CARTRIDGE # 76-358

BECHTEL

CALCULATION COVER SHEET

Job No. ~~6600-1~~ 11406-130

DISCIPLINE Civil / Struct.

Q

Calc. No. 11406-130
No. of Sheets 31

TITLE

A. P. & L. ~~AUXILIARY BLDG~~ MISCELLANOUS

SUBJECT

Spent Fuel Shipping Cask drop.

STATEMENT OF PROBLEM

In Case of Shipping Cask drop [illegible] [illegible] The floor [illegible] [illegible] that [illegible] as sufficient [illegible] capacity to [illegible]

SAR CHECKED ☒ SAR CHANGE REQ'D ☐ SAR CHANGE NOTICE INITIATED ☐

SOURCES OF DATA

MAX. [illegible] Point 7', Cask Diameter 6'-0
Concrete strength Test # 464, [illegible], [illegible], 632.
[illegible] Certificates [illegible] Armco [illegible]
(FOR SH. 13-21) CASK DIAMETER = 4'-2"

SOURCES OF FORMULAE & REFERENCES

ACI 318-71, Structures to resist the effects of accidental explosion TM5-1300 Dept of the Army, June 1969
BC-TOP 9A REV 2, CATALOGUE "TSB 122" FROM HEXCEL
"DESIGN OF CONCRETE STRU." BY WINTER, URQUHART, O'ROURKE, AND NILSON, 7 TH ED. ACI-318-63

PRELIMINARY CALC ☐ FINAL CALC ☒ SUPERSEDES CALC NO. ______

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
2	SH. 27-31	F. CHEN	9/78	T. Yeh	10/78	[signature]	10/11/78
1	SH. 13-26	F. CHEN	3/78	B.C. McConnel	3.28.78	[signature]	10/11/78
[illegible]	Final Calc 1-12	[illegible]	[illegible]		4-76	[signature]	4/26/76

SFPD ED-1 REV 2 (8-73)

CALCULATION SHEET

DATE 4/21/76

DESIGN BY L. T. [illegible] DATE [illegible] 76 CHECKED BY KK [illegible] SHEET NO. 1

PROJECT A P [illegible] 4 - Aux Bldg unit 1 JOB NO. 11406-13

SUBJECT Cask Drop CALCULATION NO. 11406-130 FILE NO. 11406-130

0057

The calculation of unit 1 Cask drop is following the same procedure of unit #2

Data : Between (C) and (D)
Bottom rebar (#11 @ 6" & 11 @ 12") see DWG C-212
Top rebar (#10 @ 12") see DWG C 212
Stirrup 7-#5 per set @ 12" see DWG C-212
Based on actual mill certificates (see File 2-2300)
$F_y = 42.? ^{ksi}$ (SHT 12B) Aux. Bldg.

Conc. compression strength is assumed $f_c' = 6500^{psi}$ which is based on actual 6" x 12" cylinder strengths at 28 and 90 days extrapolated to four years. Because this part of concrete was approximately placed in Jan 197? (SHT 12A)

From Table 5-3 "Structures to resist the effects of accidental explosions" TM5-1300 Dept. of the Army Washington D.C Dated June 1969
Dynamic Increase Factor D.I.F = 1.10

Slab $D = 3'-6$ effective $d = 38"$ $d' = 3"$
Cask WT. $W_0 = 225^K$
$E_c = 57000\sqrt{f_c'} = 57000\sqrt{6500} = 4600000^{psi}$

Poisson's Ratio $\nu = 0.2$

Shear modulus $G = \frac{E}{2(1+\nu)} = \frac{4600^{ksi}}{2(1+0.2)} = 1920^{ksi}$

Adjacent slab $D = 2'-0$ $d = 21"$

Rebar #5 $F_y = 55.2^{ksi}$ From mill certificate File : 2-2300

0510 (11-74)

BECHTEL

CALCULATION SHEET

DATE 4/7/76

DESIGN BY L. T. Chang DATE MAR '76 CHECKED BY K... SHEET NO. 2

PROJECT A + C Aux. Bldg. unit #1 JOB NO. 11406-13

SUBJECT Calc Drop CALCULATION NO. 11406-130 FILE NO. 11406-130

Slab @ El 404'0 Between (C) & (D)

Let $B = 18'\text{-}0 = 216''$ $\quad \frac{V_u d}{M_u} = 1.0$

$\rho = 0.0103 \left(= \frac{3 \times 1.56}{12 \times 38}\right)$

$\omega_{DL} = 0.15 \times 3.5 \times 18 = 9.45\ ^{K}/_{FT}$

$A = 42 \times 216 = 9072\ IN^2$

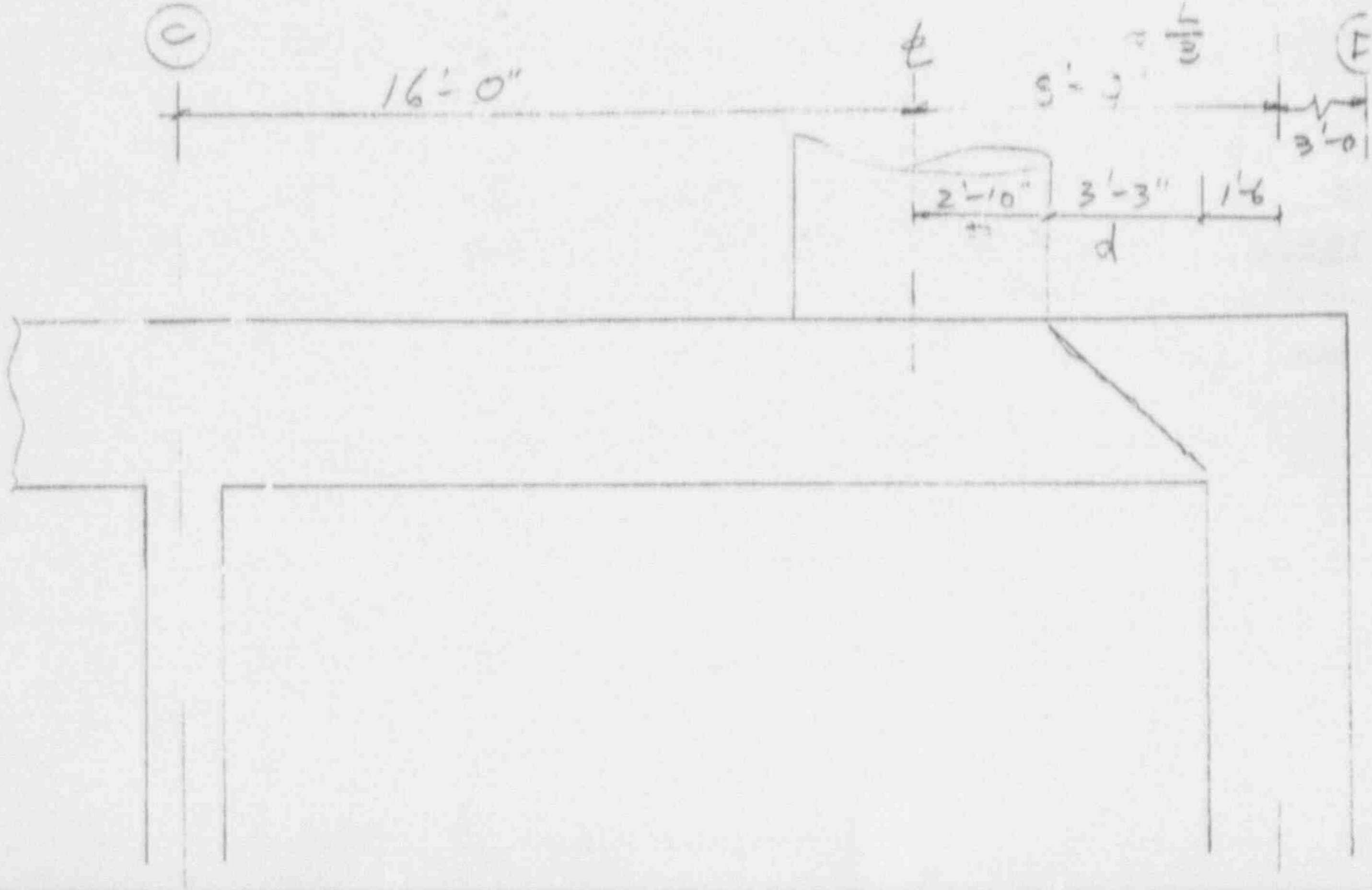
$I_g = \frac{BD}{12} = \frac{216 \times 42^3}{12} = 1333,584\ IN^4$

Allowable shear at d distance from support

$v_c = \left[1.9\sqrt{f_c'} + 2500\,\rho\,\frac{V_u d}{M_u}\right](DIF)$

$v_c = \left[1.9\sqrt{6500} + 2500 \times 0.0103 \times 1\right] 1.1$

$= (153.5 + 25.7)\,1.1 = 179\ P^{si}$



0058

$V_c = v_c B d = 0.179 \times 216 \times 38 = 1469.^{K}$

$A_s f_y = 3(5 \times 0.31 \times 55.2) = 257 \quad \Sigma V_c = 1726$

Available shear resistant force R_s

$$R_s = \frac{(\Sigma V_c - W_{DL} C_1) L}{C_2 / L} = \frac{1726 - 9.45 \times 7.58}{2/3} = 2482^{K}$$

$\therefore \underline{R_s = 2482 \text{ kips}}$

Slab Response

(a) Initial Mode

Modulus of Rupture

$f_r = 7.5\sqrt{f'_c}\ D{=}F = 7.5\sqrt{6500} \times 1.1 = 666 \text{ psi}$

Cracking moment

$$M_{cr} = f_r S = 0.666\left[\frac{216 \times 42^2}{6}\right] = 42{,}294^{K\text{-}"} = 3524^{K\text{-}FT}$$

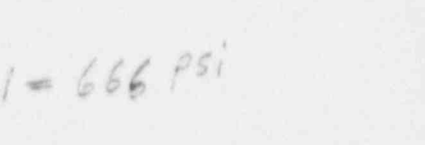
$$M_{DL} = \frac{W_{DL} L^2}{12} = \frac{9.45 \times 24^2}{12} = 453.6^{K\text{-}FT} = 5443.2^{K\text{-}"}$$

Find available R_{cr}

$$R_{cr} = \frac{(M_{cr} - M_{DL}) L^2}{C_1 C_2^2} = \frac{(42{,}294 - 5443)}{\frac{1}{3}\left(\frac{2}{3}\right)^2 \times 24 \times 12} = \underline{863.7^{K}}$$

Displacement at point of load

(Both bending & shear)



$$\delta_{cr} = \frac{R_{cr} C_1^3 C_2^3}{3 E_c I_g L^3} + \frac{R_{cr} C_1 C_2}{G \cdot A \cdot L} + \frac{W_{DL} C_1^2 C_2^2}{24 E_c I_g} + \frac{W_{DL} L^2}{6 G \cdot A}$$

.0059

CALCULATION SHEET

DATE 4/9/76

DESIGN BY L. T Chang DATE MAR '76 CHECKED BY SHEET NO. 4

PROJECT A P & L Aux Bldg unit #1 JOB NO. 11406-130

SUBJECT Cask Drop CALCULATION NO. 11406-130 FILE NO. 11406-130

AT one-third point

$$\delta_{cr} = \frac{864' \times 96^3 \times 0.67^3}{3 \times 4600 \times 1333584} + \frac{864 \times 96 \times 0.67}{1920 \times 9072}$$

$$\frac{9.45 \times 8^2 \times 16^2 \times 1728}{24 \times 4600 \times 1333.584} + \frac{9.45 \times 24^2 \times 12}{6 \times 1920 \times 9072}$$

$$= 0.01248 + 0.00319 + 0.00182 + 0.00062$$

$\underline{\delta_{cr} = 0.01811}$

(b) First Mode

Moment capacity

$A_s' = 1.27 \times 18 = 22.86$ □

$A_s = 3 \times 1.56 \times 18 = 84.24$

$$a = \frac{A_s f_y}{0.85 f_c' B} = \frac{84.24 \times 48.3}{0.85 \times 6.5 \times 216} = 3.4''$$

$$+M_u = A_s' f_y (d - d') + (A_s - A_s') f_y \left(d - \frac{a}{2}\right)$$

$$M_u = 22.86 \times 48.3 (38 - 3) + (84.24 - 22.86) 48.3 \left(38 - \frac{3.4}{2}\right)$$

$$= 38644.8 + 107616.9 = 146,261.7^{K-''}$$

$M_u = 12,188^{K-FT}$

$$M_u' = A_s' f_y (d - d') = 22.86 \times 48.3 (38 - 3)$$

$$M_u' = 38644.8^{K-''} = 3220^{K-FT}$$

$R_1 = 77.$

C_2 C_1

$$R_1 = \frac{(M_u' - M_{DL}) L^2}{C_1 C_2^2} = \frac{3220 - 454}{8 \times \left(\frac{2}{3}\right)^2}$$

$\underline{R_1 = 778^{\,Kips}}$

0060

0510 (11-74)

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CALCULATION SHEET

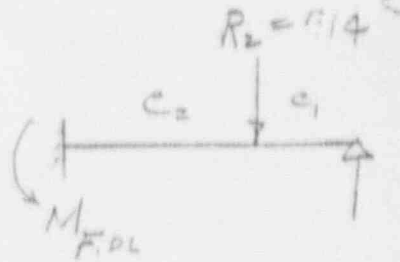
DATE 11/11/...

DESIGN BY L.T. Chang DATE MAR '76 CHECKED BY ... SHEET NO. 5

PROJECT AP&L Aux. Bldg. JOB NO. 11406-130

SUB'JC' Cask Drop CALCULATION NO. 11406-130 FILE NO. 11406-130

(c) Second Mode



$$M_{F.D.L} = \frac{w_{DL} L^2}{8} = \frac{9.45 \times 24}{8}$$

$$M_{FDL} = 680.4^{K\text{-}FT}$$

$$R_2 = \frac{2L^2 (M_u' - M_{FDL})}{C_1 C_2 (C_1 + L)}$$

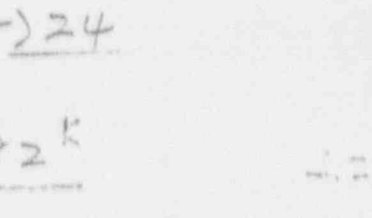
$$R_2 = \frac{2 \times 24^2 (3220 - 680)}{8 \times 16 \times 32} = 714.4^k$$

R_1 & R_2 $< R_{cr}$

Therefore the top rebar will pull out about the same time or shortly after concrete cracks

0061

(d) Third Mode



$$M_p = \frac{w_{DL} C_1 C_2}{2}$$

$$M_p = \frac{9.45 \times 8 \times 16}{2} = 604.8^{K\text{-}FT}$$

$$R_3 = \frac{(M_u - M_p) L}{C_1 C_2} = \frac{(12188 - 605) 24}{8 \times 16}$$

$$\underline{R_3 = 2172^k < R_s = 2482^k}$$

The slab failure will be governed in flexural mode.

BECHTEL

CALCULATION SHEET

0810 (11-74)

DATE 1/9/76

DESIGN BY L.T. Chang DATE MAR '76 CHECKED BY KK SHEET NO. 6

PROJECT A P & L Aux. Bldg unit #1 JOB NO. 11406-130

SUBJECT Cask Drop CALCULATION NO. 11406-130 FILE NO. 11406-130

$$\frac{M_{cr}}{M_a} = \frac{M_{cr}}{M_u} = \frac{3524^{K-1}}{12188^{K-1}} = 0.289$$

$$\left(\frac{M_{cr}}{M_a}\right)^3 = 0.0242$$

$pn = 0.0103 \times 6.5 = 0.067$

From Figure 4-1 BC TOP 9A Rev. 2

$F = 0.043$

$I_{cr} = FBd^3 = 0.043 \times 216 \times 38^3 = 509651^{IN^4}$

0062

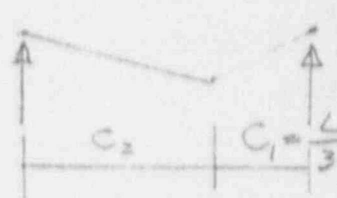
ACI-318-71 Section 9.5 Eq. 9-4

$$I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr}$$

$I_e = 0.0242 \times 1333524 + [1 - 0.0242]\, 509651$

$I_e = 32272.7 + 497317.4 = 529590.1\ IN^4$

$$\delta_y = \frac{R_3 C_1^2 C_2^2}{3 E_c I_e L} + \frac{R_3 C_1 C_2}{G.A.L} + \frac{w_{DL} L^2}{6G.A} + \frac{w_s C_1}{24 E I_e}(L^3 - 2 L C_1^2 + C_1^3)$$



C_2 $C_1 = \frac{L}{3}$

$$\delta_y = \frac{2172 \times 96^2 \times 192^2}{3 \times 4600 \times 529590 \times 288} + \frac{2172 \times 96 \times 192}{1920 \times 288 \times 9072} + \frac{9.45 \times 24^2 \times 12}{6 \times 1920 \times 9072} + \frac{9.45 \times 8}{24 \times 4600 \times 529590}(288^3 - 2 \times 288 \times 96^2 + 96^3)$$

$\delta_y = 0.3506 + 0.00798 + 0.000625 + 0.03775 = \underline{0.397}''$

0510 (11-74)

BECHTEL

CALCULATION SHEET

DATE 5/4/7-

DESIGN BY L. T. Chang DATE MAR '76 CHECKED BY [illegible] SHEET NO. 7

PROJECT A P & L Aux. Bldg unit #1 JOB NO. 11406-130

SUBJECT Cask Drop CALCULATION NO. 11406-130 FILE NO. 11406-130

0063

Energy Balance:

The slab will deform to three plastic hinges

$$\lambda W_0 H + W_0 \mu \delta_y + \frac{D}{2}\mu \delta_y = R_3 \delta_y (\mu - \tfrac{1}{2})$$

where

$$D = 0.15 \times 3.5 \times 18 (24 - 2.25) = 205.5$$

$$\lambda = \frac{W_0}{W_0 + D/2} = \frac{225}{225 + 103} = 0.686$$

$$0.686 \times 225 \times 9 + 225 \times 0.397\mu + 103 \times 0.397\mu$$
$$= 2172 \times 0.397 (\mu - 0.5)$$

$$\mu = \frac{1389 + 431}{862 - 89 - 41} = \underline{2.49} < \mu_c = 10$$

Available bending strain energy

$$B.E = R_3 \delta_y (\mu_{max} - \tfrac{1}{2}) = 2172 \times 0.397 (10 - 0.5)$$
$$= 8192 \text{ K-ft}$$

$$\mu \delta_y = 2.45 \times 0.397 = 0.99'' = \delta_1$$

Cask drop energy transmitted to slab

$$K.E = W_0 [\lambda H + \mu \delta_y] + \frac{D}{2}\mu \delta_y$$

$$K.E = 225 [0.686 \times 9 + 2.49 \times 0.397] + 103 \times 0.99$$
$$= 1944 + 102 = 2046 \text{ K-ft}$$

0510 (11-74)

BECHTEL

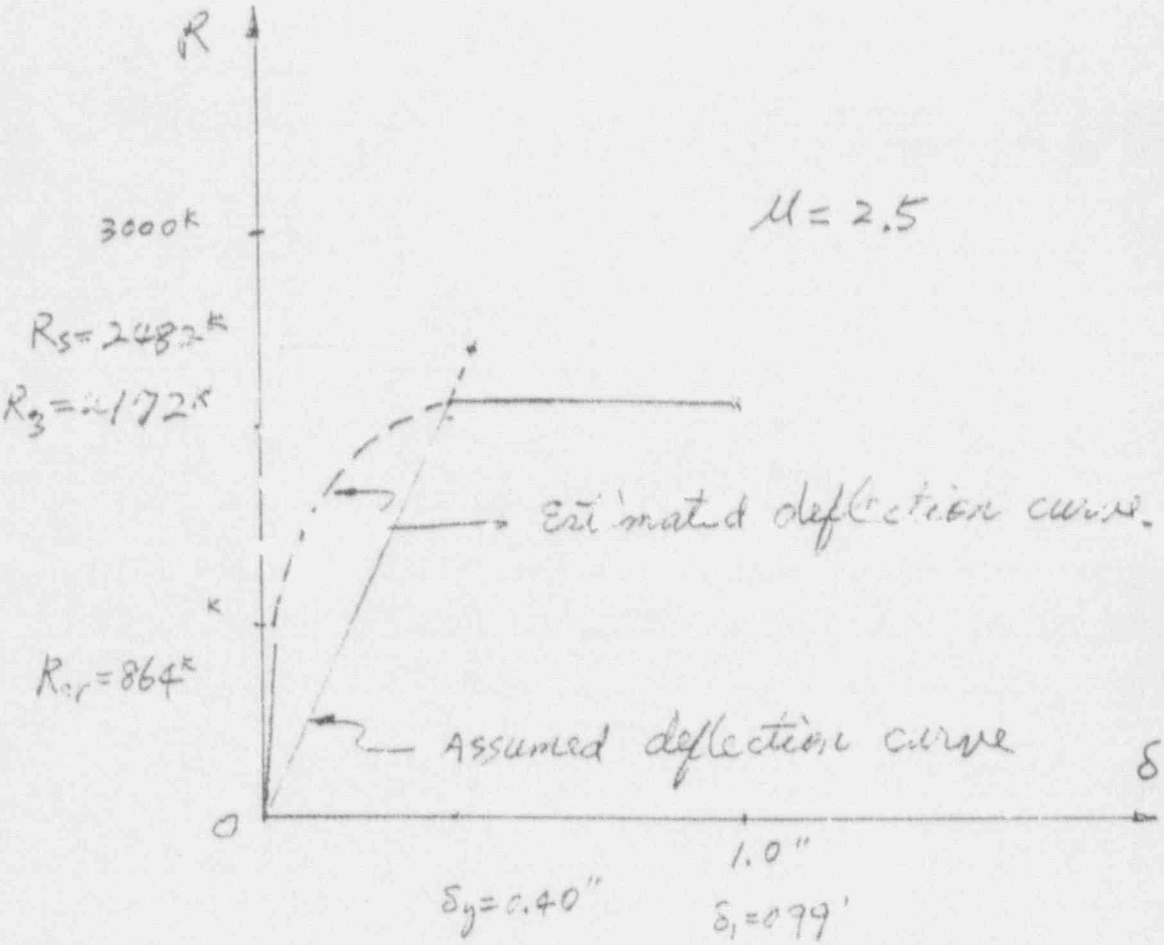
CALCULATION SHEET

DATE 1/10/--

DESIGN BY L. T. Chang DATE MAR 76 CHECKED BY ---- SHEET NO. 8

PROJECT A P & L Aux. Bldg Unit #1 JOB NO. 11406-130

SUBJECT Cask Drop CALCULATION NO. 11406-130 FILE NO. 11406-130



Force - Displacement Diagram

Between (C) and (D)

0064

CALCULATION SHEET

0510 (8-71)

BECHTEL

DATE 4/?/76

DESIGN BY L. T. Chang DATE MAR '76 CHECKED BY [illegible] SHEET NO. 9

PROJECT A P & L Aux. Bldg. Unit #1 JOB NO. 11406-130

SUBJECT Cask Drop FILE NO. 11406-130

This is a back up calculation for top reinf. exceeded $\mu = 10$ at column line C so that becomes hinge due to M_u

C) CONT. Bending deflection

δ_1 (due to dead load)

$$\delta_1 = \frac{w_o c_1}{48EI}(L^3 - 3Lc_1^2 + 2c_1^3)$$

$$= \frac{9.45 \times 7.58}{48\ EI}(288^3 - 3 \times 288 \times 91^2 + 2 \times 91^3)$$

$$\delta_1 = \frac{27.22 \times 10^6}{EI}$$

δ_2 (due to R_2)

$$\delta_2 = \frac{R_2 c_1^2 c_2^3}{12EIL^3}(3L + c_1)$$

$$= \frac{714 \times 91^2 \times 0.684^3 (3 \times 288 + 91)}{12EI} = \frac{150.6 \times 10^6}{EI}$$

$$\delta_b = \frac{177.8 \times 10^6}{EI} = \frac{177.8 \times 10^6}{4600 \times 1.33 \times 10^6} = 0.029''$$

$E_c = 4600$ ksi $\quad I = 333,584$ in^4

Shear deflection

$$\delta_s = \frac{R_2 c_1 c_2}{GAL} + \frac{w_o L^2}{6GA}$$

$$= \frac{714 \times 91 \times 0.684}{1920 \times 9072} + \frac{9.45 \times 24^2 \times 12}{6 \times 1920 \times 9072}$$

$$= 0.00255 + 0.00063 = 0.0032''$$

$$\Sigma\delta = 0.029 + 0.0032 = 0.0322''$$

0065

0810 (8-71)

CALCULATION SHEET

DATE 1/-/--

DESIGN BY L. T Chang DATE MAR 76 CHECKED BY --- SHEET NO. 10

PROJECT A P & L Aux Bldg unit #1 JOB NO 11406-130

SUBJECT Cask Drop FILE NO 11406-130

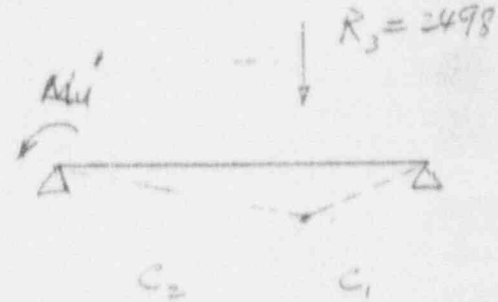
(d) Third Mode

$L = 24'-0 = 288''$

$C_1 = 7'-7'' = 91$ IN

$C_2 = 16'-5 = 197$ IN

$= 0.684 L$



$$M_{DL} = \frac{W_{DL} C_1 C_2}{2}$$

$$M_{DL} = \frac{9.45 \times 7.58 \times 16.42}{2} = 588^{K-FT}$$

$$M_u' = A_s' f_y (d - d')$$

$$= 22.86 \times 48.3 (38 - 3) = 38645^{K-''} = 3220^{K-FT}$$

$$M_p + M_u' \frac{C_1}{L} - M_{DL} = \frac{R_3 C_1 C_2}{L}$$

$$12.188 + 3220 \times \frac{91}{216} - 588 = 12,957^{K-FT}$$

$$R_3 = \frac{12,957 \times 24}{7.58 \times 16.42} = 2498^{K}$$

$$\frac{M_{cr}}{M_u} = \frac{3524^{K-'}}{12188} = 0.289 \qquad \left(\frac{M_{cr}}{M_u}\right)^3 = 0.0242$$

$$pn = 0.0103 \times 6.5 = 0.067$$

From Figure 4-1 BC TOP 9A Rev. 2

$F = 0.043$

$$I_{cr} = F B d^3 = 0.043 \times 216 \times 38^3 = 509.651 \text{ IN}^4$$

$$I_e = \left(\frac{M_{cr}}{M_u}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_u}\right)^3\right] I_{cr} = 0.0242 \times 1333584$$

$$+ [1 - 0.0242]\, 509.651 = 529570 \text{ IN}^4$$

0065

0810 (8-71)

CALCULATION SHEET

DATE ______

DESIGN BY L. T. Chang DATE MAR 76 CHECKED BY ______ SHEET NO. 11

PROJECT A P & L Aux. Bldg unit #1 JOB NO 11406-130

SUBJECT Cask Drop FILE NO 11406-130

(d) deflection

δ_1 (due to dead load)

$$\delta_1 = \frac{w_3 C_1}{24EI}(L^3 - 2LC_1^2 + C_1^3)$$

$$= \frac{9.45 \times 7.58 (288^3 - 2 \times 288 \times 91^2 + 91^3)}{24\,EI}$$

$$= \frac{59.3 \times 10^6}{EI}$$

δ_2 (due to R_3)

$$\delta_2 = \frac{R_3 C_1^2 C_2^2}{3EIL} = \frac{2528 \times 91^2 \times 197 \times 0.684}{3EI} = \frac{940 \times 10^6}{EI}$$

δ_3 (due to M_u')

$$\delta_3 = \frac{M_u'}{6EI}\left(3C_2^2 - \frac{C_2^3}{L} - 2LC_2\right)$$ see Roark

$$= \frac{42061^{k\text{-}in}(3 \times 197^2 - 197^2 \times 0.684 - 2 \times 288 \times 197)}{6EI}$$

$$= \frac{169.3 \times 10^6}{EI}$$

Bending deflection

$$\delta_b = (59.3 + 940 + 169.3)\frac{10^6}{EI_e}$$

$$\delta_b = \frac{1168.6 \times 10^6}{4600 \times 529590} = 0.497''$$

0810 (5-71)

CALCULATION SHEET

BECHTEL

DATE 11/2/76

DESIGN BY L.T. Kang DATE MAR 76 CHECKED BY KES SHEET NO. 12

PROJECT A P & L Aux. Bldg unit #1 JOB NO. 11406-130

SUBJECT Cask Drop FILE NO. 11406-130

Shear deflection

$$\delta_s = \frac{R_3 C_1 C_2}{G A L} + \frac{w_0 L^2}{6 G A}$$

$$= \frac{2498 \times 91 \times 0.684}{1920 \times 9072} + \frac{9.45 \times 24^2 \times 12}{6 \times 1920 \times 9072}$$

$$= 0.00892 + 0.0032 = 0.01212''$$

$$\delta_y = \delta_b + \delta_s = 0.497 + 0.012 = 0.509''$$

$$u = \frac{\delta y}{\Sigma \delta} = \frac{0.509''}{0.0322} = 15.8 \quad > u_{max} = 10$$

0068

4 to 5 A to D

[redacted]

SH. 12 A

Concrete strength Test JOB 1140-[illegible]

FILE NO. 11406-1

Unit # 1

			28 DAY	90 DAY	[illegible]
A to C / 4 to 5			4210	5340	1.[illegible]
pour # 375	B-2	# 469	4240	4530 *	
Elev. 404					
C to D / 1 to 5	B-1	630	4850	6230	1.285
pour # 517			4950	6510	1.315
Elev. 404					
		631	4240	6370	1.50
282 yL.			4420	6260	1.42
		632	4370	6010	1.375
			3400 *	5810	

0070

These concrete strength and its age data, and rebar mill test reports are obtained from our field in 1975. The purpose is to check floor slab EL 404'-0 above control room whether failure mode in bending or shear under the extreme catastrophic accident i.e. the shipping cask 225 Kips drops from 9" above the floor. Calculation file number is $\frac{5.4}{2.12}$

Leon T. [illegible]

4/6/76

FPL Q-1387

REPORT OF CHEMICAL ANALYSIS AND PHYSICAL

Customer: [illegible] Corporation

Shipped to: Same

Car No.: [illegible]

Shop Order No.: SP 229

Customer Order No.: [illegible]

Shipping Date: 7-7-70

HEAT NO.	DESCRIPTION	YIELD LBS. PER SQ. IN.	TENSILE LBS. PER SQ. IN.	ELONGATION % 8"	REDUCTION OF AREA %	BEND TEST	CAR.	MANG.	PHOS.	SUL.	CU.	SI.	MO.	CR.
14315	#3	46000	65000	18.4		OK	.13	1.07	.011	.018				
53326	#4	56987	84733	20.2		OK	.29	.68	.019	.034				
53412	#5	55237	83167	20.8		OK	.29	.60	.021	.032				
50737	#6	52053	81092	21.1		OK	.30	.68	.024	.033				
53035	#7	51563	80172	20.0		OK	.30	.63	.029	.027				
50510	#8	51555	77077	23.7		OK	.31	.74	.024	.034				
50720	#9	50000	77700	24.8		OK	.29	.68	.018	.021				
53673	#10	48262	76321	19.3		OK	.29	.70	.016	.030				
52835	#11	48287	76337	22.0		OK	.30	.63	.016	.022				

GRADE 40. ASTM A615 AND A305. NEW BILLET STEEL; BASIC ELECTRIC FURNACE PROCESS.

MILL TEST REPORT FOR UNIT #1
AUX. BLDG. [illegible] @ 40'
(A - [illegible] STORAGE [illegible] /4-5)
RHL

RECEIVED
DEC 03 A.M.
POWER DIV.
S. F.

JOB 11406-130
FILE NO. 11406-130

Subscribed and sworn to before me
this 8 day of July 1970
[signature]
Notary Public Tulsa County, Okla.
My Commission Expires [illegible] - 7-71.

THIS CERTIFIED TEST REPORT HAS BEEN DELIVERED TO A CONSIGNEE OF MATERIAL PURCHASED FROM ARMCO STEEL CORPORATION TO AVOID THE POSSIBILITY OF ITS MISUSE. ON THE REDELIVERY OF THIS REPORT TO A THIRD PARTY IT MUST BE RECERTIFIED BY

The Chemical, Physical, or Mechanical Tests reported above correct as contained in the records of the corporation.

[signature]

F1-70

CALCULATION SHEET

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 3-10-78 CHECKED BCM DATE 3-22-78

PROJECT AP&L AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJEC. CASK DROP EVALUATION SHEET NO. 13

P.S. THE EVALUATION WAS TRANSMITTED TO AP&L BY LETTER BL-G-369 DATED 3/11/78.

PROBLEM : A SHIPPING CASK OF TEST CONTROL RODS WILL TRAVEL FROM THE RAILROAD HATCH TO THE WASH DOWN AREA AND BACK OVER THE CONTROL ROOM. BEFORE NRC APPROVES THE OPERATION, A DROP EVALUATION ALONG THE MOVEMENT ROUTE MUST BE COMPLETED.

0066

GIVEN : WEIGHT OF CASK = 25 TONS.

DIAMETER OF CASK = 4'-2"

MAX. HEIGHT OF VERTICAL DROP = 9"

FROM CAL. 2.12 SH 2, WE KNOW SHEAR CAPACITY GOVERNS. IF THE CASK DROPS AT ABOUT 7'-0" FROM CENTER OF COL. C OR D BETWEEN COL. LINE C AND D, IT WILL GIVE MAX. SHEAR STRESS AT A DISTANCE OF ONE EFFECTIVE DEPTH OF THE SLAB FROM THE FACE OF THE WALL.

REQUIRED : 1. TO ANALYZE IF 9" MAX. DROP WILL CAUSE ANY FAILURE OF SLAB OR NOT? IF IT WILL, THEN.

2. WHAT IS THE MAX. DROP ALLOWED? OR

3. WHAT ARE OTHER OPTIONS?

SOURCES OF FORMULAE : BC-TOP-9, REV. 1, ACI-318-63 CATALOGUE "TSB 122" FROM HEXCEL.

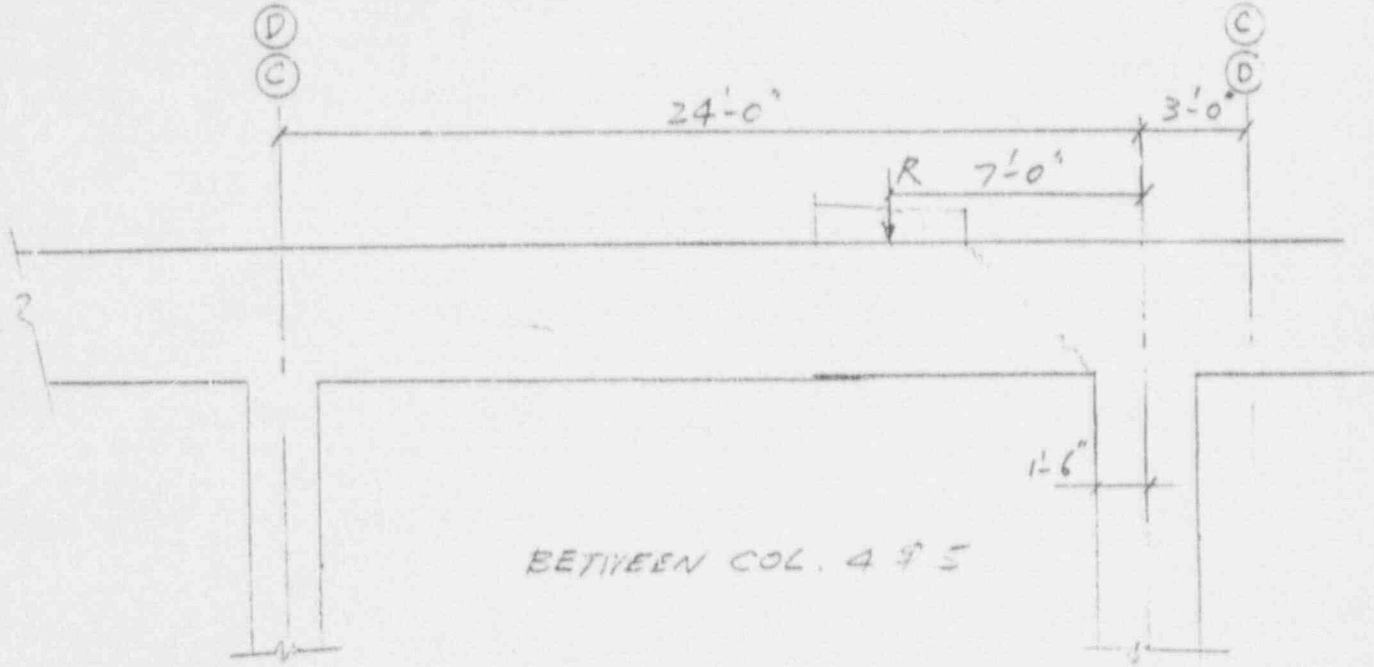
CALCULATION SHEET

CALC. NO. 11406.120 REV. NO. 2

ORIGINATOR F. CHEN DATE 2-21-78 CHECKED BCM DATE 3-22-78

PROJECT AP&L AUXILIARY BLDG - UNIT #1 JOB NO. 11406.120

SUBJECT CASK DROP EVALUATION SHEET NO. 14



DATA: REF. DWG. C-206 REV. 14 & C-212 REV. 9

$f_c' = 4{,}850$ PSI @ 28 DAYS (POUR NO. 517)

$f_c' = 6{,}500$ PSI @ 4 YEARS BY INTERPORATION PER FIG 1.4 P.15 OF "DESIGN OF CONCRETE STRUCTURES" BY WINTER, URQUHART, O'ROURKE, AND NILSON, 7TH EDITION.

$f_y = 40000$ PSI MIN. (48,300 PSI FROM MILL CERTIFICATE (SEE FILE: 2-2300 AUX. BLDG)

SLAB: $t = 3'\text{-}6"$, $d = 38"$

PER AP&L LETTER NDC-6969 DATED 2/15/78
CASK WEIGHT = 50,000#
CASK DIAMETER = 4'-2"

BECHTEL

CALCULATION SHEET

CALC. NO. 11426-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 2-27-78 CHECKED [illegible] DATE 2.28.78

PROJECT AP&L AUXILIARY BLDG - UNIT #1 JOB NO. [illegible]

SUBJECT CASK DROP EVALUATION SHEET NO. 15

1. P - Δ CURVE

USING FORMULA (4-2) OF BC-TOP-9

$$I_a = \frac{1}{2}(I_g + I_c) = \frac{1}{2}\left(\frac{bt^3}{12} + Fbd^3\right)$$

$$p = \frac{A_s}{bd} = \frac{3 \times 1.56}{12 \times 38} = 0.010263$$

$$E_c = w^{1.5}\, 33 \sqrt{f'_c}$$

$$= (145)^{1.5} \times 33 \times \sqrt{4850}$$

$$= 4012699 \text{ PSI}$$

$$n = \frac{E_s}{E_c} = \frac{29000000}{4012699} = 7.23 \quad \text{SAY } 7$$

CHECKERS NOTE:
$f_c' = 6500$ PSI FROM PG 14.
THIS WILL RESULT IN A CONSERVATIVE UNDERESTIMATE IN THE ENERGY ABSORPTION CAPACITY OF THE SYSTEM.
NO CALC REVISION REQUIRED [illegible]
2.28.78

FROM FIG 4-1 OF BC-TOP-9

($p = 0.010263$, $n = 7$) GIVES $F = 0.045$

EFFECTIVE WIDTH OF BEAM

$= T + 2d$

$= 4'\text{-}2'' + 2 \times (3'\text{-}2'')$

$= 10'\text{-}6''$

$= 126''$

$t = 42''$

$$I_a = \frac{1}{2} \times \left[\frac{126 \times (42)^3}{12} + 0.045 \times 126 \times (38)^3\right]$$

$$= \frac{1}{2} \times (777924 + 311125)$$

$$= 544524 \text{ IN}^4$$

CALCULATION SHEET

BECHTEL

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR F CHEN DATE 2-27-78 CHECKED [illegible] DATE 2-28-78

PROJECT AP&L AUXILIARY BLDG-UNIT#1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION SHEET NO. 16

$$M_u = \phi\left[A_s f_y \left(d - \frac{a}{2}\right)\right]$$

$$\phi = 0.90$$

$$a = \frac{A_s f_y}{0.85 f_c' b} = \frac{3 \times 1.56 \times 10.5 \times 48.3}{0.85 \times 4.7 \times 10.5 \times 12} = 4.715''$$

$$M_u = 0.90 \times \left[3 \times 1.56 \times 10.5 \times 48.3 \times \left(38 - \frac{4.715}{2}\right)\right] \times \frac{1}{12}$$

$$= 6344.71^{\,1\text{-}k}$$

$$(P_s)_u = \frac{24}{7 \times 17} \times (6344.71 - \tfrac{1}{2} \times 24 \times 10.5 \times 3.5 \times 0.15 \times 17 + \tfrac{1}{2} \times 10.5 \times 3.5 \times 0.15 \times 17$$

$$= 1279.51^k - 66.15^k = 1213.46^k$$

$$\Delta_u = \frac{P a^2 b^2}{3 E_c I \ell} + \Delta_0$$

$$= \frac{1213.46 \times (7 \times 17)^2 \times (12)^3}{3 \times 3950.159 \times 544524 \times 24} + 0.015$$

$$= 0.207 \text{ IN}$$

Δ_0 (INITIAL DEFLECTION DUE TO WT OF BEAM)

$$= \frac{w a}{24 E_c I}(\ell^3 - 2\ell a^2 + a^3)$$

$$= \frac{10.5 \times 3.5 \times 0.15 \times 7}{24 \times 4012.699 \times 544524}\left[(24)^3 - 2 \times 24 \times (7)^2 + (7)^3\right] \times (12)^3$$

$$= 0.015 \text{ IN.}$$

$(P_0)_{\text{equivalent}}$

$$= \frac{24}{7 \times 17} \times \left(\tfrac{1}{2} \times 24 \times 10.5 \times 3.5 \times 0.15 \times 17 - \tfrac{1}{2} \times 10.5 \times 3.5 \times 0.15 \times 17^2\right)$$

$$= 66.15^k$$

CALCULATION SHEET

BECHTEL

CALC. NO. 11486-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 2-27-78 CHECKED BCM DATE 3-28-78

PROJECT AP & L AUXILIARY BLDG - UNIT #1 JOB NO. 11495-...

SUBJECT CASK DROP EVALUATION SHEET NO. 17

MAX. SHEAR CAPACITY

(1) FOR SHEAR CARRIED BY CONCRETE

$$v_c = 1.9\sqrt{f_c'} + 2500\,\rho_w \frac{Vd}{M}$$

$$= 1.9\sqrt{6500} + 2500 \times \frac{3 \times 1.56}{12 \times 38} \times 0.7 \qquad \left(\because \frac{Vd}{M} \doteq \frac{V \times 38}{V \times 54} = 0.7\right)$$

$$= 153.18 + 17.96$$

$$= 171.14 \text{ PSI} < 3.5\sqrt{f_c'}\ (= 282.18 \text{ PSI}) \quad \text{O.K.}$$

$$V_c = \phi\, v_c\, b\, d = 0.85 \times 171.14 \times 126 \times 38 = 696506^{\#} = 696.51^{k}$$

(2) FOR SHEAR CARRIED BY WEB REINFORCEMENT

$$v_c' = \frac{A_v f_y}{b_w S}$$

$$= \frac{0.31 \times 48300}{46 \times 12} \qquad (\#5 \text{ STIRRUP @ } 3'\text{-}10'' \text{ IN E-W}, \ 1'\text{-}0'' \text{ IN N-S})$$

$$= 27.12 \text{ PSI}$$

$$V_c' = \phi\, v_c'\, b\, d = 0.85 \times 27.12 \times 126 \times 38 = 110372^{\#} = 110.37^{k}$$

$$V_{max} = V_c + V_c' = 696.51 + 110.37 = 806.88^{k}$$

$$\frac{(P_s)_{max} \times 17}{24} + \underbrace{\frac{1}{2} \times 24 \times 10.5 \times 3.5 \times 0.15}_{40.24^{k}} - 4.7 \times 10.5 \times 3.5 \times 0.15 = 806.88$$

$$(P_s)_{max} = 1082.31^{k}$$

BOND STRESS AT FACE OF COLUMN

$$u = \frac{806.88 + 3.5 \times 10.5 \times 3.2 \times 0.15}{4.43 \times 3 \times 10.5 \times 0.852 \times 38} \times 1000 = 182.5 \text{ PSI}$$

$$< 543.2 \text{ PSI} \left(= \frac{9.5\sqrt{6500}}{1.41}\right)$$

O.K.

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CALCULATION SHEET

BECHTEL

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 2-27-78 CHECKED Bem DATE 2-28-78

PROJECT AP&L AUXILIARY BLDG - UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION SHEET NO. 18

FOR P_1

$$\begin{cases} \Delta = 0.207'' \\ P = 1213.46 + 66.15 = 1279.61^K \end{cases}$$

FOR P_2

SEE PREVIOUS SHEET

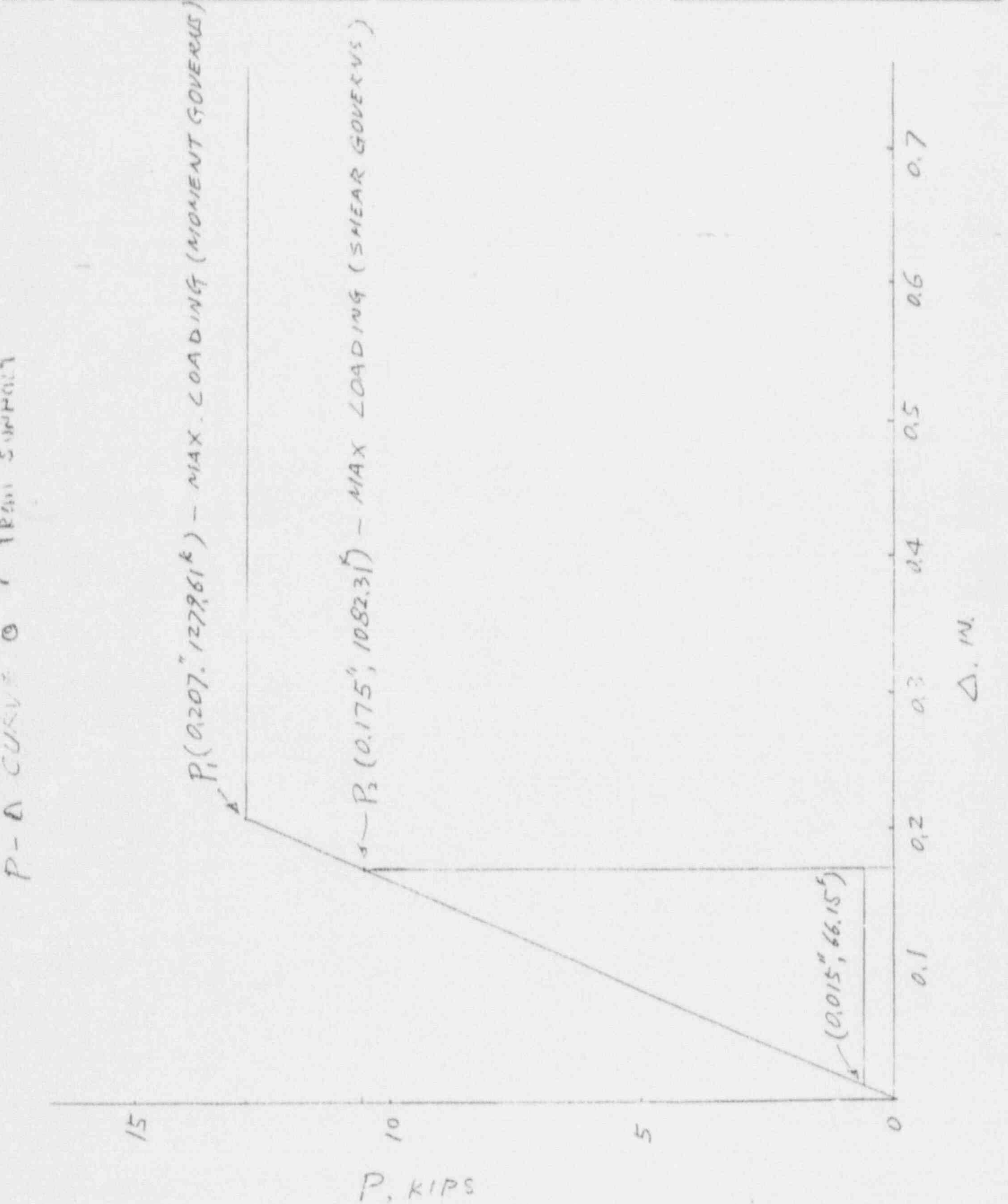
$P = 1082.31^K$

$$\Delta = 0.207 \times \frac{1082.31}{1279.61} = 0.175 \text{ IN.}$$

FOR P_0

$P = 66.15^K$

$\Delta = 0.015''$


P-Δ CURVE @ 7'
P1(0.207", 1279.61k) - MAX. LOADING (MOMENT GOVERNS)
P2 (0.175", 1082.31k) - MAX LOADING (SHEAR GOVERNS)
(0.015", 66.15k)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Δ, IN.
15
10
5
0
P, KIPS

BECHTEL

CALCULATION SHEET

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 2-27-78 CHECKED [illegible] DATE 2-28-78

PROJECT AP&L AUXILIARY BLDG - UNIT #1 JOB NO. 11486-130

SUBJECT CASK DROP EVALUATION SHEET NO. 20

2. ALLOWABLE HEIGHT OF DROP.

$V_s^2 = 2gh$, $M_m = \frac{50^k}{g}$

$M_e = \frac{\gamma_c T}{g}(D_x + 2T)(D_y + 2T)$ (FROM EQ 3-15 OF BC-TOP-9

BECAUSE CASK IS CIRCLE, USE $M_e = \frac{\gamma_c T}{g} \times \frac{\pi (D+2T)^2}{4}$

$M_e = \frac{1}{g} \times \left[\frac{\pi}{4} \times (11.1)^2 \times 3.5 \times 0.15\right]$

$= \frac{50}{g}$

$E_s = \frac{M_m^2 V_s^2}{2(M_m + M_e)}$

$\frac{\left(\frac{50}{g}\right)^2 2gh}{2\left(\frac{50}{g} + \frac{50}{g}\right)} = \frac{1}{2} \times (10823.1 - 66.15) \times (0.175 - 0.015)$

$\therefore h = 3.19$ IN.

3. REQUIRED THICKNESS OF HEXCELL FOR 9" DROP.

FROM "DESIGN DATA FOR THE PRELIMINARY SELECTION OF HONEYCOMB ENERGY ABSORPTION SYSTEMS TSB 122 BY HEXCELL" P. 12

$K.E. = f_{cr} \cdot A \cdot 0.7 t_c$

FOR $f_{cr} = 450$ PSI

$t_c = \frac{\frac{1}{2} \times \frac{50000}{32.2} \times (2 \times 32.2 \times 9)}{450 \times \frac{\pi}{4} \times (50)^2 \times 0.7} = 0.728$ IN.

FOR $f_{cr} = 400$ PSI

$t_c = \frac{450}{400} \times 0.728 = 0.819$ IN.

SFP-20768 Rev. (6/76)

ED-69 (5/7

BECHTEL

CALCULATION SHEET

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 3-1-78 CHECKED BLM DATE 3.28.78

PROJECT JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION SHEET NO. 21

ESTIMATED f_{cr} FOR HONEYCOMB

FOR 25 TON CASK

$$f_0 = \frac{50000}{\frac{\pi \times (50)^2}{4}} = 25.5 \text{ PSI}$$

$$f_1 = \frac{1061000}{\frac{\pi \times (50)^2}{4}} = 540.4 \text{ PSI}$$

$$f_{cr} = \frac{(25.5+540.4)}{2} = 282.95 \text{ PSI}$$

$\therefore$ USE $f_{cr} = 250$ PSI

$$t_c = \frac{K.E.}{f_{cr} A\, 0.7}$$

$$= \frac{\frac{1}{2} \times \frac{50000}{32.2} \times 2 \times 32.2 \times 9}{250 \times 1963.5 \times 0.7}$$

$= 1.31$ IN.

$\therefore$ USE 2" $f_{cr} = 250$ PSI HONEYCOMB

FOR 100 TON CASK

DIAMETER OF CASK = 6 FT BASED ON CAL. 2.12

$$t_c = \frac{\frac{1}{2} \times \frac{200000}{32.2} \times 2 \times 32.2 \times 9}{250 \times \frac{\pi}{4}(72)^2 \times 0.7}$$

$= 2.53$ IN.

$\therefore$ USE 3" $f_{cr} = 250$ PSI HONEYCOMB

SUMMARY OF STRESSES FOR 25^T CASK DROP

DATA $f_c' = 6{,}500$ PSI @ 4 YEARS

$f_y = 48{,}300$ PSI FROM MILL CERTIFICATE

CRITICAL DROP LOCATION : 7'-0" FROM END SUPPORT GIVES MAX. FAILURE SHEAR

(1) ON ED ON 3.00 IN. DROP WITH NO HEXCELL

(a) MAX. SHEAR FORCE AND SAFTY FACTOR

$$E_s = \frac{M_m^2 V_s^2}{2(M_m + M_e)} \quad , \quad V_s^2 = 2gh$$

$$\frac{(\frac{50}{g})^2 \times 2g \times 3.00}{2(\frac{50}{g} + \frac{50}{g})} = \frac{1}{2} \times (P - 66.15) \times (\frac{0.175}{1082.31} P - 0.015)$$

$$75 = \frac{0.175}{2164.62} P^2 - \frac{27.81}{2164.62} P + \frac{1073.922}{2164.62}$$

$$0.175 P^2 - 27.81 P \quad -161272.58 = 0$$

$$P = \frac{27.81 \quad + \sqrt{(27.81 \quad)^2 + 4 \times 161272.58 \times 0.175}}{2 \times 0.175}$$

$$= 1044.2^k$$

V AT 38" FROM FACE OF WALL = MAX. SHARE

$$= \frac{17}{24} \times 1044.20 + \frac{1}{2} \times 24 \times 10.5 \times 3.5 \times 0.15 - 4.7 \times 10.5 \times 3.5 \times 0.15$$

$$= 779.88^K$$

0075

CALCULATION SHEET

0810 (1-74)

DATE 3·28·78

DESIGN BY F. CHEN DATE 3-20-78 CHECKED BY BCM SHEET NO. 23

PROJECT A P & L AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION CALCULATION NO. 11406-130 FILE NO. 11406-130

ALLOWABLE COMBINED SHEAR CAPACITY OF CONCRETE AND WEB REINFORCEMENT

$= 806.88^k$

SAFTY FACTOR $= \frac{806.88}{779.88} = 1.035$

(b) MAX. MOMENT AND SAFTY FACTOR

M AT DROP POINT = MAX. MOMENT

$M = \frac{1044.2 \times 17 \times 7}{24} + \frac{1}{2} \times 10.5 \times 3.5 \times 0.15 \times 17 \times (24-17)$

$= 5177.49 + 327.99$

$= 5505.98^{1-k}$

ALLOWABLE MOMENT CAPACITY $= 6344.71^{1-k}$

SAFTY FACTOR $= \frac{6344.71}{5505.98} = 1.15$

(C) BOND STRESS

u AT FACE OF WALL = MAX. u

V AT FACE OF WALL

$= \frac{17}{24} \times 1044.20 + \frac{1}{2} \times 24 \times 10.5 \times 3.5 \times 0.15 - 1.5 \times 10.5 \times 3.5 \times 0.15$

$= 797.52^k$

$u = \frac{797520}{4.43 \times 3 \times 10.5 \times 0.852 \times 38} = 176.50 PSI$

0076

CALCULATION SHEET

0810 (11-74)

DATE 3-22-78

DESIGN BY F CHEN DATE 3-20-78 CHECKED BY BCW SHEET NO. 24

PROJECT A P & L AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION CALCULATION NO. 11406-130 FILE NO. 11406-130

$$\text{ALLOWABLE BOND STRESS} = \frac{9.5\sqrt{f_c'}}{D}$$

$$= \frac{9.5\sqrt{6500}}{1.41}$$

$$= 543.20 \text{ PSI}$$

$$\text{SAFTY FACTOR} = \frac{543.20}{176.50} = 3.077$$

0077

CALCULATION SHEET

BECHTEL

DATE 3-21-78

DESIGN BY F. CHEN DATE 3-20-78 CHECKED BY Ben SHEET NO. 25

PROJECT A P & L AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION CALCULATION NO. 11406-130 FILE NO. 11406-130

0076

(2) BASED ON 9" DROP WITH 2 THICK $f_{cr} = 260$ PSI HEXCELLS

$$K.E. = f_{cr} \times A \times 0.7 t_c$$

$$f_{cr} = \frac{K.E}{A \times 0.7 t_c}$$

$$= \frac{\frac{1}{2} \times \frac{50000}{32.2} \times 2 \times 32.2 \times 9}{2 \times 1963.5 \times 0.7}$$

$$= 163.7 \text{ PSI} < 260 \text{ PSI}$$

$$P = 260.0 \times 1963.5$$

$$= 510510^{\#}$$

$$= 510.51^{k}$$

(a) MAX. SHEAR FORCE AND SAFTY FACTOR

V AT 38" FROM FACE OF WALL = MAX. SHARE

$$= \frac{17}{24} \times 510.5 + \frac{1}{2} \times 24 \times 10.5 \times 3.5 \times 0.15 - 4.7 \times 10.5 \times 3.5 \times 0.15$$

$$= 401.56^{k}$$

CONSERVATIVELY ALLOWABLE COMBINED SHEAR CAPACITY OF CONCRETE AND WEB REINFORCEMENT

$= 806.88$

$$\text{SAFTY FACTOR} = \frac{806.88}{401.56} = 2.009$$

CALCULATION SHEET

0510 (11-74)

DATE 3-21-78

DESIGN BY F. CHEN DATE 3-20-78 CHECKED BY BCull SHEET NO. 26

PROJECT AP&L AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION CALCULATION NO. 11406-130 FILE NO. 11406-130

(b). MAX. MOMENT AND SAFTY FACTOR

M AT DROP POINT = MAX. MOMENT

$$M = \frac{510.51 \times 17 \times 7}{24} + \frac{1}{2} \times 10.5 \times 3.5 \times 0.15 \times 17 \times (24-17)$$

$$= 2531.28 + 327.99$$

$$= 2859.27^{\prime-K}$$

ALLOWABLE MOMENT CAPACITY $= 6344.71^{\prime-K}$

$$\text{SAFTY FACTOR} = \frac{6344.71}{2859.27} = 2.219$$

(C) BOND STRESS

U AT FACE OF WALL = MAX. U

V AT FACE OF WALL

$$= \frac{17}{24} \times 510.51 + \frac{1}{2} \times 24 \times 10.5 \times 3.5 \times 0.15 - 1.5 \times 10.5 \times 3.5 \times 0.15$$

$$= 419.49^{K}$$

$$u = \frac{419490}{4.43 \times 3 \times 10.5 \times 0.852 \times 38} = 92.85\ PSI$$

ALLOWABLE BOND STRESS = 543.20 PSI

$$\text{SAFTY FACTOR} = \frac{543.20}{92.85} = 5.850$$

0079

CALCULATION SHEET

BECHTEL

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 9-17-73 CHECKED TY DATE 10/5/73

PROJECT APEL AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION (COMPARISION BTW 1963 & 1971 ACI) SHEET NO. 27

1963 REQUIREMENTS		1971 REQUIREMENTS
1. SECTION MODULUS FOR CALCULATING DEFLECTION (§ 909 (C)) $I_e = I_g$ WHEN $pf_y \le 500$ PSI $I_e = I_{cr}$ WHEN $pf_y > 500$ PSI (USED: FORMULA (4-2) OF BC-TOP-9) $I_a = \frac{1}{2}(I_g + I_c)$	DIFF	1. § 9.5.2.2 $I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr}$ WHERE $M_{cr} = \frac{f_r I_g}{y_t}$, & $f_r = 7.5\sqrt{f_c'}$
2. $E_c = w^{1.5} 33\sqrt{f_c'}$ (§ 1102(a))	SAME	2. $E_c = w^{1.5} 33\sqrt{f_c'}$ (§ 8.3.1)
3. EFFECTIVE WIDTH OF BEAM NOT SPECIFIED	SAME	3. EFFECTIVE WIDTH OF BEAM NOT SPECIFIED
4. MOMENT CAPACITY (§ 1601) $M_u = \phi\left[A_s f_y \left(d - \frac{a}{2}\right)\right]$	SAME	4. MOMENT CAPACITY ANY FORMULA RECOGNIZED. THEREFORE FORMULA USED IN 1963 ACI CODE CAN BE USED IN 1971 ACI CODE. ($M_u = \phi\left[A_s f_y \left(d - \frac{a}{2}\right)\right]$)
(a) ϕ FOR MOMENT CAPACITY § 1504 (b) $\phi = 0.90$	SAME	(a) ϕ FOR MOMENT CAPACITY § 9.2.1.1 $\phi = 0.90$
(b) $a = A_s f_y / 0.85 f_c' b$ § 1601(a) & § 1503(g) $= k_1 c$	SAME	(b) $a = A_s f_y / 0.85 f_c' b$ § 10.2.7 $= \beta_1 c$

SFP-20768 Rev. (6/76) ED-69 (5/76)

1963 REQUIREMENTS		1971 REQUIREMENTS
5 SHEAR CAPACITY		5. SHEAR CAPACITY
(a). SHEAR CARRIED BY CONCRETE §1701(d)	SAME	(a) SHEAR CARRIED BY CONCRETE §11.4.2
$V_c = \phi bd(1.9\sqrt{f'_c} + 2500 \rho_w \frac{Vd}{M})$		$V_c = \phi bd(1.7\sqrt{f'_c} + 2500 \frac{\rho_w V_u d}{M_u})$
$\leq \phi bd\, 3.5\sqrt{f'_c}$		$\leq \phi bd\, 3.5\sqrt{f'_c}$
(1) $\phi = 0.85$ (§1504(b))	SAME	(1) $\phi = 0.85$ (§9.2.1C)
(2) $\rho_w = A_s/b'd$		(2). $\rho_w = A_s/b_w d$
b' = WIDTH OF WEB IN I AND T SECTION	SAME	b_w = WEB WIDTH
(3) V = TOTAL SHEAR AT SECTION	SAME	(3). V_u = TOTAL APPLIED DESIGN SHEAR FORCE AT SECTION
(4) M = BENDING MOMENT	SAME	(4) M_u = APPLIED DESIGN LOAD MOMENT AT SECTION, IN-lb
(5) $Vd \geq M$	SAME	(5) $\frac{V_u d}{M_u} \leq 1.0$
(b) SHEAR CARRIED BY WEB REBARS. OR A_v REQ'D		(b) SHEAR CARRIED BY WEB REBARS OR A_v REQ'D
(1). $A_v = \frac{V'_u S}{\phi f_y d}$ (§1703(a))	SAME	(1) $A_v = \frac{(v_u - v_c) b_w S}{f_y}$ (§11.6.1)
WHERE $V'_u = \phi(v_u - v_c) b_w d$ AS IN 1971 ACI.		
(2) WHEN $v_u > 6\phi\sqrt{f'_c}$, EVERY 45-DEG. LINE SHALL BE CROSSED BY AT LEAST TWO LINES OF WEB REBAR		(2) WHEN $(v_u - v_c) > 4\sqrt{f'_c}$ S SHALL BE REDUCED BY ONE-HALF (§11.6.3)

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CALCULATION SHEET

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR I. CHEN DATE 9-20-78 CHECKED -4- DATE 10/9/78

PROJECT AP & L AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION (COMPARISION BTW 1963 & 1971 ACI) SHEET NO. 29

1963 REQUIREMENTS		1971 REQUIREMENTS
$V_u = \phi V_u$ (IN 1971 ACI)	SAME	$V_c = 2\sqrt{f_c'}$ (§ 11.4.1) $V_u = \frac{V_u (\text{IN 1963 ACI})}{\phi}$ (§ 11.2.1)
$\therefore \{V_u > 6\phi\sqrt{f_c'}\}$ OF 1963 $= \{(V_u - V_c) > 4\sqrt{f_c'}\}$ OF 1971		$V_c = \frac{1}{\phi} V_c$ (IN 1963 ACI) (§ 11.2.1, § 11.4.2)
(3) $V_u \le 10\phi\sqrt{f_c'}$ (§ 1705)	SAME	(3) $(V_u - V_c) \le 8\sqrt{f_c'}$ (§ 11.6.4)
(4) $Av_{min} = 0.0015\, bS$ (§ 1706 (b)) $= 0.0015 \times 46 \times 12$ $= 0.83\ IN.^2$	DIFF (N.A.)	4) $Av_{min} = 50 \frac{b_w S}{f_y}$ (§ 11.1.2) $= 50 \times \frac{46 \times 12}{48300} = 0.57\ IN.^2$
6. BOND CAPACITY IN TERM OF BOND STRESS	SAME	6. BOND CAPACITY IN TERM OF DEVELOPMENT LENGTH.

1963:

(a) $u_u = \frac{V_u}{\phi \Sigma o j d}$ (§ 1801 (a))

(b) $u_u = \frac{M}{\phi j d \Sigma o \ell_d}$ (§ 1801 (b))

OR $\ell_d = \frac{f_y D}{4 u_u}$ FOR $f_s = f_y$

FOR BARS OTHER THAN TOP BARS

$u_u \le \frac{9.5\sqrt{f_c'}}{D}$ NOR 800 PSI

(§ 1801 (c))

$\ell_d = \frac{48300 \times 1.41}{4 \times 543} = 31.4$ IN

1971:

$\ell_d = 0.8(0.04 A_b f_y / \sqrt{f_c'})$

$\ge 0.8(0.0004\, d_b f_y)$

(§ 12.5 (a) & (d))

ACCORDING TO COMMENTORY OF 1971 CODE (CHAPTER 12 GENERAL),

ℓ_d OF 1971 CODE IS SUPPOSED SAME AS OF 1963.

$0.8(0.04 A_b f_y / \sqrt{f_c'})$

$= 0.8 \times (0.04 \times 1.56 \times 48300 \times \frac{1}{\sqrt{6500}})$

$= 29.9$ IN.

$0.8(0.0004\, d_b f_y) = 0.8 \times 0.0004 \times 1.41 \times 48300$

$= 21.8$ IN

$\therefore \ell_d = 29.9$ IN. ≈ 31.4 IN.

SFP-20768 Rev. (6/76) ED-69 (8/76)

0083

CALCULATION SHEET

CALC. NO. 11406-130 REV. NO. 2

ORIGINATOR F. CHEN DATE 9-21-78 CHECKED TN DATE 10/9/78

PROJECT AP&L AUXILIARY BLDG UNIT #1 JOB NO. 11406-130

SUBJECT CASK DROP EVALUATION (COMPARISION BTW 1963 & 1971 ACI) SHEET NO. 30

1963 REQUIREMENTS

7. DISTRIBUTION OF FLEXURAL REINF. (CRACK CONTROL)

NO PROVISION

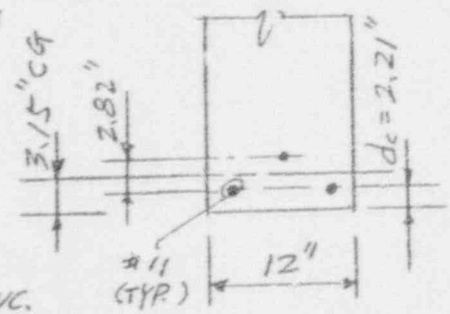
N.A.

1971 REQUIREMENTS

7. DISTRIBUTION OF FLEXURAL REINF (CRACK CONTROL)

$Z = f_s \sqrt[3]{d_c A} \leq 175$ KIPS/IN. (§10.6.3)

$f_s = f_y = 48.3$ KSI



CG. OF BARS

$= 2.21 + \frac{1}{3} \times 2.82$

$= 3.15"$

TOTAL AREA OF CONC. AROUND BARS

$= 2 \times 3.15 \times 12$

$= 75.6$ IN.^{2}

$A = \frac{75.6}{3} = 25.2$

$Z = 48.3 \sqrt[3]{2.21 \times 25.2}$

$= 184.4$

> 175

SFP-20768 Rev. (6/76)

ED-C9 (5/76)

SHT #5

0084

CAL. No. 31
JOB # 11406-130
SHT. No. 11406.130

COMPARISON BETWEEN 1963 AND 1971 ACI CODES

FOR

DROP EVALUATION SUMMARY

FOR

THE 25 TON HANDLING CASK

ELEVATION 404

(Over Control Room)

Case I - A drop evaluation for 3" travel height with no hexagonal honeycomb.

Case II - A drop evaluation for 9" travel height with 2 inches of hexagonal honeycomb.

The following results are based on Bechtel BC-TOP-9 (including formula 4-2 for effective moment of inertia for calculation of deflection) and the Ultimate Strength Design Methods:

	CASE I		CASE II	
	1963 Code	1971 Code	1963 Code	1971 Code
Shear Capacity / Shear Computed :	807 kips / 780 kips =1.03;	807 kips / 780 kips =1.03	807 kips / 401 kips =2.01;	807 kips / 401 kips =2.01
Moment Capaicty / Moment Computed :	6345 kip-ft / 5506 kip-ft =1.15;	6345 kip-ft / 5506 kip-ft =1.15	6345 kip-ft / 2859 kip-ft =2.22;	6345 kip-ft / 2859 kip-ft =2.22
Bond Stress Capacity / Bond Stress Computed :	543 psi / 177 psi =3.07;	Calculation of peak bond stress not req'd	543 psi / 93 psi =5.84;	Calculation of peak bond stress not req'd
Development Length Provided / Development Length Required :	33 in. / 32 in. =1.03;	33 in. / 30 in. =1.10	33 in. / 32 in. =1.03;	33 in. / 30 in. =1.10