file → 200 PARK PL Bldg. file Parking

8/25/94

BVH Engineers, Inc.

200 PARK PLACE
WEST PARKING STRUCTURE

STRUCTURAL ENGINEERING REPORT

Prepared for:

200 Park Place Associates
2 Park Place
Hartford, CT 06106

Prepared By:

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EXECUTIVE SUMMARY

The free standing garage at 200 Park Place, a post-tensioned slab structure designed in 1985, has been analyzed for adequacy to carry proper gravity loads. BVH has also offered an opinion regarding the use of traffic bearing membrane on the top surface of the slab. It should be noted that no actual testing of the concrete or reinforcing verification was made.

The structure was designed for gravity loads, as required by the 1978 Connecticut Basic Building Code. Current codes require parking structures to be designed for 50 PSF for intermediate floors and 70 PSF for roof level, which is the same Code requirements of 1985.

The structural analysis of the garage, revealed that the slab and beams are designed adequately and there is no danger of failure of the structure. The analysis is based on the Construction Documents signed and sealed by the Structural Engineer of record.

Inspection of existing joint sealant material in routed slab cracks revealed successful performance to resist moisture intrusion.

We do not recommend the use of a traffic bearing membrane since there are problems with UV exposure, cleanliness and security as a result of lower footcandles, associated with darker membrances.

In short, the structure as designed, is expected to serve it's life expectancy with proper maintenance.

STRUCTURAL SYSTEM

The 200 park place garage, also referred to as Xerox Center Parking Structure, was originally designed by the office of Lev Zetlin Associates, New York, Structural Engineer of the record, and issued for bid on May 1, 1985. Drawings used for our analysis were signed and sealed by Mr. Charles Thornton, P.E. and are adequate for obtaining a building permit and also construction purposes.

The garage consists of 6 stories (Ground, 2, 3, 4, 5 and roof levels). It is designed as a one- way post-tensioned slab construction, supported by cast in place concrete beams and columns. The structure is supported by spread footings.

The post-tensioning strands consist of 1/2" diameter, 270 ksi, 7-wire, low-relaxation strands, with a minimum yield point of 243 ksi. Concrete slab was designed to reach a minimum compressive strength of 5000 psi in 28 days. The number of strands in each strip is calculated by dividing strip effective force shown on Construction Documents by the final effective force in strands after all losses. The slab is supported by cast-in-place concrete beams supported by the interior columns and cantilevers 15 feet over exterior columns. Distance between interior and exterior columns are 45 feet. Concrete strength for beams and columns were also required to reach a minimum compressive strength of 5000 psi in 28 days.

ASSUMPTIONS AND AVAILABLE INFORMATION

The structural system information stated is based on Construction Documents dated May 1, 1985. Drawings used are part of the set that include structural documents for the tower, the garage below and also the post-tensioned garage referred to in this report. Drawings pertaining the post-tensioned garage are following:

Plan	Description	Latest Date
F2	Foundation Plan	08-19-85
S2	Parking Level 2	09-04-85
S4	Parking Levels 3, 4 and 5	11-07-85
S8	Roof Level Parking Framing Plan	11-07-85
S21	Typical Post-tensioned Slab Detail	11-07-85
S22	Section and Details	11-26-85

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OBSERVATIONS

We have observed and concluded the following:

- The garage was designed for current gravity loads as required by the latest Connecticut Building Code.
- At the time the garage was designed and constructed, there were no seismic requirements.
- The post-tensioned slab, designed as a one-way slab, is adequate to support dead and superimposed live loads.
- There is no sign of concrete spalling or corrosion of reinforcement observed.
- Tensioning strands were specified to be individually coated with rust inhibiting grease and encased in plastic sheathing as per Construction Documents. This should minimize risk of corrosion in strands.
- Existing slab cracks are routed and filled with joint sealant are performing successfully to prevent moisture intrusion to reinforcing and leaching mineral deposits onto vehicles parked below.
- The cantilevered beams supporting the slab are designed to provide adequate support for the one-way slab.
- There is no danger of structural failure at this point and the garage should serve its' life expectancy, if proper maintenance procedures are followed.

Our observations of post-tensioned garage were made during a recent rainstorm. Observations included a check of the effectiveness of the joint sealant installed in routed out cracks. Field observations revealed that joint sealant material installed in the Spring of 1992 are effective and perform well in resisting water intrusion. Observations of the slab underside did not reveal any active water leakage through the sealed joints.

TRAFFIC BEARING MEMBRANE

Installation of a traffic bearing membrane on the post-tensioned garage parking deck is not recommended for the following reason:

- The number of cracks in the slab is minimized as a result of post-tension design.
- All cracks are found to be sealed with a joint sealant material that effectively prevents moisture and water penetration through the cracks. This helps eliminate concerns of concrete stain to automobile finishes parked below and also reinforcing corrosion.
- Specified slab post-tensioning strands are encased in plastic sheathing to prevent corrosion. Should the joint sealant installed in the routed cracks fail, the sheathing should protect post-tensioning strands from corrosion.
- Traffic bearing membrane would be subject to UV radiation on top parking deck and at the perimeter on all other floors. The most popular traffic membrane has showed to have significant durability problems when subjected to UV exposure.
- Unless traffic membrane material is installed in black color, it will show staining from automobile oil leakage. Dark colors reduce effectiveness of existing garage lighting system, which could result in either relighting expenses or reduced security.
- Traffic membrane solution are normally considered for application on cast-in-place, conventionally reinforced concrete. The post-tensioned slabs are very effective in resisting cracks, therefore membrances are not a design solution.
- If a traffic membrane system is installed, the top surface will require sand blasting. This procedure will destroy the effectiveness of the joint sealant material presently installed in existing cracks.

POSSIBLE CAUSE OF CRACK PRESENCE

Although the post-tensioned slab is designed as a one-way slab to be supported by the cantilevered beams, the aspect ratio of the slabs outside exterior columns (ratio of slab width to slab span) is approximately 0.75. Realizing that structures follow their nature and load travels through the least resistant path, this slab has tried to act as a two-way slab and load travel to be in the shorter direction.

In order for the load to travel in shorter direction, there needs to be a support along the exterior column line. The strip along the exterior column line is inherently stiffer and is providing more bending resistance along the column line, however, is still very weak in torsion. The torsional resistance of this column strip is the element that provides the support for exterior slab. Since the torsional resistance provided by the column strip is not adequate, the slab has cracked, and has no choice but to perform as a one-way slab (the original design intent). The cracks could have been minimized, should there have been added reinforcing perpendicular to strands on top of column strip, and the concrete slab designed as a two-way slab, to allow for natural behavior of the structure.

CONCLUSION

The structure is designed and meets current building code load carrying requirements. Our analysis concludes that the structure is not in danger of failure. The routed joints have performed well since they have been sealed in the Spring of 1992. Our walk-through of the structure did not show any new cracks since repairs were done. The structure is stabilized and the repairs are performing well. With periodic maintenance the structure should last expected service life. We recommend yearly observation and inspection to be performed by a professional engineer experienced with parking garage structures in order to maximize the structures life. The repairs as they stand today should be performing well for the next four (4) years. Rerouting and resealing of the joints are to be expected on nine to ten (9-10) year frequency. Annual inspections would reveal isolated repairs and maintenance to be made for particular areas.

EXHIBIT A

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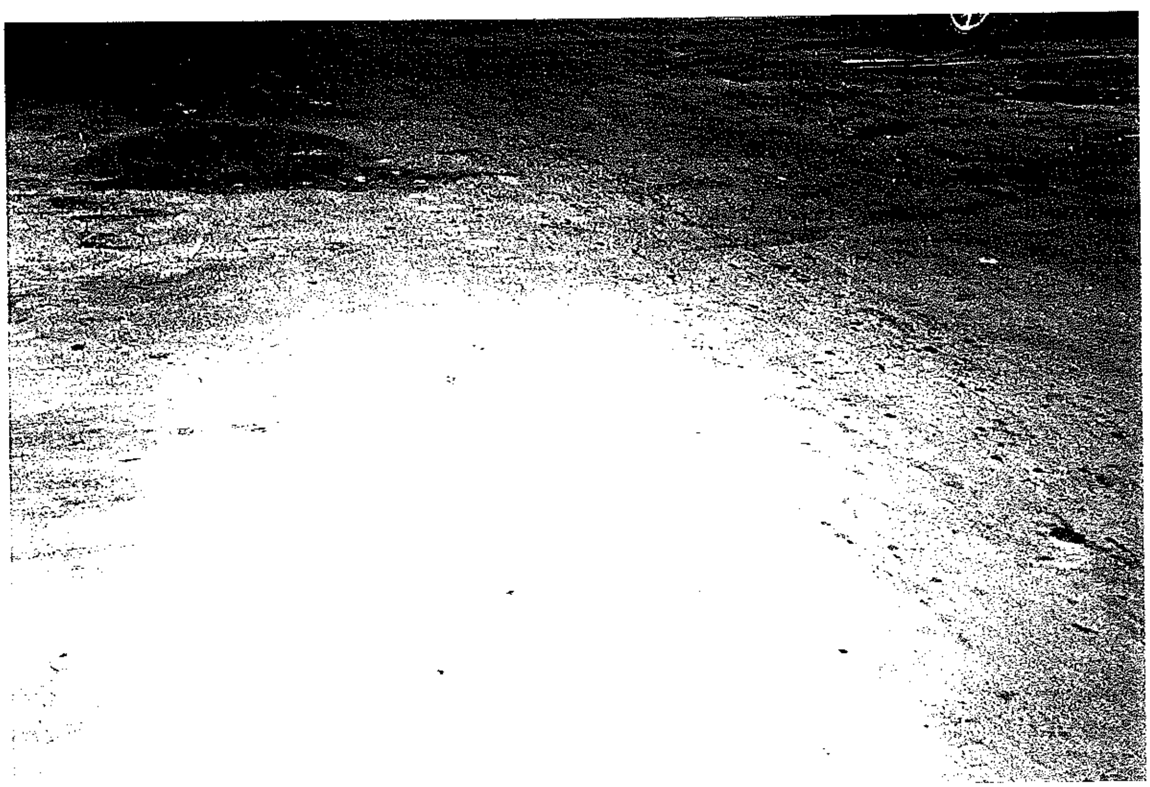

Condition of majority of deck.
(Crack free)

EXHIBIT A (CONTINUED)

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Typical crack location on floors.
(Sealed with joint sealant and water tight)

EXHIBIT B

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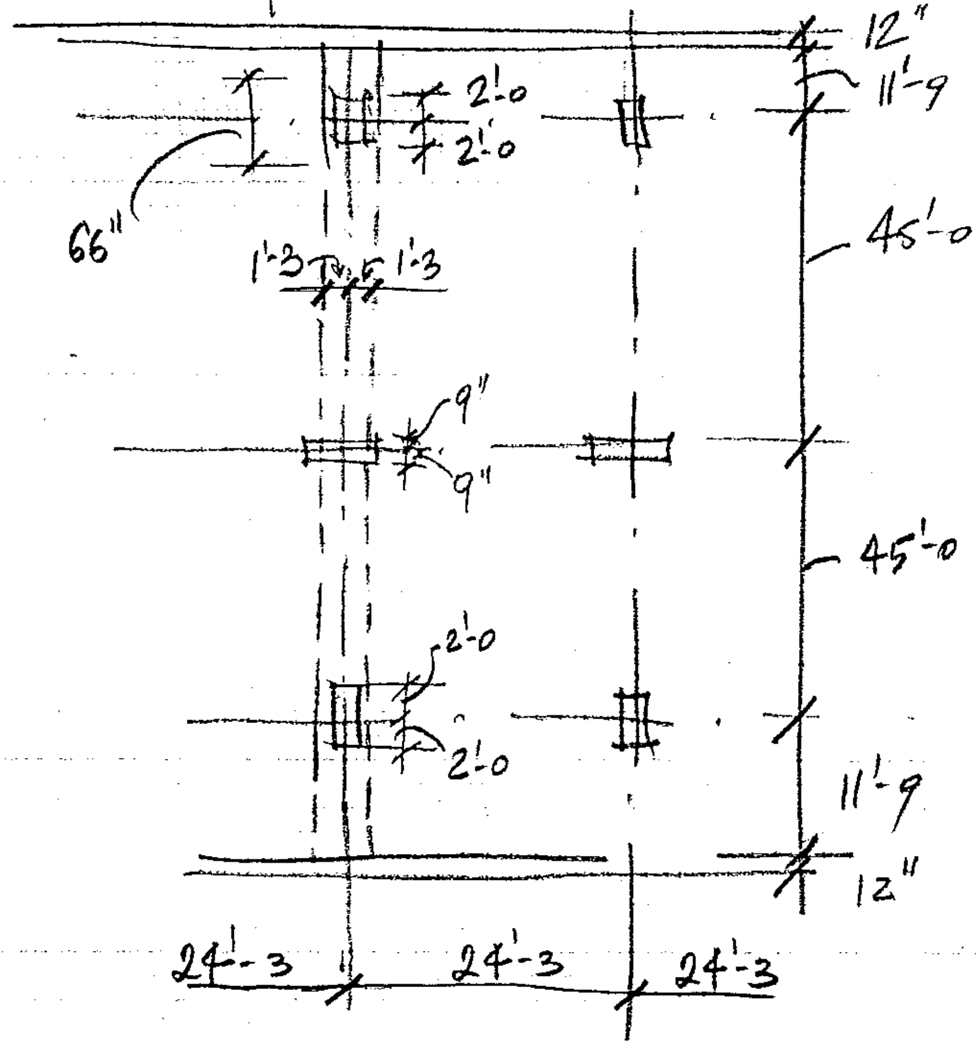
STRUCTURAL CALCULATIONS

COMPUTATION SHEET

Job: XEROX CENTRE | Page 1
Location: PARKING-GARAGE | Comm. No.: | Date 08.22.94
Designer LGR

EXIST. CONDITIONS:
CONCRETE f'c = 5000 psi
6" POST TENSIONED CONCRETE SLABS



DESIGN LOADS (DWG. S20)

(GARAGE PARKING)

	FLOOR		ROOF
SLAB DL =	75 psf		75
TOPPING =	0		0
CEILING, HUNG, MISC =	0		0
PARTIT. =	0		0
TL DL =	75 psf	TL DL =	75 psf
TL LL =	50 psf	TL LL =	70 psf

INCLUDES SNOW + VEHICLE LOAD

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COMPUTATION SHEET

Job: XEROX CENTRE

Location: PARKING GARAGE

Comm. No.:

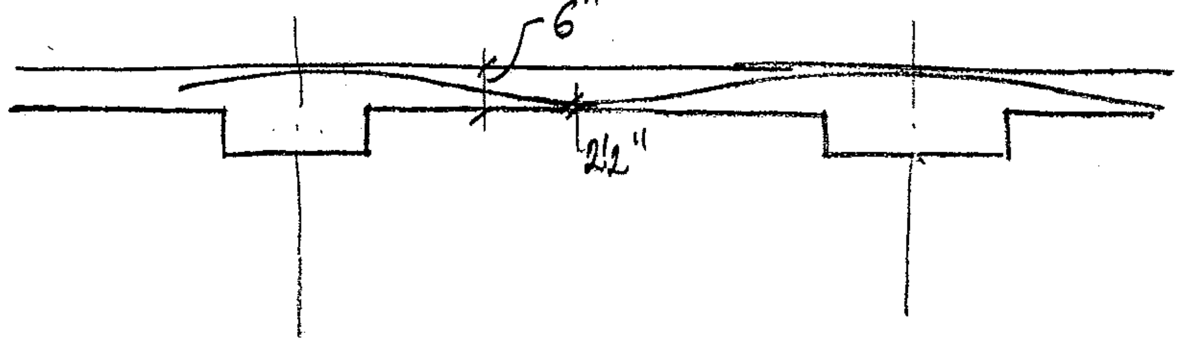
Page 2

Date 08.22.94

Designer LER

PRESTRESSING STEEL – 1/2"φ 270 KSI, 7 WIRE, LOW-RELAXATION (LR) STRAND, WITH A MIN. YIELD POINT (1% STRAIN) OF 243 KSI AND A $A_{MIN} = 0.153\ IN^2$

STRANDS COATED W/ RUST INHIBITING GREASE & ENCASED IN CONTIN. PLASTIC SHEATHING



ACI 318-83 CODE

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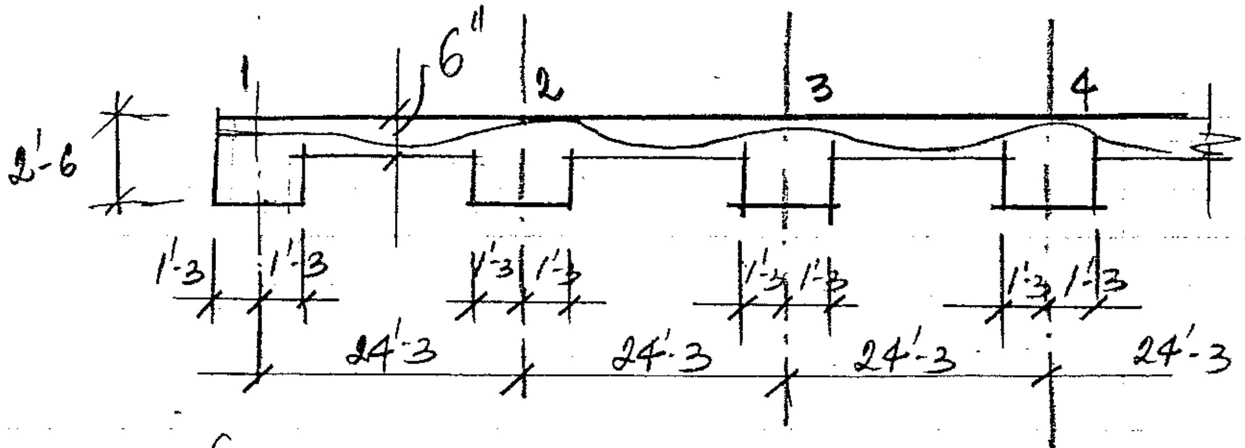
COMPUTATION SHEET

Job: XEROX CENTRE | Page 3 | Date 08.23.94

Location: PARKING-GARAGE | Comm. No.: | Designer IER

ONE-WAY SLAB PARKING STRUCTURE



$f'_c = 5000$ psi

1. CHECK THK. for 50 psf LL → $h = \frac{24.25(12)}{45} = 6.46$ in

6 IN USED

2. LOADS; DL = $150\left(\frac{6}{12}\right) = 75 \times 1.4 = 105$ psf

LL = $50 \times 1.7 = 85$ psf

TOTAL; SERVICE = 125 psf ULTIMATE = 190 p

3 ESTIMATE BALANCED LOAD (ARBITRARY BALANCE ≈ 65% DL)

$W_{bal} = (0.65)(75) = 49$ psf

4. EI - CONSTANT, NO COLUMN STIFFNES

SAY $K_{INTERIOR} = 1$, $K_{END\ SPAN} = 3/4$

5. MOMENTS DUE TO DL

$M_{END} = 0.075\,(24.25)^2/12 = -3.7$ K-1

$M_{INT} = 0.075\,(24.25)^2/8 = -5.51$ K-1

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	2		3		4	
DIST FACTOR	0.43	0.57	0.5	0.5	0.5	0.5
F.E.M.	-5.51	-3.7	-3.7	-3.7	-3.7	-3.7
DIST.	+0.77	-1.03				
CARRY-OVER			+0.515			
DIST			-0.26	+0.26		
SUM	-4.74	-4.73	-3.44	-3.44	-3.7	-3.7

BALANCED LOADS

ASSUME 49psf BALANCED LOAD AT ALL SPANS (65% DL)

$$M_{BAL(2)} = 0.65(4.74) = +3.08 \text{ k-1}$$

$$M_{BAL(3)} = 0.65(3.44) = +2.24 \text{ k-1}$$

$$M_{BAL(4)} = 0.65(3.7) = +2.4 \text{ k-1}$$

LIVE LOAD (SKIPPED LL) ⇒ LOAD ON FIRST TWO SPAN ONLY)

$$FEM = (0.05)(24.25)^2/12 = -2.45 \text{ k-1}$$

	1	2		3		4	
		0.43	0.57	0.5	0.5	0.5	0.5
	-2.45	-2.45	2.45	-2.45	0	0	0
DIST	+2.45	-1.23					
		-3.68	-2.45	-2.45	0		
		+0.53	-0.70	+1.22	-1.22		
			-0.61	+0.35			
		+0.26	+0.35	-0.17	+0.18		
		-3.41	-3.41	-1.05	-1.04		

MAX. POS. MOMENT IN SPAN 1: LOADS ON FIRST AND THIRD SPANS

2		3		4	
-3.68			-2.45	-2.45	
+1.58	-2.09	-1.22	+1.22	+1.22	-1.22
	+0.61	+1.04	-0.61	-0.61	0
0.26	-0.35	-0.825	+0.825	+0.31	-0.31
	+0.41	+0.17	-0.15	-0.41	
+0.175	-0.23				

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1	2		3	4
	1.66	1.65		

POSITIVE MOMENT @ MID. OF FIRST SPAN (LL)

$$M_{pos} = \frac{WL^2}{8} - \frac{1.66}{2} = 3.68 - 0.83 = 2.85^{K\text{-}1}$$

MAXIMUM NEGATIVE MOMENT @ SPT. 3 (LOADS ON SECOND & THIRD SPANS)

1	2		3		4	
	0	-2.45	-2.45	-2.45	-2.45	0
	-1.05	+1.4	0	0	+1.22	-1.22
		0	-0.7	-0.61	0	
			+0.045	-0.045		
			-3.1	-3.1		

MAXIMUM POSITIVE MOMENT @ MID OF SPAN 2 (LOADS ON SPANS 2 & 4)

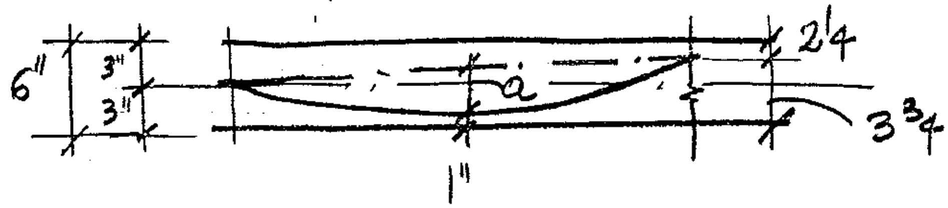
	2		3		4		5	
FEM	0	-2.45	-2.45	0	0	-2.45	-2.45	0
	-1.05	+1.4	+1.22	-1.22	+1.22	+1.22	+1.22	-1.22
	0	-0.61	-0.7	+0.61	+0.61	-0.61	-0.61	0
	-0.26	+0.35	+0.65	-0.65	-0.61	+0.61	+0.31	-0.31
		-0.32	-0.17	+0.3	+0.32	-0.15		
	-0.14	+0.18	+0.23	-0.23				
	-1.45	-1.45	-1.22	-1.22				

MAXIMUM POSITIVE MOMENT IN SPAN 2 =

$$= \frac{WL^2}{8} - \text{AVERAGE FEM} = 2.45 - 1.33 = 1.12 \text{ K-1}$$

6. CALCULATE POST TENSIONING FORCE REQ'D TO BALANCE ASSUMED LOADS

SAG @ END SPAN

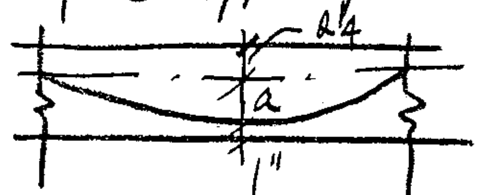


ASSUME TYP. ¾" COVER FOR BOT. COVER (2 HR FIRE RATING, (1" TO C.G. OF STRAND)

ASSUME TYP 2" TOP COVER (EXPOSURE TO WEATHER & CHEMICALS)

$$\text{SAG } a = \frac{3 + 3\tfrac{3}{4}}{2} - 1 = 2.375''$$

SAG @ TYP. SPAN



$$a = 6 - 2\tfrac{1}{4} - 1 = 2.75''$$

$$F = \frac{M}{a} = \frac{W_b L^2}{8a} \; ; \; W_{b_{AL}} = 49 \text{ psf}$$

$$F_{(\text{END SPAN})} = \frac{(0.049)(24.25)^2(12)}{8(2.375)} = 18.2 \text{ K/FT}$$

$$\frac{F}{A} = \frac{18.2(1000)}{(6)(12)} = 252.8 \text{ psi}$$

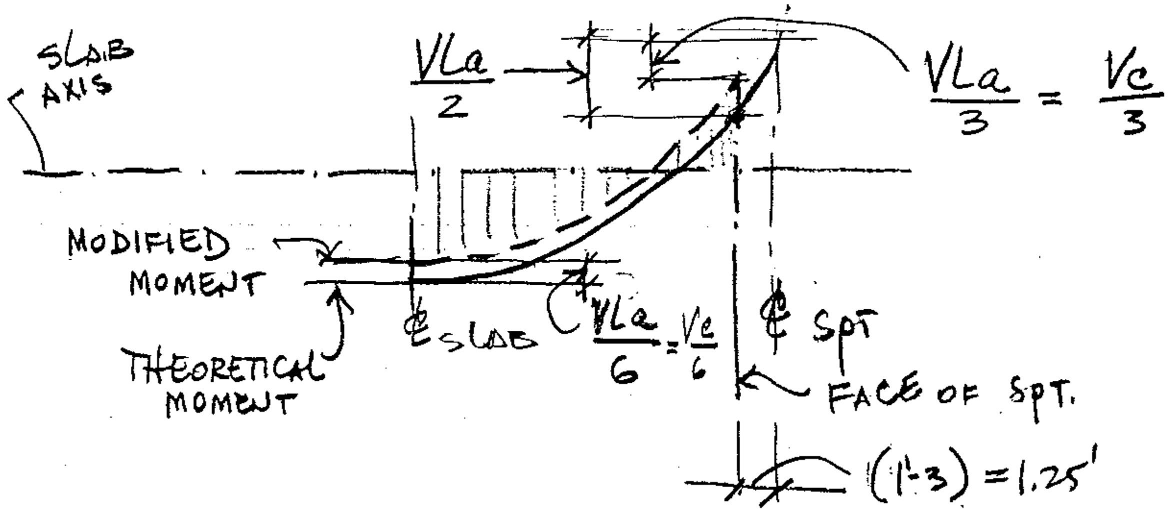
$$F_{(\text{INT. SPAN})} = \frac{(0.049)(24.25)^2(12)}{8(2.75)} = 15.7 \text{ K/FT}$$

$$\frac{F}{A} = \frac{15.7(1000)}{(6)(12)} = 218 \text{ psi}$$

LOADING	MAGNITUDE KSF	MOMENTS (FT-KIPS @ SUPPORT) 2	3	4
DL	0.075	-4.74	-3.44	-3.7
LL	0.050	-3.41	-3.1	-3.1
BALANCED LD	-0.049	+3.08	+2.24	+2.4
NET LOAD	0.076	-5.07	-4.3	-4.3

MIN V @ SPT. (KIPS) $= \frac{0.076\,(24.25)}{2} = 0.92^{K}$

SECTION MODULUS $S = \frac{t^2}{6} = \frac{(6)^2}{6} = 6\ \text{IN}^2/\text{FT}$



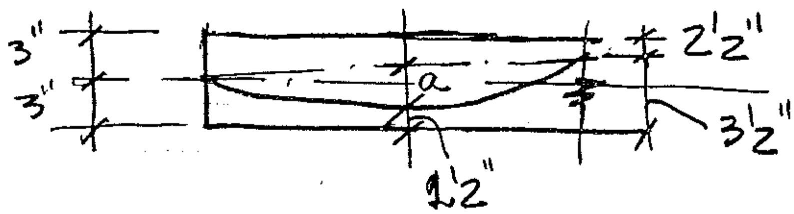
	2	4
MIN. V @ SPT.	0.92	0.92
$\left(\frac{Vc}{3}\right) = (0.92)(1.25)(\frac{1}{3})$	+0.38	+0.38
FACE MOMENT	-4.69	-3.92
M/S	+0.781	+0.653
P/A = (F/A)	-0.253	-0.218
STRESS @ TOP OF SLAB (KSI)	+0.528	+0.435

MAX. NET TENSILE STRESS $= 0.528$ KSI $= 7.47\sqrt{f'_c} > 6\sqrt{f'_c}$

$0.528 = \frac{X\sqrt{5000}}{1000}$; $X = 7.47$ N.G.

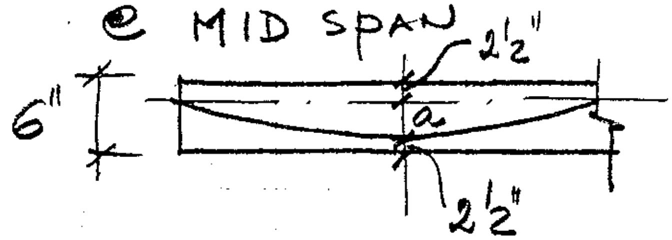
REDUCE SAGGING

@ END SPAN



$$a = \frac{3 + 3\tfrac{1}{2}}{2} - 2\tfrac{1}{2} = 0.75''$$

@ MID SPAN



$$a = 6 - 2\tfrac{1}{2} - 2\tfrac{1}{2} = 1''$$

$$F = \frac{W_b L^2}{8a};\qquad F_{(END\ SPAN)} = \frac{(0.049)(24.25)^2(12)}{8\,(0.75)} = 57.6$$

$$F_{(MID\ SPAN)} = \frac{(0.049)(24.25)^2(12)}{8\,(1)} = 43.$$

$$(END\ SPAN)\ \frac{F}{A} = \frac{57.6}{(6)(12)}(1000) = 800\ psi$$

$$(MID\ SPAN)\ \frac{F}{A} = \frac{43.2}{(6)(12)}(1000) = 600\ psi$$

	2	4
FACE MOMENT	- 4.69	- 3.92
M/S	+ 0.781	+ 0.653
F/A	- 0.8	- 0.6
	- 0.019	+ 0.053

$$0.053 = \frac{x\sqrt{5000}}{1000};\quad x = 0.749$$

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$0.053\ KSI = 0.75\sqrt{f'_c} < 6\sqrt{f'_c}$ O.K.

8. CALCULATE SECONDARY MOMENTS

$M_{bAL} = M_1 + M_2$ OR $M_{bAL} = Fe + M_2$

$\therefore M_2 = M_{bAL} - Fe$

BALANCED LOAD MOMENT CORRECTION TO FACE OF SPT.

$\frac{Vc}{3}$ @ SPT 2 $= 0.049\left(\frac{24.25}{2}\right) \times 1.25 \times \frac{1}{3} = 0.25^{k\text{-}1}$

SUPPORTS	2	3	4
BALANCED MOMENT @	+3.08	+2.24	+2.4
SUPPORTS $-\frac{Vc}{3}$	−0.25	−0.25	−0.25
BALANCED MOMENTS @ FACE	+2.83	+1.99	+2.15
$Fe = 57.6(0.5)/12 =$	−2.4		
$Fe = 43.2(0.5)/12 =$		−1.8	−1.8
SECONDARY MOMENTS $M_2 =$	+0.43	+0.19	+0.35

COMBINE $1.4\,DL + 1.7\,LL + 1.0\,M_2$

	MID. SPAN 2		MID. SPAN 3		MID. SPAN 4	
1.4 DL	+1.08	−6.64	+1.99	−4.82	+2.72	−5.18
1.7 LL	+4.85	−5.8	+1.9	−5.27	+1.9	−5.27
$1.0\,M_2$	+0.22	+0.43	+0.31	+0.19	+0.27	+0.35
M	+6.15	−12.01	+4.2	−9.9	+4.89	−10.1
V		2.3		2.3		2.3
Vc/3		+0.95		+0.95		+0.95
Vc/6	−0.48		−0.48		−0.48	
M	+5.67	−11.06	+3.72	−8.95	+4.41	−9.15

9. ULTIMATE TENDON FORCE FROM EQUATION 18-5 ACI 318

$$f_{ps} = f_{se} + 10{,}000 + \frac{f'_c}{300\rho_b}$$

STRESSING TENDONS TO 0.7 (270) = 189 KSI & ALLOWING 29,000 PSI FOR LOSSES PROVIDES AN EFFECTIVE TENDON FORCE $f_e = 160{,}000\,(0.153) = 24.5^k$ FOR EACH 1/2" φ 270 KSI STRAND

$$\rho_p = \frac{A_{ps}}{b\,d_p};$$

END SPAN; $A_{ps} = \frac{57.6}{24.5}(0.153) = 0.36\ IN^2/F$

USE AVERAGE d = 3.5"

$$\rho_p = \frac{0.36}{(12)(3.5)} = 0.0086$$

$$f_{ps} = 160{,}000 + 10{,}000 + \frac{5000}{(300)(0.0086)} =$$

$$= 171{,}938\ PSI$$

INTERIOR SPAN; $A_{ps} = \frac{43.2}{24.5}(0.153) = 0.27\ IN^2/FT$

$$\rho_p = \frac{0.27}{(12)(3.5)} = 0.0064$$

$$f_{ps} = 160\,000 + 10000 + \frac{5000}{(300)(0.0064)} =$$

$$= 172{,}604\ PSI$$

USE AVERAGE VALUE OF $\frac{171{,}938 + 172{,}604}{2} = 172271\ PSI$ THROUGHOUT FOR f_{ps}

$$F_{ps} = \frac{172{,}271}{160}(57.6) = 62.0^K/FT \quad \text{END SPANS}$$

$$F_{ps} = \frac{172{,}271}{160}(43.2) = 46.5^K/FT \quad \text{INTER. SPANS}$$

Calculate DESIGN CAPACITY

EXT. MIDSPAN $A_s = 0.002(b)(h) = 0.002(12)(6) = 0.144\ in^2$

$\#4 @ \frac{0.2(12)}{0.144} = 16.6\ IN$

$\#4 @ 16"\ o/c = 0.15\ in^2$

$F_{SU} = 62\ ^K/_{FT}$

$A_s F_y = 0.15(60) = 9\ K$

$T_U = 71$ KIPS - END SPAN

DEPTH OF COMPRESSION BLOCK $a = \frac{T_U}{0.85 f'_c b}$

$a = \frac{71}{0.85(5)(12)} = 1.39\ IN$

$(d - \frac{a}{2}) = 3.5 - \frac{1.39}{2} = 2.8\ IN$

$M_U = \varphi T_U (d - \frac{a}{2}) = 0.9(71)(\frac{2.8}{12}) = 14.91^{K\text{-}1}$

$> M = 5.67^{K\text{-}1}$ (REQ'D) O.K.

CAPACITY @ FIRST EXTERIOR SPT.

$A_s = 0.15\ in^2$ $\#4 @ 16"\ o/c$; $T_U = 71^K$

$a = 1.39\ IN$, $M_U = 14.91^{K\text{-}1} > M = 11.06^{K\text{-}1}$ REQ'D

O.K.

CHECK TYPICAL MIDSPAN MOMENT CAPACITY
W/ #4 @ 16" o/c

$F_{SU} = 46.5\ ^K/_{FT}$

$A_s F_y = 9^K$

$T_U = 55.5^K$

$$a = \frac{55.5}{0.85\,(5)(12)} = 1.09 \text{ IN}$$

$$\left(d - \frac{a}{2}\right) = 3.5 - \left(\frac{1.09}{2}\right) = 2.955 \text{ IN}$$

$$\frac{2.955}{12} = 0.246 \text{ FT}$$

$$M_U = \varphi T_U \left(d - \frac{a}{2}\right) = 0.9\,(55.5)(0.246) = 12.29^{K-1} >$$
$$> M_{REQ} = 4.41^{K-1} \quad \underline{O.K.}$$

CHECK TOTAL CAPACITY OF TYPICAL INTERIOR SPT.
MOMENT CAPACITY W/ #4 @ 16" o/c

$T_U = 55.5^K$; $a = 1.09$ IN ; $M_U = 12.29^{K-1} > M_{REQ} = 9.15^{K-1}$

<u>O.K.</u>

CHECK TOTAL CAPACITY OF TYPICAL INTERIOR SPAN ASSUMING FULL REDISTRIBUTION

$$M_{U\,(REQ)} = (0.190)\,(24.25 - 2.5)^2 / 8 = 11.2^{K-1} <$$
$$< M_{U\ PROVIDED} = 12.29 + 12.29 = 24.58^{K-1} \quad \underline{O.K.}$$

10. CHECK SHEAR CAPACITY

$$V_U = (0.190)\left(\frac{24.25}{2} - 1.25\right) = 2.07^K$$

$$V_U = \frac{2.07}{(0.85)(12)(3.5)} = 0.058 \text{ KSI} <$$

$$< 2\sqrt{f_c'} = 2\sqrt{5000}/1000 = 0.141 \text{ KSI} \quad \underline{O.K.}$$

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EFFECTIVE TENDON FORCE = 24.5^{K}

$\frac{518^{K}}{37'} = 14^{K}/'$ (WHERE 518^{K} - EFFECTIVE FORCE FOR 37' ZONE INDICATED ON DWG

REQ'D SPACING BTWN. TENDONS

$\frac{24.5}{14} = 1.75'$

$\frac{24.5\,(1000)}{(1.75)(12)(6)} = 194$ psi < 125 psi ALLOWED

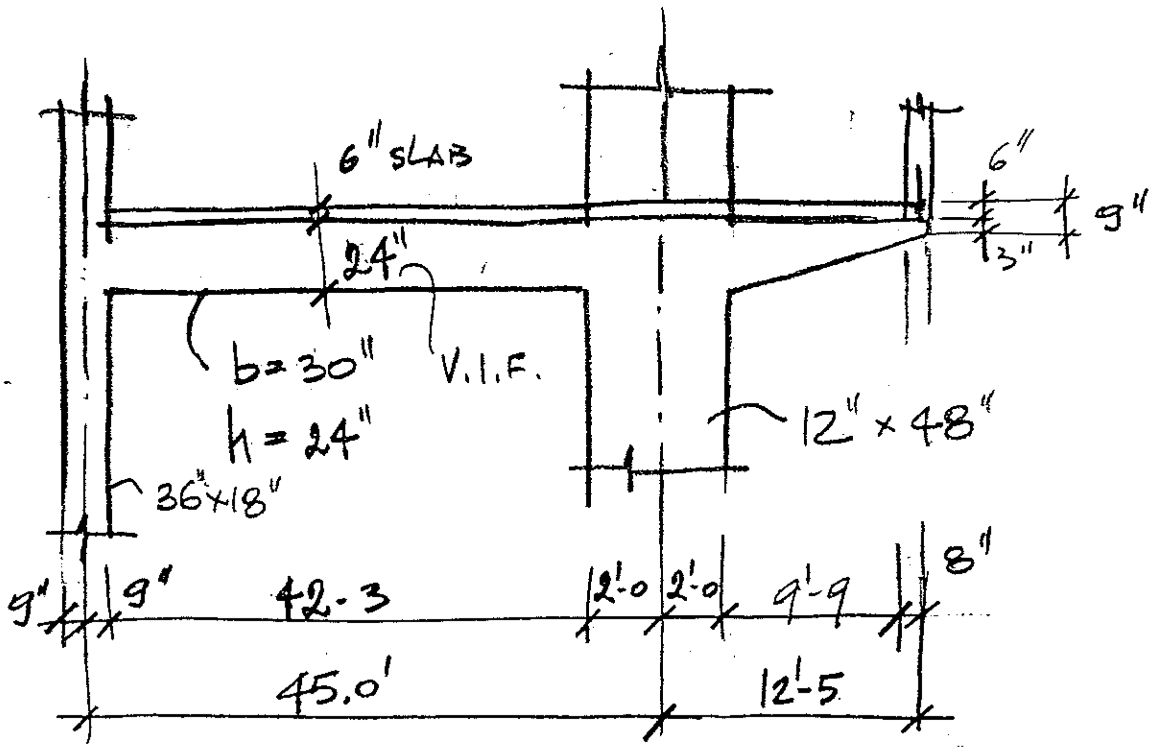
O.K.

CONCLUSION

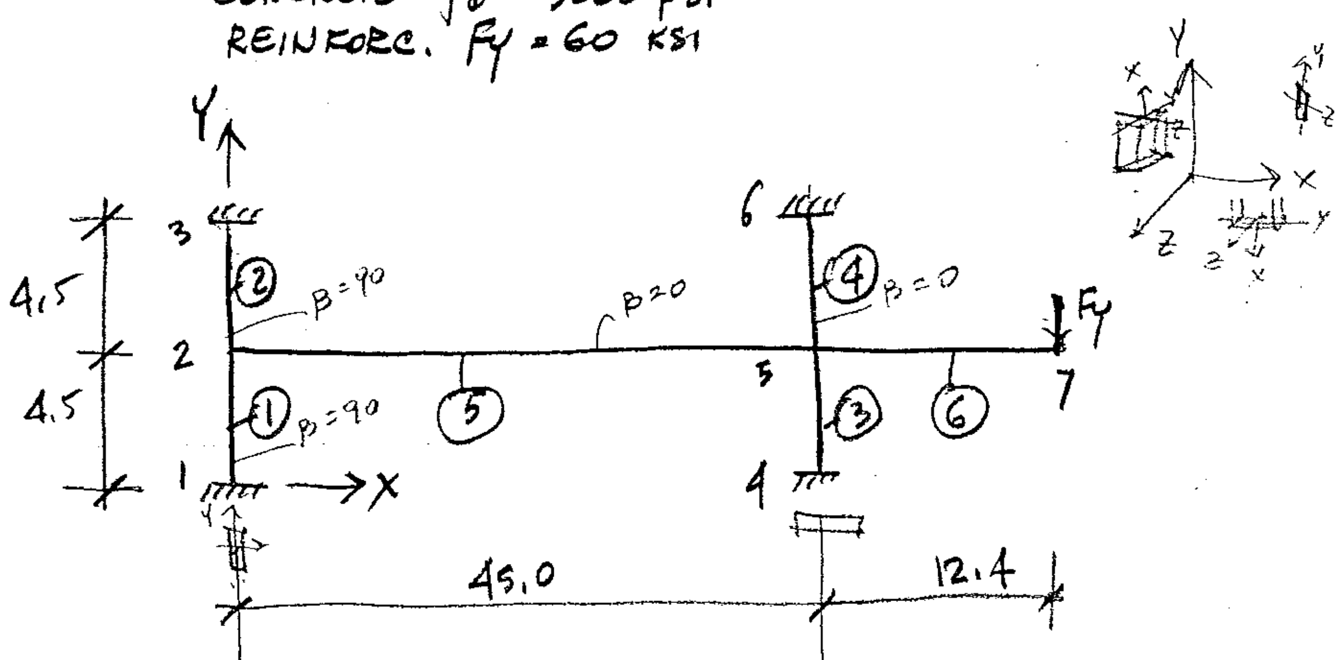
1. THERE WAS NO AS-BUILT OR SHOP DWG'S DEPICTING PLACEMENT OF PRESTRESSED STRANDS OR BUNDLES & SPACING BTWN THEM AVAILABLE.
2. MAGNITUDE OF ACTUAL PRESTRESS LOSSES WAS NOT AVAILABLE
3. ANALYSIS OF 6" THK TYPICAL POST-TENSIONED CONCRETE SLAB WAS DONE BASED ON INFO AVAILABLE FROM DESIGN DWG'S S2, S4, S17, S20, S21, S22 ISSUED BY VELTON BECKET ASSOCIATES & LEV ZETLIN ASSOCIATES IN 1985
4. ALL ASSUMPTIONS TAKEN IN CALC'S BASED ON STANDARD ENGINEERING PRACTICE
5. ANALYSIS PROVED ADEQUACY OF TYP. 6" THK. POST-TENSIONED CONCRETE SLAB DESIGN @ TYPICAL PARKING GARAGE FLOOR

6. ACTUAL LOSSES, GREATER OR SMALLER THAN THE COMPUTED VALUES, HAVE LITTLE EFFECT ON THE DESIGN STRENGTH OF THE MEMBER, BUT CAN AFFECT SERVICE LOAD BEHAVIOR, SUCH AS DEFLECTIONS, CAMBER, CRACKING LOAD.

CHECK N-S DIR. TYPICAL BEAM PB-6
@ PARKING-GARAGE



REF. DWG. S.2 ; SECT. 1/S22 ;
CONCRETE f'_c = 5000 psi
REINFORC. F_y = 60 KSI

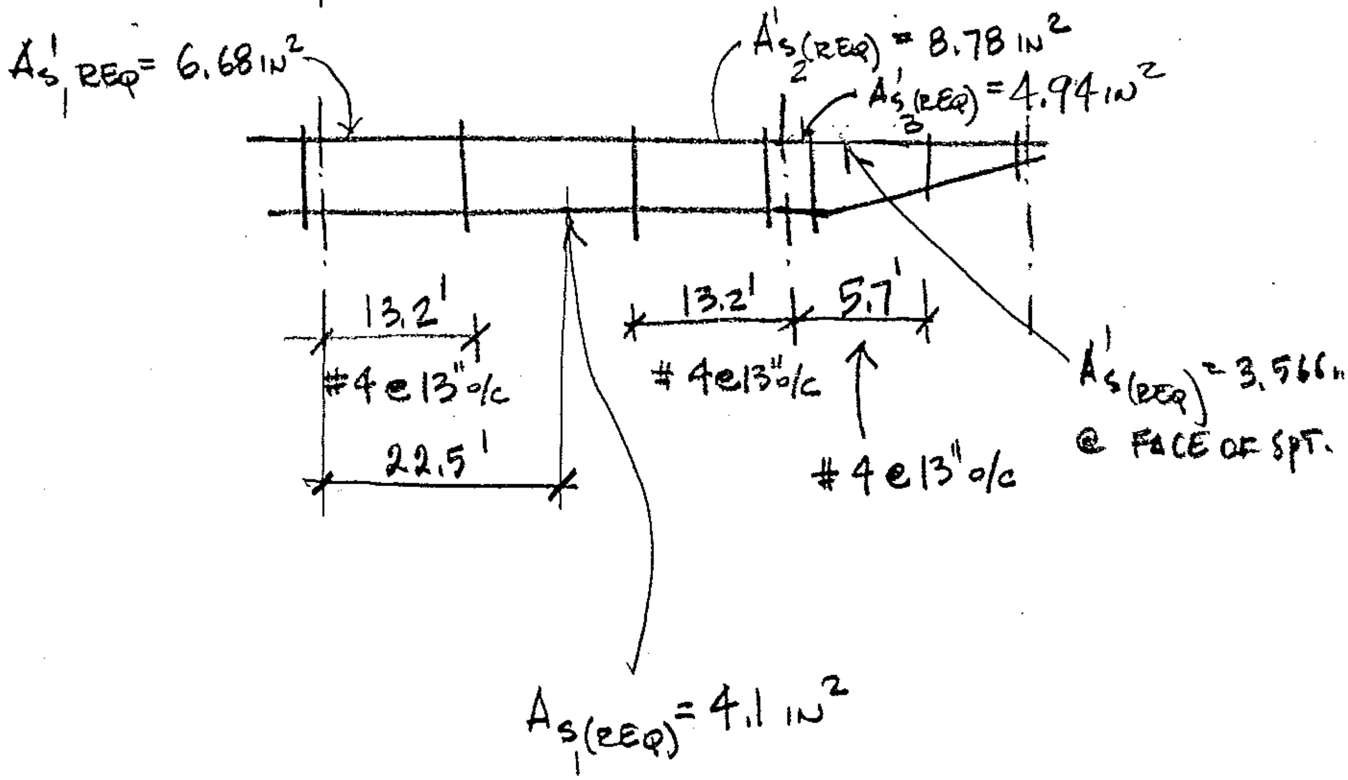


LOAD

JT. 7 ⇒ $F_y = 1.4(0.150)\left(\frac{8}{12}\right)(3.5)(24.25) = 11.9^k$

MEM. 5, 6 ⇒ UNI Y = $(1.4)(0.150)[(1.5)(2.0) + (0.5)(24.25)] + (1.7)(0.050)(24.25) = 5.24^k/_1$

BASED ON COMPUTER MODEL "XEROXBM" ANALYSIS RESULT REQ'D REINFORCEMENT:



REINFORCEMENT USED : (DWG. S22)

@ CANT. $A'_{s_3} = (2-\#11) = (2)(1.56) = 3.12\ IN^2 < 3.566\ IN^2$ (@ FACE OF SPT) (CAN BE ACCEPTABLE)

@ JT. 5 (INSIDE) $A'_{s_2} = (7-\#11) = (7)(1.56) = 10.92\ IN^2 > 8.78\ IN^2$ O.K.

@ JT. 2 (INSIDE) $A'_{s_1} = (8-\#11) = (8)(1.56) = 12.48\ IN^2 > 6.68\ IN^2$ O.K

@ BOT. SPAN $A_s = (7-\#11) = (7)(1.56) = 10.92\ IN^2 > 4.1\ IN^2$ O.K

SHEAR REINF. @ SPAN #4 @ 10" o/c > #4 @ 13" o/c

CANT #3 @ 6" $A_s = \frac{0.11(12)}{6} = 0.22\ IN/_1 > \frac{0.2(12)}{13} = 0.185\ IN^2$ O.K

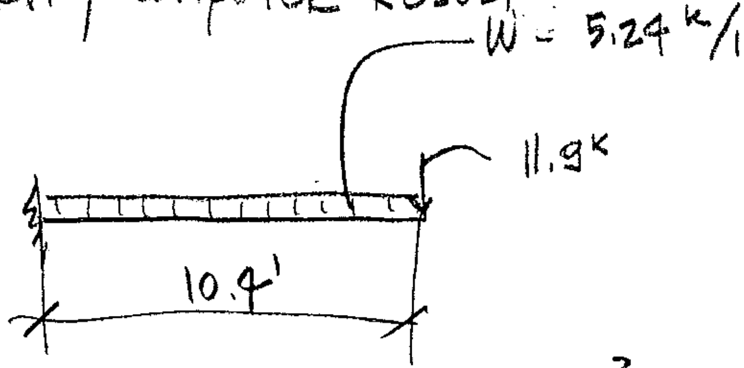
BVH ENGINEERS, INC.

COMPUTATION SHEET

Job: XEROX CENTRE | Page 16
Location: PARKING - GARAGE | Comm. No.: | Date 08.24.94 | Designer

BVH ENGINEERS, INC.

VERIFY COMPUTER RESULT



$$M = 11.9(10.4) + \frac{5.24(10.4)^2}{2} = 407.1^{k\text{-}1}$$

$$F = \frac{bd^2}{12{,}000} = \frac{30(27)^2}{12{,}000} = 1.82$$

$$K_n = \frac{407.1}{1.82} = 224 \qquad \rho = 0.0044$$

$$A'_{s\,(REQ)} = 0.0044(30)(27) = 3.56 \text{ IN}^2$$

∴ TYP REINFORCED CONCRETE BEAM PB-6 IS ADEQUATE BASED ON INFO PROVIDED BY CONTRACT DOCUMENTS DWG. No A37, S17 & S22 ISSUED IN 1985.

SHOP DWG'S OR AS-BUILT DWG. ARE NOT AVAILABLE

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```
****************************************************
*                                          *
*          S T A A D - III                    *
*          Revision 19.0                       *
*          Proprietary Program of                  *
*          RESEARCH ENGINEERS, Inc.                      *
*          Date=    AUG 24, 1994                     *
*          Time=     19:15:55                      *
*                                          *
*     USER ID: BVH ENGINEERS INC.                 *
****************************************************
```

```
 1. STAAD PLANE N-S REINF. CONCRETE FRAME XEROXBM
 2. * FILE NAME C:\LER\XEROXBM
 3. UNIT KIP FT
 4. JOINT COORDINATES
 5. 1    0.0    0.0
 6. 2    0.0    4.5
 7. 3    0.0    9.0
 8. 4   45.0    0.0
 9. 5   45.0    4.5
10. 6   45.0    9.0
11. 7   57.4    4.5
12. *
13. MEMBER INCIDENCES
14. 1   1   2 ; 2   2   3 ; 3   4   5 ;  4   5   6 ;  5   2   5
15. 6   5   7
16. *
17. UNIT INCHES
18. MEMBER PROPERTIES
19. 1 2  PRISM YD 36.0 ZD 18.0
20. 3 4  PRISM YD 48.0 ZD 12.0
21. 5 6  PRISM YD 30.0 ZD 30.0
22. *
23. *MEMBER RELEASES
24. *
25. CONSTANTS
26. E 4030.0 ALL
```

```
DEN 0.000283 ALL
BETA 90.0 MEM 1 2
*
SUPPORTS
1 3 4 6 FIX
*
UNIT FEET
*
LOADING 1
JOINT LOAD
7   FY -11.9
LOADING 2
MEMBER LOAD
5 6 UNI Y -5.24
LOAD COMBINATION 3
1   1   2   1
```

43. *
44. UNIT INCH
45. *
46. PDELTA ANALYSIS

P R O B L E M   S T A T I S T I C S

NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS = 7/ 6/ 4
ORIGINAL/FINAL BAND-WIDTH = 3/ 3
TOTAL PRIMARY LOAD CASES = 2, TOTAL DEGREES OF FREEDOM = 9
SIZE OF STIFFNESS MATRIX = 54 DOUBLE PREC. WORDS
REQUIRED DISK SPACE = 12.01 MB, TOTAL EXMEM = 4.80 MB

++ PROCESSING ELEMENT STIFFNESS MATRIX. 19:15:55
++ PROCESSING GLOBAL STIFFNESS MATRIX. 19:15:55
++ PROCESSING TRIANGULAR FACTORIZATION. 19:15:56
++ CALCULATING JOINT DISPLACEMENTS. 19:15:56
++ ADJUSTING DISPLACEMENTS 19:15:56
++ CALCULATING MEMBER FORCES. 19:15:56

47. PRINT MEM PROP ALL

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EMBER PROPERTIES. UNIT - INCH

MEMB	PROFILE	AX/ AY	IZ/ AZ	IY/ SZ	IX/ SY
1	PRISMATIC	648.00	69984.00	17496.00	47823.57
		648.00	648.00	3888.00	1944.00
2	PRISMATIC	648.00	69984.00	17496.00	47823.57
		648.00	648.00	3888.00	1944.00
3	PRISMATIC	576.00	110592.00	6912.00	23270.63
		576.00	576.00	4608.00	1152.00
4	PRISMATIC	576.00	110592.00	6912.00	23270.63
		576.00	576.00	4608.00	1152.00
5	PRISMATIC	900.00	67500.00	67500.00	99009.00
		900.00	900.00	4500.00	4500.00
6	PRISMATIC	900.00	67500.00	67500.00	99009.00
		900.00	900.00	4500.00	4500.00

************ END OF DATA FROM INTERNAL STORAGE ************

48. PRINT MEM INFO ALL

MEMBER INFORMATION

MEMBER	START JOINT	END JOINT	LENGTH (INCH)	BETA (DEG)	RELEASES
1	1	2	54.000	90.00	
2	2	3	54.000	90.00	
3	4	5	54.000	0.00	
4	5	6	54.000	0.00	
5	2	5	540.000	0.00	
6	5	7	148.800	0.00	

************ END OF DATA FROM INTERNAL STORAGE ************

49. DRAW

```
50. LOADING LIST 3
51. START CONCRETE DESIGN

52. CODE ACI
53. FC 5
54. CLT 3.0
55. CLB 1.5
56. CLS 1.5
57. TRACK 1.0
58. TRACK 2.0
59. DESIGN BEAM 5 6
```

B E A M N O. 5 D E S I G N R E S U L T S - FLEXURE

LEN - 45.00FT. FY - 60000. FC - 5000. SIZE - 30.00 X 30.00 INCHES

LEVEL	HEIGHT FT. IN.	BAR INFO	FROM FT. IN.	TO FT. IN.	ANCHOR STA	ANCHOR END
1	0 + 2-3/8	13-NUM.5	8 + 0-5/8	38 +10-0/0	NO	NO

```
CRITICAL POS MOMENT=    488.58 KIP-FT  AT 22.50 FT, LOAD   3
REQD STEEL=  4.03 IN2, ROW=0.0049, ROWMX=0.0252 ROWMN=0.0033
MAX/MIN/ACTUAL BAR SPACING= 15.00/ 1.63/ 2.11 INCH
BASIC/REQD. DEVELOPMENT LENGTH = 10.52/ 15.91 INCH
```

LEVEL	HEIGHT FT. IN.	BAR INFO	FROM FT. IN.	TO FT. IN.	ANCHOR STA	ANCHOR END
2	2 + 1-7/8	15-NUM.6	0 + 0-0/0	14 + 5-7/8	YES	NO

```
CRITICAL NEG MOMENT=    732.82 KIP-FT  AT  0.00 FT, LOAD   3
REQD STEEL=  6.59 IN2, ROW=0.0085, ROWMX=0.0252 ROWMN=0.0033
MAX/MIN/ACTUAL BAR SPACING= 15.00/ 1.75/ 1.80 INCH
BASIC/REQD. DEVELOPMENT LENGTH = 14.93/ 38.83 INCH
```

LEVEL	HEIGHT FT. IN.	BAR INFO	FROM FT. IN.	TO FT. IN.	ANCHOR STA	ANCHOR END
3	2 + 1-1/2	4-NUM.14	27 + 9-3/4	45 + 0-0/0	NO	YES

```
CRITICAL NEG MOMENT=    942.76 KIP-FT  AT 45.00 FT, LOAD   3
REQD STEEL=  8.97 IN2, ROW=0.0115, ROWMX=0.0252 ROWMN=0.0033
MAX/MIN/ACTUAL BAR SPACING= 15.00/ 3.39/ 8.10 INCH
BASIC/REQD. DEVELOPMENT LENGTH = 72.12/ 93.76 INCH
```

REQUIRED REINF. STEEL SUMMARY :

SECTION (FEET)	REINF STEEL(+VE/-VE) (SQ. INCH)	MOMENTS(+VE/-VE) (KIP-FEET)	LOAD(+VE/-VE)
0.00	0.000/ 6.684	0.00/ 732.82	0/ 3
3.75	0.000/ 3.040	0.00/ 345.04	0/ 3
7.50	0.000/ 0.266	0.00/ 30.94	0/ 3
11.25	1.722/ 0.000	209.47/ 0.00	3/ 0
15.00	3.131/ 0.000	376.20/ 0.00	3/ 0
18.75	3.933/ 0.000	469.23/ 0.00	3/ 0
22.50	4.101/ 0.000	488.58/ 0.00	3/ 0
26.25	3.630/ 0.000	434.24/ 0.00	3/ 0
30.00	2.535/ 0.000	306.22/ 0.00	3/ 0
33.75	0.853/ 0.000	104.50/ 0.00	3/ 0
37.50	0.000/ 1.484	0.00/ 170.90	0/ 3
41.25	0.000/ 4.651	0.00/ 519.99	0/ 3
45.00	0.000/ 8.776	0.00/ 942.76	0/ 3

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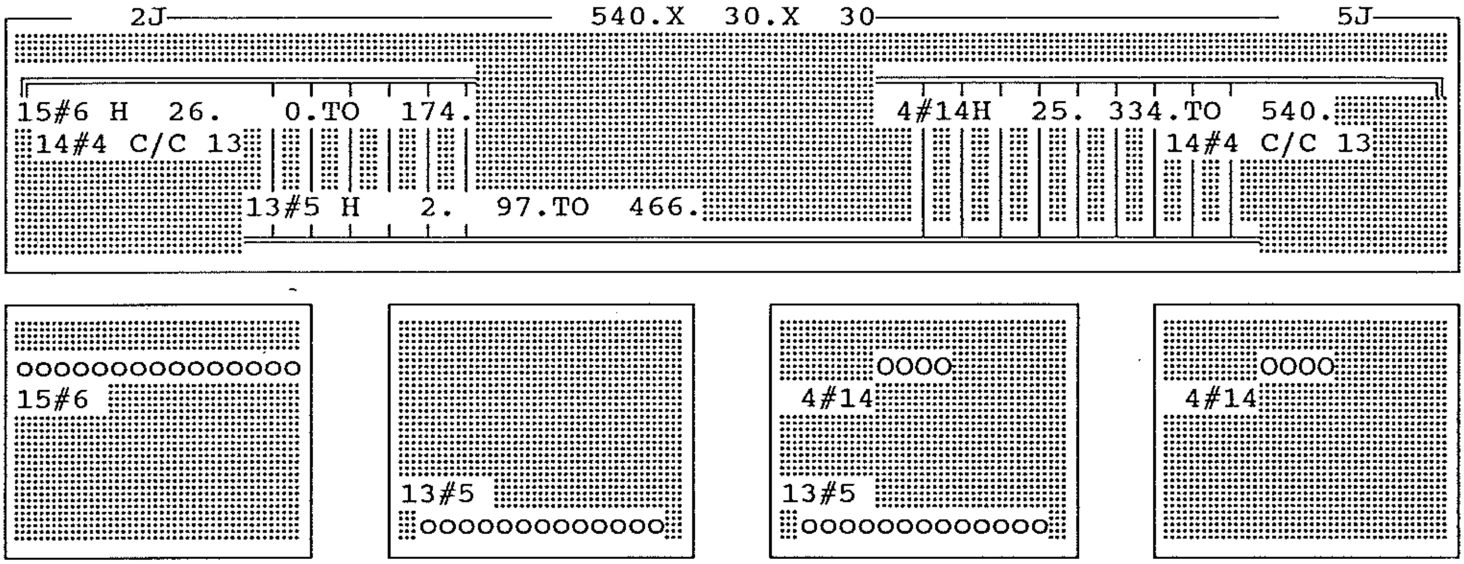
B E A M N O. 5 D E S I G N R E S U L T S - SHEAR

AT START SUPPORT - Vu= 101.88 KIP Vc= 110.31 KIP Vs= 9.55 KIP
PROVIDE NUM. 4 BARS AT 13.0 IN. C/C FOR 158. IN.
AT END SUPPORT - Vu= 111.21 KIP Vc= 110.31 KIP Vs= 20.53 KIP
PROVIDE NUM. 4 BARS AT 13.0 IN. C/C FOR 158. IN.



B E A M N O. 6 D E S I G N R E S U L T S - FLEXURE

LEN - 12.40FT. FY - 60000. FC - 5000. SIZE - 30.00 X 30.00 INCHES

LEVEL	HEIGHT FT. + IN.	BAR INFO	FROM FT. + IN.	TO FT. + IN.	ANCHOR STA	ANCHOR END
1	2 + 1-3/4	5-NUM.9	0 + 0-0/0	12 + 4-7/8	YES	YES

CRITICAL NEG MOMENT= 550.41 KIP-FT AT 0.00 FT, LOAD 3
REQD STEEL= 4.94 IN2, ROW=0.0063, ROWMX=0.0252 ROWMN=0.0033
MAX/MIN/ACTUAL BAR SPACING= 15.00/ 2.26/ 6.22 INCH
BASIC/REQD. DEVELOPMENT LENGTH = 33.94/ 44.12 INCH

REQUIRED REINF. STEEL SUMMARY :

SECTION (FEET)	REINF STEEL(+VE/-VE) (SQ. INCH)		MOMENTS(+VE/-VE) (KIP-FEET)		LOAD(+VE/-VE)	
0.00	0.000/	4.937	0.00/	550.41	0/	3
1.03	0.000/	4.221	0.00/	473.77	0/	3
2.07	0.000/	3.566	0.00/	402.72	0/	3
3.10	0.000/	2.970	0.00/	337.27	0/	3