TECHNICAL REPORT #2
ALTERNATE FLOOR SYSTEM ANALYSIS

CITY VISTA.

BUILDING 2. 5TH AND K STREET . WASHINGTON D. C.

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OCTOBER 26, 2007

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EXECUTIVE SUMMARY:

The purpose of this report is to explore alternative floor systems for City Vista Building 2. Currently the building uses a two way flat plate post tension system. Tendons are unbound, banded tendons run north to south and uniform tendon run east to west. City Vista is located in downtown Washington DC where there is a height restriction of 130'. Currently the building is 128'-6" tall with a 9'-4" floor to ceiling height. The floor slab has a thickness of 7 ½". When selecting and designing alternate systems floor slab depth is the governing factor so no rentable floors space is lost. In many cases this meant smaller bays to accommodate a thinner slab. This report takes an in-depth look at (4) alternative floor systems:

1. Girder slab
2. Two way slab
3. Composite Beam
4. Pre-cast Hollow core slab with inverted tee beams

Due to City Vista's current irregular column grid many of these systems forced a new column grid. Some preliminary column sizing is included in this report, although further architectural and structural analysis will be done in the future.

After design and examining cost and constructability issues the two way slab and girder slab system are possible alternatives to the current post tension system. Both systems provide a thin monolithic light weight floor system, although these systems require additional columns and an altered column grid. These issues will need to be examined further in future reports.

EXISTING FLOOR SYSTEM

City Vista is a three building mixed used complex in downtown Washington D.C. Building 2 is strictly residential and contains 149 condos along with a community room, library, steel frame pedestrian bridge, and outdoor patio. This 11 story 324,298 square feet building reaches a height of 114'-0" not including the penthouse. Currently a flat plate two way post tension system is used. The slab is supported by a grid of (52) cast in place concrete columns and (4) concrete shear walls which are used for lateral stability. The current layout can be seen in Figure 1. Post tension tendons are unbounded and span in both directions with a minimum of (2) tendons above columns. Banded tendon run north to south and uniformed tendon run east to west. Bundle sizes varies but is restricted to a minimum of 4 tendons per bundle. The 7 ½" slab is also reinforced two-ways with #4@24" bottom mesh reinforcement and #5 top bars at various locations, rebar is also provided around the perimeter.

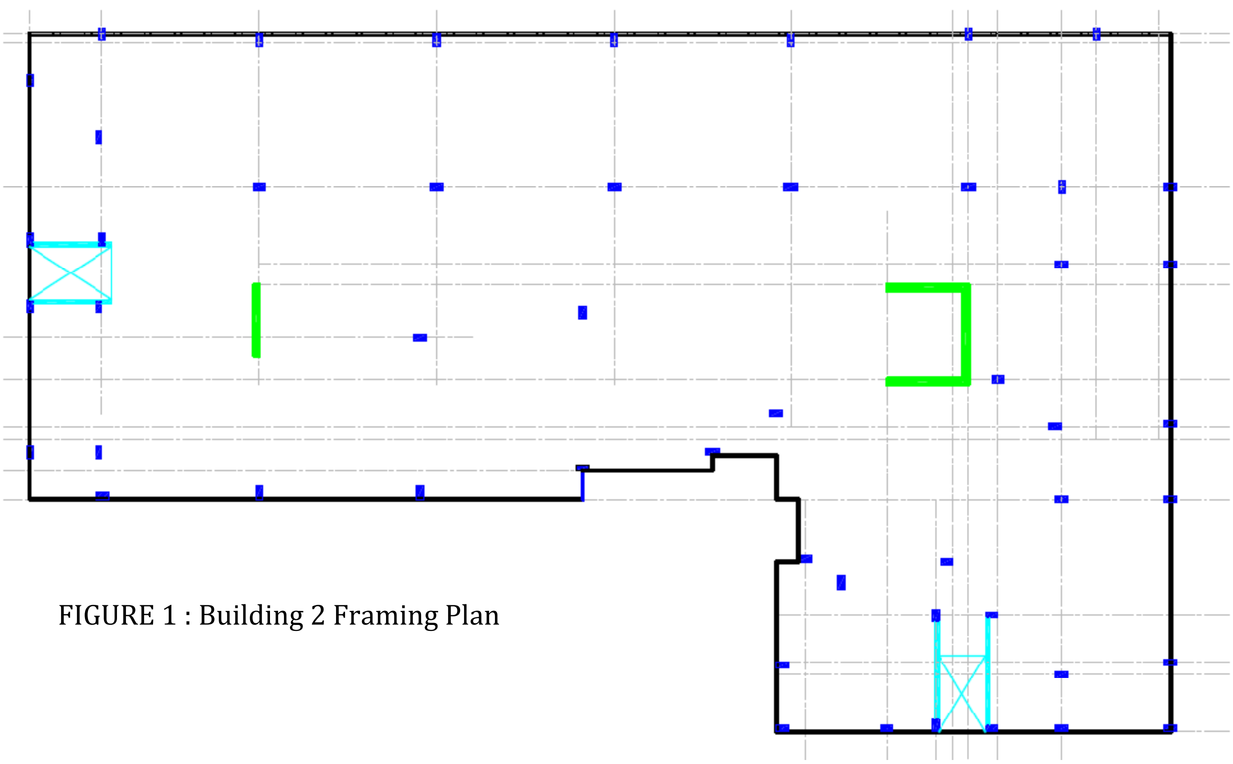

FIGURE 1 : Building 2 Framing Plan

Post tension was not examined in technical assignment 1, therefore PT calculations have been included in this report.

Advantages:

1. Shallower floor plenum: Post tension building can reduce floor to ceiling height
2. Reduction in materials: PT slabs require less rebar and are generally thinner so less concrete is needed.
3. Longer clear spans: PT slabs allow long continuous spans resulting in fewer columns which ultimately results in a lighter building.
4. Strength: Higher ultimate strength because of bond between concrete and strands

Disadvantages:

1. Cable Integrity: Cables can distress over time, although this is not a promenade problem
2. Remodeling: If the building is renovated in the future the floor slab can only be punctured once exact locations of tendons is known.
3. Shorting issues: As a result of PT ability to hold shrinkage cracks together tightly when shorting occurs large tension cracks can occur around perimeter of building.

For this report I will concentrate on one typical interior bay. To simplify this exercise I have altered the column grid to the following, column that have been moved are now yellow, and the bay being analyzed is highlighted in red . (See Figure 2)

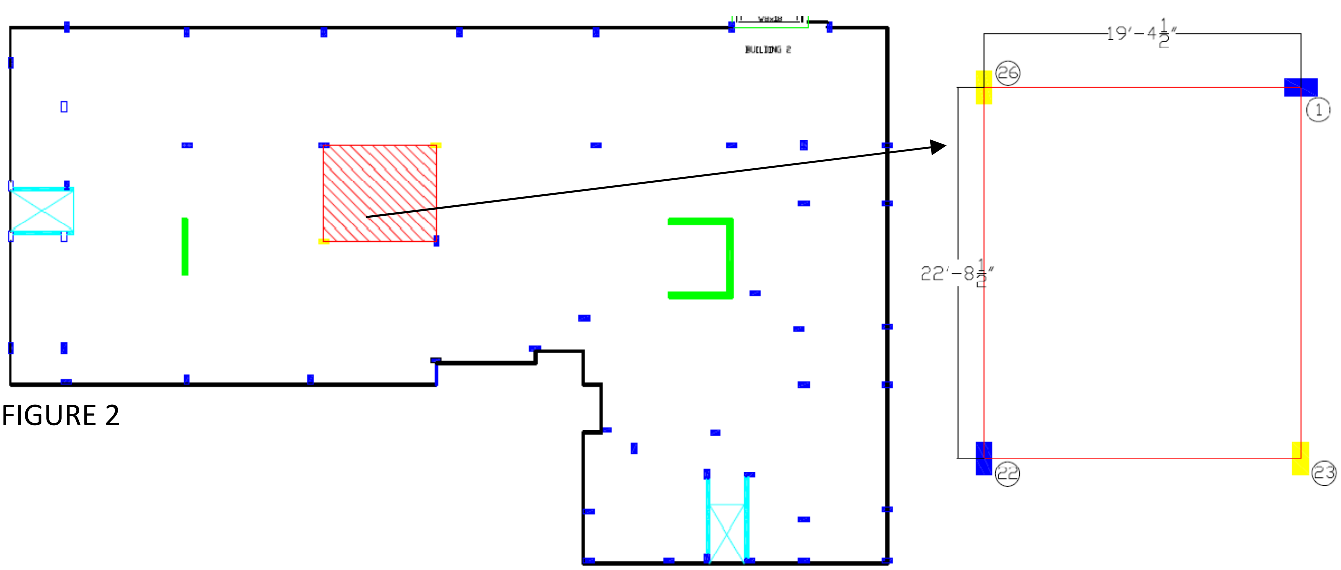

FIGURE 2

Columns 22, 23, and 26 are 28"x16" and column 1 is 16"X28". All columns have a specified f'c of 6000 psi.

GRAVITY LOAD SUMMARY

DEAD LOAD

7 ½" Post Tension Slab	150 PCF
Beams	VARIES
Façade #1 (4" Brick, 8" CMU)	95 PSF
Façade #2 (4" Brick, Glass, Cold form)	35 PSF
Superimposed Dead Loads:	
Partitions	20 PSF

LIVE LOAD

Residential Units:	40 PSF
Lobbies/Corridors:	100 PSF
Balconies:	100 PSF
Mechanical/Storage:	125 PSF
Canopy:	60 PSF
Public Areas:	100 PSF
Snow:	30 PSF
Elevator Rooms:	150 PSF

ALTERNATE FLOOR SYSTEMS

In this report I will be evaluating the existing post tension floor system and four alternate floor systems:

1. Girder Slab
2. Two-Way Flat Plat
3. Composite Beam
4. Pre-Cast hollow core planks with inverted tee beams

City Vista's presents designers with several challenges due to its design and location.

1. City Vista is located in Washington D.C where there is a height limit of 130 ft. Currently Building 2 is 114'-0" not including the penthouse. At section that include the penthouse the building height is 128'-6". It will be a challenge to stay within the 130' limit.
2. Because a flat plate system is used the underside of the floor slab is already a finished ceiling. When choosing floor systems this will be taken into consideration.

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GIRDER SLAB

The Girder slab is a relatively new floor system used in conjunction with a steel framed building. The system provides a 10” monolithic slab consisting of an 8” precast pre-stressed hollow core slab with 2” of concrete topping. The panels are grouted to D shape steel beams which are connected to the columns. After grouting in performed the slab and girder develop composite action. The girder slab system can span up to 28’-0” and are ideal for bays up to 20’x28’. After performing calculation the bay sizes will be restricted to 20’X20 due to the current loading conditions. Roughly this system would also require 73 columns, 21 more than the original design. This system will impact both the foundation design and architectural plan, although it will provide a monolithic slab and a final building height of roughly 131’-0” (including penthouse).

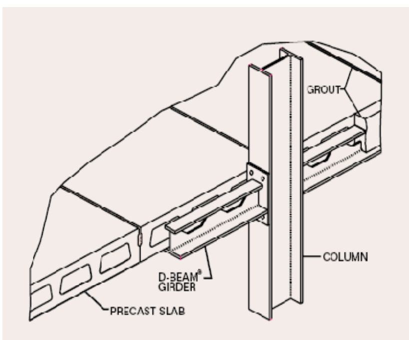

FIG 3: Typical Section w/out topping

FIG 4: Floor system before topping is applied

Advantages:

1. Light weight : This system is lightweight
2. Ceiling Finish: Pre-cast planks are monolithic so the bottom of the planks can be used as a finished ceilings,
3. Construction Time: Fast construction time due to precast planks.

Disadvantages

1. Restricted Use: Only practical in residential construction due to loading capabilities.
2. Restricted column lay out : Restriction of 28’-0”x 20’-0” bay size.
3. Fireproofing: Is required on all steel members

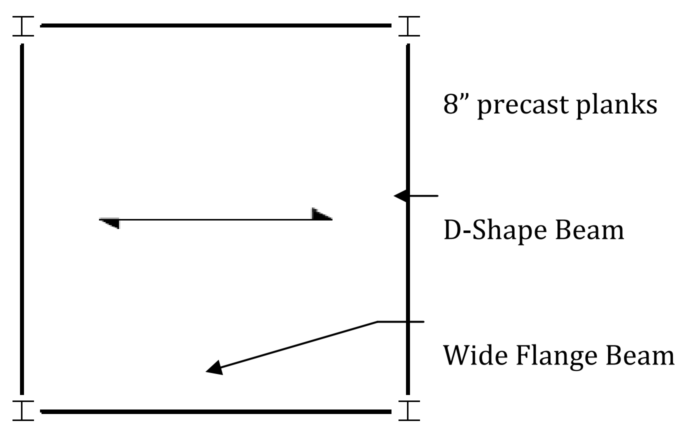

FIGURE 5: Girder Slab Plan

***For full calculations and detailed floor plans see Appendix PAGE:18 ***

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TWO WAY FLAT PLATE

Currently City Vista is a flat plate PT system , as an alternative system I have chosen a two way concrete flat plate. Calculation were performed and a 7 ½" slab will work as long as all bays are approximately 20'x23' (** ALL CALC IN APPENDIX **). This system will require the current column layout to be altered, although the totally building height will stay constant at 128'-6". Since slab depth drives the design this is a viable option. This system will also require column grid alterations.

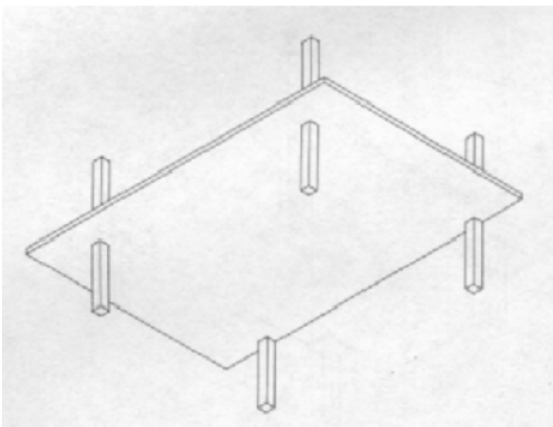

FIG 6 : Typical 2 Way Slab Detail

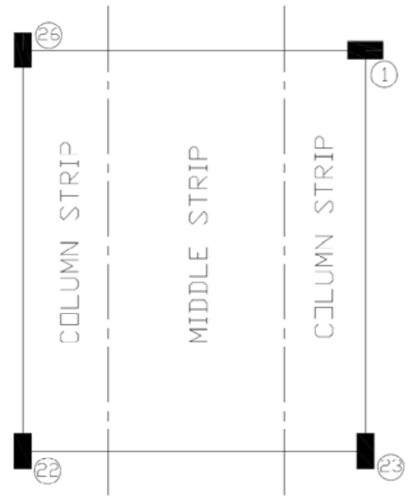

FIG 7: 2 Way Slab Plan for N-S Analysis

Advantages :

1. Thinner Slab: Like PT slabs, a two way concrete slab provided a thin slab without beams.
2. Fire Proofing: Depending on slab thickness very little to no fire proofing is needed.

Disadvantages:

1. Column Layout: Current lay out will need to be altered to a more typical bay scheme to apply this floor system.
2. Punching Shear: The two way flat slab is very prone to punching shear, this will need to be examined closely to ensure that failure won't occur.

***For full calculations and detailed floor plans see Appendix PAGE: 24 ***

COMPOSITE BEAM

Most steel system will increase the floor to ceiling height of City Vista as a result reducing the rentable space. The composite beam system potentially could be thinner than other steel systems. Composite action of the concrete and steel allow for smaller beams. Composite action is created though the transfer of forces though shear studs welded to the W beam. This system will provide a minimum floor plenum of 1'-0" resulting in the loss of a floor. Although compared to the other systems bay sizes can potentially be much larger. After doing analysis bay sized could be up to 30x35' this is significantly larger than other proposed systems

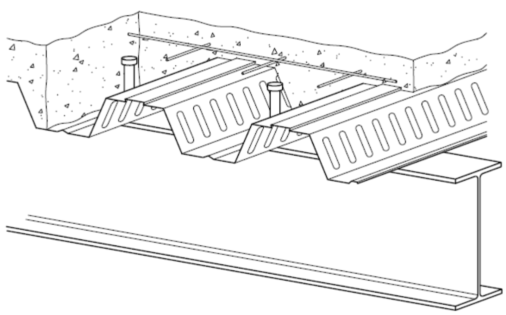

FIG 8. Composite Beam Section

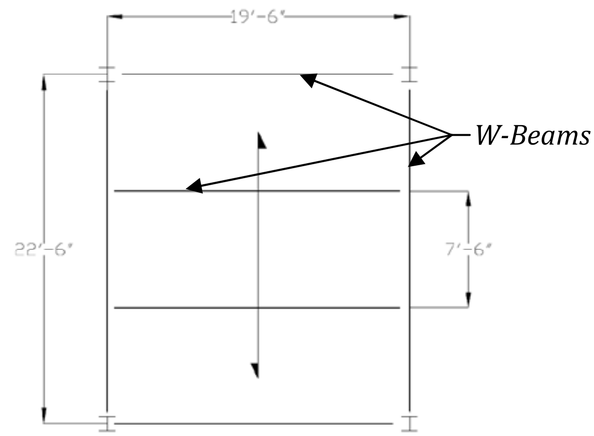

FIG 9. Typical Frame Plan

Advantages:

1. Light Weight: The current system is light weight, to avoid increasing the foundation capacity a light weight system is key
2. Stronger System: Compared to other steel systems the composite action gives a stronger system with less materials.

Disadvantages:

1. Fireproofing: Steel would require fire proofing
2. Increased floor Height: Depending the sizing of the steel beams floor plenum could range from 1-2 Feet.
3. Construction Time: Shear studs would require additional construction time.

***For full calculations and detailed floor plans see Appendix PAGE :29 ***

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PRE-CAST FLOOR SYSTEM

For the last system precast hollow core slabs supported by precast L and inverted Tee beams will be used. Floor depth was a controlling factor during design; therefore I used smaller bays so each member would have to carry fewer loads resulting in a thinner slab. Since the current system has such a variable column grid I will design and model 1 typical exterior and interior bay. The pre-cast system can provide an 8" slab, consisting of a 6" hollow core slab with 2" topping. Inverted Tee-beams with a depth of 24" will span between columns to support the 4'x 23' pre-cast floor panels.

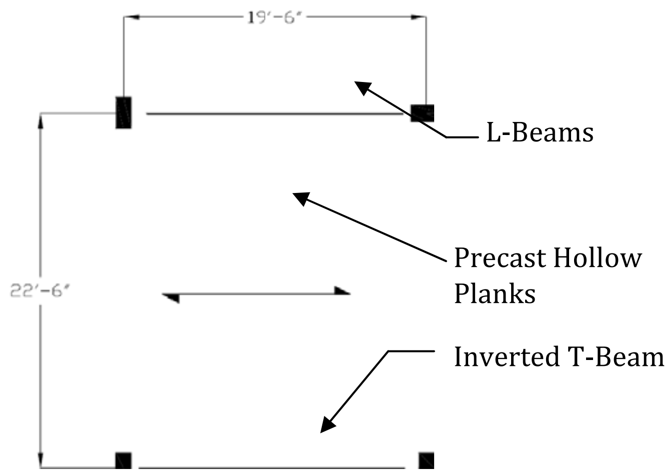


FIG 10: Typical Exterior Panel

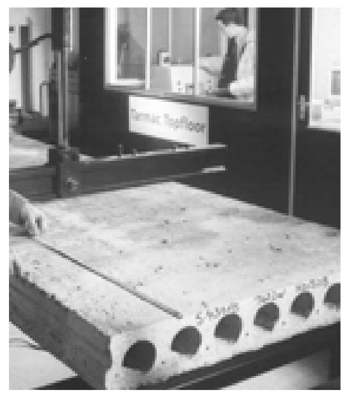


FIG 11: Floor Planks w/out Topping

Advantages:

1. Construction Time: Since pouring and curing is done offsite construction is significantly faster than other systems
2. Lightweight: resulting in few alterations to current foundation design for lightweight PT system.
3. Fireproofing: No fireproofing needed

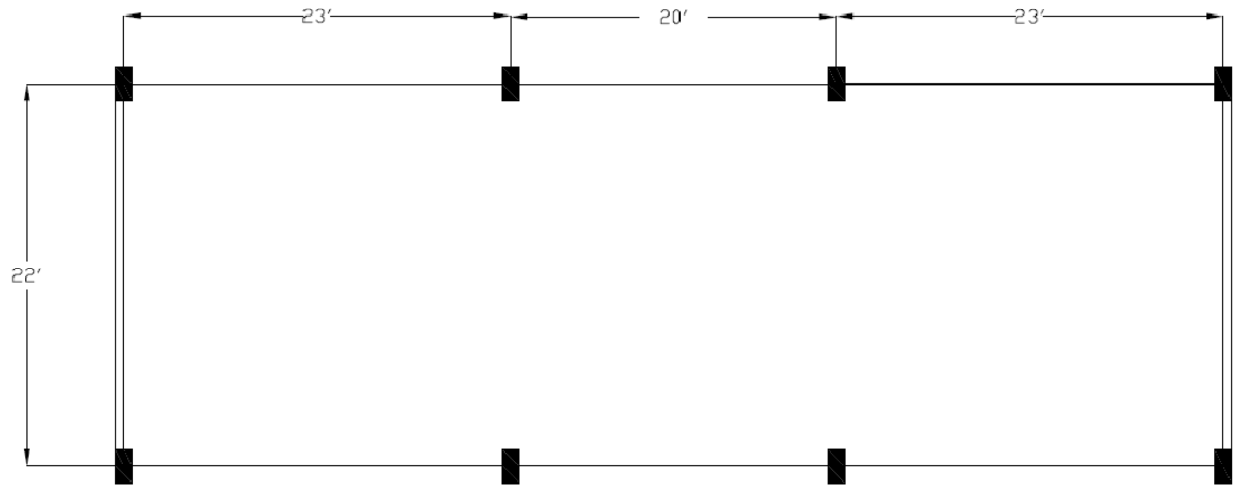
Disadvantages:

1. Lead Time: Since construction is done off site, a pre-cast system requires more planning so materials arrive on time.
2. Size Restrictions: Panels and beams come in standard sizes; therefore column grid will be restricted.

***For full calculations and detailed floor plans see Appendix PAGE: 33 ***

POST TENSION SUMMARY

*Due to irregular Column Layout the following Frame was used for analysis, this frame uses common span lengths from the original design **



Current System:
The plans call out for Fe = 13.5 k/ft
Effective Prestress forces: Interior Bay range 108-316 Kips
Exterior Bays 162-270 Kips

After Calc :
Fe= 13.4 K/ft
Interior force = 214 K
Exterior Force 295 K

Due to the irregular floor plan and my limited knowledge on the subject results are vague. Future tech reports will explore prestress in greater detail

- ➔ For now it can be concluded that the PT system in place is adequate to support the loads Building 2 will see.
  ** All Calc can be found in Appendix**

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SYSTEM SUMMARY

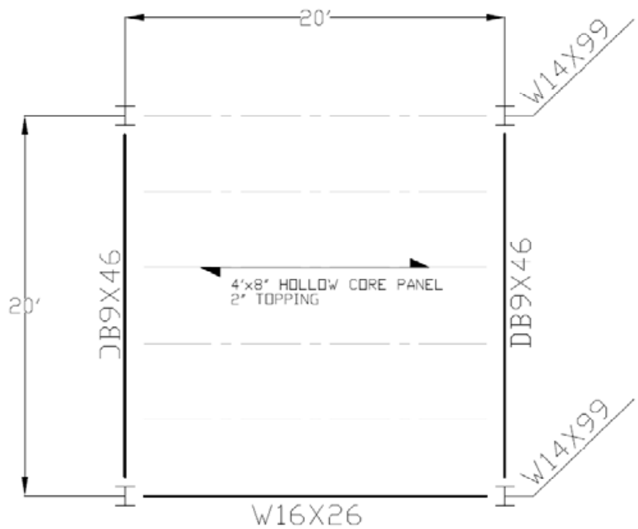


FIG 12 : Exterior Girder Slab Floor Panel

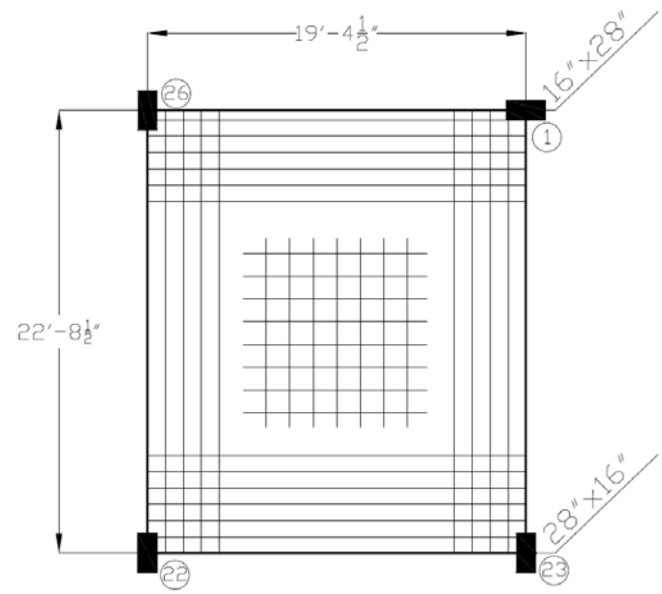


FIG 13 :Interior Panel 2 Way Slab

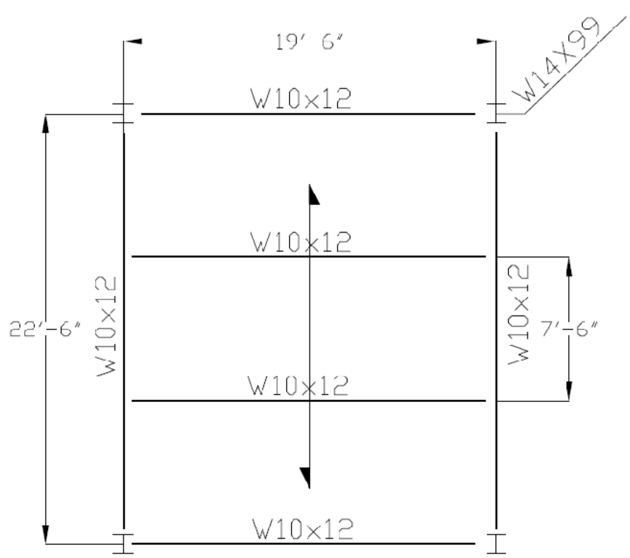


FIG 14 : Interior Panel Composite Beam

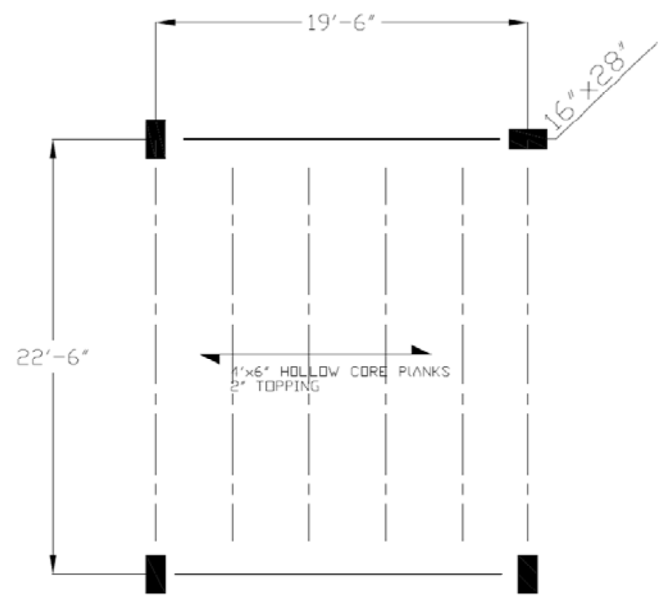


FIG 15: Interior Panel Pre-Cast

***For full calculations and detailed floor plans see Appendix ***

CONCLUSION

	Post Tension	**Girder Slab**	**2-Way Slab**	**Composite Beam**	**Pre-Cast**
Depth	7.5”	10”	7.5”	1’-6”	8”
Weight	94PSF	81PSF	94PSF	80PSF	74PSF
Column (Approx)	16”x28”	W14	16”x28”	W14	16”X28”
Fireproofing Req’d	No	Yes	No	Yes	No
Formwork	Yes	No	Yes	No	No
Cost: Just floor slab	$12.75SQ/FT	No exact cost info but very similar to pre-cast planks	$12.75 SQ/FT	$18.60 SQ/FT	$12.12 SQ/FT
Construction Time	-Fast construction time, faster than conventional cast in place concrete	-Quick field assembly -Lead time for prefab components	-Same as original	- Due to installation of shear studs construction time will increase	-Quick field assembly -Lead time for prefab components
Comments	-Flexible column grid -long clear spans	-Column grid alteration -Restricted bay size	-Column grid alteration	-Column grid alteration -long clear spans	-Column grid alteration
Practical Solution		YES	YES	NO	MAYBE

Each System presents its own set of advantages and disadvantages which impacts City Vista’s overall design differently. Due to governing height restriction composite beam will not be a option.

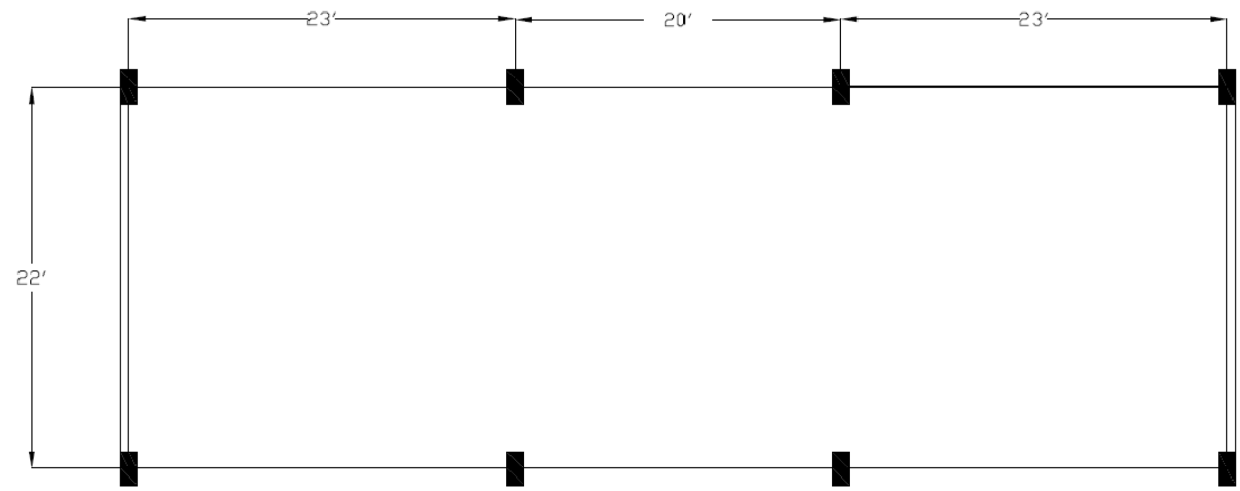
After weighting advantages and disadvantages of each system girder slab and two way slab are the best alternatives. Both systems provide a thin, monolithic, light weight floor system, similar to original. This is important because the foundation is currently designed to support a lightweight system. Constructability and cost were also examined. The girder slab could potentially cut construction time since panels are manufactured off site, and the two way system has a construction time very similar to post tension. On the negative side these two systems will require additional columns and a altered column grid. These issues will need to be examined further in future reports.

APPENDIX

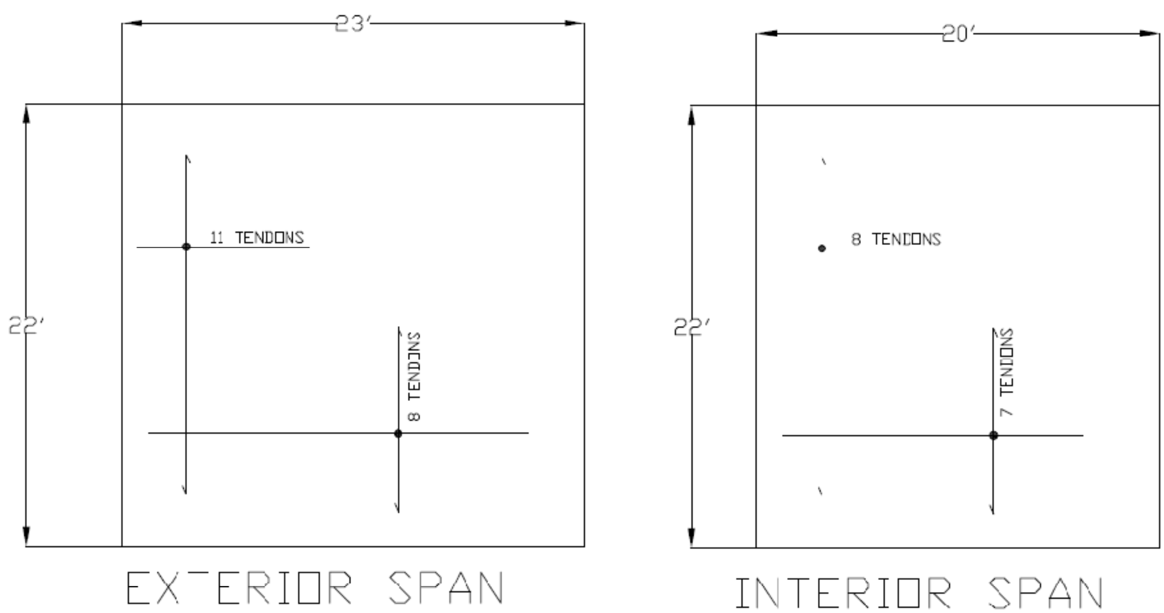
ADDITIONAL CALCULATIONS NOT INCLUDED
IN APPENDIX CAN BE OBTAINED BY REQUEST

Current System: PT Slab

*Due to irregular Column Layout the following Frame will be used, this frame uses common span lengths from the original design **



Tendon Lay Out: Calculation on next page



$f'c = 5000$ psi
$W = 150$ PCF
$f_y = 60{,}000$ psi
$f_{pu} = 270{,}000$ psi
Live load = 40 psf
Superimposed = 15 psf

1. SLAB THICKNESS

longitudinal $\frac{(23)(12)}{45} = 6.13$

Transversal $= \frac{(22)(12)}{45} = 5.86$

Depth = 6" → use 7.5
Due to several larger spans in design

2. LOADS

Interior span: $40\left(1 - \frac{[(20)(22)-150]0.08}{100}\right) = 31$ psf

$1.2(93.75+20) + 1.6(30.72) = 185.65$ psf

Exterior span: $40\left(1 - \frac{[(23)(20)-150].8}{100}\right) = 30$ psf

$1.2(93.75+20) + 1.6(30) = 184$ psf

3. Load Balancing 80% SLAB SW.

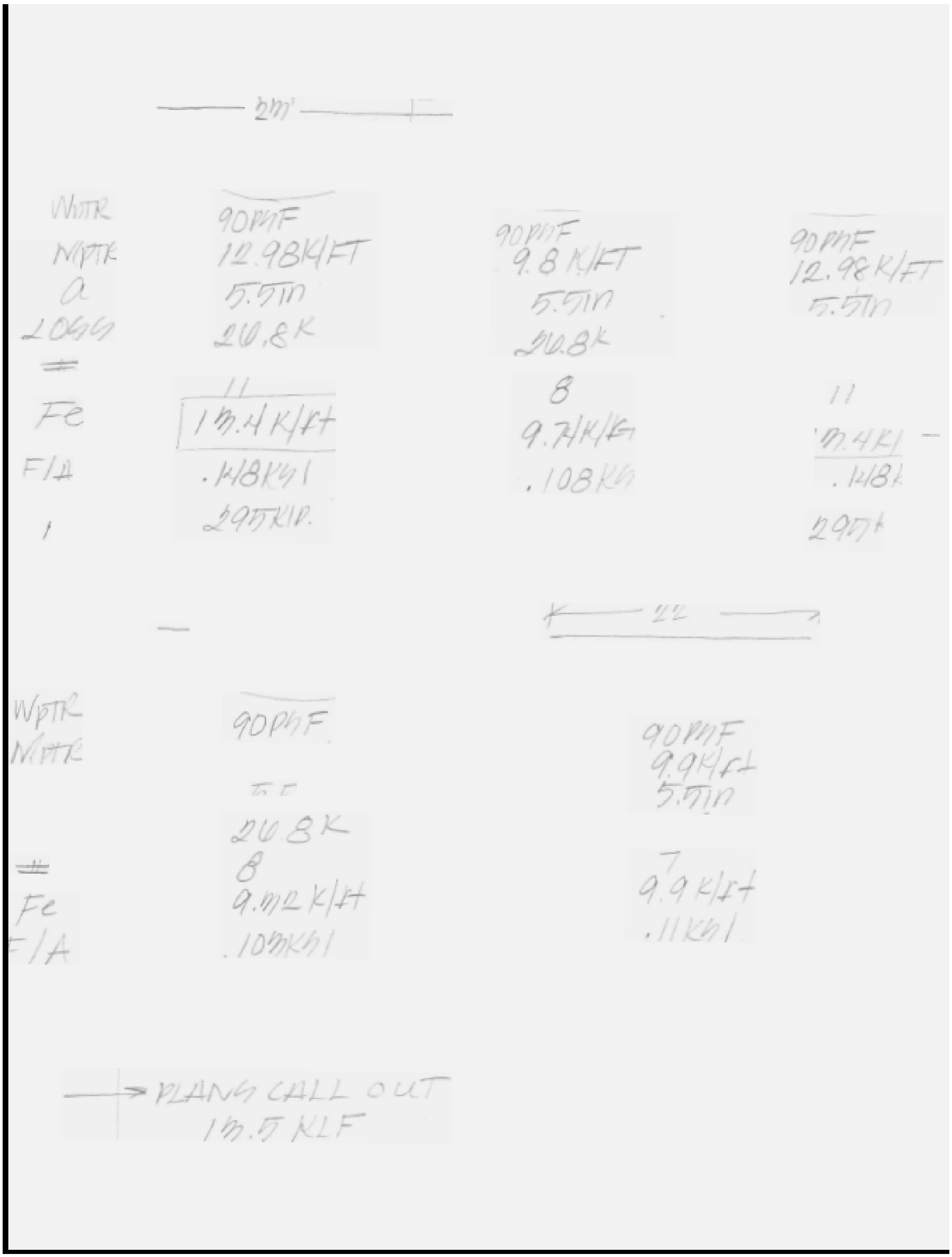
$1.2(.8)(93.75) = .075$ ksf

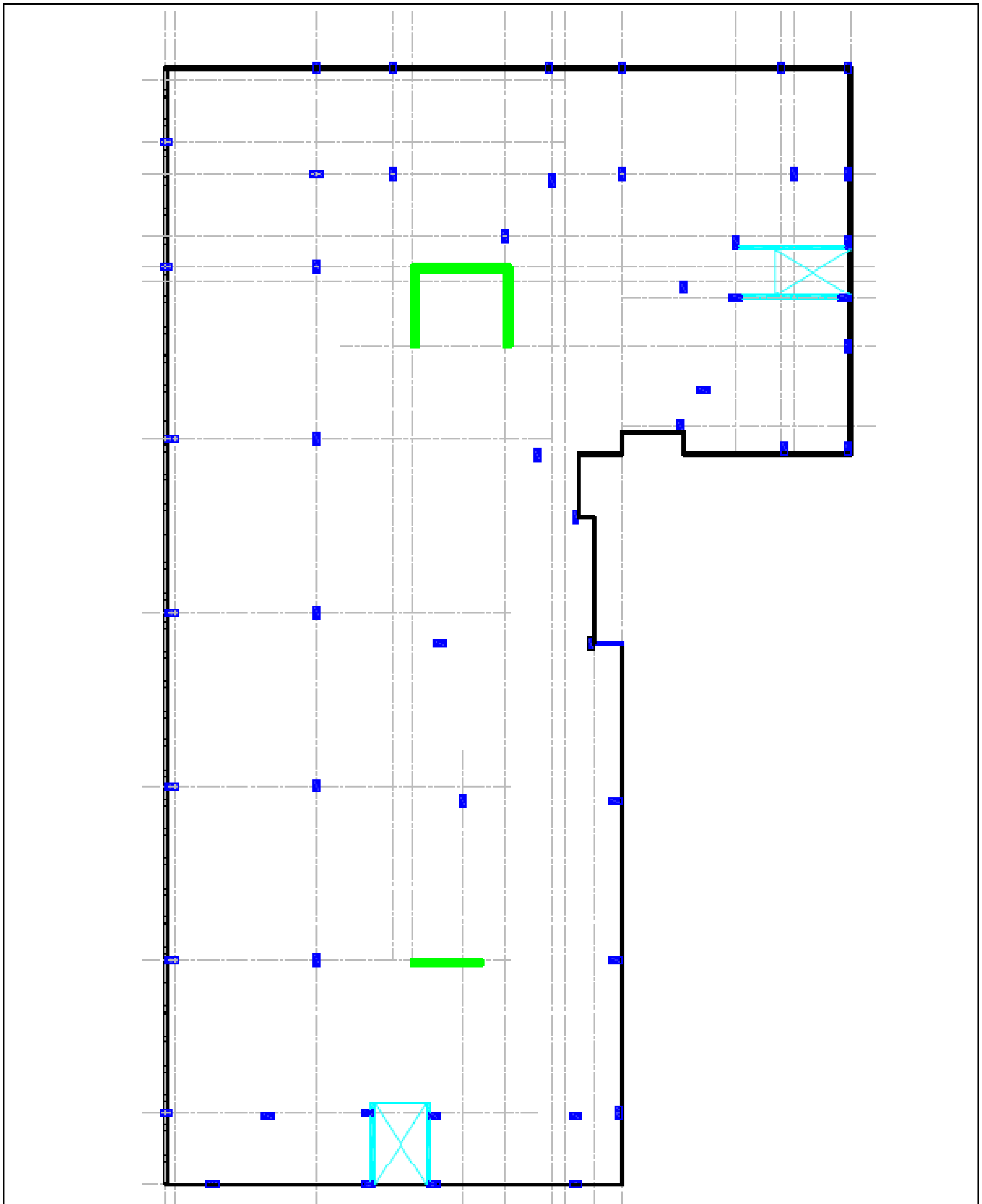
$a_{INT} = 7.5 - 1 - 1 = 5.5$ in

$F_e = \frac{wL^2}{8a} = \frac{(.075)(23)^2}{8(5.5/12)} = 12.98$ k/ft

→ ½ DIAM, 270 ksi/STRAND, 14 ksi loss.

Effective loss $= 0.153(.7)(270-14) = 20.8$ k
(0.153 = A tendon)


90psf
12.98K/FT
5.5in
20.8K
9.8 K/FT
PLANS CALL OUT
13.5 KLF

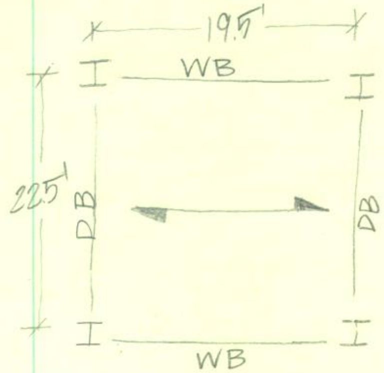


S.1	City Vista Building 2	Original Plan

Floor System #1: GIRDER SLAB

GIRDER SLAB DESIGN

*REFERENCES
- GIRDER-SLAB DESIGN GUIDE
- D-BEAM REFERENCE CALC.



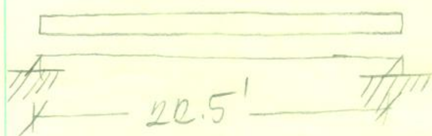
DEAD: PLANKS = 55.45PSF
TOPPING = (150PCF)(.167FT) = 25PSF
SUPERIMPOSED = 20PSF

LIVE: 40 PSF

$\Delta_{ALLOW\,LIVE} = \frac{(22.5)(12)}{360} = .75''$

$\Delta_{ALLOW\,T} = \frac{(22.5)(12)}{240} = 1.125$

$L_{RED} =$



PRECOMPOSITE: $M_{DL} = \frac{(S_{PS} W_{DL})(S_{DB})^2}{8} = \frac{(19.5FT \cdot .055KSF) \cdot (22.5FT)^2}{8}$

$M_{DL} = 68.2\ Kip \cdot ft$

→ D-BEAM TABLE DB9×46 M = 84 KIP·FT

$\Delta DL = \frac{(f'_{C\,PLANK})(S_{PS})(W_{DL})(S_{DB})^4}{384 I_D E_D} = \frac{(5KSI)(19.5FT)(.055KSF)(22.5)^4}{384(195in^4)(29{,}000K/in^2)}$

$= 1.10in$ ∴ OK

COMPOSITE:

$M_{SUP} = \frac{(19.5ft)(.075KSF)(22.5)^2}{8} = 92.9\ KIP \cdot FT$

$M_{TL} = 92.9 + 68.2 = 161\ KIP \cdot ft$

$S_{REQ} = \frac{(161.0\ KIP \cdot FT)(12in/ft)}{.6(50K/in^2)} = 64.4in^3 < 68.0in^3$ ∴ OK

$$\Delta_{SIP} = \frac{(5ksi)(19.5FT)(.075)(22.4)^4(1728)}{384(195)(29000)} = 0.82in > .75in \therefore BAD$$

TRY SMALLER BAY → USING GIRDERSLAB D-BEAM CALCULATOR

20'x20'

$M_T = 131.5 ft\text{-}K$
$S_{REQ} = 52.6 in^3$
$\Delta = 0.57 in$

Results from D-Beam Calculator listed Summarized on next page

$$N = \frac{29000}{57000(4000)^{1/2}} = 8.04 \qquad S_{TC} = 8.04(68.6) = 551.5$$

$$f_c = \frac{(70.2ft\cdot kip)(12in/ft)}{551.5} = 1.65$$

$$F_c = (.45)(4) = 1.8 > 1.65 \therefore OK$$

TENSION BOTTOM FLANGE

$$f_b = \frac{(55.3ft\text{-}K)(12in/ft)}{50.8in^3} + \frac{(70.2ft\text{-}K)(12in/ft)}{80.6in^3}$$

$$13.06ksi + 11.34ksi = 24.37ksi$$

$$F_b = 0.9(50ksi) = 45 > 24.37 \therefore OK$$

SHEAR CHECK

$W_T = 131.25$

$w = (.131)(20) = 2.62$

$R = (2.62)(20ft)/2 = 26.2K$

$f_v = (26.2)/(.375)(5.75) = 12.15ksi$

$F_v = 0.4(50) = 20ksi > 12.15ksi \therefore OK$

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D Beam Specifications:

Designation	Steel Only Web Ignored						Transformed Section Web Ignored				
	Ix	C bot	C top	S bot	S top	Allowable Moment Fy=50 KSI f_b = 0.6Fy	Ix	C bot	C top	S bot	S top
	$In.^4$	In.	In.	$In.^3$	$In.^3$	kft	$In.^4$	In.	In.	$In.^3$	$In.^3$
DB 8 x 35	102	2.80	5.20	36.5	19.7	49	279	4.16	4.40	67.1	63.5
DB 8 x 37	103	2.76	5.24	37.3	19.7	49	282	4.16	4.42	67.7	63.8
DB 8 x 40	122	3.39	4.61	36.1	26.5	66	289	4.26	4.30	67.9	67.2
DB 8 x 42	123	3.35	4.65	36.9	26.5	66	291	4.26	4.32	68.4	67.5
DB 9 x 41	159	3.12	6.51	51.0	24.4	61	332	4.27	5.35	77.7	62.1
DB 9 x 46	195	3.84	5.79	50.8	33.7	84	356	4.43	5.20	80.6	68.6

Designation	Web Included		Depth	Web	Parent Beam			Top Bar
	Weight	AVG AREA	d	Thickness t_w	Size	a	b	w x t
	lb./ft.	$In.^2$	In.	In.		In.	In.	In. x In.
DB 8 x 35	34.7	10.2	8	.340	W10 x 49	4	3	3 x 1
DB 8 x 37	36.7	10.8	8	.345	W12 x 53	2	5	3 x 1
DB 8 x 40	39.8	11.7	8	.340	W10 x 49	3	3.5	3 x 1.5
DB 8 x 42	41.8	12.3	8	.345	W12 x 53	1	5.5	3 x 1.5
DB 9 x 41	40.7	11.9	9.645	.375	W14 x 61	3.375	5.25	3 x 1
DB 9 x 46	45.8	13.4	9.645	.375	W14 x 61	2.375	5.75	3 x 1.5

Initial Load - Precomposite

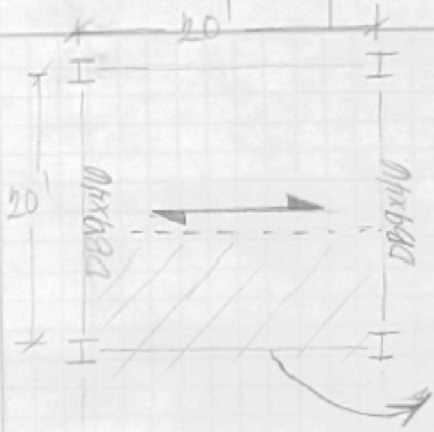
M_{DL} =	55.3	ft-k	<	84.0	ft-k	**OK**
Δ_{DL} =	0.70	in				

Total Load - Composite

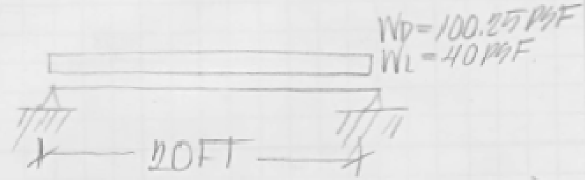
M_{sup} =	76.2	ft-k				
M_{TL} =	131.5	ft-k				
S_{REQ} =	52.6	in^3	<	68.6	in^3	**OK**
Δ_{SUP} =	0.53	in	<	0.67	in	**OK**
Δ_{TOT} =	1.23	in	= L/	194		

Above Values Calculated By: D-Beam Reference Calculator which can be accessed at www.girder-slab.com/downloads/GSDGv1_3.pdf

3 OF 4



DESIGN W BEAM



$W_u = 1.2D + 1.6L = 1.2(100.25) + 1.6(40)$
$= 184.3\ PSF (10FT) =$
$= 1.84$

USE W16x

$M_u = \frac{1.84(20)^2}{8} = 92\ KIP \cdot FT$

$\phi M_n = 828\ KIP \cdot FT$

$I = 301\ in^4$

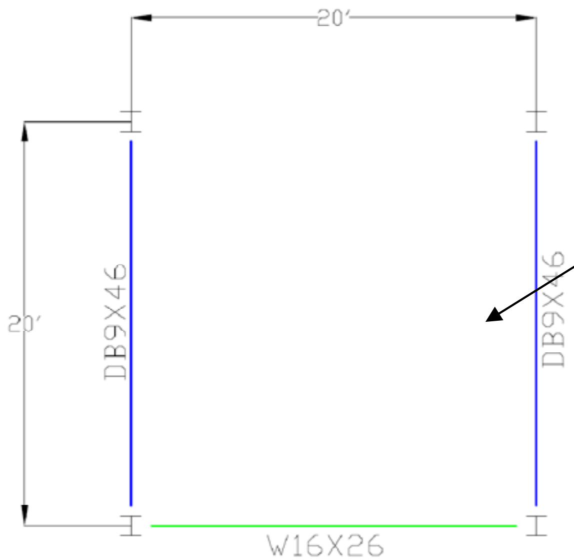
$Z = \frac{\ (12)}{.9(50)} = 34\ in^2$

TRY W16x26 $\phi M_n = 166 > 92 \therefore OK$

$\Delta = \frac{5wl^4}{384EI} = \frac{5}{384} \cdot \frac{(1.4)(20)^4(12)^3}{(29000)(301\ in^4)} = .164\ in$

$\Delta = \frac{L}{360} = \frac{20(12)}{360} = .667\ in \therefore OK$

→ USE W16x26 ext beams.



Typical Exterior Floor Panel (6TH FLOOR)

After Preliminary Sizing

W14x99 INTRIOR COLUMNS
W14x61 EXTRIOR COLUMNS

W16x26 EXTERIOR BEAMS

Nitterhouse hollow core planks
2” Topping, 2 Hr Fire Rating
8”x4’ Panels w/ 4-1/2”Ø strand pattern
Wt= 55.25PSF   Allowable = 181 PS

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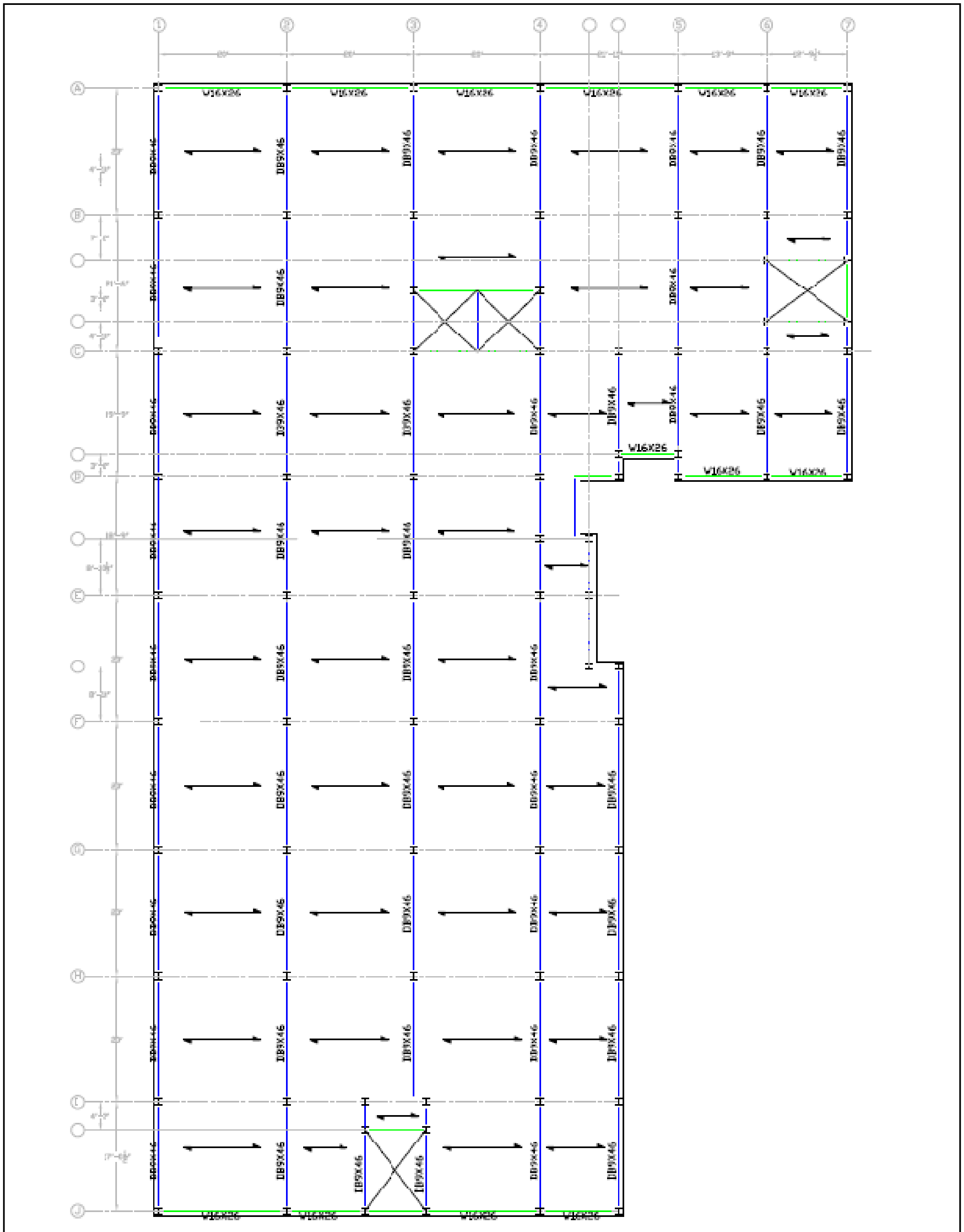

S.2	City Vista Building 2	Girder Slab Plan

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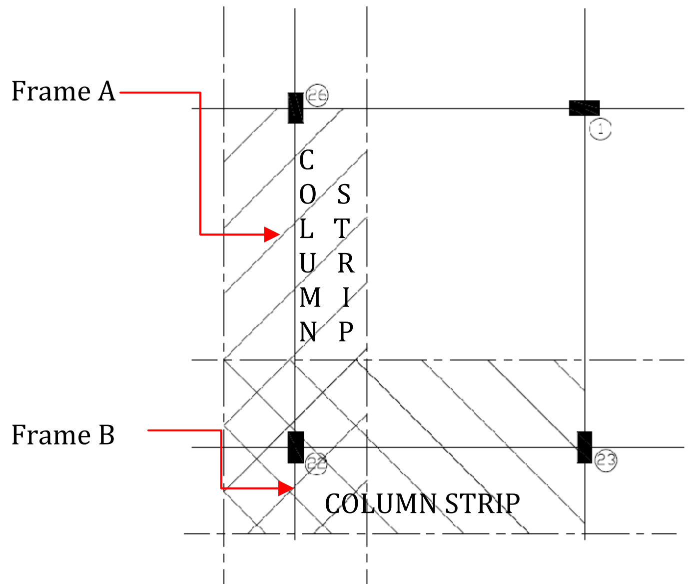
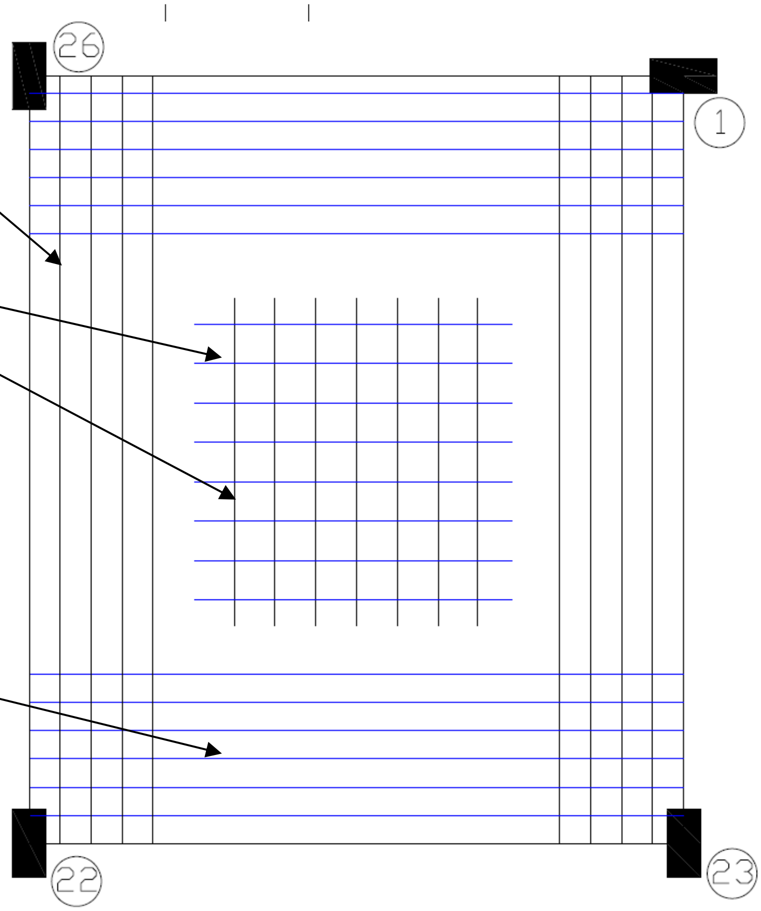
2 Two-Way Flat Plate



REBAR LAYOUT :



** BLUE REBAR FROM FRAME B CALCS**
BLACK REBAR FROM FRAME A CALCS

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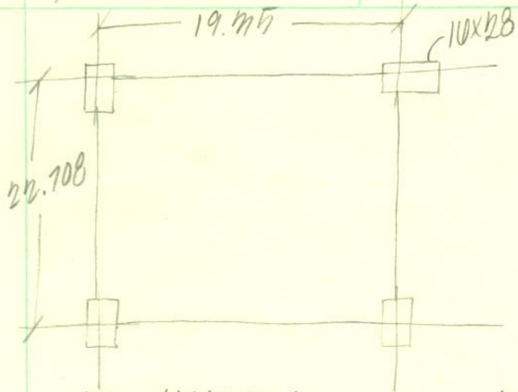
CITY VISTA
WASHINGTON D.C
ADVISOR: DR. MEMARI

2-WAY FLAT PLATE



$f'_c = 5000\ psi$
$f_y = 60{,}000\ psi$
W_D = self weight + 20 psf (part)
W_L = 40 psf (residential)

SLAB THICKNESS
- w/out drop panels
- interior panel

$\rightarrow \frac{l_n}{33} = \frac{20.375(12)}{33} = 7.4 = \boxed{7.5''}$

$7.5 > 5''$ min

$l_n = 22.708 - 28'' = 20.375'$

Check punching shear

$D = 7.5 - .625 - .75 = 6.125$

$SW = \frac{(7.5)(12)(12)}{12^3} \cdot 150 = 93.75\ psf + 20\ psf$

$W_u = 1.2(93.75 + 20) + 1.6(40) = 200.5$

$V_u = .20(22.708)(19.375) = 87.87^k$

$b_o = (16 + 6.125)2 + (28 + 6.125)2 = 112.5$

$22/19 = 1.17 \longrightarrow V_c = 4\sqrt{f'_c}\, b_o d$

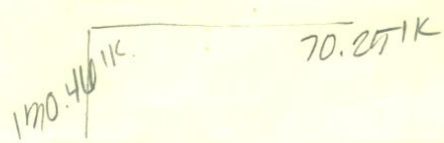
$V_c = 4\sqrt{5000}(112.5)(6.125) = 194 = \phi 194 = 146.17$

$146.17 > 87.87 \therefore OK$

$M_o = \frac{q_u l_2 l_n^2}{8}$

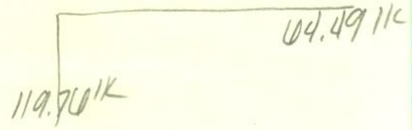
FRAME A $= \frac{.200(19.375)(20.375)^2}{8} = 200.72'^k$

$-M: .65(200.72) = 130.46'^k$
$+M: .35(200.72) = 70.252'^k$



FRAME B: $\frac{.200(22.708)(18.016)^2}{8} = 184.26$

$-M: .65(184.26) = 119.76'^{K}$
$+M: .35(184.26) = 64.49'^{K}$



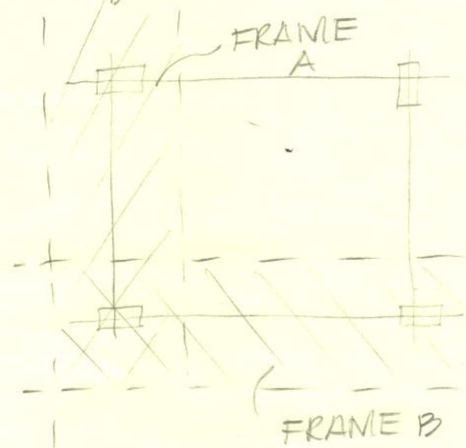
$\frac{l_2}{l_1} = 1.365 \quad \alpha = 0$

	M(-)	M(+)
	130.46	70.25
C.S	.75	.6
	97.84	42.15
M.S	.25	.3
	32.62	21.07

DEPTH

$D_A = 7.5 - .75 - \frac{.625}{2} = 6.359$

$D_B = 6.359 - .625 = 5.734$



	M(-)	M(+)
	119.76	64.49
C.S	.75	.6
	89.82	38.69
M.S	.25	.3
	29.94	19.34

FRAME A

ITEM	DESCRIPTION	-Mcs	-Mms	+Mc.s	+Mm.s
1	MOMENT	97.84	32.62	42.15	21.07
2	WIDTH (B)	116.1	116.1	116.1	116.1
3	DEPTH (D)	6.359	6.359	6.359	6.359
4	$Mn = Mu/\phi$	108.71	36.24	46.83	23.41
5	$Rn = Mn/bd^2$	277.86	93.60	107.73	53.850
6	A.5 ρ =	.0042	.0014	.0018	—
7	As = ρbd	3.10 ✓	1.03	1.32	—
8	Asmin	1.74	1.74 ✓	1.74 ✓	1.74
9	N = As/Abar	10 ✓	6	5.61	—
10	Nmin = W/2T	7.74	7.74 ✓	7.74 ✓	7.74
	REINFORCING	10(#5) @ 11" O.C	8(#5) @ 14.5" O.C	8(#5) @ 14.5" O.C	8(#5) @ 14.5" O.C

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FRAME B

ITEM	DESCRIPTION	-Mc.s	-Mm.s	+Mc.s	+Mm.s
1	MOMENT	89.82	29.94	38.09	19.34
2	WIDTH (B)	136.3	136.3	136.3	136.3
3	DEPTH (D)	5.73	5.73	5.73	5.73
4	$M_n = M_u/\phi$	99.8	33.26	42.98	21.48
5	$R_n = M_n/bd^2$	208.2	89.18	115.25	57.59
6	$\rho \rightarrow$ A.5	.0045	.0015	.0020	.00098
7	$A_s = \rho bd$	3.514 ✓	1.17	1.56	.705
8	A_{smin}	2.04	2.04 ✓	2.04 ✓	2.04 ✓
9	$N = A_s/A_{BAR}$	11.33	6.58	6.58	6.58
10	$N_{min} = W/2T$	9.08	9.08 ✓	9.08 ✓	9.08 ✓
	REINFORCING	12(#5)@ 11" O.C	10(#5)@ 13.5" O.C	10(#5)@ 13.5" O.C	10(#5)@ 13.5" O.C

Check Beam shear

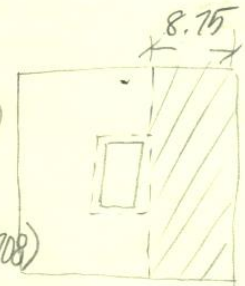
$V_u = W_u A = .200(22.708)(8.75)$

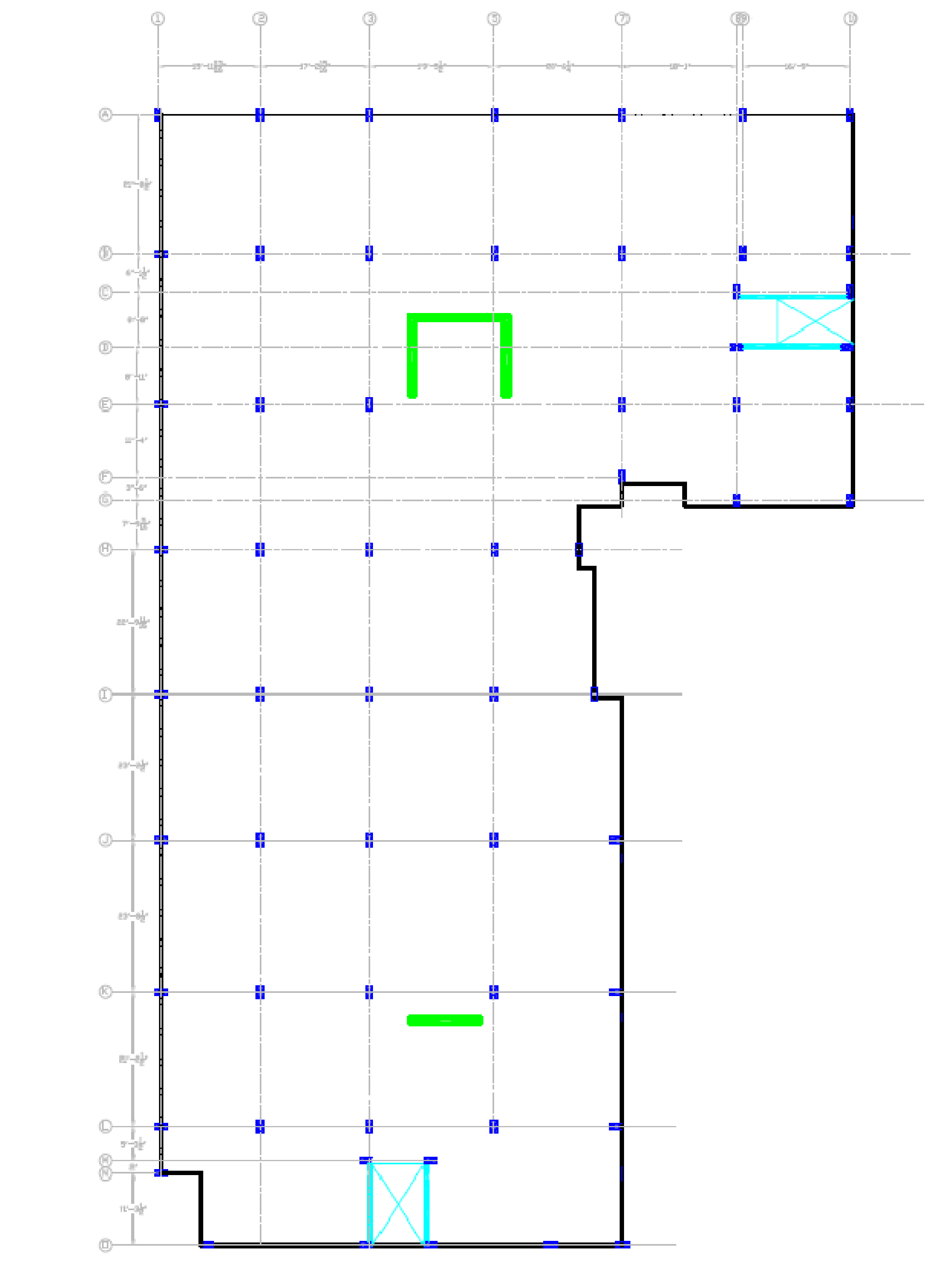
$V_u = 39.73$ KIPS

$\phi V_c = 2\sqrt{f'_c}\,bd = 2\sqrt{5000}\,(5.73)(22.708)$

$V_c = 105.6$ KIPS

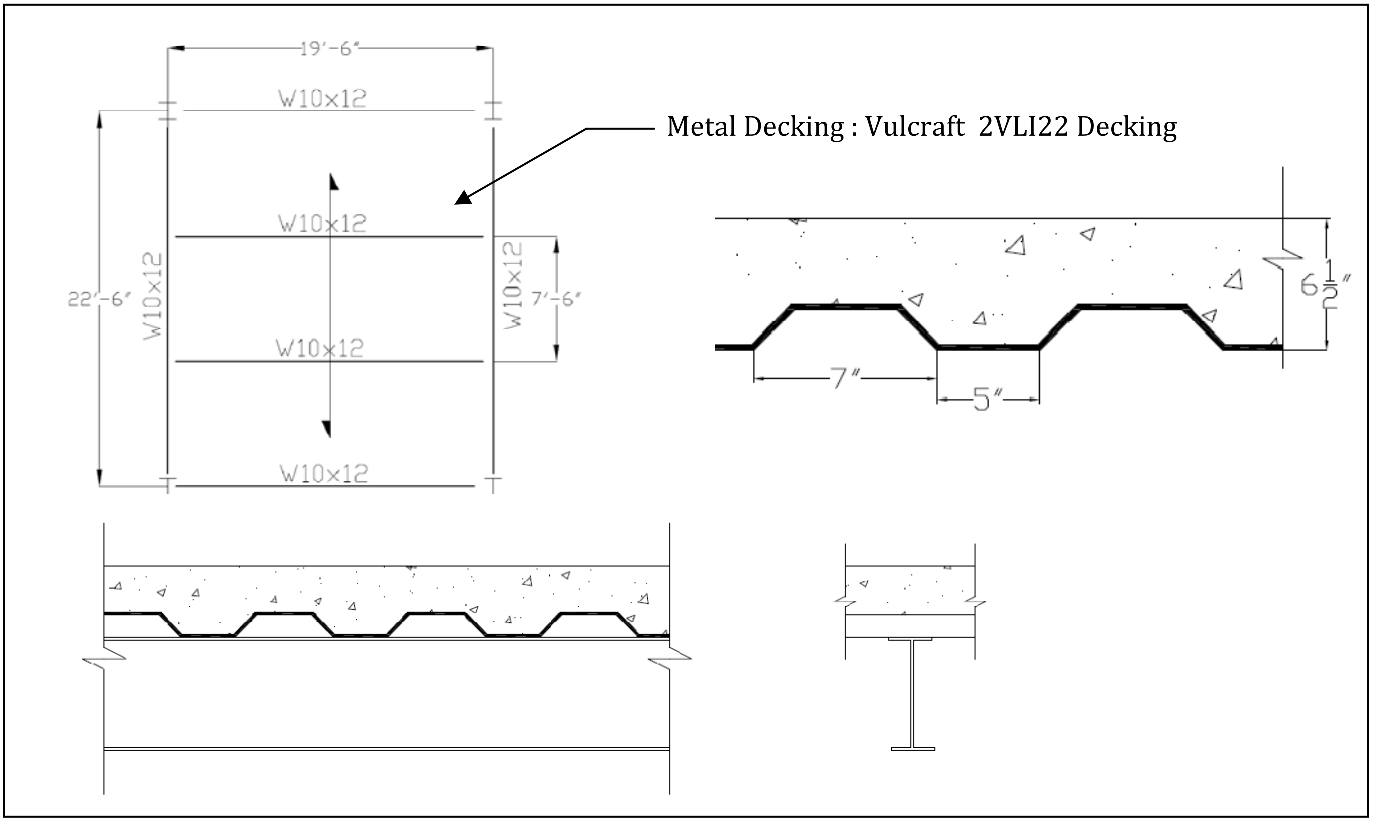
$105.6 > 39.73 \therefore$ OK

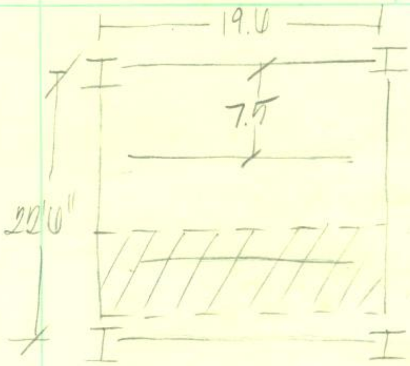


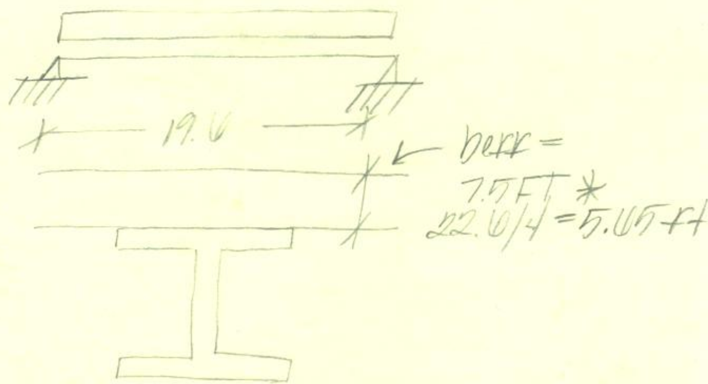


S.3	City Vista Building 2	2-Way Flat Plat

3.Composite Beam

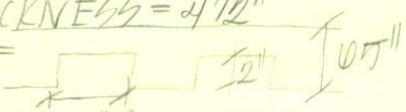






f'c = 3 KSI
fy = 60
WLL = 40 PSF
WDL = 93.75 + 20 = 113.75 PSF
Wu = 1.2(113.75) + 1.6(40) = 200.5 PSF (7.5') = 1.50 K

SLAB THICKNESS = 4 1/2"
DECK =



$M = \frac{1.5(19.6)^2}{8} = 72.03$ ft-kip

beff = (5.65')(12) = 67.8"

Y2 = 6.5 - 1/2 = 6
assumption a = 1

TRY → W10x12
φMn = 148 K

a = 1" → 72.03 < 145 ∴ OK
ΣQn = 117 SHEAR STUDS

$\frac{145}{.85(3)(5.65)} = .83' < 1"$ ∴ OK

3/4 φ STUDS
qn = w/Hr = 6"/2" = 3 > 1.5, +, → 21.0

$\frac{\Sigma Qn}{qn} = \frac{117}{21.0} = 5.5 = 6(2) = 12$ STUDS

USE W10x12 w/ 12 3/4" φ shear studs "Long

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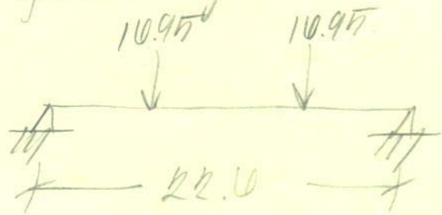
girder design



P=(1.50)(11.??)=10.95K

M = 10.95(7.5) = 127.12'K

beff = 22.6(12)/4 = 67.8" *

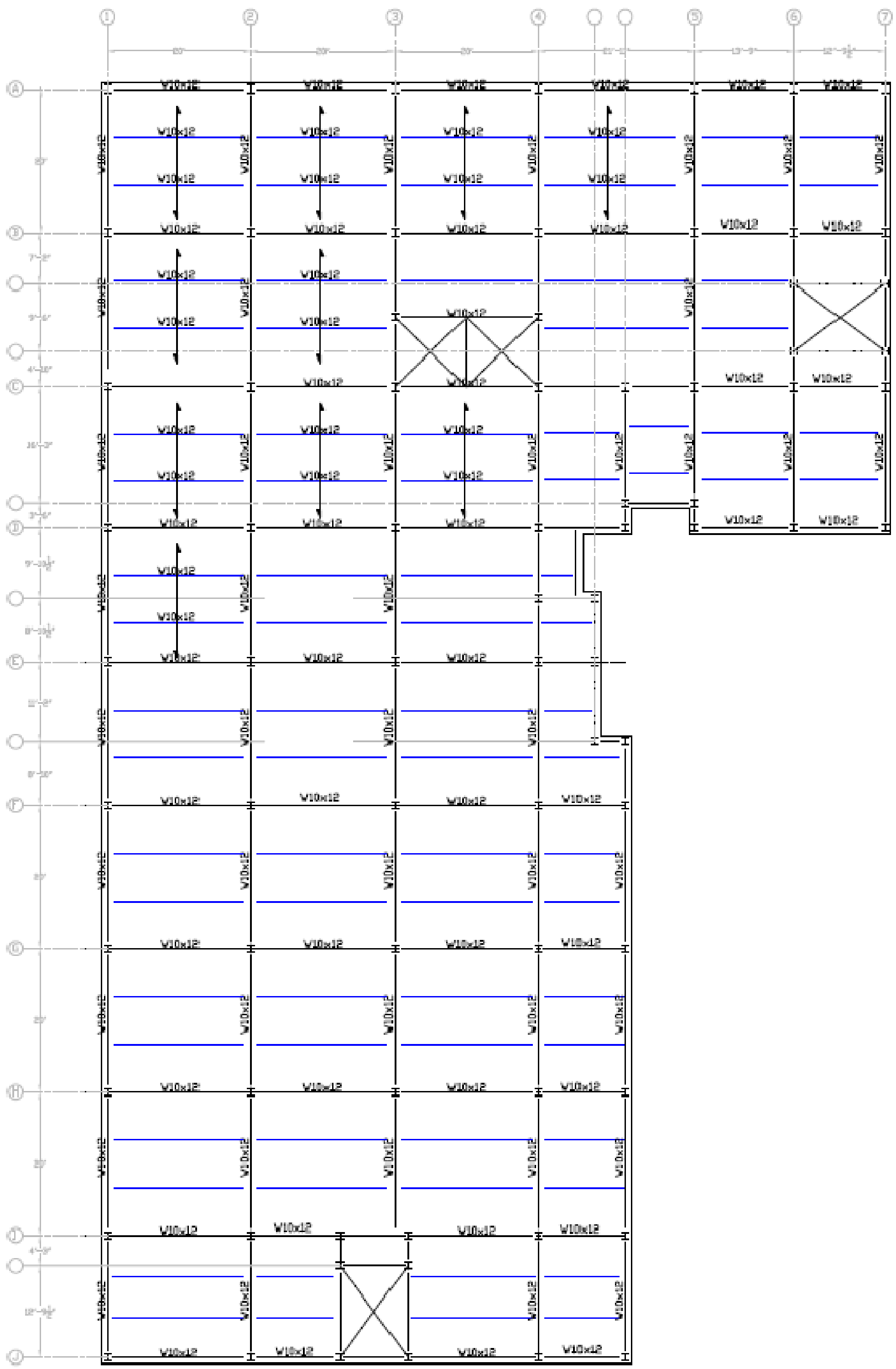
(7.5)(12) = 90"

a = 1
Y2 = 6

TRY → W10x12 ΣQn = 117

a = .8??<1 ∴ OK

USE 12 ¾ϕ STUDS + W10x12



S.4	City Vista Building 2	Composite Beam

4: Pre-Cast

LOADS	
Superimposed	20PSF
Live	40PSF
1.2D+1.6L = 88PSF	

Hollow Core Floor Panels :

Strand Pattern Designation
76-S

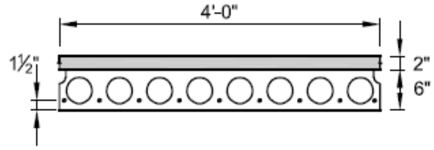
S = straight
Diameter of strand in 16ths
No. of Strand (7)

Safe loads shown include dead load of 10 psf for untopped members and 15 psf for topped members. Remainder is live load. Long-time cambers include superimposed dead load but do not include live load.

Capacity of sections of other configurations are similar. For precise values, see local hollow-core manufacturer.

Key
444 – Safe superimposed service load, psf
0.1 – Estimated camber at erection, in.
0.2 – Estimated long-time camber, in.

HOLLOW-CORE
4′-0″ x 6″
Normal Weight Concrete



$f'_c = 5{,}000$ psi
$f_{pu} = 270{,}000$ psi

Section Properties

	Untopped		Topped	
A =	187	in.^{2}	283	in.^{2}
I =	763	in.^{4}	1,640	in.^{4}
y_b =	3.00	in.	4.14	in.
y_t =	3.00	in.	3.86	in.
S_b =	254	in.^{3}	396	in.^{3}
S_t =	254	in.^{3}	425	in.^{3}
wt =	195	plf	295	plf
DL =	49	psf	74	psf
V/S =	1.73	in.		

4HC6 + 2

Table of safe superimposed service load (psf) and cambers (in.) **2 in. Normal Weight Topping**

Strand Designation Code	Span, ft																		
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
66-S	470	396	335	285	244	210	182	158	136	113	93	75	59	46	34				
	0.2	0.2	0.2	0.2	0.2	02	0.2	0.2	0.2	0.2	0.1	0.1	0.0	–0.1	–0.2				
	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	–0.1	–0.2	–0.3	–0.5	–0.7	–0.9	–1.2				
76-S		461	391	334	287	248	216	188	163	137	115	95	78	63	50	38	27		
		0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.1	–0.0	–0.1	–0.3		
		0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	–0.2	–0.3	–0.5	–0.7	–0.9	–1.2	–1.5		
96-S			473	424	367	319	279	245	216	186	160	137	116	98	82	68	55	43	33
			0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.1	0.0	–0.1
			0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.1	–0.1	–0.3	–0.5	–0.7	–1.0	–1.4	–1.7
87-S			485	446	415	377	331	292	258	224	195	169	147	127	109	94	80	67	55
			0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.4	0.3
			0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.2	0.1	–0.1	–0.3	–0.5	–0.8	–1.2
97-S			494	455	421	394	357	327	288	251	219	192	168	146	127	110	95	82	70
			0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.8	0.7	0.6
			0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.2	0.0	–0.2	–0.5	–0.8

Strength is based on strain compatibility; bottom tension is limited to $7.5\sqrt{f'_c}$; see pages 2–7 through 2–10 for explanation.

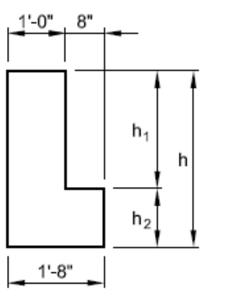
L-Beam:

LOADS	
Dead (Plank)	74PSF
Superimposed	20PSF
Live	40PSF
1.2D+1.6L = 176.8PSF	

PLF=176.8PSF *11.5FT=2033.2PLF

L-BEAMS

Normal Weight Concrete



f'_c = 5,000 psi
f_{pu} = 270,000 psi
½ in. diameter
low-relaxation strand

Designation	h in.	h_1/h_2 in./in.	A in.^{2}	I in.^{4}	y_b in.	S_b in.^{3}	S_t in.^{3}	wt plf
20LB20	20	12/8	304	10,160	8.74	1,163	902	317
20LB24	24	12/12	384	17,568	10.50	1,673	1,301	400
20LB28	28	16/12	432	27,883	12.22	2,282	1,767	450
20LB32	32	20/12	480	41,600	14.00	2,971	2,311	500
20LB36	36	24/12	528	59,119	15.82	3,737	2,930	550
20LB40	40	24/16	608	81,282	17.47	4,653	3,608	633
20LB44	44	28/16	656	108,107	19.27	5,610	4,372	683
20LB48	48	32/16	704	140,133	21.09	6,645	5,208	733
20LB52	52	36/16	752	177,752	22.94	7,749	6,117	783
20LB56	56	40/16	800	221,355	24.80	8,926	7,095	833
20LB60	60	44/16	848	271,332	26.68	10,170	8,143	883

1. Check local area for availability of other sizes.
2. Safe loads shown include 50% superimposed dead load and 50% live load. 800 psi top tension has been allowed, therefore, additional top reinforcement is required.
3. Safe loads can be significantly increased by use of structural composite topping.

Table of safe superimposed service load (plf) and cambers (in.)

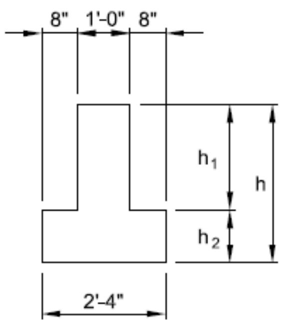
Desig-nation	No. Strand	y_s(end) in. y_s(center) in.	Span, ft 16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
20LB20	98-S	2.44	6566	5131	4105	3345	2768	2318	1961	1674	1438	1243	1079							
		2.44	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.2							
			0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2							
20LB24	108-S	2.80	9577	7495	6006	4904	4066	3414	2896	2479	2137	1854	1617	1416	1244	1097	969			
		2.80	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2			
			0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0			
20LB28	128-S	3.33			8228	6733	5596	4711	4009	3443	2979	2595	2273	2000	1768	1567	1394	1243	1110	992
		3.33			0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.3
					0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0
20LB32	148-S	3.71				8942	7446	6281	5356	4611	4001	3495	3071	2712	2406	2143	1914	1715	1540	1386
		3.71				0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.3
						0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1
[illegible]	[illegible]	4.25					9457	7988	6823	5883	5113	4476	3941	3489	3103	2771	2483	2231	2011	1816

Inverted T-Beam:

PLF=176.8PSF*23FT=4066.4PLF

INVERTED TEE BEAMS

Normal Weight Concrete



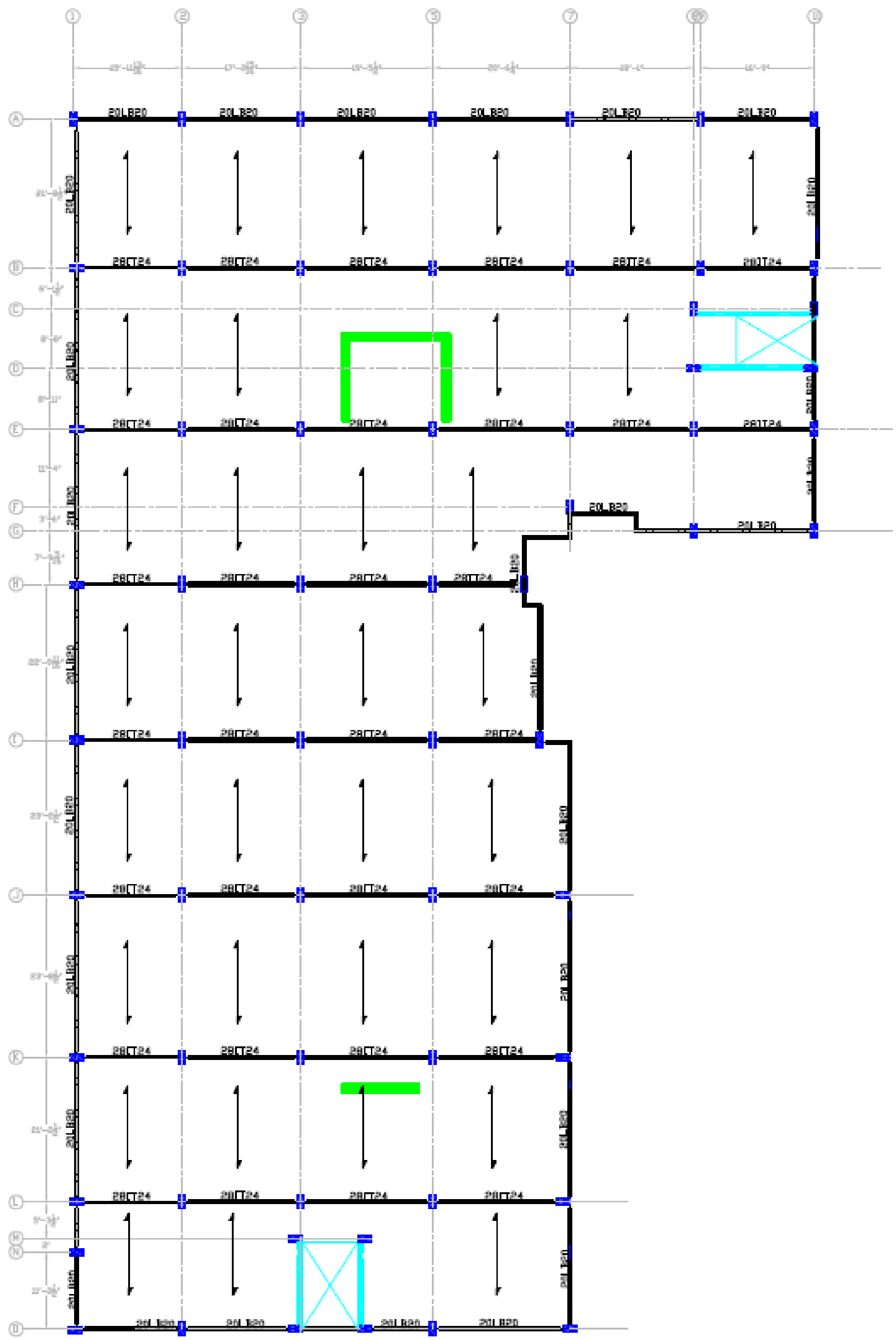
f'_c = 5,000 psi
f_{pu} = 270,000 psi
½ in. diameter
low-relaxation strand

Section Properties								
Designation	h in.	h_1/h_2 in./in.	A in.^{2}	I in.^{4}	y_b in.	S_b in.^{3}	S_t in.^{3}	wt plf
28IT20	20	12/8	368	11,688	7.91	1,478	967	383
28IT24	24	12/12	480	20,275	9.60	2,112	1,408	500
28IT28	28	16/12	528	32,076	11.09	2,892	1,897	550
28IT32	32	20/12	576	47,872	12.67	3,778	2,477	600
28IT36	36	24/12	624	68,101	14.31	4,759	3,140	650
28IT40	40	24/16	736	93,503	15.83	5,907	3,869	767
28IT44	44	28/16	784	124,437	17.43	7,139	4,683	817
28IT48	48	32/16	832	161,424	19.08	8,460	5,582	867
28IT52	52	36/16	880	204,884	20.76	9,869	6,558	917
28IT56	56	40/16	928	255,229	22.48	11,354	7,614	967
28IT60	60	44/16	976	312,866	24.23	12,912	8,747	1,017

1. Check local area for availability of other sizes.
2. Safe loads shown include 50% superimposed dead load and 50% live load. 800 psi top tension has been allowed, therefore, additional top reinforcement is required.
3. Safe loads can be significantly increased by use of structural composite topping.

Table of safe superimposed service load (plf) and cambers (in.)

Desig-nation	No. Strand	y_s(end) in. y_s(center) in.	Span, ft 16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
28IT20	98-S	2.44	6511	5076	4049	3289	2711	2262	1905	1617	1381	1186	1022							
		2.44	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8							
			0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	–0.1							
28IT24	188-S	2.73	9612	7504	5997	4882	4034	3374	2850	2427	2081	1795	1555	1351	1178	1029				
		2.73	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8				
			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	–0.1	–0.2				
28IT28	138-S	3.08			8353	6822	5657	4750	4031	3451	2976	2582	2252	1973	1735	1530	1352	1197	1061	
		3.08			0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.8	0.8	
					0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	–0.1	–0.2	–0.2	
28IT32	158-S	3.47				9049	7521	5333	5389	4628	4006	3490	3057	2691	2379	2110	1876	1673	1495	1337
		3.47				0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9
						0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	–0.1
28IT36	168-S	3.50					9832	8295	7075	6092	5287	4619	4060	3587	3183	2835	2534	2271	2040	1836
		3.50					0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9



S.5	City Vista Building 2	Pre-Cast System