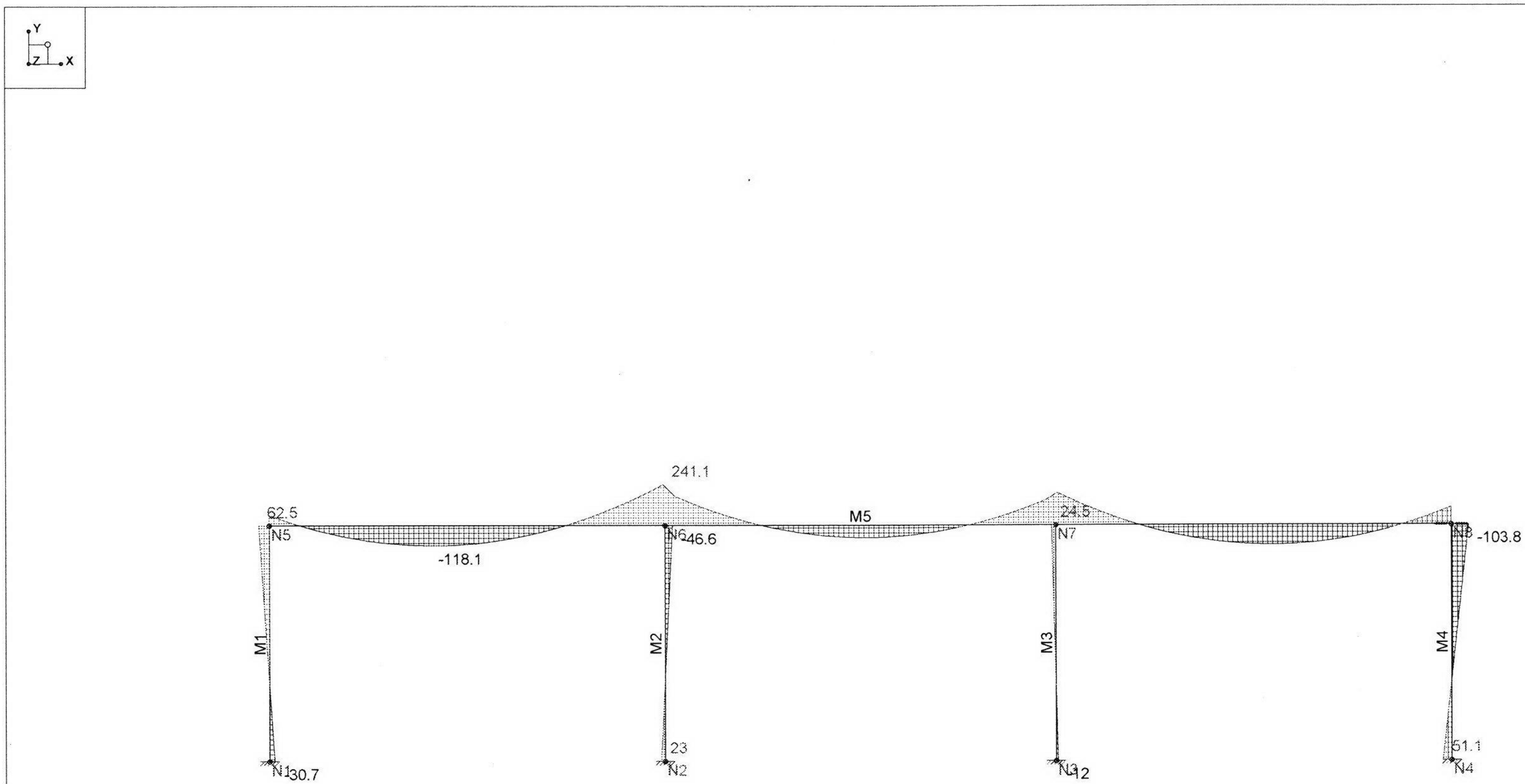
Results for LC 10, Quf(static at N3)
Member z Bending Moments (k-ft)

		SK - 16
		Dec 12, 2014 at 9:34 AM
		Column Vert. Disp. 20ft bays static+eq.r3d



Results for LC 11, Quf(static at N4)
Member z Bending Moments (k-ft)

		SK - 17
		Dec 12, 2014 at 9:34 AM
		Column Vert. Disp. 20ft bays static+eq.r3d

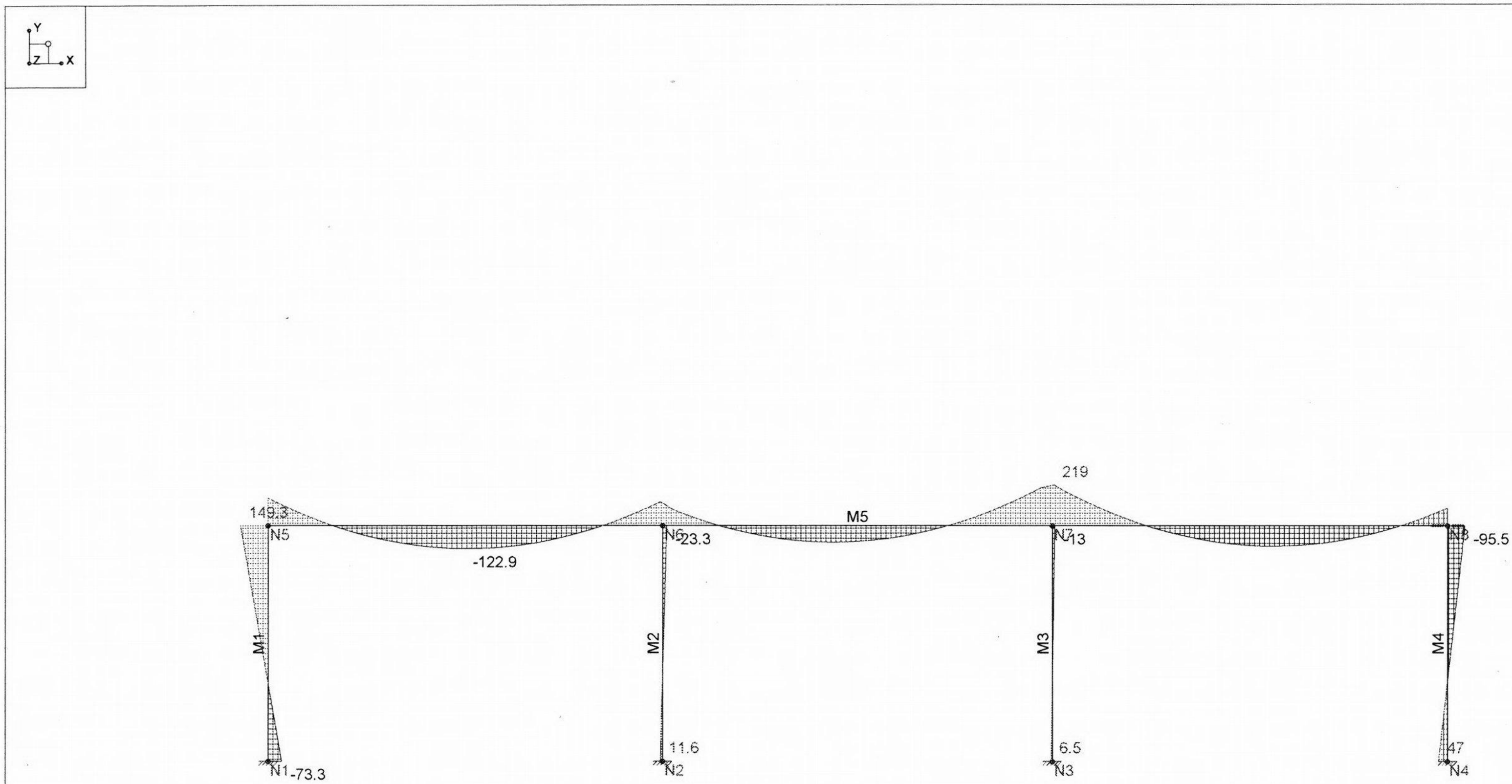


Results for LC 12, Gravity only (Static N1)
Member z Bending Moments (k-ft)

SK - 18

Dec 12, 2014 at 9:35 AM

Column Vert. Disp. 20ft bays static+eq.r3d

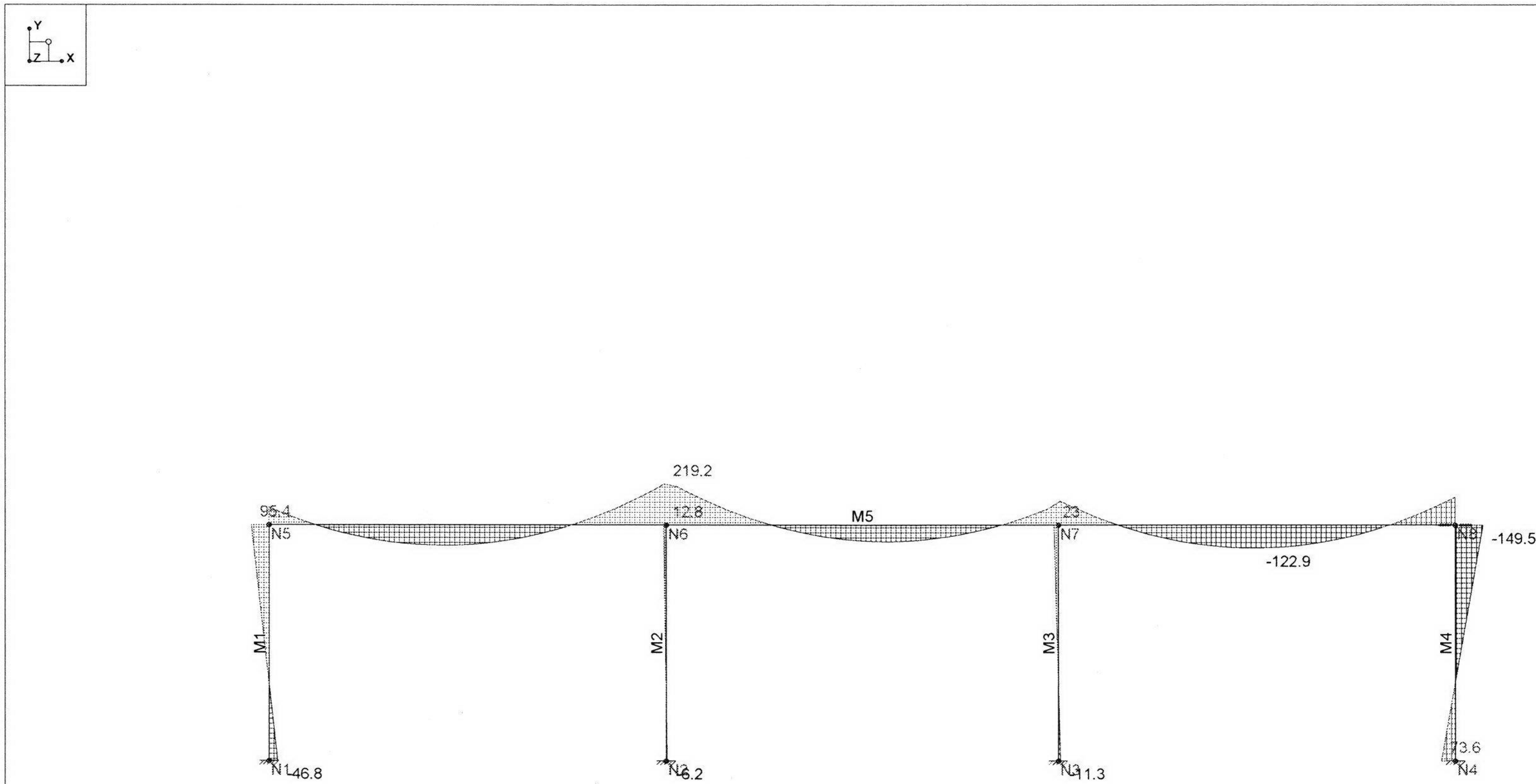


Results for LC 13, Gravity only (Static N2)
Member z Bending Moments (k-ft)

SK - 19

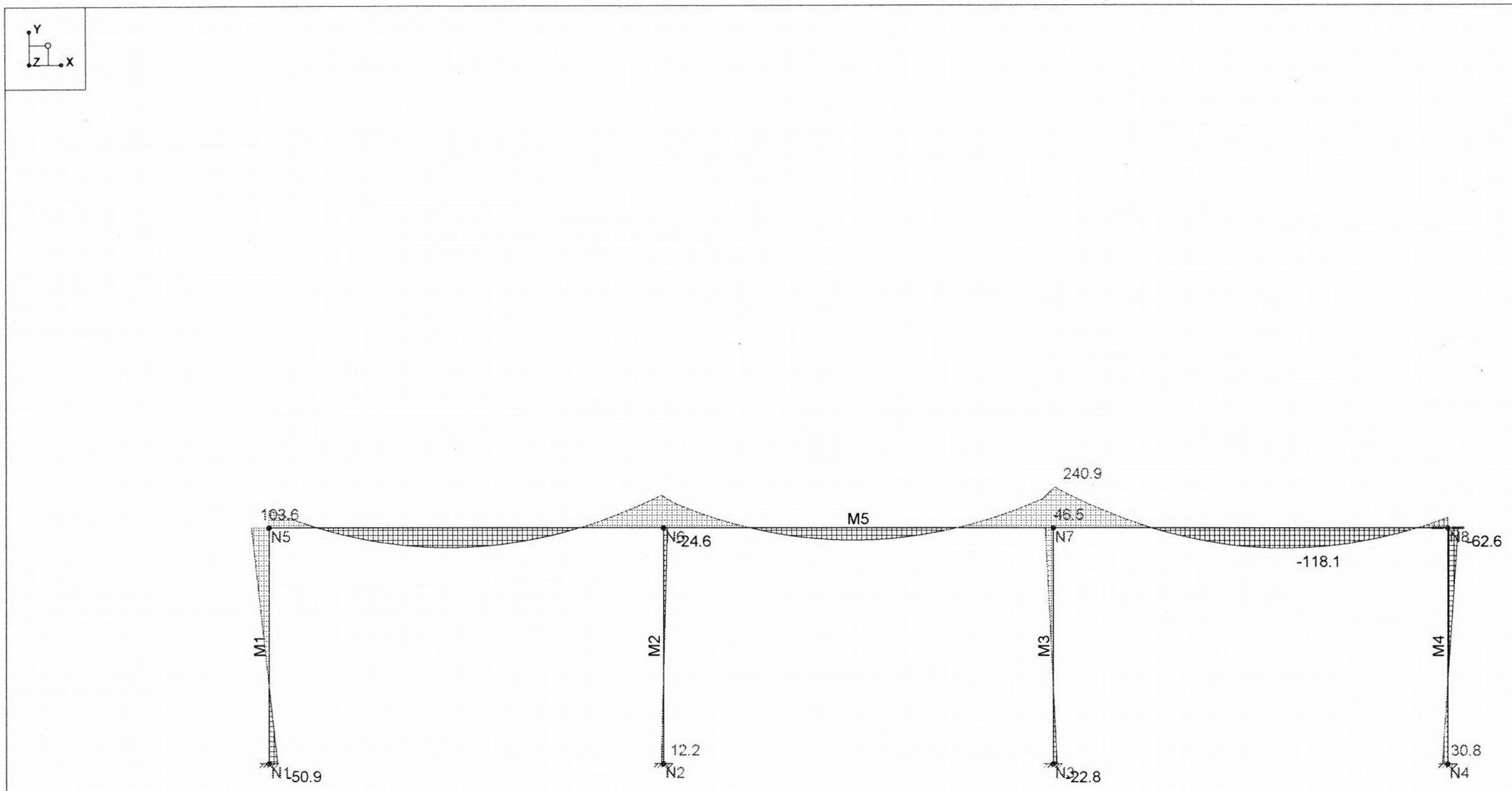
Dec 12, 2014 at 9:36 AM

Column Vert. Disp. 20ft bays static+eq.r3d



Results for LC 14, Gravity only (Static N3)
Member z Bending Moments (k-ft)

		SK - 20
		Dec 12, 2014 at 9:36 AM
		Column Vert. Disp. 20ft bays static+eq.r3d



Results for LC 15, Gravity only (Static N4)
Member z Bending Moments (k-ft)

		SK - 21
		Dec 12, 2014 at 9:37 AM
		Column Vert. Disp. 20ft bays static+eq.r3d

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	3	N1	10.21	37.931	0	0	0	-50.437
2	3	N2	-2.037	86.909	0	0	0	10.141
3	3	N3	2.012	86.913	0	0	0	-9.923
4	3	N4	-10.235	37.945	0	0	0	50.65
5	3	N5	0	0	0	0	0	0
6	3	N6	0	0	0	0	0	0
7	3	N7	0	0	0	0	0	0
8	3	N8	.05	0	0	0	0	0
9	3	Totals:	0	249.698	0			
10	3	COG (ft):	X: 37.833	Y: 15	Z: 0			

DCI ENGINEERS	Project No.	Sheet No. 3.0
Project		Date
Subject		By

3. Acceptance Criteria - 7.5.2.2.

Deformation Controlled (Moment)

$m k Q_{CE} > Q_{UD}$

$2.75(1) Q_{CE} > Q_{UD}$

$2.75 Q_{CE} > Q_{UD}$

From Risa 3D

$M_{QUD} = 284^{1\text{-}K}$ (@ col.)

or

$-135^{1\text{-}K}$ (@ mid)

$K = 1.0$ (6.2.4)

m = see table 10-16

Q_{CE} = see Ram output

Forced Controlled (Shear)

$K Q_{CL} > Q_{UF}$

$Q_{CL} = 277^{K}$

$Q_{UF} = 87^{K}$

(1)(277 > 87 okay

$K = 1.0$

Q_{CL} = Lower bound capacity using

$F'_c = 5\text{ksi}$

$F_y = 60\text{ksi}$

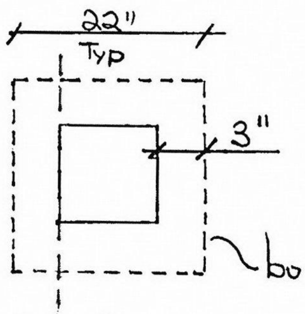
DCI ENGINEERS	Project No.	Sheet No. 3.2
Project		Date
Subject		By

m value determination → Table 10-16

based on V_g/V_o

V_g = gravity shear @ critical section per ACI for two-way (punching) shear = d/2

$V_g = 86.91^K$ (per RISA 3d)



d = 6"

$b_o = (4)(16+6)$
= 88" (int)
= 60" (ext)

V_o = punching shear strength (per ACI)

$V_c = (\beta_p \lambda \sqrt{f'_c} + 0.3 f_{pc}) b_o d + V_p$ [11-34 from ACI 318]

$[3.5(1)\sqrt{7500} + 0]\, 88(6) + 0$

$V_c = 160K$

$V_{c\,max} = 3\sqrt{f'_c}\, b_o d = 137^K$ (governs)

$\lambda = 1.0$
$\beta_p = 3.5$ @ int.
3.5 @ edge
$f_{pc} = 0$ assume 0
$b_o = 88"$
$f'_c = 7500$ psi
$d = 6"$
$V_p = 0$ conservative t use 0 per AC

Allowable punching shear for deformation controlled

$V_s = \dfrac{A_v f_{y(E)} d}{s}$

$V_s = \dfrac{(2.35)(50)6}{4.25} = 165^K$

$A_v = 2.35\,in^2$
(0.196)(12)
A_{stud} ∟ # of stud
$s = 4\frac{1}{4}"$
$f_y = 50$ ksi

$V_o = V_n = V_c + V_s = \underline{302^K}$ → Governs

$V_{n\,max} = 8\sqrt{f'_c}\, b_o d = 365K$

$V_g/V_o = 86.91^K/302 = \underline{0.29}$

DCI ENGINEERS	Project No.	Sheet No. 3.3
Project		Date
Subject		By

$V_g/V_o = 0.29$

M @ CP for secondary members

@ $\frac{V_g}{V_o} = 0$ $M = 3.25$

@ $\frac{V_g}{V_o} = 0.6$ $M = 2.25$

Interpolate

$M = 2.75$

DCI ENGINEERS

Project No.	Sheet No. 3.4
Project	Date
Subject	By

Shear Design @ Lower Bound

$$V_c = [\beta_p \lambda \sqrt{f'_c} + 0.3 f_{ps}] b_o d + V_p$$

$$V_c = 130^k$$

$$V_{c\,max} = 3\sqrt{f'_c}\, b_o d = 112^k \text{ Governs}$$

$$V_s = \frac{A_v f_{yt} d}{s}$$

$$V_s = 165^k$$

$$V_n = 112 + 165 = 277^k$$

↑ Allowable Punching Shear for force controlled

$f'_c = 5000\text{psi}$

$f_{y\,stud} = 50\text{ksi}$

$V_p = 0$ conservative

$f_{ps} = 0$ conservative

$\beta_p = 3.5$

$b_o = 88$

$d = 6$

$s = 4\frac{1}{4}$

$A_v = 2.35$

Materials

Concrete Mix

Mix Name	Density (pcf)	Density For Loads (pcf)	f'ci (psi)	f'c (psi)	fcui (psi)	fcu (psi)	Poissons Ratio	Ec Calc	User Eci (psi)	User Ec (psi)
3000 psi	150	150	3000	3000	3725	3725	0.2	Code	2500000	3000000
4000 psi	150	150	3000	4000	3725	4975	0.2	Code	2500000	3000000
5000 psi	150	150	3000	5000	3725	6399	0.2	Code	2500000	3000000
6000 psi	150	150	3000	6000	3725	7450	0.2	Code	2500000	3000000
7500 psi	150	150	3000	7500	3725	9050	0.2	Code	2500000	3000000

PT Systems

System Name	Type	Aps (in^2)	Eps (ksi)	fse (ksi)	fpy (ksi)	fpu (ksi)	Duct Width (inches)	Strands Per Duct	Min Radius (feet)
½" Unbonded	unbonded	0.153	28000	175	243	270	0.5	1	6
½" Bonded	bonded	0.153	28000	160	243	270	3	4	6
0.6" Unbonded	unbonded	0.217	28000	175	243	270	0.6	1	8
0.6" Bonded	bonded	0.217	28000	160	243	270	4	4	8

PT Stressing Parameters

System Name	Jacking Stress (ksi)	Seating Loss (inches)	Anchor Friction	Wobble Friction (1/feet)	Angular Friction (1/radians)	Long-Term Losses (ksi)
½" Unbonded	216	0.25	0	0.0014	0.07	22
½" Bonded	216	0.25	0.02	0.001	0.2	22
0.6" Unbonded	216	0.25	0	0.0014	0.07	22
0.6" Bonded	216	0.25	0.02	0.001	0.2	22

Reinforcing Bars

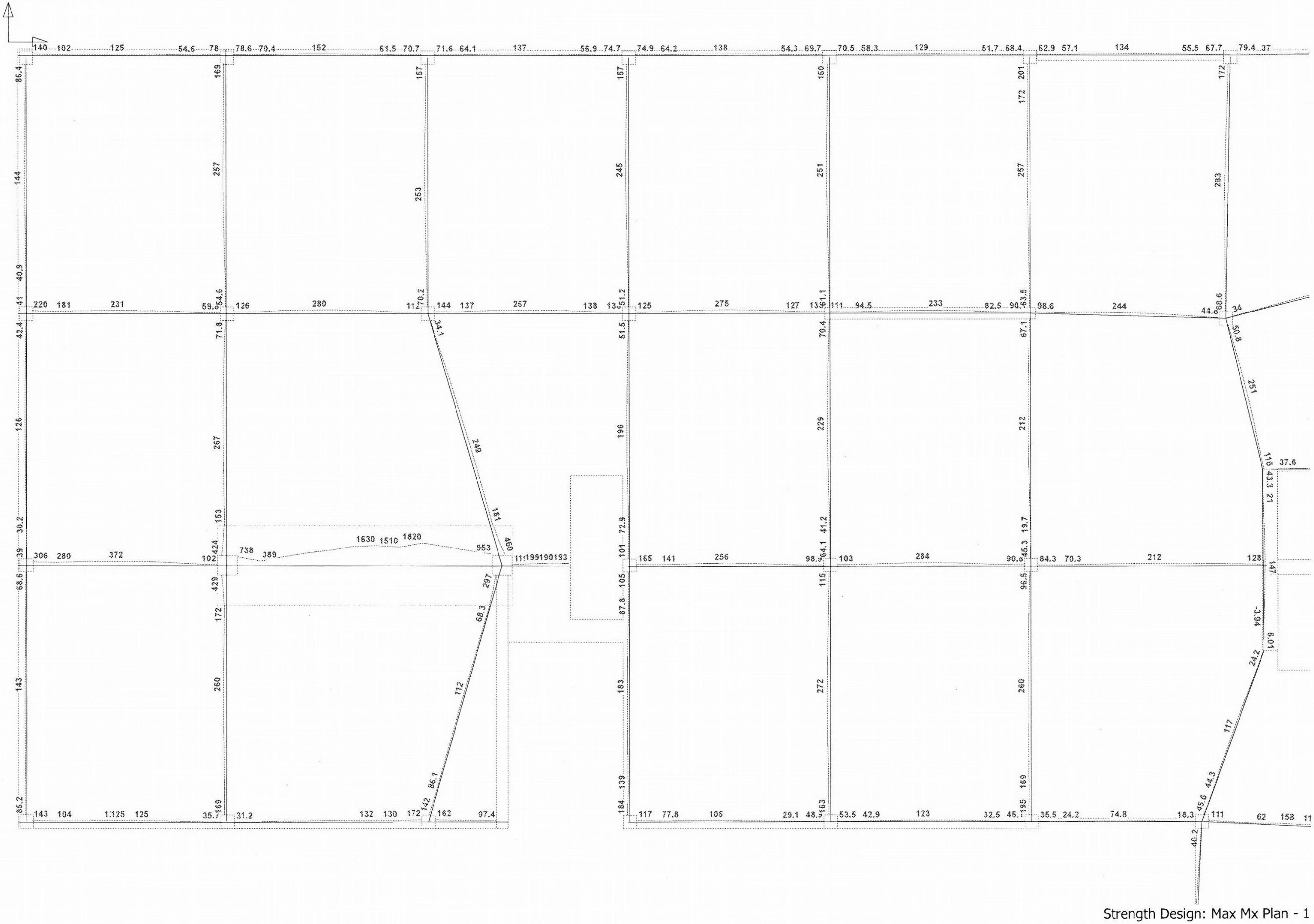
Bar Name	As (in^2)	Es (ksi)	Fy (ksi)	Coating	Straight Ld/Db	90 Hook Ld/Db	180 Hook Ld/Db
#3	0.11	29000	75	None	Code	Code	Code
#4	0.2	29000	75	None	Code	Code	Code
#5	0.31	29000	75	None	Code	Code	Code
#6	0.44	29000	75	None	Code	Code	Code
#7	0.6	29000	75	None	Code	Code	Code
#8	0.79	29000	75	None	Code	Code	Code
#9	1	29000	75	None	Code	Code	Code
#10	1.27	29000	75	None	Code	Code	Code
#11	1.56	29000	75	None	Code	Code	Code

SSR Systems

SSR System Name	Stud Area (in^2)	Head Area (in^2)	Min Clear Head Spacing (inches)	Specified Stud Spacing (inches)	Fy (ksi)	Stud Spacing Rounding Increment (inches)	Min Studs Per Rail	System Type
3/8" SSR	0.11	1.11	0.5	None	50	0.25	2	Rail
1/2" SSR	0.196	1.96	0.5	None	50	0.25	2	Rail
5/8" SSR	0.307	3.07	0.5	None	50	0.25	2	Rail
3/4" SSR	0.442	4.42	0.5	None	50	0.25	2	Rail

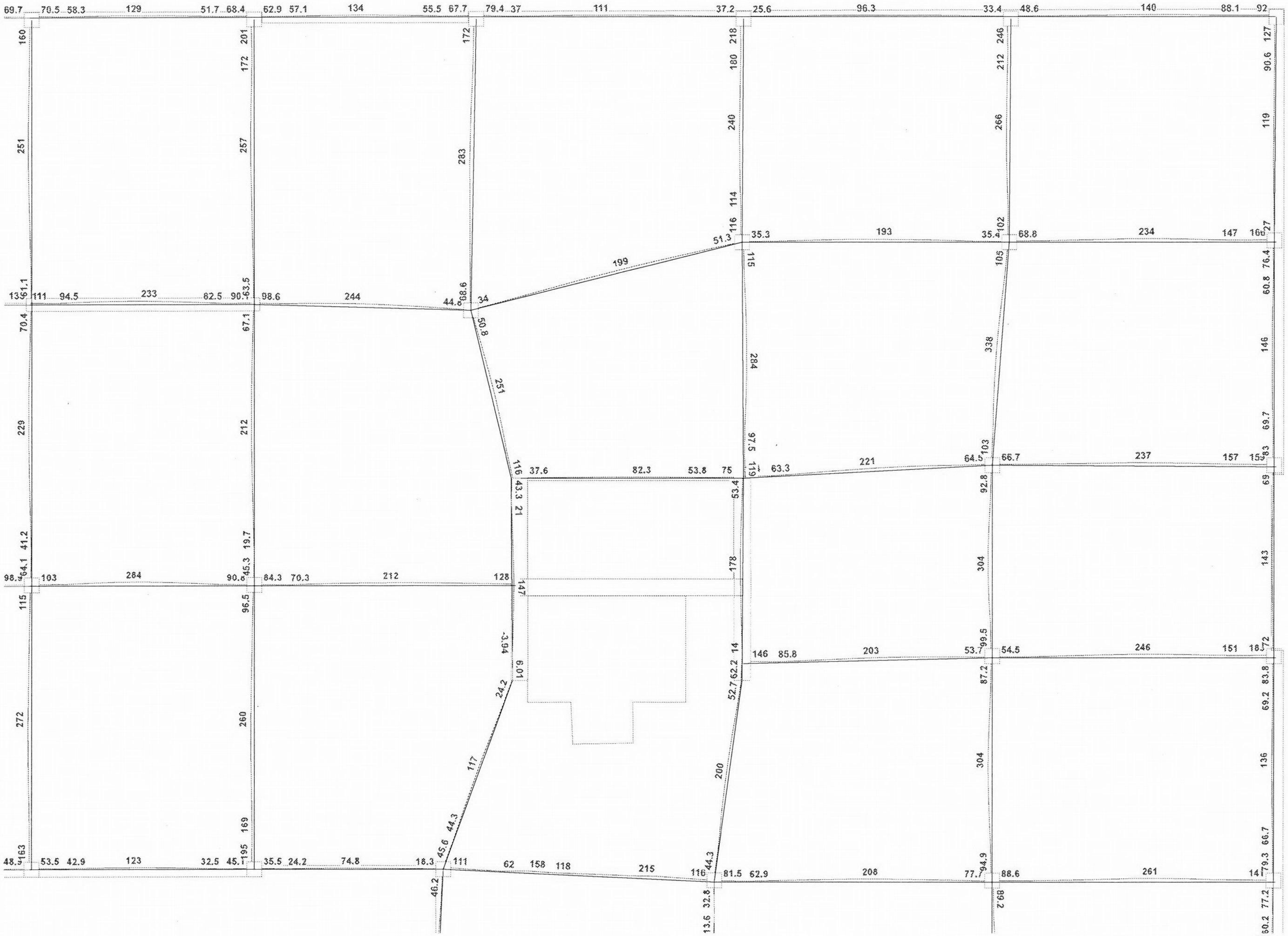
Strength Design: Max Mx Plan

Strength Design: User Lines; User Notes; User Dimensions; Latitude Span Designs; Longitude Span Designs; Latitude DS Designs; Longitude DS Designs; PC Designs;
Drawing Import: User Lines; User Notes; User Dimensions;
Element: Wall Elements Below; Wall Elements Above; Wall Element Outline Only; Column Elements Below; Column Elements Above; Slab Elements; Slab Element Outline Only;
Scale = 1:150
Strength Design - Section Analysis Plot: (Moment)(Context: Max Capacity)



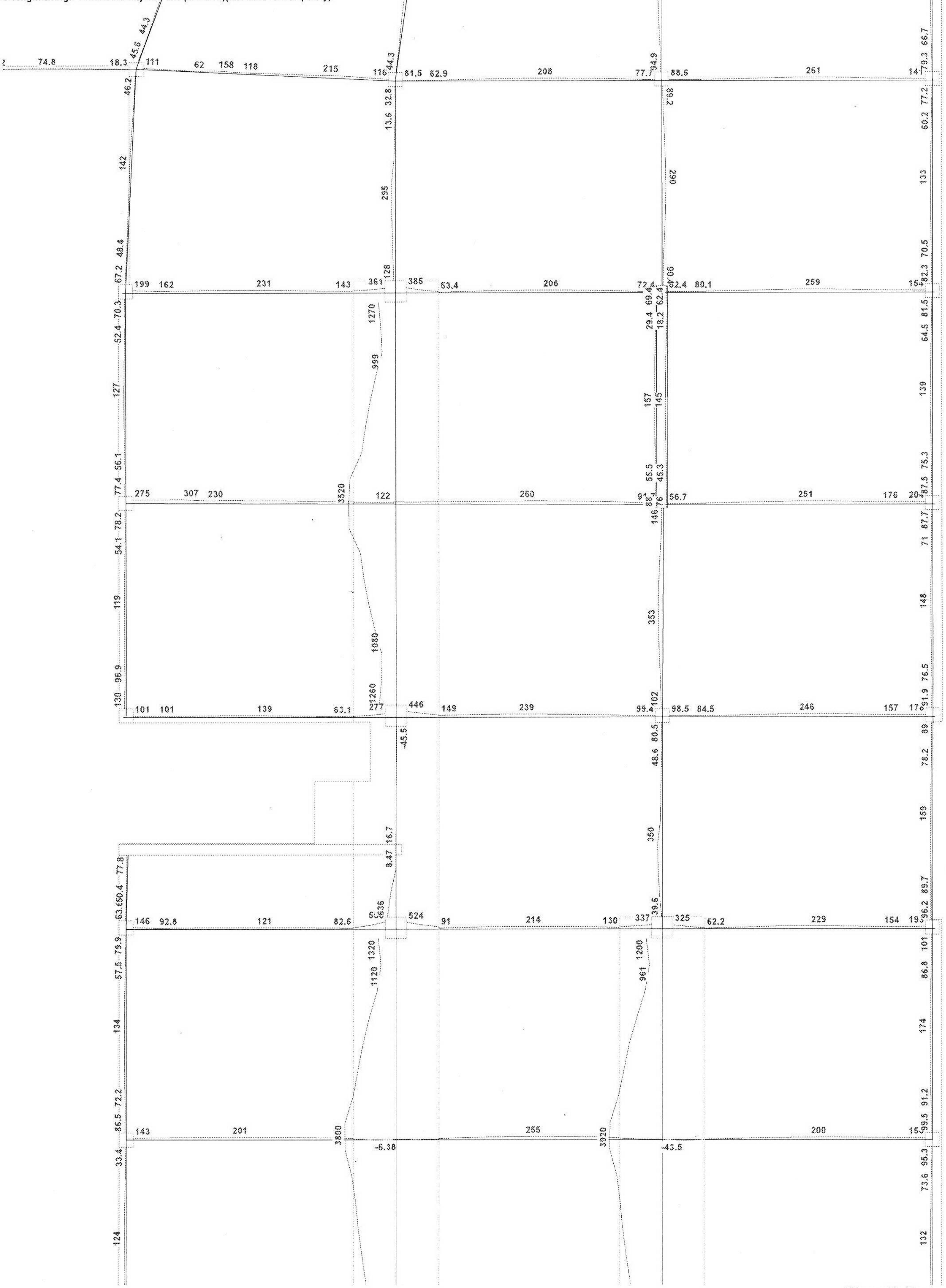
Strength Design: Max Mx Plan

Strength Design: User Lines; User Notes; User Dimensions; Latitude Span Designs; Longitude Span Designs; Latitude DS Designs; Longitude DS Designs; PC Designs;
Drawing Import: User Lines; User Notes; User Dimensions;
Element: Wall Elements Below; Wall Elements Above; Wall Element Outline Only; Column Elements Below; Column Elements Above; Slab Elements; Slab Element Outline Only;
Scale = 1:150
Strength Design - Section Analysis Plot: (Moment)(Context: Max Capacity)

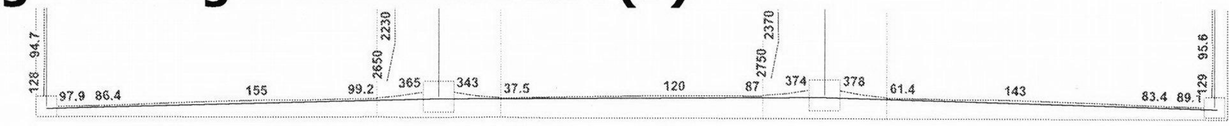


Strength Design: Max Mx Plan

Strength Design: User Lines; User Notes; User Dimensions; Latitude Span Designs; Longitude Span Designs; Latitude DS Designs; Longitude DS Designs; PC Designs;
Drawing Import: User Lines; User Notes; User Dimensions;
Element: Wall Elements Below; Wall Elements Above; Wall Element Outline Only; Column Elements Below; Column Elements Above; Slab Elements; Slab Element Outline Only;
Scale = 1:150
Strength Design - Section Analysis Plot: (Moment)(Context: Max Capacity)

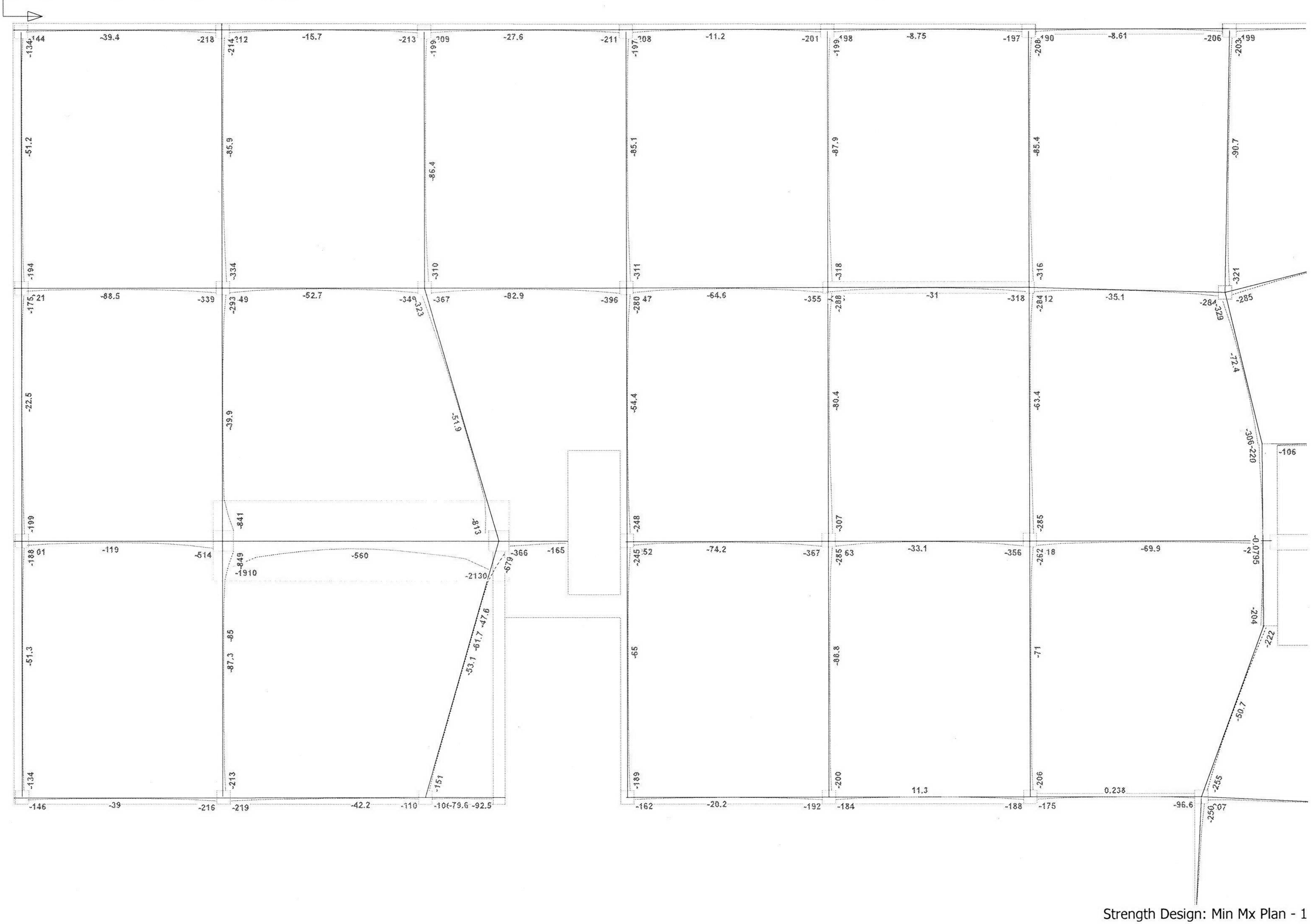


Strength Design: Max Mx Plan (2)



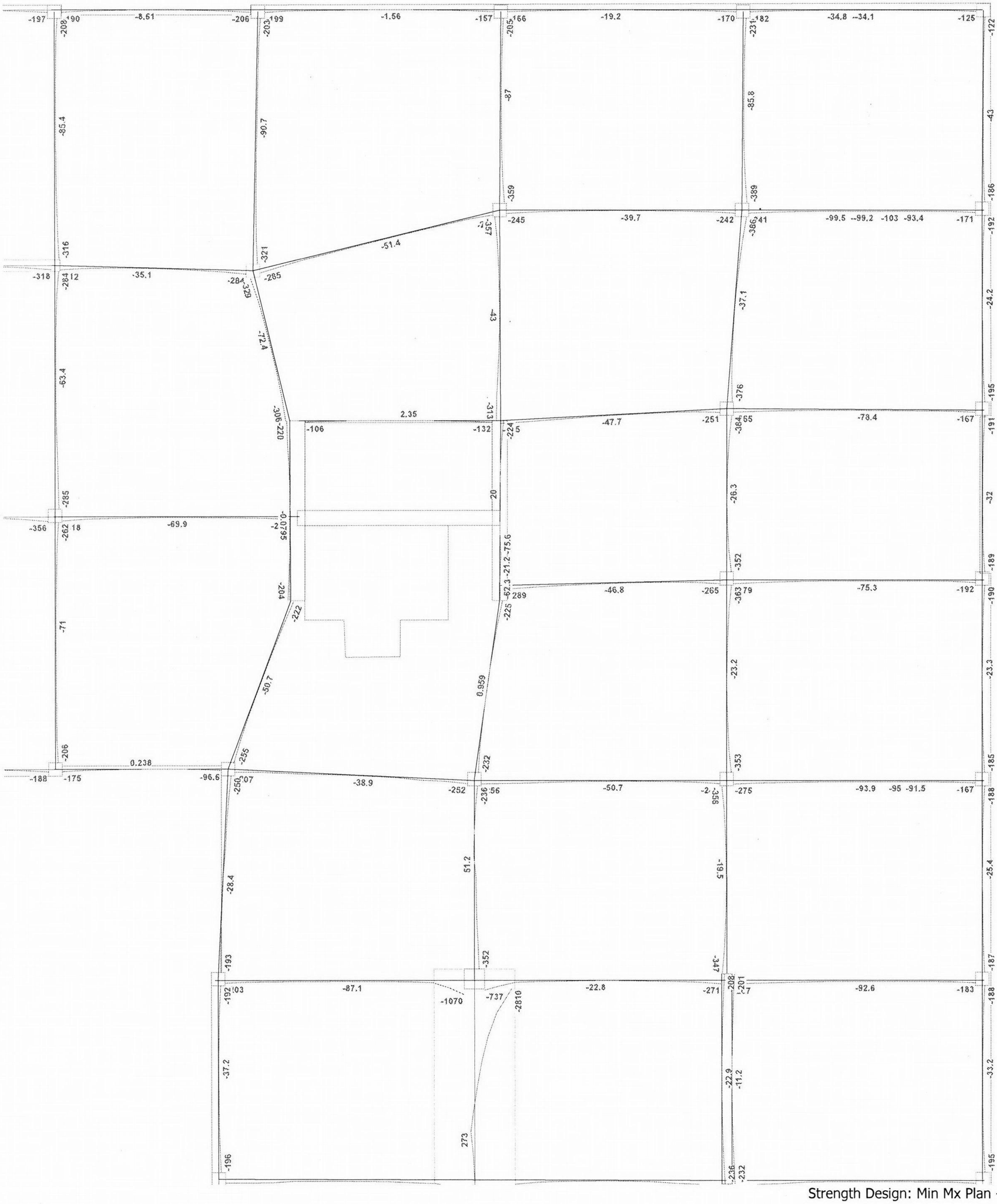
Strength Design: Min Mx Plan

Strength Design: User Lines; User Notes; User Dimensions; Latitude Span Designs; Longitude Span Designs; Latitude DS Designs; Longitude DS Designs; PC Designs;
Drawing Import: User Lines; User Notes; User Dimensions;
Element: Wall Elements Below; Wall Elements Above; Wall Element Outline Only; Column Elements Below; Column Elements Above; Slab Elements; Slab Element Outline Only;
Scale = 1:150
Strength Design - Section Analysis Plot: (Moment)(Context: Min Capacity)



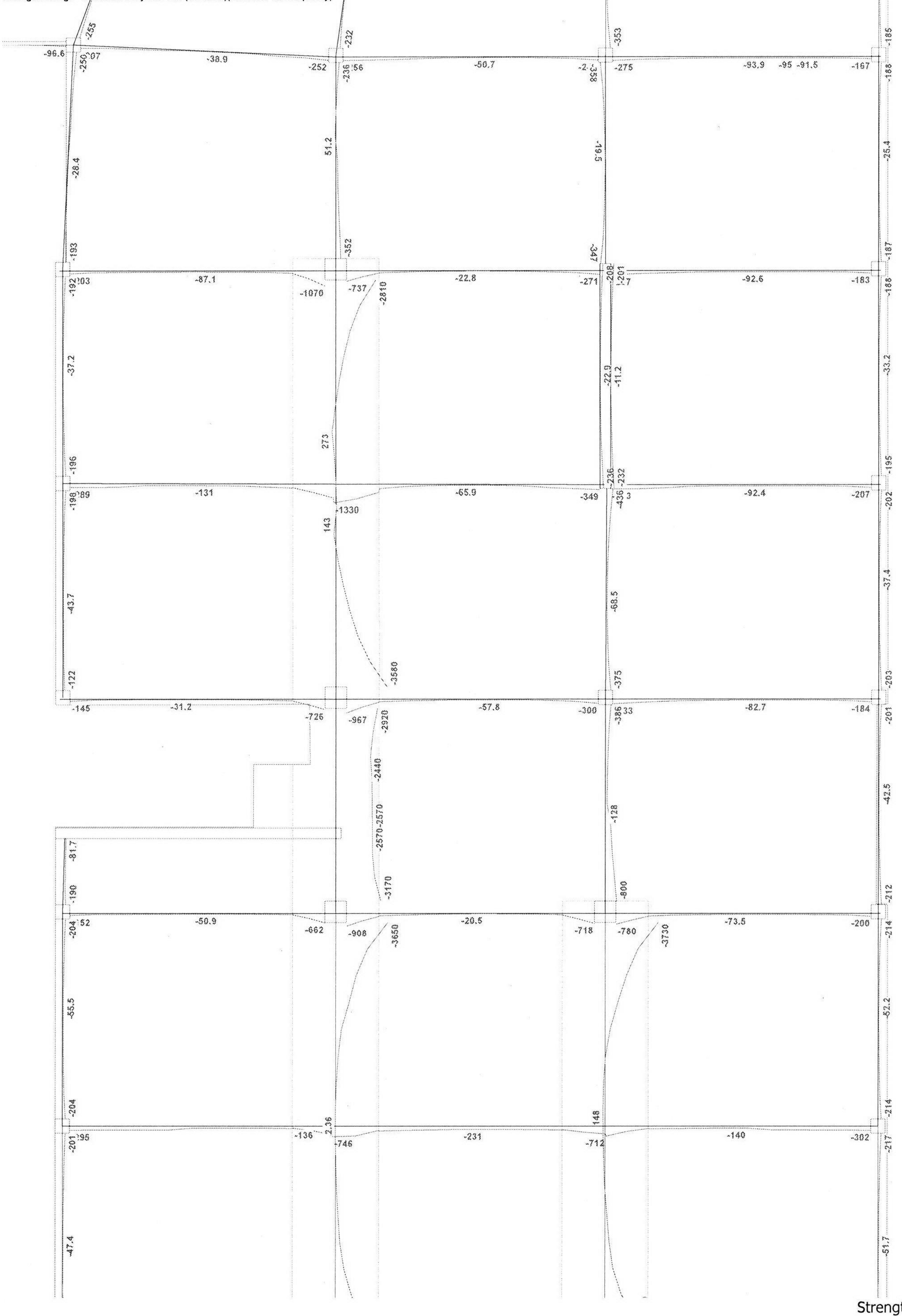
Strength Design: Min Mx Plan

Strength Design: User Lines; User Notes; User Dimensions; Latitude Span Designs; Longitude Span Designs; Latitude DS Designs; Longitude DS Designs; PC Designs;
Drawing Import: User Lines; User Notes; User Dimensions;
Element: Wall Elements Below; Wall Elements Above; Wall Element Outline Only; Column Elements Below; Column Elements Above; Slab Elements; Slab Element Outline Only;
Scale = 1:150
Strength Design - Section Analysis Plot: (Moment)(Context: Min Capacity)

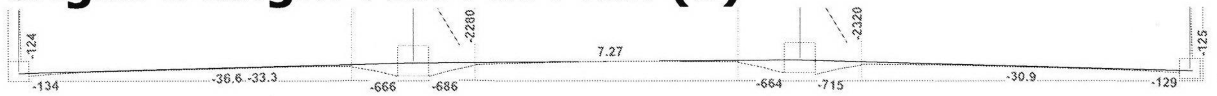


Strength Design: Min Mx Plan

Strength Design: User Lines; User Notes; User Dimensions; Latitude Span Designs; Longitude Span Designs; Latitude DS Designs; Longitude DS Designs; PC Designs;
Drawing Import: User Lines; User Notes; User Dimensions;
Element: Wall Elements Below; Wall Elements Above; Wall Element Outline Only; Column Elements Below; Column Elements Above; Slab Elements; Slab Element Outline Only;
Scale = 1:150
Strength Design - Section Analysis Plot: (Moment)(Context: Min Capacity)



Strength Design: Min Mx Plan (2)



CHAPTER 7
ANALYSIS PROCEDURES AND ACCEPTANCE CRITERIA

7.1 SCOPE

This chapter sets forth requirements for analysis of buildings using either the Tier 2 deficiency-based procedures or Tier 3 systematic procedures. Section 7.2 specifies general analysis requirements for the mathematical modeling of buildings, including basic assumptions, consideration of torsion, diaphragm flexibility, P-Δ effects, soil–structure interaction (SSI), multidirectional effects, and overturning as well as analysis of diaphragms, continuity, and structural walls. Section 7.3 describes how to select one of the four analysis procedures and sets limitations on their application. Section 7.4 specifies the requirements for the four analysis procedures. Section 7.5 defines component acceptance criteria, including behavior types and capacities. Section 7.6 specifies procedures for developing alternative modeling parameters and acceptance criteria.

For Tier 2 deficiency-based procedures in Chapter 5, the analysis need only be used to determine demands, capacities, and acceptance criteria for those elements that the Tier 2 procedures designate to be evaluated.

Analysis of buildings with seismic isolation or energy dissipation systems shall comply with the requirements of Chapter 14.

C7.1 SCOPE

This chapter covers analysis for both the evaluation of an existing building and the design of retrofit measures. It describes the loading requirements, mathematical model, and detailed analytical procedures required to estimate seismic force and deformation demands on components of a building. General analysis requirements are specified in Section 7.2 for gravity loads, primary and secondary components, damping, foundation modeling, multidirectional excitation, vertical seismic effects, P-Δ effects, overturning, diaphragms, continuity of the framing system, walls, buildings sharing common components, and building separations.

The relationship of the analysis procedures described in this chapter with provisions in other chapters is as follows:

- Information on Performance Objectives, including Seismic Hazard Levels and target Building Performance Levels, is provided in Chapter 2.
- For Tier 3 systematic procedures in Chapter 6, the analysis must include the entire structural system in accordance with Section 7.2.
- Information on the calculation of appropriate stiffness and strength characteristics for components is provided in Chapters 8 through 12 and 14.
- Component force and deformation demands obtained from analysis using procedures described in this chapter, based on component acceptance criteria outlined in this chapter, are compared with permissible values provided in Chapters 8 through 12 and 14 for the desired Performance Level.
- Evaluation and retrofit methods for nonstructural components (including mechanical and electrical equipment) are presented in Chapter 13.

7.2 GENERAL ANALYSIS REQUIREMENTS

An analysis of the building shall be conducted in accordance with the requirements of this section.

7.2.1 Analysis Procedures An analysis of the building shall be performed using the linear static procedure (LSP), the linear dynamic procedure (LDP), the nonlinear static procedure (NSP), or the nonlinear dynamic procedure (NDP), selected based on the limitations specified in Section 7.3.

7.2.2 Component Gravity Loads and Load Combinations For linear procedures, the following actions caused by gravity loads, Q_G, shall be considered for combination with actions caused by seismic forces.

Where the effects or actions of gravity loads and seismic forces are additive, the action caused by gravity loads, Q_G, shall be obtained in accordance with Eq. (7-1):

$$Q_G = 1.1(Q_D + Q_L + Q_S) \quad (7\text{-}1)$$

where Q_D = Action caused by dead loads;
Q_L = Action caused by live load, equal to 25% of the unreduced live load obtained in accordance with ASCE 7 but not less than the actual live load; and
Q_S = Action caused by effective snow load.

Where the effects or actions of gravity loads and seismic forces are counteracting, the action caused by gravity loads, Q_G, shall be obtained in accordance with Eq. (7-2):

$$Q_G = 0.9Q_D \quad (7\text{-}2)$$

Where the flat roof snow load calculated in accordance with ASCE 7 exceeds 30 lb/ft^2, the effective snow load shall be taken as 20% of the calculated snow load. Where the flat roof snow load is less than 30 lb/ft^2, the effective snow load shall be permitted to be zero.

For nonlinear procedures, the following actions caused by gravity loads, Q_G, in accordance with Eq. (7-3) shall be considered for combination with actions caused by seismic forces:

$$Q_G = Q_D + Q_L + Q_S \quad (7\text{-}3)$$

where Q_D, Q_L, and Q_S are as defined for Eq. (7-1) above.

See Chapter 14 for gravity loads and load combinations for seismic isolation and energy dissipation systems.

C7.5.1.4 Material Properties Where calculations are used to determine expected or lower-bound strengths of components, expected or lower-bound material properties, respectively, shall be used.

7.5.1.5 Component Capacities

7.5.1.5.1 General Detailed criteria for calculation of individual component force and deformation capacities shall comply with the requirements in individual materials chapters as follows:

1. Foundations: Chapter 8;
2. Components composed of steel or cast iron: Chapter 9;
3. Components composed of reinforced concrete: Chapter 10;
4. Components composed of reinforced or unreinforced masonry: Chapter 11;
5. Components composed of timber, cold-formed steel light frame, gypsum, or plaster products: Chapter 12;
6. Nonstructural (architectural, mechanical, and electrical) components: Chapter 13; and
7. Seismic isolation systems and energy dissipation systems: Chapter 14.

Elements and components composed of combinations of materials are covered in the chapters associated with each material.

7.5.1.5.2 Linear Procedures If linear procedures are used, capacities for deformation-controlled actions shall be defined as the product of m-factors, κ-factors, and expected strengths, Q_{CE}. Capacities for force-controlled actions shall be defined as lower-bound strengths, Q_{CL}, as summarized in Table 7-6.

7.5.1.5.3 Nonlinear Procedures If nonlinear procedures are used, component capacities for deformation-controlled actions shall be taken as permissible inelastic deformation limits. Component capacities for force-controlled actions shall be taken as lower-bound strengths, Q_{CL}, as summarized in Table 7-7.

Table 7-6. Calculation of Component Action Capacity: Linear Procedures

Parameter	Deformation Controlled	Force Controlled
Existing material strength	Expected mean value with allowance for strain-hardening	Lower-bound value (approximately mean value 1σ level)
Existing action capacity	κQ_{CE}	κQ_{CL}
New material strength	Expected material strength	Specified material strength
New action capacity	Q_{CE}	Q_{CL}

Table 7-7. Calculation of Component Action Capacity: Nonlinear Procedures

Parameter	Deformation Controlled	Force Controlled
Deformation capacity (existing component)	$\kappa \times$ Deformation limit	N/A
Deformation capacity (new component)	Deformation limit	N/A
Strength capacity (existing component)	N/A	$\kappa \times Q_{CL}$
Strength capacity (new component)	N/A	Q_{CL}

7.5.2 Linear Procedures

7.5.2.1 Forces and Deformations Component forces and deformations shall be calculated in accordance with linear analysis procedures of Sections 7.4.1 or 7.4.2.

7.5.2.1.1 Deformation-Controlled Actions for LSP or LDP Deformation-controlled actions, Q_{UD}, shall be calculated in accordance with Eq. (7-34):

$$Q_{UD} = Q_G + Q_E \tag{7-34}$$

where Q_E = Action caused by the response to the selected Seismic Hazard Level calculated using either Section 7.4.1 or Section 7.4.2;

Q_G = Action caused by gravity loads as defined in Section 7.2.2; and

Q_{UD} = Deformation-controlled action caused by gravity loads and earthquake forces.

C7.5.2.1.1 Deformation-Controlled Actions for LSP or LDP Because of possible anticipated nonlinear response of the structure, the actions as represented by Eq. (7-34) may exceed the actual strength of the component to resist these actions. The acceptance criteria of Section 7.5.2.2.1 take this overload into account through use of a factor, m, that is an indirect measure of the nonlinear deformation capacity of the component.

7.5.2.1.2 Force-Controlled Actions for LSP or LDP Force-controlled actions, Q_{UF}, shall be calculated using one of the following methods:

1. Q_{UF} shall be taken as the maximum action that can be developed in a component based on a limit-state analysis considering the expected strength of the components delivering force to the component under consideration, or the maximum action developed in the component as limited by the nonlinear response of the building.
2. Alternatively, Q_{UF} shall be calculated in accordance with Eq. (7-35).

$$Q_{UF} = Q_G \pm \frac{Q_E}{C_1 C_2 J} \tag{7-35}$$

where Q_{UF} = Force-controlled action caused by gravity loads in combination with earthquake forces; and

J = Force-delivery reduction factor, greater than or equal to 1.0, taken as the smallest demand capacity ratio (DCR) of the components in the load path delivering force to the component in question, calculated in accordance with Eq. (7-16).

Alternatively, values of J equal to 2.0 for a high level of seismicity, 1.5 for a moderate level of seismicity, and 1.0 for a low level of seismicity shall be permitted where not based on calculated DCRs. J shall be taken as 1.0 for the Immediate Occupancy Structural Performance Level.

In any case where the forces contributing to Q_{UF} are delivered by components of the seismic-force-resisting system that remain elastic, J shall be taken as 1.0.

C7.5.2.1.2 Force-Controlled Actions for LSP or LDP The basic approach for calculating force-controlled actions for evaluation or retrofit differs from that used for deformation-controlled actions because nonlinear deformations associated with force-controlled actions are not permitted. Therefore, force demands for force-controlled actions should not exceed the force capacity (strength).

Ideally, an inelastic mechanism for the structure is identified, and the force-controlled actions, Q_{UF}, for evaluation or retrofit are determined by limit analysis using that mechanism. This approach always produces a conservative estimate of the actions, even if an incorrect mechanism is selected. Where it is not possible to use limit (or plastic) analysis, or in cases where forces do not produce significant nonlinear response in the building, it is acceptable to determine the force-controlled actions for evaluation or retrofit using Eq. (7-35).

Coefficients C_1 and C_2 were introduced in Eq. (7-21) to amplify the base shear to achieve a better estimate of the maximum displacements expected for buildings responding in the inelastic range. Displacement amplifiers, C_1 and C_2, are divided out of Eq. (7-35) when seeking an estimate of the force level present in a component where the building is responding inelastically.

Because J is included for force-controlled actions, it may appear to be more advantageous to treat an action as force controlled where m-factors are less than J. However, proper application of force-controlled criteria requires a limit state analysis of demand and lower-bound calculation of capacity that yields a reliable result whether an action is treated as force or deformation controlled.

7.5.2.2 Acceptance Criteria for Linear Procedures

7.5.2.2.1 Acceptance Criteria for Deformation-Controlled Actions for LSP or LDP Deformation-controlled actions in primary and secondary components shall satisfy Eq. (7-36).

$$m\kappa Q_{CE} > Q_{UD} \tag{7-36}$$

where m = Component capacity modification factor to account for expected ductility associated with this action at the selected Structural Performance Level. m-factors are specified in Chapters 8 through 12 and 14;

Q_{CE} = Expected strength of component deformation-controlled action of an element at the deformation level under consideration. Q_{CE}, the expected strength, shall be determined considering all coexisting actions on the component under the loading condition by procedures specified in Chapters 8 through 14; and

κ = Knowledge factor defined in Section 6.2.4.

7.5.2.2.2 Acceptance Criteria for Force-Controlled Actions for LSP or LDP Force-controlled actions in primary and secondary components shall satisfy Eq. (7-37):

$$\kappa Q_{CL} > Q_{UF} \tag{7-37}$$

where Q_{CL} = Lower-bound strength of a force-controlled action of an element at the deformation level under consideration. Q_{CL}, the lower-bound strength, shall be determined considering all coexisting actions on the component under the loading condition by procedures specified in Chapters 8 through 12 and 14.

7.5.2.2.3 Verification of Analysis Assumptions for LSP or LDP In addition to the requirements in Section 7.2.14, the following verification of analysis assumptions shall be made.

Where moments caused by gravity loads in horizontally spanning primary components exceed 75% of the expected moment strength at any location, the possibility for inelastic flexural action at locations other than member ends shall be specifically investigated by comparing flexural actions with expected member strengths. Where linear procedures are used, formation of flexural plastic hinges away from member ends shall not be permitted.

7.5.3 Nonlinear Procedures

7.5.3.1 Forces and Deformations Component forces and deformations shall be calculated in accordance with nonlinear analysis procedures of Sections 7.4.3 or 7.4.4.

7.5.3.2 Acceptance Criteria for Nonlinear Procedures

7.5.3.2.1 Acceptance Criteria for Deformation-Controlled Actions for NSP or NDP Primary and secondary components shall have expected deformation capacities not less than maximum deformation demands calculated at target displacements. Primary and secondary component demands shall be within the acceptance criteria for nonlinear components at the selected Structural Performance Level. Expected deformation capacities shall be determined considering all coexisting forces and deformations in accordance with Chapters 8 through 14.

C7.5.3.2.1 Acceptance Criteria for Deformation-Controlled Actions for NSP or NDP Where all components are explicitly modeled with full backbone curves, the NSP or NDP can be used to evaluate the full contribution of all components to the seismic force resistance of the structure as they degrade to residual strength values. Where degradation is explicitly evaluated in the analysis, components can be relied upon for lateral-force resistance out to the secondary component limits of response.

Studies on the effects of different types of strength degradation are presented in FEMA 440 (2005). As components degrade, the post-yield slope of the force–displacement curve becomes negative. The strength ratio, μ_{max}, limits the extent of degradation based on the degree of negative post-yield slope.

7.5.3.2.2 Acceptance Criteria for Force-Controlled Actions for NSP or NDP Primary and secondary components shall have lower-bound strengths not less than the maximum analysis forces. Lower-bound strengths shall be determined considering all coexisting forces and deformations by procedures specified in Chapters 8 through 12 and 14.

7.5.3.2.3 Verification of Analysis Assumptions for NSP or NDP In addition to the requirements in Section 7.2.14, the following verification of analysis assumptions shall be made:

Flexural plastic hinges shall not form away from component ends unless they are explicitly accounted for in modeling and analysis.

7.6 ALTERNATIVE MODELING PARAMETERS AND ACCEPTANCE CRITERIA

It shall be permitted to derive required parameters and acceptance criteria using the experimentally obtained cyclic response characteristics of a subassembly, determined in accordance with this section. Where relevant data on the inelastic force–deformation behavior for a structural subassembly are not available, such data shall be obtained from experiments consisting of physical tests of representative subassemblies as specified in this section. Approved independent review of this process shall be conducted.

C7.6 ALTERNATIVE MODELING PARAMETERS AND ACCEPTANCE CRITERIA

This section provides guidance for developing appropriate data to evaluate construction materials and detailing systems not specifically addressed by this standard. This standard specifies stiffnesses, m-factors, strengths, and deformation capacities for a wide range of components. To the extent practical, this standard

Innovations such as prestressed and precast concrete, posttensioning, and lift-slab construction have created a diverse inventory of existing concrete structures.

When modeling a concrete building, it is important to investigate local practices relative to seismic design. Specific benchmark years can be determined for the implementation of earthquake-resistant design in most locations, but caution should be exercised in assuming optimistic characteristics for any specific building. Particularly with concrete materials, the date of original building construction significantly influences seismic performance. Without deleterious conditions or materials, concrete gains compressive strength from the time it is originally cast and in place. Strengths typically exceed specified design values (28-day or similar). Early uses of concrete did not specify design strength, and low-strength concrete was common. Early use of concrete in buildings often used reinforcing steel with relatively low strength and ductility, limited continuity, and reduced bond development. Continuity between specific existing components and elements, such as beams, columns, diaphragms, and shear walls, may be particularly difficult to assess because of concrete cover and other barriers to inspection.

Properties of welded wire reinforcement for various periods of construction can be obtained from the Wire Reinforcement Institute (WRI 2009).

Documentation of the material properties and grades used in component and connection construction is invaluable and can be effectively used to reduce the amount of in-place testing required. The design professional is encouraged to research and acquire all available records from original construction, including photographs, to confirm reinforcement details shown on the plans.

Design professionals seeking further guidance on the condition assessment of existing concrete buildings should refer to the following:

- ACI 201.1R, which provides guidance on conducting a condition survey of existing concrete structures;
- ACI 364.1R, which describes the general procedures used for the evaluation of concrete structures before retrofit; and
- ACI 437R, which describes methods for strength evaluation of existing concrete buildings, including analytical and load test methods.

10.2.2 Properties of In-Place Materials and Components

10.2.2.1 Material Properties

10.2.2.1.1 General The following component and connection material properties shall be obtained for the as-built structure:

1. Concrete compressive strength; and
2. Yield and ultimate strength of conventional and prestressing reinforcing steel and metal connection hardware.

Where materials testing is required by Section 6.2, the test methods to quantify material properties shall comply with the requirements of Section 10.2.2.3. The frequency of sampling, including the minimum number of tests for property determination, shall comply with the requirements of Section 10.2.2.4.

C10.2.2.1.1 General Other material properties and conditions of interest for concrete components include

1. Tensile strength and modulus of elasticity of concrete;
2. Ductility, toughness, and fatigue properties of concrete;
3. Carbon equivalent present in the reinforcing steel; and
4. Presence of any degradation such as corrosion or deterioration of bond between concrete and reinforcement.

The extent of effort made to determine these properties depends on availability of accurate, updated construction documents and drawings; construction quality and type; accessibility; and material conditions. The analysis method selected—for example, linear static procedure (LSP) or nonlinear static procedure (NSP)—might also influence the testing scope. Concrete tensile strength and modulus of elasticity can be estimated based on the compressive strength and may not warrant the damage associated with any extra coring required.

The sample size and removal practices followed are referenced in FEMA 274 (1997b), Sections C6.3.2.3 and C6.3.2.4. ACI 228.1R provides guidance on methods to estimate the in-place strength of concrete in existing structures, whereas ACI 214.4R (2010) provides guidance on coring in existing structures and interpretation of core compressive strength test results. Generally, mechanical properties for both concrete and reinforcing steel can be established from combined core and specimen sampling at similar locations, followed by laboratory testing. Core drilling should minimize damage to the existing reinforcing steel.

10.2.2.1.2 Nominal or Specified Properties Nominal material properties, or properties specified in construction documents, shall be taken as lower-bound material properties. Corresponding expected material properties shall be calculated by multiplying lower-bound values by a factor taken from Table 10-1 to translate from lower-bound to expected values. Alternative factors shall be permitted where justified by test data.

10.2.2.2 Component Properties The following component properties and as-built conditions shall be established:

1. Cross-sectional dimensions of individual components and overall configuration of the structure;
2. Configuration of component connections, size of anchor bolts, thickness of connector material, anchorage and interconnection of embedments and the presence of bracing or stiffening components;
3. Modifications to components or overall configuration of the structure;
4. Most recent physical condition of components and connections, and the extent of any deterioration;
5. Deformations beyond those expected because of gravity loads, such as those caused by settlement or past earthquake events; and
6. Presence of other conditions that influence building performance, such as nonstructural components that may interfere with structural components during earthquake excitation.

C10.2.2.2 Component Properties Component properties may be required to properly characterize building performance in seismic analysis. The starting point for assessing component properties and condition is retrieval of available construction documents. A preliminary review should identify primary gravity- and seismic-force-resisting elements and systems and their critical components and connections. If there are no drawings of the building, the design professional should perform a

Table 10-1. Factors to Translate Lower-Bound Material Properties to Expected Strength Material Properties

Material Property	Factor
Concrete compressive strength	1.50
Reinforcing steel tensile and yield strength	1.25
Connector steel yield strength	1.50

Table 10-16. Numerical Acceptance Criteria for Linear Procedures—Two-Way Slabs and Slab–Column Connections

Conditions		m-Factors[a]				
		Performance Level				
			Component Type			
			Primary		Secondary	
		IO	LS	CP	LS	CP
Condition i. Reinforced concrete slab–column connections[b]						
$\frac{V_g}{V_o}$[c]	Continuity reinforcement[d]					
0	Yes	2	2.75	3.5	3.5	4.5
0.2	Yes	1.5	2.5	3	3	3.75
0.4	Yes	1	2	2.25	2.25	3
≥0.6	Yes	1	1	1	1	2.25
0	No	2	2.25	2.25	2.25	2.75
0.2	No	1.5	2	2	2	2.25
0.4	No	1	1.5	1.5	1.5	1.75
0.6	No	1	1	1	1	1
>0.6	No	—[e]	—[e]	—[e]	—[e]	—[e]
Condition ii. Posttensioned slab–column connections[b]						
$\frac{V_g}{V_o}$[c]	Continuity reinforcement[d]					
0	Yes	1.5	2	2.5	2.5	3.25
0.6	Yes	1	1	1	2	2.25
>0.6	Yes	1	1	1	1.5	1.75
0	No	1.25	1.75	1.75	1.75	2
0.6	No	1	1	1	1	1
>0.6	No	—[e]	—[e]	—[e]	—[e]	—[e]
Condition iii. Slabs controlled by inadequate development or splicing along the span[b]						
		—[e]	—[e]	—[e]	3	4
Condition iv. Slabs controlled by inadequate embedment into slab–column joint[b]						
		2	2	3	3	4

[a]Values between those listed in the table should be determined by linear interpolation.
[b]Where more than one of conditions i, ii, iii, and iv occur for a given component, use the minimum appropriate numerical value from the table.
[c]V_g is the the gravity shear acting on the slab critical section as defined by ACI 318, and V_o is the direct punching shear strength as defined by ACI 318.
[d]"Yes" should be used where the area of effectively continuous main bottom bars passing through the column cage in each direction is greater than or equal to $0.5V_g/(\phi f_y)$. Where the slab is posttensioned, "Yes" should be used where at least one of the posttensioning tendons in each direction passes through the column cage. Otherwise, "No" should be used.
[e]Action should be treated as force controlled.

unity, the following design actions shall be determined using limit analysis principles as prescribed in Chapter 7:

1. Moments, shears, torsions, and development and splice actions corresponding to the development of component strength in slabs and columns; and
2. Axial load in columns, considering likely plastic action in components above the level in question.

Design actions shall be compared with design strengths in accordance with Section 7.5.2.2, and m-factors for slab–column frame components should be selected from Tables 10-9 and 10-16.

Where the average DCRs for columns at a level exceed the average value for slabs at the same level and exceed the greater of 1.0 and $m/2$, the element shall be defined as a weak story element and shall be evaluated by the procedure for weak story elements in Section 10.4.2.4.1.

10.4.4.4.2 Nonlinear Static and Dynamic Procedures Inelastic response shall be restricted to actions in Tables 10-8 and 10-15, except where it is demonstrated by experimental evidence and analysis that other inelastic actions are acceptable for the selected performance levels. Other actions shall be defined as force controlled.

Calculated component actions shall satisfy the requirements of Section 7.5.3.2. Maximum permissible inelastic deformations shall be taken from Tables 10-8 and 10-15. Alternative values shall be permitted where justified by experimental evidence and analysis.

C10.4.4.4.2 Nonlinear Static and Dynamic Procedures Section C10.4.4.2.2 has a discussion of Table 10-15 and acceptance criteria for reinforced concrete slab–column connections. Section C10.4.2.2.2 has a discussion of Table 10-8 and acceptance criteria for reinforced concrete columns.

10.4.4.5 Retrofit Measures for Slab–Column Moment Frames Seismic retrofit measures for slab–column moment frames shall meet the requirements of Section 10.3.7 and other provisions of this standard.

C10.4.4.5 Retrofit Measures for Slab–Column Moment Frames Retrofit measures for reinforced concrete beam–column