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Structural Details & Calculations for a PreCast Box Culvert Section

PCN 470.12.31 Low Org 6975
FCD Contract No. 2004C051
Assignment No. 1

Reems Road Channel and Basin Project

Design Assistance for Rail Road Crossing

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Phone: (602) 506-4601

File: L9601-2005-Assignment 1

Registered Professional Engineer (Structural)
CERTIFICATE NO.
14423
ANDREW G.
DILEO
Date Signed 7.25.05
ARIZONA, U.S.A.

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TO: Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

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DATE: July 25, 2005

ATTN: Kumar Hanumaiah, P.E.
Structural Engineer

As requested, I have provided the reinforcing steel design and details for a section of a precast concrete box culvert to support a Cooper E-80 Rail Road Loading plus 3 feet of soil fill for the Reems Road Channel and Basin Project.

The design was developed from a 3-dimensional finite element analysis. The attached sheet 1 is a section through the longitudinal direction defining how the loading from each wheel on the 5' wide track is distributed through the rail road ties and the soil fill. A 1:H to 2:V slope was selected for a conservative design.

Sheet 2 shows the individual loading conditions used to make up the various loading combinations to arrive at the most critical loadings for the design.

Sheets 3, 4, and 5 are the reference material defining the Copper E-80 Loading.

Sheets 6 and 7 are the reference materials used to determine the lateral loading to the vertical side of the box due to an 80 kip axial approaching the box. .

Sheets 8, 9, 10, and 11 are the finite element analysis representations of the loading cases defined on sheet 2.

Sheets 12, 13, and 14 are the plate corner forces resulting from the various load combinations. The finite element model is made up of hundreds of plate elements, but only those located in critical locations were selected for printout and analysis purposes.

Sheet 15 is the Design Summary of the critical design moments.

Sheets 16 to 20 are the reinforcing steel designs for the critical sections.

Sheet 21 is the Detail Summary for the reinforcing steel.

Sheet 22 is a shear analysis of the critical shear load. The shear capacity of the design section is within the requirements of AASHTO Shear Friction Section 8.15.5.4 .

Sheets 23 and 24 are data containing the deflection of the center of the top slab. The maximum deflection of 0.066 inches is equivalent to L/1818.

Should you have any questions regarding this document feel free to contact me at telephone number (602) 395-0756.

Respectfully Submitted;

Andrew G. DiLeo, P.E.
Structural Engineer

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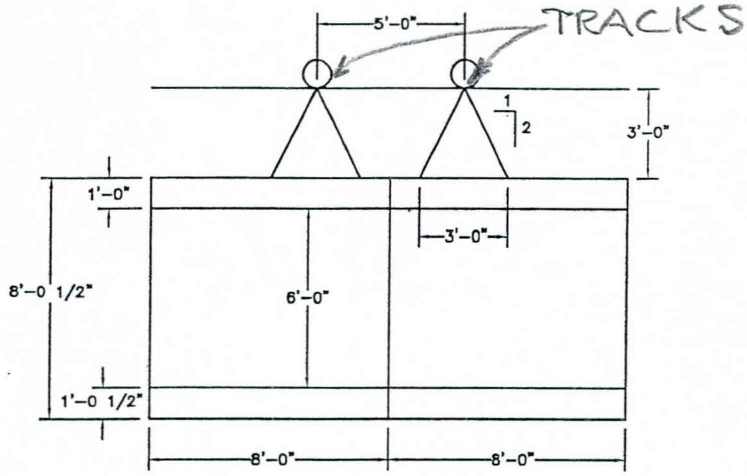
JOB NO. ______ SHT. 1 OF ______
DESC. ______ BY AGD
DATE JULY 23, 2005

LOADING TO TOP OF BOX



DIST POINT LOAD AT 1:H TO 2:VERT THROUGH SOIL & TIES

USE WEIGTH OF TRAIN WHEEL
IMPACT
TRACK → NEGLIGIBLE
SOIL

WHEEL = 40^k FROM 80^k AXLE

$$\text{IMPACT} = RE + 40 - \frac{3L^3}{1600}$$

RE = ROCKING EFFECT = 10%

$$= 10 + 40 - \frac{3(10^3)}{1600} = 48.1$$

WHEEL + IMPACT IS APPLIED TO 3' x 3' AREA

$$\text{WHEEL + IMPACT} = \frac{40^k(1.481)}{3' \times 3'} = 6.582 \text{ KSF}$$

$$\text{SOIL} = 3 \times 0.130 = \underline{0.390}$$

$$\text{TOTAL} = 6.972 \text{ KSF}$$

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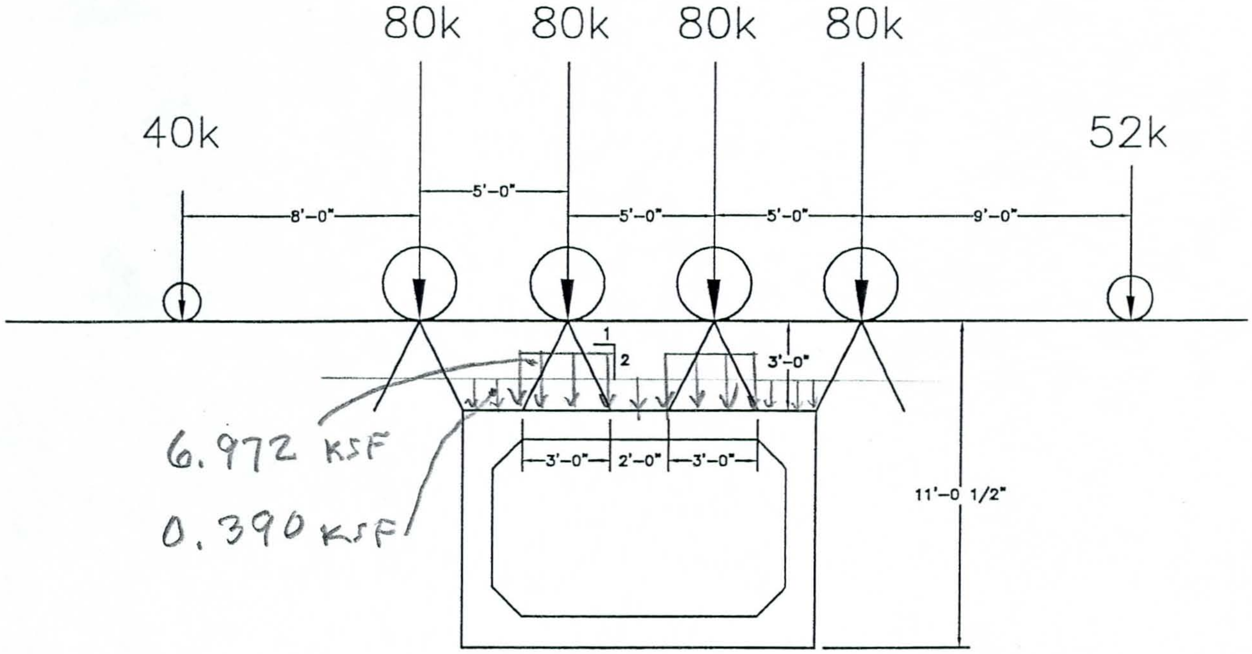
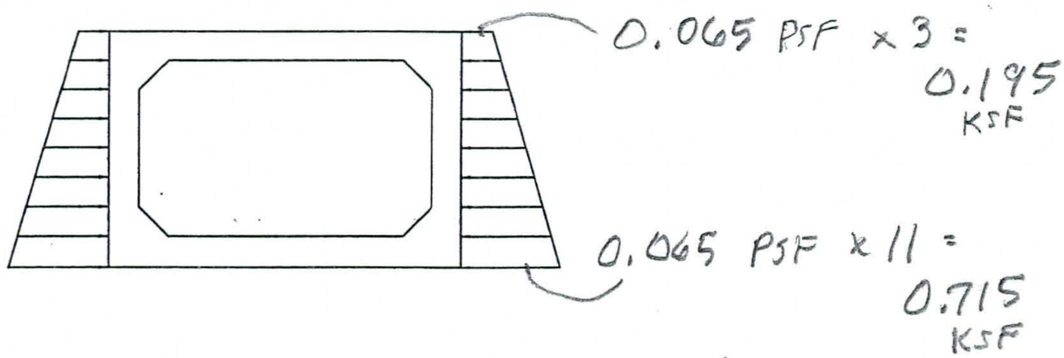
JOB NO.
DESC.

SHT. 2 OF
BY AGD
DATE JULY 23, 2005

APPLIED LOADS



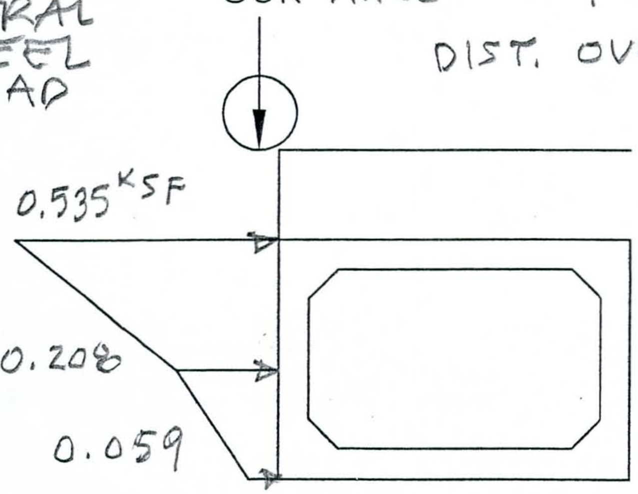
LATERAL SOIL PRESSURE



LATERAL WHEEL LOAD

80k AXLE → 40 K WHEEL

DIST. OVER 3' LENGTH OF BOX PER WHEEL



Material	Weight lb/cu ft
Timber	60
Ballast	120
Concrete	150
Steel	490

Note that walkway construction may add significantly to the dead load. Also, when a long body rail casting, such as expansion joints, are specified for a bridge, the castings should be supported only on one span of the stringers.

11.35.2 Live Load

Railroad bridges have been designed for many years using specified Cooper E Loadings. See Fig. 11.16*a* for the wheel arrangement and the trailing load for the Cooper E80 loading, which includes 80 kip axle loads on the drivers. This configuration can be moved in either direction across a span to determine the maximum moments and shears. With the continuing increase in car axle loads, AREMA has also adopted the Alternate Live Load on four axles shown in Fig. 11.16*b*. It recommends that bridge design be based on the E80 or the Alternate Loading, whichever produces the greater stresses in the member. A table of live load moments, shears, and reactions for both the E80 and the Alternate Loading may be found in the Appendix of Chapter 15 of the AREMA *Manual*. The table values are presented in terms of wheel loads (one-half of an axle load).

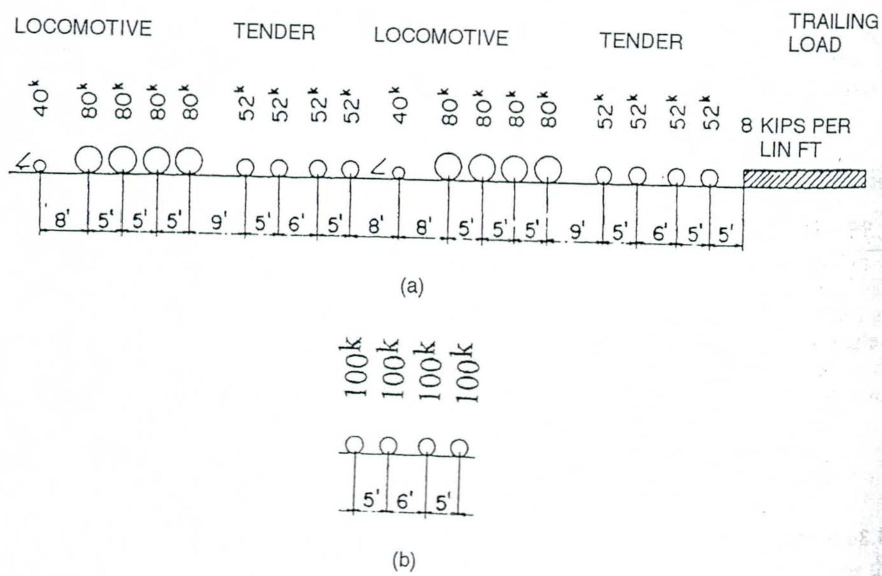


FIGURE 11.16 Loadings for design of railway bridges. (*a*) Cooper E80 load. (*b*) Alternate live load on four axles. (Adapted from *AREMA Manual*, American Engineering and Maintenance-of Way Association, 8201 Corporate Drive, Suite 1125, Landover, MD 20785-2230.)

3

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11.35.3 Load Path

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11.35.4 Load on M

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11.35.5 Impact Load

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For $L <$

Some owners may elect to use loadings other than E80 in some cases. Such loadings may be directly proportioned from the E80 loading according to the axle load on the drivers. For example, an owner specifying a new through truss or girder span may specify an E95 loading for the floor system and hangers, and an E80 loading for the rest of the structure. It is considered good practice to keep the bridge design loading well above the economical loading capacity of rolling stock and track structure.

11.35.3 Load Path

The path of the load from the wheels through the rail and into the tie, is either directly to the supporting beams, or through a ballast bed to a deck and thence into the supporting beams. Direct fixation of the rails to supporting members is not considered here.

Figure 11.17*a* provides a sectional view of an open-deck through-girder span. This type of construction should provide a clear space between ties of no more than 6 in. The guard timber shown at the end of the tie has the function of keeping the ties uniformly spaced and preventing tie skewing. Tie skewing must be prevented because it closes the gage between the rails. Hook bolts or tie anchor assemblies, not shown in the sketch, are used to fasten the tie to the support beam. The guard timbers are fastened to the ties with ⅝-in-diameter washerhead drive spikes, through bolts, or lag bolts.

Figure 11.17*b* provides a sectional view of a ballast-deck through-girder span. Many such spans are designed with closely spaced floorbeams, thus eliminating the stringers.

11.35.4 Load on Multi-Track Structures

To account for the effect of multiple tracks on a structure, the proportion of full live load on the tracks should be taken as follows:

Two tracks—Full live load.

Three tracks—Full live load on two tracks, one-half live load on third track.

Four tracks—Full live load on two tracks, one-half live load on one track, one-quarter live load on remaining track.

The tracks selected for these loads should be such that they produce the maximum live load stress in the member under consideration. For bridges carrying more than four tracks, the track loadings should be specified by the owner's engineer.

11.35.5 Impact Load

Impact loads, I, are expressed as a percentage of the specified axle load and should be applied downward or upward at the top of the rail. For open-deck bridge construction, the percentages are obtained from the applicable equations given below. For ballast-deck bridges designed according to specifications, use 90% of the impact load given for open deck bridges.

For rolling equipment without hammer blow (diesel or electric locomotives, tenders, rolling stock):

For $L < 80$ ft:

$$I = RE + 40 - \frac{3L^2}{1600} \tag{11.78}$$

For $L \geq 80$ ft:

$$I = RE + 16 + \frac{600}{L - 30} \tag{11.79}$$

For steam locomotives (hammer blow):

For girders, beam spans, stringers, floor beams, floor beam hangers, and posts of deck trusses that carry floor beam loads only:

For $L < 100$ ft:

$$I = RE + 60 - \frac{L^2}{500} \tag{11.80}$$

For $L \geq 100$ ft:

$$I = RE + 10 + \frac{1800}{L - 40} \tag{11.81}$$

For truss spans:

$$I = RE + 15 + \frac{4000}{L - 25} \tag{11.82}$$

In the above equations, $RE = 10\%$ (RE represents the rocking effect, acting as a couple with a downward force on one rail and an upward force on the other rail, thus increasing or decreasing the specified load); for stringers, transverse floor beams without stringers, longitudinal girders and trusses, L = length, ft, center to center of supports; for floor beams, floor beam hangers, subdiagonals of trusses, transverse girders, supports for longitudinal and transverse girders, and viaduct columns, L = length, ft, of the longer supported stringer, longitudinal beam, girder, or truss.

On multi-track bridges, the impact should be applied as follows:

When load is received from two tracks:

For $L \leq 175$ ft:

Full impact on two tracks.

For 175 ft $\leq L \leq$ 225 ft:

Full impact on one track and a percentage of full impact on the other track as given by $(450\text{-}2L)$

For $L > 225$ ft:

Full impact on one track and no impact on other track.

When load is received from more than two tracks:

For all values of L:

Full impact on any two tracks.

For all design checks for fatigue, use the *mean impact* expressed as a percentage of the values given by the above equations, as follows:

zero at a greater depth, Fig. 4-16. The unit horizontal pressure may be computed by the following equation (Terzaghi, 1954):

$$\left.\begin{aligned} p_q &= 1.27q\frac{xz}{R^4} \\ &= 1.27\frac{q}{H}\frac{m^2n}{(m^2+n^2)^2} \end{aligned}\right\} \quad (m > 0.4) \qquad \text{(4-8a)}$$

$$p_q = 0.203\frac{q}{H}\frac{n}{(0.16+n^2)^2} \quad (m < 0.4) \qquad \text{(4-8b)}$$

D. Point load. A wheel load or any load concentrated on a small area may be treated as a point load. The intensity of lateral pressure in this case varies not only with the depth but also with the horizontal distance from the load. The pressure is greatest along the vertical line *ab* closest to the load, Fig. 4-17. Along this line *ab*, the unit horizontal pressure *p* may be computed by the following empirical equations (Terzaghi, 1954):

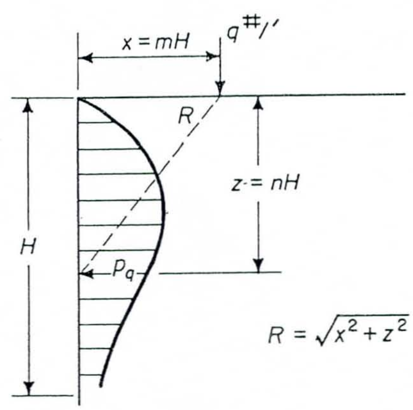


Fig. 4-16 Lateral pressure due to line load.

$$p_1 = 1.77\frac{Q}{H^2}\frac{m^2n^2}{(m^2+n^2)^3} \quad (m > 0.4) \qquad \text{(4-9a)}$$

$$p_1 = 0.28\frac{Q}{H^2}\frac{n^2}{(0.16+n^2)^3} \quad (m < 0.4) \qquad \text{(4-9b)}$$

The unit horizontal pressure on any other points on both sides of *ab* is smaller than p_1 at the same depth, and may be calculated by the following equation.

$$p_Q = p_1 \cos^2 (1.1\psi) \qquad \text{(4-9c)}$$

The notations used in the equations above are self-explanatory in Fig. 4-17.

4-10 Ice Thrust

Substructures are subjected to ice thrust where the ground water or capillary water is above the frost line (depth of frost penetration). Lateral thrust is caused by the volume expansion of ice upon change in temperature. The magnitude of the thrust is very large, being equal to the buckling or crushing strength of the ice sheet. In practice the horizontal ice thrust acting

Lateral Pressure due to Axial Load

$Q := 40.0$
$H := 11.0$
$n := \frac{3}{11}$

$$p := 0.28 \cdot \left(\frac{Q}{H^2}\right) \cdot \frac{n^2}{\left(0.16 + n^2\right)^3}$$

$p = 0.535$

$n := \frac{7}{11}$

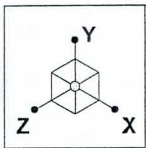
$$p := 0.28 \cdot \left(\frac{Q}{H^2}\right) \cdot \frac{n^2}{\left(0.16 + n^2\right)^3}$$

$p = 0.208$

$n := \frac{11}{11}$

$$p := 0.28 \cdot \left(\frac{Q}{H^2}\right) \cdot \frac{n^2}{\left(0.16 + n^2\right)^3}$$

$p = 0.059$



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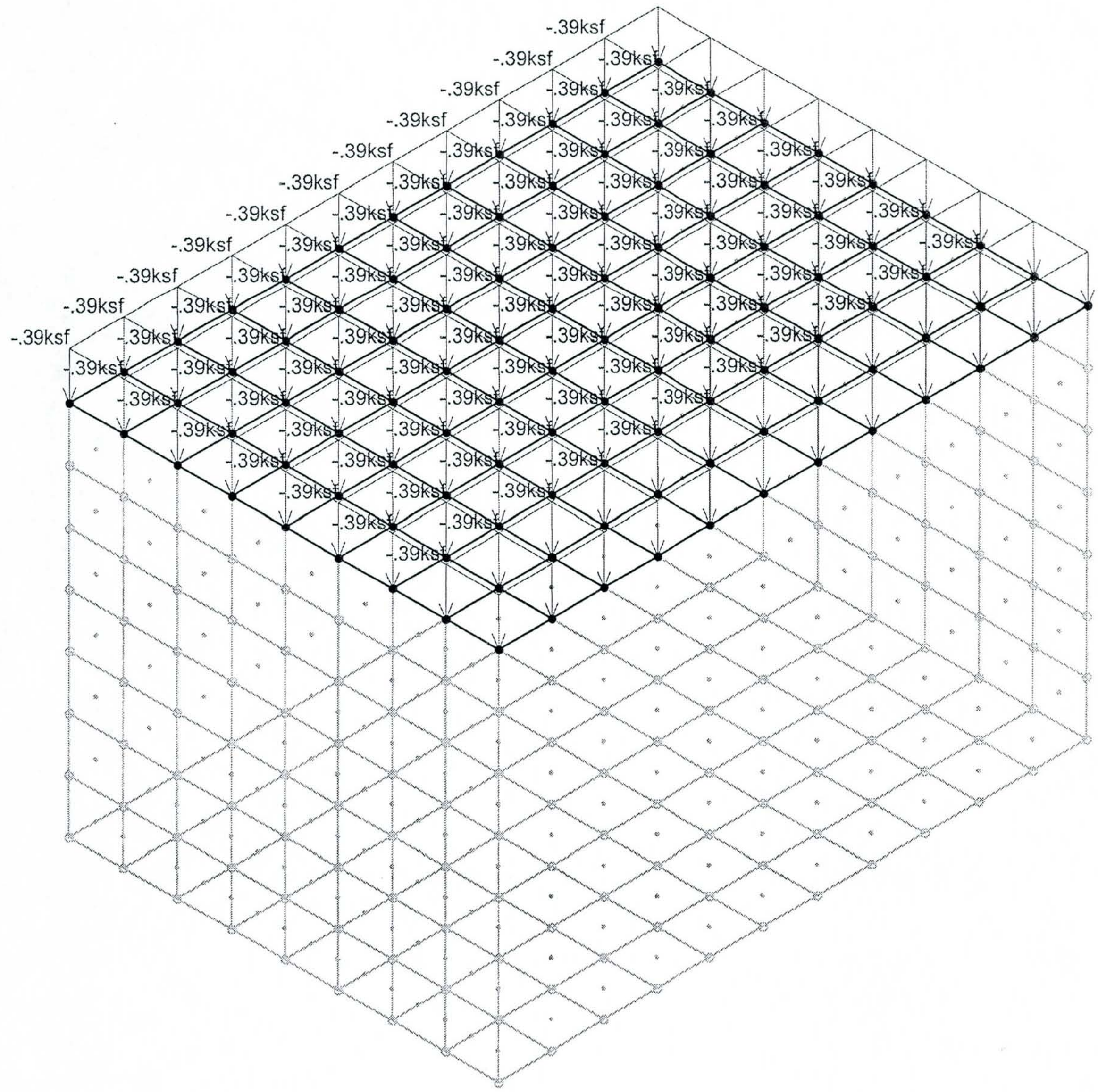
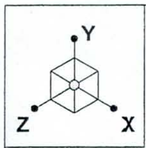
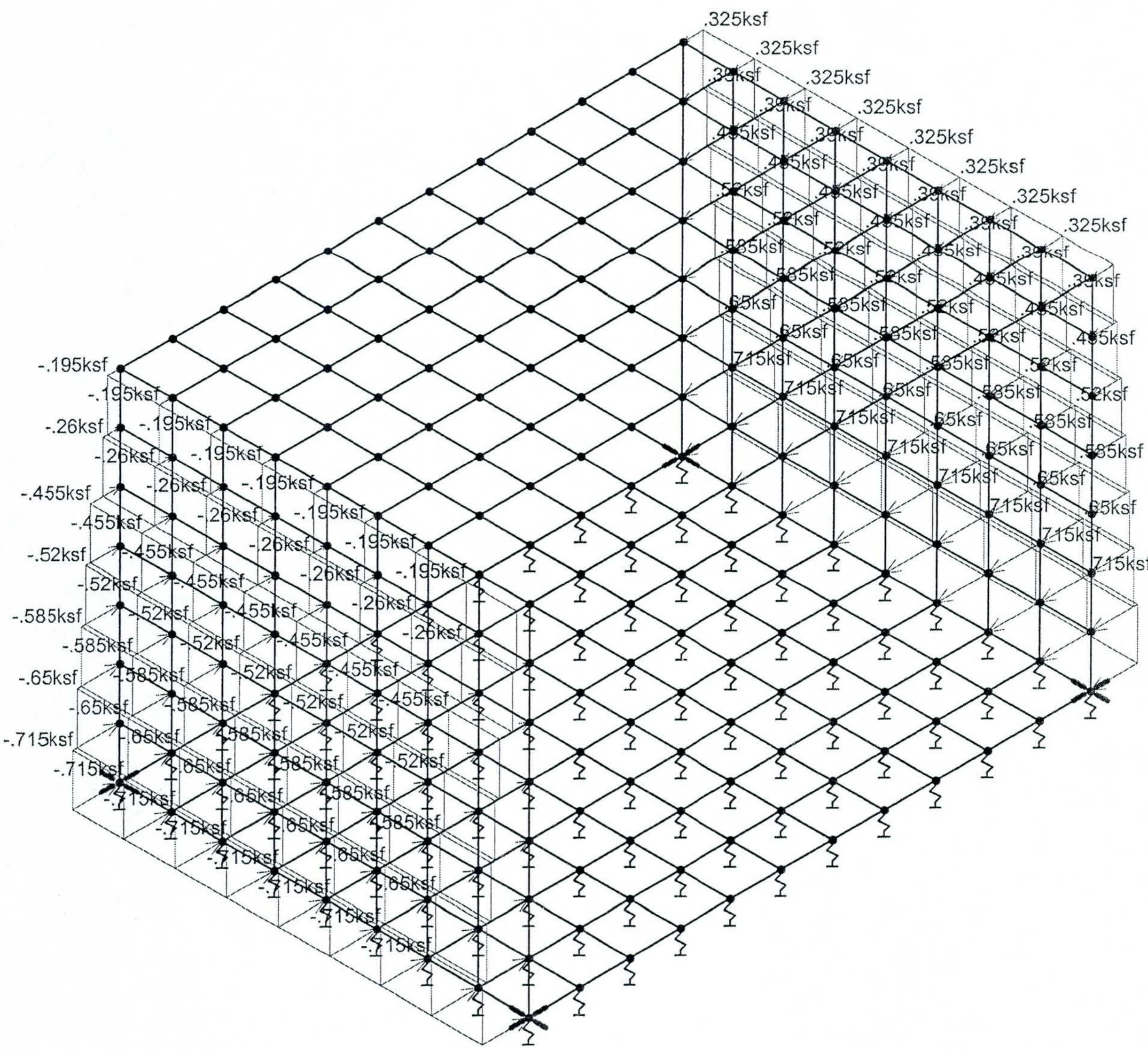


Loads: BLC 1, Vertical Soil

	C9601- 2005-Assignment 1, CDRW #1	
		July 23, 2005 at 4:15 PM
		C9601-2005-Assignment 1.r3d



(9)



Loads: BLC 2, Lateral Soil

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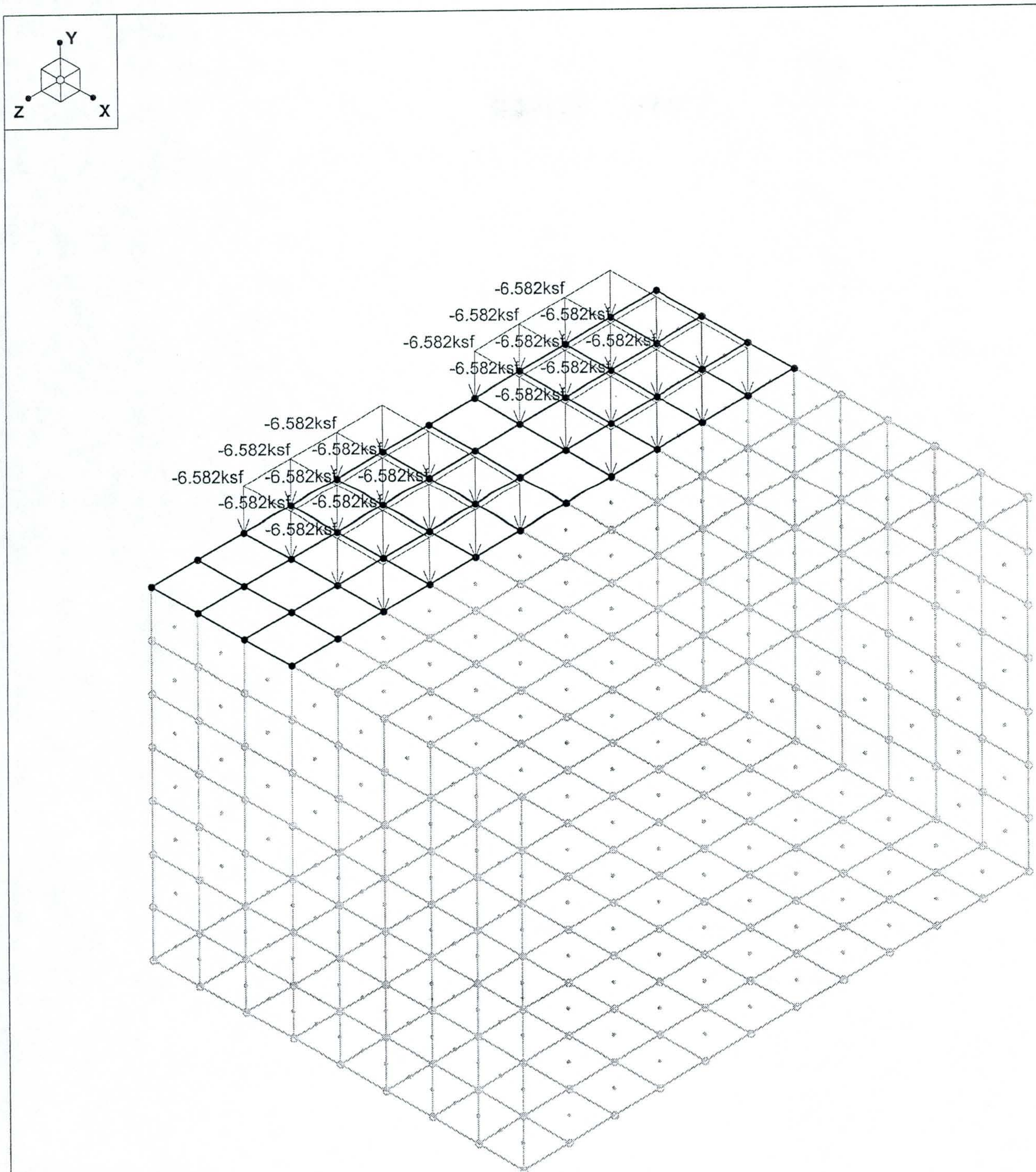
		C9601-2005-Assignment 1.r3d



(10)

Loads: BLC 3, Wheel - Vert.

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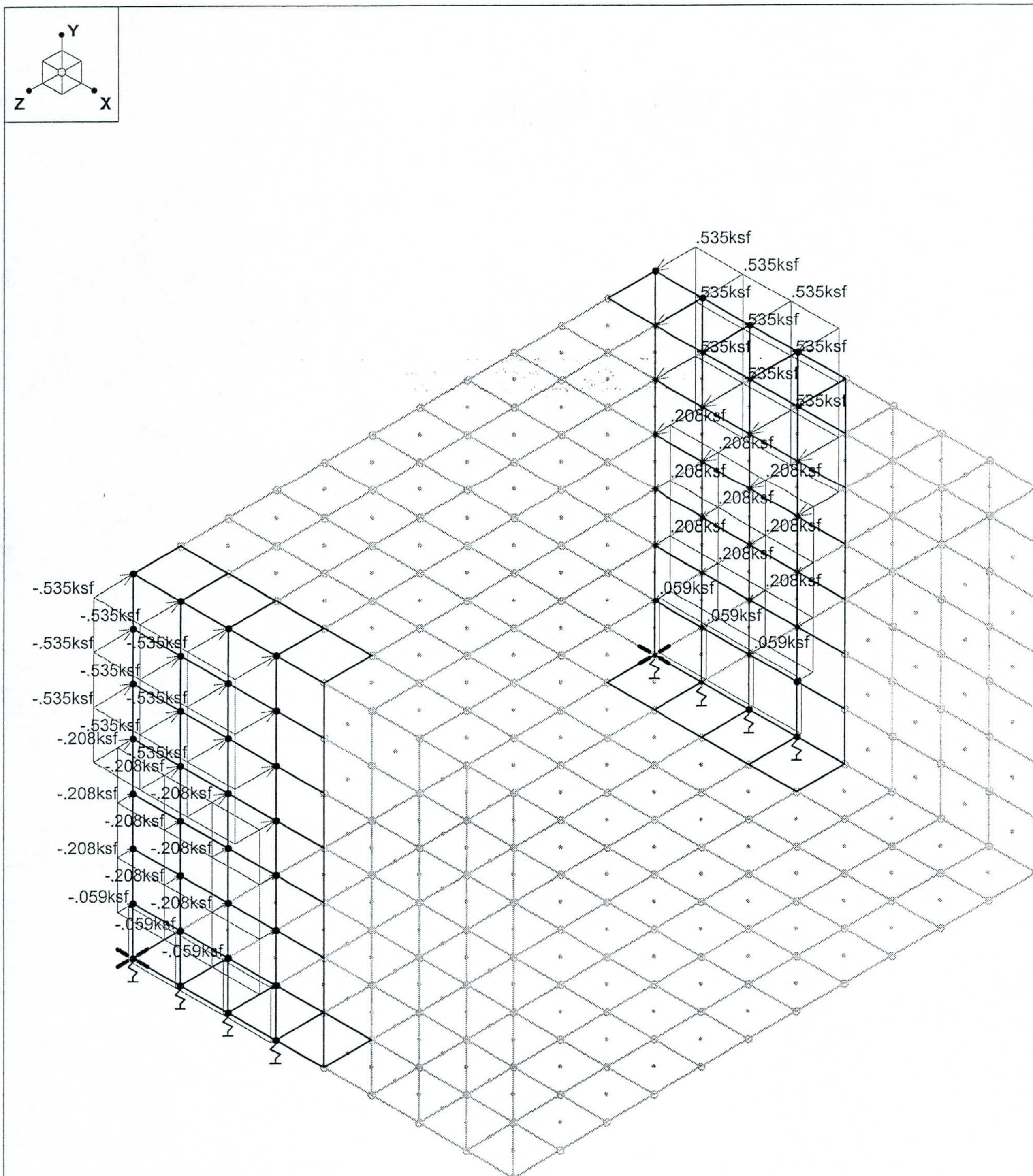
		C9601-2005-Assignment 1.r3d



Loads: BLC 4, Wheel - Lateral

	C9601- 2005-Assignment 1, CDRW #1	
		July 24, 2005 at 12:09 PM
		C9601-2005-Assignment 1.r3d

(12)

Load Combinations

	Description	Solve	PDe...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Dead Load	Yes			Y	-1														
2	DL+SOIL	Yes			Y	-1	1	1												
3	DL+Soil+Ver...	Yes			Y	-1	1	1	2	1	3	1								
4	DL+Soil+All ...	Yes			Y	-1	1	1	2	1	3	1	4	1						

Plate Corner Forces

LOAD COMB. 3

	LC	Plate Label	Joint	X[k]	Y[k]	Z[k]	MX[k-ft]	MY[k-ft]	MZ[k-ft]
1	3	P6	N22	.033	1.128	-.825	11.102	0	-.568
2			N21	.009	2.802	-.913	10.333	0	-.403
3			N17	-.034	-1.942	.871	-9.351	0	1.053
4			N18	-.008	-1.988	.868	-8.154	0	.778
5	3	P12	N46	-.771	-6.644	-1.669	-10.673	0	.913
6			N45	-1.248	-13.472	2.225	-8.696	0	-.003
7			N41	.65	10.791	-.206	.615	0	-2.512
8			N42	1.369	9.324	-.351	-1.361	0	-1.078
9	3	P19	N45	3.189	16.974	-3.356	8.696	0	.003
10			N40A	-.879	-13.617	-.488	-7.381	1.145	0
11			N42B	-2.478	-13.31	.416	-8.307	1.843	0
12			N46	.168	9.953	3.428	7.063	.856	.003
13	3	P22	N45A	.109	11.634	-.812	5.816	-.274	0
14			N47	.056	-11.577	.636	-6.263	.03	0
15			N48A	-.113	-10.786	.639	-6.347	.339	0
16			N46B	-.052	10.729	-.463	5.519	.081	0
17	3	P25	N51	-.623	12.553	-1.465	9.654	1.035	0
18			N53	2.018	-14.805	-2.738	-11.775	0	.003
19			N54	.234	-9.806	4.507	-10.136	1.133	.003
20			N52	-1.629	12.058	-.304	10.488	2.034	0
21	3	P31	N66	.016	-1.042	-1.075	-11.35	0	.496
22			N65	.007	-.484	-1.166	-11.726	0	-.423
23			N63	-.014	.945	1.144	10.84	0	-.286
24			N64	-.008	.581	1.097	10.71	0	.674
25	3	P36	N54	-.627	7.316	-2.408	14.001	0	-.983
26			N53	-2.018	14.635	2.69	11.775	0	-.003
27			N73	.767	-11.335	-.044	-3.105	0	2.878
28			N74	1.878	-10.617	-.238	-.72	0	1.409

(13)

Load Combinations

	Description	Solve	PDe...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Dead Load	Yes			Y	-1														
2	DL+SOIL	Yes			Y	-1	1	1												
3	DL+Soil+Ver..	Yes			Y	-1	1	1	2	1	3	1								
4	DL+Soil+All ...	Yes			Y	-1	1	1	2	1	3	1	4	1						

Plate Corner Forces

LOAD COMB. 4

	LC	Plate Label	Joint	X[k]	Y[k]	Z[k]	MX[k-ft]	MY[k-ft]	MZ[k-ft]
1	4	P6	N22	.04	1.131	-.955	11.002	0	-.562
2			N21	.01	2.804	-1.06	10.235	0	-.402
3			N17	-.041	-1.941	1.009	-9.247	0	1.048
4			N18	-.01	-1.994	1.006	-8.056	0	.778
5	4	P12	N46	-.907	-6.765	-1.928	-10.874	0	.933
6			N45	-1.383	-13.378	2.569	-8.977	0	-.003
7			N41	.752	10.82	-.279	.825	0	-2.471
8			N42	1.538	9.323	-.362	-1.116	0	-1.017
9	4	P19	N45	3.18	16.875	-2.631	8.977	0	.003
10			N40A	-.857	-13.561	-.924	-7.298	1.022	0
11			N42B	-2.457	-13.288	-.042	-8.139	1.719	0
12			N46	.134	9.974	3.597	7.425	.814	.003
13	4	P22	N45A	.102	11.635	-.662	5.385	-.228	0
14			N47	.059	-11.588	.518	-5.737	.032	0
15			N48A	-.106	-10.785	.513	-5.811	.28	0
16			N46B	-.055	10.737	-.37	5.132	.059	0
17	4	P25	N51	-.595	12.531	-2.104	9.394	.925	0
18			N53	1.91	-14.669	-1.903	-12.076	0	.003
19			N54	.228	-9.869	4.964	-10.524	1.133	.003
20			N52	-1.542	12.006	-.956	10.146	1.95	0
21	4	P31	N66	.014	-1.041	-1.784	-11.23	0	.493
22			N65	.008	-.486	-1.939	-11.605	0	-.421
23			N63	-.012	.944	1.916	10.719	0	-.284
24			N64	-.01	.582	1.807	10.591	0	.67
25	4	P36	N54	-.628	7.457	-3.119	14.227	0	-1.014
26			N53	-1.91	14.499	1.721	12.076	0	-.003
27			N73	.741	-11.354	.817	-3.345	0	2.828
28			N74	1.797	-10.602	.581	-1.002	0	1.333

(14)

Load Combinations

	Description	Solve	PDe...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Dead Load	Yes			Y	-1														
2	DL+SOIL	Yes			Y	-1	1	1												
3	DL+Soil+Vert W	Yes			Y	-1	1	1	2	1	3	1								
4	DL+Soil+All Wh...	Yes			Y	-1	1	1	2	1	3	1	4	1						
5	DL+Lateral Soil	Yes			Y	-1	2	1												

Plate Corner Forces

LOAD COMB. 5

	LC	Plate Label	Joint	X[k]	Y[k]	Z[k]	MX[k-ft]	MY[k-ft]	MZ[k-ft]
1	5	P6	N22	.054	.168	-.616	.8	0	.008
2			N21	.019	.325	-.685	.761	0	-.029
3			N17	-.052	-.22	.612	-.561	0	.058
4			N18	-.021	-.273	.689	-.507	0	.068
5	5	P12	N46	-.388	-.866	-.937	-1.301	0	.128
6			N45	-.593	-.94	1.135	-1.274	0	0
7			N41	.345	1.016	-.154	.42	0	-.113
8			N42	.635	.79	-.043	.348	0	.061
9	5	P19	N45	.223	1.327	1.135	1.274	0	0
10			N40A	-.07	-1.058	-.997	-.302	-.086	0
11			N42B	-.198	-1.179	-.955	-.279	-.029	0
12			N46	.045	.91	.817	1.259	-.022	0
13	5	P22	N45A	.012	.7	-.003	-.488	.026	0
14			N47	-.007	-.676	.05	.435	.003	0
15			N48A	-.017	-.707	.019	.449	-.051	0
16			N46B	.012	.683	-.066	-.465	-.025	0
17	5	P25	N51	.023	.405	-.608	.352	-.027	0
18			N53	-.018	-.343	.488	-.91	0	0
19			N54	-.044	-.492	.65	-.924	.076	0
20			N52	.038	.43	-.53	.345	.07	0
21	5	P31	N66	0	.028	-.634	-.319	0	.011
22			N65	-.002	.054	-.631	-.327	0	-.011
23			N63	0	-.035	.633	.362	0	0
24			N64	.002	-.047	.632	.365	0	.018
25	5	P36	N54	-.051	.468	-.645	.923	0	-.082
26			N53	.018	.271	-.536	.91	0	0
27			N73	.022	-.41	.57	-.551	0	.017
28			N74	.011	-.329	.611	-.543	0	-.073

DESIGN SUMMARY

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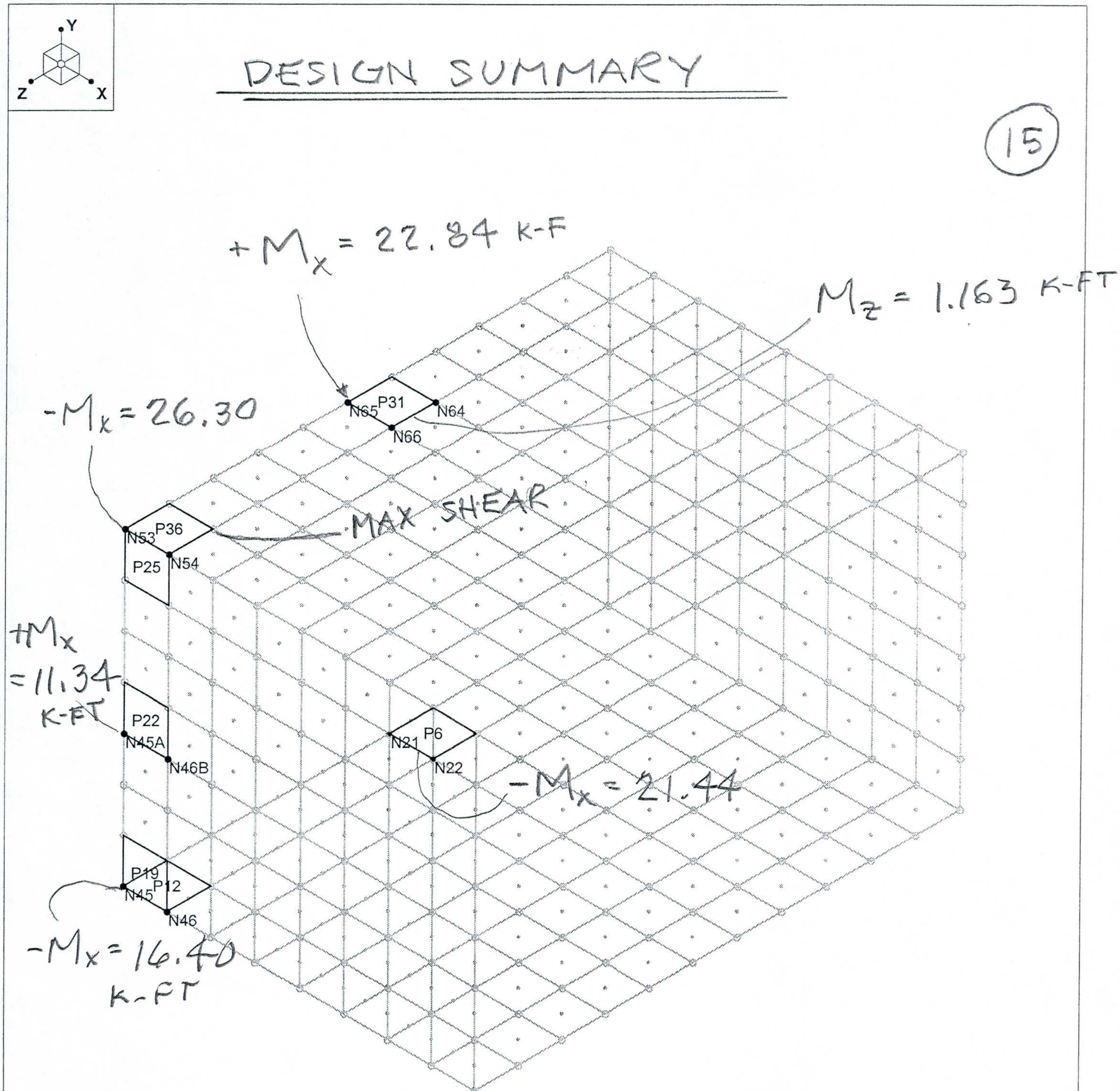

Results for LC 3, DL+Soil+Vert W

	C9601- 2005-Assignment 1, CDRW #1	
		July 24, 2005 at 12:18 PM
		C9601-2005-Assignment 1.r3d

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REINFORCED CONCRETE BEAM ANALYSIS

Working Stress Design Method

Project: Reams Road Channel and Basin Project

Beam analysed this sheet: **Culvert Top - Positive Moment (Plate 31)**

Allowable Stresses: AASHTO 8.15.2
fc = .40f'c
fs (Gr. 40) = 20.0 ksi
fs (Gr. 60) = 24.0 ksi

Design concrete strength (ksi): 5.000
E conc. (ksi): 4030.509 Modular Ratio: 7.000
E steel (ksi): 29,000.00

Design Moment (Kip-Feet): 22.840

Design Moment (kip-inches): 274.08

Beam Width (inches): 12.000
Depth to rein. (inches): 10.000
Area of rein. (sq.in.): 1.320 **#6 @ 4"**

p =	0.011	np =	0.077	
k =	0.323	j =	0.892	
Balanced Steel Ratio =			0.015	
Balanced Steel Area =			1.842	Sq. in *
75% Balanced Steel =			1.382	Sq. in

Reinforcing Design MEETS CODE REQUIREMENTS
Maximum Flexural Capacity for single reinforced beam of these dimensions:
296 Kip-Inches

Stress Analysis of Single Reinforced Beam:

		Max. Allowed
Concrete Stress (ksi) =	1.585	2.000
Steel Stress (ksi) =	23.268	24.000

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REINFORCED CONCRETE BEAM ANALYSIS

Working Stress Design Method

Project: Reams Road Channel and Basin Project

Beam analysed this sheet: **Culvert Top - Negative Moment (Plate 36)**

Allowable Stresses: AASHTO 8.15.2
fc = .40f'c
fs (Gr. 40) = 20.0 ksi
fs (Gr. 60) = 24.0 ksi

Design concrete strength (ksi):		5.000		
E conc. (ksi):	4030.509		Modular Ratio:	7.000
E steel (ksi): 29,000.00				

Design Moment (Kip-Feet): 26.300

Design Moment (kip-inches): 315.60

Beam Width (inches):	12.000	
Depth to rein. (inches):	12.000	
Area of rein. (sq.in.):	1.320	**#6 @ 4"**

p =	0.009	np =	0.064	
k =	0.300	j =	0.900	
Balanced Steel Ratio =			0.015	
Balanced Steel Area =			2.211	Sq. in *
75% Balanced Steel =			1.658	Sq. in

Reinforcing Design MEETS CODE REQUIREMENTS
Maximum Flexural Capacity for single reinforced beam of these dimensions:
430 Kip-Inches

Stress Analysis of Single Reinforced Beam:

		Max. Allowed
Concrete Stress (ksi) =	1.354	2.000
Steel Stress (ksi) =	22.136	24.000

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REINFORCED CONCRETE BEAM ANALYSIS

Working Stress Design Method

Project: Reams Road Channel and Basin Project

Beam analysed this sheet: **Culvert Side - Negative Moment (Plate 22)**

Allowable Stresses: AASHTO 8.15.2
fc = .40f'c
fs (Gr. 40) = 20.0 ksi
fs (Gr. 60) = 24.0 ksi

Design concrete strength (ksi): 5.000
E conc. (ksi): 4030.509 Modular Ratio: 7.000
E steel (ksi): 29,000.00

Design Moment (Kip-Feet): 11.340

Design Moment (kip-inches): 136.08

Beam Width (inches):	12.000	
Depth to rein. (inches):	10.000	
Area of rein. (sq.in.):	0.930	**#5@ 4"**

p =	0.008	np =	0.054	
k =	0.280	j =	0.907	
Balanced Steel Ratio =			0.015	
Balanced Steel Area =			1.842	Sq. in *
75% Balanced Steel =			1.382	Sq. in

Reinforcing Design MEETS CODE REQUIREMENTS
Maximum Flexural Capacity for single reinforced beam of these dimensions:
301 Kip-Inches

Stress Analysis of Single Reinforced Beam:

		Max. Allowed
Concrete Stress (ksi) =	0.895	2.000
Steel Stress (ksi) =	16.136	24.000

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REINFORCED CONCRETE BEAM ANALYSIS

Working Stress Design Method

Project: Reams Road Channel and Basin Project

Beam analysed this sheet: **Culvert Bottom - Negative Moment (Plate 6)**

Allowable Stresses: AASHTO 8.15.2
fc = .40f'c
fs (Gr. 40) = 20.0 ksi
fs (Gr. 60) = 24.0 ksi

Design concrete strength (ksi): 5.000
E conc. (ksi): 4030.509 Modular Ratio: 7.000
E steel (ksi): 29,000.00

Design Moment (Kip-Feet): 21.440

Design Moment (kip-inches): 257.28

Beam Width (inches): 12.000
Depth to rein. (inches): 10.000
Area of rein. (sq.in.): 1.320 **#6@ 4"**

p =	0.011	np =	0.077	
k =	0.323	j =	0.892	
Balanced Steel Ratio =			0.015	
Balanced Steel Area =			1.842	Sq. in *
75% Balanced Steel =			1.382	Sq. in

Reinforcing Design MEETS CODE REQUIREMENTS
Maximum Flexural Capacity for single reinforced beam of these dimensions:
296 Kip-Inches

Stress Analysis of Single Reinforced Beam:

		Max. Allowed
Concrete Stress (ksi) =	1.488	2.000
Steel Stress (ksi) =	21.842	24.000

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REINFORCED CONCRETE BEAM ANALYSIS

Working Stress Design Method

Project: Reams Road Channel and Basin Project

Beam analysed this sheet: **Distribution Steel (Plate 31)**

Allowable Stresses: AASHTO 8.15.2
fc = .40f'c
fs (Gr. 40) = 20.0 ksi
fs (Gr. 60) = 24.0 ksi

Design concrete strength (ksi): 5.000
E conc. (ksi): 4030.509 Modular Ratio: 7.000
E steel (ksi): 29,000.00

Design Moment (Kip-Feet): 1.163

Design Moment (kip-inches): 13.96

Beam Width (inches): 12.000
Depth to rein. (inches): 10.000
Area of rein. (sq.in.): 0.300 **#4 @ 8"**

p =	0.003	np =	0.018	
k =	0.170	j =	0.943	
Balanced Steel Ratio =			0.015	
Balanced Steel Area =			1.842	Sq. in *
75% Balanced Steel =			1.382	Sq. in

Reinforcing Design MEETS CODE REQUIREMENTS
Maximum Flexural Capacity for single reinforced beam of these dimensions:
313 Kip-Inches

Stress Analysis of Single Reinforced Beam:

		Max. Allowed
Concrete Stress (ksi) =	0.145	2.000
Steel Stress (ksi) =	4.932	24.000

DETAIL SUMMARY

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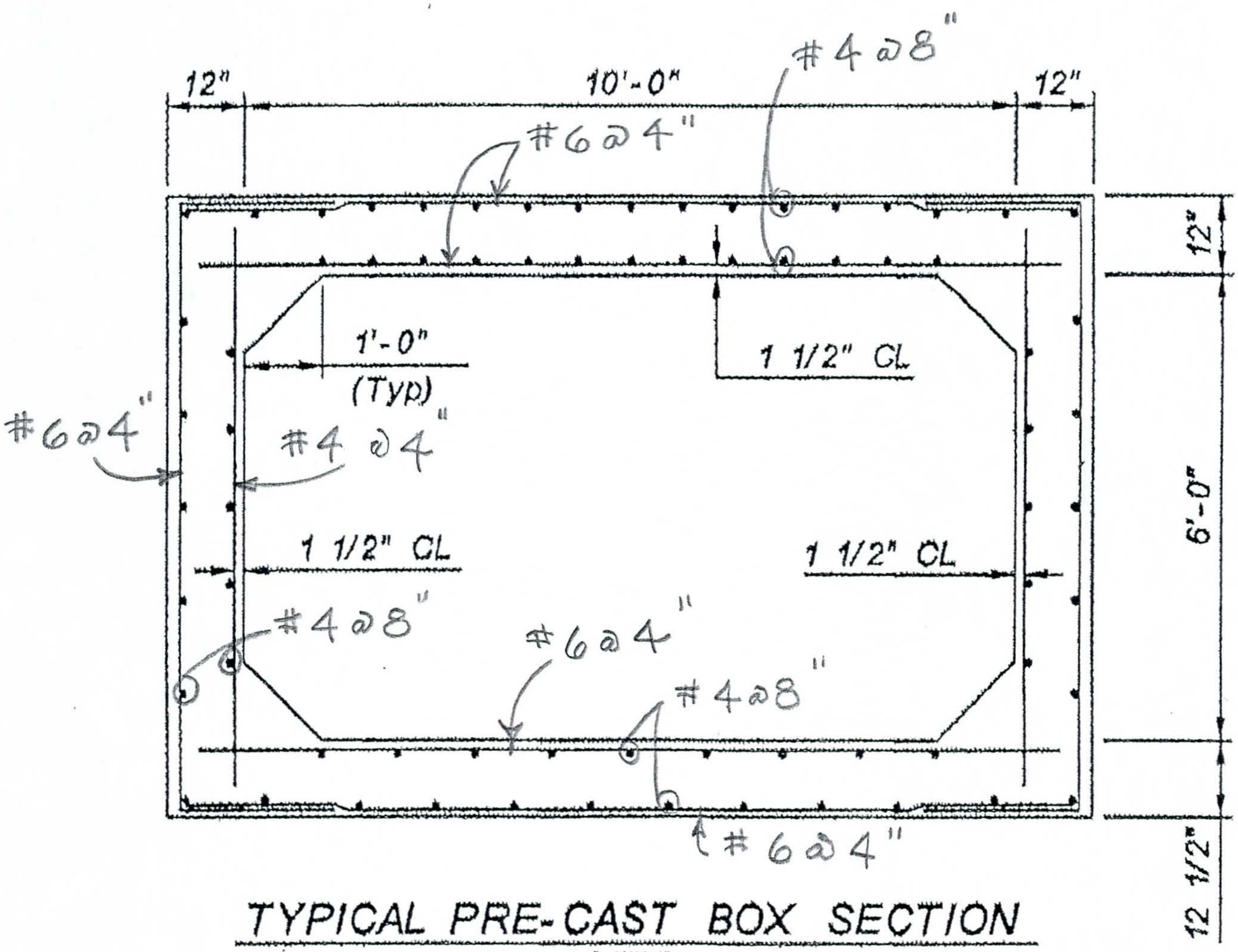

TYPICAL PRE-CAST BOX SECTION
NTS

GENERAL NOTES
PRE-CAST BOXES

Concrete - f'c = 5,000 psi
Grade 60 Reinf - f's = 24,000 psi

All reinforcing shall have 2" clear cover

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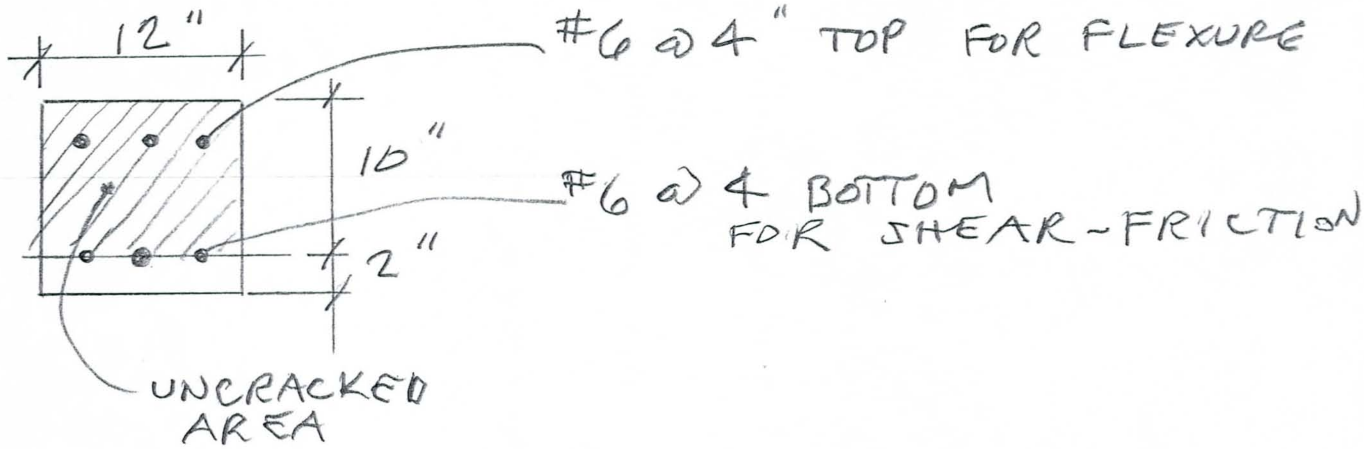
MAX SHEAR OCCURS AT THE CORNERS OF PLATE 36 IN LOAD COMBINATION 3

$$V = \begin{array}{r} 7.316^{K} \\ +14.635 \\ \hline 21.951^{K} \end{array}$$

APPLY TO A 12" THICK SECTION



$$A_{vf} = \frac{V}{f_s \mu} = \frac{21.951}{(24.0)\,1.4}$$

(24.0 KSI; 1.4 ← MONOLITHIC)

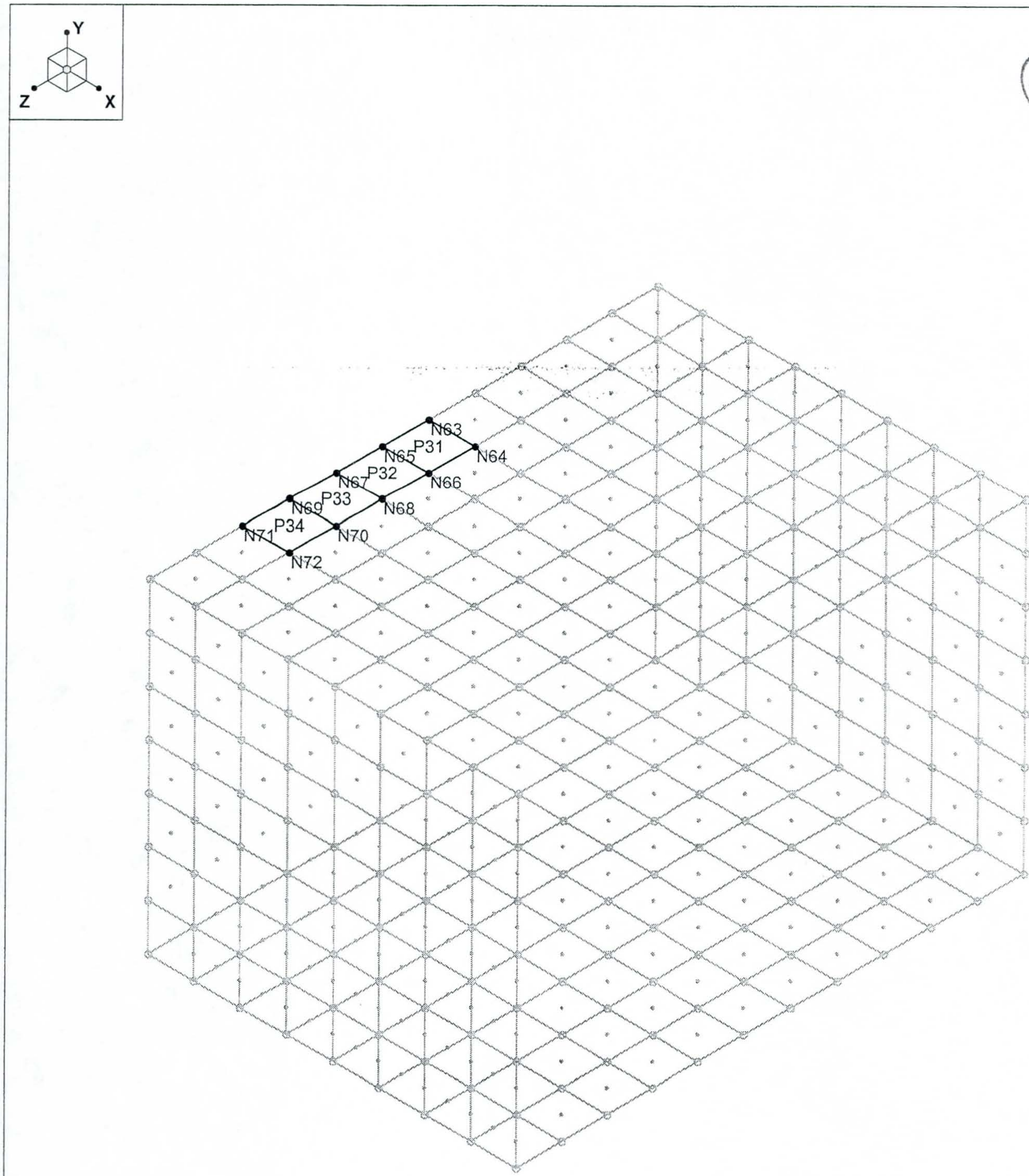
$$= 0.653 \text{ IN}^2$$

$$A_s \; 3\text{-}\#6 = 3 \times 0.44 = 1.32 \text{ IN}^2$$

$$v \le 0.09 f'_c \text{ OR } 360 \text{ PSI}$$

$$v = \frac{21951}{12 \times 10} = 183 < 360$$

O.K. PER AASHTO 8.15.5.4



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PLATES IN MAX. DEFL. AREA

Results for LC 3, DL+Soil+Vert W

	C9601- 2005-Assignment 1, CDRW #1	
		July 24, 2005 at 2:10 PM
		C9601-2005-Assignment 1.r3d

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Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
1	3	N48	-.002	-.004	.003	9.306e-4	-7.559e-5	8.321e-5
2	3	N53	-.002	-.004	.002	-8.513e-4	7.85e-5	6.897e-5
3	3	N55	-.002	-.019	.003	1.269e-3	0	1.838e-4
4	3	N57	-.002	-.036	.003	1.242e-3	0	3.521e-4
5	3	N59	-.002	-.051	.003	9.853e-4	0	4.888e-4
6	3	N61	-.002	-.061	.003	6.144e-4	0	5.81e-4
7	3	N63	-.002	-.066	.002	2.112e-4	0	6.271e-4
8	3	N65	-.002	-.066	.002	-2.162e-4	0	6.285e-4
9	3	N67	-.002	-.061	.002	-6.613e-4	0	5.796e-4
10	3	N69	-.002	-.05	.002	-1.049e-3	0	4.768e-4
11	3	N71	-.002	-.034	.002	-1.263e-3	0	3.306e-4
12	3	N73	-.002	-.018	.002	-1.22e-3	0	1.637e-4

L/1818