APPENDIX A – FIGURES

Figure 1: Architectural Rendering of Silver Spring Gateway from the corner of East-West Highway and Blair Mill Road.

Figure 2: Original site (red hatch) and surrounding streets, railway, and buildings.

Figure 3: Current site (red hatch) abandons a portion of Blair Mill Road.

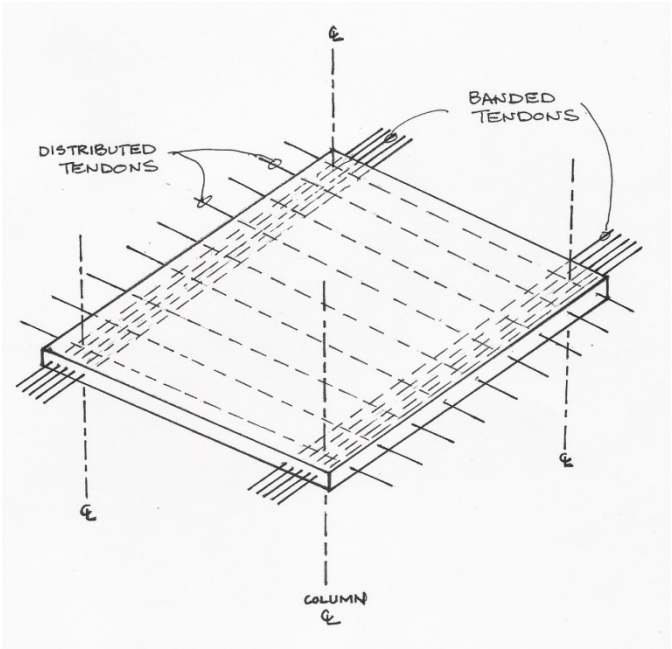

Figure 4: Typical post-tensioning tendon layout.

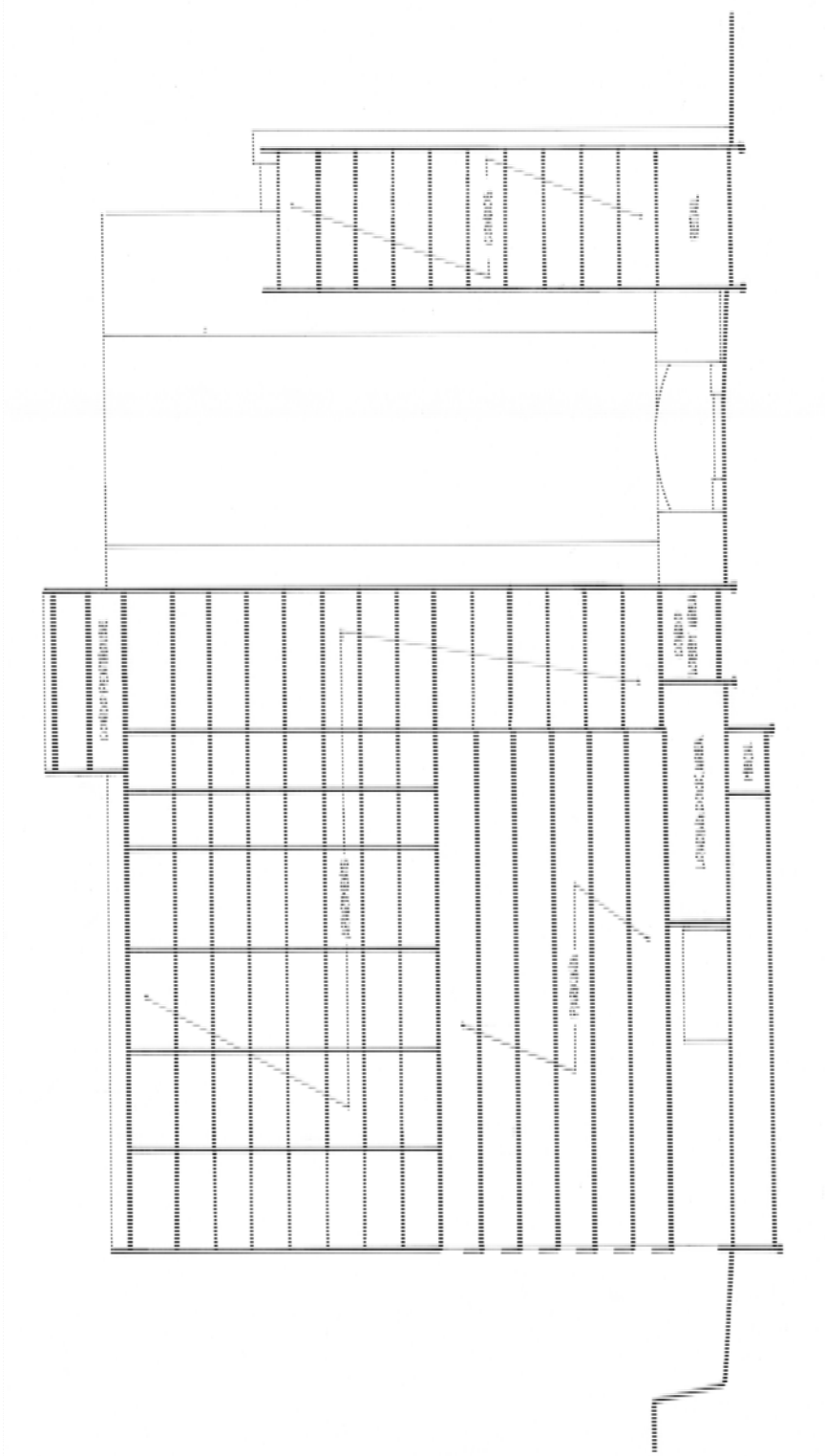

Figure 5: Building section showing occupancies per floor.

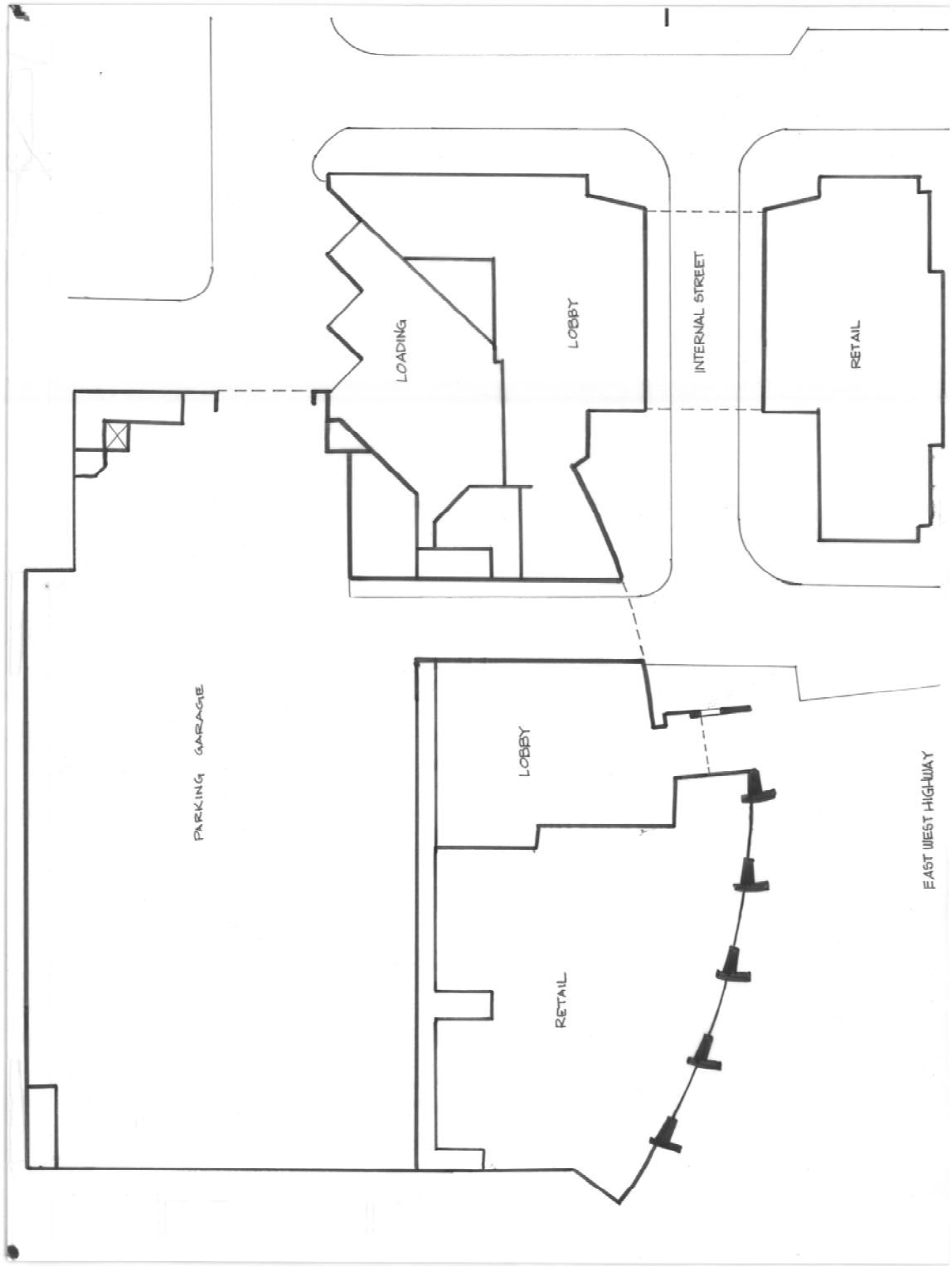

Figure 6: First Floor and Overall Site Plan showing overall shape for lower floors.

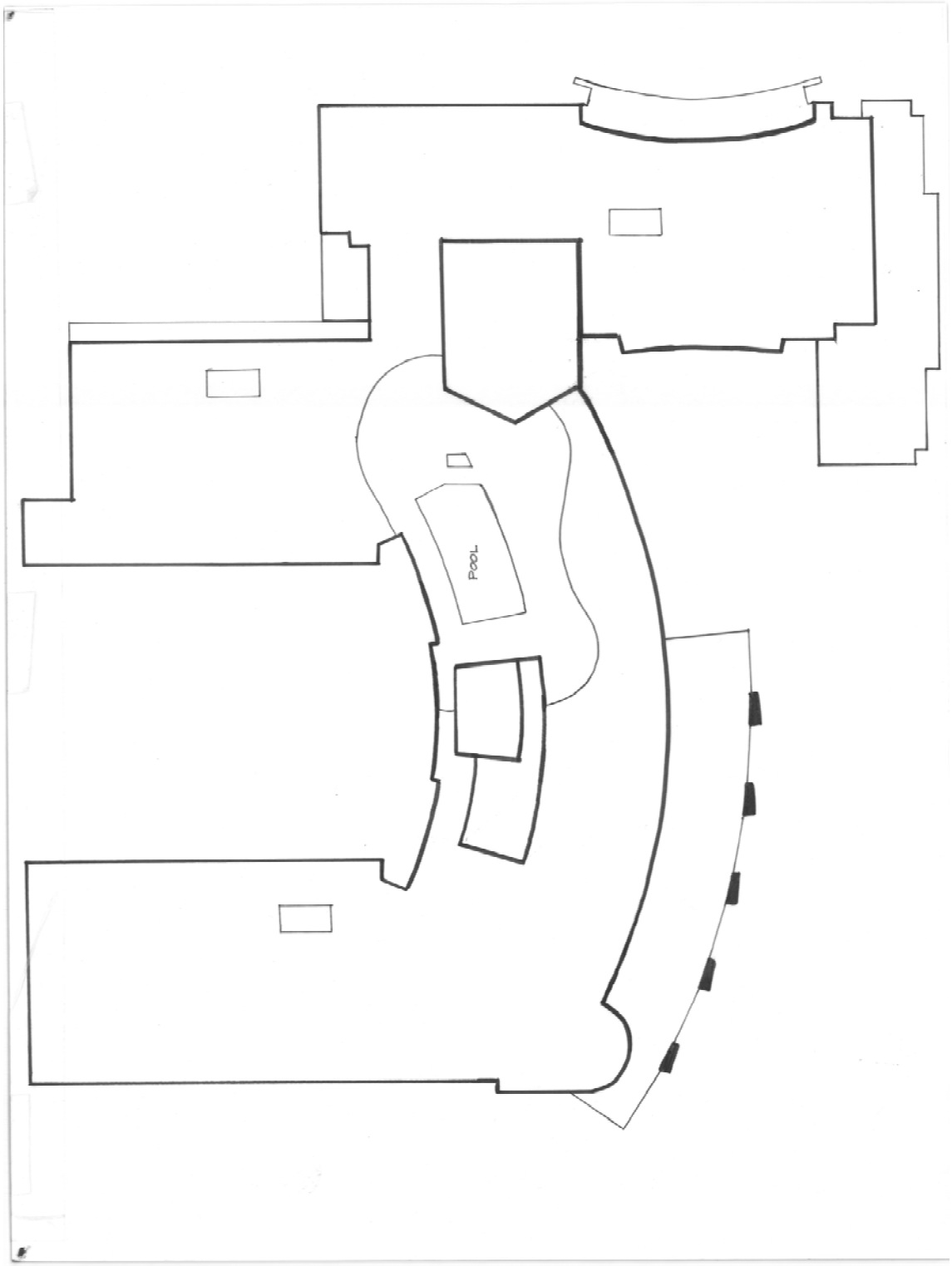

Figure 7: Penthouse Roof Plan showing overall shape of the upper floors and location of penthouse amenities.

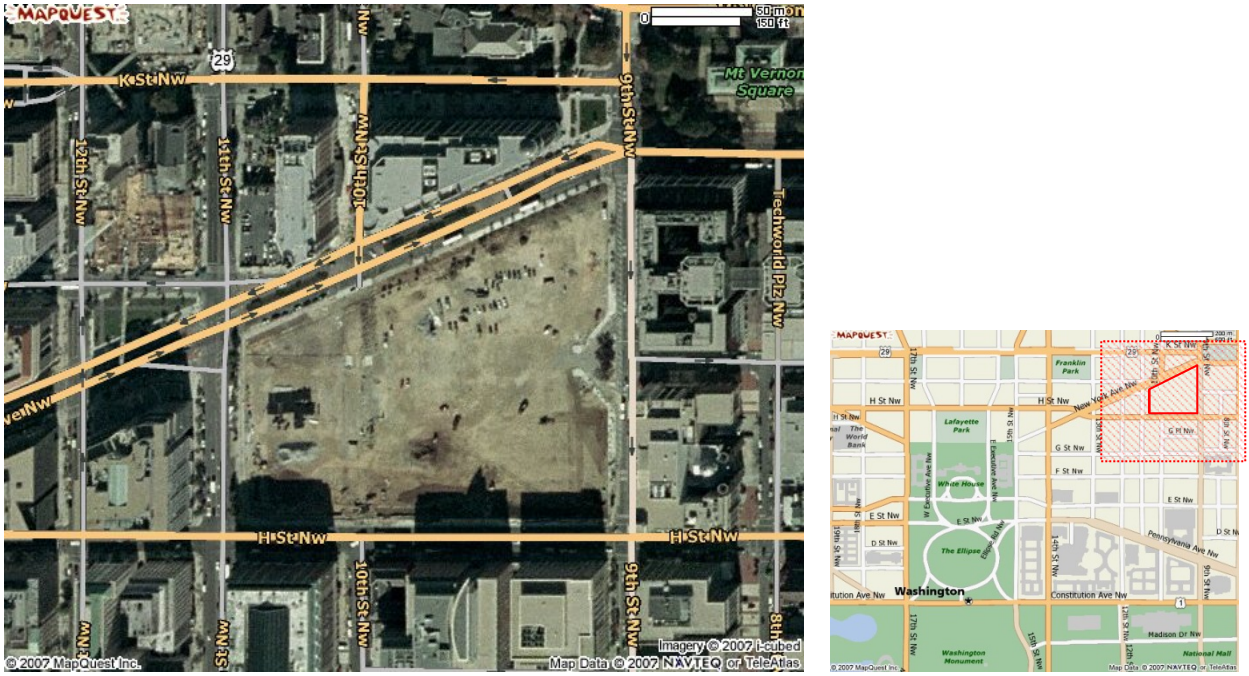

Figure 8: Location of new development site in Washington D.C.

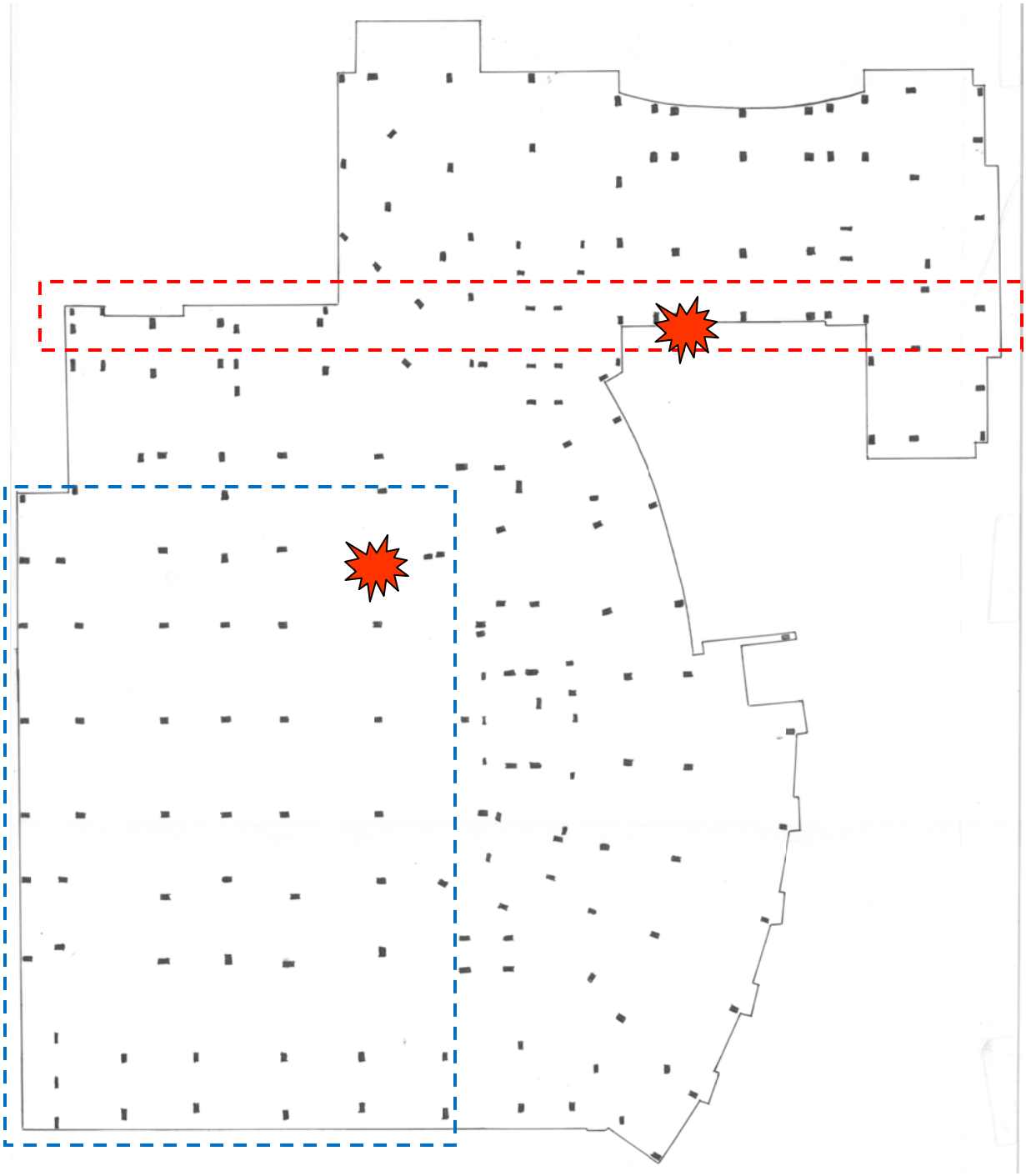

Figure 9: Column Layout with Transfer Girder Frame (red) and Parking Garage Slab (blue) location. (Blast locations are also annotated).

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APPENDIX B – PHOTOS

Photo 3: Overall view of Southeast elevation of Silver Spring Gateway.

Photo 4: Partial view of courtyard from the top level of the parking garage.

Photo 5: Partial view of the Southwest elevation.

Photo 6: Partial view of the inside corner between the Southwest elevation and a small portion of the West elevation.

Photo 7: Partial view of lower floor construction on East-West Highway elevation (Southwest).

Photo 8: Interior View of the parking garage.

Photo 9: Interior view of pedestrian bridge steel structure.

Photo 10: Typical full penetration welded connection of the bridge truss structure.

Photo 11: Interior view of a typical residential corridor.

Photo 12: View of post-tensioning cables prior to jacking force application.

APPENDIX C – PROJECT TEAM DIRECTORY

Role	Firm	Website
Owner	The JBG Companies 4445 Willard Ave., Suite 400 Chevy Chase, MD 20815	www.jbg.com
Architect	WDG Architecture 1025 Connecticut Ave., Suite 300 Washington, DC 20036	www.wdgarch.com
Civil Engineer	Loiederman Soltesz Associates, Inc. 1390 Piccard Drive, Suite 100 Rockville, MD 20850	www.LSAssociates.net
Structural Engineer	Tajder-Cohen-Edelson Associates, Inc. 1109 Spring Street Silver Spring, MD 20910	www.tadjerco.com
Landscape Architect	Hord Coplan Macht 750 E. Pratt Street, Suite 1100 Baltimore, MD 21202	www.hcm2.com
Interior Designer	Carlyn and Company 746 Walker Road, Suite 22 Great Falls, VA 22066	www.carlynco.com
Environmental Consultant	Environmental Resolutions, Inc. 14609 Jaystone Drive, Suite 100 Silver Spring, MD 20905	
Geotechnical Consultant	GeoConcepts Engineering, Inc. 19955 Highland Vista Drive, Suite 170 Ashburn, VA 20147	www.geoconcepts-eng.com
Acoustics Engineer	Cerami & Associates, Inc. 1250 Connecticut Ave., N.W. Washington, DC 20036	www.ceramiassociates.com
Mechanical Engineer	Atlas Air Conditioning Company 10693 Wakeman Ct. Manassas, VA 20110	www.atlascsusa.com
Electrical Engineer	Power Design, Inc. 11207 S. Danka Blvd., Suite A St. Petersburg, FL 33716	www.powerdesigninc.us
Construction Manager	Turner Construction Company 10400 Little Patuxent Pkwy., Suite 200 Columbia, MD 21044	www.tcco.com
Seismic Monitoring	Seismic Surveys P.O. Box 1185 Frederick, MD 21702	www.seismicsurveys.net

APPENDIX D – BUILDING LOADS

In order to analyze the Silver Spring Gateway, the gravity loads acting on the building must be determined. The construction documents, including drawings and specifications, AISC 13th ed., and ASCE 7 provide insight to code compliant loadings and material specifications and weights. The following table lists the appropriate gravity loads classified by type and system:

Floor System Loads			
Load Type	Material / Occupancy	Load	Reference
Dead Load	Normal Weight Concrete	150 pcf	ACI 318
	Steel	Per shape	AISC 13th ed.
	Steel Deck	2 psf	USD
	Partitions	15 psf	ASCE 7
	Brick Masonry	40 psf	AISC 13th ed.
	Miscellaneous	10 psf	
Live Load	Lobby and Common Spaces	100 psf	ASCE 7
	Corridors	100 psf	ASCE 7
	Apartments and Condominiums	40 psf	ASCE 7
	Corridors servicing Residential Spaces	40 psf	ASCE 7
	Balconies	60 psf	ASCE 7
	Parking Garage	40 psf	ASCE 7
	Retail Spaces	100 psf	ASCE 7

Roof and Terrace System Loads			
Load Type	Material / Occupancy	Load	Reference
Dead Load	Normal Weight Concrete	150 pcf	ACI 318
	Water (Swimming Pool)	62.4 pcf	AISC 13th ed.
	Green Roof	70 pcf	AISC 13th ed.
	Ballast, insulation, and waterproofing membrane	8 psf	AISC 13th ed.
	Brick Masonry	40 psf	AISC 13th ed.
	Miscellaneous	10 psf	
Live Load	Assembly and Pool Space	100 psf	ASCE 7
	Roof	20 psf	ASCE 7
Snow Load	Ground Snow Load	30 psf	Montgomery County
	Terrain Category	B	ASCE 7
	C_e Exposure Factor	1.0	ASCE 7
	C_t Thermal Factor	1.0	ASCE 7
	Importance Factor	1.0	ASCE 7
	Flat Roof Load	21 psf	ASCE 7

The miscellaneous gravity load will include building components such as ductwork, lighting, telecommunications, drop ceilings, etc. Snow drift loads will accumulate around the penthouses increasing the dead load on the roof; however, the magnitude of this loading was not determined for this report.

APPENDIX E – STRUCTURAL CALCULATIONS

PROGRESSIVE COLLAPSE — INDIRECT METHOD — TIE FORCES — 1

THE FOLLOWING HAND CALCULATION WILL SHOWN THE DETERMINATION OF THE REQUIRED TIE FORCES AT THE TRANSFER GIRDER TRUSS LOCATION:

PERIPHERAL TIES

REQUIRED TIE FORCE = $1.0\,F_t$

$F_t = \begin{cases} 4.5 + 0.9 n_o ; \; n_o = \#\text{ OF STORIES} = 18^k \\ \text{MIN } 13.5^k \checkmark \end{cases}$

DESIGN STRENGTH = $\phi \Omega f_y A_s$; $\phi = 0.75$, $\Omega = 1.25$

$A_{s,\,REQ'D} = \dfrac{13.5}{(0.75)(1.25)(60)} = 0.24\ IN^2$

$A_{s,\,PROV'D} = 3.95\ IN^2$ ADDITIONAL $A_s = 0.00\ IN^2$

∴ PROVIDED REINFORCEMENT IS ADEQUATE

INTERNAL TIES

REQUIRED TIE FORCE = $\begin{cases} \dfrac{(D+L)}{156.6} \cdot \dfrac{L_r}{16.4} \cdot \dfrac{F_t}{3.3} \\ \text{MAX } \dfrac{F_t}{3.3} \end{cases}$

WHERE: D = SW + SDL = 87.5 + 20 = 107.5 PSF
L = 40 PSF
L_r = GREATEST SPAN LENGTH IN DIRECTION OF TIE,

$F_t = 13.5^k$ (CALCULATED ABOVE)

$R_{u_{N-S}} = \begin{cases} \left(\dfrac{147.5}{156.6}\right)\left(\dfrac{30}{16.4}\right)\left(\dfrac{13.5}{3.3}\right) = 7049 \text{ LB/FT WIDTH} \checkmark \\ \text{MAX } \left(\dfrac{13.5}{3.3}\right) = 4091 \text{ LB/FT WIDTH} \end{cases}$

$R_n = \phi \Omega f_y A_s = 56250\, A_s$

$A_{s,\,REQ'D} = \dfrac{7049}{56250} = 0.1253\ IN^2/FT \cdot WIDTH$ (N-S)

$A_{s,\,PROV'D} = 0.61\ IN^2/FT$ ADDITIONAL $A_s = 0.00\ IN^2/FT$

PROGRESSIVE COLLAPSE | INDIRECT METHOD | TIE FORCES | 2

$R_{u_{E-W}} = \left(\frac{147.5}{156.6}\right)\left(\frac{28}{16.4}\right)\left(\frac{13.5}{3.3}\right) = 6579$ LB/FT-WIDTH ✓

MAX $\left(\frac{13.5}{3.3}\right) = 4091$ LB/FT-WIDTH

$A_{s,REQ'D} = \frac{6579}{56250} = 0.117$ IN^2/FT·WIDTH (E-W)

$A_{s,PROV'D} = 0.402$ IN^2/FT ADDITIONAL $A_s = 0.00$ IN^2

∴ (N-S): PROVIDED REINFORCEMENT IS ADEQUATE
(E-W): PROVIDED REINFORCEMENT IS ADEQUATE

HORIZONTAL TIES TO COLUMNS

$R_u = 0.03 A_T (4)(D+L) = 0.03(9)(70)(4)(147.5) = 11.15^k$

$2.0 F_t = 2(13.5) = 27^k$

MAX | MIN $\frac{F_t L_s}{8.2} = \frac{13.5(9.0833)}{8.2} = 14.95^k$ ✓✓

$A_{s,REQ'D} = \frac{14.95}{56.25} = 0.266$ IN^2

$A_{s,PROV'D} = 1.24$ IN^2 ADDITIONAL $A_s = 0.00$ IN^2

∴ PROVIDED REINFORCEMENT IS ADEQUATE

VERTICAL COLUMN TIES

$R_u = A_T(D+L) = (9+35)(9+14)(147.5) = 149.3^k$

$A_{s,REQ} = \frac{149270}{56250} = 2.654$ IN^2

$A_{s,PROV'D} = (4)\#10 = 5.08$ IN^2

ADDITIONAL $A_s = 0.00$ IN^2

∴ DESIGNED COLUMN REINFORCEMENT WILL PROVIDE ENOUGH TIE STRENGTH

THIS ANALYSIS SHOWS THAT THE PROVIDED AMOUNT OF REBAR SATISFIES THE STRENGTH REQUIREMENT; HOWEVER, CURRENTLY ARE NOT DETAILED PROPERLY TO DEVELOP THE STRENGTH.

PROGRESSIVE COLLAPSE | INDIRECT METHOD | TIE FORCES · 3

THE FOLLOWING HAND CALCULATION WILL SHOWN THE DETERMINATION OF THE REQUIRED TIE FORCES WITHIN THE PARKING GARAGE:

PERIPHERAL TIES

REQUIRED TIE FORCE = $1.0\ F_t$

$F_t = \begin{cases} 4.5 + 0.9\, n_o = 11.7^k \checkmark \\ \text{MIN}\ 13.5^k \end{cases}$

DESIGN STRENGTH = $\phi \Omega f_y A_s$; $\phi = 0.75$, $\Omega = 1.25$

$A_{s,REQ} = \dfrac{11.7}{56.25} = 0.208\ IN^2$

$A_{s,PROV} = 1.24\ IN^2$

∴ PROVIDED REINFORCEMENT IS ADEQUATE

INTERNAL TIES

REQUIRED TIE FORCE, $R_{u_{E-W}} = \begin{cases} \left(\frac{255}{156.6}\right)\left(\frac{30}{16.4}\right)\left(\frac{11.7}{3.3}\right) = \frac{10561\ LB}{FT.\ WIDTH} \checkmark \\ \text{MAX}\ \left(\frac{11.7}{3.3}\right) = 3545\ LB/FT\text{-}WIDTH \end{cases}$

$R_n = \phi \Omega f_y A_s = 56250\, A_s$

$A_{s,REQ'D} = \dfrac{10561}{56250} = 0.1877\ IN^2/FT\text{-}WIDTH$

$A_{s,PROV} =$

$R_{u_{N-S}} = \begin{cases} \left(\frac{255}{156.6}\right)\left(\frac{27.25}{16.4}\right)\left(\frac{11.7}{3.3}\right) = 9593\ LB/FT.\ WIDTH \checkmark \\ \text{MAX}\ 3545\ LB/FT.\ WIDTH \end{cases}$

$A_{s,REQ'D} = \dfrac{9593}{56250} = 0.1705\ IN^2/FT\text{-}WIDTH$

$A_{s,PROV} = 0.62\ IN^2\ (N\text{-}S)$ AND $0.93\ IN^2\ (E\text{-}W)$

∴ PROVIDED REINFORCEMENT IS ADEQUATE

PROGRESSIVE COLLAPSE | INDIRECT METHOD | TIE FORCES · 4

HORIZONTAL TIES TO COLUMN

R_u = $0.03(30)(27.25)(255)(4) = 25.02^k$ ✓

MAX | MIN: $2(11.7) = 23.4^k$

$\frac{(11.7)(9.0833)}{8.2} = 12.96^k$ ✓

$A_{s,\,REQ'D} = \frac{25.02}{56.25} = 0.445\ IN^2$

$A_{s,\,PROV} = 0.93\ IN^2$

∴ PROVIDED REINFORCEMENT IS ADEQUATE

VERTICAL COLUMN TIES

$R_u = (27.25)(30)(255) = 208.5^k$

$A_{s,\,REQ} = \frac{208500}{56250} = 3.71\ IN^2$

$A_{s,\,PROV} = (4)\ \#10 = 5.08\ IN^2$

∴ DESIGNED COLUMN REINFORCEMENT WILL PROVIDE ENOUGH TIE STRENGTH

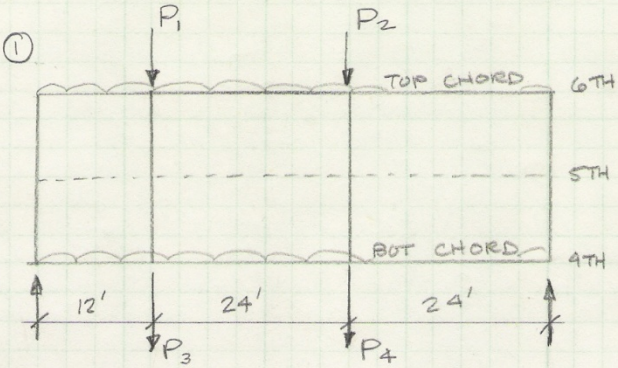
PROGRESSIVE COLLAPSE | DIRECT DESIGN | VIERENDEEL TRUSS | 1

① CHECK THE FEASIBILITY OF ONE TRUSS AT THE 6TH (TOP CHORD) AND 4TH (BOTTOM CHORD) FLOORS

② CHECK THE FEASIBILITY OF TWO TRUSSES AT THE 6TH AND 4TH AND 15TH AND 13TH FLOORS.

CHORD BEAM DEPTH ≤ 13" TO MAINTAIN A CEILING-TO-FLOOR HEIGHT OF 8'-0"

①



$f'_c = 5000$ PSI
$f_y = 60$ KSI

$h \leq 13''$

COL: 16 x 28 TYP.

D + 0.5L + 0.2S

LOADS:

DL = SLAB WT = 7(150)/12 = 88 PSF
COL WT = 16(28)(93.083)/144 = 43439 LB

LL = 40 PSF + 20 PSF = 60 PSF
L_r = 30 PSF

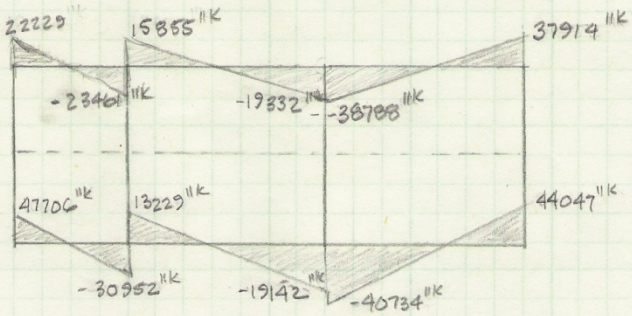
$P_1 = (88 + 60(.5))(20)(18)(9) + 43.4 + .2(30)(20)(18)$
$= 428^k + 4.24^k = 432^k$

$P_2 = (88 + .5(60))(24)(20)(9) + 43.4 + .2(30)(20)(24)$
$= 556^k + 4.24^k = 560^k$

$P_3 = 8478 + (88 + 60(.5))(20)(18) + (88 + 60(.5)(20)(6)$
$= 65^k + 4.24^k + (88 + 60(.5)(20)(18) = 112^k$

$P_4 = 8478 + 2(88 + 60(.5)(20)(24) = 122^k$

PROGRESSIVE COLLAPSE | DIRECT METHOD | VIERENDEEL TRUSS | 2



STAAD PRO OUTPUT

TOP CHORD DESIGN

MAX POSITIVE MOMENT: 40734 ''k (3395 'k)

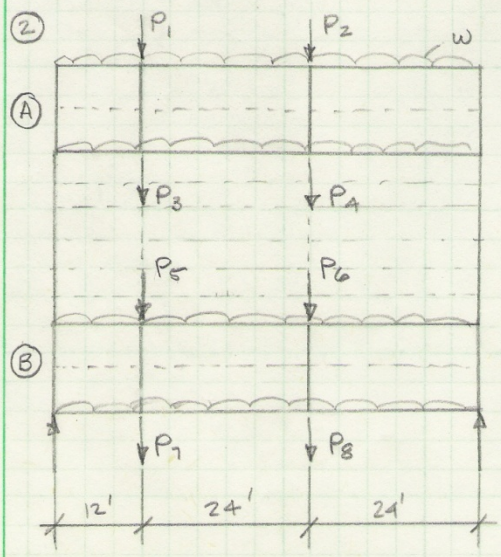
ESTIMATE SIZE: $bd^2 = 20M_u$

$d = 13'' - 2.5'' = 10.5''$ $\quad b = \frac{20(3395)}{(10.5)^2} = 616''$

REQUIRED STEEL AREA:

$A_s = \frac{M_u}{4d} = \frac{3395}{4(10.5)} = 80.82 \text{ IN}^2$

BOTH ESTIMATED REQUIRED WIDTH AND STEEL AREA UNPRACTICAL. TRY TWO TRUSSES.



$f'_c = 5000$ PSI
$f_y = 60000$ PSI

$h \leq 13''$
COL: 16 X 28, TYP

$D + 0.5L + 0.2S$

$P_7 = P_3$ (PREVIOUS)

$P_8 = P_4$ (PREVIOUS)

LOADS: SLAB = 88 PSF
COL = 4239 #/COL

LL = 60 PSF
SL = 30 PSF

PROGRESSIVE COLLAPSE | DIRECT METHOD | VIERENDEEL TRUSS | 3

$w = 88 + 0.5(60) = 118\ (20) = 2.36$ kLF

$P_1 = 8478 + [(88 + 0.2(30))(20)(18)] = 42.3^k$

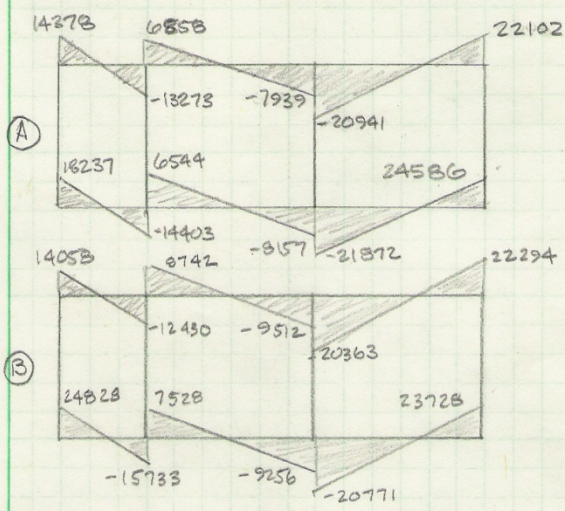
$P_2 = 8478 + [(88 + 0.2(30))(20)(24)] = 53.6^k$

$P_3 = 4.5(4239) + 4(118)(20)(18) = 189^k$

$P_4 = 4.5(4239) + 4(118)(20)(24) = 246^k$

$P_5 = 4.5(4239) + 3(118)(20)(18) = 147^k$

$P_6 = 4.5(4239) + 3(118)(20)(24) = 189^k$



MAX POSITIVE CHORD MOMENT = 21872 "k

MAX POSITIVE CHORD MOMENT: 20771 "k

BOTTOM CHORD (A) DESIGN

ESTIMATE SIZE: $bd^2 = 20 M_u$

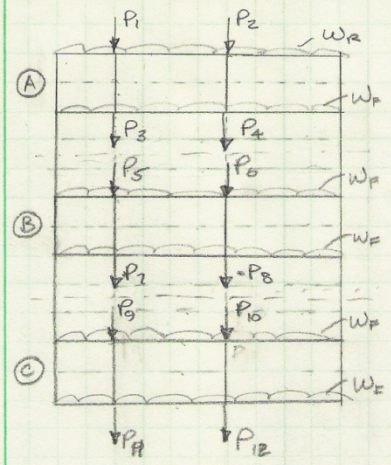
$$b = \frac{20(1823)}{(10.5)^2} = 331''$$

REQUIRED STEEL AREA $= \frac{M_u}{4d} = \frac{1823}{4(10.5)} = 43.4\ in^2$

AGAIN, SIZE AND STEEL REQUIREMENTS ARE UNPRACTICAL

EACH TRUSS APPEARS TO HALVE THE MOMENT, SIZE, AND STEEL AREA, SO HOW MANY TRUSSES ARE NEEDED.

PROGRESSIVE COLLAPSE | DIRECT METHOD | VIERENDEEL TRUSS | 4



$P_{11} = P_3$ (ONE TRUSS) $= 112^k$
$P_{12} = P_4$ (ONE TRUSS) $= 122^k$

$w_F = 2.36$ klf $\quad w_R = 1.88$ klf.
COL $= 4239$ #/COL

$D_s = 88 \quad L = 60$

$P_1 = 4239 = 4.24^k = P_2$

$P_3 = 2(118)(18)(20) + 2.5(4239) = P_7$
$= 95.6^k$

$P_4 = 2(118)(24)(20) + 2.5(4239) = 124^k = P_8$

$P_5 = 2.5(4239) + 118(18)(20) = 53.1^k = P_9$

$P_6 = 2.5(4239) + 118(24)(20) = 67.2^k = P_{10}$

ESTIMATE BEAM SIZE:

$M_{u,MAX} = 15304''^k \qquad b = \dfrac{20(1275)}{(10.5)^2} = 231''$

$A_s = 1275/42 = 30.4 \text{ in}^2$

AFTER THREE ITERATIONS, IT IS EVIDENT THAT EACH ADDITIONAL TRUSS REDUCES THE SIZE BY THE NUMBER OF TOTAL TRUSSES, THEREFORE THE SMALLEST BEAM WIDTH WOULD APPROX. EQUAL:

$$\frac{616''}{13} = 47.9'' \text{ OR } 4'$$

WITH 13" OF POSSIBLE DEPTH VIERENDEEL ACTION IS NOT THE BEST APPROACH.

PROGRESSIVE COLLAPSE | MOMENT CAPACITY | TWO-WAY PT SLAB | 1

EXISTING SLAB PROPERTIES

$A_{ps} = 0.153(12) = 1.836 \text{ IN}^2$ # OF TENDONS = 12

$f'_c = 5000$ PSI $\quad d = 5\frac{1}{4} + \frac{1}{4} = 5\frac{1}{2}''$

$f_y = 60000$ PSI $\quad t = 7''$

$b = 10(12) = 120''$ $\quad A_s = 2.48 \text{ IN}^2 ; 1.24 \text{ IN}^2$

$f_{ps} = 184000 + [(5000)(120)(5.5)/(300)(1.836)] = 190000$ PSI

ULTIMATE MOMENT CAPACITY

$M_n = (A_s f_y + A_{ps} f_{ps})(d - a/2)$

$a = (A_s f_y + A_{ps} f_{ps}) / (0.85 f'_c b)$

$= (2.48(60) + 1.836(190)) / (0.85(5)(120))$

$= 0.976''$

$M_n = [2.48(60) + 1.836(190)](5.5 - \frac{0.976}{2})$

$= 498(5.012) = 2494^{''k} = 208^{'k}$ (NEG. MOMENT)

$M_n = (A_s f_y + A_{ps} f_{ps})(d - a/2)$

$a = (A_s f_y + A_{ps} f_{ps}) / 0.85 f'_c b$

$= (1.24(60) + 1.836(190)) / (0.85(5)(120))$

$= 0.8299''$

$M_n = [1.24(60) + 1.836(190)](5.5 - \frac{0.8299}{2})$

$= 423.24(5.0851) = 2152^{''k} = 179^{'k}$ (POS. MOMENT)

GSA ALLOWABLE

$D_{CR} = Q_{UD} / Q_{CE}$

$D_{CR} = 1.5$

Q_{UD} = ACTING FORCE

Q_{CE} = UNFACTORED EXPECTED ULTIMATE CAPACITY

$Q_{UD}^- = 3741^{''k}$

$Q_{UD}^+ = 3228^{''k}$

PROGRESSIVE COLLAPSE | MOMENT CAPACITY | TWO-WAY PT SLAB · 2

ITERATION #1

MAX FAILING MOMENT : 6360 ''k

$$D_{CR} = \frac{Q_{UD}}{Q_{CE}}$$

$$Q_{CE} = Q_{UD} / D_{CR} = 6360 / 1.5 = 4240$$

$$M_n^+ = 4240 = \left[A_s(60) + 348.84\right]\left(5.5 - \left[\frac{A_s(60) + 348.84}{0.85(5)(120)}\right]\right)$$

$$4240 = (60A_s + 348.84)(5.5 - (.117647A_s + .684))$$

$$= (60A_s + 348.84)(5.158 - 0.058824A_s)$$

$$A_s = 9.56 \text{ IN}^2 \quad (10 \ \#9)$$

ITERATION #2

$$Q_{UD}^- = 5000 \text{ ''k}$$

$$Q_{CE} = 5000/1.5 = 3333 \text{ ''k}$$

$$M_n^- = 3333 = (60A_s + 348.84)(5.158 - 0.059A_s)$$

$$A_s = 5.71 \text{ IN}^2 \quad (6 \ \#9)$$

ITERATION #3

$$Q_{UD}^- = Q_{UD}^+ = 6360$$

$$A_s = 9.56 \text{ IN}^2 \quad (10 \ \#9)$$

ITERATION #4

$$Q_{UD}^+ = 7500 \text{ ''k} \qquad Q_{CE} = 5000 \text{ ''k}$$

$$A_s = 13.21 \text{ IN}^2 \quad (11 \ \#10)$$

STEEL AREA IS GETTING EXCESSIVE; HOWEVER FROM PAST ITERATIONS A Q_{CE}^+ OF 9000 ''k IS IDEAL INCREASE SLAB THICKNESS TO GAIN MORE CAPACITY

PROGRESSIVE COLLAPSE | MOMENT CAPACITY | TWO-WAY PT SLAB | 3

ITERATION #5

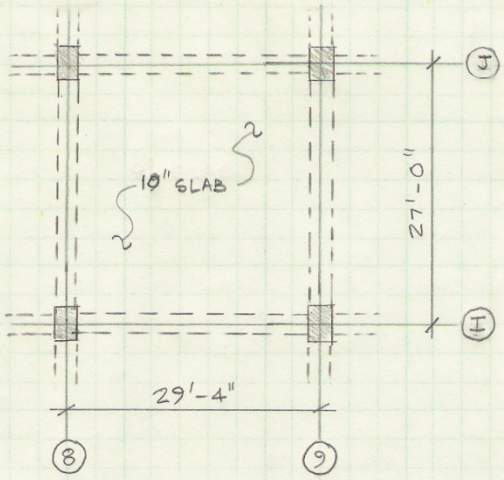
$A_s = 10.00 \text{ IN}^2$ (10 #9)

$M_n = 6000 = 948.84 (x - 0.93024)$ $x = 7.25''$

$7.25'' + 1.0'' + .25 = 8.5''$

$Q_{UD} = 6000 (1.5) = 9000$ "k ✓

PROGRESSIVE COLLAPSE | FLOOR SYSTEM | RC TWO-WAY SLAB W/ BEAMS | 1



$f'_c = 5000$ PSI
$f_y = 60000$ PSI

LL = 50(1.6) = 80 PSF
DL = 5(1.2) = 6 PSF

BEAM SIZE = 12 X 18

TO VERIFY THE PCA SLAB OUTPUT, THE INTERIOR BAY SHOWN WILL BE DESIGNED FOR COMPARISON

ASSUME $t = 9''$

$b_{eff} = b_w + 2h_w \le b_w + 8t$
$= 12 + 18 = 30 \le 12 + 72$ ✓

$\beta = \frac{l_n}{s_n} = \frac{336}{296} =$

$b_e/b_w = 2.5$; $t/h = 0.5$ $\quad I_b = 1.5\left(\frac{12(18)^3}{12}\right) = 8748 \text{ IN}^4$

$I_s = (29.33)(12)(9)^3/12 = 21384 \text{ IN}^4$

$\alpha_m = 0.41$: $t_{min} = \frac{336\,(0.8 + 0.3)}{36 + 5(1.14)(0.21)} = 9.94'' \Rightarrow 10''$

SELF WT: $\frac{10(150)}{12} = 125\,(1.2) = 150$ PSF

TOTAL LOAD = 236 PSF

TOTAL STATIC MOMENT

$M_{o_{N-S}} = \frac{0.236\,(29.33)(27 - 28/12)^2}{8} = 527^{\text{IK}}$

$M_{o_{E-W}} = \frac{0.236\,(27)(29.33 - 16/12)^2}{8} = 624^{\text{IK}}$

INTERIOR SPAN MOMENT DISTRIBUTION

$\alpha = 0.41 \quad l_1 = 29.33 \quad l_2 = 27$

N-S: $\frac{\alpha l_2}{l_1} = 0.45$ $\qquad$ E-W: $\frac{\alpha l_2}{l_1} = 0.38$

PROGRESSIVE COLLAPSE | FLOOR SYSTEM | RC TWO-WAY SLAB W/BEAMS | 2

$M_{o\,N\text{-}S}^{+} = 0.35(527) = 184^{k}$

$M_{o\,N\text{-}S}^{-} = 0.65(527) = 343^{k}$

$M_{o\,E\text{-}W}^{+} = 0.35(624) = 218^{k}$

$M_{o\,E\text{-}W}^{-} = 0.65(624) = 406^{k}$

COLUMN STRIP	N-S M⁻	N-S M⁺	E-W M⁻	E-W M⁺
TOTAL STATIC MOMENT, k	343	184	406	218
COLUMN STRIP MOMENT, k	261	123	309	146
SLAB MOMENT, k	177	84	210	99
BEAM MOMENT, k	84	39	99	47
STRIP WIDTH, IN	162	162	162	162
EFFECTIVE DEPTH, IN	8.625	8.625	8.625	8.625
M_n, k	197	93	233	110
R, PSI	196	93	232	110
ρ	.0033	.0016	.00397	.0019
A_s, IN^2	4.61	2.24	5.55	2.65
$A_{s,MIN}$, IN^2	3.24	3.24	3.24	3.24
N, # OF BARS	15	11	18	11
N, MIN, # OF BARS	9	9	9	9

MIDDLE STRIP	N-S M⁻	N-S M⁺	E-W M⁻	E-W M⁺
M_o, k	343	184	406	218
MIDDLE STRIP MOMENT, k	82	61	97	72
STRIP WIDTH, IN	162	162	162	162
EFFECTIVE DEPTH, IN	8.625	8.625	8.625	8.625
M_n, k	91	68	108	80
R, PSI	91	68	108	80
ρ	.0015	.0011	.0018	.0013
A_s, IN^2	2.1	1.54	2.52	1.82
$A_{s,MIN}$, IN^2	3.24	3.24	3.24	3.24
N, # OF BARS	11	11	11	11
N, MIN, # OF BARS	9	9	9	9

BEAM CAPACITY

$M^{-}_{MAX} = 99^{k}$ $\quad M^{+}_{MAX} = 47^{k}$

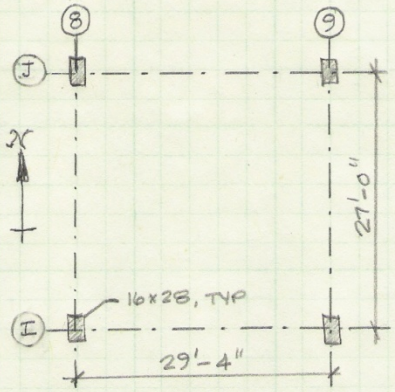
$\frac{\phi f_y^2}{1.7 f'_c b} A_s^2 - \phi f_y d A_s = 99^{k}$ (NEGATIVE)
47^{k} (POSITIVE)

$A_s^{-} = 1.34\ IN^2 \Rightarrow 4\#6$

$A_s^{+} = 0.65\ IN^2 \Rightarrow 3\#5$

SHEAR NOT CHECKED @ THIS TIME

PROGRESSIVE COLLAPSE | FLOOR SYSTEM | REIN. CONC. SLAB DESIGN | 1



TWO-WAY FLATE PLATE SLAB

$f'_c = 5000$ PSI $\quad f_y = 60000$ PSI

LL = 50 PSF (1.6) = 80 PSF
DL = 5 PSF (1.2) = 6 PSF
TL = 86 PSF + SELF WT.

$$t = \frac{l_n}{30} = \frac{352 - 16}{30} = 11.2'' \ (11\tfrac{1}{2}'')$$

TO VERIFY THE PCA SLAB OUTPUT, THE INTERIOR BAY SHOWN WILL BE DESIGNED FOR COMPARISON

TOTAL STATIC MOMENT

$$M_{o_{N-S}} = \frac{0.259\,(29.33)(27 - 28/12)^2}{8} = 578^{lk}$$

$$M_{o_{E-W}} = \frac{0.259\,(27)(29.33 - 16/12)^2}{8} = 711^{lk}$$

INTERIOR SPAN MOMENT DISTRIBUTION

$M_{o_{N-S}}^{+} = 0.35\,(578) = 202^{lk}$

$M_{o_{N-S}}^{-} = 0.65\,(578) = 376^{lk}$

$M_{o_{E-W}}^{+} = 0.35\,(711) = 249^{lk}$

$M_{o_{E-W}}^{-} = 0.65\,(711) = 462^{lk}$

COLUMN STRIP	N-S M⁻	N-S M⁺	E-W M⁻	E-W M⁺
TOTAL STATIC MOMENT, (lk)	376	202	462	249
COLUMN STRIP MOMENT, (lk)	282	121	347	149
STRIP WIDTH, b, (IN)	162	162	162	162
EFFECTIVE DEPTH, d, (IN)	10.125	10.125	10.125	10.125
M_n, (lk)	313	134	386	166
R, (PSI)	226	96.8	279	120
ρ	.0039	.0016	.0048	.0020
A_s, (IN^2)	6.35	2.69	7.90	3.33
$A_{s,MIN}$, (IN^2)	3.73	3.73	3.73	3.73
N, (# OF BARS)	21	13	26	13
N_{MIN}, (# OF BARS)	8	8	8	8

PROGRESSIVE COLLAPSE | FLOOR SYSTEM | REIN. CONC. SLAB DESIGN | 2

MIDDLE STRIP	N-S M⁻	N-S M⁺	E-W M⁻	E-W M⁺
TOTAL STATIC MOMENT, (1K)	376	202	462	249
MIDDLE STRIP MOMENT, (1K)	94	81	115	100
STRIP WIDTH, b, (IN)	162	162	162	162
EFFECTIVE DEPTH, d, (IN)	10.125	10.125	10.125	10.125
M_n, (1K)	104	90	128	111
R, (PSI)	75.1	65	92.5	80.2
ρ	.0013	.0011	.0016	.0014
A_s, (IN^2)	2.13	1.80	2.68	2.30
$A_{s\,MIN}$, (IN^2)	3.73	3.73	3.73	3.73
N, (# OF BARS)	13	13	13	13
N_{MIN}, (# OF BARS)	8	8	8	8

BEAM ACTION SHEAR

$V_u = wA = 0.259(355) = 92^k$

$\phi V_c = 0.75(2)\sqrt{5000}(10.125)(27)(12) = 348^k \quad V_u \le \phi V_c$ ✓

PUNCHING SHEAR

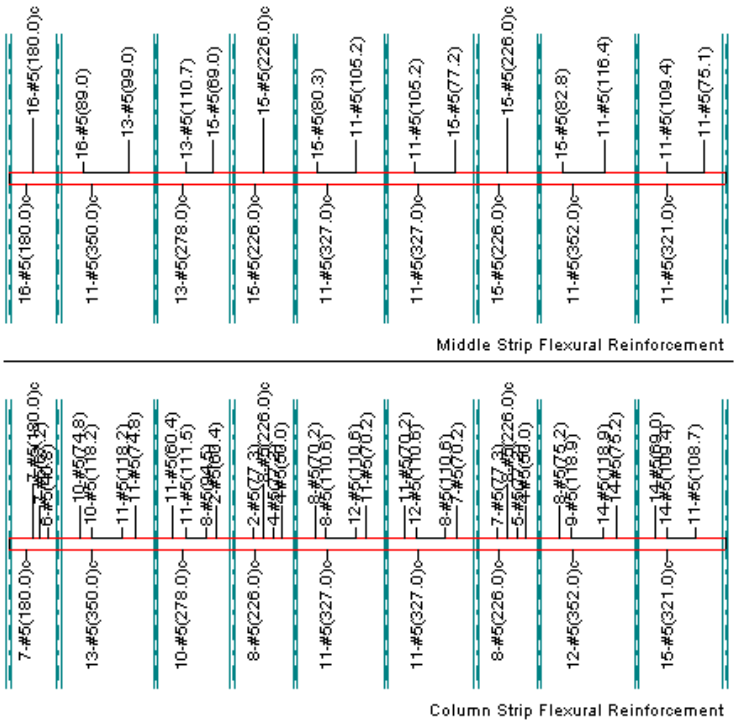
$\alpha_c = 40 \quad \beta_c = 28/16 = 1.75 \quad b_o = 128.5$ IN

$V_u = wA = 0.259(792 - (996/144) = 203^k$

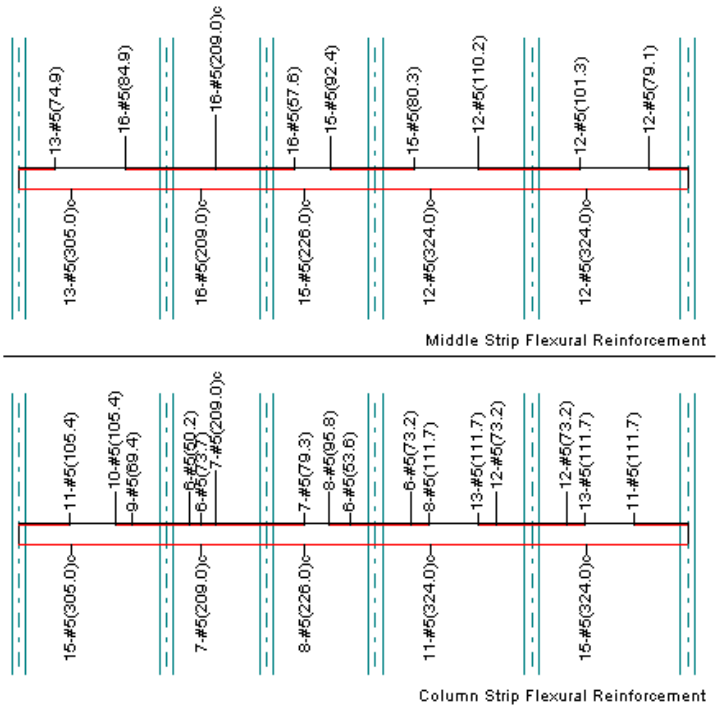
min | 4 ✓
2 + 4/1.75 = 4.29
2 + 40(10.125)/128.5 = 5.15

$\phi V_c = 0.75(4)\sqrt{5000}(128.5)(10.125) = 276^k$

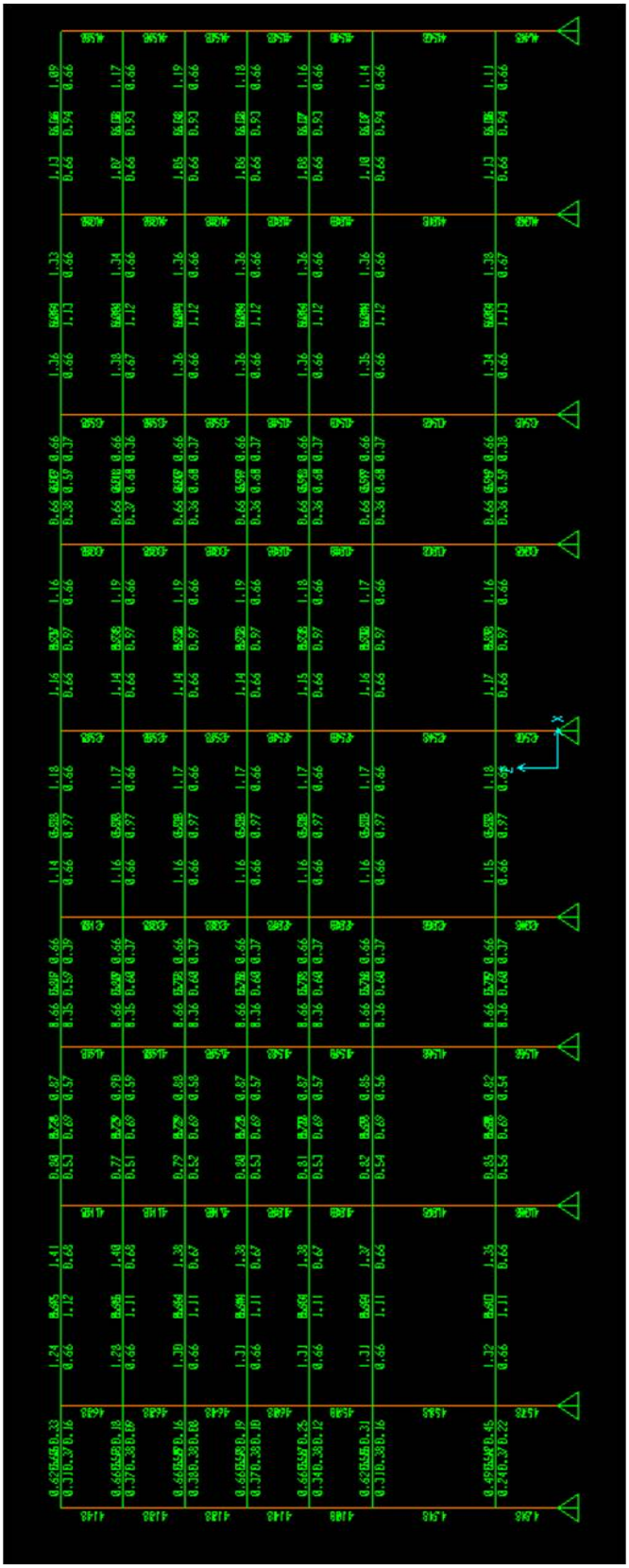
$V_u \le \phi V_c$ ✓



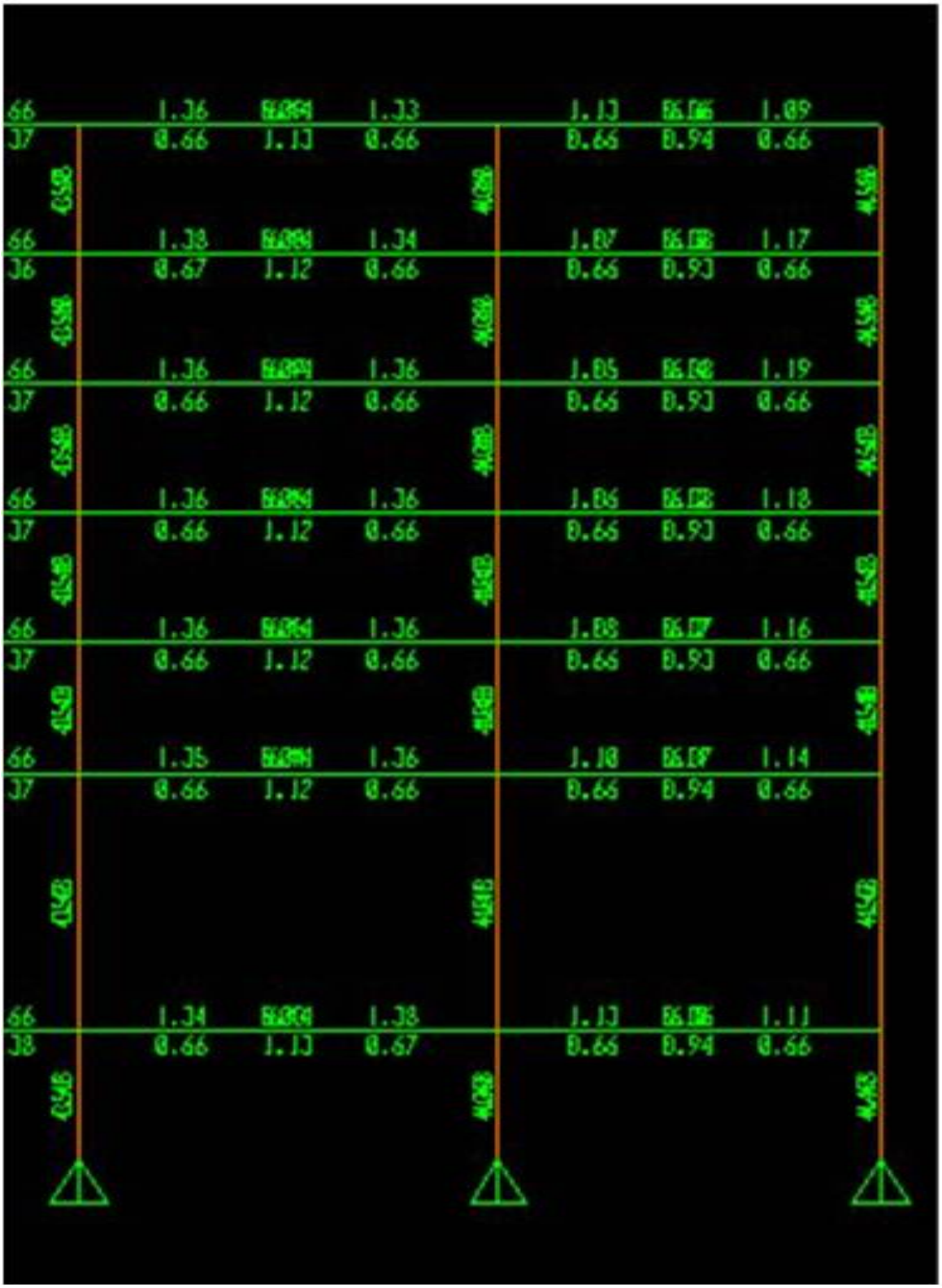
PCA Slab Output of reinforcement for flat plate reinforced concrete slab in E-W Direction.



PCA Slab Output of reinforcement for flat plate reinforced concrete slab in N-S Direction.



SAP 2000 Output of reinforcement for reinforced concrete slab with beams in E-W Direction (Location of interest on following page).



*Enlarged view of SAP 2000 Output of r**reinforcement for reinforced concrete slab with beams in E-W Direction.***

APPENDIX F – THERMAL AND MOISTURE CALCULATIONS

Thermal Gradient and Vapor Pressure Data for Existing Wall Assembly:

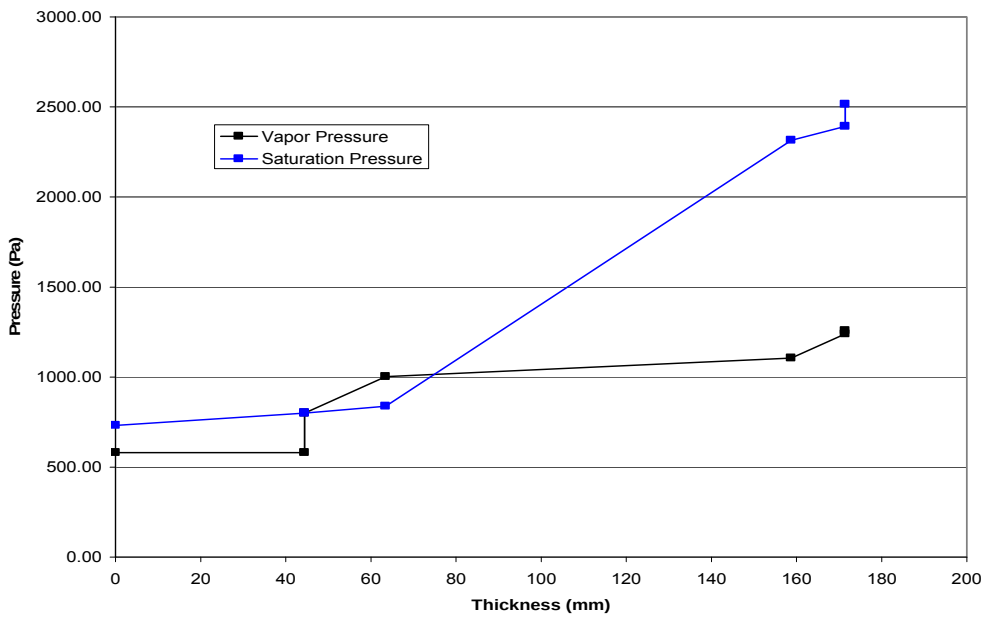
Metal Panel Thermal Gradient							
Surface	Thickness (in)	Stud			Insulation		
		R	T_{xhigh} (°F)	T_{xlow} (°F)	R	T_{xhigh} (°F)	T_{xlow} (°F)
Outside	0	0.17	76.87	36.65	0.17	76.93	36.36
Metal Panel	1.75	1.07	76.03	40.71	1.07	76.46	38.64
Air Barrier	1.75	0.00	76.03	40.71	0.00	76.46	38.64
Sheathing	2.5	0.56	75.59	42.85	0.56	76.21	39.84
Stud w/ Insulation	6.25	6.00	70.89	65.70	13.00	70.50	67.59
GWB	6.75	0.45	70.53	67.41	0.45	70.30	68.55
Inside	6.75	0.68	70.00	70.00	0.68	70.00	70.00
	ΣR	8.93		ΣR	15.93		
	U-Value	0.11		U-Value	0.06		

Metal Panel Vapor Pressure							
Surface	Thickness (mm)	Stud			Insulation		
		R_v	P (Pa)	P_{sat} (Pa)	R_v	P (Pa)	P_{sat} (Pa)
Outside	0	0.000013	580.75	739.58	0.000013	580.14	731.31
Metal Panel	44.45	0.0000	580.75	867.10	0.0000	580.14	799.89
Air Barrier	44.45	0.00083	839.50	867.10	0.00083	799.88	799.89
Sheathing	63.5	0.00077	1078.54	941.47	0.00077	1002.88	838.10
Stud w/ Insulation	158.75	0.00000	1078.54	2168.51	0.00039	1105.48	2315.05
GWB	171.45	0.00051	1236.40	2300.93	0.00051	1239.54	2392.73
Inside	171.45	0.000067	1257.22	2514.45	0.000067	1257.22	2514.45
	ΣR_v	0.00219		ΣR_v	0.00258		

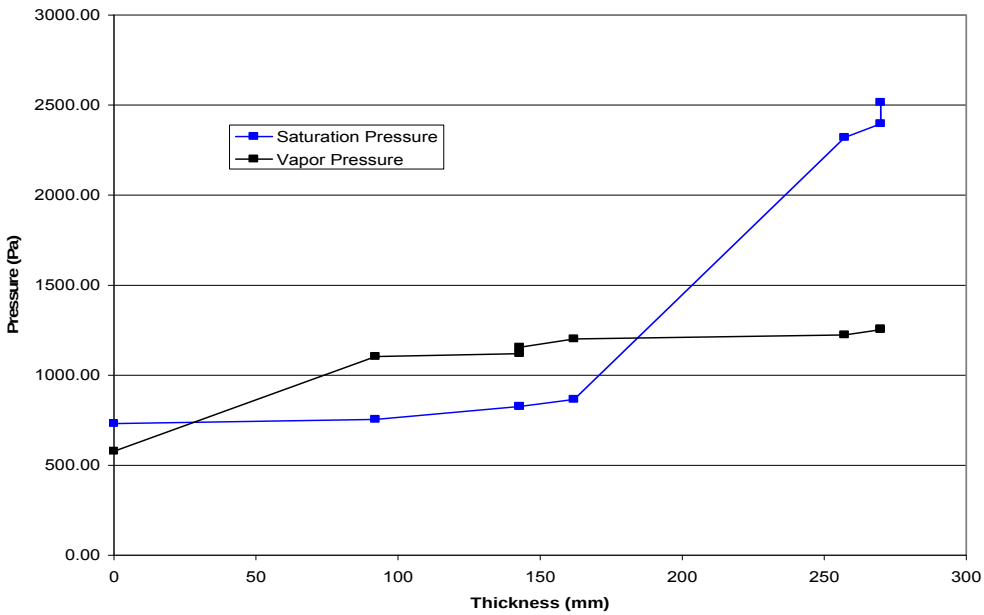
Brick Veneer Thermal Gradient							
Surface	Thickness (in)	Stud			Insulation		
		R	T_{xhigh} (°F)	T_{xlow} (°F)	R	T_{xhigh} (°F)	T_{xlow} (°F)
Outside	0	0.17	76.87	36.62	0.17	76.93	36.35
4" Face Brick	3.625	0.385	76.59	38.01	0.385	76.76	37.15
2" Air Space	5.625	1.13	75.74	42.10	1.13	76.28	39.49
Air Barrier	5.625	0.00	75.74	42.10	0.00	76.28	39.49
Sheathing	6.375	0.56	75.33	44.13	0.56	76.04	40.65
Stud w/ Insulation	10.125	6.00	70.84	65.90	13.00	70.48	67.65
GWB	10.625	0.45	70.51	67.53	0.45	70.29	68.59
Inside	10.625	0.68	70.00	70.00	0.68	70.00	70.00
	ΣR	9.37		ΣR	16.37		
	U-Value	0.11		U-Value	0.06		

Brick Veneer Vapor Pressure							
Surface	Thickness (mm)	Stud			Insulation		
		R_v	P (Pa)	P_{sat} (Pa)	R_v	P (Pa)	P_{sat} (Pa)
Outside	0	0.000013	577.49	738.69	0.000013	577.47	731.03
4" Face Brick	92.075	0.009	1121.92	780.45	0.009	1103.71	754.47
2" Air Space	142.875	0.00027	1138.27	914.71	0.00027	1119.51	826.82
Air Barrier	142.875	0.00062	1175.91	914.71	0.00062	1155.89	826.82
Sheathing	161.925	0.00077	1222.44	988.85	0.00077	1200.87	865.07
Stud w/ Insulation	257.175	0.00000	1222.44	2183.86	0.00039	1223.60	2320.25
GWB	269.875	0.00051	1253.17	2310.65	0.00051	1253.31	2395.95
Inside	269.875	0.000067	1257.22	2514.45	0.000067	1257.22	2514.45
	ΣR_v	0.01125		ΣR_v	0.011638		

Vapor Pressure for Existing Metal Panel Wall Assembly



Vapor Pressure for Existing Brick Veneer Cavity Wall Assembly



Thermal Gradient and Vapor Pressure Data for New Wall Assembly:

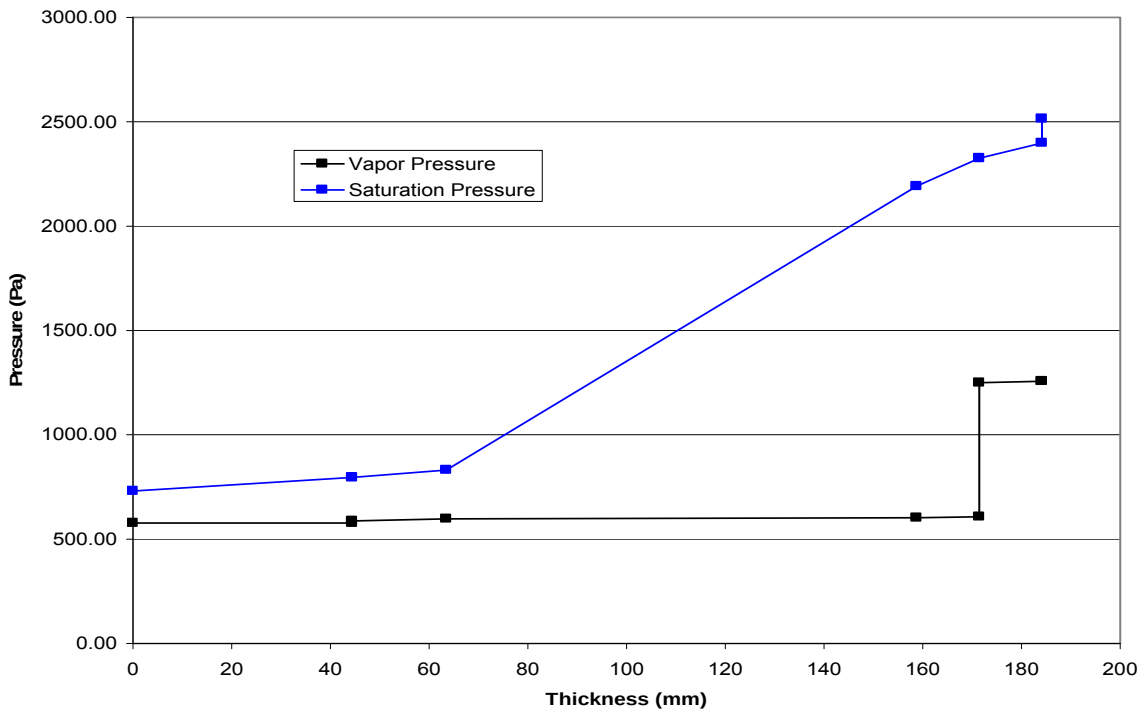
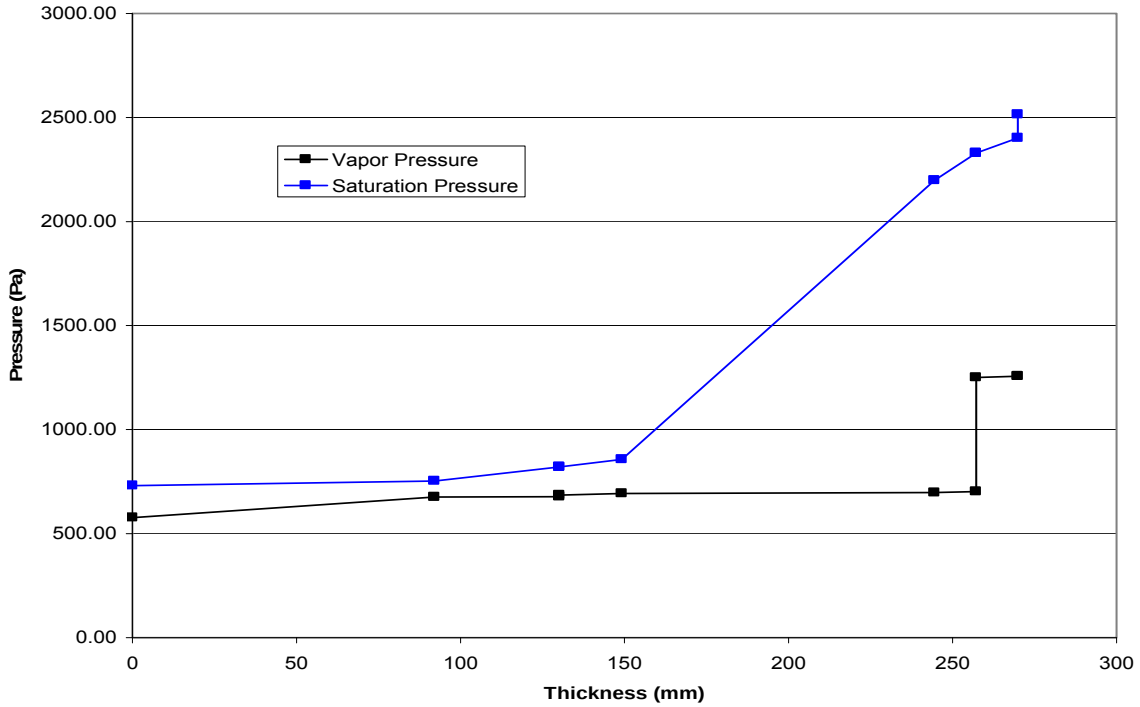
Metal Panel							
Surface	Thickness (in)	Stud			Insulation		
		R	T_{xhigh} (°F)	T_{xlow} (°F)	R	T_{xhigh} (°F)	T_{xlow} (°F)
Outside	0	0.17	76.88	36.59	0.17	76.93	36.34
Metal Panel	1.75	1.07	76.11	40.30	1.07	76.48	38.51
Air Barrier	1.75	0.00	76.11	40.30	0.00	76.48	38.51
Sheathing	2.5	0.56	75.71	42.25	0.56	76.25	39.64
Stud w/ Insulation	6.25	6.00	71.42	63.11	13.00	70.83	65.99
Sheathing	6.75	0.85	70.81	66.07	0.85	70.47	67.71
Vapor Barrier	6.75	0.00	70.81	66.07	0.00	70.47	67.71
GWB	7.25	0.45	70.49	67.64	0.45	70.28	68.62
Inside	7.25	0.68	70.00	70.00	0.68	70.00	70.00
	ΣR	9.78		ΣR	16.78		
	U-Value	0.10		U-Value	0.06		

Metal Panel							
Surface	Thickness (mm)	Stud			Insulation		
		R_v	P (Pa)	P_{sat} (Pa)	R_v	P (Pa)	P_{sat} (Pa)
Outside	0	0.000013	576.88	737.94	0.000013	576.87	730.78
Metal Panel	44.45	0.0000	576.88	853.43	0.0000	576.87	795.71
Air Barrier	44.45	0.00083	587.65	853.43	0.00083	587.57	795.71
Sheathing	63.5	0.00077	597.61	920.17	0.00077	597.45	831.78
Stud w/ Insulation	158.75	0.00000	597.61	1981.63	0.00039	602.45	2190.52
Sheathing	171.45	0.00040	602.74	2196.84	0.00040	607.54	2324.81
Vapor Barrier	171.45	0.0500	1249.78	2196.84	0.0500	1249.84	2324.81
GWB	184.15	0.00051	1256.36	2318.84	0.00051	1256.36	2398.77
Inside	184.15	0.000067	1257.22	2514.45	0.000067	1257.22	2514.45
	ΣR_v	0.05259		ΣR_v	0.05298		

Brick Veneer							
Surface	Thickness (in)	Stud			Insulation		
		R	T_{xhigh} (°F)	T_{xlow} (°F)	R	T_{xhigh} (°F)	T_{xlow} (°F)
Outside	0	0.17	76.88	36.40	0.17	76.93	36.34
4" Face Brick	3.625	0.385	76.62	37.31	0.385	76.77	37.10
1.5" Air Space	5.125	1.12	75.86	41.56	1.12	76.32	39.30
Air Barrier	5.125	0.00	75.86	41.56	0.00	76.32	39.30
Sheathing	5.875	0.56	75.47	43.43	0.56	76.09	40.41
Stud w/ Insulation	9.625	6.00	71.36	63.41	13.00	70.81	66.09
Sheathing	10.125	0.85	70.77	66.24	0.85	70.46	67.77
Vapor Barrier	10.125	0.00	70.77	66.24	0.00	70.46	67.77
GWB	10.625	0.45	70.47	67.74	0.45	70.28	68.66
Inside	10.625	0.68	70.00	70.00	0.68	70.00	70.00
	ΣR	10.21		ΣR	17.21		
	U-Value	0.10		U-Value	0.06		

Brick Veneer							
Surface	Thickness (mm)	Stud			Insulation		
		R_v	P (Pa)	P_{sat} (Pa)	R_v	P (Pa)	P_{sat} (Pa)
Outside	0	0.000013	576.85	732.46	0.000013	576.85	730.53
4" Face Brick	92.075	0.009	676.31	759.28	0.009	675.68	752.80
1.5" Air Space	130.175	0.00021	678.58	896.03	0.00021	677.94	820.71
Air Barrier	130.175	0.00062	685.46	896.03	0.00062	684.78	820.71
Sheathing	149.225	0.00077	693.96	962.66	0.00077	693.22	856.82
Stud w/ Insulation	244.475	0.00000	693.96	2002.01	0.00039	697.49	2198.19
Sheathing	257.175	0.00040	698.34	2209.54	0.00040	701.85	2329.41
Vapor Barrier	257.175	0.0500	1250.87	2209.54	0.0500	1250.91	2329.41
GWB	269.875	0.00051	1256.48	2326.85	0.00051	1256.49	2401.62
Inside	269.875	0.000067	1257.22	2514.45	0.000067	1257.22	2514.45
	ΣR_v	0.061582		ΣR_v	0.061971		

Vapor Pressure for New Metal Panel Wall Assembly



Vapor Pressure for New Brick Veneer Cavity Wall Assembly