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AUTH.NAME AUTHOR AFFILIATION
KEISER,H.W. Pennsylvania Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
ADENSAM,E. BWR Project Directorate 3 see Encls

SUBJECT: Forwards response to request for addl info re proposed Amends 80 & 30 to Licenses NPF-14 & NPF-22, respectively, revising Tech Specs to reflect incorporation of fifth diesel generator into plant design. Three oversize drawings encl.

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NOTES:			3	3				

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7 Encls

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PP&L Pennsylvania Power & Light Company
Two North Ninth Street • Allentown, PA 18101 • 215 / 770-5151

Harold W. Keiser
Vice President-Nuclear Operations
215/770-7502

JUN 24 1986

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Project Director
BWR Project Directorate No. 3
Division of BWR Licensing
U.S. Nuclear Regulatory Commission
Washington DC 20555

SUSQUEHANNA STEAM ELECTRIC STATION
REQUEST FOR ADDITIONAL INFORMATION
FOR PROPOSED AMENDMENT NO. 80 TO
NPF-14 AND PROPOSED AMENDMENT NO. 30
TO NPF-22
PLA-2668 FILE R41-2/A17-2

DOCKET NOS 50-387
AND 50-388

Dear Ms. Adensam:

The purpose of this letter is to transmit additional information requested by your Staff related to the subject proposed amendments which are the technical specification changes reflecting incorporation of a fifth diesel generator into the Susquehanna design.

Specifically, PP&L was requested to:

- Provide a typical calculation for the diesel generator E facility cable tray supports.

  This calculation is provided as Attachment 1 to this PLA.

- Provide the tornado barrier design calculation for the diesel generator E facility removable wall section.

  This calculation is provided as Attachment 2 to this PLA.

- Provide clearer copies of the FSAR revisions previously submitted under PLA-2645 dated May 19, 1986.

  These copies are provided as Attachment 3 to this PLA.

- Clarify that the Standard Review Plan acceptance criteria responses (provided under PLA-2645 dated May 19, 1986) take precedence over any deviations between those responses and the reference material also provided under PLA-2645.

8606270213 860624
PDR ADOCK 05000387
P PDR

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A001 1/1

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Drawings
To: Reg Files

The SRP responses reflect the latest information available and do take precedence over the reference material.

If you have any further questions please contact D. J. Walters at (215) 770-7861.

Very truly yours,

H. W. Keiser
Vice President - Nuclear Operations

cc:	M. J. Campagnone	USNRC
	L. R. Plisco	USNRC

ATTACHMENT 1

OVERVIEW
of
CABLE TRAY SUPPORT DESIGN
for the
"E" DIESEL GENERATOR FACILITY

The attached drawings C5025, C5030 and C5033 sheet 1; and Calculation SC-DB-08 Set B provide a sample of cable tray support design pertaining to the "E" Diesel Generator Facility.

Cable tray routing is shown on drawing C5025. Support numbers are identified on this routing (i.e. ①). The Cable Tray Support Schedule provides a correlation between the support number (i.e. ①) and the support detail (i.e. detail 1). The support detail is shown on drawing C5030. The dimensions and reference elevations on the support schedule correlate to this detail. The support type (i.e. T) on the schedule is described on drawing C5033 sheet 1. The connection details (i.e. A, F, K, H) indicated on the support detail, are shown on drawing C5033 sheet 1.

Calculation SC-DB-08 Set B provides a design basis to detail 1. Sheets 2 through 6 provide an overview and inputs to the calculation. Sheet 11 provides the correlation between generic support types (i.e. Type Ia) and the support details (i.e. Details 1, 12, 13). Sheets 13 through 21 provide the design basis to Detail 1.

Gibbs & Hill, Inc.

Calculation Cover Sheet

SH. 1

G&H Job No. 3544 Client P.P.&L.

Calculation Number SC-DB-08 SET-B

Number of Sheets in Original Issue 97

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

☑ Nuclear Safety Related

☐ Non-Nuclear Safety Related—QA Program Applicable

☐ Non-Nuclear Safety Related

		Sheets Deleted	Sheets Added	Sheets Revised	Job Engineer	
					Signature	Date
Original						12/20/84
Revision	1	—	50A, 50B, 50C	45 To 50		2/14/85
	2	—	98 To 101	7		2/27/85
	3	—	102 To 105	7		6/30/85

F-167, 4-81

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

alculation Number SC-DB-08 SET B Sheet No. 2

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.27.84									
Checker		[illegible]									

CONTENT

THE FOLLOWING CALCULATIONS COVER THE DESIGN OF CABLE TRAY SUPPORTS IN THE BASEMENT (EL. 656'-6 TO EL. 675'-6) OF THE EMERGENCY DIESEL GENERATOR "E" BUILDING FOR THE SUSQUEHANNA STEAM ELECTRIC STATION, UNITS 1 & 2, P.P. & L.

PURPOSE

THE OBJECTIVE OF THE CALCULATIONS INCLUDED IN THIS BOOK IS TO ESTABLISH THE STATIC CONFIGURATION, DESIGN THE SECTIONS AND CONNECTION DETAILS AND CHECK COMPATIBILITY WITH THE EMBEDDED PLATES FOR THE ABOVE MENTIONED STRUCTURAL ELEMENTS. HOWEVER VERIFICATION OF EMBEDDED PLATE FOR ACTUAL DESIGN WILL BE DONE SEPARATELY.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

alculation Number SC - DB - 08 SET B Sheet No. 3

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.27.84									
Checker		12·20·84									

CODES, MATERIALS, STRESSES, LOADS & REFERENCES

THE FOLLOWING LIST INCLUDES:

1. - CLASSIFICATION OF THE STRUCTURE
2. - CODES, STANDARDS & DESIGN GUIDES UTILIZED
3. - MATERIALS
4. - STRESSES
5. - LOADS
6. - LOAD COMBINATIONS
7. - TECHNICAL REFERENCES
8. - DRAWING REFERENCES

1. - CLASSIFICATION OF THE STRUCTURES INCLUDED IN THIS BOOK.

a) SEISMIC CATEGORY I

2. - CODES, STANDARDS & DESIGN GUIDES UTILIZED

a) G&H DOC. 3544-SDC-001, ISSUE 0, JAN 1984 TITLED "DESIGN CRITERIA FOR CIVIL/STRUCTURAL WORK FOR NEW EMERGENCY DIESEL GENERATOR FACILITY"

b) AISC "MANUAL OF STEEL CONSTRUCTION" 8th ED.

c) AMERICAN WELDING SOCIETY (AWS) - "STRUCTURAL WELDING CODE" AWS D1.1 - 81

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 4

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	X		X		X		X		X	
Preparer	RS	11.27.84									
Checker		12.20.84									

d) - P.P.&L. SPECIFICATION C-1020, REV. 0 TITLED "TECHNICAL SPECIFICATION FOR FURNISHING AND INSTALATION OF EXPANSION-TYPE ANCHORS"

e) - G&H DOC. 3544 - SPECIFICATION E-1032, REV. 0 TITLED "TECHNICAL SPECIFICATION FOR CABLE TRAY AND ACCESSORIES (NUCLEAR) FOR THE D/G E BLDG"

f) - P.P.&L. SPECIFICATION E-1013, REV. 0 TITLED "INSTALATION SPECIFICATION FOR SEISMIC CLASS I CABLE TRAY AND CONDUIT SUPPORTS"

g) - BLODGETT'S "DESIGN OF WELDED STRUCTURES"

h) - G&H DOC. 3544 - SC-DB-08 SET A TITLED "DESIGN CRITERIA FOR CABLE TRAYS, CONDUITS AND JUNCTION BOXES SUPPORTS".

3. - MATERIAL

a) - ASTM A36-81 STRUCTURAL STEEL

b) - A500 - GRADE B STRUCTURAL TUBING

c) - E-70XX WELDING

d) - NELSON STUDS

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET B Sheet No. 5

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.27.84									
Checker		12.20.84									

4. - STRESSES

STRESSES IN ACCORDANCE WITH THE CORESPONDING CODES AND/OR MANUFACTURER'S SPECIFICATIONS AS OUTLINED IN ART. 3 ABOVE

5. - LOADS

DESIGN LOADS IN ACCORDANCE WITH ART. 2.9 OF G&H. Doc. 3544-SC-DB-08 SET A

6. - LOAD COMBINATIONS

THE LOAD COMBINATIONS FOR THE CABLE TRAY SUPPORT STRUCTURES ARE IN ACCORDANCE WITH ART. 3.3.1. AND 3.3.2. OF THE STRUCTURAL DESIGN CRITERIA. (Ref 2a)

7. - TECHNICAL REFERENCES

AS NOTED IN CALCULATIONS AT THE BEGINNING OF INDEXED SECTIONS

8. - DRAWING REFERENCES

a) - E 81-1 / E-199311-1 REV. 0 - D/G E BLDG - TRAY & CONDUIT PLAN @ EL. 656-6'

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 6

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.27.84									
Checker		12-20-84									

b) - E81-2/E-199311-2 REV. 0 - D/G E BLDG - TRAY & CONDUIT PLAN @ EL. 675-6

c) - E81-3/E-199311-3 REV. 0 - D/G E BLDG - TRAY & CONDUIT PLAN @ EL. 702'-0 & 726'-0

d) C-5025, C-5030, C-5031 & C-5033

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

alculation Number SC - DB - 08 SET B Sheet No. 7

Revision	Original Issue	Date	Rev. 2	Date	Rev. 3	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒	1	☒	1	☒		☒		☒	
Preparer	RS	11.27.84	R.S	2.26.85	RS	4.29.85					
Checker		11.30.84		[illegible]		4.30.85					

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

Calculation Number SC - DB - 08 SET B Sheet No. 8

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS.	11.27.84									
Checker		12-20-84									

LIST OF ITEMS FOR WHICH DATA IS NOT AVAILABLE AT THE DATE THE CALCULATIONS ARE MADE. THESE ITEMS ARE TO BE VERIFIED LATER

1. CLAMPS CONNECTING CABLE TRAYS TO SUPPORTS

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P.& L.

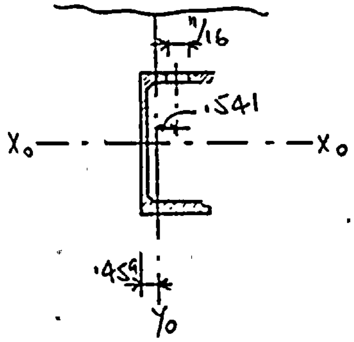
Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 9

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.15.84									
Checker		12.20.84									

1.0 SECTION REDUCTION DUE TO 11/16 HOLES (5/8" φ BOLTS)

1.1 C4 x 7.25



$A_o = 2.13 \text{ in}^2$ $S_{x_o} = 2.29$ $S_{y_o} = .343$

$r_{x_o} = 1.47$ $r_{y_o} = .45$

$A_{net} = 2.13 - .296 \times .688 = 1.926 \text{ in}^2$

$I_{x\,net} = 4.59 - .296 \times .688 \times 1.852^2 = 3.89 \text{ in}^4$

$S_{x\,net} = \frac{3.89}{2} = 1.946 \text{ in}^3$

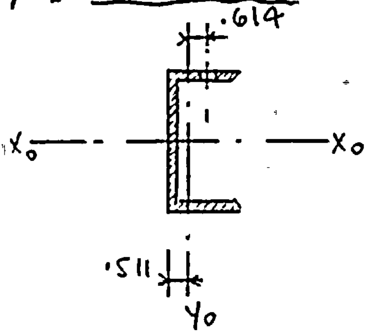
$I_{y\,net} = .433 - .296 \times .688 \times .541^2 = .373 \text{ in}^4$

$S_{y\,net} = \frac{.373}{1.262} = .296 \text{ in}^4$

$r_{x\,net} = \sqrt{\frac{3.89}{1.926}} = 1.42"$ $r_{y\,net} = \sqrt{\frac{.373}{1.926}} = .44 \text{ in}$

NOTE: IT IS ASSUMED THAT NEUTRAL AXIS POSITION DOES NOT CHANGE (FOR SIMPLICITY)

1.2 C6 x 8.2



$A_o = 2.4 \text{ in}^2$ $S_{x_o} = 4.38$ $S_{y_o} = .492$

$r_{x_o} = 2.34$ $r_{y_o} = .537$

$A_{net} = 2.4 - .343 \times .688 = 2.16 \text{ in}^2$

$I_{x\,net} = 13.1 - .343 \times .688 \times 2.83^2 = 11.21 \text{ in}^4$

$S_{x\,net} = \frac{11.21}{3} = 3.74 \text{ in}^3$ $r_{x\,net} = \sqrt{\frac{11.21}{2.16}} = 2.2$[illegible]

$I_{y\,net} = .693 - .343 \times .688 \times .614^2 = .604 \text{ in}^4$

$S_{y\,net} = \frac{.604}{1.409} = .429 \text{ in}^3$ $r_{y\,net} = \sqrt{\frac{.604}{2.16}} = .529 \text{ in}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

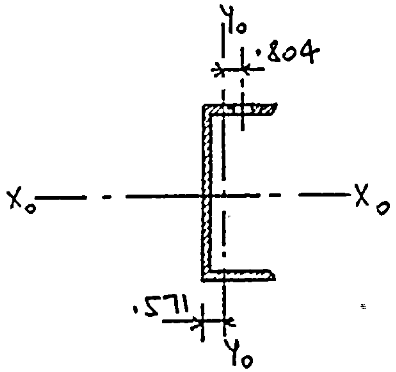
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 10

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.16.84									
Checker		12-20-84									

SECTION REDUCTION DUE TO 11/16 HOLES (5/8" ϕ BOLTS)



C8 x 11.5

$A_0 = 3.38$ $S_{x_0} = 8.14$ $S_{y_0} = .781$

$r_{x_0} = 3.11$ $r_{y_0} = .625$

$A_{net} = 3.38 - .39 \times .688 = 3.11 \text{ in}^2$

$I_{x_{net}} = 32.6 - .39 \times .688 \times 3.8^2 = 28.7 \text{ in}^4$

$S_{x_{net}} = \frac{28.7}{4} = 7.18 \text{ in}^3$ $r_{x_{net}} = \sqrt{\frac{28.7}{3.11}} = 3.04 \text{ in}$

$I_{y_{net}} = 1.32 - .39 \times .688 \times .804^2 = 1.15 \text{ in}^4$

$S_{y_{net}} = \frac{1.15}{1.689} = .68 \text{ in}^3$ $r_{y_{net}} = \sqrt{\frac{1.2}{3.11}} = .61 \text{ in}$

NOTE: BOLT HOLE IN THE WEB WILL GIVE INSIGNIFICANT REDUCTION.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET B Sheet No. 11

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.28.84									
Checker		12 20-84									

2.0 LEGEND

TYPE I_a - TRANSV. - DETAIL 1, 12, 13

TYPE I_{a_1} - TRANSV. - DETAIL 4

TYPE I_b - MULTIDIR. - DETAIL 8, 24

TYPE I_{b_1} - MULTIDIR - DETAIL 11

TYPE II_a - TRANSV. - DETAIL 2, 14, 15, 16

TYPE II_b - MULTIDIR. - DETAIL 9, 22, 23, 29
TYPE II_{b_1} - " - DETAIL 26
TYPE III_b - MULTIDIR. - DETAIL 27, 28

TYPE IV_a - TRANSV. - DETAIL 3, 6,

TYPE IV_b - MULTIDIR. - DETAIL 10

TYPE V_a - TRANSV. - DETAIL 5, 7, 17

TYPE V_b - MULTIDIR - DETAIL 21, 25,

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

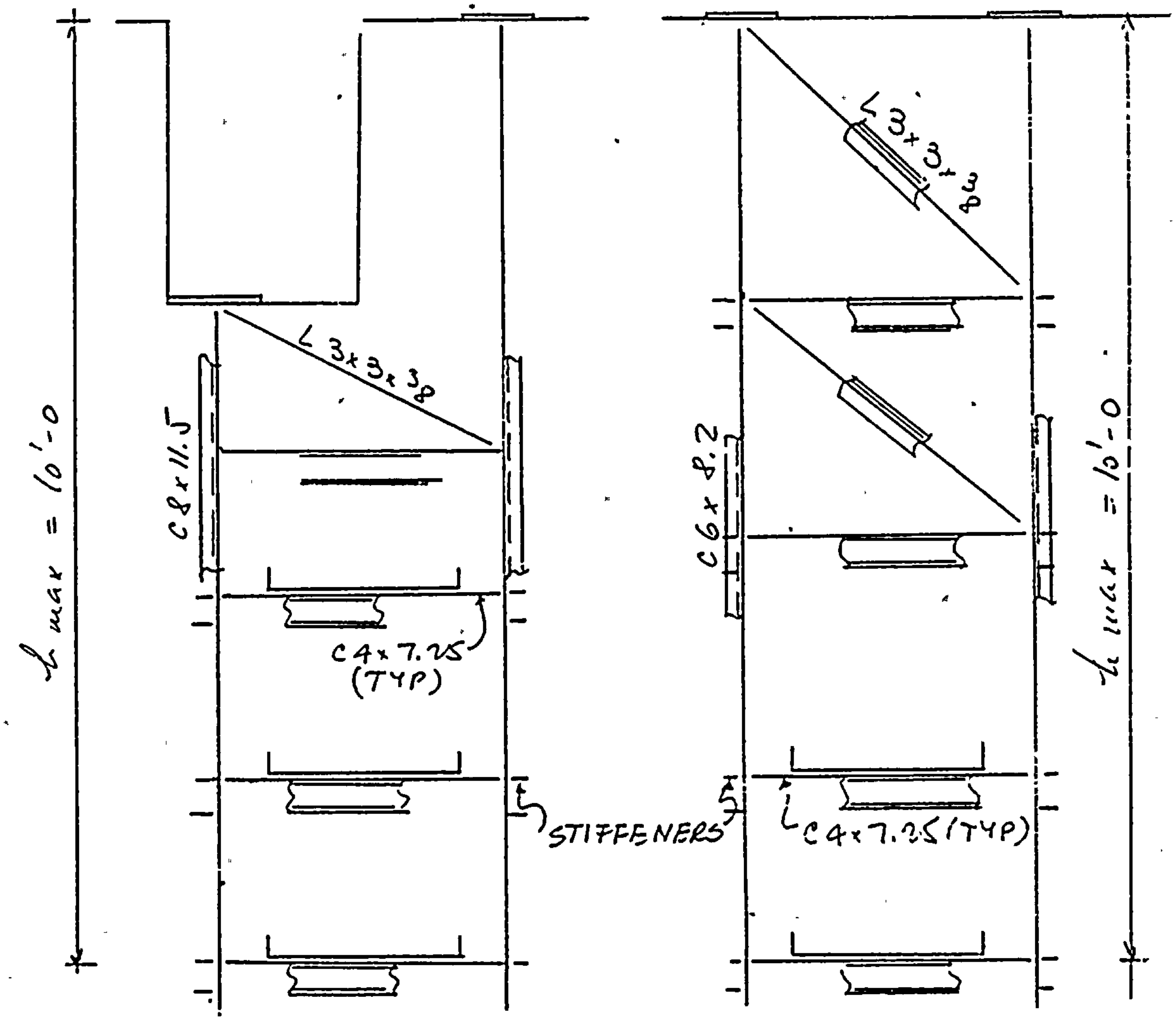
Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 12

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.22.84									
Checker		12.20.84									

3.0 TRANSVERSAL SUPPORTS



TYPE Ia TYPE IIa

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

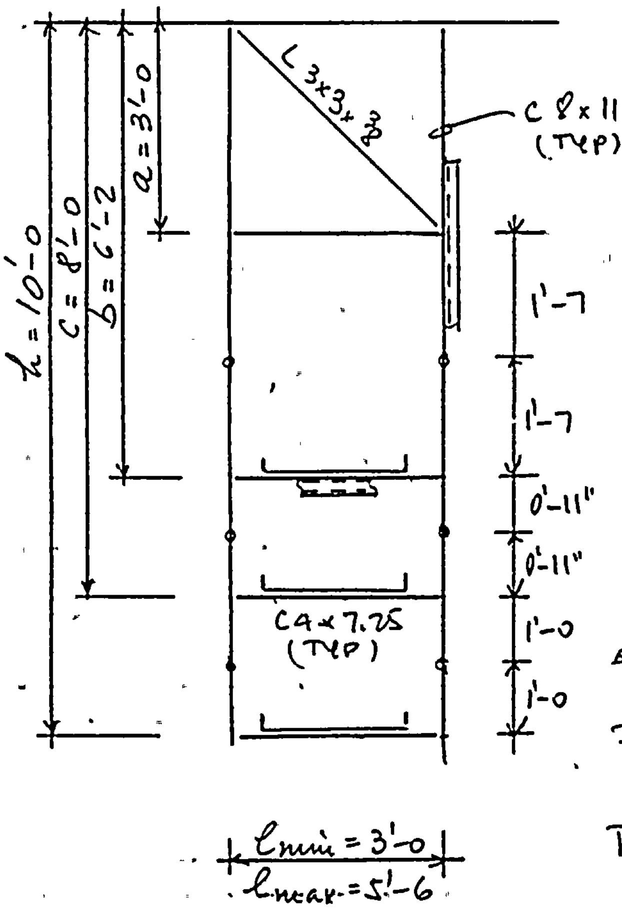
Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 13

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	RS	10.15.84								
Checker		12-20-84								

3.1

TYPE Ia - TRANSVERSAL SUPPORT



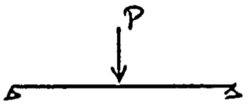
FOR ALL SUPPT'S SUSPENDED FROM 675'-6 CEILING $g_V = 1.2$ $g_H = .54$

MAX. TRAY LOAD:

$2 \times 35 \times 9 = 630^{\#}$

HORIZ. MEMBER	C 4x7.25
VERT. MEMBER	C 8x11.5
BRACING	L 3x3x 3/8

HORIZONTAL MEMBER C4x7.25



$l_{max} = 5'-6$

$P_{DL} = \overbrace{630 + 7.25 \times 5.5}^{40} = 670^{\#}$

$P_T = .67 \times .54 = .36^k$

NOTE: ALL TRANSVERSE FRAMES ARE RIGID FRAMES BEYOND THE BRACED BAYS. SINCE THEY ARE SIMPLE ONE BENT FRAMES SYMETRICAL ABOUT CENTERLINE, THEY WILL BE ANALYZED BY PORTAL METHOD ASSUMING POINT OF INFLECTION AT MID POINT. THE METHOD GIVES CONSERVATIVE RESULTS.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

E

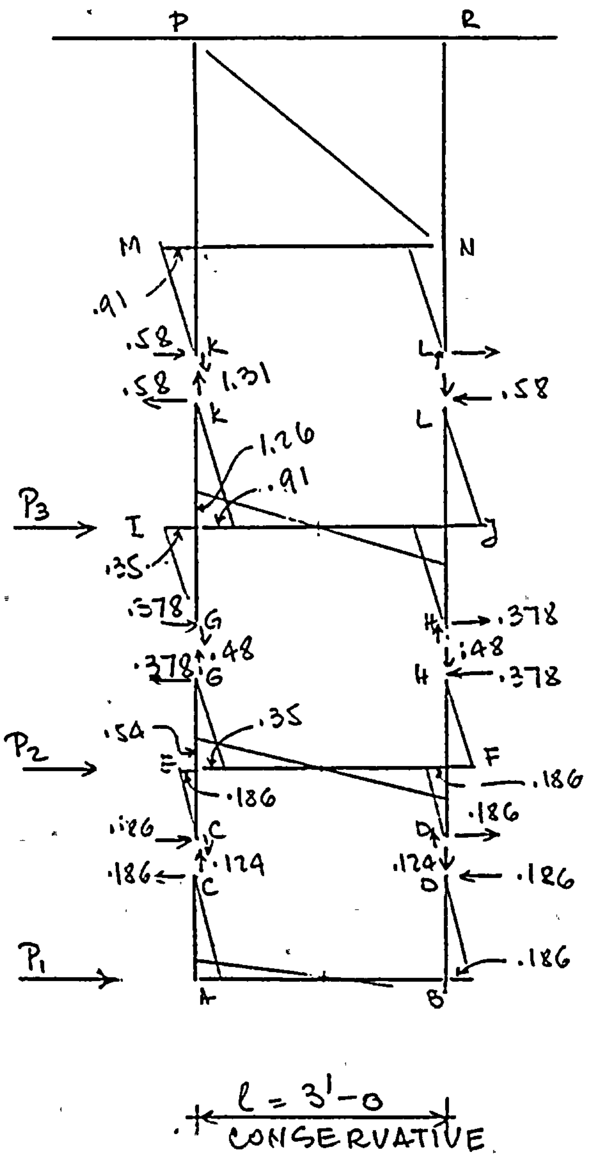
Gibbs & Hill, Inc. Job.No. 3544 Client P.P. & L

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET B Sheet No. 14

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	10.15.84								
Checker	KB	12-20-84								

Type Ia -(cont'd)



$P_1 = .36 + 2\times\overbrace{.0115\times1.0\times.54}^{.012} = .372^k$

$M_A = M_B = \frac{.372}{2}\times1.0 = .186^{1k}$

$M_{CE} = M_{DF} = .186^{1k}$

$H_c = \frac{.372}{2} = .186^k$

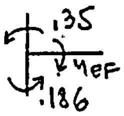
$V_c = \frac{.372\times1.0}{3.0} = .124^k$

$P_2 = .36 + 2\times\overbrace{.0115\times1.91\times.54}^{.024} = .384^k$

$H_G = .186 + \frac{.384}{2} = .378^k$

$V_G = \frac{1}{3.0}(.372\times2.91 + .384\times.91) = .48^k$

$M_{GE} = .378\times.91 = .343^{1k}$



$\underset{TOTAL}{M_{EF}} = .35 + .186 = .54^{1k}$

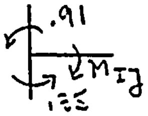
$M_{GI} = M_{HJ} = .378\times.91 = .343^{1k}$

$P_3 = .36 + 2\times\overbrace{.0115\times2.5\times.54}^{.031} = .391^k$

$H_K = \frac{.391}{2} + .378 = .574^k$

$V_K = \frac{1}{3.0}(.372\times5.41 + .384\times3.41 + .391\times1.58) = 1.31^k$

$M_{KI} = .574\times1.58 = .91^{1k}$



$\underset{TOTAL}{M_{IJ}} = .91 + .35 = 1.26^{1k}$

$M_{KM} = M_{LN} = .574\times1.58 = .91^{1k}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

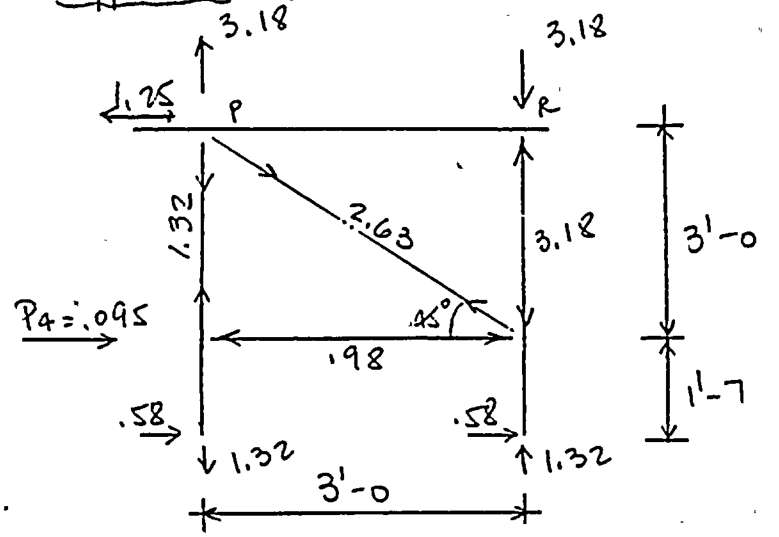
Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 15

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.15.84									
Checker		12.20.84									

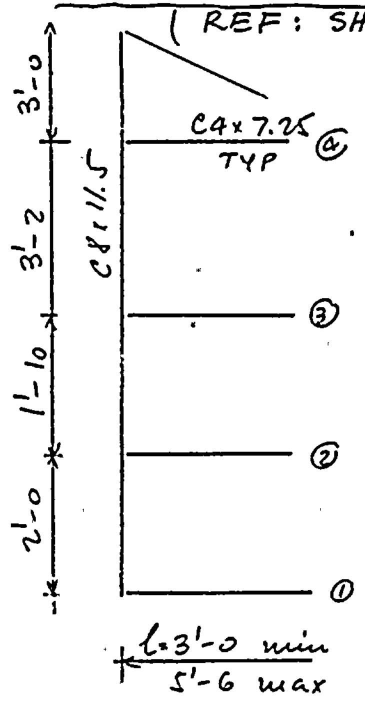
Type Ia - (CONT'D)



$P_4 = (.040 + 2 \times .0115 \times 4.58 + .0072 \times 4.23) \times .54 = .095^k$

$V_p = \frac{1}{3.0}(.58 \times 4.58 \times 2 + .095 \times 3) + 1.32 = 3.18^k$

EFFECTIVE LENGTH OF VERTICAL MEMBERS
(REF: SH. 5-125 AISC MANUAL 8th ED.)



$I_{C8} = 1.2 \text{ in}^4$ $I_{C4} = 3.89 \text{ in}^4$ - GROSS AREA TO BE CONSIDERED. HOWEVER RATIO CONSIDERING GROSS A IS TO BE CONSIDERED. ∴ O.K.

$G_{4c} = 0.00$

$G_{3c} = \dfrac{\frac{1.2}{38} + \frac{1.2}{22}}{\frac{3.89}{36}} = \dfrac{.086}{.108} = .797$

$G_{2c} = \dfrac{\frac{1.2}{22} + \frac{1.2}{24}}{\frac{3.89}{36}} = \dfrac{.105}{.108} = .962$

$G_{1c} = \dfrac{\frac{1.2}{24}}{\frac{3.89}{36}} = \dfrac{.05}{.108} = .462$

FOR l = 3'-0

$G'_{4c} = 0.00$

$G'_{3c} = \dfrac{.086}{.059} = 1.458$

$G'_{2c} = \dfrac{.105}{.059} = 1.779$

$G'_{1c} = \dfrac{.05}{.059} = .847$

[illegible]

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC - DB - 08 SET B Sheet No. 16

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.8.84									
Checker		12-20-84									

Type Ia - (CONT'D).

EFFECTIVE LENGTH OF HORIZ MEMBERS

IN IT'S STRONG DIRECTION TRANSLATION IS FIXED AND ROTATION CAN BE ASSUMED FREE.

$\therefore$ $K = 1.0$ - (CASE d OF AISC TABLE C1.8.1).

IN IT'S WEAK DIRECTION, ASSUMING THAT CABLE TRAYS PROVIDE LATERAL SUPPORT, K CAN BE TAKEN AS 1.0

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client . P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 17

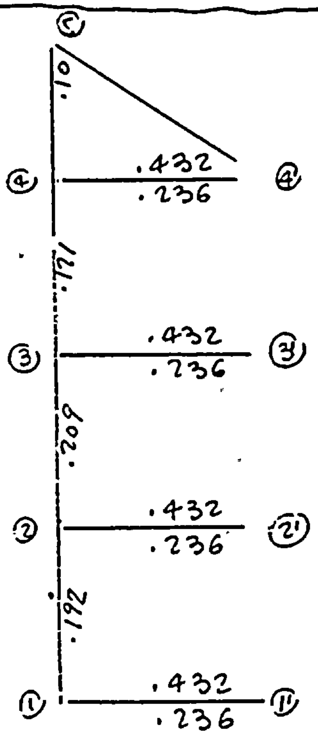
Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	11.2.84								
Checker		12-20-84								

Type Ia - (CONT'D)

CORESPONDINGLY :

$K_{43\,VERT} = 1.15$	$k_{43\,VERT} = 1.2$
$k_{32\,VERT} = 1.3$	$k_{32\,VERT} = 1.5$
$k_{21\,VERT} = 1.25$	$k_{21\,VERT} = 1.42$
FOR $l = 3'-0$	FOR $l = 5'-6$

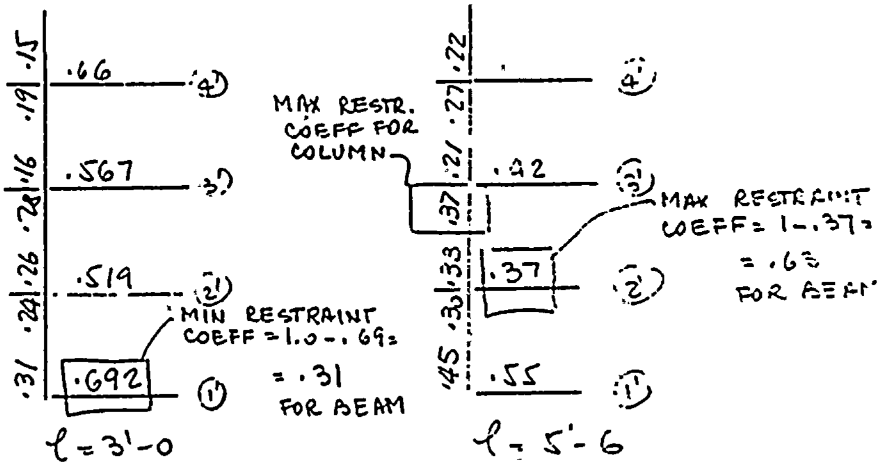
APROXIMATE CALCULATION OF MAXIMUM END MOMENT COEFF.



$G_{45} = 0$ $G_{43} = \frac{4 \times 1.15}{38} = .121$ $G_{44'} = \frac{4 \times 3.89}{36} = .$[illegible] $l = 3'-0.$

$G_{44'} = \frac{4 \times 3.89}{66} = .236$ $l = 5-6$

$G_{32} = \frac{4 \times 1.15}{22} = .209$ $G_{21} = \frac{4 \times 1.15}{.24} = .192$



MOMENT DISTRIBUTION COEFICIENTS

Gibbs & Hill, Inc. Job No. 3544 Client D.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

alculation Number SC-DB-08 SET B Sheet No. 18

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.2.84									
Checker		12-20-84									

Type Ia - (CONT'D)

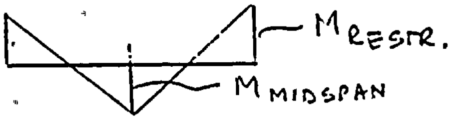
CHECK HORIZONTAL MEMBER. $C4 \times 7.25$

$k_{max} = 1.0$

$\frac{kl}{r_x} = \frac{1.00 \times 5.5 \times 12}{1.42} = .46$ $F_a = \frac{12\pi^2 \times 29 \times 10^3}{23 \times 150^2} = 6.63\text{ksi}$

$\frac{kl}{r_y} = \frac{1.0 \times 5.5 \times 12}{.44} = 150.0$

$P_{DL} = .67^k$ (SEE SH. 13 R.0)



$M_{DL\ RESTR.MAX} = \frac{.63 \times .67 \times 5.5}{8} = .29'^k$ $M_{DL\ RESTR.MIN} = \frac{.31 \times .67 \times 5.5}{8} = .14'^k$

$M_{DL\ MIDSPAN\ MAX} = \frac{.67 \times 5.5}{4} - .14 = .92 - .14 = .78'^k$ $M_{DL\ MIDSPAN\ MIN} = .92 - .29 = .63'^k$

$M_{V\ RESTR} = 1.2 \times .29 = .35'^k$ $M_{V\ MIDSPAN} = 1.2 \times .78 = .94'^k$

$P_{AT_{max}} = 2 \times .58 = 1.16^k$ $M_{T_{max}} = 1.26'^k$

$M_L = \frac{7.25 \times 5.5^2}{12} \times .54 = 10^{\#'}$ @ ENDS $M_L = 5^{\#'}$ @ MIDSPAN

$fa_T = \frac{1.16}{1.93} = .60\text{ ksi}$ $fb_{DL_1} = \frac{.78 \times 12}{1.95} = 4.80\text{ ksi}$

$fb_{V_1} = \frac{.94 \times 12}{1.95} = 5.78\text{ ksi}$ $fb_{T_1} = 0$ $fb_{L_2} = \frac{.005 \times 12}{.296} = .2\text{ ksi}$

in MIDSPA

METHOD 1 $\frac{4.80}{21.6} + \left[\left(\frac{.6}{6.63}\right)^2 + \left(\frac{5.78}{21.6}\right)^2 + \left(\frac{.2}{21.6}\right)^2\right]^{1/2} = .505 < 1.0$

METHOD 2 $\frac{.6}{6.63} + \frac{4.8 + 5.78}{21.6} + \frac{.2}{21.6} = .590 < 1.0$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 19

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.2.84									
Checker	VS	12.20.84									

Type Ia - (CONT'D)

$f_{aT} = .60$ ksi $\quad f_{bDL_1} = \frac{.29 \times 12}{1.95} = 1.78$ ksi $\quad f_{bV_1} = \frac{.35 \times 12}{1.95} = 2.15$ ksi

$f_{bT_1} = \frac{1.26 \times 12}{1.95} = 7.75$ ksi $\quad f_{bL_2} = 0.4$ ksi

METHOD 1. $\frac{1.78}{21.6} + \left[\left(\frac{.60}{6.63} + \frac{7.75}{21.6}\right)^2 + \left(\frac{2.15}{21.6}\right)^2 + \left(\frac{.4}{21.6}\right)^2\right]^{1/2} = .543 < 1.0$

METHOD 2. $\frac{.6}{6.63} + \frac{1.78 + (2.15^2 + 7.75^2)^{1/2}}{21.6} + \frac{.4}{21.6} = .564 < 1.0$

THE EFFECTS OF THE EXCENTRIC APPLICATION OF TRAY LOADS ON SUPPORT BEAMS ARE NOT INCLUDED SINCE THE SUPPORTS ARE CONSERVATIVELY DESIGNED FOR CENTRAL APPLICATION OF TRAY LOAD.

FOR CONN. WELD SEE SH. 73 R.0

CHECK VERTICAL MEMBER C8 x 11.5

$K_{max} = 1.3$ (FOR $l = 3'-0$)

$\frac{kl}{r_x} = \frac{2 \times 10 \times 12}{3.04} = 78.9 \qquad \frac{kl}{r_y} = \frac{1.3 \times 3.8 \times 12}{.61} = 81.0 \qquad F_a = 15.24$ ksi

$M_{T_{max}} = .92^{1k}$ ASSUMING THE HORIZONTAL MEMBER IS PINNED.

$M_{DL} = (.37 \times .67 \times 5.5) \times \frac{1}{8} = .17^{1k}$

$M_y = 1.2 \times .17 = .2^{1k}$

} MAX MOM OCCURING AT JOINT I.

$V_{DL} = .0115 \times 10 + 3 \times \frac{.67}{2} + \frac{1}{2} \times (.0072 \times 5.5 + .0072 \times 4.23) = 1.15^k$

$V_V = 1.2 \times 1.15 = 1.39^k$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

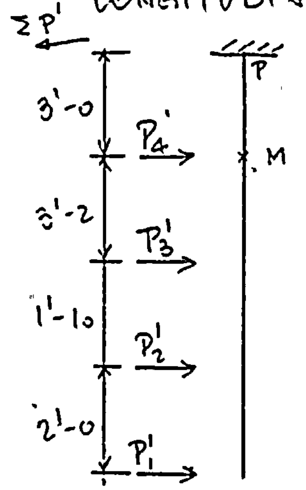
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-0

Calculation Number SC-DB-08 SET B Sheet No. 20

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	RS	10.16.84								
Checker		12-20-84								

Type Ia - (CONT'D)

LONGITUDINAL EFFECT (FRAME ONLY - NO TRAYS)



THESE LOADS ARE FOR TWO VERT MEMBERS

$$P_1' = (\overbrace{7.25 \times 5.5}^{40} + \overbrace{2 \times 11.5 \times 1.0}^{23}) \times .54 = 34^{\#}$$

$$P_2' = (40 + \overbrace{2 \times 11.5 \times 1.91}^{44}) \times .54 = 45.4^{\#}$$

$$P_3' = (40 + \overbrace{2 \times 11.5 \times 2.5}^{57.5}) \times .54 = 52.7^{\#}$$

$$P_4' = (40 + \overbrace{2 \times 11.5 \times 4.58}^{105.3} + \overbrace{7.2 \times 4.23}^{30.4}) \times .54 = 94.9^{\#}$$

$\Sigma P' = \frac{1}{2} \times 227 = 113.5^{\#}$ / ONE VERT MEMB.:

$$M_{@M} = \frac{1}{2}(34 \times 7 + 45.4 \times 5 + 52.7 \times 3.16) = 315.8^{1\#}$$

$$M_{@P} = \frac{1}{2}(34 \times 10 + 45.4 \times 8 + 52.7 \times 6.16 + 94.9 \times 3) = 655.2^{1\#}$$

$f_{a_{DL}} = \frac{1.15}{3.11} = .37$ ksi $f_{a_V} = \frac{1.39}{3.11} = .45$ ksi $f_{b_{L_2}@M} = \frac{315.8 \times 12}{7.18} = 528$ psi

$f_{b_{T_1}} = \frac{.91 \times 12}{.68} = 16.05$ ksi $f_{a_{T_2}} = \frac{1.32}{3.11} = .42$ ksi

$f_{b_{DL_1}} = \frac{.17 \times 12}{.68} = 3$ ksi $f_{b_{V_1}} = \frac{.2 \times 12}{.68} = 3.6$ ksi

THESE VALUES ARE CONSERVATIVE BECAUSE

L = 3'-0 IS USED FOR CALC'S OF P_T LOADS AND L = 5'-6 IS USE

FOR CALC'S OF P_L & P_V LOADS AND LOCATION OF P_T & P_V MAX D

NOT COINCIDE WITH LOCATION OF M_T, M_V & M_{DL} MAX

METHOD 1 $$-\frac{.37}{15.24} + \frac{3.0}{21.6} + \left[\underset{V}{\left(\frac{.45}{15.24} + \frac{3.6}{21.6}\right)^2} + \underset{T}{\left(\frac{.42}{15.24} + \frac{16.05}{21.6}\right)^2} + \underset{L}{\left(\frac{.53}{21.6}\right)^2}\right]^{1/2} = .909 < 1$$

O.K.

METHOD 2 $$\frac{-.37 + (.45^2 + .42^2)^{1/2}}{15.24} + \frac{3.0 + (3.6^2 + 16.05^2)^{1/2}}{21.6} + \frac{(.42^2 + .53^2)^{1/2}}{21.6} = .947 < 1$$

O.K.

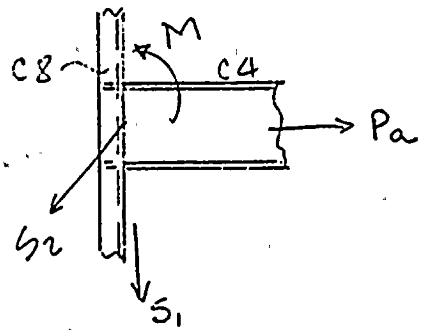
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject T/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 21

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	11.27.84								
Checker		12 20-84								

Type Ia - (CONT'D)



MAX. FORCES TO BE CONSIDERED IN DESIGNING THE CONNECTION:

$M_{DL} = .29^{1k}$ $M_V = .35^{1k}$ $M_T = 1.26^{1k}$

$Pa_T = 1.16^k$

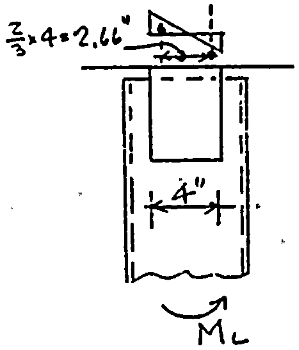
$S_{1DL} = \frac{0.67}{2} = 0.34^k$ $S_{1V} = 1.2 \times 0.34 = 0.41^k$

$S_{1T} = \frac{2 \times 1.26}{3} = .84^k$

$S_{2L} = \frac{7.25 \times 5.5}{2} \times .54 = 10^{\#}$

TOTAL REACTION @ CEILING CONNECTION (SUPP'T Ia)

REFER TO CONN. DETAIL ON SH. 72 R.0



$T_{\text{DUE TO } M_L} = \frac{656.2 \times 12}{2.66} = 2960^{\#}$ (see sh. 20 - M_{LP})

$\downarrow\uparrow$ 3.18 TRANSV. $\leftrightarrows$ 1.25 TRANSV.

$\downarrow$ 1.15 D.L.

$\downarrow$ 1.39 VERT.

$\downarrow\uparrow$ 2.96 LONGIT

$V_{max} = 1.15 + \left[3.18^2 + 1.39^2 + 2.96^2\right]^{1/2} = 5.71^k < \frac{11.52}{1.3}$ (see sh. 41)

O.K.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

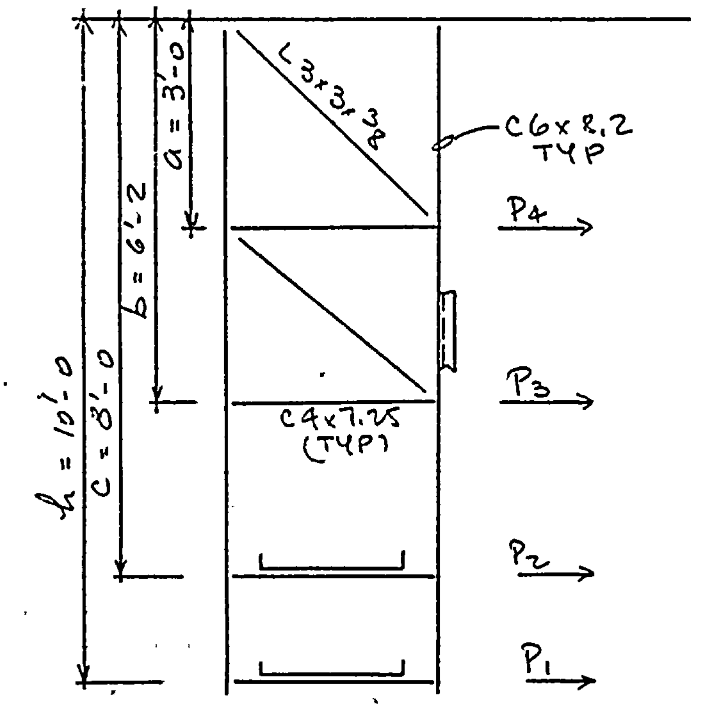
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL 675-

Calculation Number SC-DB-08 SET B Sheet No. 22

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	10.15.84								
Checker		12.20-84								

3.2 TYPE IIa - TRANSVERSAL SUPPORT



FROM SH. 13 R.0

$$P_1 = .36 + \overbrace{2 \times .0082 \times 1.0 \times .54}^{.008} = .368$$

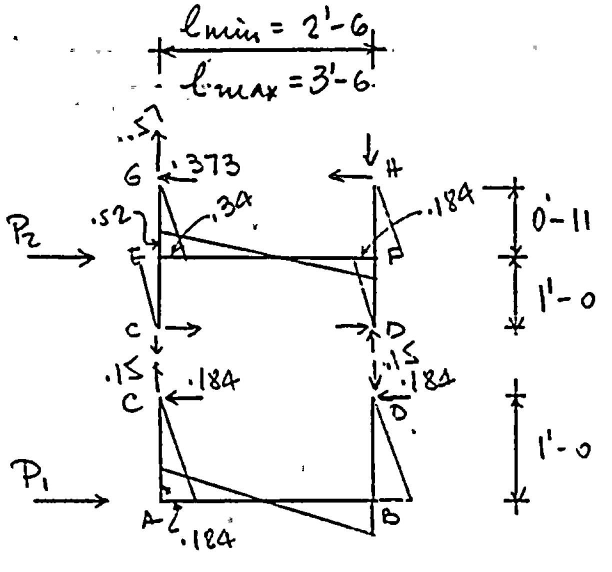
$$P_2 = .36 + \overbrace{2 \times .0082 \times 1.92 \times .54}^{.017} = .377^k$$

$$P_3 = (.04 + 2 \times .0082 \times 2.51 \times .54 +$$

$$+ \overbrace{.0072 \times 3.9 \times .54}^{.015} = .06^k$$

$$P_4 = (.04 + 2 \times .0082 \times 4.58) \times .54 +$$

$$+ .0072 \times 4.25 \times .54 = .079^k$$



$$M_A = M_B = \frac{.368}{2} \times 1.0 = .124^{'k}$$

$$H_c = \frac{.368}{2} = .184^k$$

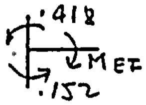
$$V_c = .368 \times \frac{1.0}{2.5} = .15^{'k}$$

$$H_G = \frac{.377}{2} + .184 = .373^k$$

$$V_G = \frac{1}{2.5}(.368 \times 2.91 + .377 \times .91) =$$

$$= .57^k$$

$$M_{GE} = .373 \times .91 = .34$$



$$\underset{\text{TOTAL}}{M_{EF}} = .340 - .124 = .52^{'k}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

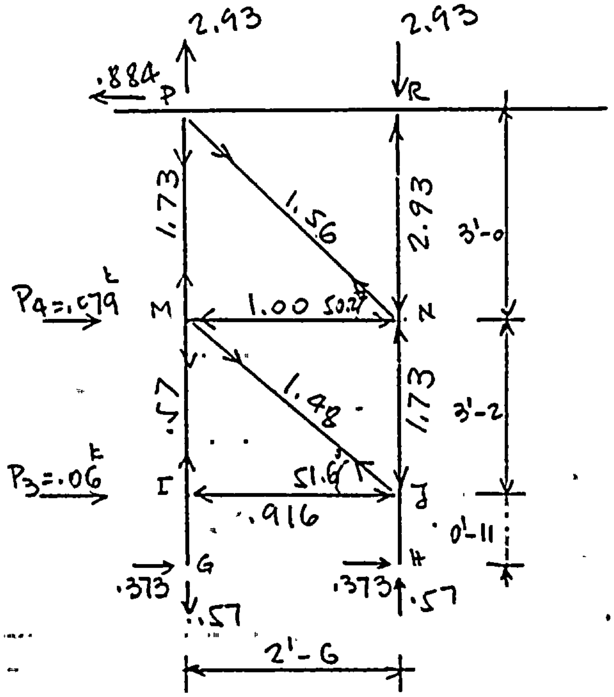
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET B Sheet No. 23

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	R.S.	10.15.84									
Checker		12 20-84									

Type IIa - (CONT'D)



$$V_P = \frac{1}{2.5}\left[.368\times10 + .377\times8.0 + .06\times6.16 + .079\times3\right]$$

$$= 2.93^k$$

LONGITUDINAL EFFECT SIMILAR TO TYPE Ia

$$P_1' = (.04 + .0082\times2)\times.54 = .03$$

$$P_2' = (.04 + .0082\times1.92\times2)\times.54 = .039$$

$$P_3' = .06^k$$

$$P_4' = .079^k$$

} FOR TWO VERTICAL MEMBERS

$$M_L = \frac{1}{2}(.03\times10.0 + .039\times8.0 + .06\times6.16 + .079\times3.0) = .61^{\prime k}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

7c

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

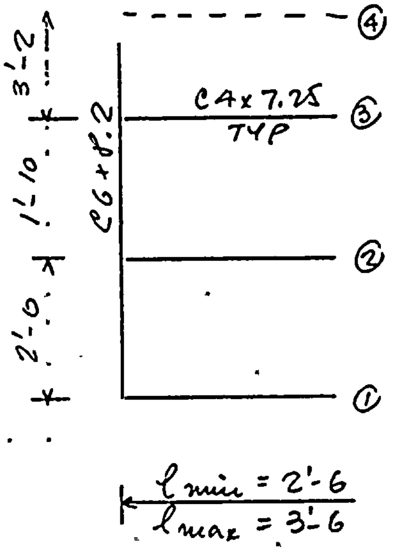
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 24

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11-8-84									
Checker		12-20-84									

Type IIa - (CONT'D)

EFFECTIVE LENGTH OF VERTICAL AND HORIZ. MEMBERS:



BY TAKING A LOOK AT k VALUES CALCULATED FOR SUPP'T TYPE Ia IT IS OBSERVED THAT k TAKES HIGHER VALUES FOR A LARGER l

AS A RESULT ONLY $l_{max} = 3'-6$ WILL BE CHECKED.

$I_{C6} = .604 in^4$ $I_{C4} = 3.89 in^4$

$G_{3_C} = 0.00$

$$G_{2_C} = \frac{\frac{.60}{22} + \frac{.60}{24}}{\frac{3.89}{42}} = \frac{.055}{.093} = .56$$

$$G_{1_C} = \frac{\frac{.60}{24}}{\frac{3.89}{42}} = \frac{.026}{.093} = .27$$

CORESPONDINGLY :

$K_{32\,VERT} = 1.10$

$K_{21\,VERT} = 1.15$

K_{MAX} IS 1.15 FOR VERTICAL MEMBER < k = 1.5 FOR SUPP'T Ia
CONSERVATIVELY USE SAME k VALUES AS FOR SUPP'T Ia FOR VERTICAL MEMBER.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET B Sheet No. 25

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.8.84									
Checker		12-20-84									

Type IIa -(CONT'D)

FOR HORIZ MEMBER: SPAN IS SMALLER THAN TYPE Ia
∴ TYPE Ia IS MORE CRITICAL, SO
SAME SIZE FOR IIa IS O.K.

CHECK C6 x 8.2

$$\frac{kl}{r_x} = \frac{2 \times 10 \times 12}{2.28} = 105.3$$

$$\frac{kl}{r_y} = \frac{1.5 \times 3.16 \times 12}{.529} = 108 \qquad F_a = 11.94 \text{ ksi}$$

FOR 5'-6 SPAN

$$V_{DL} = 8.2 \times 10 + 2 \times \frac{67.0}{2} + \frac{1}{2} \times 7.2 \times 4.25 \times 2 = 782^{\#}$$

$$V_V = 1.2 \times 782 = 940^{\#}$$

$$V_{T_{max}} = 2.93^k \text{ (CONSERVATIVE)} \qquad M_{T_{max}} = .34^{1k}$$

FROM SH. 19, R.0
FOR 5'-6 SPAN & SAME
F.E. COEFF.

$$M_{DL} = .17^{1k}$$
$$M_V = .2^{1k}$$

$$fa_{DL} = \frac{.78}{2.16} = .36 \text{ ksi} \qquad fa_V = \frac{.94}{2.16} = .44 \text{ ksi} \qquad fa_T = \frac{2.93}{2.16} = 1.36 \text{ ksi}$$

$$fb_{T_1} = \frac{.34 \times 12}{.429} = 9.51 \text{ ksi} \qquad fb_{L_2} = \frac{.61 \times 12}{3.74} = 1.96 \text{ ksi} \qquad fb_{DL_1} = \frac{.17 \times 12}{.429} = 4.76 \text{ ksi}$$

$$fb_{V_1} = 1.2 \times 4.76 = 5.7 \text{ ksi}$$

$$\text{METHOD 1} - \frac{.36}{11.94} + \frac{4.76}{21.6} + \left[\left(\frac{.44}{11.94} \underset{V}{+} \frac{5.7}{21.6}\right)^2 + \left(\frac{1.36}{11.94} \underset{T}{+} \frac{9.51}{21.6}\right)^2 + \left(\underset{L}{\frac{1.96}{21.6}}\right)^2\right]^{1/2} = .826 < 1.0$$

$$\text{METHOD 2} - \frac{.36 + (.44^2 + 1.36^2)^{1/2}}{11.94} + \frac{4.76 + (5.7^2 + 9.51^2)^{1/2}}{21.6} + \frac{1.96}{21.6} = .914 < 1.0$$

O.K.

SUMMARY:

HANGERS SUPPORTING 2 x 2'-0 TRAYS - USE C6

— " — — " — 3 x 2'-0 — " — — USE C8

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

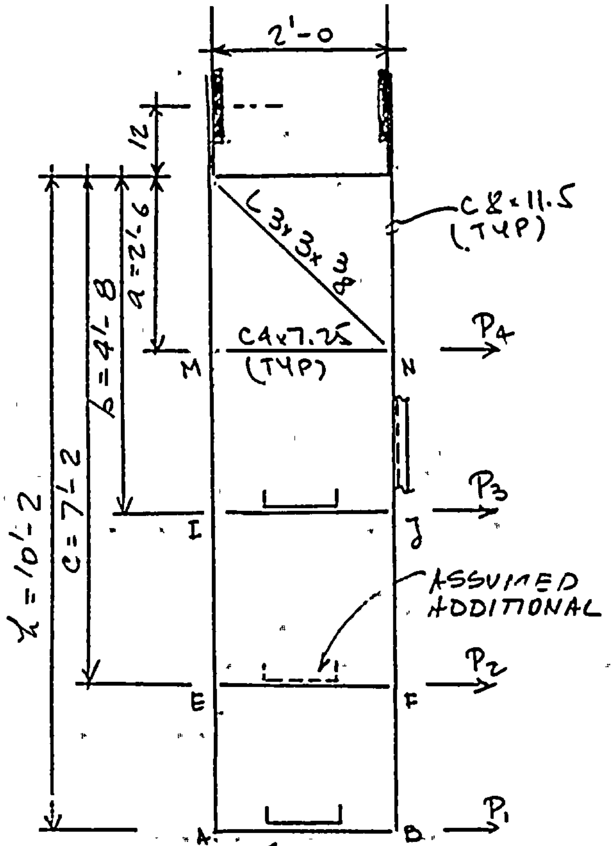
Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

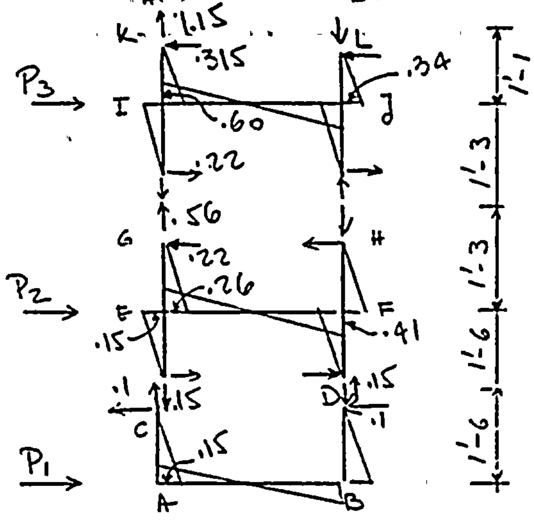
Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC - DB - 08 SET B Sheet No. 26

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	10.15.84								
Checker		12-20-84								

3.3 TYPE Ia_1 - TRANSVERSAL SUPPORT





CAPACITY : 3 x 1'-0 TRAYS

MAX TRAY LOAD :

$35 \times 9 = 315^{\#}$

HORIZ MEMBER LOAD :

$7.25 \times 2 = 15^{\#}$

$$P_1 = (.315 + .015 + \overbrace{2 \times .0115 \times 1.5}^{.03}) \times .54 = .20^k$$

$$P_2 = (.315 + .015 + \overbrace{2 \times .0115 \times 2.75}^{.06}) \times .54 = .21^k$$

$$P_3 = (.315 + .015 + \overbrace{2 \times .0115 \times 2.35}^{.05}) \times .54 = .21^k$$

$$P_4 = (.015 + 2 \times .0115 \times 4.58 + .0072 \times 3.5) \times .54 =$$
$$= .08^k$$

$$H_C = \frac{.20}{2} = .10^k \qquad M_A = .1 \times 1.5 = .15$$

$$V_C = .20 \times 1.5 \times \frac{1}{2.0} = .15^k$$

$$H_G = \frac{.23}{2} + .1 = .22^k$$

$$V_G = \frac{1}{2.0} \cdot (.2 \times 4.25 + .21 \times 1.25) = .56^k$$

$$M_{GE} = .21 \times 1.25 = .26^{'k}$$

$$H_K = \frac{.21}{2} + .21 = .315^k$$

$$V_K = \frac{1}{2.0} (.2 \times 6.58 + .21 \times 3.58 + .21 \times 1.08) = 1.15^k$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

F-166, 7-82

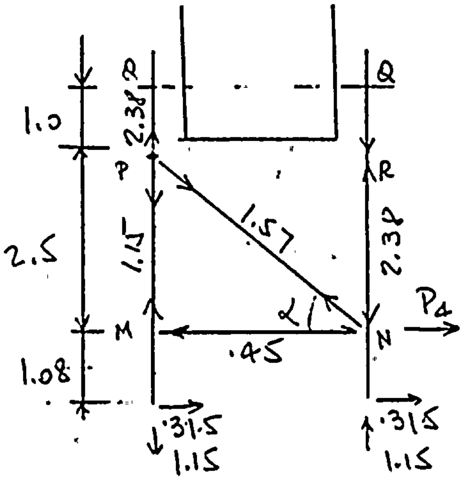
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 27

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	10.15.84									
Checker		12-20-84									

Type Ia_1 -(CONT'D)



$M_{KI} = .315 \times 1.08 = .34^{1k}$

$M_{IJ} = .34 + .26 = .60^{1k}$

$H_p = 2 \times .325 + .08 = .73^{k}$ $\alpha = \arctan \frac{2.5}{2.0} = 57.3$

$M_Q = .70 \times 1.0 = .70^{1k}$

$M_L = .96^{1k}$ (same as Type IIa)

VERT. MEMBER C8x11.5

$M_{T\,max} = .60^{1k}$ $V_{max\,T} = 2.38^{k}$ $M_L = .32^{1k}$ (see sh. 20.R.0) CONSERVATIV O.K.

$V_{DL} = \frac{1}{.54} \times \frac{1}{2} \times (.20 + .21 + .21 + .08) = .65^{k}$ $V_V = 1.2 \times .65 = .78^{k}$

FROM SH. 172R.0 $K_{32\,VERT}$ IS CRITICAL

FOR $\ell = 2'-0$ $G_3 = 0.00$ $G_2 = \frac{\frac{1.2}{26} + \frac{1.2}{30}}{\frac{3.89}{24}} = .53$

$K_{32\,VERT} = 1.1$

MOMENT DISTRIBUTION COEF: $G_{23} = \frac{4 \times 1.15}{30} = .15$

$G_{21} = \frac{4 \times 1.15}{26} = .18$ $G_{1,1'} = \frac{4 \times 3.89}{24} = .65$

$f_{21} = \frac{.18}{.15 + .15 + .65} = .184$ $M_{DL} = \frac{.184 \times .33 \times 2}{8} = .015^{1k}$

$M_V = 1.2 \times .015 = .018^{1k}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET B Sheet No. 28

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.2.84									
Checker		12-20-84									

Type Ia_1 - (CONT'D)

$\frac{kl}{r_x} = \frac{7.66 \times 12}{3.04} = 30.2$ $\frac{kl}{r_y} = \frac{1.2 \times 3.0 \times 12}{.61} = \underset{\text{GOVERNS}}{\underline{71}}$ $F_a = 16.33$ ksi

$f_{a_{DL}} = \frac{.65}{3.11} = .21$ ksi $f_{a_V} = \frac{.78}{3.11} = .25$ ksi $f_{a_T} = \frac{2.38}{3.11} = .76$ ksi

$f_{b_{T_1}} = \frac{.60 \times 12}{.68} = 10.59$ ksi $f_{b_{L_2}} = \frac{.32 \times 12}{7.18} = .53$ ksi $f_{b_{DL_1}} = \frac{.015 \times 12}{.68} = .26$ ksi

$f_{b_{V_1}} = 1.2 \times .26 = .32$ ksi

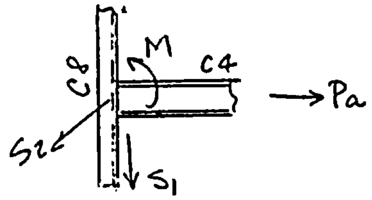
METHOD 1 $\frac{.21}{16.33} + \frac{.26}{21.6} + \left[\left(\frac{.25}{16.33} + \frac{.32}{21.6}\right)^2 + \left(\frac{.76}{16.33} + \frac{10.59}{21.6}\right)^2 + \left(\frac{.53}{21.6}\right)^2\right]^{1/2} = .563 < 1.0$

METHOD 2 $\frac{.21 + (.25^2 + .76^2)^{1/2}}{16.33} + \frac{.26 + (.32^2 + 10.59^2)^{1/2}}{21.6} + \frac{.53}{21.6} = .589 < 1.0$ O.K.

FORCES TO BE CONSIDERED IN DESIGNING THE CONN.:

$M_{DL} = .015'^{k}$; $M_V = .018'^{k}$

$M_T = .6'^{k}$ $P_a = .70^{k}$



$S_{1_{DL}} = \frac{.33}{.2} = .165$ $S_{1_V} = 1.2 \times .165 = 0.2^{k}$

$S_{1_T} = \frac{2 \times .6}{2} = .6^{k}$ $S_{2_L} = \frac{7.25 \times 2}{2} \times .54 = 4^{\#}$

MOMENT @ Q, DUE TO OFSET IN BRACING :

$M_{T_Q} = 1.57 \times .707 \times 12 = 13.18''^{k}$ $f_{b_{T_p}} = \frac{13.18}{.68} = 19.38$ ksi

CONSERVATIVELY, USING M_{T_p} IN CHECKING THE VERT. MEMBER:

METHOD 1 : $\frac{.21}{16.33} + \left[\left(\frac{.25}{16.33}\right)^2 + \left(\frac{.76}{16.33} + \frac{19.38}{21.6}\right)^2 + \left(\frac{.53}{21.6}\right)^2\right]^{1/2} = .957 < 1.0$

METHOD 2 : $\frac{.21 + (.25^2 + .76^2)^{1/2}}{16.33} + \frac{19.38}{21.6} + \frac{.53}{21.6} = .983 < 1.0$

Checking Method #

1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

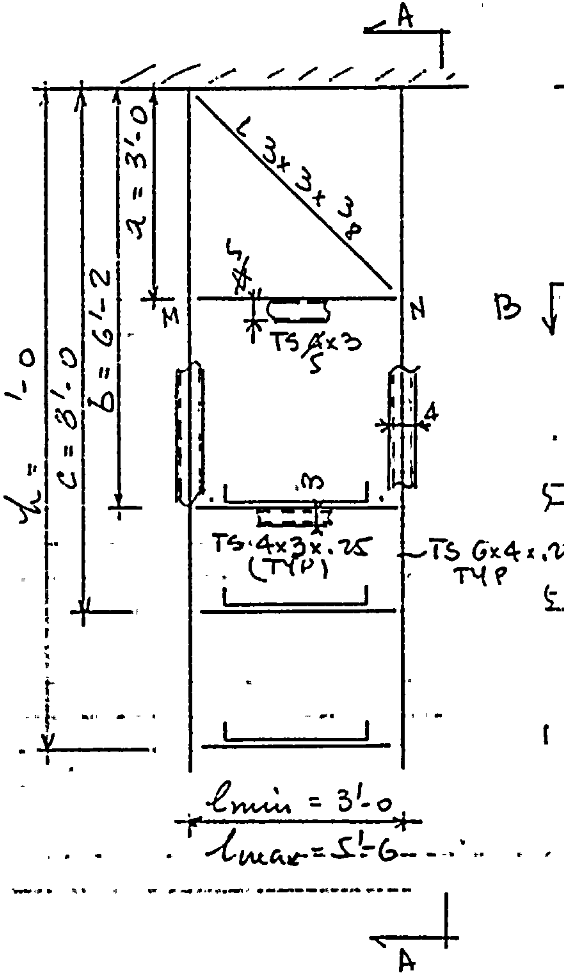
Calculation Number SC-DB-08 SET B Sheet No. 29

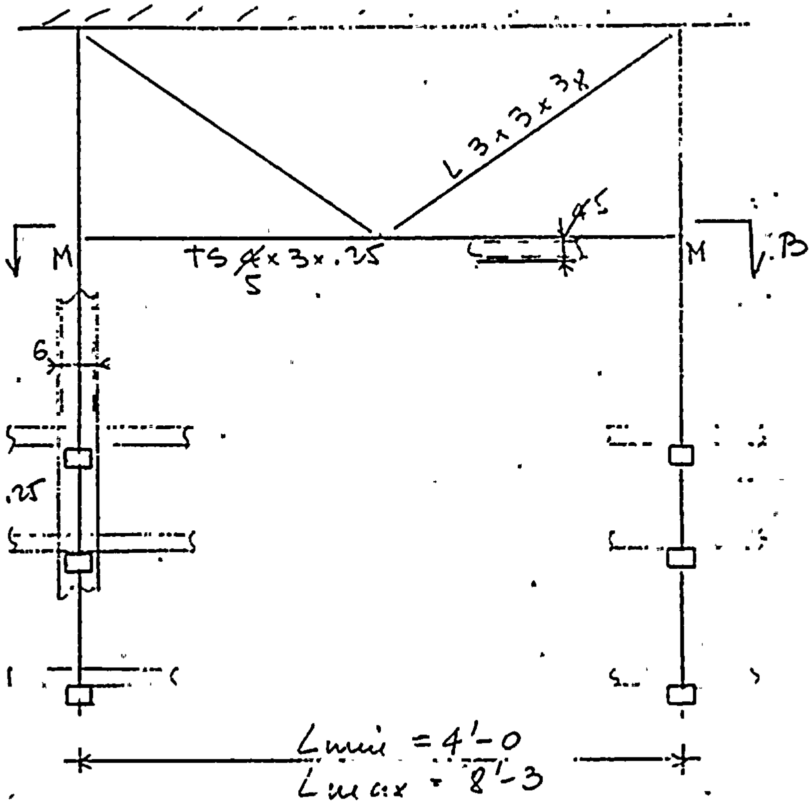
Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.16.84									
Checker		12.20.84									

4.0 MULTIDIRECTIONAL SUPPORTS:

4.1 TYPE Ib - MULTIDIRECTIONAL SUPPORT

CAPACITY: 3x 2'-0 TRAYS



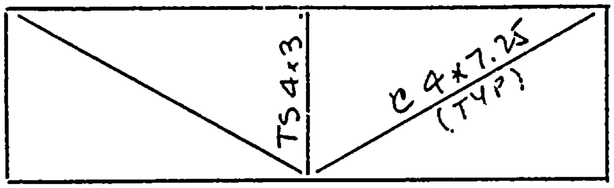


SECT A-A

TRIBUTARY LONG. SPAN:

L = 6'-0 → 21'-0

32'-0 - MAX LONG SPAN (CONSERVATIVE ASSUMPTION)



PLAN B-B

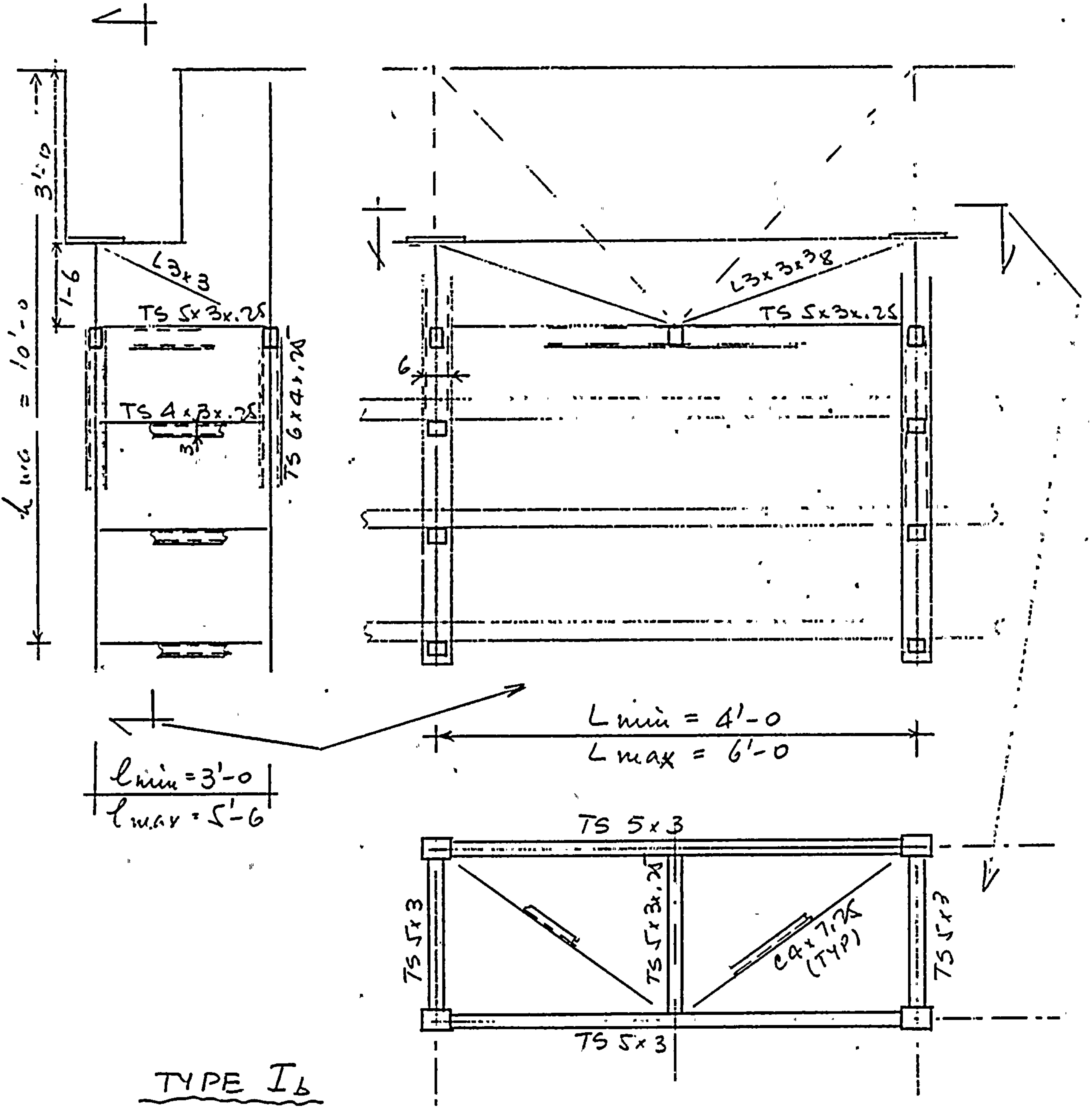
Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 30

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	R.S.	10.27.84									
Checker		12-20-84									

Type I_b - (CONT'D)



TYPE I_b

MULTIDIRECTIONAL SUPPORT (ALTERNATIVE)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

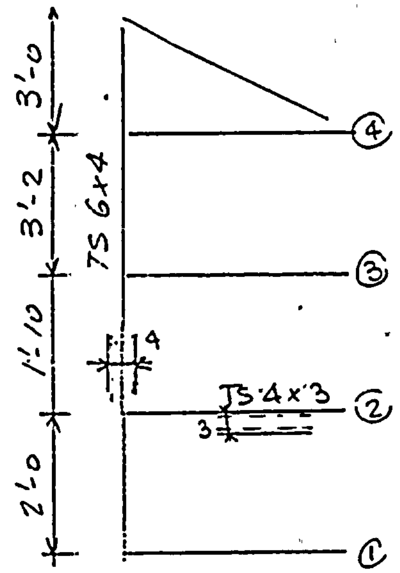
Subject D/G & BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 31

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.8.84									
Checker	KB	12.20-84									

Type I_b -(CONT'D)

EFFECTIVE LENGTH OF VERTICAL AND HORIZ. MEMBERS:



$l_{min} = 3'-0$

$l_{max} = 5'-6$

$I_{TS6} = 11.7$ $I_{TS4} = 4.1$

$G_{4_c} = 0$

$$G_{3_c} = \frac{\frac{11.7}{38} + \frac{11.7}{22}}{\frac{4.1}{36}} = \frac{.84}{.114} = 7.36$$

$$G_{2_c} = \frac{\frac{11.7}{22} + \frac{11.7}{24}}{\frac{4.1}{36}} = \frac{1.019}{.114} = 8.94$$

$$G_{1_c} = \frac{\frac{11.7}{24}}{\frac{4.1}{36}} \rightarrow \frac{.487}{.114} = 4.28$$

FOR $l = 3'-0$

$G'_{4_c} = 0$

$$G'_{3_c} = \frac{.84}{.062} = 13.5$$

$$G'_{2_c} = \frac{1.02}{.062} = 16.45$$

$$G'_{1_c} = \frac{.487}{.062} = 7.85$$

FOR $l = 5'-6$

CORRESPONDINGLY:

K_{43} VERT = 1.6

K_{32} VERT = 2.8

K_{21} VERT = 2.4

FOR $l = 3'-0$

K_{43} VERT = 1.8

K_{32} VERT = 3.5

K_{21} VERT = 3.1

FOR $l = 5'-6$

FOR BEAMS:

IN VERTICAL DIRECTION $k = 1.0$

IN HORIZONTAL DIRECTION k DEPENDS UPON TORSIONAL & BENDING STIFFNESS OF COL'S TUBE WHICH ARE HIGH, ALSO TRAY CAN BE ASSUMED LATERALLY SUPPORTING THE HORIZ MEMBERS

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

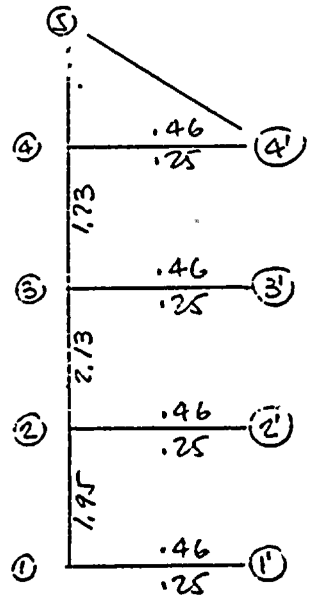
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET B Sheet No. 32

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.8.84									
Checker	KB	12.20.84									

Type I_b - (CONT'D)

MOMENT DISTRIBUTION COEFICIENTS (MAX & MIN.)



$G_{45} = 0$

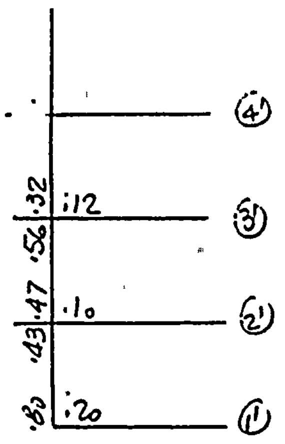
$G_{43} = \frac{4 \times 11.7}{38} = 1.23$

$G_{32} = \frac{4 \times 11.7}{22} = 2.13$

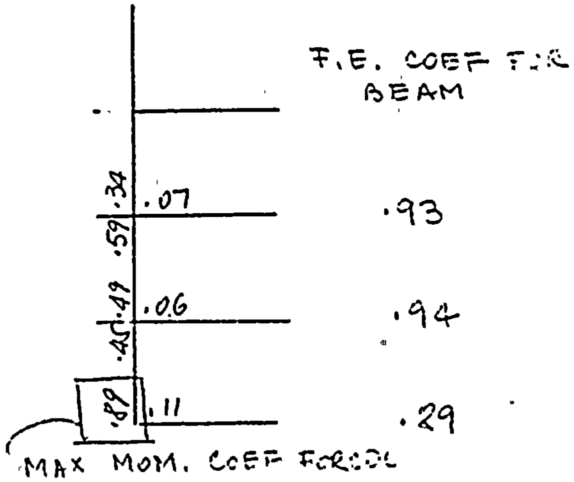
$G_{21} = \frac{4 \times 11.7}{24} = 1.95$

$G_{44'} = \frac{4 \times 4.1}{36} = .46$ $\ell = 3'\text{-}0$

$G_{44'} = \frac{4 \times 4.1}{66} = .25$ $\ell = 5'\text{-}6$



$\ell = 3'\text{-}0$



$\ell = 5'\text{-}6$

MOMENT DISTRIB. COEF.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

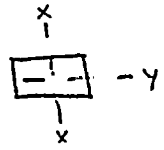
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

alculation Number SC-DB-08 SET B Sheet No. 33

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	RS	11.8.84								
Checker		12-20-84								

Type Ib - (CONT'D)

CHECK HORIZONTAL MEMBER TS 4×3×.25



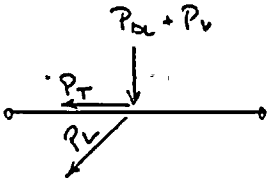
$\ell_{max} = 5'-6$ MAX TRIB. TRANSV. SPAN - 9'-0
MAX TRIB. LONGIT. SPAN - 32'-0

$S_x = 3.23$ $S_y = 2.74$

Fy FOR A500, GRADE B IS 46 ksi, HOWEVER Fy = 36 ksi WAS USED - - CONSERVATIVE APPROACH

$K_{x\,max} = 1.0$ (FROM SH. 32 R.0)
$K_{y\,max} = 1.0$

$\frac{K\ell}{r_x} = \frac{1.0 \times 5.5 \times 12}{1.45} = 46$ $\frac{k\ell}{r_y} = \frac{1.0 \times 5.5 \times 12}{1.15} = 57$ $F_a = 17.71$ k



$P_{DL} = 2 \times 35 \times 9 + 10.51 \times 5.5 = 688^{\#}$

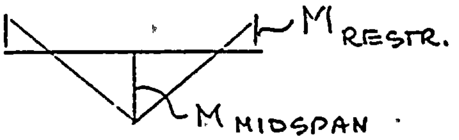
$P_{T_1} = .54 \times 688 = 371^{\#}$ ONE BEAM

$P_{T_2} = 2 \times .58 = 1.16^{k}$ (MAX. IN MEMBER L=3'-0 See sh. 14 R.0.).

$P_V = 1.2 \times 688 = 826^{\#}$

$P_L = .54 \times \left(\overbrace{\frac{2 \times 35 \times 32}{2}}^{1.120} + \overbrace{5.5 \times 10.51}^{.58}\right) = 636^{\#}$

MEMBER 3-3'



$M_{DL\ RESTR} = \frac{.69 \times 5.5}{8} \times .93 = .44^{'k}$

$M_{DL\ MIDSPAN} = \frac{.69 \times 5.5}{4} - .44 = .51^{'k}$

$M_{T\ max\ @\ RESTR.} = 1.26^{'k}$ (see sh. 14 R.0)
APROX VALUE SINCE D.L. ARE DIFFERENT - O.K.

$M_{V\ RESTR} = 1.2 \times .44 = .53^{'k}$

$M_{L\ @\ MIDSPAN} = \frac{.636 \times 5.5}{4} = 0.87^{'k}$

$M_{V\ MIDSPAN} = 1.2 \times .51 = .61^{'k}$

FOR MAX MIDSPAN MOM CHECK MEMBER 1-1'

$M_{DL} = \left(\frac{.69 \times 5.5}{4} - \frac{.69 \times 5.5}{8} \times .89\right) = .53$ ALMOST SAME AS MEMBER 3-3'

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6"

Calculation Number SC - DB - 08 SET B Sheet No. 34

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.8.84									
Checker		12.20.84									

Type I_b - (CONT'D)

$f_{b_{DL}} = \frac{.44 \times 12}{2.74} = 1.93$ ksi

$f_{b_T} = \frac{1.26 \times 12}{2.74} = 5.52$ ksi

$f_{a_T} = \frac{1.16}{3.09} = .38$ ksi

$f_{b_V} = \frac{.53 \times 12}{2.74} = 2.32$ ksi

$f_{b_L} = 0$ THERE IS SOME RESTRAINT DUE TO TORSIONAL STIFFNESS OF TS 6x4 COL. SINCE STRESSES ARE VERY LOW AT END, MAY BE NEGLECTED

@ RESTR.

METHOD 1: $\frac{1.93}{21.6} + \left[\left(\frac{2.32}{21.6}\right)^2 + \left(\frac{.38}{17.71} + \frac{5.52}{21.6}\right)^2\right]^{1/2} = .386 < 1.0$

METHOD 2: $\frac{.38}{17.71} + \frac{1.93 + (2.32^2 + 5.52^2)^{1/2}}{21.6} = .388 < 1.0$

$f_{b_{DL}} = \frac{.51 \times 12}{2.74} = 2.23$ ksi $\quad f_{b_V} = \frac{.61 \times 12}{2.74} = 2.67$ ksi

$f_{b_T} = 0 \quad f_{b_L} = \frac{0.87 \times 12}{3.23} = 3.23$ ksi $\quad f_{a_T} = .38$ ksi

METHOD 1: $\frac{2.23}{21.6} + \left[\left(\frac{2.67}{21.6}\right)^2 + \left(\frac{.38}{17.71}\right)^2 + \left(\frac{3.23}{21.6}\right)^2\right]^{1/2} = .0.30 < 1.0$

METHOD 2: $\frac{.38}{17.71} + \frac{2.23 + 2.67}{21.6} + \frac{3.23}{21.6} = 0.40 < 1.0$

@ MID SPAN

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675-0

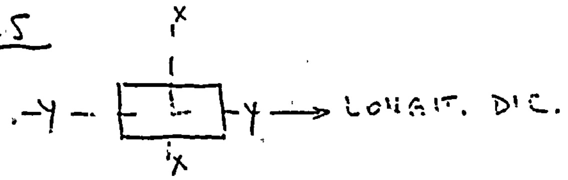
Calculation Number SC - DB - 08 SET B Sheet No. 35

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	10.16.84									
Checker		12.20.84									

Type I_b - (CONT'D)

VERTICAL MEMBER TS 6×4×.25

32'-0 - MAX TRIB. LENGTH FOR LONGIT. ACTION



LONGITUDINAL ACTION

TS 4×3×.25 wt

$$P_1' = .54 \times \left(\overbrace{\tfrac{1}{2} \times 2 \times 35 \times 32}^{1120} + \overbrace{5.5 \times 10.51}^{58} + \overbrace{2 \times 15.62 \times 1.0}^{31.2}\right) = 653^{\#}$$

$$P_2' = .54 \times \left(1120 + 58 + \overbrace{2 \times 15.62 \times 1.91}^{60}\right) = 668^{\#}$$

$$P_3' = .54 \times \left(1120 + 58 + \overbrace{2 \times 15.62 \times 2.5}^{78}\right) = 678^{\#}$$

$$P_4' = .54 \times \left(58 + \overbrace{2 \times 15.62 \times 4.58}^{143} + \overbrace{7.2 \times 6.26}^{45}\right) = 133^{\#}$$

FOR TWO VERT MEMBER.

$$M_L = (.653 \times 7 + .668 \times 5 + .678 \times 3.16) \times \frac{1}{2} = 5.03^{1k}$$ / PER LEG

@ MN LEVEL

$$V_{DL} = 15.62 \times 10 + 3 \times \frac{688}{2} + 10.51 \times 5.5 \times \frac{1}{2} + 7.2 \times 6.26 \times \frac{1}{2} = 1240^{\#}$$

$$V_V = 1.2 \times 1240 = 1488^{\#}$$

$M_{DL} = .34 \times \frac{.68 \times 5.5}{2} = .16^{1k}$ $M_V = 1.2 \times .16 = .19^{1k}$ | MEMBER 3-4

$M_{DL} = \frac{.59}{.34} \times .16 = .28^{1k}$ $M_V = 1.2 \times .28 = .33^{1k}$ | MEMBER 2-3

TRANSV. ACTION - USE RESULTS FROM TYPE I_a TRANSV. SUPP'T.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG. – CABLE TRAY SUPPORTS UP TO EL. 675'-0

Calculation Number SC – DB – 08 SET B Sheet No. 56

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	10.16.84								
Checker	KB	12.20.84								

Type Ib – (CONT'D)

$\frac{kl}{r_x} = \frac{2\times7\times12}{2.19} = 76.7$ $Fa = 15.69$ ksi

$\frac{kl_{43}}{r_y} = \frac{1.8\times3.2\times12}{1.6} = 43.0$ $\frac{kl_{32}}{r_y} = \frac{3.5\times1.83\times12}{1.6} = 48.0$

$fa_{DL} = \frac{1.24}{4.59} = .27$ ksi $fa_V = \frac{1.49}{4.59} = .32$ ksi $fa_T = \frac{3.18}{4.59} = .69$ ksi

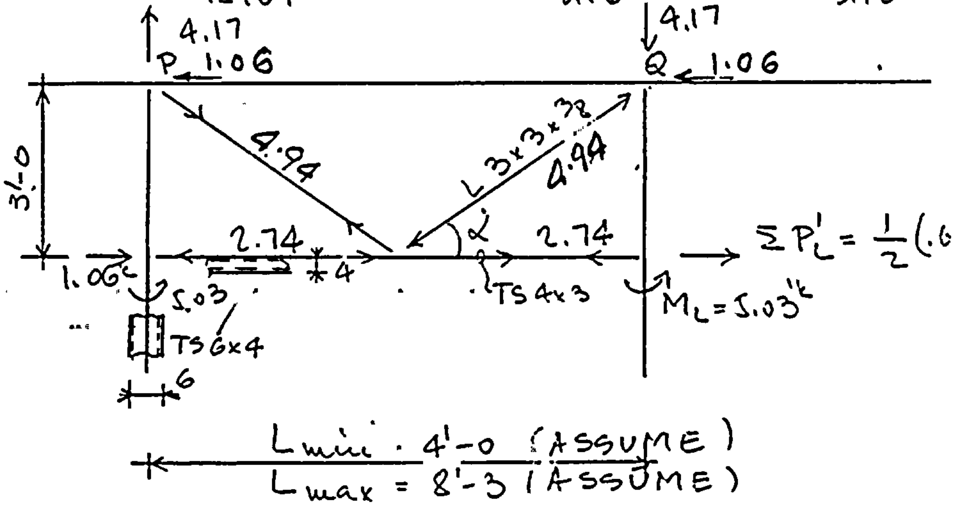
$fb_{DL} = \frac{.16\times12}{5.87} = .33$ ksi

$fb_T = \frac{.91\times12}{5.87} = 1.86$ ksi $fb_L = \frac{5.03\times12}{7.36} = 8.2$ ksi

$fb_V = 1.2\times.33 = .39$

METHOD 1: $\frac{.27}{15.69} + \frac{.33}{21.6} + \left[\left(\frac{.69}{15.69} + \frac{1.86}{21.6}\right)^2 + \left(\frac{.32}{15.69} + \frac{.39}{21.6}\right)^2 + \left(\frac{8.2}{21.6}\right)^2\right]^{1/2} = .491 < 1.0$

METHOD 2: $\frac{.27 + (.32^2 + .69^2)^{1/2}}{15.69} + \frac{.33 + (.39^2 + 1.86^2)^{1/2}}{21.6} + \frac{8.2}{21.6} = .549 < 1.0$



$\Sigma P'_L = \frac{1}{2}(.653 + .662 + .672 +$ [illegible]$) =$
$= 1.06^k$

L = 4'-0 $\alpha = \arctan\frac{3.0}{2.0} = 56.3°$

HORIZ MEMBER + BRACE LOAD: $(3.75\times10.51 + 4\times3.54\times7.2)\times.54 =$
$= 76^{\pm}$

$V_P = \frac{1}{4.0}\left[(2\times1.06 + .08)\times3.0 + 2\times5.03\right] = 4.17^k$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

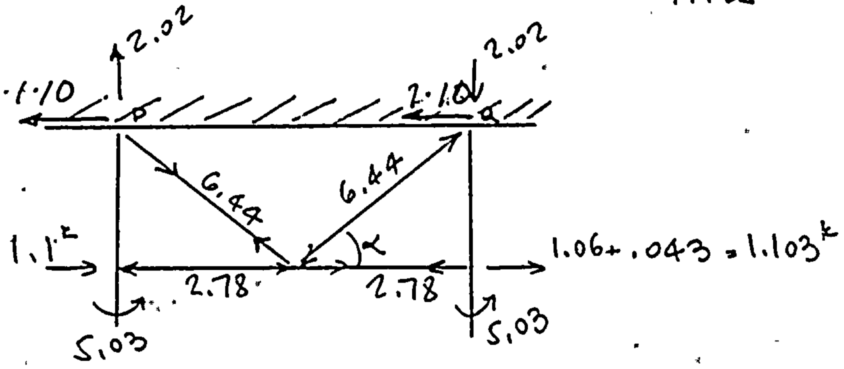
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 37

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.16.84									
Checker		12.20.84									

Type I_b - (CONT'D)

L = 8'-3 $\alpha = \arctan \frac{3.0}{4.125} = 36^\circ$



HORIZ MEMBER + BRACE LOAD : $(8.25 \times 10.51 + 2 \times 5.1 \times 7.2) \times .54 =$

$= 86^{\#}$

$$V_p = \frac{1}{8.25}\left[(2 \times 1.06 \times .09) \times 3.0 + 2 \times 5.03\right] = 2.02^k$$

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E. BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675-3

Calculation Number SC-DB-08 SET-B Sheet No. 38

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.17.84									
Checker	KS	12-20-84									

Type I_b - (CONT'D)

CHECK VERTICAL BRACING L 3x3x3/8

L = 5.1' MAX COMPRESSION LOAD 5.01^k (See sh.36 F

$$\frac{kl}{r} = \frac{5.1 \times 12}{.587} = 104.3 \qquad F_a = 12.40 \text{ ksi}$$

$$f_a = \frac{4.94}{2.11} = 2.33 \text{ ksi} < 12.5 \qquad \text{O.K.}$$

TOTAL REACTION @ CEILING CONNECTION

↓↑ 3.18^k	TRANSV. ACTION	
↓ 1.24^k	DEAD LOAD	
↓ 1.49^k	VERT. ACTION	
↓↑ 4.17^k	LONGIT. ACT.	L=4'-0
↓↑ 2.02^k	LONGIT. ACT	L=8'-3

⇆ 1.25^k	TRANSV. ACTION
⇆ 1.1^k	LONGIT. ACTION

$$S_{max} = (1.25^2 + 1.10^2)^{1/2} = 1.67^k$$

$$\underset{L=4'-0}{T_{MAX}} = 1.24 + \left[3.18^2 + 1.49^2 + 4.17^2\right]^{1/2} = 6.69^k$$

$$\underset{L=8'-3}{T_{max}} = 1.24 + \left[3.18^2 + 1.49^2 + 2.02^2\right]^{1/2} = 5.29^k$$

FOR L = 6'-0 $V_L = \frac{1}{6.0}\left[(2 \times 1.06 + .08) \times 3.0 + 2 \times 5.03\right] = 2.78^k$ See sh.36 R

$$\underset{L=6'-0}{T_{MAX}} = 1.24 + \left[3.18^2 + 1.49^2 + 2.78^2\right]^{1/2} = 5.72^k$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

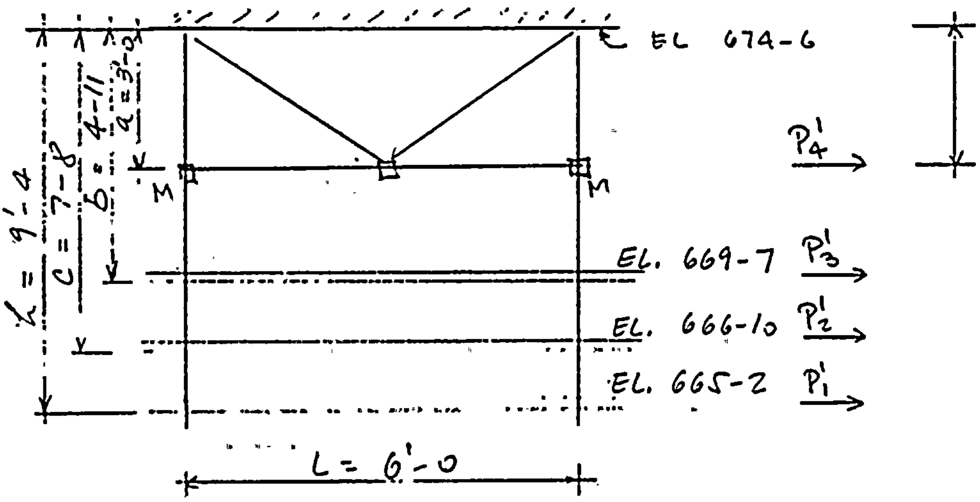
Calculation Number SC - DB - 08 SET-B Sheet No. 39

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	10.23.84									
Checker		12-20-84									

Type Ib - (CONT'D)

THE CASE PREVIOUSLY CHECKED IS AN ENVELOPE CASE. IN ORDER TO ESTABLISH THE ACCURATE REACTION @ EMBEDED PLATE, INDIVIDUAL CASES ARE CHECKED

(1.) 3 - 2'-0 TRAY LEVELS, h_{max} = 9'-4, ℓ = 3'-0
L = 6'-0, 21'-0 TRIBUTARY LONG. TRAY



a = 3'-0 - IN REALITY a IS LARGER, BUT BY USING a = 3'-0, THE RESULTS ARE CONSERVATIVE

$$P_1' = .54 \times \left(\tfrac{1}{2} \times \overbrace{2 \times 35 \times 21}^{735} + \overbrace{6.0 \times 10.5}^{63.0} + \overbrace{2 \times 15.62 \times .83}^{26.0}\right) \times \tfrac{1}{2} = 222^{\#}$$

$$P_2' = .54 \times \left(735 + 63.0 + \overbrace{2 \times 15.62 \times 2.25}^{70.3}\right) \times \tfrac{1}{2} = 234^{\#}$$

$$P_3' = .54 \times \left(735 + 31.5 + \overbrace{2 \times 15.62 \times 2.33}^{73}\right) \times \tfrac{1}{2} = 227^{\#}$$

$$P_4' = .54 \times \left(\overbrace{2 \times 15.62 \times 3.96}^{123.7} + \overbrace{1.5 \times 31.5}^{47.2} + \overbrace{2 \times 5.75 \times 12.21}^{140.4} + \overbrace{4 \times 4.25 \times 7.2}^{122.4}\right) \times \tfrac{1}{2} =$$

$$= 118^{\#}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG. – CABLE TRAY SUPPORTS UP TO EL. 675'-6

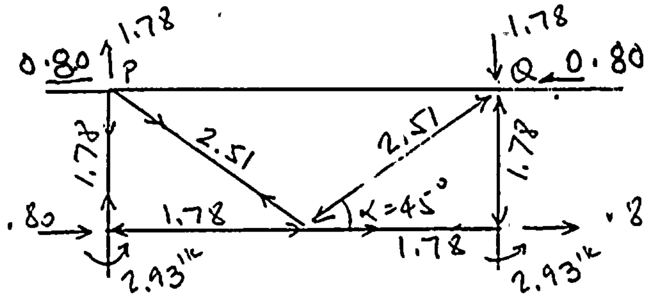
Calculation Number SC – DB – 08 SET-B Sheet No. 40

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	R.S	10.23.84								
Checker	KS	12.20.84								

Type Ib – (CONT'D)

M_L @ M LEVEL $= .222 \times 6.33 + .234 \times 4.66 + .227 \times 1.91 = 2.93^{1k}$

H_L @ M LEVEL $= .222 + .234 + .227 + .118 = .801^k$



$V_P = \frac{1}{6.0}\left(2 \times .8 \times 3.0 + 2 \times 2.93\right) =$

$= 1.78^k$

TOTAL REACTION @ CEILING CONN.

↓↑ 3.18^k TRANSV.

↓ 1.24^k D.L.

↓ 1.49^k VERT.

↓↑ 1.78^k LONG.

⇆ 1.25^k TRANSV.

⇆ 0.8^k LONG.

$S_{MAX} = (1.25^2 + 0.8^2)^{1/2} = 1.48^k$

$V_{MAX} = 1.24 + (3.18^2 + 1.49^2 + 1.78^2)^{1/2} = 5.18^k$

AS OUTLINED IN DESIGN CRITERIA (SL. 10 R.0, JEFA) MAX. RESULT VALUES FOR SSE, 5% DAMPING CONDITION FOR GROUP I ARE:

$g_H = .47 \times 1.5 = .705$

$g_{V_1} = .36 \times 1.5 = .54$ SUPP'T ATT. TO WALL

$g_{V_2} = .88 \times 1.5 = 1.32$ SUPP'T ATT. TO CEILING

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

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Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject I/G E. BLDG. — CABLE TRAY SUPPORTS UP TO EL

Calculation Number SC-DB-08 SET-B Sheet No. 41

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.23.84									
Checker		12-20-84									

Type Ib - (CONT'D)

COMPARED WITH OBE, 3% DAMPING VALUES :

$\frac{SSE}{OBE}$

$$\frac{g_H\ SSE}{g_H\ OBE} = \frac{.705}{.54} = 1.3$$

$$\frac{g_{V_1}\ SSE}{g_{V_1}\ OBE} = \frac{.54}{.36} = 1.5$$

$$\frac{g_{V_2}\ SSE}{g_{V_2}\ OBE} = \frac{1.32}{1.2} = 1.1$$

MAX. INCREASE IN SEISMIC VALUES (FOR THE SUPPORTS ATTACHED TO CEILING) IS 1.3

BOOK SC-DB-06, SH. 65 TO 83 R.0 LISTS CAPACITIES FOR EMBEDDED PLATES CORESPONDING TO FACTORED LOAD, OR SSE CONDITION.

IN ORDER TO COMPARE THESE CAPACITIES WITH RESULTS OF THESE CALCULATIONS, IT IS SAFE TO REDUCE THEM BY 1.3 (CONSERVATIVE APPROACH) OR, MORE ACCURATE, APPLY 1.3 TO HORIZ FORCES AND 1.1 TO VERT. FORCES.

THEN, $V_{MAX} = 1.24 \times 1.1 + \left[(3.18 \times 1.3)^2 + (1.49 \times 1.1)^2 + (1.78 \times 1.3)^2 \right]^{\frac{1}{2}} =$

$= 6.38^k < 11.52^k$ (REDUCED CAPACITY)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

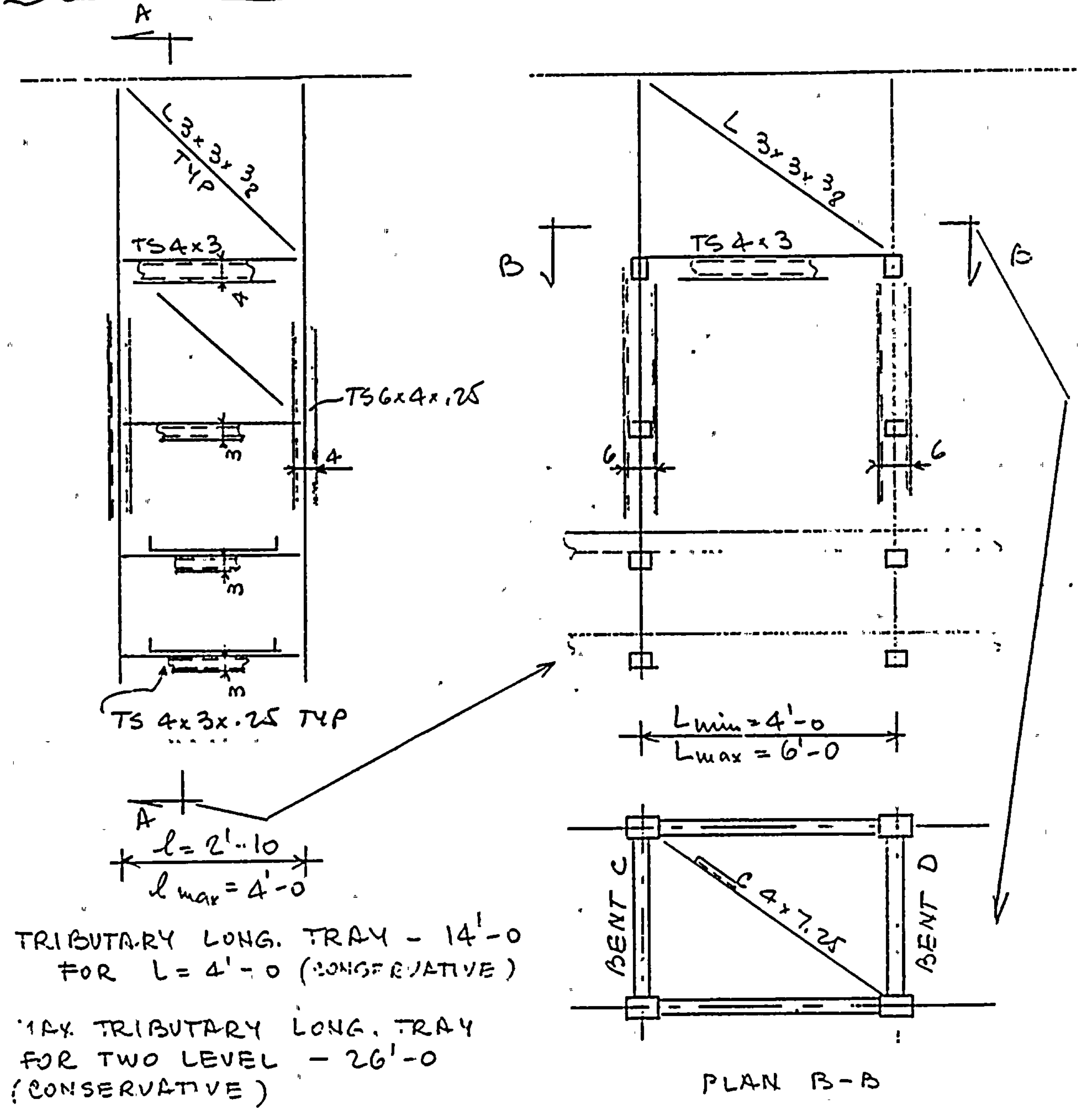
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 42

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	RS	10.23.84								
Checker		12.20.84								

4.2 TYPE II_b - MULTIDIRECTIONAL SUPPORT



TRIBUTARY LONG. TRAY - 14'-0 FOR L = 4'-0 (CONSERVATIVE)

MAX. TRIBUTARY LONG. TRAY FOR TWO LEVEL - 26'-0 (CONSERVATIVE)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6"

Calculation Number SC-DB-08 SET B Sheet No. 43

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.23.84									
Checker		12-20-84									

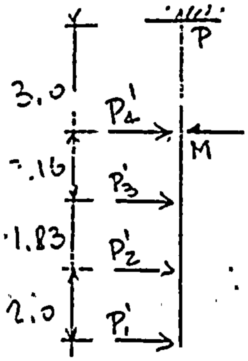
Type II_b - (CONT'D)

HORIZONTAL MEMBER - TS 4×3×.25

SEE CALC'S FOR TYPE I_a - MULTIDIRECTIONAL

VERTICAL MEMBER - TS 6×4×.25

LONGITUDINAL ACTION :



$$P_1' = .54\times\left(\tfrac{1}{2}\overbrace{2\times35\times26}^{910} + \overbrace{4\times10.5}^{42} + \overbrace{2\times15.62\times1.0}^{31.2}\right)\times\frac{1}{2} = 265^{\#}$$

$$P_2' = .54\times\left(910 + 42 + \overbrace{2\times15.62\times1.91}^{60}\right)\times\frac{1}{2} = 273^{\#}$$

$$P_3' = .54\times\left(42 + \overbrace{2\times15.62\times2.5}^{78}\right)\times\frac{1}{2} = 32^{\#}$$

$$P_4' = .54\times\left(42 + \overbrace{2\times15.62\times4.58}^{143} + \overbrace{7.2\times4.23}^{30}\right)\times\frac{1}{2} = 52^{\#}$$

$$M_L = .265\times7.0 + .273\times5.0 + .032\times3.16 = 3.32^{'k}$$
@ M LEVEL

$$V_{DL} = \overbrace{15.62\times10.0}^{156} + \overbrace{2\times(2\times35\times9 + 4\times10.5\times2)\times\frac{1}{2}}^{714} + \overbrace{2\times3\times10.5\times\frac{1}{2}}^{30} + \overbrace{2\times7.2\times4.23\times\frac{1}{2}}^{30} = 930^{\#}$$

$$V_V = 1.2\times930 = 1120^{\#}$$

$V_{T_{max}} = 2.93^k$ (FROM TRANSV. SUPP'T CALC'S @ 24 R.O.)

$M_T = .34^{'k}$

$$\frac{kl}{r_x} = \frac{2\times7.0\times12}{2.19} = 76.7$$

$$f_{b_{DL}} = \frac{.29\times12}{5.87} = .59\ ksi$$

$$\frac{kl}{r_y} = \frac{1.8\times3.2\times12}{1.6} = 43.0 \qquad F_a = 15.69\ ksi \qquad f_{b_V} = 1.2\times.59 = .71\ ksi$$

$$f_{a_{DL}} = \frac{.930}{4.59} = .20\ ksi \qquad f_{a_V} = \frac{1.120}{4.59} = .25\ ksi \qquad f_{a_T} = \frac{2.93}{4.59} = .64\ ksi$$

$$f_{b_T} = \frac{.34\times12}{5.87} = .70\ ksi \qquad f_{b_L} = \frac{3.32\times12}{7.36} = 5.41\ ksi$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

Gibbs & Hill, Inc.	**Job No.** 3544	**Client** P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC - DB - 08 SET-B **Sheet No.** 44

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	10.23.84									
Checker	KS	12-20-84									

-Type IIb - (CONT'D)

METHOD 1:

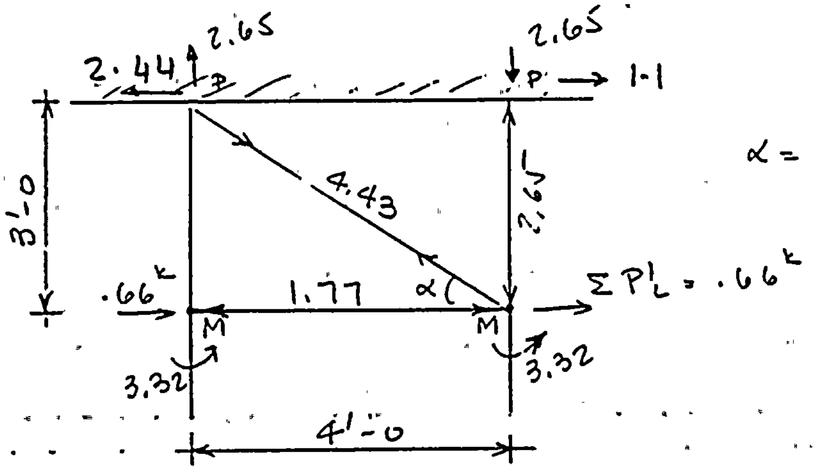
$$\frac{.59}{21.6} + \frac{.20}{15.69} + \left[\left(\frac{.25}{15.69} + \frac{.71}{21.6}\right)^2 + \left(\frac{.64}{15.69} + \frac{.70}{21.6}\right)^2 + \left(\frac{5.41}{21.6}\right)^2\right]^{1/2} = .303 < 1.0$$

O.K.

METHOD 2:

$$\frac{.20 + (.25^2 + .64^2)^{1/2}}{15.69} + \frac{.59 + (.71^2 + .7^2)^{1/2}}{21.6} + \frac{5.41}{21.6} = .380 < 1.0$$

O.K.



$\alpha = \arctan\frac{3}{4} = 36.87°$

$$\Sigma P'_L = 265 + 273 + 32 + 58 + \left[2 \times 10.51 \times 4 \times \frac{1}{2} + 2 \times 7.2 \times 5 \times \frac{1}{2} + 2 \times 7.25 \times 5 \times \frac{1}{2}\right] \times \frac{.54}{2} = 659^{\#}$$

$$V_P = \frac{1}{4} \times (2 \times 3.32 + 2 \times .66 \times 3.0) = 2.65^k$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675-6

Calculation Number SC - DB - 03 SET - B Sheet No. 45

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒	1	☒		☒		☒		☒
Preparer	R S	10.23.84	R. S.	2.8.85						
Checker		12-20-84		2.13-85						

Type II_b - (CONT'D)

TOTAL REACTION @ CEILING CONNECTION :

$\downarrow\uparrow$ 2.93^k TRANSV.

$\downarrow$ $.93^k$ D.L

$\downarrow$ 1.12^k VERT.

$\downarrow\uparrow$ 2.65^k LONGIT.

$\rightleftarrows$ $.88^k$ TRANSV.

$\rightleftarrows$ 2.44^k LONGIT

$$S_{MAX} = (.88^2 + 2.44^2)^{1/2} = 2.59^k$$

$$T_{max} = .93 + \left[2.93^2 + 1.12^2 + 2.65^2\right]^{1/2} = 5.04^k < \frac{11.52}{1.3} \text{ (see sh 41 R.0)}$$

$\triangle 1$

4.1.1. Type I_{b1} - SUPP'T NO. 11 (DET. 11)

SUPP'T NO. 11 IS A COMBINATION OF TYPE I_a, FOR TRANSVERSAL ACTION AND TYPE I_b FOR LONGITUDINAL ACTION. SUPP'T NO. 11 IS DESIGNED TO SUPPORT 3 x 1'-0 TRAYS, WHEREAS: SUPPORT TYPE I_b IS DESIGNED TO SUPPORT 3 x 2'-0 TRAYS, THEREFORE THE LOAD APPLIED IS MUCH SMALLER.

DUE TO PIPING INTERFERENCES, THE LONGITUDINAL BRACING IN SUPP'T NO. 11 WAS LOWERED TO 5'-5 FROM THE BOTTOM OF THE BEAM - MAKING THIS A LESS CRITICAL CASE.

HOWEVER THE DIAGONAL BRACE IS LONGER - CHECK BRACE:

$\frac{K\ell}{r} = \frac{1 \times 7.71 \times 12}{.587} = 157.6$ $F_a = 7.39$ ksi $P_{max} = 7.39 \times 2.11 = 15.5^k > 4.94^k$

o.k. (sh. 38)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

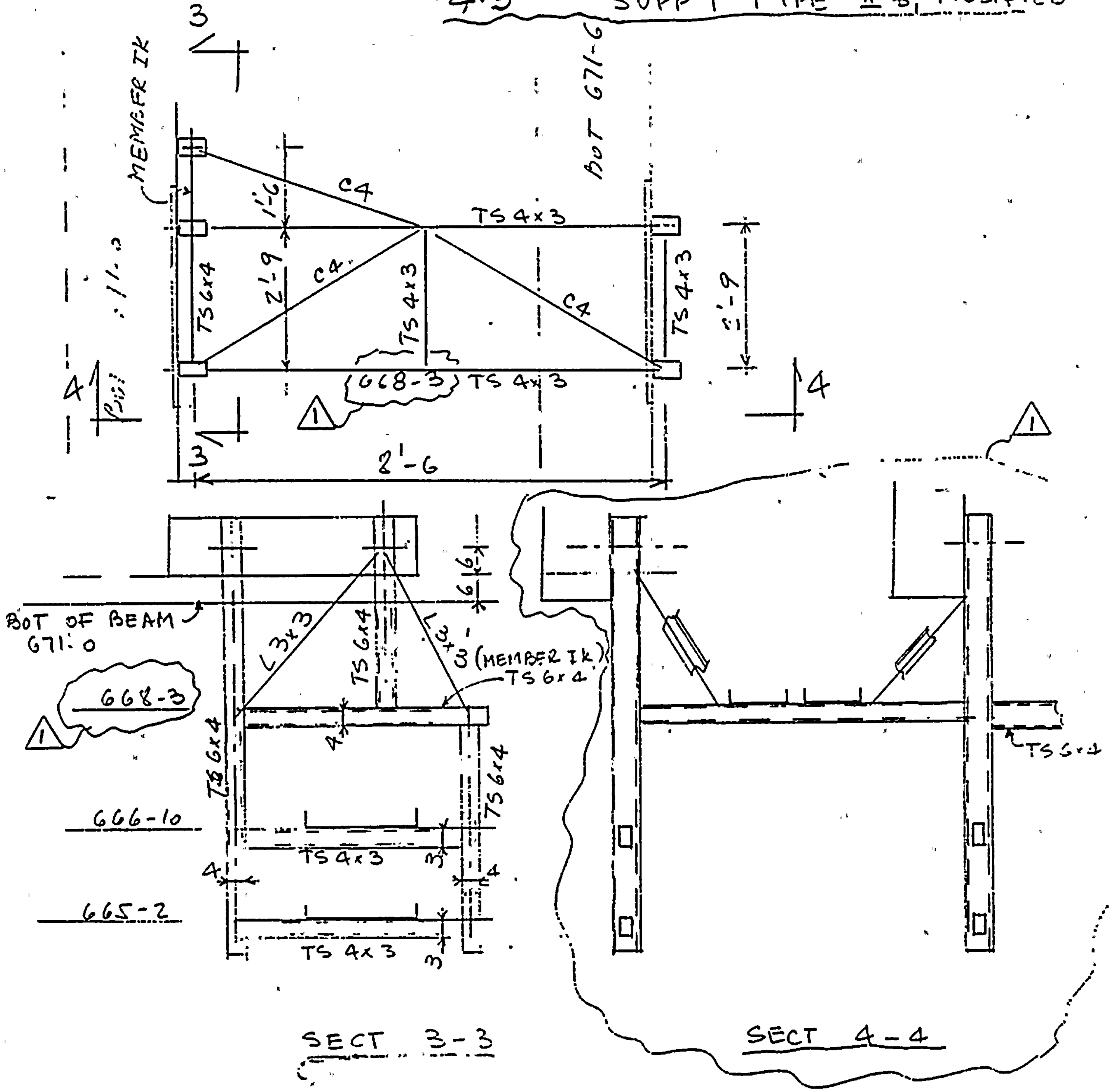
Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 46

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	X	.	X		X		X		X	
Preparer	RS	11.7.84	R.S.	2.8.85							
Checker		12-20-84		2-13-85							

4.3 SUPP'T TYPE II b, MODIFIED



Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

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Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

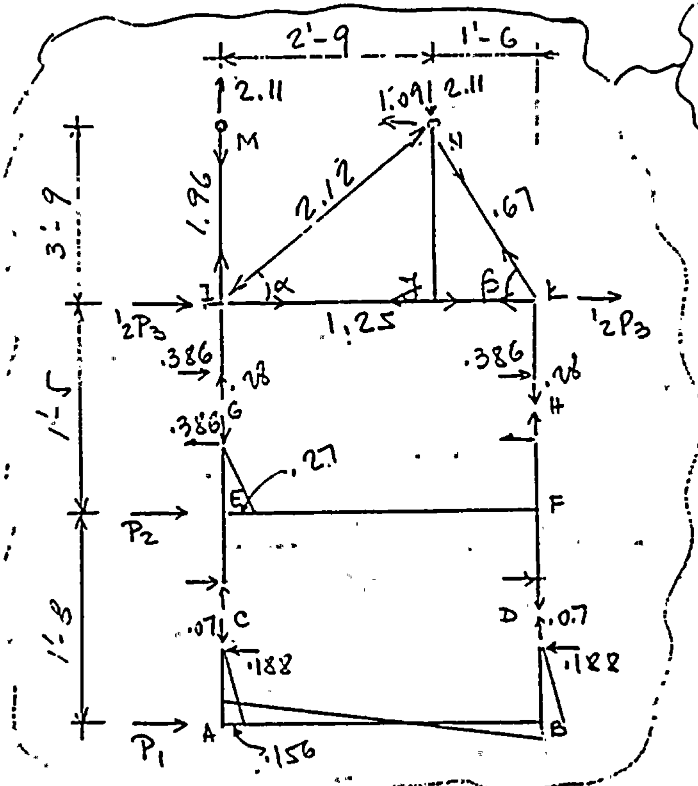
Subject D/G & BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 47

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒	1	☒		☒		☒		☒
Preparer	RS	11.13.84	R.S.	2.8.85						
Checker		12-20-84		2.13.85						

Type II b. - (CONT'D)

BENT @ SECT 3-3



TRANSV. ACTION

△1

ASSUME LOADED WITH 2'-0 TRAYS @ EL. 665'-2 & 666'-10 AND 2×1'-0 TRAYS @ EL 668'-3

$$P_1 = .54\times(\overbrace{2\times35\times9}^{630} + \overbrace{10.51\times4}^{42} + \overbrace{2\times.83\times15.62}^{26}) = 377^{\#}$$

$$P_2 = .54\times(630 + 42 + \overbrace{2\times1.91\times15.62}^{60}) = 395^{\#}$$

$$P_3 = .54\times(42 + \overbrace{2\times4.08\times15.62}^{127}) + .54\times2\times35\times\left(\frac{3.5+2.75}{2} + \frac{2.75}{2} + 1.5\right)^{*} = 318^{\#}$$

$$H_C = \frac{377}{2} = 188^{\#} \qquad V_C = \frac{1}{4.25}\times.377\times.83 = .07^{k}$$

$$M_A = .188\times.83 = .156^{'k}$$

$$H_G = \frac{395}{2} + 188 = 386^{\#}$$

$$V_G = \frac{1}{4.25}\times(377\times2.36 + 395\times.71) = .28^{k}$$

$$M_{GE} = .386\times.71 = .27^{'k}$$

△1

$$H_N = 377 + 395 + 318 = 1090^{\#}$$

$$V_M = \frac{1}{2.75}\times(.377\times6.83 + .395\times5.16 + .32\times3.75) = 2.11^{k}$$

$$\alpha = \arctan\frac{3.75}{2.75} = 53.7^{\circ} \qquad V_I = V_K = \frac{1}{4.25}(.377\times3.07 + .395\times1.41) = .4^{k}$$

$$\beta = \arctan\frac{3.75}{1.5} = 68.2^{\circ}$$

* ASSUMING THAT THE ENTIRE LOAD FROM 2×1'-0 TRAYS @ EL. 668-3 GOES INTO THIS FRAME (TRAYS ARE CLOSER TO THIS FRAME THAN TO THE OTHER END)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG – CABLE TRAY SUPPORTS UP TO EL. 675'-6

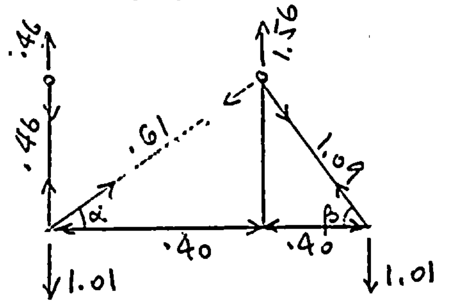
alculation Number SC – DB – 08 SET-B Sheet No. 48

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒	1	☒		☒		☒		☒	
Preparer	R.S.	11.13.84	R.S.	2.8.85							
Checker		12-20-84		2-13-85							

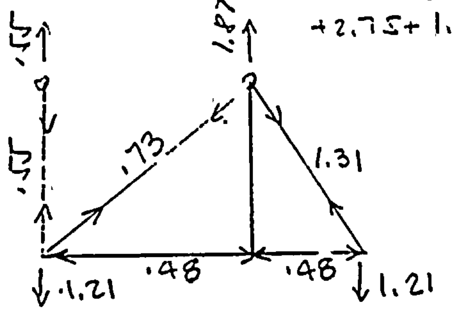
Type II_{b_L} – (CONT'D)

$$V_{DL} = \frac{1}{2}\times\Big[\overbrace{2\times2\times35\times9}^{1260} + \overbrace{3\times42}^{126} + \overbrace{2\times6.83\times15.62}^{213}\Big] + \frac{1}{2}\Big(\frac{3.5}{2} + 2.75 + 1.5\Big)\times2\times35 = 1010^{\#}$$

VERT. MEMBER



D.L. ACTION



VERT ACTION (×1.2)

△1

LONGITUDINAL ACTION

TRIBUTARY LENGTH FOR LONGIT ACTION – 19'-0 – TRAYS @ 666-10 & 665-2

$$P_1' = .54\times\frac{1}{2}\times\frac{1}{2}\times\Big[\overbrace{2\times35\times19}^{1330} + \overbrace{2\times42}^{84} + \overbrace{2\times26}^{52}\Big] = 198^{\#}$$ @ EL 665'-2 ONE LEG

$$P_2' = .54\times\frac{1}{2}\times\frac{1}{2}\times\Big[1330 + 84 + 2\times60\Big] = 207^{\#}$$ @ EL 666'-10 ONE LEG

$$P_3' = .54\times\frac{1}{2}\times\frac{1}{2}\times\Big[\overbrace{3\times42}^{126} + \overbrace{2\times127}^{254} + \overbrace{2\times10.51\times8.5}^{179} + \overbrace{3\times7.25\times5.1}^{111} + \underbrace{\overbrace{2\times7.2\times4.0\times2}^{115}}_{L3\times3}\Big] + .54\times\Big(\overbrace{2\times35\times\frac{3.5+2.75}{2}}^{118}\Big) = 224^{\#}$$ C6 @ 668'-3 ONE LEG

$M_L = 198\times3.07 + 207\times1.41 = 900^{1\#}$
@ K

△1

$\Sigma P' = 198 + 207 + 224 = 629^{\#}$

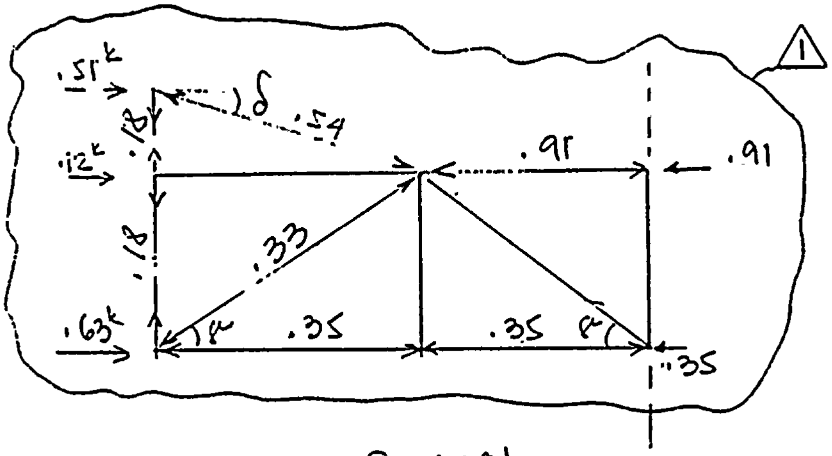
Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET - B Sheet No. 49

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1		1								
Preparer	RS	11.13.84	R.S.	2.8.85							
Checker		12-20-84		2-13-85							

Type II_{bL} - (CONT'D)

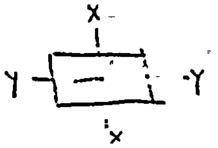


γ = arctan $\frac{2.75}{4.25}$ = 32.9°

δ = arctan $\frac{1.5}{4.25}$ = 19.4°

PLAN @ 669'-0
LONGIT EFFECT

CHECK MEMBER IK TS 6 x 4 x .25



AXIAL LOAD : 1.25k DUE TO TRANSV.
.40k DUE TO D.L.
.48k DUE TO VERT
.18k DUE TO LONGIT

MOMENT : $\frac{15.62 \times 2.75^2}{8}$ = 14.8'# DUE TO DL
15 × 1.2 = 18.0'# DUE TO VERT
15 × .54 = 8.1'# DUE TO LONGIT

TORSION : 900'# DUE TO LONGIT. ($M_{L_{\omega k}}$) SEE SH. 48 R.

1

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC - DB - 02 SET-B Sheet No. 50

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒	1	☒		☒		☒		☒	
Preparer	RS	11.13.84	R.S.	2.8.85							
Checker		12-20-84		2-13-85							

Type II_{bL} - (CONT'D)

$f_{a_T} = \frac{1.25}{4.59} = .27$ ksi $f_{a_{DL}} = \frac{.4}{4.59} = .09$ ksi $f_{a_V} = \frac{.48}{4.59} = .10$ ksi

$f_{a_L} = \frac{.18}{4.59} = .04$ ksi

$f_{b_{DL}} = \frac{15 \times 12}{5.87} = 30.7$ psi $f_{bV} = 1.2 \times 30.7 = 36.8$ psi

$f_{b_L} = .54 \times 30.7 = 16.6$ psi

△1

$\frac{kl}{r} = \frac{1 \times 2.75 \times 12}{1.6} = 20.6$ $F_a = 20.54$ ksi

$$\frac{.09}{20.54} + \frac{.031}{21.6} + \left[\left(\underset{V}{\frac{.10}{20.54} + \frac{.037}{21.6}}\right)^2 + \left(\underset{T}{\frac{.27}{20.54}}\right)^2 + \left(\underset{L}{\frac{.04}{20.54} + \frac{.017}{21.6}}\right)^2\right]^{1/2} = .018 < \text{O.K.}$$

TORSION EFFECT : $f_{v_x} = \frac{900 \times 12}{22.1 + 1.7} \times 3.0 = 959$ psi

$f_{v_y} = \frac{900 \times 12}{22.1 + 11.7} \times 2.0 = 319$ psi O.K.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

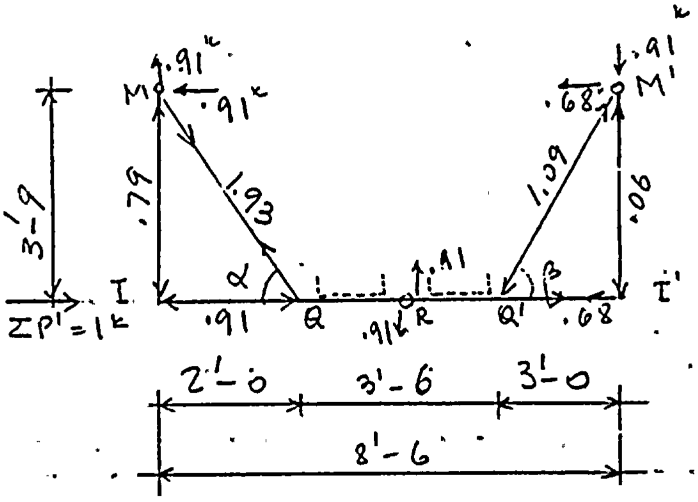
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

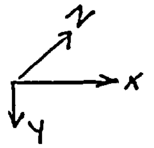
Calculation Number SC-DB-08 SET-B Sheet No. 50 A

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #		☒	1	☒		☒		☒		☒
Preparer			R.S.	2.8.85						
Checker				2/13/85						

Type II_b - (CONT'D) - LONGITUDINAL FRAME



CONSERVATIVELY, ASSUME A POINT OF INFLECTION @ MID. ELEMENT QQ'



$$\alpha = \arctan \frac{3.75}{2.0} = 61.9^\circ$$

$$\beta = \arctan \frac{3.75}{3.0} = 51.3^\circ$$

FROM SH. 48 - R.1 (BOTTOM)

$$\Sigma P' = 2 \times 629 + \underbrace{\left(5 \times 1.0 \times 35 \times \frac{3.5 + 3.5}{2}\right) \times .54}_{5 \times 1'-0 \text{ TRAYS ON ADJACENT MEMBER)}} = 1258 + 331 = 1589^{\#}$$

$$V_M = -V_{M'} = \frac{2}{8.5} \times \left[198 \times 6.83 + 207 \times 5.17 + \left(224 + \frac{331}{2}\right) \times 3.75\right] = 914^{\#}$$

$$H_M = \frac{.91 \times 3.75}{3.75} = .91^{k} \qquad H_{M'} = 1589 - 914 = 675^{\#}$$

$$M_Q = .91 \times 1.75 = 1.59'^{k} = M_{Q'}$$

ELEMENT QQ'

- HAS A MOMENT @ Q. = 1.59'k DUE TO LONGIT ACTION OF TRAYS @ 666'-10 & 665'-2 AND TRANSV. ACTION OF TRAYS @ 668'-3 AND A MAX. AXIAL FORCE OF .91k (x)
- HAS A MOMENT OF $\frac{3.5 + 2.75}{2} \times 35 \times 2 \times \frac{3.5}{4} = 191'^{\#}$ DUE TO DEAD LOAD ON TRAYS @ 668'-3 (Y)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG – CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 50 B

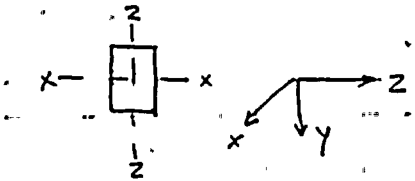
Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #			1								
Preparer			R.S.	2.8.85							
Checker				2/13/85							

TYPE II_{b_1} – (CONT'D)

ELEMEMENT QQ'

- HAS A MOMENT OF 1.2 × 191 = $230^{1\#}$ DUE TO VERTICAL ACTION ON TRAYS @ 668'-3 (Y)
- HAS A MOMENT OF .54 × 191 = $103^{1\#}$ DUE TO LONGITUDINAL ACTION ON TRAYS @ 668'-3 (Z).

CHECK TS 4 × 3 × .25



$$fa_{x_T} = \frac{.91}{3.09} = .29 \text{ ksi}$$

$$fb_{x_T} = \frac{1.59 \times 12}{3.23} = 5.91 \text{ ksi} \qquad fb_{x_{DL}} = \frac{.191 \times 12}{3.23} = 710 \text{ psi}$$

$$fb_{x_V} = \frac{230 \times 12}{3.23} = 854 \text{ psi} \qquad fb_{z_L} = \frac{103 \times 12}{2.74} = 451 \text{ psi}$$

$$\frac{kl}{r} = \frac{3.5 \times 12}{1.15} = 36.5 \qquad Fa = 19.42 \text{ ksi}$$

$$\text{METHOD 2}: \frac{.29}{19.42} + \frac{.71 + (.85^2 + 5.91^2)^{1/2}}{21.6} + \frac{.45}{21.6} = .345 < 1.0$$

METHOD 1 GIVES A LOWER RATIO.

SELF WT OF TS 4×3 WAS NEGLECTED FOR SIMPLIFICATION, IT HAS A VERY SMALL CONTRIBUTION TO THE FINAL RATIO.

O.K.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO

Calculation Number SC - DB - 08 SET - B Sheet No. 53C

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #			1								
Preparer			R.S.	2.8.85							
Checker				2/12/85							

Type II_{b_1} - (CONT'D)

HORIZONTAL MEMBER CONNECTING TO FRAME @ EL 668'-3

TS 6 x 4 x .25

SPAN OF BEAM - 9'-3

THE BEAM IS LOADED WITH 5 x 1'-0 TRAYS, COVERING MOST OF BEAM'S LENGTH.

$$\text{TRAYS' DEAD LOAD} = 5 \times 35 \times \frac{2.75 + 3.5}{2} = 547^{\#}$$

$$\text{EQUIVALENT DISTRIBUTED LOAD} = \frac{547}{9.25} = 59^{\#}/ft$$

$$\text{BEAM'S OWN WT} = 15.62^{\#}/ft$$

$$M_{DL} = \frac{(\overbrace{59 + 15.62}^{74.62}) \times 9.25^2}{8} = 798^{'\#} \qquad M_V = 1.2 \times 798 = 957.7^{'\#}$$

$$M_L = .54 \times 798 = 431^{'\#} \qquad P_{a_T} = .54 \times (74.62 \times 9.25) = 373^{\#}$$

$$fa_T = \frac{373}{4.59} = 81.2 \text{ psi} \qquad \frac{kl}{r} = \frac{9.25 \times 12}{1.6} = 69.4 \qquad Fa = 16.43 \text{ ksi}$$

$$fb_{DL} = \frac{798 \times 12}{7.36} = 1301 \text{ psi} \qquad fb_V = 1.2 \times 1301 = 1561 \text{ psi}$$

$$fb_L = \frac{431 \times 12}{5.87} = 881 \text{ psi}$$

$$\text{METHOD 2}: \frac{.081}{16.43} + \frac{1.30 + 1.56}{21.6} + \frac{.881}{21.6} = .178 < 1.0 \quad \text{o.k.}$$

$$\text{DEFLECTION}: \Delta_x = \frac{5}{384} \times \frac{74.62 \times 9.25^3 \times 12^4}{29 \times 10^6 \times 22.1} \times (1 + 1.2) = .055 \text{ in}$$

$$\Delta_y = \frac{.54}{1 + 1.2} \times .055 = .014 \text{ in} \qquad \Delta_{max} = (.055^2 + .014^2)^{1/2} = .057 \text{ in} = \frac{1}{1947} \times \text{SPAN LENGTH}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

F-166, 7-82

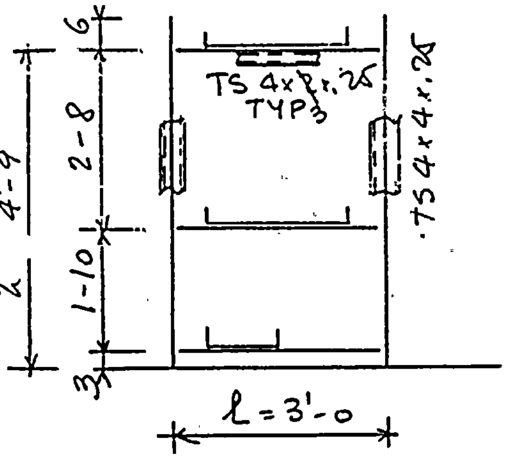
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

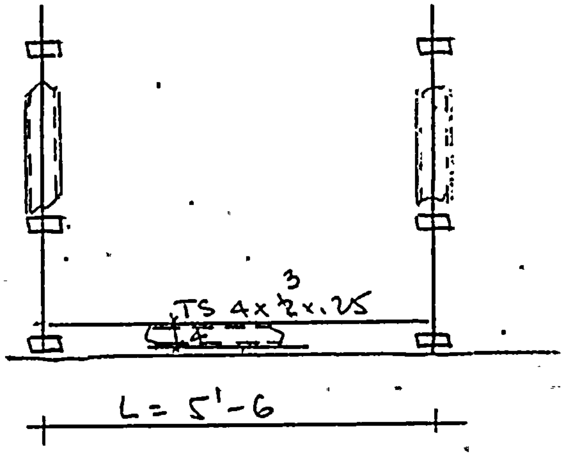
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 51

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	10.22.84								
Checker		12-20-84								

4·4 TYPE III b – MULTIDIRECTIONAL





ASSUME 2' TRAYS ON TOP TWO LEVELS

MAX TRANSV. TRIBUTARY LENGTH : $\frac{7.5}{2} + \frac{5.5}{2} = 6.5'$

LONGIT TRIBUTARY LENGTH $\frac{7.0}{2} + 5.5 + 10 = 19'$ FOR 2' TRA

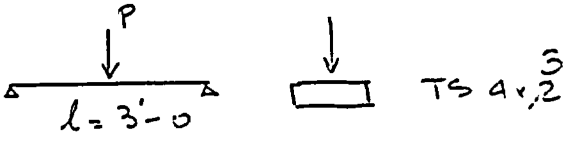
$\frac{7.0}{2} + 5.5 + 18 = 27'$ FOR 1' TR

HORIZ MEMBER TS $4 \times \overset{3}{2} \times .25$

VERT MEMBER TS $4 \times 4 \times .25$

BRACING L $3 \times 3 \times {}^{3}{}_{2}$

HORIZ. MEMBER



$P_{DL} = 2 \times 35 \times 6.5 + 8.81 \times 3.0 = 481^{\#}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

(3)

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	RS	10.27.84								
Checker	KS	12-20-84								

Type III b - (CONT'D.)

$P_T = .54 \times 481 = 260^{\#}$

$M_{DL} = .48 \times \frac{3.0}{4} = .36^{'k}$ $M_V = 1.2 \times .36 = .43^{'k}$

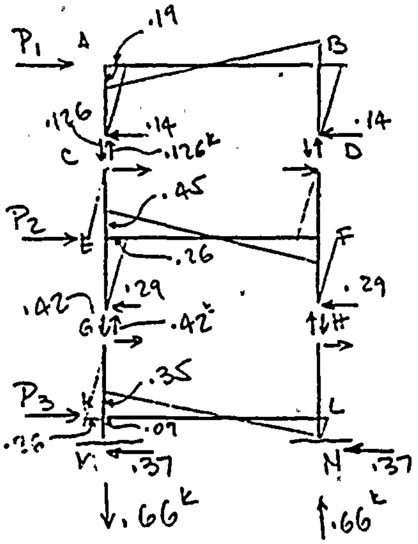
$\frac{k\ell}{r} = \frac{3 \times 12}{.77} = 46.8$ $F_a = 18.61$ ksi

$f_{b_{DL}} = \frac{.36 \times 12}{1.54} = 2.8$ ksi $f_{b_V} = \frac{.43 \times 12}{1.54} = 3.35$ ksi

$P_L = \frac{1}{2} \times 2 \times 35 \times 19 \times .54 + 8.8 \times 3.0 \times .54 = 373^{\#}$
TOP TWO
LEVELS

$P_L = \frac{1}{2} \times 35 \times 27 \times .54 + 8.8 \times 3.0 \times .54 = 270^{\#}$
BOT. LEVEL

$M_L = .373 \times \frac{3.0}{4} = .28^{'k}$ $f_{b_L} = \frac{.28 \times 12}{2.35} = 1.43$ ksi



$P_1 = \overbrace{.54 \times 481}^{260} + \overbrace{12.21 \times 1.83 \times 2 \times .54}^{24} = 284^{\#}$

$P_2 = 260 + \overbrace{12.21 \times 2.24 \times 2 \times .54}^{30.} = 290^{\#}$

$P_3 = (1 \times 35 \times 6.5 + 8.81 \times 3.0) \times .54 +$

$+ 12.21 \times 1.16 \times 2 \times .54 = 137 + 15 = 152^{\#}$

$H_C = \frac{284}{2} = .142^{\#}$ $M_A = .14 \times 1.33 = .19^{'k}$

$V_C = \frac{1}{3.0}(.284 \times 1.33) = .126$

$H_G = .14 + \frac{.29}{2} = .29^k$

$V_G = \frac{1}{3.0}(.29 \times .91 + .284 \times 3.57) = .42^k$

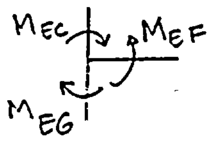
Gibbs & Hill, Inc. Job No. 3544. Client P.P.& L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UPTO EL. 675-

Calculation Number SC-DB-08 SET-B Sheet No. 53

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	10.22.84									
Checker	KS	12.20.84									

Type III_b - (CONT'D)



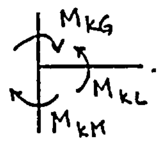
$M_{EC} = .14 \times 1.33 = .19^{1k}$

$M_{EG} = .29 \times .91 = .26^{1k}$

$M_{EF} = .19 + .26 = .45^{1k}$

$H_M = .29 + \frac{.15}{2} = .37^k$

$V_M = \frac{1}{3.0}(.15 \times .25 + .29 \times 2.08 + .284 \times 4.74) = .66^k$



$M_{KG} = .29 \times .91 = .26^{1k}$ $M_{KM} = .37 \times .25 = .09^{1k}$

$M_{KL} = .26 + .09 = .35^{1k}$

MAX AXIAL FORCE IN HORIZ MEMBER $P_T = .29^k$

MAX MOM. DUE TO TRANSV. ACTION $M_T = .45^{1k}$

$fb_T = \frac{.45 \times 12}{1.54} = 3.5$ ksi $fa_T = \frac{.29}{2.59} = .11$ ksi

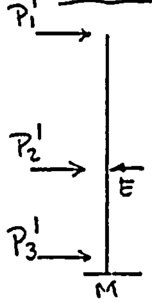
METHOD 1:

$$\frac{2.8}{21.6} + \left[\left(\frac{.11}{18.61} + \frac{3.5}{21.6}\right)^2 + \left(\frac{3.35}{21.6}\right)^2 + \left(\frac{1.43}{21.6}\right)^2\right]^{1/2} = .367 < 1.0 \text{ o.k}$$

METHOD 2:

$$\frac{.11}{18.61} + \frac{2.8 + (3.5^2 + 3.35^2)^{1/2}}{21.6} + \frac{1.43}{21.6} = .426 < 1.0 \text{ o.k.}$$

VERTICAL MEMBER



$$P_1' = \frac{1}{2} \times \left[\left(\overset{373}{\frac{1}{2} \times 2 \times 35 \times 19 + 8.8 \times 3.0}\right) \times .54 + 24\right] = 200^{\#}$$

$$P_2' = \frac{1}{2} \times (373 + 30) = 202^{\#}$$

$$P_3' = \frac{1}{2} \times \left[\left(\frac{1}{2} \times 35 \times 27 + 8.8 \times 3.0\right) \times .54 + 15\right] = 143^{\#}$$

$M_E = .20 \times 2.66 = .532^{1k}$ $R_E = 200 + 202 = 402^{\#}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 54

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	10.22.84								
Checker		12-20-84								

Type III_b - (CONT'D)

$$f_{b_L} = \frac{.53 \times 12}{4.11} = 1.55 \text{ ksi}$$

$$M_{T_{max}} = .26^{'k} \qquad f_{b_T} = \frac{.26 \times 12}{4.11} = .76 \text{ ksi} \qquad f_{a_T} = \frac{.66}{3.59} = .18 \text{ ksi}$$

$$V_{DL} = \frac{1}{2}(284 + 290 + 152) = 363^{\#} \qquad V_v = 1.2 \times 363 = 436^{\#}$$

$$f_{a_{DL}} = \frac{.363}{3.59} = .10 \text{ ksi} \qquad f_{a_v} = \frac{.436}{3.59} = .12 \text{ ksi} \qquad M_{DL} = .5 \times .36 = .18^{'k} \quad M_v = .5 \times .43 = .22^{'k}$$

$$\frac{kl}{r} = \frac{2 \times 2.66 \times 12}{1.51} = 42.3 \qquad F_a = 18.95 \text{ ksi} \qquad f_{b_{DL}} = \frac{.18 \times 12}{4.11} = .52 \text{ ksi} \quad f_{b_v} = .63 \text{ ksi}$$

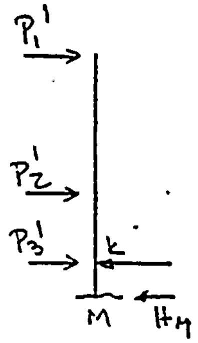
METHOD 1:

$$\frac{.52}{21.6} + \frac{.10}{18.95} + \left[\left(\frac{.12}{18.95} + \frac{.63}{21.6}\right)^2 + \left(\frac{.76}{21.6} + \frac{.18}{18.95}\right)^2 + \left(\frac{1.55}{21.6}\right)^2\right]^{1/2} = .121 < 1.0 \quad \text{O.K.}$$

METHOD 2:

$$\frac{.1 + (.12^2 + .18^2)^{1/2}}{18.95} + \frac{.52 + (.63^2 + .76^2)^{1/2}}{21.6} + \frac{1.55}{21.6} = .155 < 1.0 \quad \text{O.K.}$$

CHECK LONGITUDINAL ACTION WITH BRACE @ P_3' LOCATION:



$$M_k = .20 \times 4.57 + .202 \times 1.91 = 1.3^{'k}$$

$$R_k = 200 + 202 + 143 = 545^{\#} = H_M$$

$$V_M = \frac{1}{5.5}(2 \times 2.46 + 2 \times .27 \times .25) = .92^k$$

DIFF. IN VERTICAL REACTION IS NOT SIGNIFICANT. ONE STRUT AT K LEVEL IS SUFFICIENT

$$\frac{kl}{r} = \frac{2 \times 4.57 \times 12}{1.51} = 72.6 \qquad F_a = 16.12 \text{ ksi} \qquad f_{b_L} = \frac{1.3 \times 12}{4.11} = 3.8 \text{ ksi}$$

METHOD 1:

$$\frac{.12}{16.12} + \frac{.52}{21.6} + \left[\left(\frac{.12}{16.12} + \frac{.63}{21.6}\right)^2 + \left(\frac{.76}{21.6} + \frac{.18}{18.95}\right)^2 + \left(\frac{3.8}{21.6}\right)^2\right]^{1/2} = .216 < 1.0$$

METHOD 2:

$$\frac{1 + (.12^2 + .18^2)^{1/2}}{16.12} + \frac{.52 + (.63^2 + .76^2)^{1/2}}{21.6} + \frac{3.8}{21.6} = .321 < 1.0$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

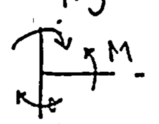
Subject D/G E BLDG – CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC – DB – 08 SET – B Sheet No. 55

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	10.22.84									
Checker		12.20.84									

Type III_b – (CONT'D)

HORIZONTAL STRUT CONNECTING TWO FRAMES TS 4×2



.545 × .25 = .14'k

$M = 1.3 + .14 = 1.44'^k$

$\frac{Kl}{r} = \frac{5.5 \times 12}{.77} = 85.7 \quad F_a = 14.67$

$f_{b_L} = \frac{1.44 \times 12}{2.35} = 17.35 \text{ ksi} \quad f_{a_L} = \frac{1.03}{2.59} = .4 \text{ ksi}$

$M_{DL} = \frac{8.81 \times 5.5^2}{8} = 33.3'^{\#} \quad f_{b_{DL}} = \frac{33.3 \times 12}{2.35} = 170 \text{ psi}$

$f_{b_T} = .54 \times .17 = .09 \text{ ksi} \quad f_{b_V} = 1.2 \times .17 = .2 \text{ ksi}$

$$\frac{.17}{21.6} + \left[\left(\overset{T}{\frac{.09}{21.6}}\right)^2 + \left(\overset{V}{\frac{.2}{21.6}}\right)^2 + \left(\overset{L}{\frac{17.35}{21.6}} + \frac{.4}{14.67}\right)^2 \right]^{1/2} = .375 < 1.0$$

o.k.

TOTAL REACTION @ EMB. PLATE

$V_T = .66^k \qquad H_T = .37^k \qquad V = .36 + (.66^2 + .44^2 + .52^2)^{1/2} = 1.31^k$

$V_{DL} = .36^k \qquad H_L = 0.545^k \qquad H = (.37^2 + .545^2)^{1/2} = 0.66^k$

$V_V = .44^k$

$V_L = .52^k$

REACTIONS ARE LOW – EMB. PLATE IS O.K.

UPGRADE ALL TS 4×2×.25 TO TS 4×3×.25

WELD CONNECTING LONGIT STRUT: $M = 1.30'^k \quad S_{x_w} = 2 \times \left(\frac{4^2}{6} + 3 \times 2\right) = 17.$

$f_w = \frac{1.3 \times 12}{17.3} = 0.9 \text{ k/in} \qquad \underline{3/16"} \text{ WELD'S CAP} = 2.32 \text{ k/in}$

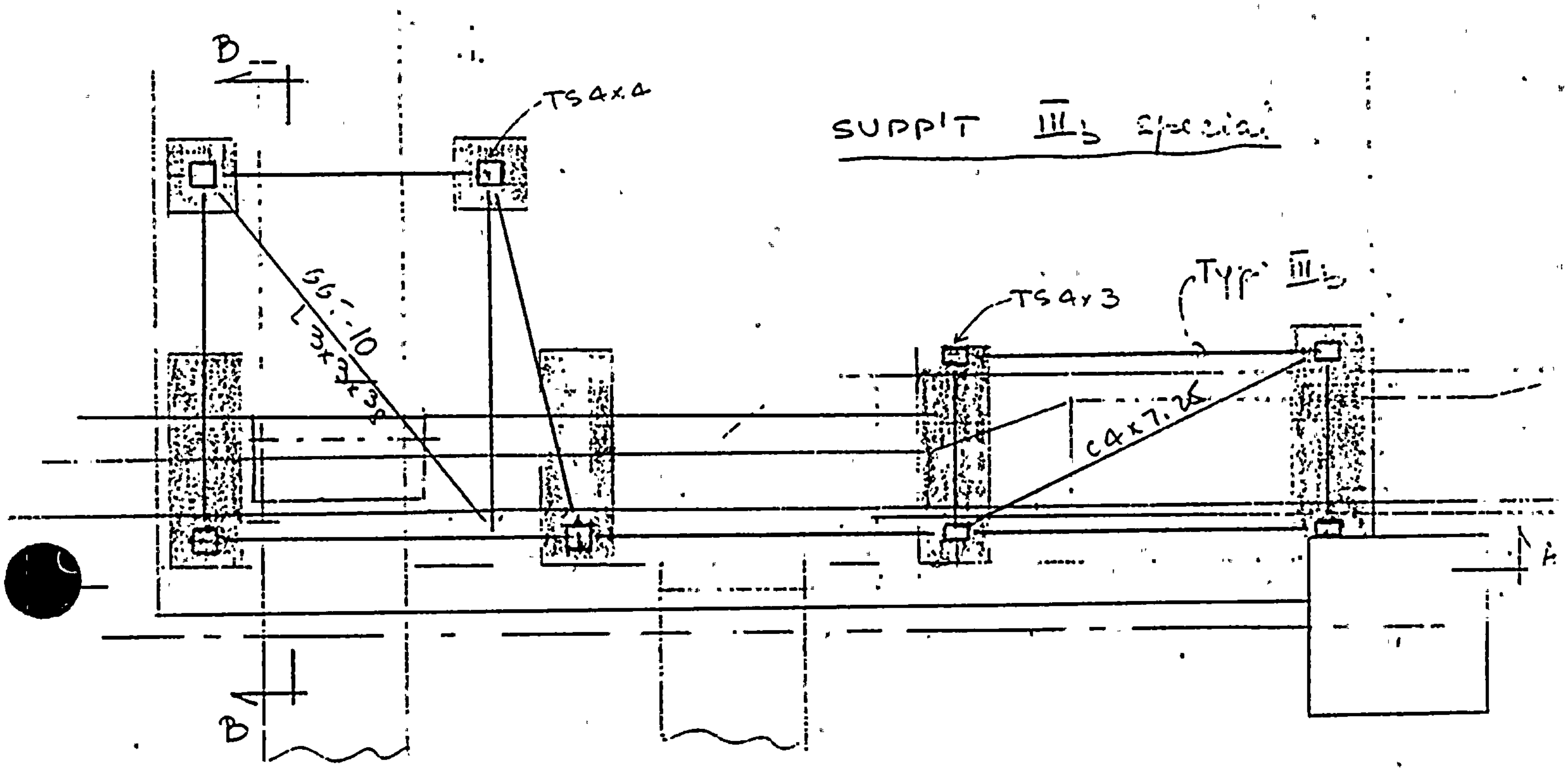
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

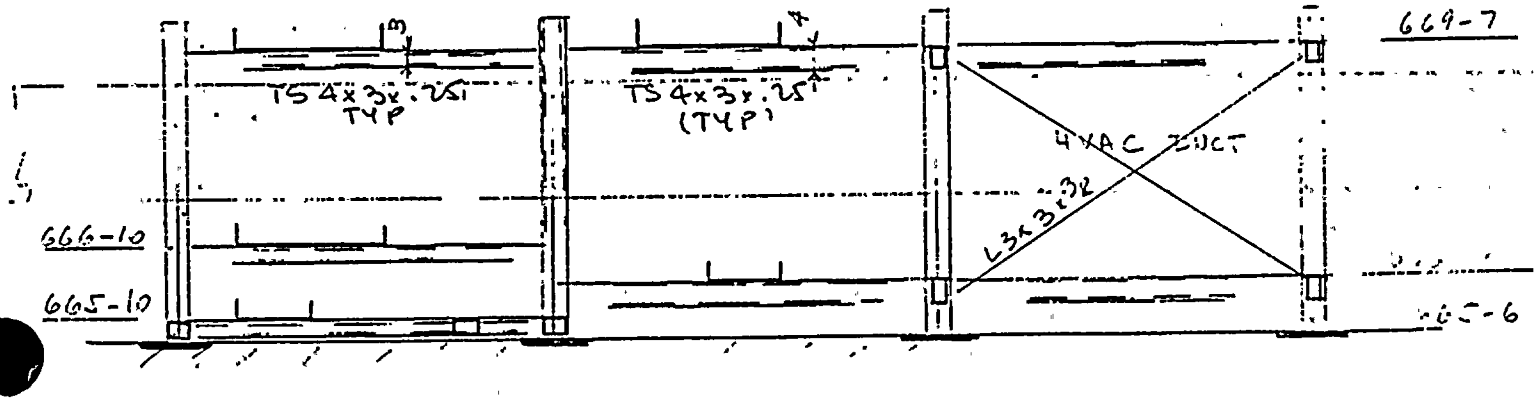
Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET - 8 Sheet No. 56

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.1.84									
Checker		12-20-84									





SECT A - A

Checking Method #

1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

F-166, 7-82

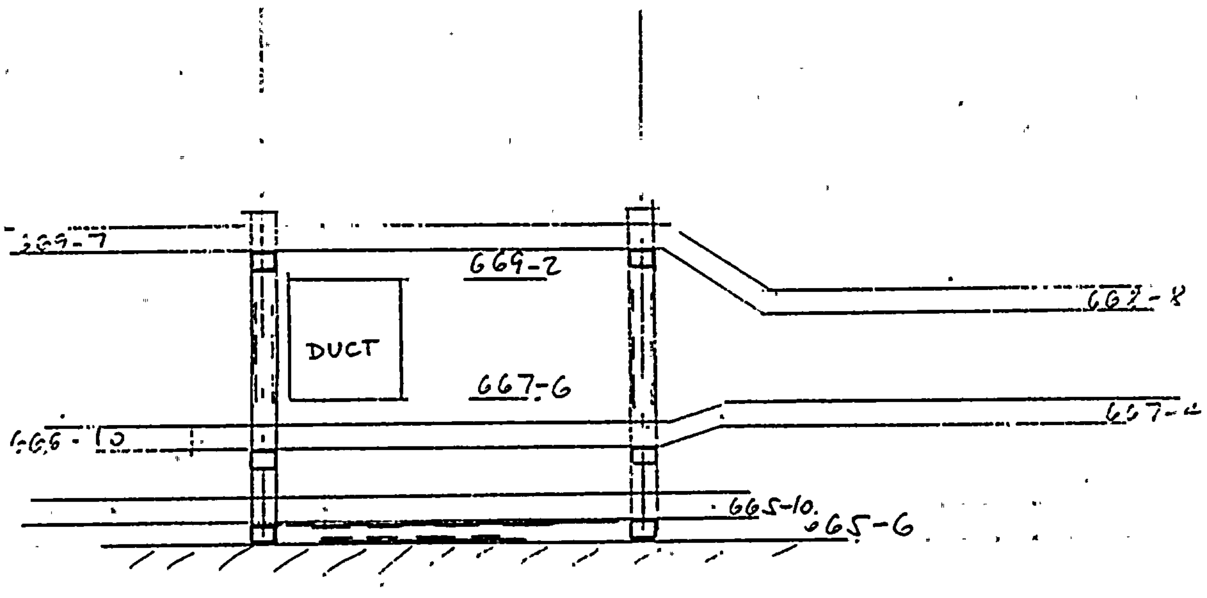
Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC - DB - 08 SET-B Sheet No. 57

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11-1-84									
Checker		12-20-84									

SUPP'T III b Special



SECT B-B

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

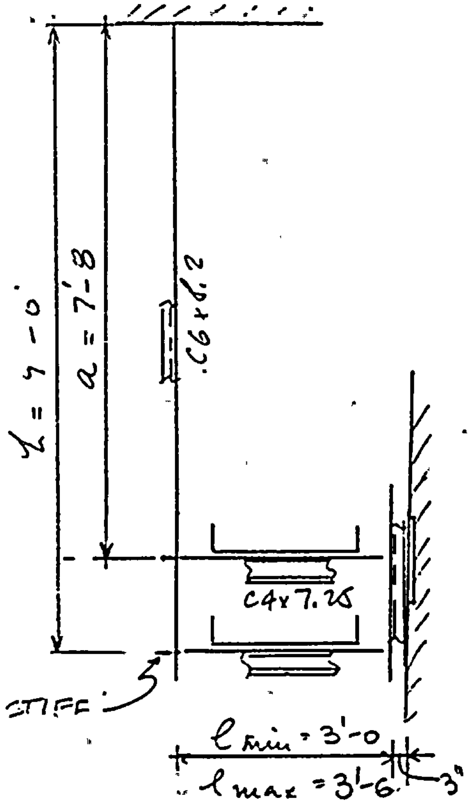
Gibbs & Hill, Inc. Job No. 3544 Client T.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET - B Sheet No. 58

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.23.84									
Checker		12-20-84									

5·1 TYPE IVa - TRANSVERSAL SUPP'T



HORIZ MEMBER C4×7.25
(See calc's for Type Ia)

VERT. MEMBER C6×8.2

$$\frac{kl}{r_y} = \frac{7.66\times12}{.537} = 171 \qquad F_a = 5.11 \text{ ksi.}$$

$$\frac{kl}{r_x} = \frac{2.1\times9\times12}{2.28} = 99$$

ALL HORIZONTAL (TRANSV.) LOADS GO DIRECTLY TO WALL

CHECK C4×7.25 TO CANTILEVER [illegible]

FROM CALC'S FOR TYPE Ia (sh. 13 TO 19 R.0)

$$f_{b_{DL_1}} = 4.8 \text{ ksi} \qquad f_{b_{V_1}} = 5.78 \text{ ksi} \qquad f_{a_T} = \frac{.36}{1.93} = .19 \text{ ksi}$$

$$P'_{LMAX} = (7.25\times3.5 + 8.2\times8.32)\times.54 = 51^{\#}$$

$$f_{b_L} = \frac{.051\times3.5\times12}{.296} = 7.24 \text{ ksi} \qquad \frac{kl}{r_y} = \frac{2\times3.5\times12}{.44} = 191 \quad F_a =$$

METHOD 1:

$$\frac{4.8}{21.6} + \left[\left(\frac{.19}{4.09}\right)^2 + \left(\frac{5.78}{21.6}\right)^2 + \left(\frac{7.24}{21.6}\right)^2\right]^{1/2} = .654 < 1.0 \quad \text{o.k.}$$

METHOD 2:

$$\frac{.19}{4.09} + \frac{4.8 + 5.78}{21.6} + \frac{7.24}{21.6} = .871 < 1.0 \quad \text{o.k.}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

F-166, 7-82

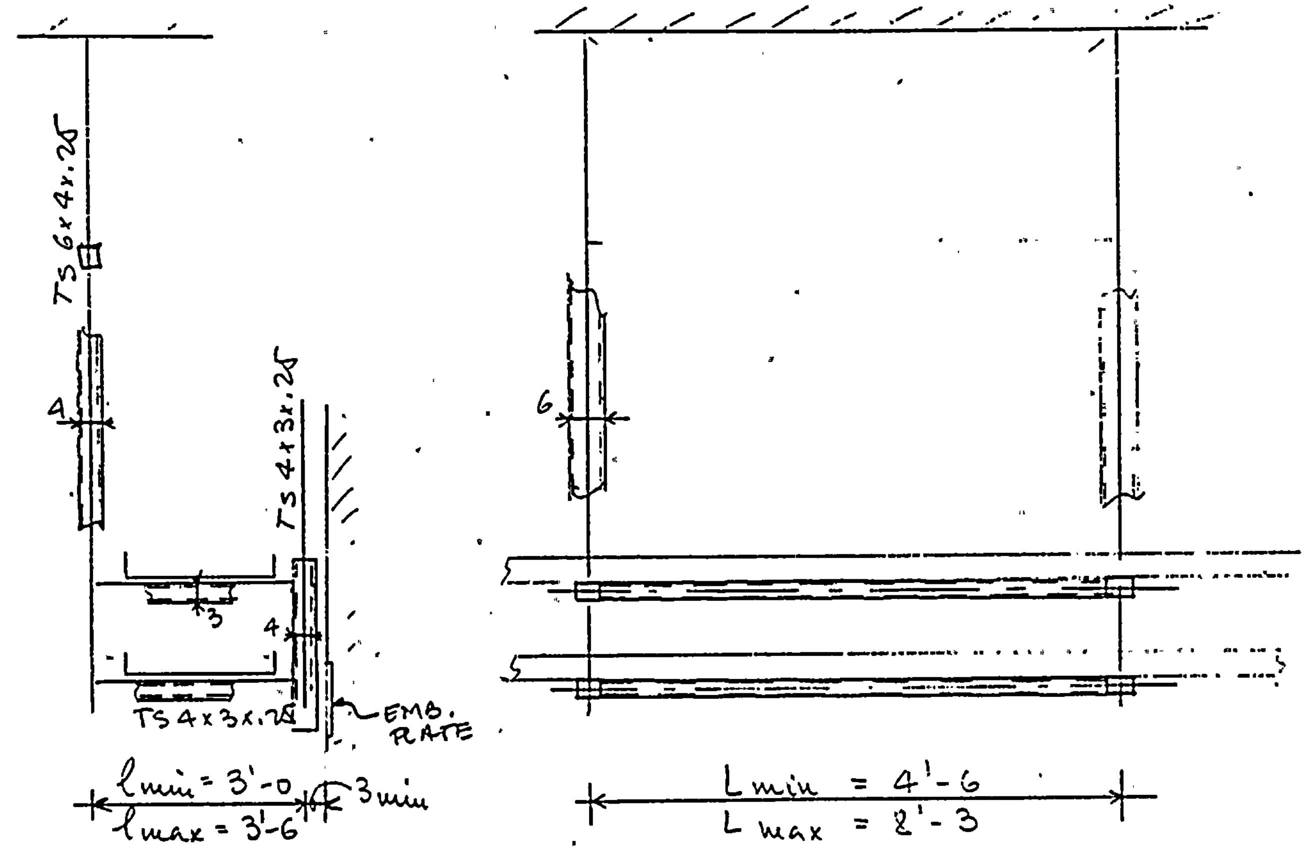
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 59

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	10.23.84									
Checker		12.20.84									

5.2 TYPE IV b. - MULTIDIRECTIONAL SUPP'T



FORCES ARE SIMILAR TO TYPE II_b, HOWEVER
VERTICAL MEMBERS WILL ACT AS SIMPLY SUPPORTED
ELEMENTS BETWEEN CEILING AND BOTTOM TRAY'S PLAN
(THE PLAN THAT IS CONNECTED TO THE WALL LONGITUDINALLY AND TRANSVERSALL!
HORIZ-BRACING)
FOR HORIZONTAL ELEMENT SEE CALC'S FOR TYPE I_b,
(SH. 18, 19 R.0)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

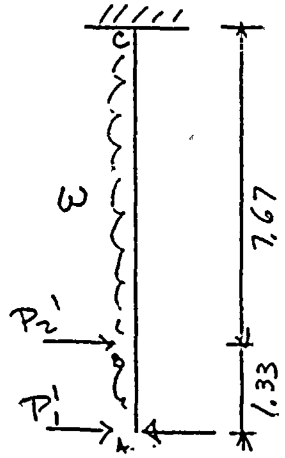
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET - B Sheet No. 60

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #		☒		☒		☒		☒		☒	
Preparer	RS	12.18.84									
Checker		12.20.84									

Type IVb - (CONT'D)

VERTICAL MEMBER - TS 6×4×.25



$$P'_{1_L} = P'_{2_L} = \left(\frac{1}{2} \times \frac{1}{2} \times 2 \times 35 \times 20 + \frac{1}{2} \times 4 \times 10.51 + \right.$$

$$\left. + \frac{10.5}{2} \times 8.25 \right) \times .54 = 224^{\#}$$

$w =$ [illegible]

$$R_A = \frac{7.67}{9.0} \times 224 + 224 + 8.43 \times \frac{9}{2} = 453^{\#}$$

$$R_c = \frac{1.33}{9.0} \times 224 + 8.43 \times \frac{9}{2} = 71^{\#}$$

$$M_L = 71 \times 7.67 - 8.43 \times \frac{7.67^2}{2} = 297^{\#'}$$

$$V_{DL} = \frac{1}{2} \times \overbrace{2 \times 35 \times 9 \times 2}^{6.30} + 2 \times \overbrace{\frac{1}{2} \times 4 \times 10.51}^{42} + \overbrace{15.62 \times 9}^{141} = 813^{\#}$$

$$V_V = 1.2 \times 813 = 975^{\#}$$

$$P_{1_T} = ([illegible] \times \overbrace{2 \times 35 \times 9}^{630} + [illegible]\ \overbrace{4 \times 10.51}^{42} + 15.62 \times \frac{9}{2}) \times .54 = 401^{\#}$$

$$\frac{kl}{r_x} = \frac{9 \times 12}{2.19} = 49.3 \qquad \frac{kl}{r_y} = \frac{7.67 \times 12}{1.6} = 57.5 \qquad F_a = 17.62 \text{ ksi}$$

$$fa_{DL} = \frac{.813}{4.59} = .18 \text{ ksi} \qquad fa_V = \frac{.975}{4.59} = .21 \text{ ksi} \qquad fa_T = 0$$

$$fb_{DL} = .59 \text{ ksi} \qquad fb_V = .71 \text{ ksi} \qquad fb_T = \frac{.8.43 \times 7.67^2 \times 12}{8 \times 5.76} = .13 \text{ ksi}$$

$$fb_L = \frac{.297 \times 12}{7.36} = .48 \text{ ksi}$$

METHOD 1:

$$\frac{.18}{17.62} + \frac{.59}{21.6} + \left[\left(\frac{.21}{17.62} + \frac{.71}{21.6} \right)^2 + \left(\frac{.13}{21.6} \right)^2 + \left(\frac{.48}{21.6} \right)^2 \right]^{1/2} = .088 < 1.0$$

O.K.

METHOD 2:

$$\frac{.18 + .21}{17.62} + \frac{.59 + (.71^2 + .13^2)^{1/2}}{21.6} + \frac{.48}{21.6} = .106 < 1.0 \quad \text{O.K.}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

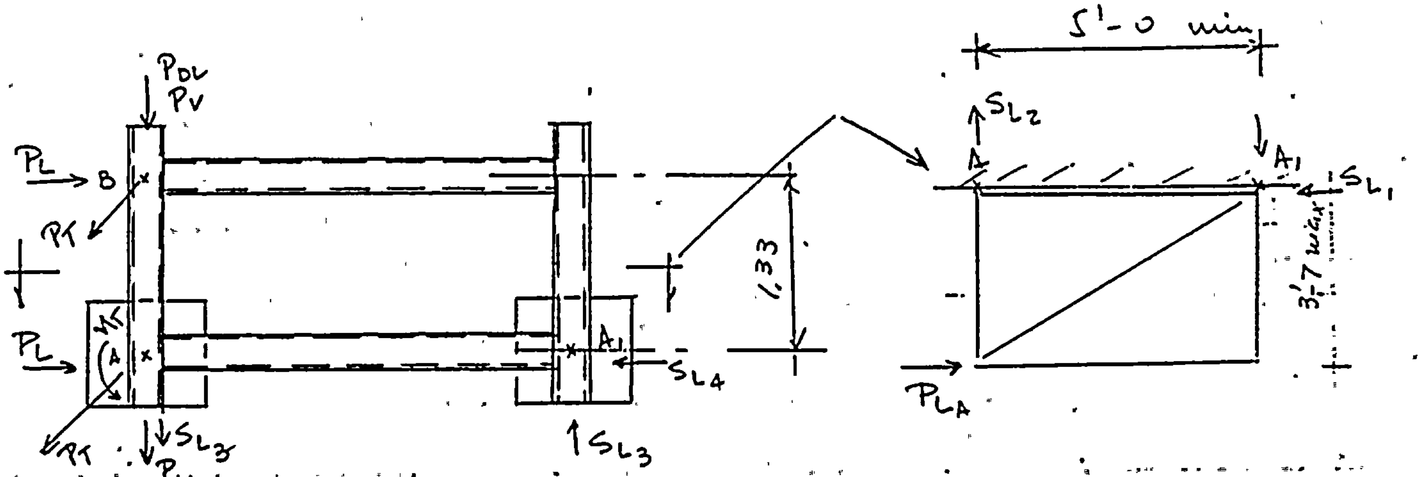
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET - B Sheet No. 61

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12.18.84									
Checker		12-20-84									

Type IV_b - (CONT'D)

CONNECTION TO WALL



NOTE: FOR MOST CONSERVATIVE DESIGN OF CONNECTION TO EMBEDDED PLATE, ALL TRANSVERSE LOADS ARE ASSUMED TRANSF. TO WALL WITHOUT HELP FROM COLUMNS SUPPORTED ~~ON~~ TO CEILING.

(CONSERVATIVELY TAKEN)

@ POINT B

$P_{DL} = \overset{672\#}{\overline{632+42}}$ $P_V = 806^{\#}$

$P_T = 672 \times .54 = 363^{\#}$ $P_L = 224^{\#}$

@ POINT A

$P_{DL} = 672 + 10.57 \times 1.83 = 691^{\#}$ $P_V = 830^{\#}$ $P_{T_1} = 401 + 363 = 764^{\#}$

$M_T = 363 \times 1.33 = 483^{'\#}$ FROM POINT B

DUE TO P_{L_A}: $S_{L_2} = 453 \times \frac{3.58}{5.0} = 324^{\#}$

$S_{L_1} = 453 + 224 + 224 = 901^{\#}$

DUE TO P_L @ B : $224 \times \frac{1.33}{5.0} = 60^{\#} = S_{L_3}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

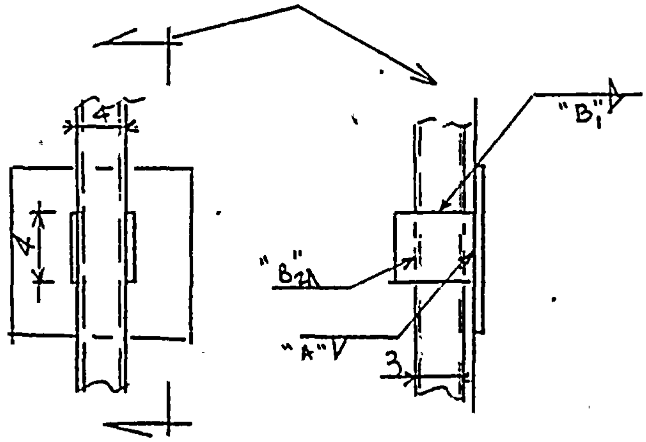
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6"

Calculation Number SC-DB-08 SET-B Sheet No. 62

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	12.18.84								
Checker	KG	12-20-84								

Type $\overline{IV}_b$ - (CONT'D)



WELD "A" 3/16" - 4" LONG

$f_{DL} = \frac{691}{2\times4} = 86\ \#/in$ $f_V = \frac{830}{2\times4} = 104\ \#/in$

$f_{T_1} = \frac{764.7}{2\times4} = 96\ \#/in$ $f_{T_2} = \frac{483\times12}{2\times\frac{4^2}{6}} = 1087\ \#/in$

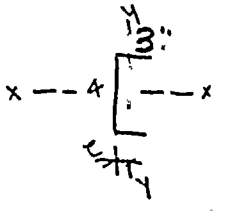
$f_{L_2} = \frac{324}{2\times4} = 41\ \#/in$ $f_{L_1} = \frac{901/2}{2\times4} = 56\ \#/in$ $f_{L_3} = \frac{60}{2\times4} = 7.5\ \#/in$

$f_{L_4} = \frac{276}{2\times4} = 35\ \#/in$

$$f = \left[\left\{86+(104^2+7.5^2)^{\frac12}\right\}^2 + \left\{(96+1087)^2+41^2\right\} + (56)^2\right]^{\frac12} = 1200\# < 2250\#$$

FOR 3/16" WELD

WELD "B"



$e = \frac{2\times3\times1.5}{2\times3+4.0} = \approx 0.9''$ $I_y = 4\times.9^2 + 2\times3\times.6^2 + 2\times\frac{3^3}{12} = 9.9$

$I_x = \frac{4^3}{12} + 2\times3\times2^2 = 29.33$

$S_y = \frac{9.9}{2.10} = 4.71 in^2$

$A = 2\times3+4 = 10\ in$

$f_{DL} = \frac{691}{2\times10} = 35\ \#/in$ $f_V = \frac{830}{2\times10} = 42\ \#/in$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG – CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 63

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	R S	12.18.84									
Checker		12.20.84									

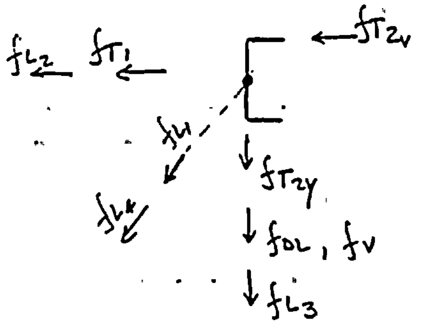
Type IV$_b$ – (CONT'D)

$$f_{T_1} = \frac{264+257}{2\times10} = 38^{\#}/in \qquad f_{T_{2x}} = \frac{483\times12}{9.9+29.33}\times2 = 295^{\#}/in$$

$$f_{T_{2y}} = \frac{483\times12}{39.23}\times2.1 = 310^{\#}/in$$

$$f_{L_2} = \frac{324}{2\times10} = 16^{\#}/in \qquad f_{L_1} = \frac{452}{2\times10} = 23^{\#}/in$$

$$f_{L_3} = \frac{60}{2\times10} = 3^{\#}/in$$



$$\left[\left\{35+\left(42^2+310^2+3^2\right)^{\frac{1}{2}}\right\}^2+\left\{\left(16^2+38^2\right)^{\frac{1}{2}}+23\right\}^2\right]^{\frac{1}{2}}$$

$$= 351^{\#} < 2250^{\#} \text{ FOR } \tfrac{3}{16} \text{ WELD}$$

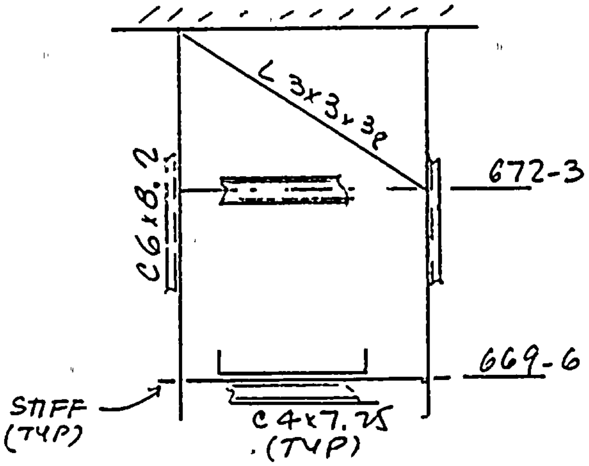
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

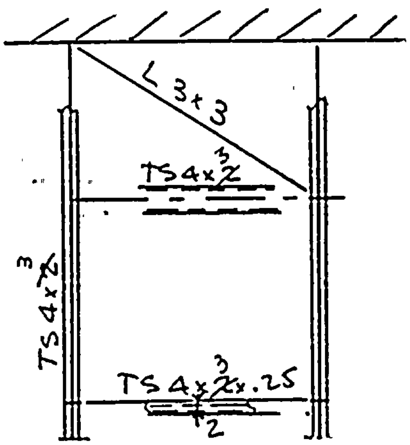
Subject D/G E BLDG. - CABLE TRAY SUPPORTS UP TO EL. 675'-6

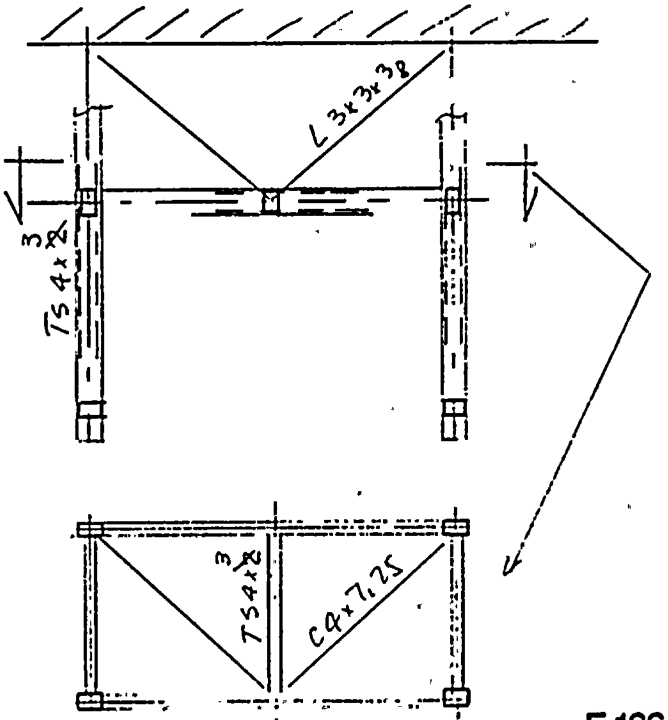
Calculation Number SC-DB-08 SET-B Sheet No. 64

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.25.84									
Checker		12-20-84									



TYPE $\overline{V}$a - TRANSV.





TYPE $\overline{V}$b - MULTIDIR.

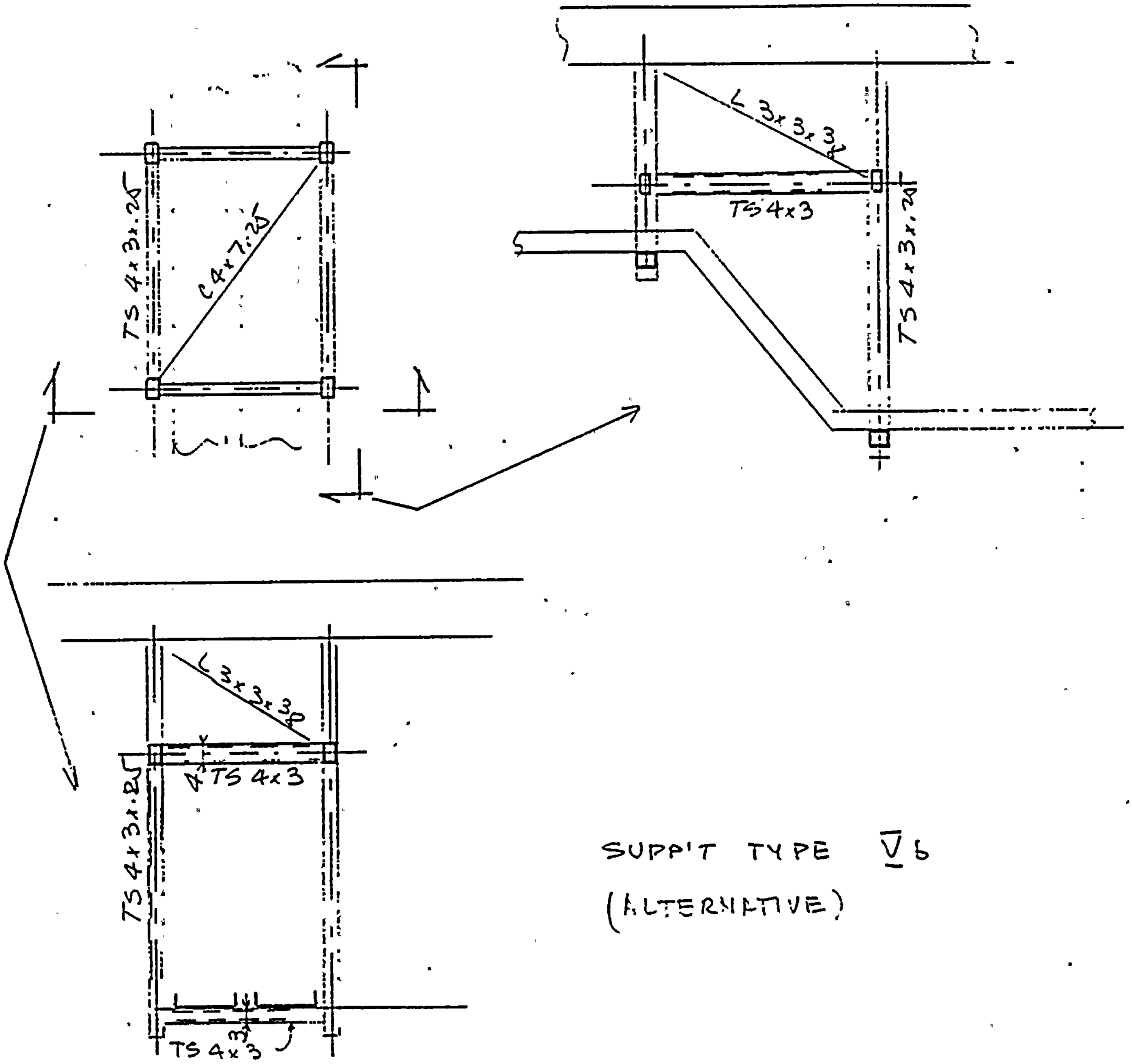
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG – CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 65

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	10.31.84									
Checker		12-20-84									



SUPP'T TYPE V b
(ALTERNATIVE)

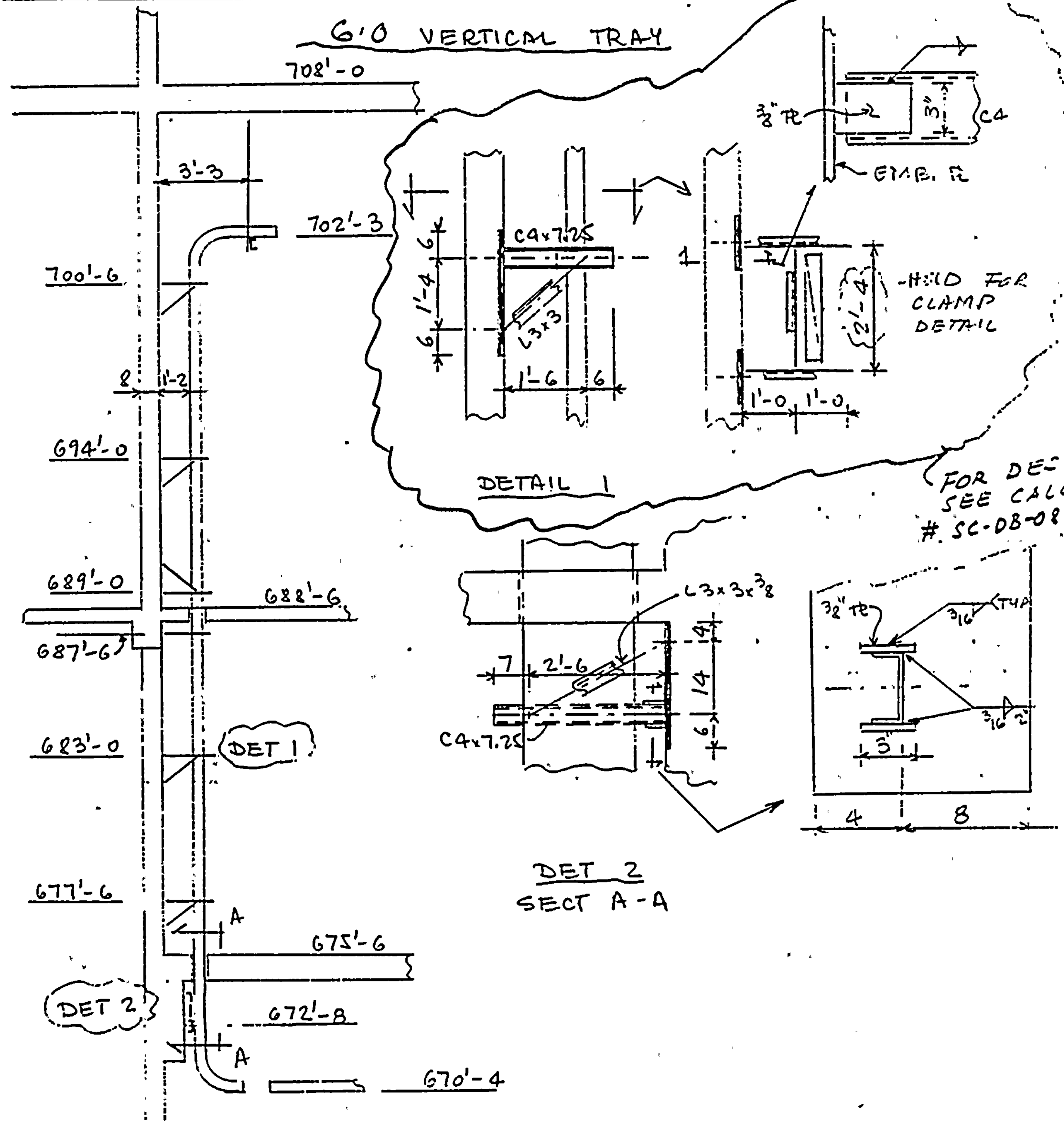
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET-B Sheet No. 66

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.16.84									
Checker		12-20-84									



FOR DESIGN SEE CALC. #. SC-DB-08 SET

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

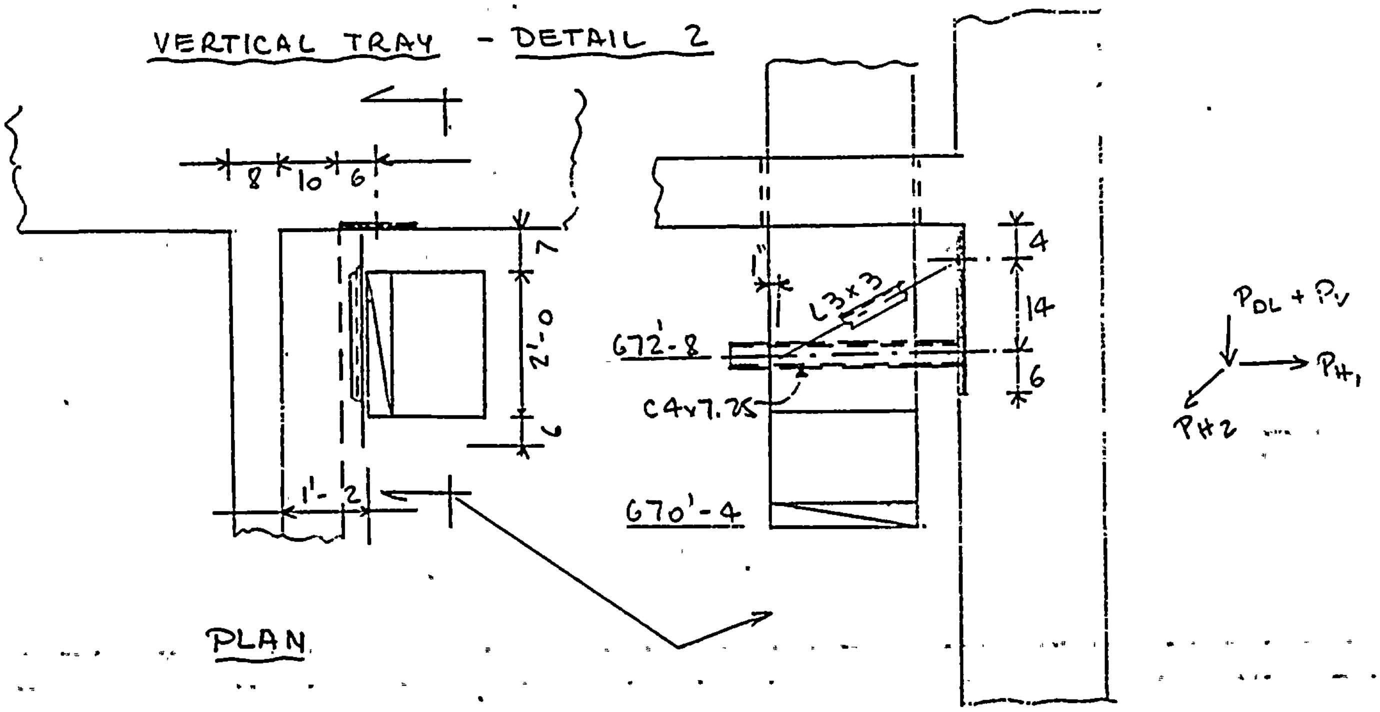
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 67

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date		
Checking Method #	1	☒		☒		☒		☒		☒		
Preparer	RS	11.16.84										
Checker		12-20-84										

VERTICAL TRAY - DETAIL 2



NEXT SUPPORT IS @ EL. 677'-6

$g_H = .54$
$g_V = .36$

TRIBUTARY TRAY LENGTH:

$$\frac{4.83}{2} + 1.0 + \frac{\pi \times 1.0}{4} + .33 = 4.53'$$

TRAY LOAD: $4.53 \times 2 \times 35 = 317^{\#}$

TOTAL DL: $317 + 7.25 \times 3.16 + 7.2 \times 2.75 = 360^{\#}$

CHECK C4 × 7.25

$M_{DL} = 360 \times \frac{2.5}{4} = 225^{'\#}$ $M_V = .36 \times 225 = 81^{'\#}$

$M_{H_2} = .54 \cdot 360 \times 1.66 = 323^{'\#}$ $P_{a_{H_1}} = .54 \times 360 = 194^{\#}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 68

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	RS	11.16.84								
Checker		12.20-84								

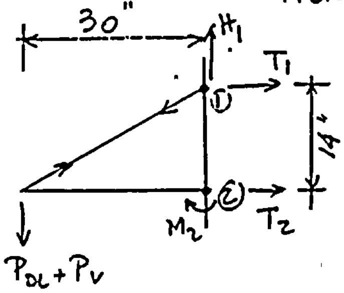
VERT. TRAY -(CONT'D)

$$\frac{kl}{r_y} = \frac{2.1\times2.5\times12}{.44} = 143.0 \qquad F_a = 7.3 \text{ ksi}$$

$$f_{a_{H_1}} = \frac{194}{1.92} = 101 \text{ psi} \qquad f_{b_{DL}} = \frac{225\times12}{1.95} = 1385 \text{ psi} \qquad f_{b_V} = \frac{81\times12}{1.95} = 498 \text{ psi}$$

$$f_{b_{H_2}} = \frac{323\times12}{.296} = 13094 \text{ psi} \qquad \frac{1.39}{21.6} + \left[\left(\frac{.101}{7.30}\right)^2 + \left(\frac{.5}{21.6}\right)^2 + \left(\frac{13.3}{21.6}\right)^2\right]^{1/2} = \text{[illegible]}$$

NOTE: SINCE MOMENT IN VERT DIRECTION 225+81 = 306 IS LESS THAN HORIZ. MOMENT 323# CHANNEL MAY BE TURNED 90°



$$\frac{.101}{7.3} + \frac{1.39+.5}{21.6} + \frac{13.3}{21.6} = .723 < 1 \text{ [illegible]}$$

CHECK EMBEDDED PL.

$P_{DL}+P_V = 360 + .36\times360 = 490\#$ (conservatively all loads taken as single [illegible])

$T_1 = 490\times\frac{30}{14} = 1050\#$ (V + DL)

$H_1 = 490\#$ (V + DL)

$$T_2 = \overset{771}{\underbrace{360\times\frac{30}{14}}_{DL}} + \left[\underbrace{194^2}_{H_1} + \Big(\underbrace{.36\times360\times\frac{30}{14}}_{V}\Big)^2\right]^{1/2} = 1110\#$$

FROM SH. 75 REV. 0, BOOK SC-DB-06, PLATE'S CAPACITY IS:

$T = \frac{11.52}{1.6} = 7.2^k$ @ ¢ OF STUDS

$V = \frac{83.0}{1.6} = 51.9^k$ FOR THE ENTIRE PL.

THESE VALUES ARE FOR OBE

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 61

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.16.84									
Checker		12-20-84									

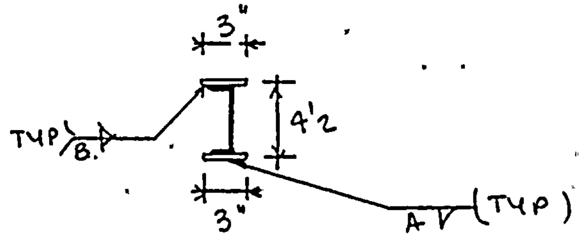
VERT TRAY - (CONT'D)

IN THIS CASE @ POINT ②

TOTAL MOM. ON ℄ $M = \frac{M_2}{2} + \frac{T_2 \times 8}{4} = \frac{323 \times 12}{2} + \frac{1110}{4} = 4158\ ''\# = 4.16\ ''k$

FROM CALC. BOOK # SC-DB-06, Sh # 67 R.0, MOMENT CAPACITY OF PLATE = 7.2 "k > 4.16 '# O.K.

CONNECTION. C9×7.25 TO EMB. PLATE:



WELD "A":

$f_1 = \frac{1110}{2 \times 3} + \frac{323 \times 12}{2 \times \frac{3^2}{6}} = 1477\ \#$

$f_2 = \frac{194}{2 \times 3} = 32\ \#$

$f_3 = \frac{490}{2 \times 6} = 41\ \#$

$f = [1477^2 + 32^2 + 41^2]^{\frac{1}{2}} = 1478\ \#/in$

3/16" FILLET WELD - 2.5 × 900 = 2250 #/in O.K.

WELD "B": 4 × 2"

$f_1 = \frac{1110}{4 \times 2} = 139\ \#/in\ (T_2)$

$f_2 = \frac{323 \times 12}{2 \times 2 \times 1.72} = 563\ \#/in\ (M_{H2})$

$f_3 = \frac{194}{8} = 24\ \#;\ f_4 = \frac{41 \times 6}{8} = 31\ \#$

O.K.

$f = [(139 + 563)^2 + 24^2 + 31^2]^{\frac{1}{2}}$

$= 703\ \# < 2250\ \#$ OK

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

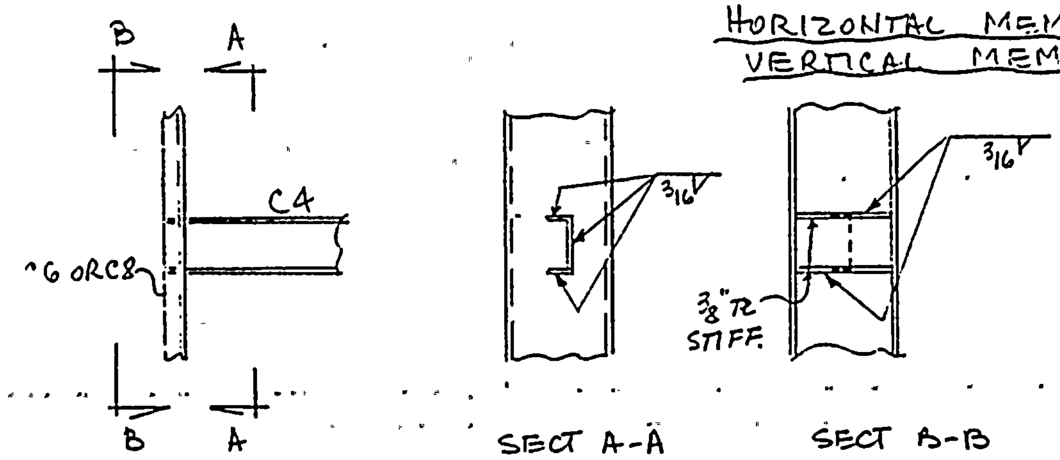
Calculation Number SC-DB-08 SET-B Sheet No. 70

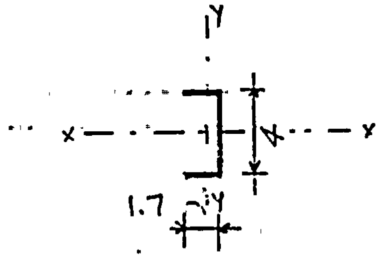
Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	11.28.84								
Checker		12.20.84								

7.0 CONNECTION DETAILS

7.1 TRANSVERSAL SUPPORT

HORIZONTAL MEMBER (C4) TO VERTICAL MEMBER (C6 OR C8)





$A_w = 4 + 2\times1.7 = 7.4$ in

$S_{wx} = \frac{4^2}{6} + 2\times1.7\times2 = 9.5$ in^2

MAX FORCES APPLIED TO CONN: (FROM SH. 21 R.0)

$M_{DL} = .29^{1k}$ $M_V = .35^{1k}$ $M_T = 1.26^{1k}$ $P_{aT} = 1.16^k$

$S_{1DL} = 335^{\#}$ $S_{1V} = 400^{\#}$ $S_{1T} = .84^k$ $S_{2L} = 10^{\#}$

$f1_{DL} = \frac{.29\times12}{9.5} = .36$ k/in $f1_V = \frac{.35\times12}{9.5} = .44$ k/in $f1_T = \frac{1.26\times12}{9.5} = 1.59$ k/in

$fa_T = \frac{1.16}{7.4} = .16$ k/in

NORMAL STRESS : $.36 + \left[.44^2 + (.16 + 1.59)^2\right]^{1/2} = 2.16$ k/in

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-02 SET-A Sheet No. 71

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.29.84									
Checker		12-20-84									

SHEAR STRESS :

$$\frac{335 + (400^2 + 840^2)^{\frac{1}{2}}}{7.4} = .171 \text{ k/in}$$

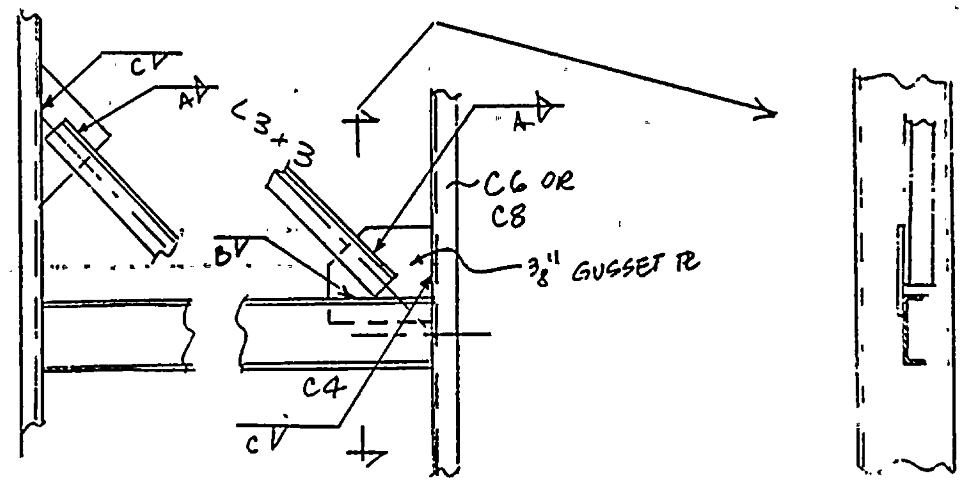
$$\frac{.01}{7.4} = .001 \text{ k/in} \quad \text{NEGLECTABLE}$$

MAX STRESS IN WELD : $(2.16^2 + .171^2)^{1/2} = 2.17$ k/in

$\frac{3}{16}$" WELD CAPACITY = $2.5 \times .90 = 2.25$ k/in > 2.17 k/in O.K.

(CONSIDERING $\frac{1}{32}$" UNDERRUN)

DIAGONAL MEMBER'S ($L3 \times 3 \times \frac{3}{8}$) CONNECTION



MAX AXIAL LOAD IN BRACE IS 2.63^{k} (See sh. 15 Rev. 0)

$\frac{3}{16}$" WELD MIN $\ell = \frac{2.63}{2.32} = 1.13$ in

WELD A → 2" min WELD B, C → 2" min

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

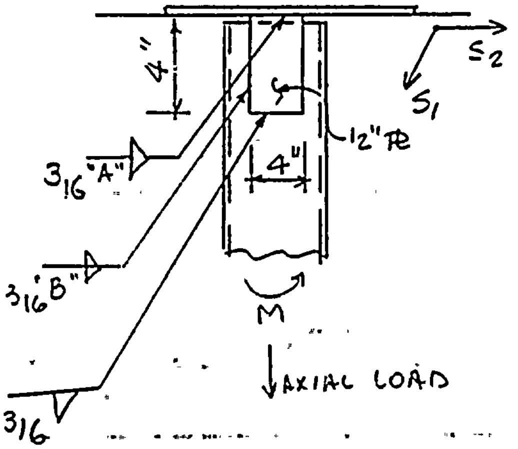
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-02 SET-B Sheet No. 72

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.29.84									
Checker		12-20-84									

CEILING CONNECTION



MAX AXIAL LOAD : (VERTICAL)

$V_{DL} = 1.15^k$ (Sh. 21 R.0) $V_V = 1.39^k$ $V_T = 3.18^k$

MAX HORIZ SHEAR :

$S_{1T} = 1.25^k$ $S_{2L} = .114^k$ (Sh. 15 R.0 Sh. 20 R.0)

MOMENT :

$M_{2L} = .65^{1k}$ (Sh. 20 R.0)

WELD "A"

$A = 4\ in$ $S = \frac{2\times 4^2}{6} = 5.33\ in^2$

$f_{DL} = \frac{1.15}{8} = .14\ k/in \downarrow$ $f_V = \frac{1.39}{8} = .17\ k/in \downarrow$ $f_T = \frac{3.18}{8} = .40\ k/in \downarrow$

$f_{b_L} = \frac{.65\times 12}{5.33} = 1.46\ k/in \downarrow\uparrow$

$f_{1T} = \frac{1.25}{8} = .16\ k/in \swarrow$ $f_{2L} = \frac{.114}{8} = .0014\ k/in \rightarrow$

$$f = \left\{\left[0.14 + (.17^2 + 0.4^2 + 1.46^2)^{\frac{1}{2}}\right]^2 + .16^2 + 0.014^2\right\}^{\frac{1}{2}} = 1.67\ ^{k/in}$$

3/16" WELD $f_{capacity} = 2.25\ ^{k/in} > 1.67\ ^{k/in}$ ok

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 73

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	11.29.84								
Checker		12-20-84								

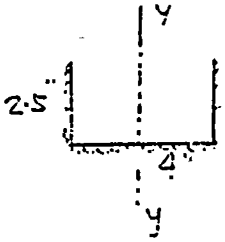
<u>WELD "B"</u> : EFFECTIVE LENGTH 4-1.5 = 2.5 in

$A = 2\times 2.5 + 4 = 9''$

DUE TO AXIAL LOAD :

$f_{DL} = \frac{1.15}{9} = .13\ k/in \downarrow$ $f_V = \frac{1.39}{9} = .15\ k/in \downarrow$ $f_T = \frac{3.18}{9} = .35\ k/in \downarrow$

DUE TO MOMENT :



$S_{yy} = \frac{b^2}{6} + 2.5\times 4$
$= 12.67\ in^2$

$f_L = \frac{.65\times 12}{12.67} = .62\ k/in \downarrow$

DUE TO SHEAR :

$f_{1T} = \frac{1.25}{9} = .14\ k/in \swarrow$ $f_{2L} = \frac{.114}{9} = .01\ k/in \rightarrow$

$f_1 = .13 + (.15^2 + .35^2 + .62^2)^{1/2} = 0.73\ k/in$

$f_{TOTAL} = (0.73^2 + .14^2 + .01^2)^{1/2} = 0.74\ k/in < 2.25\ k/in\ (3/16'')$

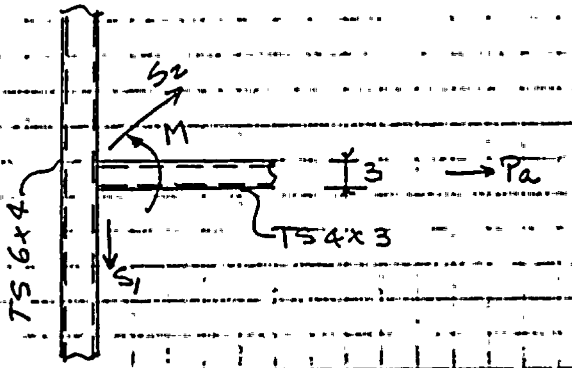
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

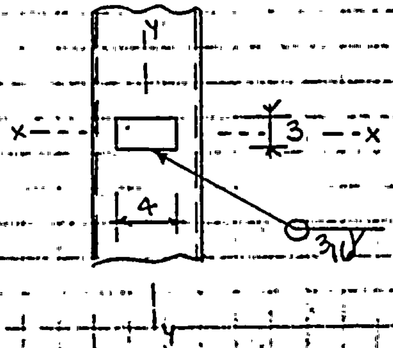
Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer	RS	11.30.84								
Checker		12-20-84								

CONNECTION DETAILS

7.2 MULTIDIRECTIONAL SUPPORT (TYPE Ia.)

TS 4x3 TO TS 6x4





$A_{WELD} = 2 \times (4+3) = 14$ in

$S_{x\,WELD} = 4 \times 3 + 3 = 15$ in^2 $S_{y\,WELD} = 3 \times 4 + \frac{32}{6} = 17.33$ in^2

MAX LOAD @ CONNECTION :

$M_{DL} = .44^{1k}$ $M_V = .53^{1k}$ $M_T = 1.26^{1k}$ (see sh. 33 R.0)

$S_{1DL} = 0.34^k$ $S_{1V} = 0.41^k$ $S_{1T} = .84^k$ see sh. 21 R.0)

$P_{aT} = 1.16^k$ $S_{2L} = \frac{.636}{2} = .32^k$ (see sh. 33 R.0).

$\overrightarrow{f_{aT}} = \frac{1.16}{14} = .08$ k/in $\overrightarrow{f_{bDL}} = \frac{.44 \times 12}{15} = .35$ k/in $\overrightarrow{f_{bV}} = 1.2 \times .35 = .42$ k

$\overrightarrow{f_{bT}} = \frac{1.26 \times 12}{15} = 1.0$ k/in

$\overset{\downarrow}{f_{1DL}} = \frac{0.34}{14} = .024$ k/in $\overset{\downarrow}{f_{1V}} = \frac{0.41}{14} = .029$ k/in $\overset{\downarrow}{f_{1T}} = \frac{.84}{14} = .06$ k/in

$\overset{\nearrow}{f_{2L}} = \frac{.32}{14} = .022$ k/in

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 75

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	11.30.84									
Checker		12-20-84									

$$f_1 = .35 + \left[(.08+1.00)^2 + .42^2\right]^{1/2} = 1.51 \text{ k/in} \rightarrow$$

$$f_2 = .024 + (.029^2 + .06^2)^{1/2} = .091 \text{ k/in} \downarrow$$

$$f_3 = 0.022 \text{ k/in}$$

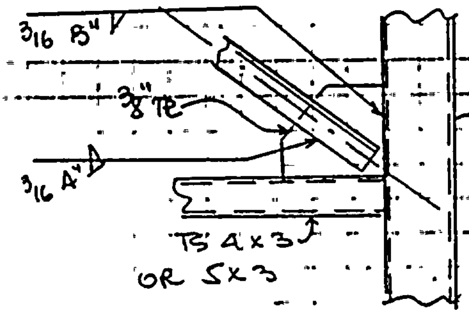
$$f_{Total} = (1.51^2 + .091^2 + .022^2)^{1/2} = 1.513 \text{ k/in.}$$

3/16" WELD'S CAPACITY IS 2.25 k/in

DIAGONAL MEMBER'S (L3x3) CONECTION (SUPP'T TYPE I_b)

MAX AXIAL LOAD IN BRACE IS 4.94^k (See Sh. 36 R.0)

$3/16"$ WELD $\rightarrow$ MIN $l = \frac{4.94}{2.25} = 2.20$ in



WELD "A" $\rightarrow l_{min} = 2"$
WELD "B" $\rightarrow l_{min} = 3"$
FOR BRACINGS IN LONGITUDINAL DIRECTION

WELD "A" $\rightarrow l_{min} = 2"$
WELD "B" $\rightarrow l_{min} = 2"$
FOR BRACINGS IN TRANSV. DIRECTION (See Sh. 74 R.0)

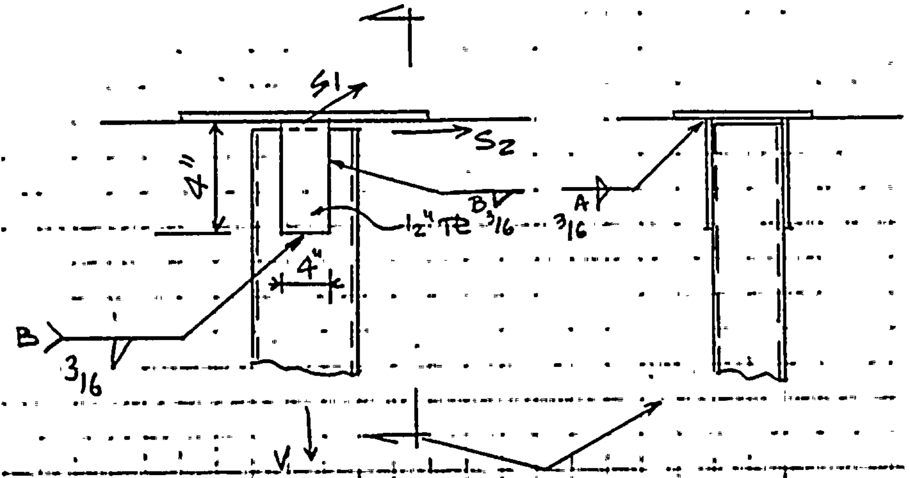
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 76

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1											
Preparer	RS	11.30.84										
Checker		12-20-84										

CEILING CONNECTION (SUPP'T TYPE I_b)



MAX AXIAL LOAD: (FROM SH. 38 R.0)

$V_{DL} = 1.24^k$ $V_V = 1.49^k$ $V_T = 3.18^k$ $V_L = 4.17^k$

$S_{1T} = 1.25^k$ $S_{2L} = 1.1^k$

WELD "A"

$A = 2 \times 4 = 8 \text{ in}$

$f_{DL} = \frac{1.24}{8} = .16 \text{ k/in}$ $f_V = \frac{1.49}{8} = .19 \text{ k/in}$ $f_T = \frac{3.18}{8} = .4 \text{ k/in}$

$f_L = \frac{4.17}{8} = .52 \text{ k/in}$

$f_{1T} = \frac{1.25}{8} = .16 \text{ k/in}$ $f_{2L} = \frac{1.1}{8} = .14 \text{ k/in}$

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 77

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	11.30.84									
Checker		12-20-84									

$$f_{Total} = \left\{\left[.16 + \left(.19^2 + .4^2 + .52^2\right)^{1/2}\right]^2 + .16^2 + .14^2\right\}^{1/2} = 0.87 k/in$$

3/16" WELD CAPACITY : 2.5 x .900 = 2.25 k/in > .87 o.k.

WELD "B" : EFFECTIVE LENGTH 4 - 1.5 = 2.5 in

A = 2 x 2 x 2.5 + 4 x 2 = 18 IN

∴ LENGTH OF WELD 18 > LENGTH OF WELD A

THEREFORE 3/16" WELD 'B' o.k.

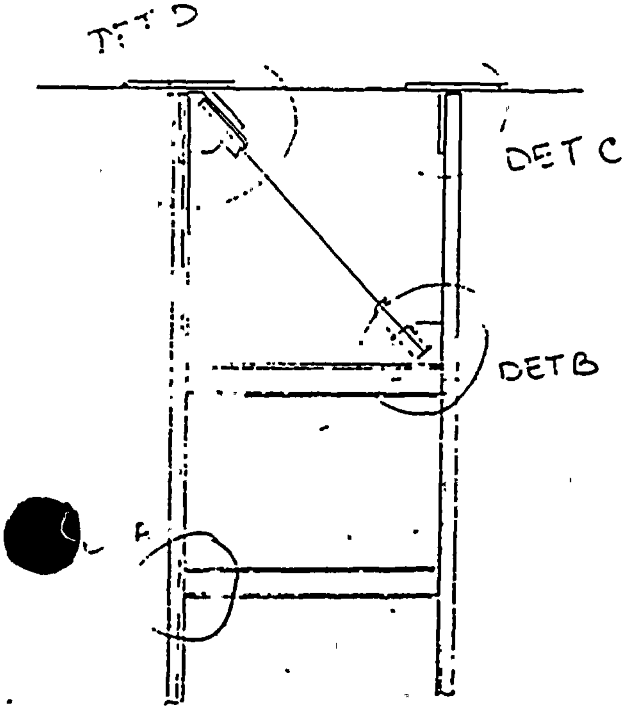
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

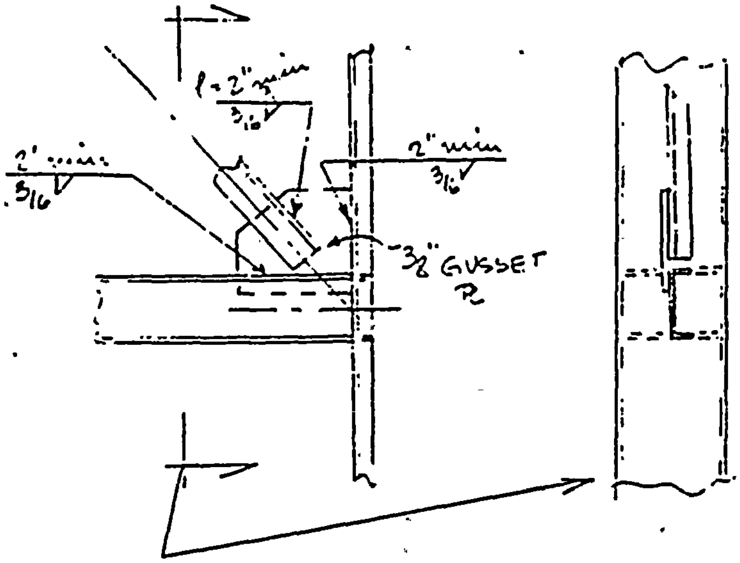
Gibbs & Hill, Inc. Job No. 2544 Client P.P.&L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

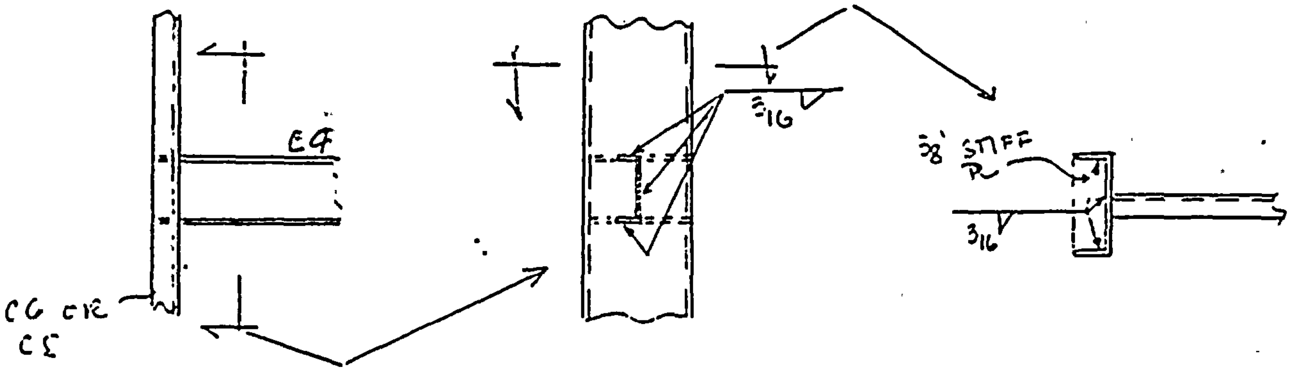
Calculation Number SC - DB - 08 SET - B Sheet No. 78.

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #											
Preparer	RS	12.6.84									
Checker		12-20-84									





DET B



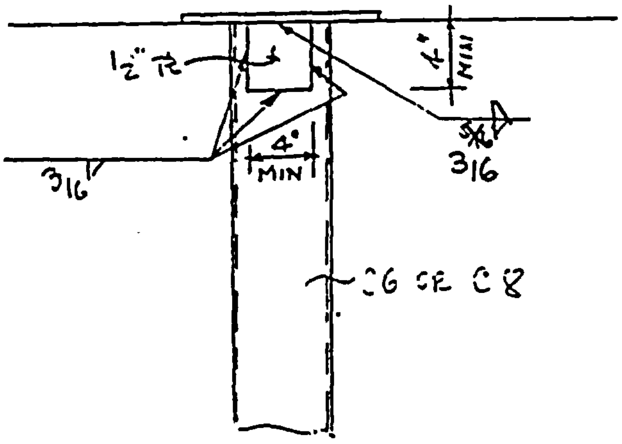
DET A

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

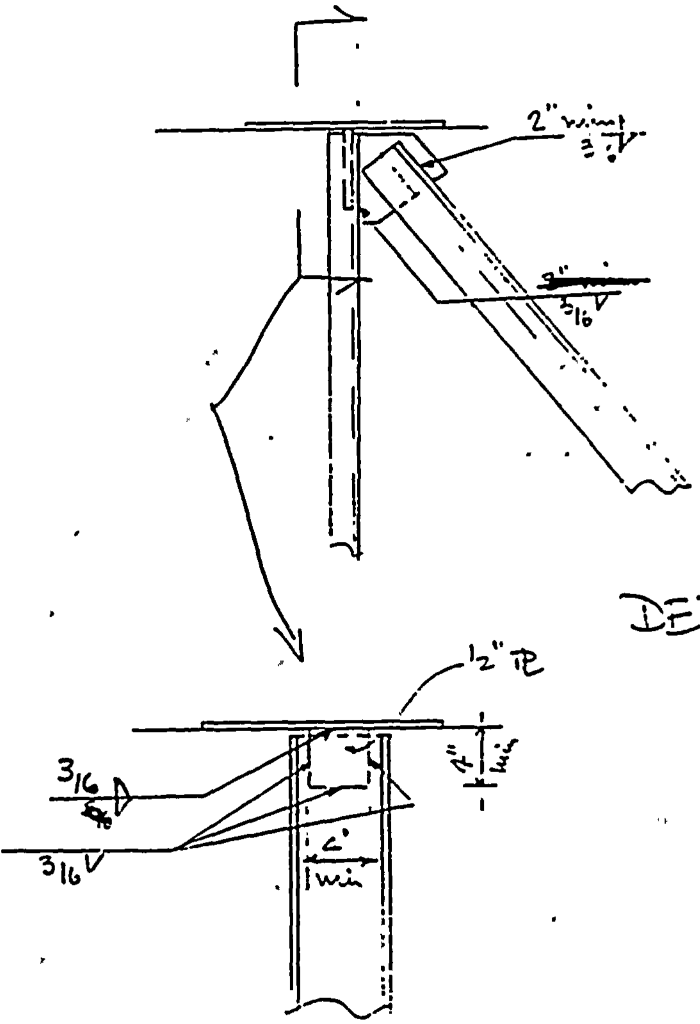
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

lculation Number SC-DB-08 SET-B Sheet No. 79.

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12.6.84									
Checker		12-20-84									



DET C



DET D

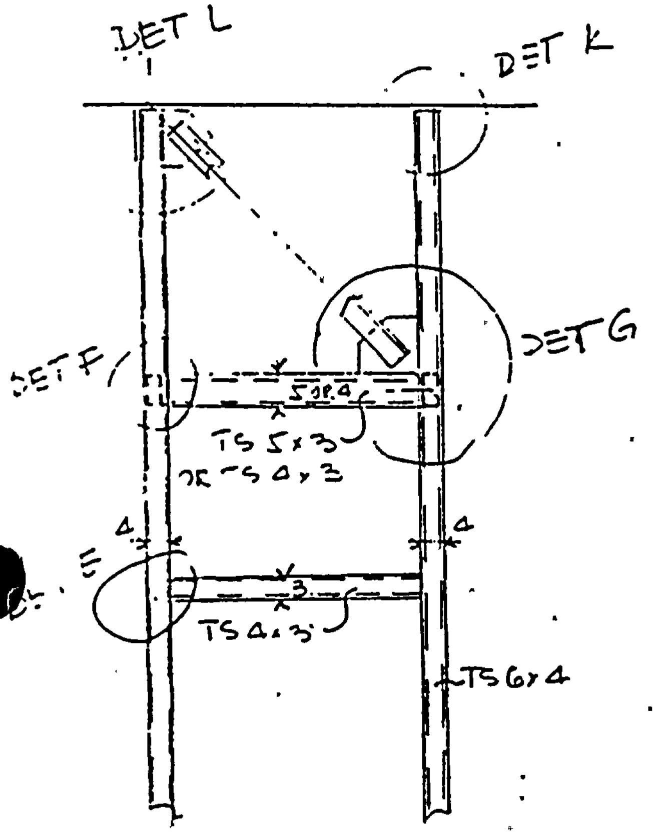
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

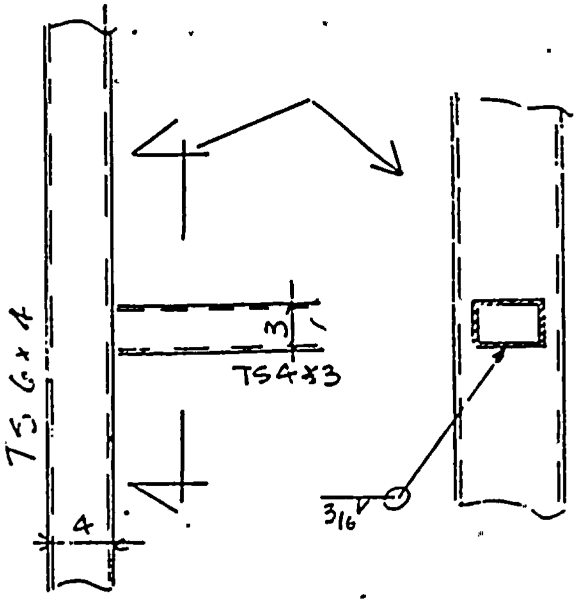
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

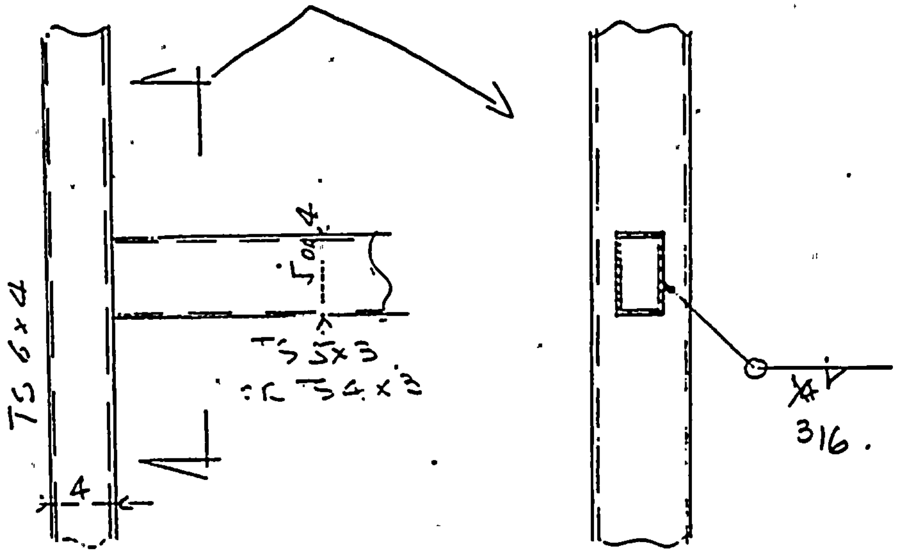
Calculation Number SC-DB-08 SET-B Sheet No. 80

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	╳		╳		╳		╳		╳	
Preparer	RS	12.6.84									
Checker	KS	12-20-84									





DET E



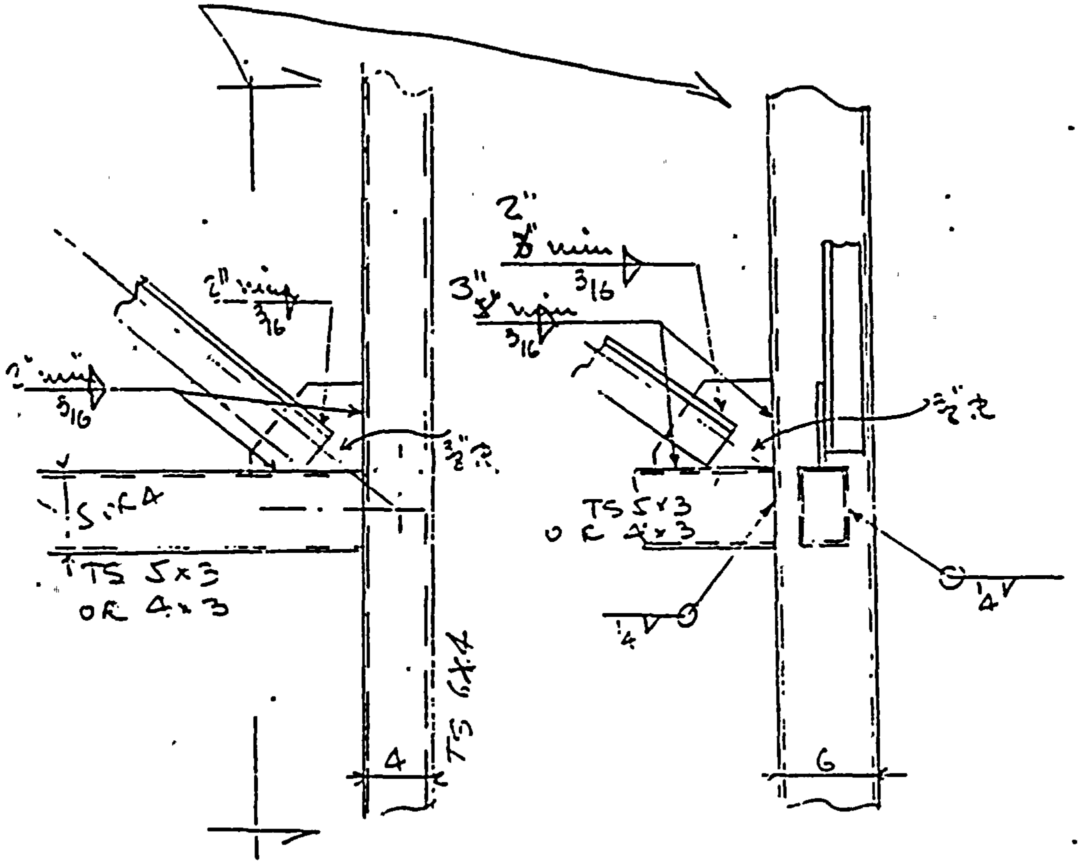
DET F

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-G Sheet No. 81

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12.6.84									
Checker		12-20-84									



DET G.

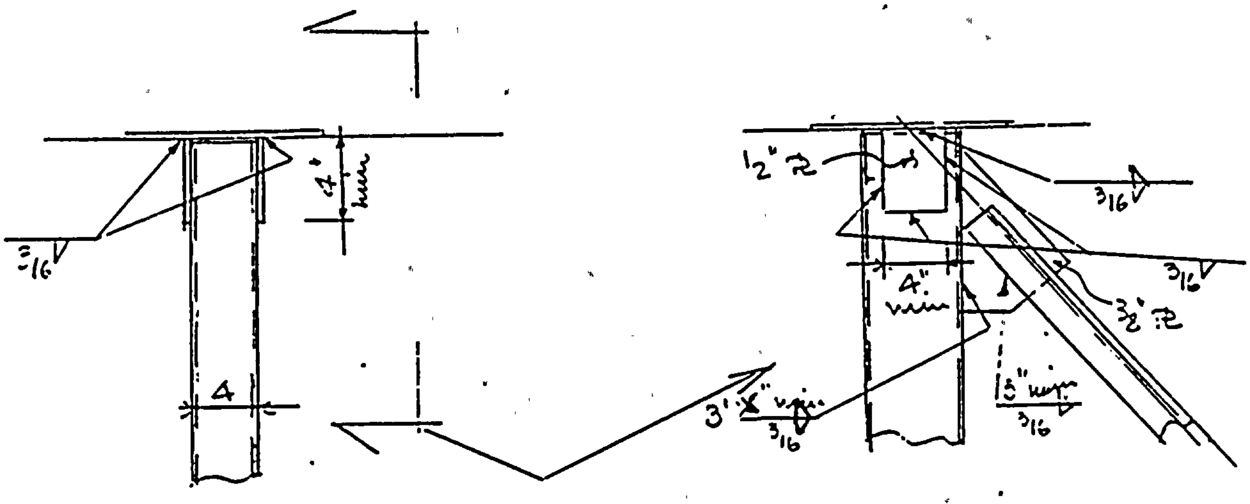
Checking Method # 1 Line-by-line checking

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

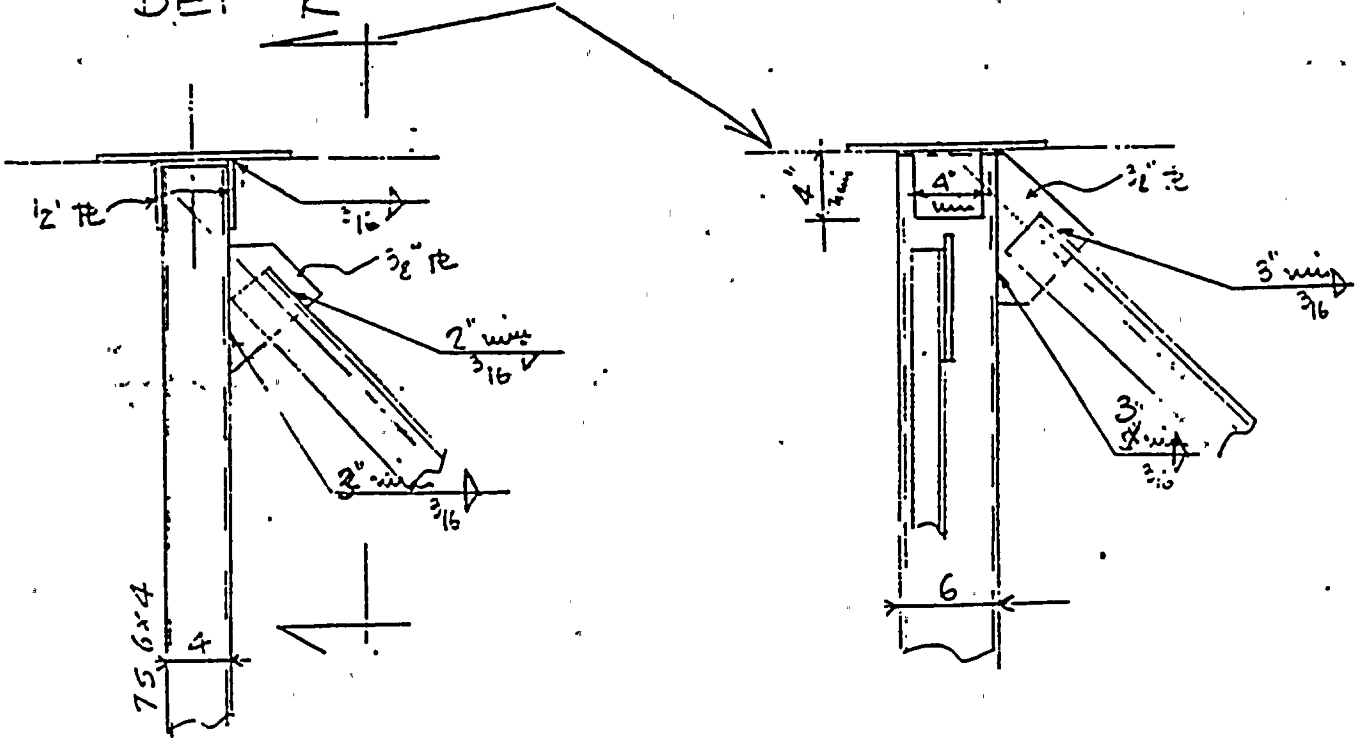
Subject D/G E BLDG - CABLE TRAY SUPPORTS UPTO EL. 675'-6

lculation Number SC-DB-08 SET-B Sheet No. 82

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	12.6.84									
Checker		12-20-84									



DET K



DET. L

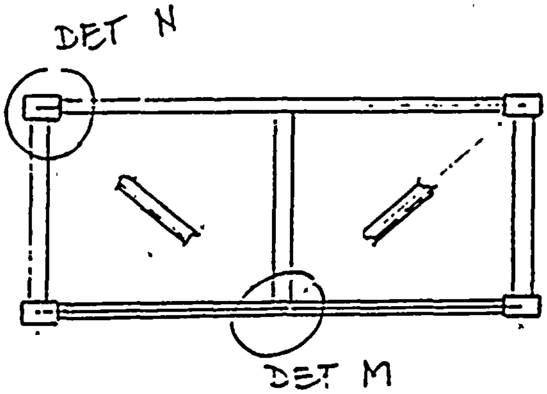
Checking Method # 1 Line-by-line checking 2 Alternative Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

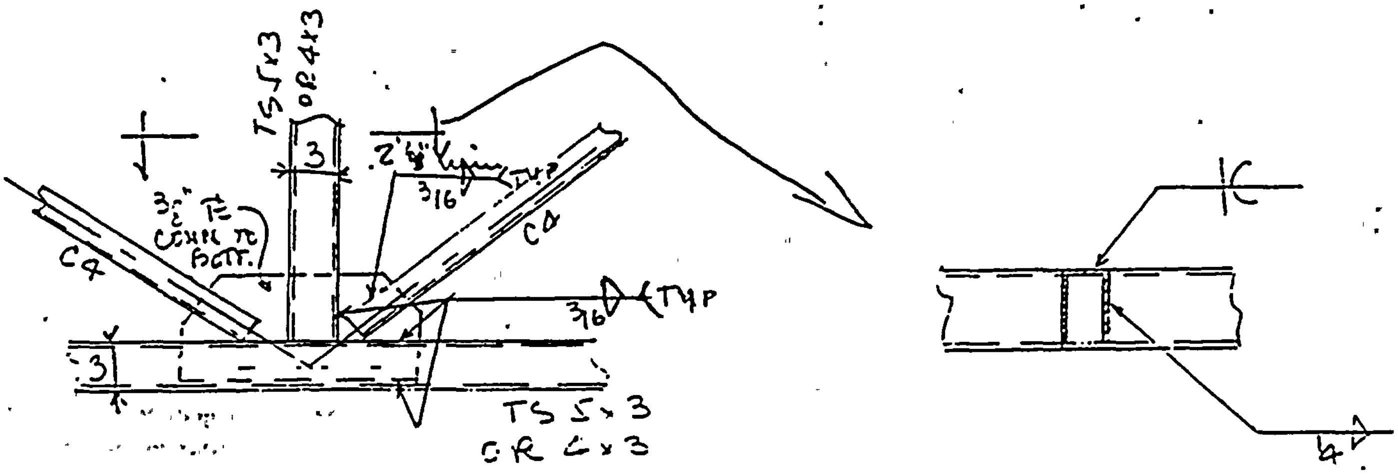
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC - DB - 08 SET - B Sheet No. 83

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12 6 84									
Checker		12.20.84									



PLAN



DET M

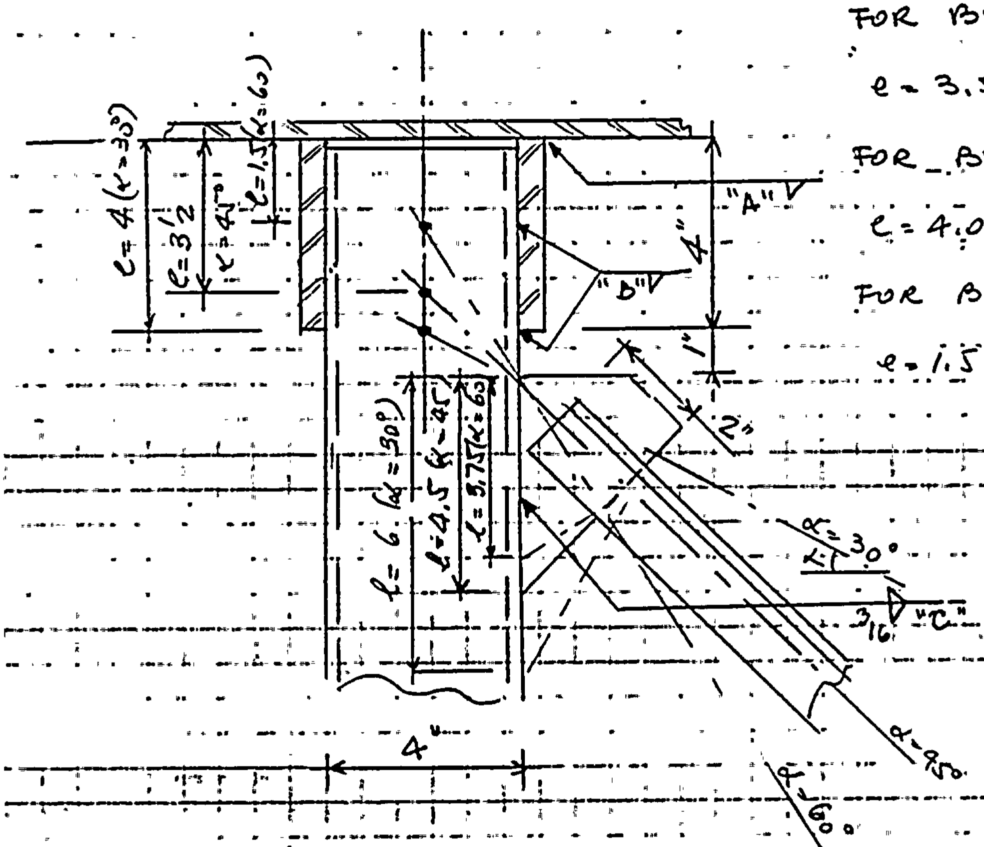
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

alculation Number SC-DB-08 SET-B Sheet No. 84

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12.12.84									
Checker		12 20-84									

DET "L" ON SH. 182 R.0 - BRACING CONNECTED EXCENTRICALLY



FOR BRACING @ 45°:
e = 3.5 in l = 4.5 in
FOR BRACING @ 30°:
e = 4.0 in l = 6.0 in
FOR BRACING @ 60°:
e = 1.5 in l = 3.75 in

MAX EXCENTRICITY IS 4 in. FOR α = 30°

MAX FORCE IN BRACE IS 2.63^k (DUE TO TRANSV. ACTION)

$P_V = 2.63 \sin 30° = 1.32^k$ $P_H = 2.63 \cos 30° = 2.28^k$

$M = P_H \times e = 2.28 \times 4 = 9.12$ in k $\Delta f_{WELD"A"} = \frac{9.12}{4 \times 4} = .57$ k/in

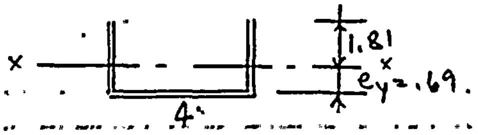
FROM SH. 77 R.0, MAX STRESS IN WELD "A" IS 0.87 k/in

CONSERVATIVELY ADDED,
.87 + .57 = 1.44 k/in < 2.25 WELD "A" (3/16") IS O.K.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	12.12.84									
Checker		12-20-84									

WELD "B"



ADDITIONAL WELD STRESS f DUE TO 9.12 K-IN MOMENT:

$$f = \frac{9.12}{4(4+2\cdot 2.5)}$$

$= 0.25\ ^{k}/_{in} < 0.57\ ^{k}/_{in}$ ADDITIONAL FOR WELD A

∴ WELD B OK

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 86

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	12.12.84									
Checker		12-20-84									

WELD "C"

FOR $\alpha = 30^\circ$ $P_H = 2.63 \cos 30^\circ = 2.28^k$

$P_V = 2.63 \sin 30^\circ = 1.32^k$

$\Delta M_{H\ \text{WELD "C"}} = 2.28 \times \frac{6}{2} = 6.84$ in.k $S_{\text{WELD}} = \frac{6^2}{6} = 6\,\text{in}^2$

$\Delta f_H = \frac{6.84}{6.0} = 1.14$ k/in $f_H = \frac{2.28}{6} = .38$ k/in

$f_V = \frac{1.32}{6} = .22$ k/in $f_{\text{WELD "C"}} = \left[(1.14 + .38)^2 + .22^2\right]^{1/2} = \frac{1.54}{2}$ k/in

$= 0.77$ k/in

FOR $\alpha = 45^\circ$ $P_H = 2.63 \cos 45^\circ = 1.86^k$

$P_V = 2.63 \sin 45^\circ = 1.86^k$

$\Delta M_{H\ \text{WELD "C"}} = 1.86 \times \frac{4.5}{2} = 4.19$ in.k $S_{\text{WELD}} = \frac{4.5^2}{6} = 3.38\,\text{in}^2$

$\Delta f_H = \frac{4.19}{3.38} = 1.24$ k/in $f_H = \frac{1.86}{4.5} = .41$ k/in

$f_V = \frac{1.86}{4.5} = .41$ k/in $f_{\text{WELD. "C"}} = \left[(1.24 + .41)^2 + .41^2\right]^{1/2} = 1.7/2 = \underbrace{.85^k}_{\text{GOVERN}}$

FOR $\alpha = 60^\circ$ $P_H = 2.63 \cos 60^\circ = 1.32^k$

$P_V = 2.63 \sin 60^\circ = 2.28^k$

$\Delta M_{H\ \text{WELD "C"}} = 1.32 \times \frac{3.75}{2} = 2.48$ in k $S_{\text{WELD}} = \frac{3.75^2}{6} = 2.34\,\text{in}^2$

$\Delta f_H = \frac{2.48}{2.34} = 1.06$ k/in $f_H = \frac{1.32}{3.75} = .35$ k/in $f_V = \frac{2.28}{3.75} = .61$ k/in

$f_{\text{WELD "C"}} = \left[(1.06 + .35)^2 + .61^2\right]^{1/2} = \frac{1.54}{2}$ k/in $= 0.77$ k/in

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 Sheet No. 87

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	12.12.84									
Checker		12-20-84									

$f_{WELD\ max} = 0.85\ k/in < 2.25$ 3/16" WELD IS O.K.

IN CONCLUSION, EXCENTRICITY CREATED BY TRANSVERSAL BRACE CONNECTED UP TO 5" BELLOW THE CONCRETE FACE ELEVATION CAN BE ABSORBED BY THE CONNECTION AND IT'S COMPONENTS.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. [illegible]

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

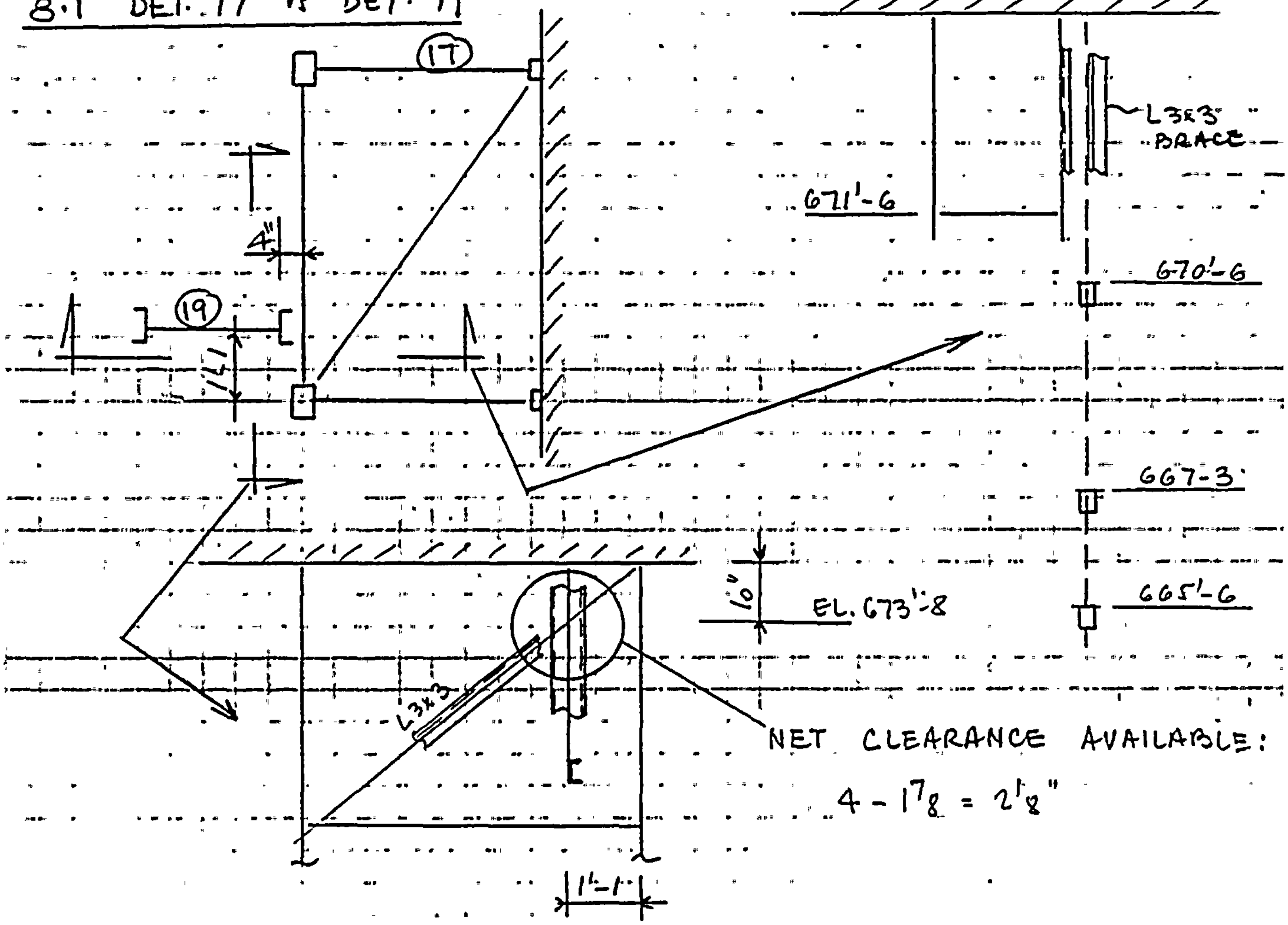
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 88

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12.13.84									
Checker		12-20-84									

8.0 VERIFICATION OF MINIMUM TOLERANCES BETWEEN ADJACENT SUPPORTS

8.1 DET. 17 Vs DET. 19



NET CLEARANCE AVAILABLE:

$4 - 1\frac{7}{8} = 2\frac{1}{8}"$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

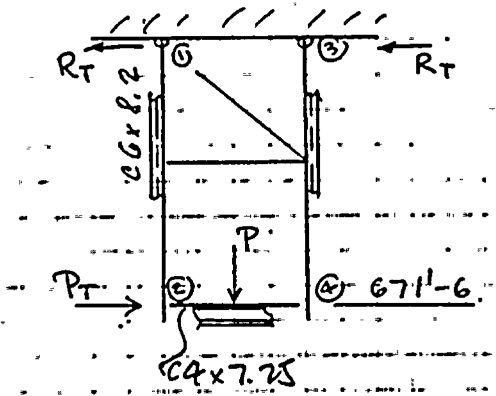
Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 89

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	R S	12.14.84									
Checker		12-20-84									

SUPPORT NO. 19



TOTAL TRIBUTARY LOAD ON SUPP'T 19 :

$$\frac{2.08}{2} + 1.0 = 2.04'$$

TRAY LOAD : $35 \times 1.0 \times 2.04 = 71.4^{\#}$

C4x7.25 : $7.25 \times 1.91 = 13.85^{\#}$

C6x8.2 : $2 \times 8.2 \times 3.5 = 57.4^{\#}$

TOTAL P_{DL} $142.7^{\#}$

TRANSVERSAL LOAD : $.54 \times 142.7 = 77^{\#}$

NOTE : AT LOCATION OF DETAIL 17 WHERE BRACING IS CLOSEST TO C 6x8.2 HANGER OF DET. 19, DEFLECTION OF FRAME 19 IS NEGLEGIBLE SINCE FRAME IS BRACED BY DIAGONAL BRACING.

∴ 2'8 CLEARANCE IS OK

Checking Method # 1. Line-by-line checking 2. Alternative Calculation Results compared

F-166, 7-82

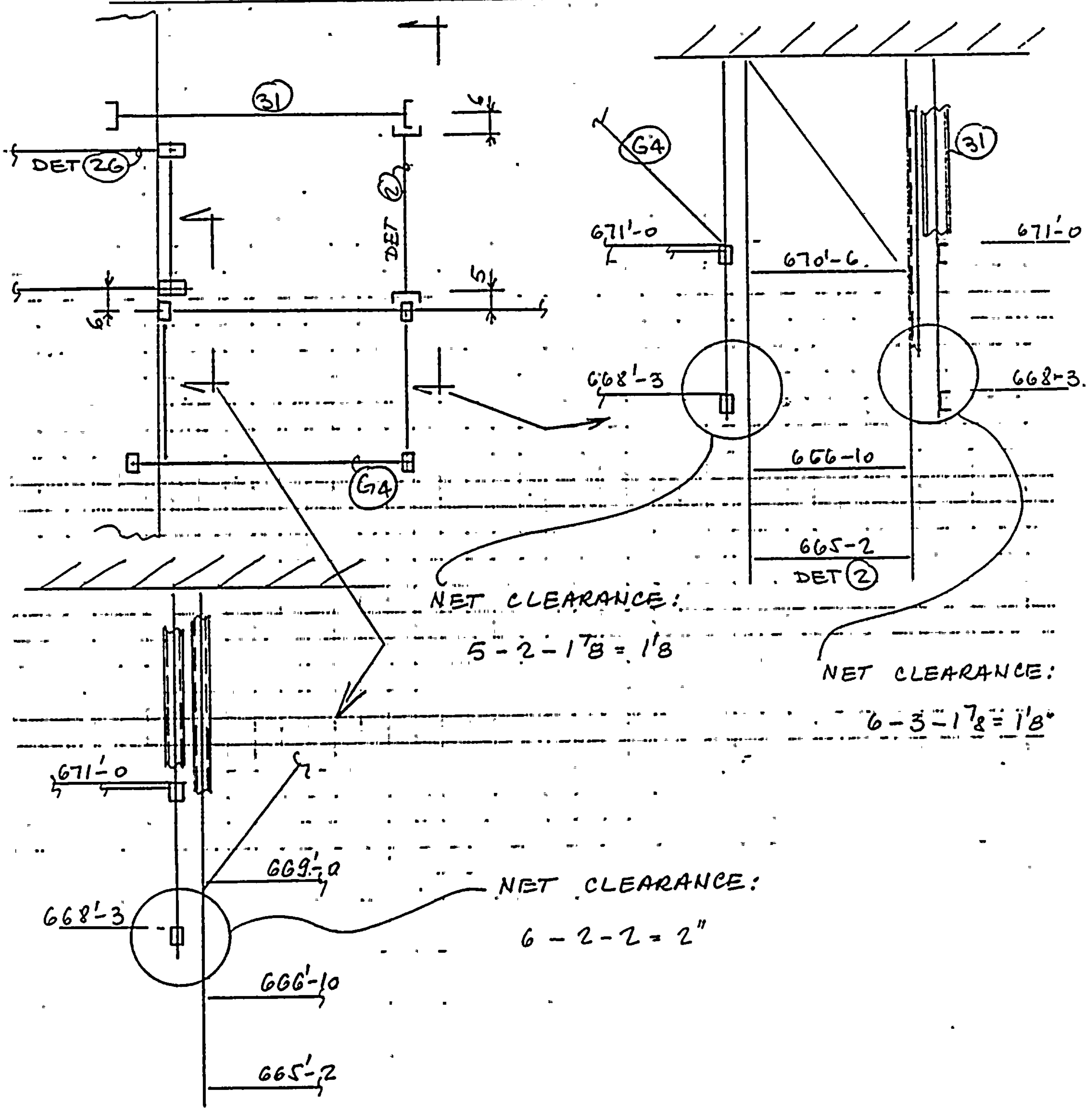
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 90

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	R.S.	12.13.84									
Checker		12-20-84									

8.2 DET. 26 - 31 - 2 & 64



NET CLEARANCE:
5 - 2 - 1 7/8 = 1/8

NET CLEARANCE:
6 - 3 - 1 7/8 = 1/8"

NET CLEARANCE:
6 - 2 - 2 = 2"

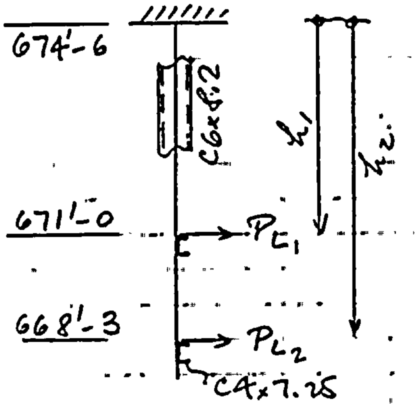
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 91

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1											
Preparer	RS	12.14.84										
Checker		12-20-84										

SUPPORT NO. 31



$$P_{L_2 @ 668'-3} = .54 \times \left(7.25 \times 5.25 + \frac{2.75}{2} \times 8.2\right) = 27^{\#}$$

$$P_{L_1 @ 671'-0} = .54 \times \left(7.25 \times 5.25 + \frac{6.25}{2} \times 8.2\right) = 34.0^{\#}$$

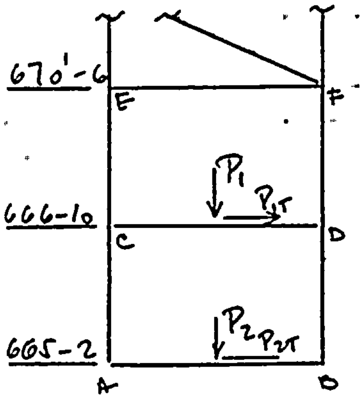
$$\underset{\text{DUE TO } P_{L_1}}{\Delta @ 671'-0} = \frac{P h_1^3}{3EI} = \frac{34 \times 42^3}{3 \times 29 \times 10^6 \times 11.21} = .0025 \text{ in}$$

$$\underset{\text{DUE TO } P_{L_1}}{\Delta @ 668'-3} = \frac{P h_1^2}{6EI}(3h_2 - h_1) = \frac{34 \times 42^2}{6 \times 29 \times 10^6 \times 11.21}(3 \times 75 - 42) = .0057 \text{ in}$$

$$\underset{\text{DUE TO } P_{L_2}}{\Delta @ 668'-3} = \frac{P h_2^3}{3EI} = \frac{27 \times 75^3}{3 \times 29 \times 10^6 \times 11.21} = .012 \text{ in}$$

$$\Sigma \Delta_{@ 668'-3} = .0057 + .012 = 0.0177 \text{ in}$$

DETAIL ②



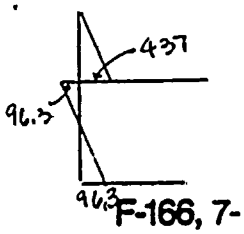
TRIBUTARY TRAY @ 666'-10 : $\frac{4.25 + 6.91}{2} = 5.58'$

$$P_{1T @ 666-10} = .54 \times (5.58 \times 2 \times 35 + 7.25 \times 2.83 + 2 \times 8.2 \times 2.67) = 245.6^{\#}$$

$$P_{2T @ 665'-2} = .54 \times (5.58 \times .2 \times 35 + 7.25 \times 2.83 + 2 \times 8.2 \times .84) = 229.4^{\#}$$

$$M_A = \frac{229.4}{2} \times .84 = 96.3^{'\#}$$

$$M_{EC} = \frac{229.4 + 245.6}{2} \times 1.84 = 437^{'\#}$$



Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC - DB - 08 SET-B Sheet No. 92

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12.14.84									
Checker		12-20-84									

$$\Delta_{@\,EL.\,666-10} = \frac{M_{EC}\,h^2}{6EI} = \frac{437 \times 12 \times 44^2}{6 \times 29 \times 10^6 \times .604} = .097 \text{ in}$$

$$\Delta_{@\,EL.\,665-2} = \frac{M_A\,h^2}{6EI} = \frac{96.3 \times 12 \times 20^2}{6 \times 29 \times 10^6 \times .604} = .004 \text{ in}$$

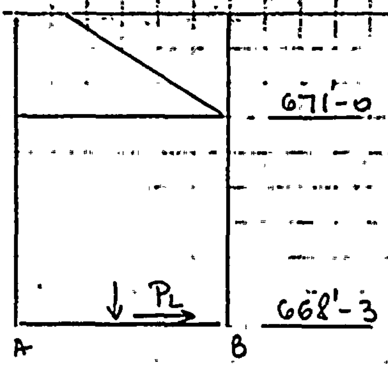
$$\Sigma\Delta_{@\,665-2} = .097 + .004 = 0.101 \text{ in}$$

ASSUMING LINEAR DISTRIBUTION (CONSERVATIVE APROACH) $\Delta_{@\,EL.\,668'-3} = \frac{2.25}{5.34} \times .101 = .043 \text{ in}$

MAX. DISPLACEMENT BETWEEN SUPP'T ㉛ AND SUPP'T TYPE ② IS $.043 + .017 = .060$ in ($\sim \frac{1}{16}$ IN.) - ASSUMING OUT OF PHASE MOVEMENT

$1\frac{1}{8}$" CLEARANCE IS O.K.

SUPPORT $\textcircled{G_4}$



TRIBUTARY TRAY @ 668'-3 : 7.16'

$$P_L = .54 \times \left[7.16 \times 3 \times 35 + 10.51 \times (5.25 + 2 \times 1.38)\right] = 451^{\#}$$

$$M_A = \frac{451}{2} \times 1.38 = 311^{'\#}$$

$$\Delta_{@\,668'-3} = \frac{311 \times 12 \times 33^2}{6 \times 29 \times 10^6 \times 6.45} = .004 \text{ in.}$$

MAX. DISPLACEMENT BETWEEN SUPPT $\textcircled{G_4}$ AND SUPP'T TYPE ② IS $.022 + .004 = .026$ in. ($\sim \frac{1}{32}$") - $1\frac{1}{8}$" CLEARANCE IS O.K.

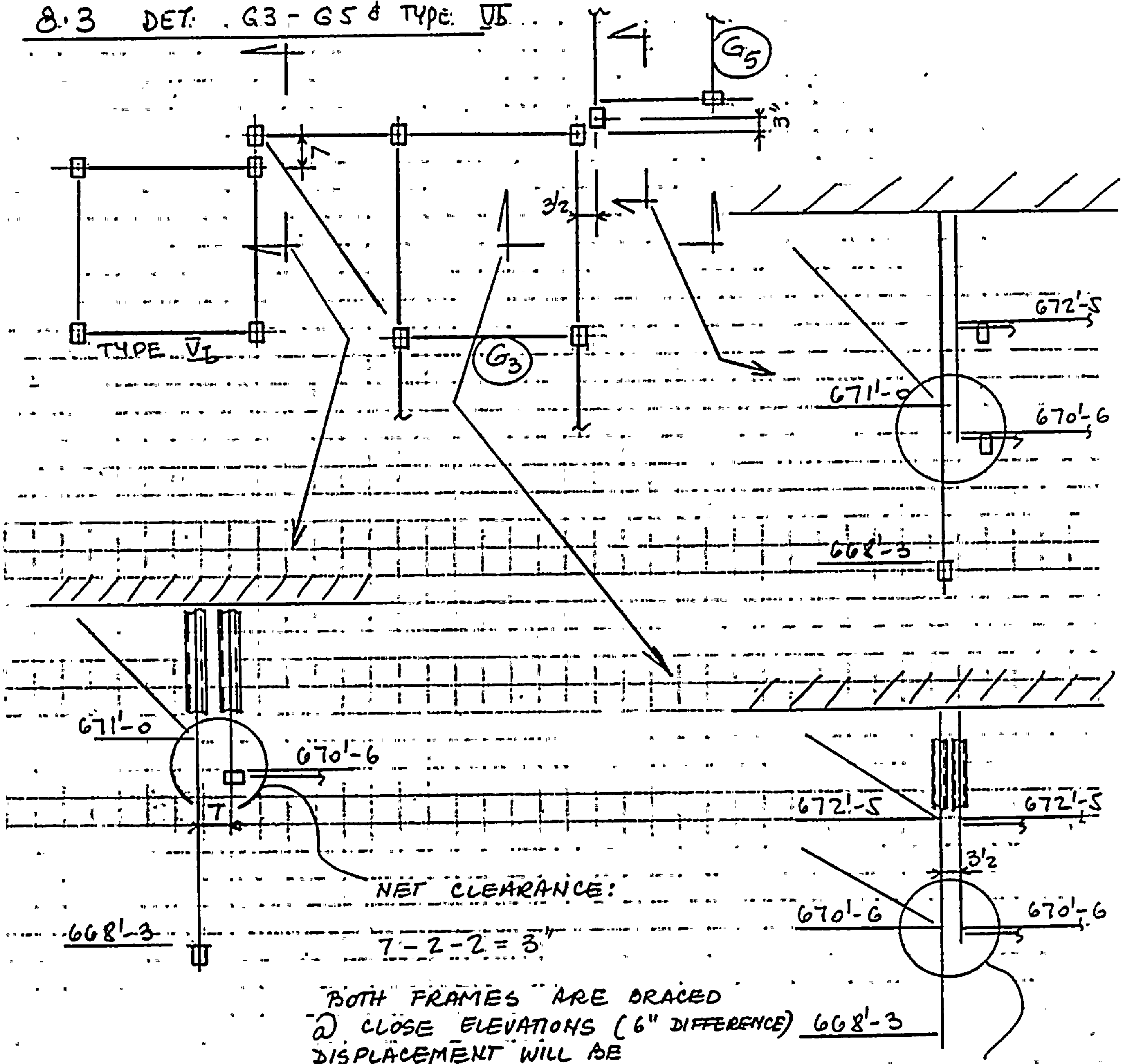
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 93

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	X		X		X		X		X	
Preparer	RS	12.13.84									
Checker		12-21-84									

8.3 DET. G3 - G5 & TYPE VI



NET CLEARANCE:
7 - 2 - 2 = 3"

BOTH FRAMES ARE BRACED
@ CLOSE ELEVATIONS (6" DIFFERENCE)
DISPLACEMENT WILL BE
MINIMAL. 3" CLEARANCE
IS SUFFICIENT.

NET CLEARANCE:
3½ - 1½ - 1½ = ½"
BOTH FRAMES ARE BRACED
@ SAME ELEVATION - THERE IS
NO DISPLACEMENT

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 94

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	RS	12.18.84									
Checker		12.20.84									

9.0 EVALUATION OF SUPPORTS DIFFERING FROM ENVELOPE CASES

ALL THE SUPPORTS IN THE BASEMENT OF THE EMERGENCY DIESEL GENERATOR "E" (EL. 656'-6 TO 674'-6) CAN BE GROUPPED IN SEVERAL TYPES (WHICH ARE ANALYSED PREVIOUSLY IN THIS BOOK).

THE CASES ANALYSED HERE ARE ENVELOPE CASES AND CONSIDERED TO COVER ALL CASES.

HOWEVER, AT FIRST GLANCE, IT SEEMS THAT SOME SUPPORTS ARE NOT COVERED BY THE ENVELOPE CASE.

THE FOLLOWING CALCULATIONS' PURPOSE IS TO PROOVE THAT THOSE CASES THAT, GEOMETRICALLY, ARE SIGHTLY DIFFERENT FROM THE ANALYSED CASES, DO NOT DEVELOP STRESSES IN THEIR COMPONENT MEMBERS THAT ARE IN EXCESS OF THE STRESSES DEVELOPPED IN THE ENVELOPE CASES (ORIGINALLY STUDIED)

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

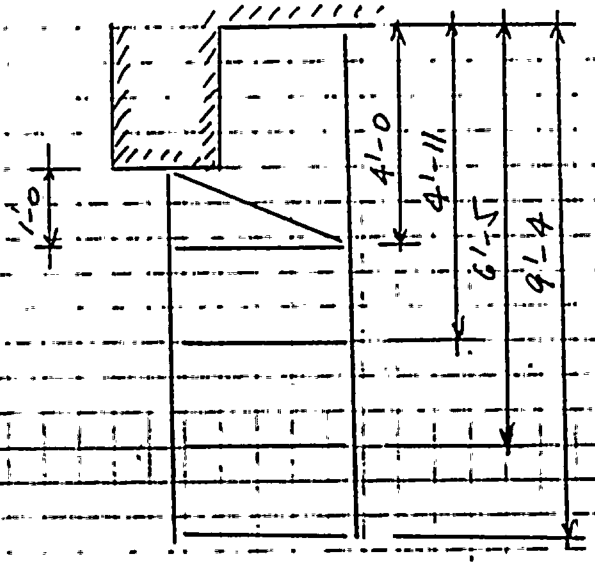
Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

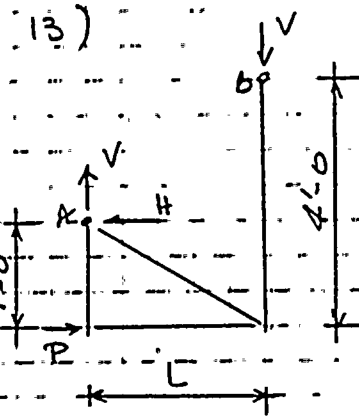
Calculation Number SC-DB-08 SET B Sheet No. 95

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer	R.S.	12.18.84									
Checker		12.20.84									

TYPE Ia

SUPP'T 1, 5, 6, 21 (DET 1, 12, 13)





TOP BAY HAS 4'-0 AS THE LARGEST DIMMENSION AS OPPOSED TO 3'-0 AS USED IN CALC'S OF TYPE Ia

SUPP'T 1 (DET 1)
(MOST CRITICAL CASE)

CHECKING THE EQUILIBRIUM OF THIS TOP BAY, $\Sigma M_b = P \times 4.0 - H \times 3.0 - V \times L = 0$

$H = P$ THEREFORE $V = \frac{P \times 1.0}{L}$ x^{x}_{x} THE EFFECTIVE HEIGHT OF THIS LAST BAY IS 1'-0 - LESS THAN 3'-0 USED IN CALC'S

TYPE Ib - SUPP'T 3, 8 (DET 8, 24) - SAME JUDGEMENT AS ABOVE APPLIES TO THESE SUPPORTS.

Checking Method # 1. Line-by-line checking 2. Alternative Calculation Results compared 3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

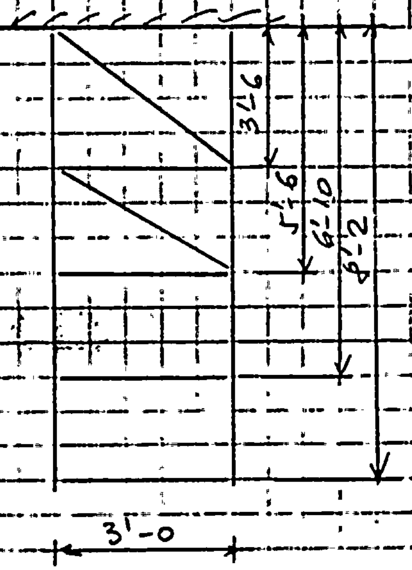
Calculation Number SC-DB-08 SET B Sheet No. 96

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	RS	12.11.84								
Checker		12.20.84								

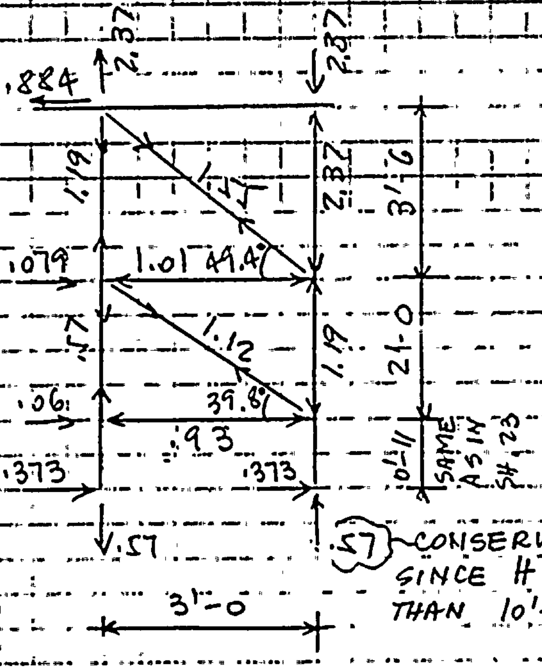
TYPE IIa - SUPP'T 32 (DET 15) - EFFECTIVE HEIGHT OF TOP BAY IS 5'-0 - 3'-0 = 2'-0 < 3'-0 (APPLY SAME JUDGEMENT AS FOR SUPP'T TYPE Ia OUTLINED IN PREVIOUS PAGE)

TYPE IIb - SUPP'T 7 (DET. 22) - EFFECTIVE HEIGHT OF TOP BAY IS 2'-8 < 3'-0 .O.K.

TYPE IIb - SUPP'T 27 (DET 23)



EVALUATE TOP TWO BAYS ASSUMING THAT ALL OTHER FORCES ARE AS ON SH. 23 R.0



CONSERVATIVE SINCE H IS LESS THAN 10'-0

COMPARING THESE RESULTS WITH THE RESULTS ON SH 23 R.0 IT IS OBSERVED THAT:

1.- VERTICAL REACTION TO EMB. PLATE IS SMALLER THAN THE ORIGINAL - O.K.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 97

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer	RS	12.18.84									
Checker		12.20.84									

COMPARING THE RESULTS (CONT'D):

2. — HORIZONTAL REACTION TO EMB. PLATE IS THE SAME AND MUCH SMALLER THAN THE SHEAR ALLOWABLE O.K.

3. — MAX AXIAL LOAD IN VERTICAL MEMBER IS SMALLER THAN THE ORIGINAL — O.K.

4. — MAX AXIAL LOAD IN HORIZONTAL MEMBER IS ALMOST THE SAME AS THE ORIGINAL — BUT, FROM SH. 18 R.0 $P_{at\,max} = 1.16^{k}$ WAS USED IN EVALUATING THE HORIZONTAL MEMBER — O.K.

5. — MAX AXIAL LOAD IN DIAGONAL BRACE IS ALMOST THE SAME AS IN THE ORIGINAL ($P = 1.79^{k}$ $L = 4.61'$). FROM SH. 38 R.0, DIAGONAL BRACE WAS CHECKED FOR A FORCE OF $5.01^{k} > 1.79$ AND A LENGTH OF $5.1' > 4.61$. — BRACE IS O.K.

IT IS CONCLUDED THAT ALTHOUGH THERE ARE MINOR VARIATIONS FROM THE ORIGINAL TYPES, IN ALL CASES, STRESSES AND FORCES DEVELOPPED ARE WITHIN THE BOUNDARIES OF ALLOWABLES AND THE DESIGN IS SAFE.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

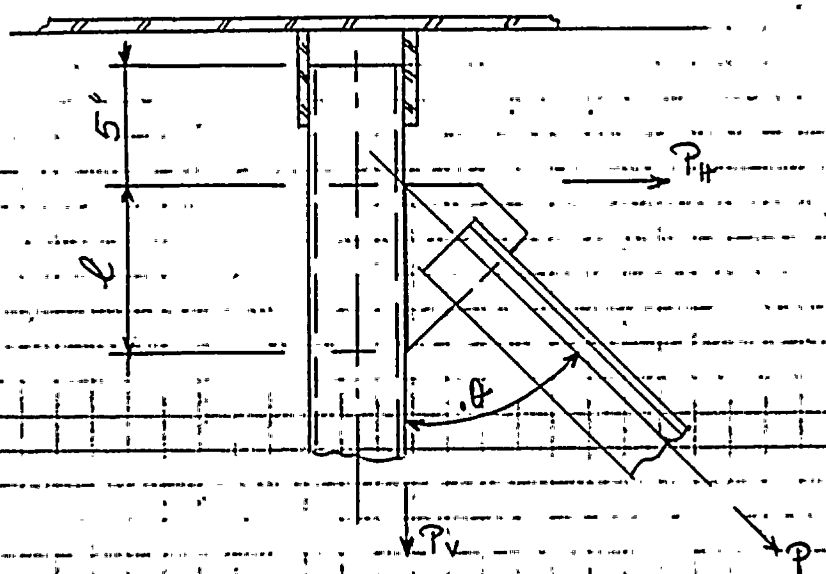
Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 98

Revision	Original Issue	Date	Rev. 2	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #			1								
Preparer			R.S.	2.20.85							
Checker				2-27-85							

VERTICAL BRACE CONNECTION - MINIMUM WELD REQ'D.

CASE I - DET. C, D, E, G, S ON DWG. C-5033



P_H = MAX. HORIZ. FORCE TRANSMITTED THRU BRACE

$$P_V = \frac{P_H}{\tan\theta}$$

$$f_{H\,WELD} = \frac{P_H}{2\ell} + \frac{P_H \times \ell}{2} \times \frac{1}{\frac{2\ell^2}{6}} = \frac{2P_H}{\ell}$$

$$f_{V\,WELD} = \frac{P_V}{2\ell} = \frac{P_H}{2\ell\tan\theta}$$

$$f_{\substack{max\\WELD}} = \left[\left(\frac{2P_H}{\ell}\right)^2 + \left(\frac{P_H}{2\ell\tan\theta}\right)^2\right]^{1/2} = \frac{2P_H}{\ell}\left[1 + \frac{1}{16\tan^2\theta}\right]^{1/2}$$

3/16" WELD CAPACITY IS 2320 #/in (CONSIDERING UNDERCUT)

$$\frac{2P_H}{\ell}\left[1 + \frac{1}{16\tan^2\theta}\right]^{1/2} \le 2.32\,k/in \qquad \ell \ge .86 \cdot P_H\left[1 + \frac{1}{16\tan^2\theta}\right]^{1/2}$$

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 99

Revision	Original Issue	Date	Rev. 2	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #			1								
Preparer			R.S.	2.20.85							
Checker				2-27-85							

FROM SH. 15, R.0, SC-DB-08 SET B, MAX HORIZONTAL FORCE @ BRACING FOR A TRANSVERSAL SUPPORT IS 2.63 cos 45° = 1.86^k

FROM SH. 37, R.0, SC-DB-08 SET B, MAX HORIZONTAL FORCE @ BRACING FOR A LONGITUDINAL SUPPORT IS 2.78^k

θ	10°	15°	30°	45°	60°	75°	89°
ℓ_{min}	$1.49P_H$	$1.18P_H$	$.94P_H$	$.89P_H$	$.87P_H$	$.86P_H$	$.86P_H$

FOR $P_H = 1.86^k$

θ	10°	15°	30°	45°	60°	75°	89°
ℓ_{min}	2.77	2.19	1.75	1.66	1.62	1.72	1.72
	NOT PRACTICAL						NOT PRACTICAL

FOR $P_H = 2.78^k$

θ	10°	15°	30°	45°	60°	75°	89°
ℓ_{min}	4.14	3.28	2.61	2.47	2.42	2.39	4.0
	NOT PRACTICAL						NOT PRACTICAL

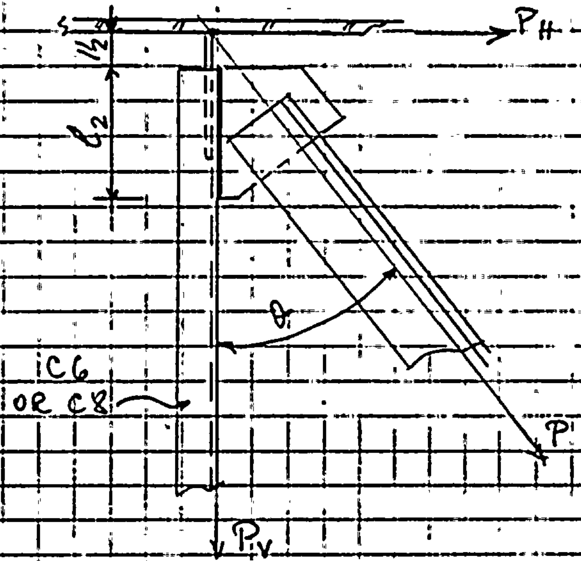
Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 100

Revision	Original Issue	Date	Rev. 2	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #		☒	1	☒		☒		☒		☒
Preparer			R.S.	2.25.88						
Checker				2.29.88						

CASE II - DET. F



$$P_V = \frac{P_H}{\tan\theta}$$

$$f^H_{WELD} = \frac{P_H}{2\ell_2} + P_H \times \left(\frac{\ell_2}{2} + 1.5\right) \times \frac{1}{\frac{2\ell_2^2}{6}} = \frac{P_H}{\ell_2} \times \left(2 + \frac{4.5}{\ell_2}\right)$$

$$f^V_{WELD} = \frac{P_V}{2\ell_2} = \frac{P_H}{2\ell_2 \tan\theta}$$

$$f^{max}_{WELD} = \left[\frac{P_H^2}{\ell_2^2} \times \left(2 + \frac{4.5}{\ell_2}\right)^2 + \frac{P_H^2}{4\ell_2^2 \tan^2\theta}\right]^{1/2} =$$

$$= \frac{P_H}{\ell_2} \times \left[\left(2 + \frac{4.5}{\ell_2}\right)^2 + \frac{1}{4\tan^2\theta}\right]^{1/2} \leq 2.32\ k/in$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G E BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET-B Sheet No. 101

Revision	Original Issue	Date	Rev. 2	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #		☒	1	☒		☒		☒		☒
Preparer			R.S.	2.25.85						
Checker				2-27-85						

FOR $P_H = 1.86^k$ - AND USING $l_2 = l$

θ	10°	15°	30°	45°	60°	75°	89°
l_2 (in)	2.77	2.19	1.75	1.66	1.62	1.72	1.72
$f_{max\,WELD}$	3.09	3.79	4.94	5.30	5.50	5.0	5.0

ALL VALUES OF $f_{max\,WELD}$ ARE LARGER THAN 2.32k/in

BY TRIAL AND ERROR CHECK FOLLOWING l_2 VALUES

θ	10°	15°	30°	45°	60°	75°	89°	
l_2 (in)	3.5	3.5	3.0	3.0	3.0	3.0	3.0	
$f_{max\,WELD}$	2.31	2.0	2.23	2.19	2.18	2.17	2.17	< 2.32k/in

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

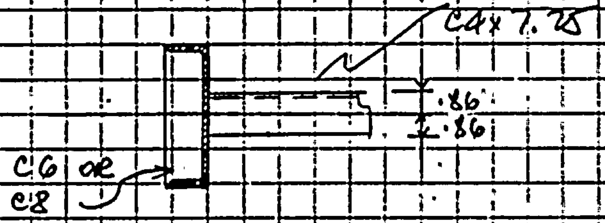
Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 102

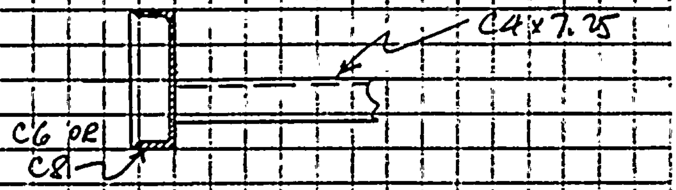
Revision	Original Issue	Date	Rev. 3	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #			1							
Preparer			RS	4-29.85						
Checker				4.30.86						

NON CONFORMANCE REPORT # 88 - EFFECT ON DESIGNED CABLE TRAY SUPPORT STRUCTURE

TRANSVERSAL SUPPORTS WERE FABRICATED WITH THE CENTERLINE OF HORIZONTAL MEMBERS ATTACHED TO THE CENTERLINE OF VERTICAL MEMBER.



AS FABRICATED



AS DESIGNED

BY SHIFTING THE WEB OF C4 FROM THE CENTERLINE OF C6, ALL VERTICAL FORCES (TRANSMITTED THRU THE WEB OF C4) WILL CREATE A MOMENT.

TYPE I_a IS MOST CRITICAL CASE (HIGHEST NO OF C4 PER SUPPORT)

DEAD LOAD APPLIED EXCENTRICALLY:

$$\frac{3 \times .67}{2} + \frac{.00725 \times 5.5}{2} = 1.025^k$$

SEE SH. 13 R.0, SC-DB-08 SET B

$P_{DL} = 1.025^k$ $R_L = 1.2 \times 1.025 = 1.23^k$

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 103

Revision	Original Issue	Date	Rev. 3	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #		☒	1	☒		☒		☒		☒
Preparer			RS	4.29.85						
Checker				4.30.85						

$\Delta M_{DL} = 1.025 \times .86 = .882^{\prime\prime k}$

$\Delta M_{V} = 1.123 \times .86 = 1.058^{\prime\prime k}$

FOR TYPE IIa, load is only 2/3 of load for Ia. CONSERVATIVELY FULL LOAD USED

$\left.\begin{aligned} \Delta f_{b_{DL}} &= \frac{.882}{7.18} = .123 \text{ ksi} \\ \Delta f_{bv} &= \frac{1.058}{7.18} = .147 \text{ ksi} \end{aligned}\right\}$ FOR TYPE Ia

$\left.\begin{aligned} \Delta f_{b_{DL}} &= \frac{.882}{3.74} = .236 \text{ ksi} \\ \Delta f_{bv} &= \frac{1.058}{3.74} = .283 \text{ ksi} \end{aligned}\right\}$ FOR TYPE IIa

REF. TO SH. 20 R.0, SC-DB-08 SET B:

METHOD I - FOR TYPE Ia

$$\frac{.37}{15.24} + \frac{3.0}{21.6} + \frac{.123}{21.6} + \left[\left(\frac{.45}{15.24} + \frac{3.6}{21.6} + \frac{.147}{21.6}\right)^2 + \left(\frac{.42}{15.24} + \frac{16.05}{21.6}\right)^2 + \left(\frac{.53}{21.6}\right)^2\right]^{1/2} = .920 < 1.0 \quad \text{O.K.}$$

METHOD II - FOR TYPE Ia

$$\frac{.37 + (.45^2 + .42^2)^{1/2}}{15.24} + \frac{3.0 + .123 + \left[(3.6 + .147)^2 + 16.05^2\right]^{1/2}}{21.6} + \frac{(.42^2 + .53^2)^{1/2}}{21.6} = .955 < 1.0 \quad \text{O.K.}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P. & L.

Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 104

Revision	Original Issue	Date	Rev. 3	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #			1							
Preparer			RS	4.29.85						
Checker				4.30.85						

METHOD I - FOR TYPE IIa (SEE SH. 25 R.0)

$$\frac{.36}{11.94}+\frac{4.76}{21.6}+\frac{.236}{21.6}+\left[\left(\frac{.44}{11.94}+\frac{5.7}{21.6}+\frac{.283}{21.6}\right)^2+\left(\frac{1.36}{11.94}+\frac{9.51}{21.6}\right)^2+\left(\frac{1.96}{21.6}\right)^2\right]^{1/2}=.853<1.0 \quad O.K.$$

METHOD II - FOR TYPE IIa

$$\frac{.36+(.44^2+1.36^2)^{1/2}}{11.94}+\frac{4.76+.236+(5.7^2+9.51^2+.283^2)^{1/2}}{21.6}+\frac{1.96}{21.6}=.925<1.0 \quad O.K.$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G "E" BLDG - CABLE TRAY SUPPORTS UP TO EL. 675'-6

Calculation Number SC-DB-08 SET B Sheet No. 105

Revision	Original Issue	Date	Rev. 3	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #			1								
Preparer			R.S.	4.29.85							
Checker				4.30.85							

CHECK CEILING CONNECTION

REF. TO SH. 72 R.0, SC-DB-08 SET B

$\Delta M_{DL} = .882^{\prime\prime k}$ $\Delta M_{L} = 1.058^{\prime\prime k}$

WELD "A"

$\Delta f_{DL} = \frac{.882}{5.33} = .165\ k/in \downarrow$ $\Delta f_{L} = \frac{1.058}{5.33} = .198\ k/in \downarrow$

$$f_{WELD} = \left\{ \left\{ .14 + .165 + \left[(.17 + .198)^2 + .4^2 + 1.46^2 \right]^{1/2} \right\}^2 + \right.$$

$$\left. + .16^2 + .014^2 \right\}^{1/2} = 1.870\ k/in < 2.25 \quad o.k.$$

WELD "B"

ASSUMING THAT ONLY THE VERTICAL SECTIONS (2.5") OF THE WELD WORK UNDER THE ADDITIONAL LOAD (CONSERVATIVE)

$\Delta f_{DL} = \frac{.882}{4 \times 2.5} = .088\ k/in$ $\Delta f_{L} = \frac{1.058}{4 \times 2.5} = .106\ k/in$

$$f_1 = .13 + .088 + \left[(.15 + .106)^2 + .35^2 + .62^2 \right]^{1/2} = .975\ k/in$$

$$f_{TOTAL} = (.975^2 + .14^2 + .01^2)^{1/2} = .985\ k/in < 2.25$$

WELDS ARE O.K.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

ATTACHMENT 2

Gibbs & Hill, Inc.

Calculation Cover Sheet

SH. NO. 1.

G&H Job No. 3544　Client PP&L

Calculation Number SC-DB-07b

Number of Sheets in Original Issue 45

Subject D/G E BLDG - REMOVABLE WALL SECTION

☑ Nuclear Safety Related

☐ Non-Nuclear Safety Related—QA Program Applicable

☐ Non-Nuclear Safety Related

		Sheets Deleted	Sheets Added	Sheets Revised	Job Engineer	
					Signature	Date
Original						5/11/84
Revision	1	—	46 THRU 50	—		6/6/85
	2	—	51, 52	—	Vinu Patel	8/8/85

F-167, 4-81

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 2

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		3/23/84									
Checker	BIA	8-15-84									

1. INTRODUCTION:

A 19 FT. HIGH x 14 FT. WIDE REMOVABLE SECTION IS TO BE PROVIDED IN THE NORTH WALL TO FACILITATE REMOVAL OF DIESEL GENERATOR FOR FUTURE MAINTENANCE. THIS SECTION IS TO BE DESIGNED TO RESIST THE MISSILE LOADS TOGETHER WITH CORRESPONDING TORNADO PRESSURES AND OTHER ASSOCIATED EFFECTS.

THE SECTION SHALL BE MADE UP OF SOLID STEEL PLATE PANELS OF THE SIZE MOST CONVENIENT TO HANDLE. VERTICALLY, A STRUCTURAL MEMBER WILL BE PROVIDED TO CUT DOWN PANEL HEIGHT TO ONE HALF THE TOTAL SECTION HEIGHT. HORIZONTALLY WHOLE SECTION WILL BE DIVIDED INTO 3 EQUAL PANEL WIDTHS. THUS, EACH SOLID PL PANEL WILL BE DESIGNED TO BE SUPPORTED AT TOP & BOTT. AND WILL BE CONNECTED TO EACH OTHER BY SPLICE PLATE. SEE SH. No. 37.

PLATE THICKNESS WILL BE ADEQUATE TO PREVENT PERFORATION USING BRL FORMULA FOR THE MISSILES UNDER CONSIDERATION.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G 'E' BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 3

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		3/23/84									
Checker		8-15-84									

OVERALL STRUCTURAL RESPONSE OF THE REMOVABLE SECTION TO THE MISSILE IMPACT LOAD WILL BE EVALUATED USING ENERGY BALANCE METHOD GIVEN IN REFERENCE 1.

2. REFERENCES:

1. TOPICAL REPORT - DESIGN OF STRUCTURES FOR MISSILE IMPACT. BC-TOP-9A REV. 2 SEPT. 1974. "BECHTEL POWER CORP."
2. STANDARD REVIEW PLAN · 3·5·3 · REV. 1 JULY 1981 "BARRIER DESIGN PROCEDURES".
3. "STRUCT. ANALYSIS & DESIGN OF NUCLEAR PLANT FACILITIES" ASCE 1980 CHAPTER 6 - DESIGN AGAINST IMPULSE AND IMPACT LOAD.
4. G & H STRUCT. DWGS.: C-5013, ISSUE 0
   C-5016, ISSUE 3
5. DESIGN CRITERIA DOCUMENT 3544·SDC·001, ISSUE 0, Jan. 198
6. FORMULAS FOR STRESS & STRAIN - BY ROARK, 4th edition

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING · REMOVABLE WALL SECTION·

Calculation Number SC·DB·07b Sheet No. 4

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		3/23/84									
Checker	BIK	8-15-84									

7. "IMPACT EFFECT OF FRAGMENTS STRIKING STRUCTURAL ELEMENTS" - by R·A·WILLIAMS & R·R·ALVY, NOV· 73, HOLMES & NARVER, INC.

8. "INTRODUCTION TO STRUCTURAL DYNAMICS" BY BIGGS

9. " ACI 349·80 "CODE REQUIREMENTS FOR NUCLEAR SAFETY RELATED CONCRETE STRUCTURES".

10. AISC "MANUAL OF STEEL CONSTRUCTION, 8th EDITION, 1980

11. TRW NELSON DIV·, DESIGN DATA 10, "EMBEDMENT PROPERTIES OF HEADED STUDS", 1977

12. ASTM SPECS.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client P.P. & L.

Subject D/G 'E' BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-076 Sheet No. 5

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		3/23/'84									
Checker	G.K.	8-15-84									

3. DESIGN CRITERIA:

3.1 MATERIALS:

a. STEEL PANEL PLATE AND CENTER GIRDER

ASTM A 514-82 WITH MIN. YIELD STRENGTH

GRADE F: F_Y = 100 ksi FOR PL TO 2½" THICK. F_U: 110 to 130 ksi.

GRADE E: F_Y = 90 ksi. FOR PL OVER 2½" to 6" INC.; F_U = 100 to 130 ksi.

b. PLATES FOR CONNECTIONS, EMBEDMENTS & CONN. ANGLES:

ASTM A 572-Gr. 50 WITH MIN. YIELD STRENGTH F_Y = 50 ksi
FOR PL UPTO 2" THICK.

C. BOLTS: ASTM A325N. UNLESS NOTED OTHERWISE.

D. WELDING ELECTRODES:

E11018-M FOR ASTM A514 MATERIAL (QUALIFY WELDS PER AWS)
E 70XX FOR ASTM A572 AND A36 MATERIAL
" FOR E11018 WELD PROCEDURES AND PREHEAT REQUIREMENTS REFER TO " HOW TO WELD USS T-1 CONSTRUCTIONAL ALLOY STEEL" OR OTHER MFGR. RECOMMENDATIONS.

3.2. LOADS:

TORNADO LOADING AND MISSILE PARAMETERS PER REF. No. 5.

3.3 ALLOWABLE DUCTILITY RATIO $\mu = 20$ (REF. 1 Pg. 4.7).
HOWEVER, CONSERVATIVELY USE $\mu = 7.5$ FOR HIGH STRENGTH STEEL A514.
& $\mu = 10.0$ FOR ALL OTHER STEEL

3.4. DYNAMIC INCREASE FACTOR (REF. 1. Pg 4.4). FOR REINF. STEEL.

1.2 FOR $F_Y = 40^{ksi}$ } FLEXURE, TENSION
1.0 FOR $F_Y = 60^{ksi}$ } & COMPRESSION
1.0 SHEAR

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G 'E' BUILDING· REMOVABLE WALL SECTION·

Calculation Number SC·DB·07b. Sheet No. 6

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		4/25/84									
Checker	M.A.	3-15-94									

3·5 APPLICABLE MISSILES FROM REF NO· 5

	MISSILE	DIMENSIONS	WEIGHT	VELOCITY	
				HORIZ·	VERT
	TORNADO GENERATED MISSILES				
A.	WOOD PLANK	4"x 12" x 12'0"	108 lbs	440 fps	352 fps
B.	3"ϕ SCH· 40 STEEL PIPE	3"ϕ x 10'-0"	72 lbs·	147 "	118 "
C	6"ϕ " " " "	6"ϕ x 15'-0"	285 lbs	170 "	136 "
D	12"ϕ " " " "	12"ϕ x 15'-0"	750 lbs	155 "	124 "
E	1"ϕ STEEL ROD	1"ϕ x 3'-0"	8 lbs.	317 "	254 "
F.	AUTOMOBILE	20 SQ·Ft·	4000 lbs·	195 "	156 "
G	UTILITY POLE	13·5"ϕ x 35'·0"	1490 lbs	211 "	169 "
	SITE PROXIMITY MISSILES.				
H	RIFLE BULLET·	0·3" DIA·	$\frac{1}{8}$ lb.	2667 fps.	2134 fps·
I	FRAGMENTS-TRUCK EXPLOSION		$\frac{3}{8}$ lb	15 fps.	12 "

Checking Method #

1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. [illegible]

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G 'E' BUILDING · REMOVABLE WALL SECTION.

Calculation Number SC-DB-076 Sheet No. 7

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		4/26/86									
Checker	MIR	8-15-86									

4.0 : PLATE PERFORATION :

$$T = \frac{\left(\frac{M V_s^2}{2}\right)^{2/3}}{672 D} \text{ —— BRL FORMULA [EQU'N 2-7, PG. 2-3 REF. 1]}$$

WHERE T : THICKNESS OF STEEL PL THAT WILL JUST BE PERFORATED

M = MASS OF MISSILE IN $\frac{lb \cdot sec^2}{ft} = W/g$

V_s : STRIKING VELOCITY OF MISSILE IN ft/sec

D : DIAMETER OF MISSILE [EQUV. DIA FOR NON CIRCULAR IMPACT AREA] IN INCHES.

MISSILE A : WOOD PLANK

$M = 108/32.2 = 3.35 \ \# sec^2/ft$

$V_s = 440$ fps

$D = 1.128\sqrt{4 \times 12} = 7.815$ IN

$T_A = 0.9$ INCH

MISSILE B : 3" ϕ PIPE

$M = 72/32.2 = 2.236 \ \# sec^2/ft$

$V_s = 147$ fps.

$D = 1.128\sqrt{2.23} = 1.68$ IN.

$T_B = 0.75$ IN.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G 'E' BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-076. Sheet No. 8

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer		4/26/84								
Checker		5-15-84								

MISSILE C : 6" ϕ PIPE

$M = 285/32.2 = 8.85 \ \# \frac{sec^2}{ft}$

$V_s = 170$ fps.

$D = 1.128\sqrt{5.58} = 2.66$ IN

$T_C = 1.42$ IN.

MISSILE D : 12" ϕ PIPE

$M = \frac{750}{32.2} = 23.29 \ \# sec^2/ft$

$V_s = 155$ fps.

$D = 1.128\sqrt{14.6} = 4.31$ IN

$T_D = 1.48$ IN.

MISSILE E : 1" ϕ ROD

$M = 8/32.2 = 0.248 \ \# sec^2/ft$

$V_s = 317$ fps

$D = 1^{IN}$

$T_E = 0.8$ IN.

MISSILE F : AUTOMOBILE MISSILE BEING CRUSHABLE, PERFORATION IS UNLIKELY

MISSILE G : UTILITY POLE

$M = \frac{1490}{32.2} = 46.27 \ \# sec^2/ft$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G 'E' BUILDING · REMOVABLE WALL SECTION

Calculation Number SC·DB·07b Sheet No. 9.

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1,2										
Preparer		4/06/84									
Checker	BIA	8-15-84									

V_S = 211 fps.

D = 13.5 IN

T_G = 1.12 IN.

MISSILE H : RIFLE BULLET

$M = \frac{0.125}{32.2} = 0.0039$ # sec²/ft.

V_S = 2667 fps.

D = 0.3 IN

T_H = 2.86 IN.*

MISSILE I : TRUCK FRAGMENTS

$M = \frac{0.375}{32.2} = 0.0116$ # sec²/ft.

V_S = 15 fps.

D = 0.25 IN.

T_I = 0.007 IN.

∴ MAXIMUM PERFORATION = 1.48 IN FOR MISSILE D.

MINIMUM PL THICKNESS REQUIRED TO PREVENT PERFORATION = 1.25 T [EQUN 2.8 Pg. 2-4 Ref. 1]

= 1.25 × 1.48

MIN. PL THICKNESS REQ'D = 1.85 IN.

* THIS VALUE OF PENETRATION FOR HIGH VELOCITY MISSILE SUCH AS BULLET IS VERY CONSERVATIVE BASED ON BRL FORMULA. BASED ON TEST RESULTS SHOWN IN "TERMINAL BALLASTIC AND EXPLOSIVE EFFECTS - CORPS OF ENGINEERS, U.S. ARMY - NRC COMMITTEE, WASHINGTON D.C. OCT 1943, PENETRATION IN STEEL PL (MILD STEEL) FOR A 30 CALIBER BULLET WITH VELOCITY = 2670 fps MEASURED ONLY 1.2 IN. [Page 78 Table 4].

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

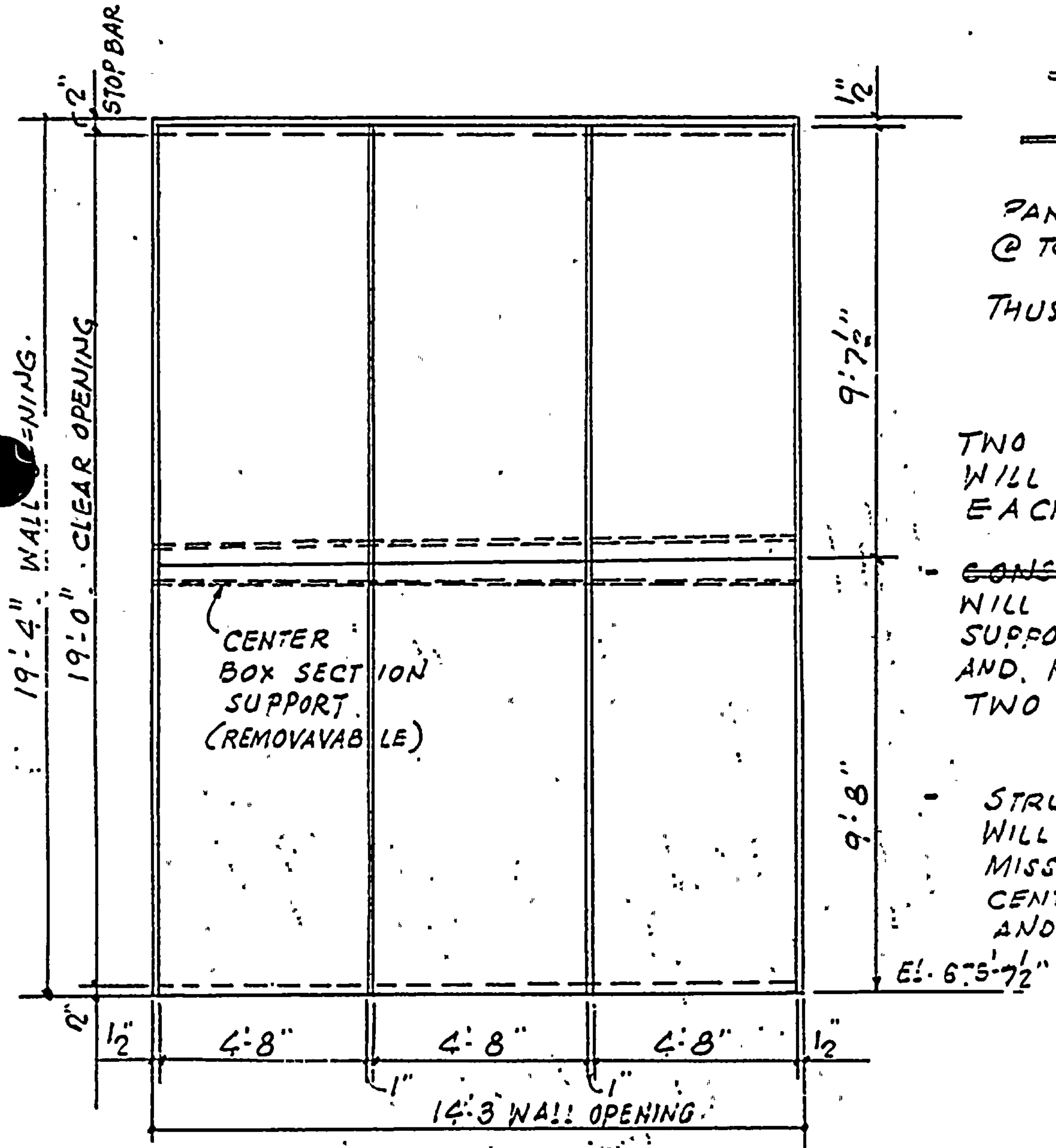
Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G. 'E' BUILDING - REMOVABLE WALL SECTION

Calculation Number Sheet No. 10

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer		4/26/84								
Checker	BIA	8-15-84								

5. STRUCTURAL RESPONSE OF PLATE TO MISSILE IMPACT



TYPICAL PANEL

4'-8"W x 9'-8" LONG.

PANEL WILL BE SUPPORTED @ TOP AND BOTTOM

THUS SPAN LENGTH = 9'-8"

TWO ADJOINING PANELS WILL BE CONNECTED TO EACH OTHER.

- ~~CONSERVATIVELY~~ PANEL WILL BE ASSUMED SIMPLY SUPPORTED @ TOP & BOTTOM AND FREE ALONG OTHER TWO FACES.

- STRUCTURAL RESPONSE WILL BE EVALUATED FOR MISSILE STRIKING AT THE CENTER OF PANEL END-ON AND NORMAL TO THE PANE

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-075 Sheet No. 11

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		4/27/84									
Checker	G'H	3-15-94									

5·1 TARGET PROPERTIES:

- ASSUME ₱ THICKNESS $t = 2.5^{IN}$.
- SPAN LENGTH $L = 9'\text{-}8'' = 116^{IN}$
- STEEL ASTM A 514 $F_Y = 100^{KSI}$.
- DYNAMIC INCREASE FACTOR DIF = 1.0 [REF. 1 pg. 4-4] FOR STRUCT. STEEL

5·1·1 ULTIMATE RESISTANCE OF ₱

$$R_M = \frac{4 M_U}{L}$$

M_U = ULTIMATE MOMENT CAPACITY

$= f_{dyn} \times \Xi$

$f_{dyn} = 1.0 \times 100 = 100 \text{ KSI}$

$\Xi = 1.5 S = 1.5 \times \frac{56 \times 2.5^2}{6} = 87.5 \text{ IN}^3$.

$\therefore M_U = 100 \times 87.5 = 8750 \text{ K·IN}$.

$$\therefore \boxed{R_M = \frac{4 \times 8750}{116} = 302^{\text{KIPS}}}$$

PER REF. NO. 5, FOLLOWING LOAD COMBINATIONS APPLY:

$W_t = W_w + W_M$

$W_t = W_w + 0.5 W_p + W_m$.

W_w = DYNAMIC WIND LOAD

W_m: MISSILE LOAD [TORNADO GENERA

W_p: DIFF. TORNADO PRESSURE LOAD

SINCE W_p OPPOSES W_m, GOVERNING COMBINATION IS $W_t = W_w + W_m$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G 'E' BUILDING REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 12

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/11/84									
Checker	G/R	6-15-84									

$W_{\omega\ max.} = 266\ psf$ ACTING INWARDS [SEE PAGE 5 OF SC-DB-07a]

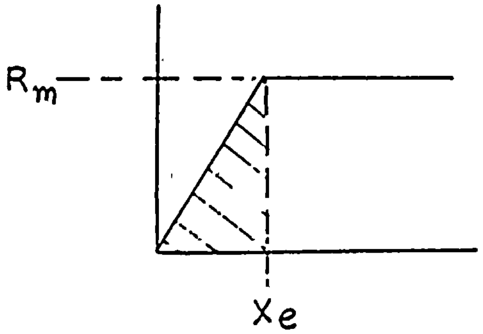
∴ MAX. ADDITIONAL LOAD = 266 lbs/ft^2

5.1.2 MAXIMUM STRAIN ENERGY OF TARGET FOR ELASTIC RESPONSE

a. NO LOAD ACTING CONCURRENT WITH MISSILE-LOAD [REF. 1 SECT. 3.5.3]

R_M: ULTIMATE RESISTANCE

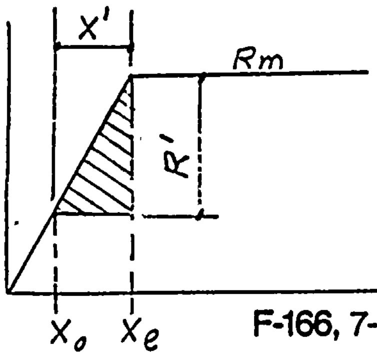
X_e: YIELD DISPLACEMENT.



STRAIN ENERGY $E_s = \frac{R_M \cdot X_e}{2}$

b. OTHER LOADS ACTING CONCURRENT WITH MISSILE LOAD

X_0 = ELASTIC DISPLACEMENT DUE TO OTHER LOADS.



$$E_s = \frac{R' \cdot X'}{2}$$

WHERE $X' = X_e - X_0$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

Subject D/G-E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 13

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		5/11/84									
Checker		3-15-84									

$$R' = R_m \cdot \frac{X_e - X_o}{X_e}$$

$$\therefore \boxed{\text{STRAIN ENERGY} = \frac{R_m (X_e - X_o)^2}{2 X_e}}$$

$$R_m = 302^k$$

$$X_e = \frac{R_m \cdot L^3}{48EI} \quad \text{———— REF. 1. TABLE 4.2.}$$

$$= \frac{302 \times 116^3}{48 \times 29000 \times 72.92} \qquad I = \frac{56 \times 2.5^3}{12} = 72.92 \text{ IN}^4$$

$$= 4.64 \text{ IN.}$$

$$X_o = \frac{5 W \ell^3}{384 EI} \qquad W = 0.266 \times 4.67 \times 9.67 = 12 \text{ kips.}$$

$$= \frac{5 \times 12 \times 116^3}{384 \times 29000 \times 72.92}$$

$$= 0.115 \text{ IN.}$$

$$X_e - X_o = 4.527 \text{ IN.}$$

∴ STRAIN ENERGY OF TARGET FOR ELASTIC IMPACT

$$E_s = \frac{302 \times 4.527^2}{2 \times 4.64}$$

$$\boxed{= 667 \text{ K.IN.}}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOUABLE WALL SECTION

Calculation Number SC-DB-076 Sheet No. 14

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/1/84									
Checker		3-15-84									

DUCTILITY RATIO μ FOR PLASTIC RESPONSE

$$\mu_{REQ'D} = \frac{E_s}{R_m[X_e - X_0]} \div \frac{1 + X_0/X_e}{2} \quad \left[\begin{matrix} REF\ 1. \\ EQU^N\ 3\text{-}24 \end{matrix}\right]$$

WHERE E_s : REQUIRED STRAIN ENERGY.

5.1.3 <u>REQUIRED STRAIN ENERGY</u>:

$$E_s = \frac{M_m^2 V_s^2}{2[M_m + M_e]} \quad \left[\begin{matrix} REF.\ 1 \\ EQU^N\ 3\text{-}8 \end{matrix}\right]$$

M_m : Mass of Missile
V_s : STRIKING VELOCITY
M_e : EFFECTIVE MASS OF TARGET DURING IMPACT

$$M_e = (D_x + 2d)\, M_x \quad \left[\begin{matrix} REF.\ 1 \\ EQU^N\ 3\text{-}17 \end{matrix}\right]$$

D_x = Missile contact dimension, IN INCHES
d = Plate thickness IN INCHES = 2.5"
M_x = Mass of Plate/Ft length
$\omega = 3.4 \times 56 \times 2.5 = 476$ #/Ft

$$M_e = \frac{476}{g}\left[\frac{D_x + 5}{12}\right] = \frac{39.67}{g}(D_x + 5)$$

Ⓐ E_s REQUIRED FOR MISSILE A [WOOD PLANK] $D_x = 4"$

$W_m = 108$ lbs; $V_s = 440$ fps; $M_e = \frac{39.76}{g}[4+5] = 357/g$

$$E_{s\,REQ'D} = \frac{108^2 \times 440^2}{2 \times 32.2[108 + 357]}$$

75,400 lb.Ft = 904.8 K.IN

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P. P&L

Subject D/G-E-BUILDING-REMOVABLE WALL SECTION

Calculation Number SC-08-07b Sheet No. 15

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		5/31/'84									
Checker	R.K.	8-15-84									

> 667 K·IN ∴ RESPONSE IS ELASTO-PLASTIC

$$\mu_{REQ'D} = \frac{904.8}{\underbrace{302[4.64 \cdot 0.115]}_{1366}} + \underbrace{\frac{1+\frac{0.115}{4.64}}{2}}_{0.51}$$

$$\boxed{= 1.2 << 7.5 \quad OK.}$$

Ⓑ - STRAIN ENERGY E_S REQUIRED FOR MISSILE B [3"φ PIPE]

$W_m = 72$ lbs $V_S = 147$ fps; $D_x = 3.5^{IN}$; $M_e = \frac{39.76[3.5+5]}{g} = \frac{338}{g}$

$$E_S = \frac{72^2 \times 147^2 \times 12}{64.4[72+338]1000} = 51 \text{ K·IN} < 667 \text{ K·IN}$$

$$\boxed{\therefore \text{ RESPONSE IS ELASTIC.}}$$

Ⓒ - STRAIN ENERGY E_S REQUIRED FOR MISSILE C [6"φ PIPE]

$W_m = 285^{lbs}$; $V_S = 170$ fps; $D_x = 6.625''$; $M_e = \frac{39.76[6.625+5]}{g} = \frac{462.2}{g}$

$$E_S = \frac{285^2 \times 170^2 \times 12}{64.4[285+462]1000}$$

$$= 585.5^{K·IN} < 667^{K·IN}$$

$$\boxed{\therefore \text{ RESPONSE IS ELASTIC.}}$$

Ⓓ - STRAIN ENERGY E_S REQUIRED FOR MISSILE D [12"φ PIPE]

$W_m = 750$ lbs; $V_S = 155$ fps; $D_x = 12.75''$; $M_e = \frac{39.76[12.75+5]}{g} = \frac{706}{g}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P&L

Subject D/G 'E' BUILDING - REMOVABLE WALL SECTION.

alculation Number SC-DB-07b Sheet No. 16

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		5/3/84									
Checker		8-15-84									

$$E_S = \frac{750^2 \times 155^2 \times 12}{64.4[750+706]1000}$$

1730 K·IN > 667 K·IN ∴ RESPONSE IS ELASTO-PLAST

$$\mu_{REQ'D} = \frac{1730}{1366} + 0.51$$

$$\boxed{= 1.78 < 7.5 \quad \text{OK.}}$$

(E)- STRAIN ENERGY E_s REQUIRED FOR TARGET E [1"ϕ ROD]

W_m : 8 lbs ; V_s = 317 fps ; D_x = 1" M_e : $\frac{39.76[1+5]}{g}$ = 238/g

$$E_S = \frac{8^2 \times 317^2 \times 12}{64.4[8+238] \cdot 1000}$$

$$= \boxed{4.9 \text{ K·IN.} < 667 \text{ K·IN.}}$$ ∴ RESPONSE IS ELASTIC

(G)- STRAIN ENERGY E_s REQUIRED FOR TARGET 'G' [UTILITY POLE]

W_m = 1490 lbs ; V_s = 211 fps. D_x = 13.5" ; M_e = $\frac{39.76}{g}[5+13.5]$ = $\frac{736}{g}$

$$E_S = \frac{1490^2 \times 211^2 \times 12}{64.4[1490+736]1000}$$

$= 8274$ K·IN. $>> 667$ K·IN ∴ RESPONSE IS ELASTO-PLASTIC.

DUCTILITY RATIO $\boxed{\mu_{REQ'D} = \frac{8274}{1366} + 0.51 = 7.0 < 7.5 \quad \text{OK.}}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION.

.alculation Number SC-DB-07b Sheet No. 17

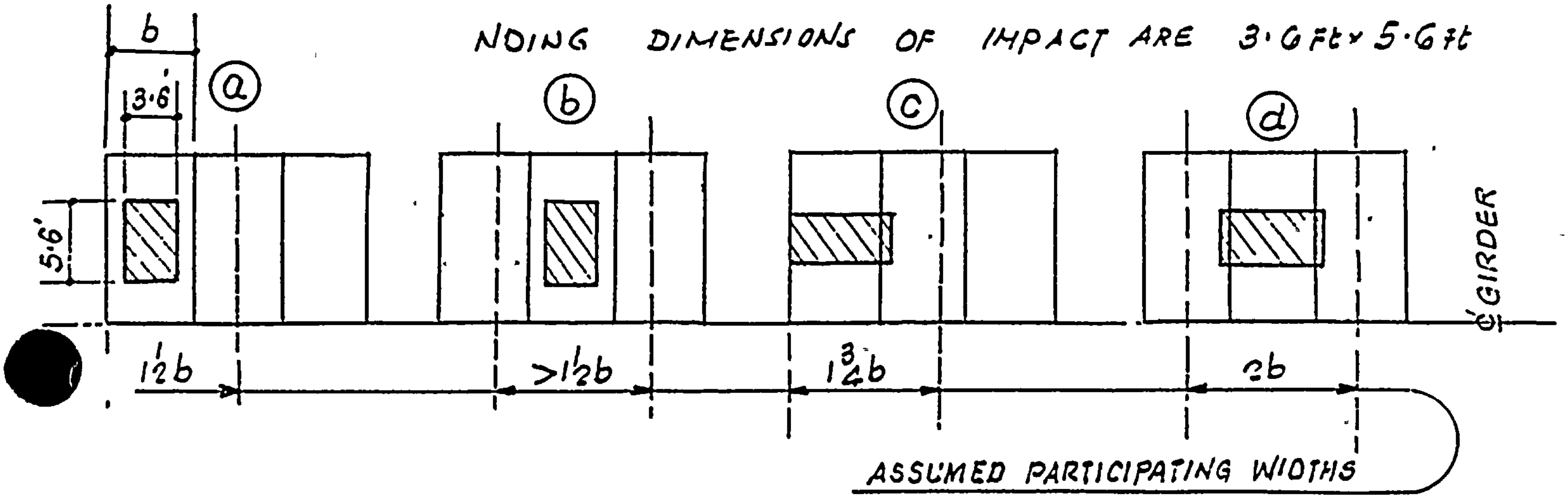
Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/7/84									
Checker		8-15-84									

. OVERALL EFFECT OF MISSILES H & I ON THE TARGET ARE INSIGNIFICANT BY INSPECTION.

Ⓕ STRAIN ENERGY REQUIRED FOR TARGET F [AUTOMOBILE].

NOTES: 1. SINCE THE AREA OF IMPACT OF THE AUTOMOBILE IS RELATIVELY LARGE, PARTICIPATION OF THE ADJOINING PANELS SHALL BE INCLUDED IN DETERMINING THE TARGET RESPONSE. PARTICIPATIN TARGET WIDTHS ARE ASSUMED TO BE AS SHOWN BELOW.

2. AUTOMOBILE DIMENSIONS PER US NRC SRP SECT 3.5.1.4 ARE 5m × 2m × 1.3m [16.4' × 6.56' × 4.27'] ∴ IMPACT AREA OF HEAD-ON COLLISION IS $6.56 \times 4.27 = 28\ \text{Ft}^2$. SINCE IMPACT AREA PER REF. 5 IS $20\ \text{Ft}^2$; CORRESPONDING DIMENSIONS OF IMPACT ARE 3.6 Ft × 5.6 Ft



Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

Subject D/G E BUILDING · REMOVABLE WALL SECTION.

alculation Number SC-DB-07b Sheet No. 18

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/8/'84									
Checker	G.K.	8-15-84									

FROM ABOVE CASES ⓐ AND ⓒ ARE CRITICAL

CASE ⓐ

$R_m = 1.5 \times 302 = 453$ KIPS.

STRAIN ENERGY OF TARGET FOR ELASTIC RESPONSE

$E_S = 1.5 \times 667 = 1000$ K·IN.

DUCTILITY RATIO REQ'D FOR ELASTO-PLASTIC RESPONSE

$$= \frac{E_S}{1.5 \times 1366} + 0.51$$

$$= \frac{E_S}{2049} + 0.51.$$

STRAIN ENERGY REQUIRED OF TARGET FOR CASE a

$W_M = 4000$ lbs; $V_S = 195$ fps; $D_X = 5.6' = 67.2^{IN.}$

$$M_e = \frac{39.76 \times 1.5}{g}\left[67.2 + 5\right] = \frac{4306}{g}$$

$$E_{S_{REQ'D}} = \frac{4000^2 \times 195^2 \times 12}{64.4(4000 + 4306)1000}$$

$$= 13{,}650 \text{ K·IN.} > 1000 \text{ K·IN}$$

∴ RESPONSE IS ELASTO-PLASTIC.

$$\mu_{REQ'D} = \frac{13.650}{2049} + 0.51$$

$$\boxed{= 7.17 < 7.5 \text{ OK.}}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION.

Calculation Number SC-DB-07b Sheet No. 19

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/8/'84									
Checker		3-15-84									

CASE ⓒ

$$R_m = 1.75 \times 302 = 528^{K}$$

$$Es_{TARGET} = 1.75 \times 667. = 1167^{K\cdot IN\cdot}$$

$$\mu_{REQ'D} = \frac{Es_{REQD}}{\underbrace{1.75 \times 1366}_{2390}} + 0.51$$

$W_m = 4000$ lbs; $V_s = 195$ fps; $D_x = 3.6 \times 12 = 43.2^{IN}$

$$Me = \frac{39.76 \times 1.75}{g}\left[43.2 + 5\right] = 3354/g.$$

$$Es_{REQD} = \frac{4000^2 \times 195^2 \times 12}{64.4(4000 + 3354)1000}$$

$$= 15{,}416 \text{ K}\cdot\text{IN}\cdot > 1167^{K\cdot IN}$$

∴ RESPONSE IS ELASTO-PLASTIC

$$\mu_{REQ'D} = \frac{15{,}416}{2390} + 0.51$$

$$\boxed{= 6.96 < 7.5 \text{ OK}}$$

SUMMARY: $2\frac{1}{2}''$ THICK PLATE OF ASTM-A514 IS ADEQUATE TO PREVENT LOCAL PERFORATION AS WELL AS FOR OVERALL RESPONSE TO THE MISSILES CONSIDERED.

Checking Method #

1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

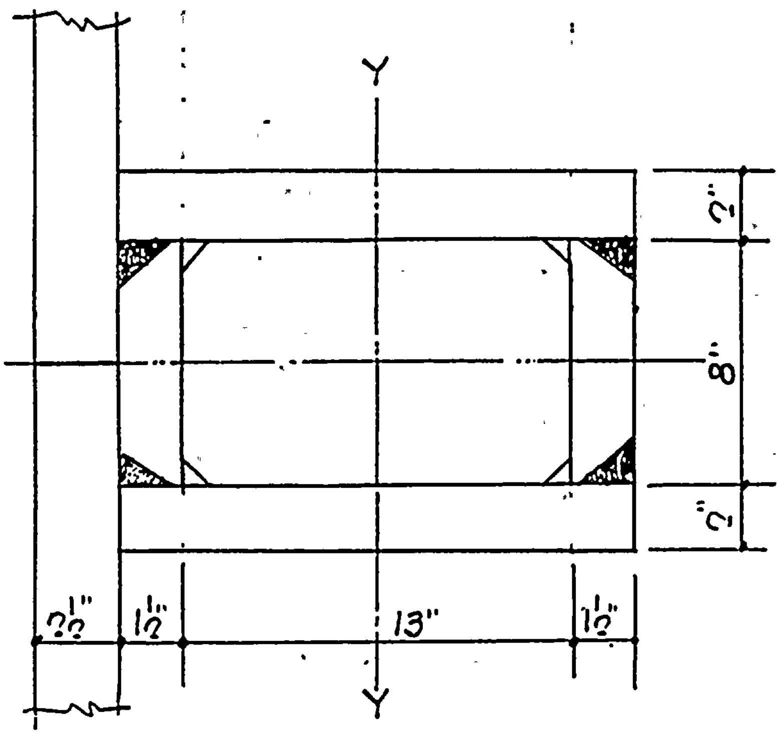
Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 20

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		5/8/84									
Checker	BIA	8-15-84									

6.0 STRUCTURAL RESPONSE OF CENTER GIRDER TO MISSILE IMPACT

6.1 SECTION & PROPERTIES



NOTE: FOR REVISED GIRDER SIZE SEE SH. NO. 24.

WIDTH/THICKNESS RATIO OK BY INSPECTION, TO SATISFY LOCAL BUCKLING REQUIREMENTS OF AISC AND HENCE ASSURE PLASTIC DEFORMATIONS.

AREA :

$8 \times 3 + 16 \times 4 = 88 \text{ IN}^2$

WEIGHT :

$88 \times 3.4 = 300 \#/\text{ft.}$

SPAN : 14'-0" [SIMPLE SPAN.]

I_{YY} :

$\frac{4 \times 16^3}{12} + 24 \times 7.25^2$

$= 2627 \text{ IN}^4$

S_{YY} : $2627/8 = 328 \text{ IN.}^3$

PLASTIC MODULUS OF SECTION

$Z = 8 \times 4 \times 2 \times 4 + 24 \times 7.25$

$= 256 + 174$

$= 430 \text{ IN}^3$ $f = \frac{Z}{S} = 1.31$

Gibbs & Hill, Inc. Job No. 3544 Client P.P&L

Subject D/G E. BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b . Sheet No. 21

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		5/9/84									
Checker		8-15-84									

6.2 ULTIMATE RESISTANCE AND STRAIN ENERGY OF ELASTIC RESPONSE OF TARGET:

$M_u = f_{dyn} \times =$

$100 \times 430 = 43{,}000$ K·IN.

$$R_M = \frac{4M_u}{L} = \frac{4 \times 43{,}000}{14 \times 12}$$

$$\boxed{R_M = 1024 \text{ KIPS}}$$

STRAIN ENERGY $E_s = \dfrac{R_M (X_e - X_0)^2}{2 X_e}$

$$X_e = \frac{R_M L^3}{48EI} = \frac{1024 \times (14 \times 12)^3}{48 \times 29000 \times 2627} = \underline{1.328} \text{ IN.}$$

$$X_0 = \frac{5 W \ell^3}{384EI} = \frac{5 \times .266 \times 9.67 \times 14 \times (14 \times 12)^3}{384 \times 29000 \times 2627} = \underline{0.029} \text{ IN.}$$

$X_e - X_0 = 1.299$ IN.

$$\therefore \boxed{E_{s_{TARGET}} = \frac{1024 \times 1.299^2}{2 \times 1.328} = 650 \text{ K·IN}}$$

Gibbs & Hill, Inc. Job No. 3544 Client P. P & L

Subject D/G E BUILDING - REMOVABLE WALL SECTION.

alculation Number SC-DB-076 Sheet No. 22

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/9/'84									
Checker	F.I.A	8-15-84									

6.3 REQUIRED STRAIN ENERGY

$$E_{s_{REQ'D}} = \frac{M_m^2 \cdot V_s^2}{2(M_m + M_e)}$$

$$M_e = (D_x + 2d)\, M_x$$

$$d = 16'' \quad M_x = \frac{300}{g}\ \text{lbs/ft.}$$

$$M_e = \frac{(D_x + 32)300}{12g} = \frac{25}{g}(D_x + 32)$$

FROM STRAIN ENERGY REQUIREMENTS OF PLATE FOR VARIOUS MISSILES, ONLY FOLLOWING MISSILES ARE CRITICAL.

F & G.

Ⓖ $E_{s_{REQ'D}}$ FOR MISSILE G (UTILITY POLE)

$W_M = 1490$ lbs ; $V_s = 211$ fps ; $D_x = 13.5''$ $M_e = \frac{25 \times 45.5}{g} = \frac{1137}{g}$

$$E_{s_{REQ'D}} = \frac{1490^2 \times 211^2 \times 12}{2 \times 32.2(1490 + 1137)1000}$$

$$= 7010 \text{ K·IN} > 650^{\text{K·IN}}$$ ∴ Response is Elasto-Plastic.

$$\mu_{REQ'D} = \frac{E_{s_{REQ'D}}}{1024 \times 1.299} + \frac{1 + \frac{0.029}{1.328}}{2}$$

$$= \frac{E_{s_{REQ'D}}}{1330} + 0.51$$

$$\boxed{\mu_{REQ'D} = \frac{7010}{1330} \div 0.51 = 5.78 < 7.5 \quad \text{OK}}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION.

Calculation Number SC-DB-07b Sheet No. 23

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		5-10-8C									
Checker	BIA	3-15-84									

Ⓕ TARGET RESPONSE FOR MISSILE F (AUTOMOBILE).

IN AS MUCH AS BOX. GIRDER TARGET, SPANNING 14'-0" IS RELATIVELY A RIGID TARGET, IT WILL NOT UNDERGO SIGNIFICANT DEFORMATIONS UNDER THE AUTOMOBILE IMPACT, AS A RESULT MISSILE WILL DEFORM PRIOR TO DELIVERING FULL IMPACTIVE LOAD. THEREFORE THE ENERGY BALANCE METHOD USED FOR PLATE TARGET IS NOT APPLICABLE.

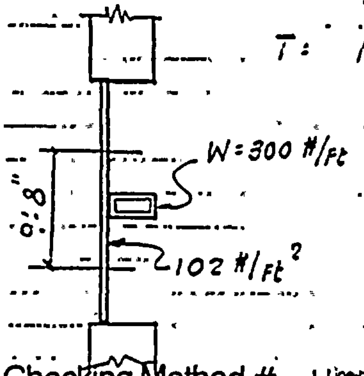
USING REF. NO. 7, CASE OF NO PENETRATION, THE MISSILE IMPACTIVE LOAD PER EQU^N 14, PG. 3-8 OF REF. 7 IS GIVEN BY

$$\boxed{Q_Y = \frac{2\pi m V}{T\sqrt{2\mu - 1}}}$$

$$m = \frac{4000}{g} \text{ lbs}\cdot\text{sec}^2/\text{ft} = 124.2 \text{ lb}\cdot\text{sec}^2/\text{ft}.$$

$$V = 195 \text{ ft/sec}.$$

$$\mu : 7.5$$



T: PERIOD OF VIBRATION OF TARGET.

EFF. TARGET MASS = [300 + 102 × 9.67] × 14 = 18000 lbs.

$$f_{\text{REQUENCY}} = \frac{3.55}{\sqrt{\frac{5Wl^3}{384EI}}} \quad \text{REF. 6, page. 369}$$

$$= \frac{3.55}{\sqrt{\frac{5 \times 18 \times (14 \times 12)^3}{384 \times 29000 \times 2627}}}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 24

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/11/84									
Checker	BJA	3-15-84									

$f = 29.4$ cps.

$T = 0.034$ sec.

$$\therefore \quad Q_Y = \frac{2\pi \cdot 124.2 \times 195}{0.034\sqrt{14}}$$

1196,000 lbs.

$$\boxed{1196 \text{ kips.}}$$

$$M_U \text{ OF TARGET} = f_{dyn}' Z - M_{\text{due to addl loads}}$$

$$M_{\text{addl loads}} = \frac{0.266 \times 9.67 \times 14^2 \times 12}{8} = 756 \text{ K·IN.}$$

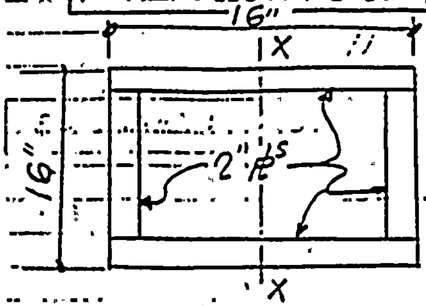
$$\therefore \quad M_U = 43000 - 756 = 42,244 \text{ K·IN.}$$

$$R_M = \frac{4 \times 42,244}{14 \times 12} = 1006^K$$

$$\sqrt{2\mu - 1} = \frac{2\pi \cdot 124.2 \times 195}{0.034 \times 1006,000} = 4.45$$

$$\boxed{\mu_{REQD} = 10.4 > 7.5.} \quad \underline{N.G.}$$

TRY FOLLOWING SECTION:



PLASTIC MODULUS $Z_{xx} = 8 \times 4 \times 4 \times 2 + 12 \times 2 \times 2 \times 7 = 592$

$$M_U = 592 \times 100 - 756 = 58,444 \text{ K·IN.}$$

$$R_M = \frac{4 \times 58,444}{14 \times 12} = 1391.5 \text{ K}$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

.alculation Number SC-DB-075 Sheet No. 25

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		8/21/84									
Checker		8/22/84									

$$I_{xx} = \frac{4\times16^3}{12} + 4\times12\times7^2 = 3717 \text{ IN.}^4$$

$$W_{GIRDER} = [16\times4+48]\times3.4 = 381 \text{ \#/FT}$$

$\therefore$ EFF. TARGET MASS = $[381 + 102\times9.67]\times14 = 19{,}140$ #

$$f = \frac{3.55}{\sqrt{\dfrac{5\times19.140(14\times12)^3}{384\times29000\times3717}}} = 33.9$$

$$T = 0.0295 \text{ SEC.}$$

$$\sqrt{2\mu-1} = \frac{2\pi\times124.2\times195}{0.0295\times1391{,}500} = 3.71$$

$$\mu_{REQD} = 7.38 < 7.5 \text{ OK.}$$

$\therefore$ USE GIRDER SECTION AS SHOWN ON SH. No 24.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION.

Calculation Number SC-DB-07b Sheet No. 26

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		5/11/84									
Checker	17A	8-15-84									

7.0 MAXIMUM DELIVERABLE IMPACT FORCE ON RIGID TARGET:

MAXIMUM FORCE DELIVERED BY DEFORMABLE MISSILE ON A RIGID TARGET IS GIVEN BY:

$$F = P_c + mv^2 \text{ —— REF. 3; SECT. 6.4.2.1.2, EQU}^{N} \text{ 6.53}$$

P_c: CRUSHING STRENGTH OF MISSILE, lbs. $= f_{CR} \times A$

m: MASS OF MISSILE PER FT. LENGTH, $\text{lb.sec}^2/\text{ft}/\text{ft}$.

V: STRIKING VELOCITY IN ft/sec.

MISSILE	MASS, m $W/l.g$	VELOCITY V	mv^2	f_{CR}* KSI	A IN^2	$f_{CR} \cdot A$ KIPS	F KIPS
A	0.28	440	54 K.	8	48	384	438
B	0.224	147	5 K	66	2.228	147	152
C	0.59	170	17 K	66	5.581	368	385
D	1.553	155	37 K	66	14.58	962	999
E		NOT CRITICAL				-	-
F	10.35	195	394	DEFORMABLE MISSILE			-
G	1.322	211	59 K	8	143.14	1145	1204

* FOR WOOD PLANK AND UTILITY POLE USE $f_{CR} = 8000$ psi

FOR PIPES USE $f_{CR} = 60{,}000$ psi (ASSUME) × 1.1 [FOR FASTER STRAIN RATE INCREASED 10%]

NOTE: SITE PROXIMITY MISSILES [BULLET & TRUCK FRAGMENTS] ARE NON-CRITICAL FOR MAX^{M} IMPACTIVE FORCE.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P P & L

Subject D/G E BUILDING REMOVABLE WALL SECTION.

alculation Number SC-DB-07b Sheet No. 37

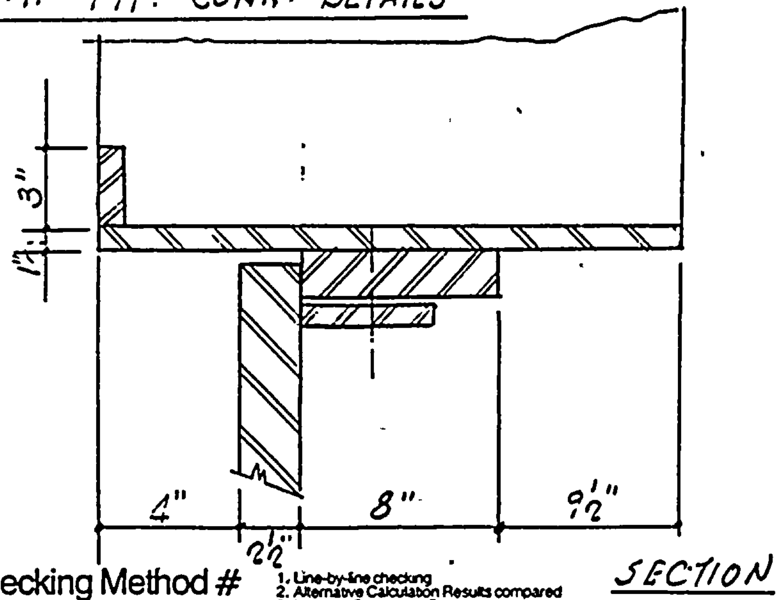
Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		5/11/84									
Checker	B'A	8-15-84									

8.0. DESIGN OF CONNECTIONS:

THE CONNECTIONS BETWEEN PL AND THE CONCRETE EMBEDMENTS AND BETN PL AND CENTER GIRDER ARE TO BE DESIGNED FOR THE FOLLOWING FOUR LOADING CASES:

1. HORIZ. MISSILE IMPACTIVE FORCE PLUS TORNADO DYNAMIC WIND PRESSURE.
2. PL REBOUND DUE TO MISSILE IMPACT PLUS TORNADO DYNAMIC WIND + 1/2 TORNADO DIFF. PRESSURE
3. FORCE PARALLEL TO THE PLATE BARRIER DUE TO OBLIQUE STRIKE OF THE MISSILES.
4. FORCE DUE TO DIRECT IMPACT ON GIRDER.

8.1. TYP. CONN. DETAILS:



DET. A
TYP. @ T. & B.

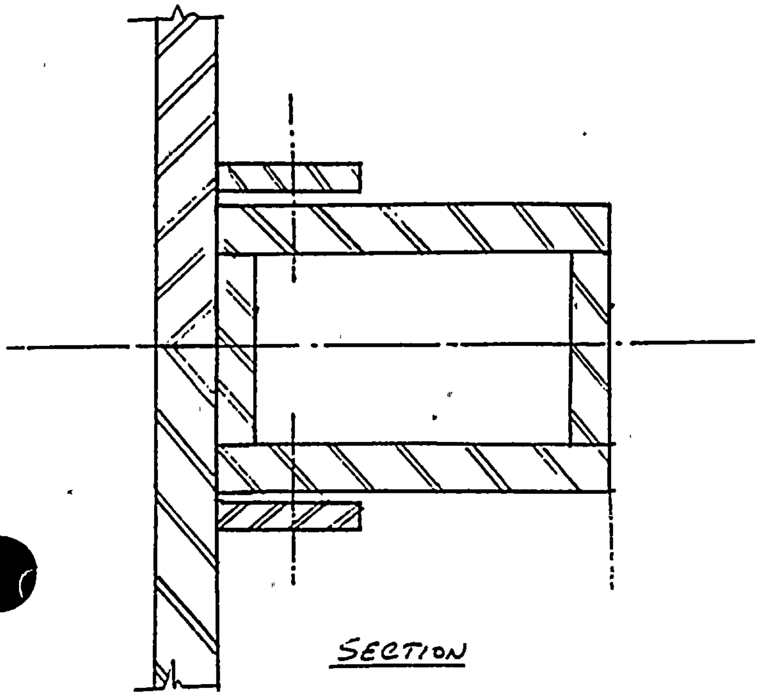
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

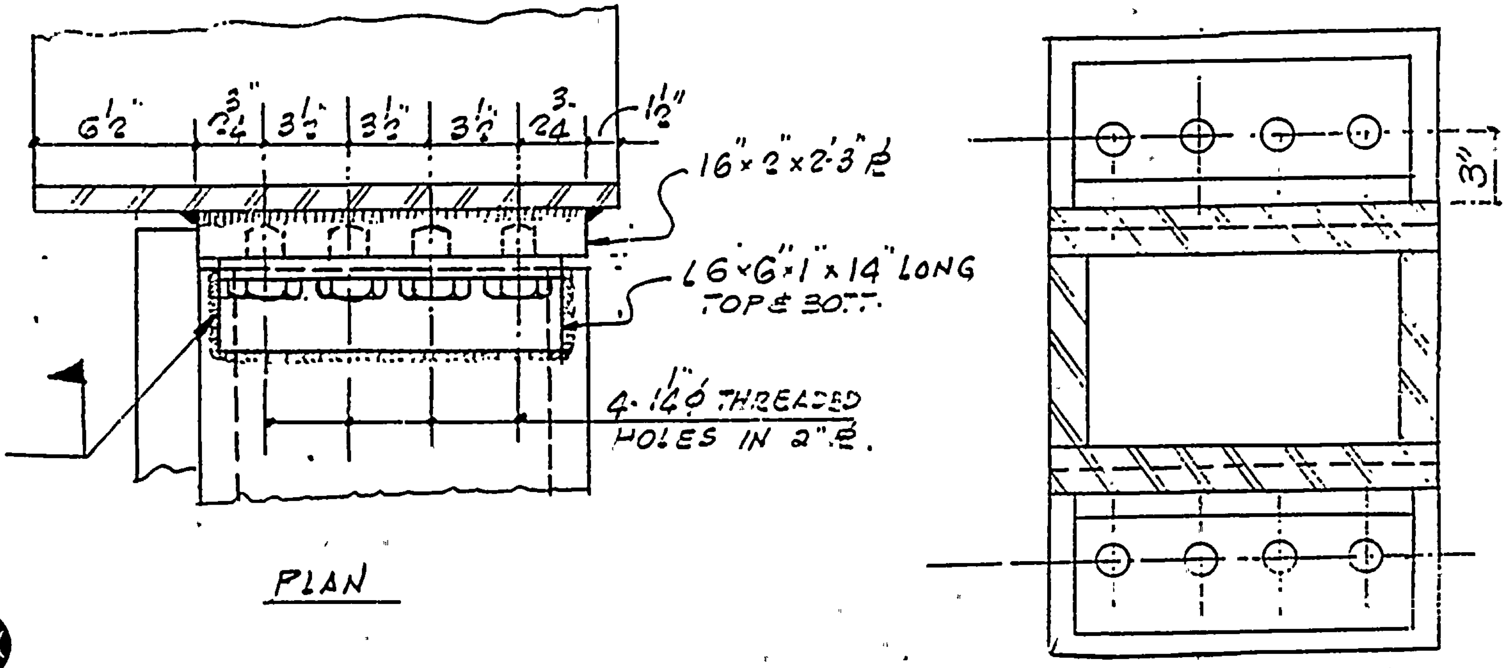
Subject D/G. E BUILDING - REMOVABLE WALL SECTION.

Calculation Number SC-DB-07b. Sheet No. 28

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		6/20/84									
Checker	DJK	3-15-84									



DET. B.
CONN. BETWEEN
PLS & GIRDER



DETAIL C
CONN. OF GIRDER
TO CONC. WALL

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

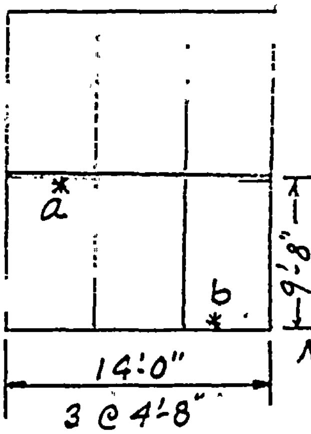
Subject D/G E BUILDING. REMOVABLE WALL SECTION.

Calculation Number SC-DB-076. Sheet No. 39

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		6/28/84									
Checker	B:A	8-15-84									

8.2 CONNECTION LOADS:

CASE 1. MISSILE IMPACTIVE LOAD + TORNADO LOADS.



FOR CONN. OF PLATE TO GIRDER & TO CONCRETE NEAR FLOOR SLAB [POINT a & b], THE IMPACT WILL BE MAXIMUM. SINCE THE TARGET IS RIGID AT THESE SUPPORT POINTS.

∴ MAXIMUM IMPACT LOAD = 1204^k [sh. No. 35]

NOTE: SINCE THE 8" STOP PL AND 24" EMBEDDED PL ARE VERY STIFF AND THAT THE HIGH PLASTIC DEFORMATIONS AT POINT OF IMPACT ARE POSSIBLE, THE LOAD CAN BE DISTRIBUTED ON FULL 14'-0

∴ IMPACT LOAD/Ft = $1204/14 = 86^k/ft$

TORNADO WIND LOAD = $266\ \#/ft^2$ [sh. No. 12]

∴ Max. DESIGN LOAD/Ft = $86 + 0.266 \times 9.67/2$.

$$\boxed{= 87\ ^K/Ft}$$

CASE 2. PLATE REBOUND LOAD:

UPON INITIAL IMPACT OF A MISSILE ON PLATE, PLATE WILL EXPERIENCE A REBOUND EFFECT. CONSERVATIVELY, THE REBOUND LOAD ON AN INDIVIDUAL PLATE WILL BE ASSUMED TO BE EQUAL

Gibbs & Hill, Inc.	Job No. 3544	Client PP&L
Subject D/G E BUILDING - REMOVABLE WALL SECTION		
Calculation Number SC-DB-07b		Sheet No. 30

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		6/28/84									
Checker	E.A	8-15-84									

TO ITS' YIELD RESISTANCE = 302^k [Sh. No. 11].
SINCE REBOUND LOAD IS ACTING OUTWARD [OPPOSITE TO THE MISSILE IMPACT LOAD], IT WILL BE COMBINED WITH THE DYNAMIC WIND SUCTION AND ONE HALF THE TORNADO DIFF PRESSURE LOAD [Sh. No. 11]

∴ TOTAL EXTERNAL LOAD / PLATE SECTION.

$$= 302 + \left[232 + \frac{3\times 144}{2}\right]\times 9.67\times 4.67/1000$$

SUCTION DUE TO DYNAM. WIND LOAD, SEE SC-DB-07 Sh. No. 5

DIFF PRESSURE = 3 psi REF. 5, Pg. 7

$= 322$ kips. AT MIDDLE OF PL SECTION

SINCE PL IS SUPPORTED ON TWO SIDES, REACTION = 161^k

∴ LOAD ACTING OUTWARD $= \frac{161}{4.67} = \boxed{34.5^k/\text{ft.}}$

CASE 3. LOAD PARALLEL TO PLATE DUE TO OBLIQUE MISSILE STRIKE

IN AN EVENT OF AN OBLIQUE STRIKE OF MISSILE, THE COMPONENT OF IMPACT LOAD IN A DIRECTION PARALLEL TO PLATE WILL HAVE TO BE RESISTED BY THE BOLTS CONNECTING PLATES TO THE EMBEDMENT.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

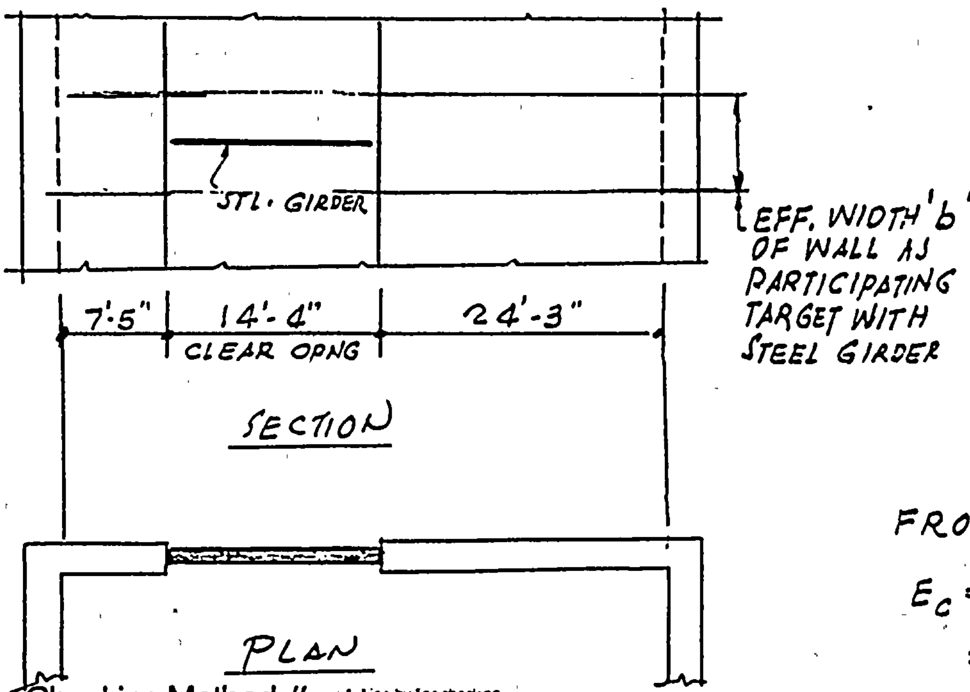
Calculation Number SC-D8-07b Sheet No. 31

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		6/29/84									
Checker	BIK	8-15-84									

FOR A MISSILE STRIKE NEAR THE SUPPORT, MAX. IMPACTIVE LOAD = 1204^k [SH. NO. 25]. SINCE THE IMPACTIVE FORCE REDUCES AS THE ANGLE OF STRIKE TO THE PLATE SURFACE DECREASES, IT WILL BE ASSUMED THAT THE MAX IMPACTIVE FORCE OCCURS AT AN ANGLE OF STRIKE NO SMALLER THAN 45°.

$\therefore$ $\boxed{\text{MAX. FORCE PARALLEL TO PLATE} = 0.707 \times 1204 = 851^k}$

CASE 4. FORCE DUE TO DIRECT IMPACT ON GIRDER



STEEL GIRDER

$EI = 2.9 \times 10^7 \times 2627$

SH. NO. 20

$= 7.618 \times 10^{10}$ # IN.^{2}

ASSUME CONCRETE WALL PARTICIPATING WITH GIRDER AS A SINGLE SYSTEM HAVING $EI = 1.5 \times 7.61 \times 10$

FROM SC-D8-07a SH. NO. 14

$E_c = 5.19 \times 10^5$ k/ft^2

$= 3.6 \times 10^6$ lbs/in^2

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING- REMOVABLE WALL SECTION

Calculation Number SC-DB-076 Sheet No. 32

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		7/10/84									
Checker	[illegible]	8-15-84									

AND FROM SAME REF. $I_a = 0.397\ ft^4/ft$

$= 8232\ IN^4/ft.$

$\therefore\ 8232 \times 3.6\times10^6 \times \underset{\text{EFF. WIDTH}}{b} = 1.5 \times 7.018\times10^{10}$

$b = 3.855\ ft$ SAY 4 ft.

∴ ASSUME A 4 ft WIDE × 2 ft THICK CONCRETE BEAM TARGET SPANNING 40'-0 TO EVALUATE TARGET RESPONSE AND CALCULATE STATIC MISSILE IMPACT LOAD FOR CONNECTION OF GIRDER TO CONCRETE WALL.

FROM REF. NO. 7 PAGE 3-8 EQU^N NO. 14,

STATIC IMPACT LOAD $q_r = \dfrac{2\pi m V}{T}\sqrt{\dfrac{1}{2\mu-1}}$

CALCULATE T = NATURAL PERIOD OF VIBRATION

$T = 2\pi\sqrt{\dfrac{K_{LM}\cdot M_t}{k}}$ — REF. NO. 8 EQU^N 5.12 pg. 219

$K_{LM} = 0.37$ REF 8 TABLE 5.2 ELASTIC COND.

$k = \dfrac{192EI}{L^3}$ " " " "

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING. REMOVABLE WALL SECTION

Calculation Number SC-D3-076 Sheet No. 33

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		7/6/84									
Checker	[illegible]	8-15-84									

M_t = UNIFORM MASS.

FOR 4'x2' TARGET
L = 46'-0" SPAN
= 552 IN.

$W = 4 \times 2 \times 150 = 1200$ #/FT
$= 1200 \times 46 = 55,200$ lbs

$$M_t = \frac{55,200}{386} = 143 \text{ lb.-sec}^2/\text{IN.}$$

$$I = 8232 \times 4 = 33,000 \text{ IN.}^4$$

$$E = 3.6 \times 10^6 \text{ lbs/IN}^2.$$

$$\therefore T = 2\pi \sqrt{\frac{0.37 \times 143 \times 552^3}{192 \times 3.6 \times 10^6 \times 33000}}$$

$$= 0.124 \text{ SECONDS.}$$

FROM TABLE OF Sh. No. 6, THE LARGEST M×V IS FOR MISSILE F AUTOMOBILE

$$\therefore \text{FOR MISSILE F} \quad q_y = \frac{2\pi \times 4000 \times 195}{32.2 \times 0.124} \sqrt{\frac{1}{2\mu - 1}}$$

CONSERVATIVELY USE $\mu = 5$

$$q_y = 408,936 \text{ lbs.}$$

$$\boxed{\text{SAY} \quad 410 \text{ kips.}}$$

TORNADO WIND LOAD = 266 lb/ft^2
AREA FOR CONN. LOAD = $9.5' \times 7' = 66.5 \text{ ft}^2$
$\therefore$ WW $= .266 \times 66.5 = 17.7^k$ say 18^k.

$$\boxed{\therefore \text{MAX. GIRDER CONN. LOAD} = 428^K} \longleftarrow$$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

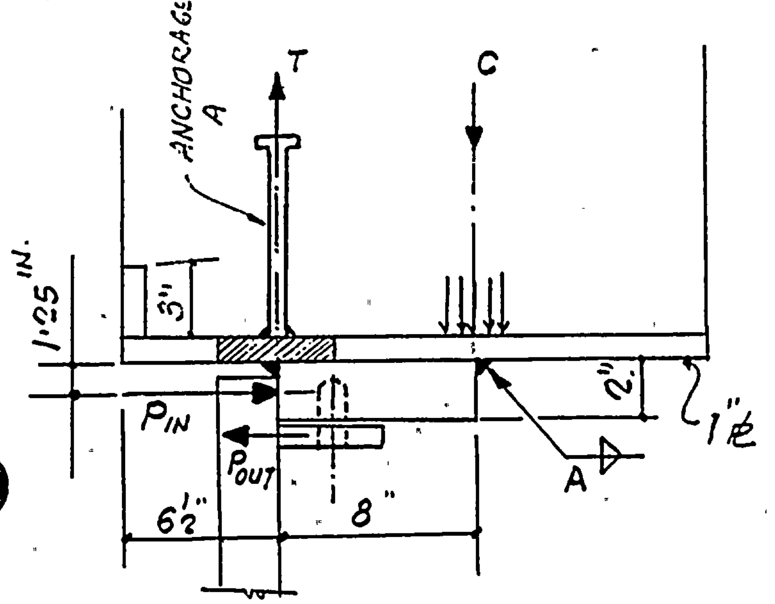
Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING· REMOVABLE WALL SECTION

Calculation Number SC·DB-07b Sheet No. 34

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		7/9/84									
Checker	B'K	8-15-84									

8·3. DESIGN CONN. BET^N PLATE AND WALL EMBEDMENT [DETAIL Sh. 23]



TOP SECTION, BOTTOM SIMILAR

$P_{IN} = 87$ K/Ft. Loading Case 1

@ DESIGN WELD A:

Shear stress

$f_v = \frac{87}{2\times12} = 3.63$ K/IN.

TENSION FORCE

$T = \frac{87\times1.25}{8} = 13.6$ K/Ft.

$f_t = \frac{13.6}{12} = 1.13$ K/IN.

∴ $f_R = \sqrt{3.63^2+1.13^2} = 3.8$ k/IN

PER AISC ALLOWABLE WELD STRESS FOR E70XX WELD.

$= 0.3\times70 = 21$ ksi.

∴ CAPACITY OF 1/16" FILLET WELD $= \frac{0.707\times21\times1.6}{16} = 1.43$ K.

OR $0.4\times50\times1.6/16 = 2.0$ K/IN

↑ Fy OF BASE METAL A572

∴ USE 1.48 K/IN

WELD A REQD IN SIXTEENTHS $\frac{3.8}{1.48} = 2.6$ IN SIXTEENTHS USE $\boxed{\tfrac{1}{2}\text{ IN. FILLET WELD}}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

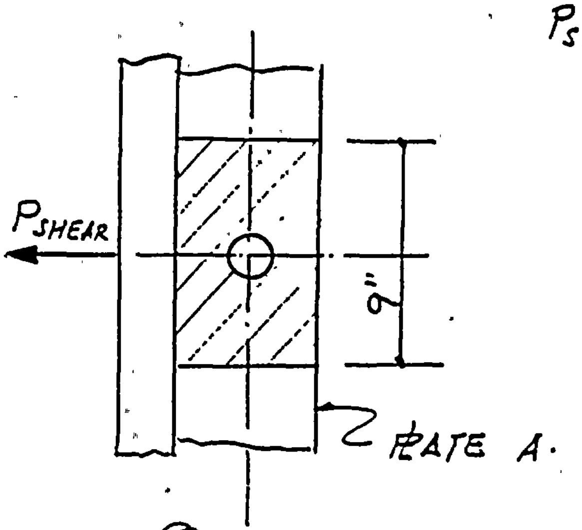
Subject D/G 'E' BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-03-076 Sheet No. 35

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		7/10/84									
Checker	[illegible]	8-15-84									

$P_{OUT\ MAX.} = 34.5^{k}/FT.$ [LOADING CASE 2]

ⓑ TRY BOLTS @ 9 IN. O.C



$P_{SHEAR}/BOLT = \frac{34.5 \times 9}{12} = 25.9^{KIPS.}$

TRY $1\frac{1}{4}$" φ A325N [BEARING TYPE WITH THREA INCLUDED IN SHEAR PLANE BOLTS.

ALLOWABLE LOAD $= 1.00 \times 25.8^{K} \simeq 25.9^{K}$ OK

USE $\boxed{1\frac{1}{4}\text{" φ A325N BOLTS @ 8" OC}}$

HOLE SIZE $1\frac{7}{16}$" φ.

ⓒ DESIGN PLATE A FOR TENSION: ASSUME t = 1"

NET AREA $= [9" - 1\frac{7}{16}"] \times 1" = 7.56\ IN^2$

t ℙ THICKNESS.

$f_t = \frac{25.9}{7.56} = 3.42\ ksi << 0.9 \times F_Y$

$\boxed{\text{USE } 1" \times 5\frac{1}{2}" \text{ CONT. ℙ.}}$

FOR FITTING, WELD 1" ℙ TO $2\frac{1}{2}$" BARRIER ℙ BY FULL PENETRATION WELD.

ⓓ INVESTIGATE BOLT CONNECTION FOR OBLIQUE STRIKE [LOADING CASE 3].

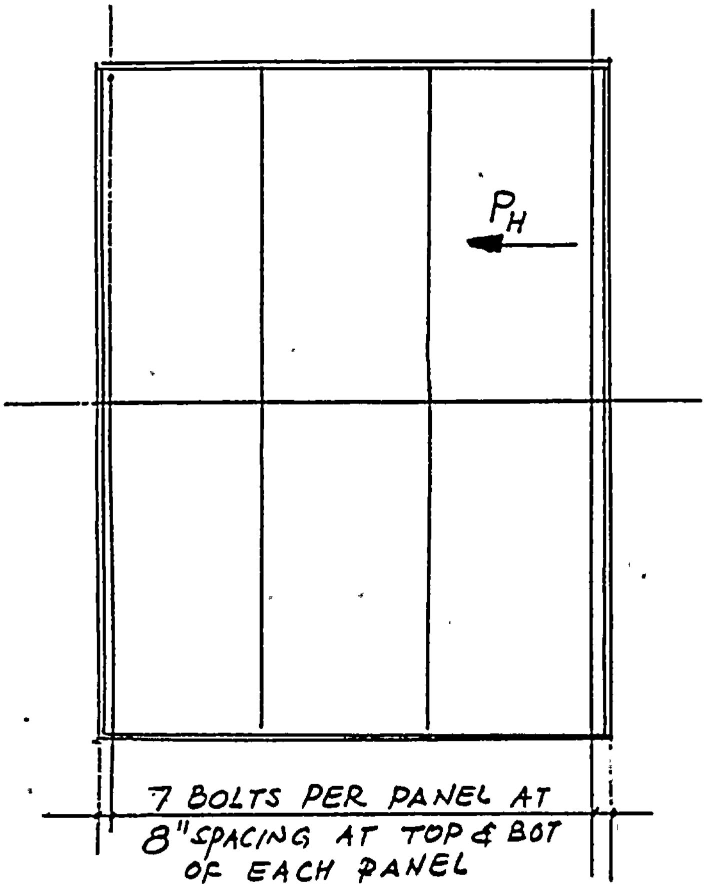
Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 36

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		7/10/84									
Checker	BJA	8-15-84									



7 BOLTS PER PANEL AT 8" SPACING AT TOP & BOT OF EACH PANEL

MAX. HORIZ. LOAD $P_H = 851^k$ (SH. NO. 30)

CONCURRENT INWARD IMPACTIVE FORCE $= 851^k$.

PART OF HORZ. LOAD WILL BE RESISTED BY FRICTION BETWEEN BARRIER PANELS AND THE SUPPORT PLATE DUE TO AN IMPACT OF 851^k PERPENDICULAR TO THE PL.

∴ LOAD TO BE RESISTED BY BOLTS $= 851(1-0.3)$ ← ASSUMED COEFF OF FRICTION

$= 596$ KIPS

THIS FORCE WILL BE RESISTED BY ALL THREE PANELS

∴ TOTAL NO. OF BOLTS $= 7 \times 3 \times 2 = 42$

∴ SHEAR/BOLT $= 596/42 = 14.19^k << 1.6 \times 25.8^k$ OK

$\boxed{\text{USE } 1\tfrac{1}{4}"\phi \text{ A325N BOLTS @ 8" O.C}}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 37

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		7/10/84									
Checker	BIA	3-15-84									

8.4: CONN. BET^N GIRDER & WALL EMBED. [DETAIL C SH. No 27]

Max. SHEAR FORCE $P = 428^{KIPS}$. [loading Case 4. sh. 32]

ⓐ TRY $8 - 1\frac{1}{2}"\phi$ A490N [BEARING TYPE W/ THDS INCL. IN SHEAR PLANE] BOLTS

$$\text{LOAD/BOLT} = \frac{428}{8} = 53.5^{K}.$$

REF. 10, page 4-5

$$\text{BOLT CAPACITY} = 1.6 \times 49.5$$

$$= 79.2^{K} >> 53.5^{K}$$

NOTE: ADDITIONAL SHEAR CAPACITY GOOD FOR ECCENTRIC APPLICATION OF MISSILE IMPACT.

USE $\boxed{8 - 1\frac{1}{2}"\phi \text{ A490N BOLTS}}$

ⓑ CONN. ANGLES:

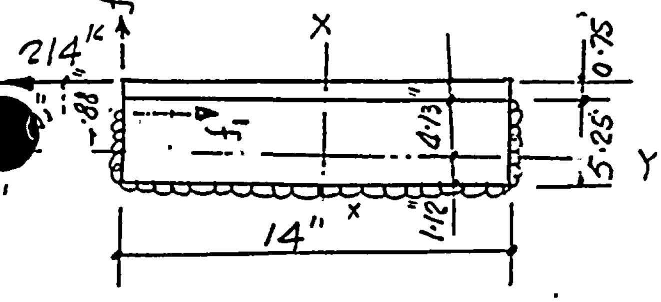
$$\text{SHEAR/ANGLE} = 428/2 = 214^{kips}$$

TRY $L\ 6 \times 6 \times 1"$ A572 $F_V = 1.6 \times .4 \times 50 = 32^{ksi}$.
14" LONG

$$f_V = \frac{214}{1" \times 14"} = 15.3^{ksi} < 32^{ksi}. \quad \text{OK}$$

$\boxed{\text{USE } L6" \times 6 \times 1" \times 14 \text{ LONG T.\&B.}}$

ⓒ WELD BET^N ⅃L AND GIRDER:



$$e = \frac{14 \times 6 + 5.25 \times 2[5.25/2 + 0.75]}{24.5} = 4.88"$$

$$M = 214 \times 4.88 = 1044^{K \cdot IN.}$$

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING- REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 38

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		7/10/84									
Checker	BIR	8-15-84									

$$I_{xy}: 10.5\times 7^2+\frac{14^3}{12} = 743\ IN^3$$

$$I_{yy} = 14\times 1.12^2+\frac{5.25^3}{12}\times 2+10.5\left(5.25/2-1.12\right)^2 = 65\ IN^3$$

$$I_P : I_{x\text{-}x}+I_{y\text{-}y} = 809$$

$$f_1 = \frac{214}{24.5}+\frac{1044\times 4.13}{809} = 14.07\ K/IN$$

$$f_2 = \frac{10.44\times 7.0}{809} = 9.03\ K/IN.$$

$$f_R = \sqrt{9.03^2+14.07^2} = 16.72\ K/IN.$$

$\therefore$ SIZE OF $\frac{1}{16}$" WELD REQUIRED : $\frac{16.72}{1.48}$ = 11.3 IN SIXTEENTHS

sh. NO. 33 ↗

$\boxed{\text{USE } \tfrac{7}{8}\text{" FILLET WELD}}$

8.5 DESIGN SPLICE BETWEEN PANELS:

EACH PANEL IS DESIGNED INDIVIDUALLY FOR CENTER IMPACT OF MISSILE. HOWEVER WHEN A MISSILE STRIKES NEAR THE EDGE OF ONE PANEL OR A LARGE MISSILE SUCH AS AUTOMOBILE STRIKES A BARRIER, TWO ADJACENT PANELS SHARE THE IMPACT THUS TRANSFERRING THE LOAD FROM ONE PANEL TO ANOTHER.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-07b Sheet No. 39

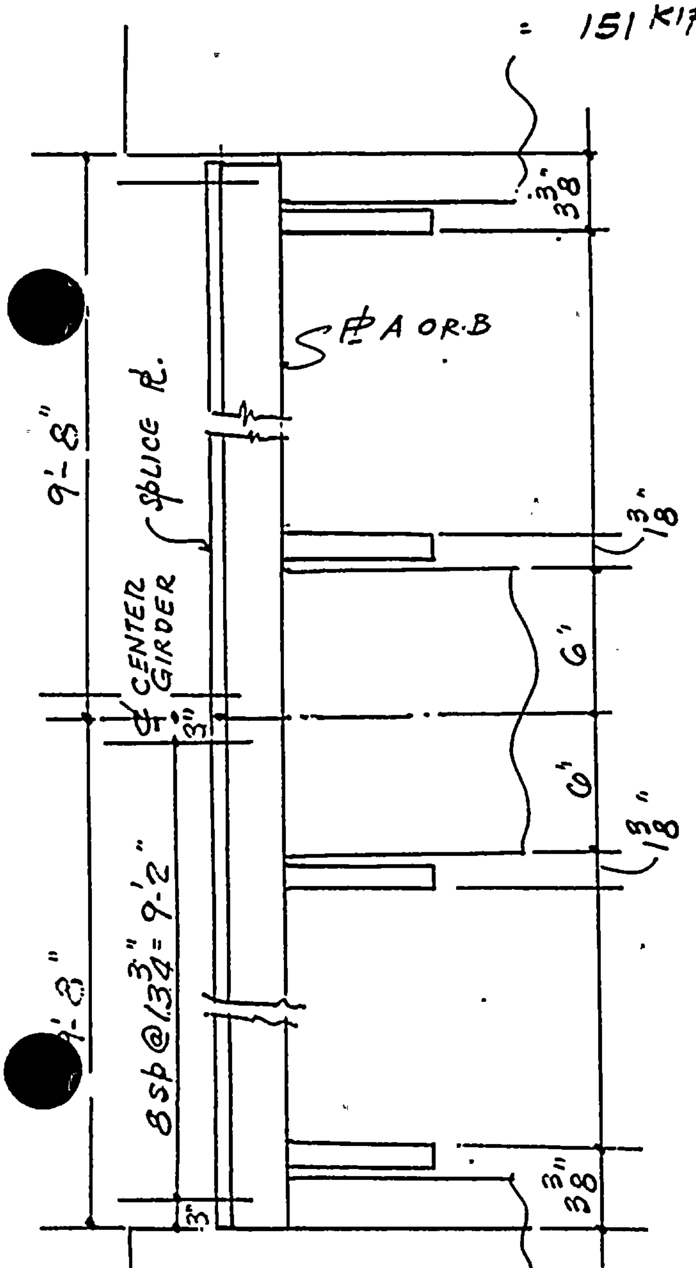
Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		7/10/84									
Checker	BIA	8-15-84									

CONSERVATIVELY ASSUME LOAD TRANSFER EQUAL TO ONE HALF THE ULTIMATE RESISTANCE OF A PL

SH. No. 11

$$= \frac{302}{2}$$

$$= 151 \text{ KIPS}$$

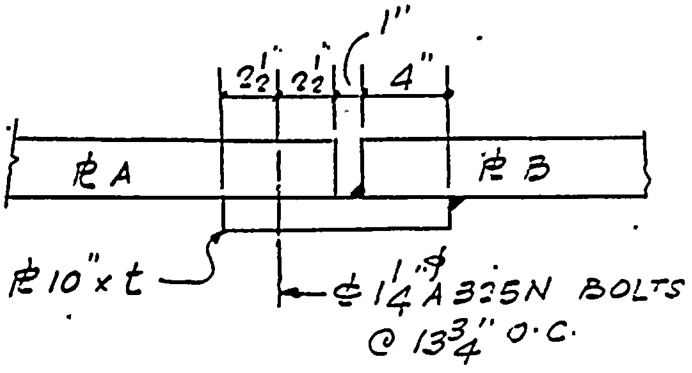


(a) NO. OF BOLTS ON SPLICE PL

= 9

ASSUME APROX. 3 BOLTS EFFECTIVE

$\therefore$ LOAD / BOLT $= \frac{151}{3} = 50.3^k$.



WHEN LOAD IS TRANSFERED FROM PL B TO PL A. BOLTS ARE IN TENSION

$T = 50.3^k$.

TENSION CAPACITY OF 1¼"φ A325 BOLTS = 1.6 × 54 (REF. 10, PG. 4.3)

$= 86^k > 50.3^k$ OK

$\boxed{\text{USE } 1\tfrac{1}{4}"\phi \text{ A325N BOLTS @ } 13\tfrac{3}{4}" \text{ O.C.}}$

Checking Method # 1. Line-by-line checking 2. Alternative Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544. Client PP&L

Subject D/G E BUILDING · REMOVABLE WALL SECTION

Calculation Number SC-DB-076 Sheet No. 40

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		7/11/84									
Checker	BIA	8-15-84									

(b) DESIGN SPLICE PL:

MOMENT $= 50.3 \times 3.5 = 170$ K·IN.

$F_b = 1.6 \times 0.75\, F_y$ OR $0.9\, F_y$

∴ USE $.9 F_y = 45$ KSI.

$$S = \frac{13.75 \times t^2}{6} = \frac{176}{45}$$

$t_{REQ'D} = 1.31$ IN.

$\boxed{\text{USE } 1\tfrac{1}{2}'' \text{ PL}}$

(c) DESIGN WELD:

SHEAR FORCE PER INCH OF WELD

$$= \frac{50.3 \times 7.5}{4 \times 13.75} = 6.86\text{K/IN.}$$

FILLET WELD SIZE REQ'D $= \dfrac{6.86}{1.48} = 4.64$ in SIXTEENTHS

Sh. # 33

$\boxed{\text{USE } \tfrac{3}{8}'' \text{ WELD}}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

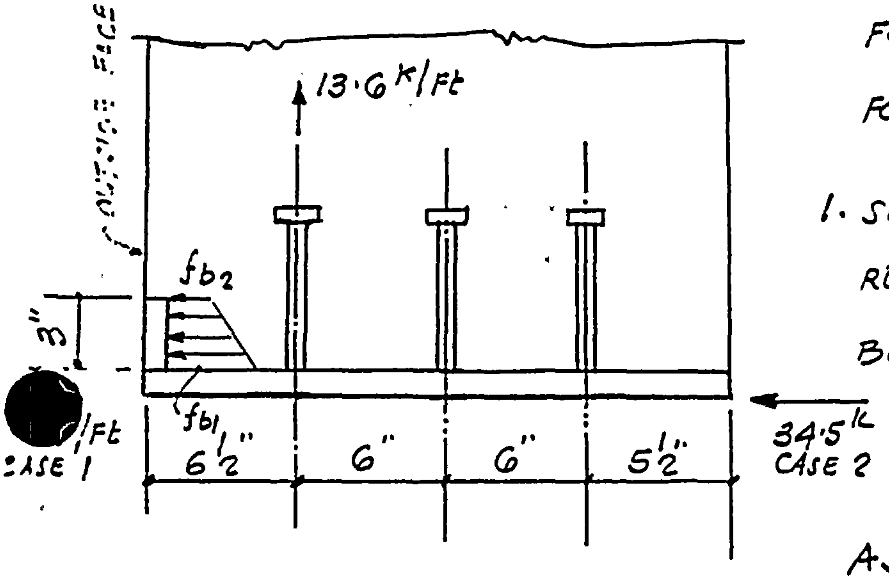
Subject D/G E BUILDING - REMOVABLE WALL SECTION.

Calculation Number SC-DB-07b Sheet No. 41

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1	☒		☒		☒		☒		☒
Preparer		7/11/84								
Checker	BIR	8-15-84								

9.0 DESIGN OF WALL EMBEDMENTS.

a. EMBEDMENT @ TOP AND BOTTOM OF THE WALL:



FOR SHEAR FORCE/Ft SEE SH. No. 28

FOR PULLOUT = 13.6 k/l SEE SH. No 33

1. SHEAR RESISTANCE BY 3 IN. RETURN ℄ :

BEARING STRESS $f_{b_1} = \phi \cdot .85 \times f_c'$

$= .7 \times .85 \times 4000$

$= 2380\ psi.$

ASSUME $f_{b_2} = \frac{1}{2} f_{b_1} = 1190\ psi$

$$\therefore \text{SHEAR RESISTANCE}/Ft = \frac{2380+1190}{2 \times 1000} \times 3 \times 12$$

$$= 64 \text{ kips}$$

∴ SHEAR TO BE RESISTED BY STUDS = 87-64 = <u>23</u> kips./Ft

ALSO SHEAR TO BE RESISTED BY STUDS = <u>34.5</u>k FOR LOADING C 2

2. DESIGN OF NELSON STUDS: ASSUME 7/8"φ STUDS

MIN. EDGE DISTANCE REQUIRED FOR SHEAR CAPACITY OF STUD

$$= m = D\sqrt{\frac{f_{ut}}{7.5\sqrt{f_c'}}}$$ REF. 9, APPENDIX 3.

$f_{ut} = 60{,}000\ psi.$ TENSILE STRENGTH OF NELSON STUDS.

$D = 7/8"\phi.$ " EMBEDMENT PROPERTIES OF HEADED STUDS - TRW-NELSON. DIVISION.

$$\therefore m = .875\sqrt{\frac{60000}{7.5 \cdot \sqrt{4000}}} = \underline{9.84"}$$

Checking Method # 1. Line-by-line checking 2. Alternative Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PPE

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-075 Sheet No. 42

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		7/11/84									
Checker	MK	8-15-84									

OUT OF 3 STUDS CONSIDER ONLY TWO STUDS EFFECTIVE IN SHEAR TRANSFER FROM EITHER DIRECTION.

PROVIDE 3-$\frac{7}{8}\phi$ STUDS @ 6" o.c. & SPACED 6" LONGITUDINALLY

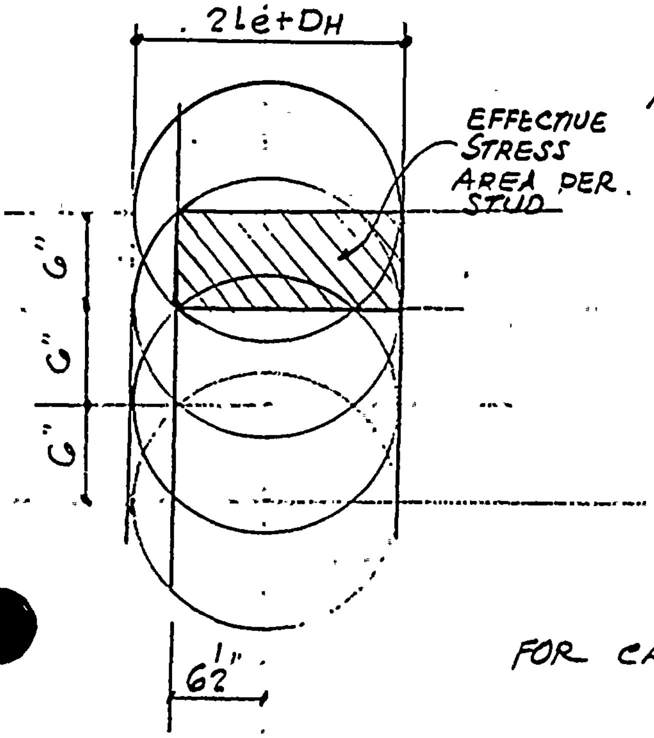
$\therefore$ FOR CASE I SHEAR/STUD = $\frac{23}{4}$ = 5.75^k

" " TENSION/STUD = $\frac{13.6}{2}$ = 6.8^k

FOR CASE 2 SHEAR/STUD = $\frac{35.4}{4}$ = 8.85^k

" " TENSION/STUD = $\frac{35.4 \times 1.75}{6 \times 2}$ = 3.7^k

TENSION CAPACITY OF SINGLE ROW OF STUDS:



$2L_e + D_H$ = 2×7.5+1.75 = 16.75

& L_e = 7.625 ok.

AN APPROX. EFF STRESS AREA/STUD

$= \left[\frac{16.75}{2} + 6.5\right] \times 6 = 89$

$\therefore P_u = 4 \times 0.65 \times \sqrt{4000} \times 100$

= 14.7 KIPS./STUD.

SHEAR CAPACITY/STUD — ULTIMATE STRESS FACTOR

$= \frac{31.69}{2} \times 1.6 = 25.3\,k$

ALLOWABLE

FOR CASE I $\frac{5.75}{25.3} + \frac{6.8}{14.7}$ = 0.69 < 1 OK

FOR CASE II. $\frac{8.85}{25.3} + \frac{3.7}{14.7}$ = 0.60 < 1 OK.

direct summ concerv

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Use 7/8" ϕ × 8 3/16"

[redacted] F-166, 7-82

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G 'E' BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-D3-076 Sheet No. 43

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		7/11/84									
Checker	In/k	8-15-84									

SINCE THE STUDS ARE DISTRIBUTED ONLY 6" APART LONGITUDINALLY THE BENDING IN 1" EMBEDDED PL TOGETHER WITH 2" STOP PL ASSOCIATED WITH TRANSFERING TENSION LOAD TO STUDS IS INSIGNIFICANT BY INSPECTION AND NEED NOT BE CHECKED

(3) CHECK 3" PL RETURN FOR BENDING ASSUME $t = 1''$
SEE. SH. NO. 40

$$M = \frac{1.19 \times 3^2}{2} + \frac{1.19 \times 3^2}{6} = 7.14 \ \text{k·in/in.}$$

$$S = t^2/6 = 1/6 = 0.1667 \ \text{in}^3/\text{in.}$$

$$f_b = \frac{7.14}{.1667} = 42.84 \ \text{ksi.}$$

$$0.9F_y = 0.9 \times 50 = 45 \ \text{ksi} > 42.84 \ \text{ksi.} \quad \boxed{OK}$$

PROVIDE FULL PENETRATION WELD BET^N TWO PLATES.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

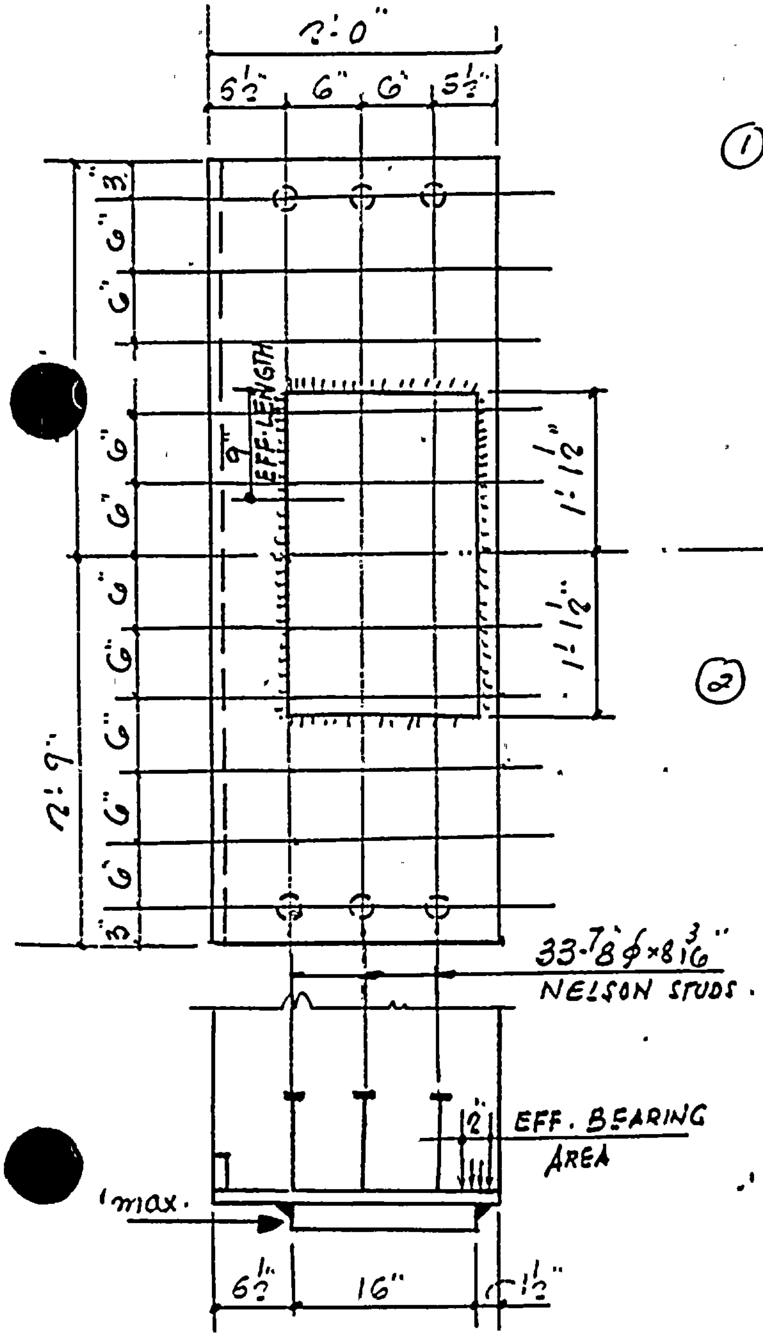
Subject D/G E BUILDING - REMOVABLE SECTION

Calculation Number SC-DB-07b Sheet No. 44

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1	☒		☒		☒		☒		☒	
Preparer		7/11'84									
Checker	lblK	8-15-84									

9.0 (CONTD)

b. EMBEDMENT ON SIDE WALLS FOR CENTER GIRDER:



$P_{MAX} = 428^{k}$ sh. No. 32.

MOMENT : 428 × 1.5 = 642 ~~K/ft~~ K-in

① PULL ON WELD & STUDS BEHIND WELD

$= \frac{642}{16} = 40$ KIPS.

$f_{v\,WELD} = \frac{40}{18} = 2.22$ K/IN

$f_{h\,weld} = \frac{428}{86} = 5.0$ K/IN

$f_R = \sqrt{5^2 + 2.22^2} = 5.47$ K-in

WELD SIZE $\frac{5.47}{1.43} = 3.7$ USE ½" WELD

② DESIGN STUDS: ASSUME ⅞" ϕ.

ASSUMING THE PULL RESISTED BY ONLY ONE STUD ON EITHER SIDE OF THE CONN..

$P_{PULL / STUD} = \frac{40}{4} = 10K$

SINCE EMBEDDED ℄ IS 2'-0" DEEP. IT'S STIFFNESS WILL PERMIT DISTRIBUTION OF SHEAR LOAD TO ENTIRE LENGTH OF 5'-6

SHEAR CAPACITY OF 3" RETURN ℄ = 64 k/ft SH. NO. 40

∴ SHEAR TO BE RESITED BY STUDS = 423 - 64 × 5.5 = 76^k

SHEAR / STUD = $\frac{76}{22} = 3.45^{k}$

^ CONSIDERING ONLY TWO LINES OF STUDS EFFECTIVE

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BUILDING - REMOVABLE WALL SECTION

Calculation Number SC-DB-076 Sheet No. 45

Revision	Original Issue	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #	1										
Preparer		7/12/84									
Checker	BIA	8-15-84									

TENSION CAPACITY OF STUDS = 14.7^k SH. NO. 41

SHEAR " " " = 25.3^k " " "

$$\frac{10}{14.7} + \frac{2.7}{25.3} = 0.79 < 1$$ OK. DIRECT SUMMATION OF STRESS COEFF CONSERVATIVE

USE 33 - $\frac{7}{8}$" φ × $8\frac{3}{16}$" STUDS

CHECK BEARING ON CONCRETE @ EDGE OF PL

$$f_p = \frac{40}{18 \times 2} = 1.11 \text{ ksi} < 2.38 \text{ ksi}$$ SH. NO. 40

OK

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared

Gibbs & Hill, Inc. Job No. 3544 Client PP&L

Subject D/G E BLDG.- REMOVABLE WALL SECTION.

Calculation Number SC-DB-076 Sheet No. 46

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #											
Preparer				4·24·'85							
Checker			JKS	1/6/83							

INTRODUCTION: SH. NO^S 46 THRU. 50 INCLUDE VERIFICATION OF DESIGN OF REMOVABLE WALL SECTION FOR THE MOST CRITICAL OF THE POSTULATED GAS BOTTLE MISSILES SHOWN IN REFERENCE 1.

REFERENCES:

1-1 MEMO TO IKS. FROM GF/DR, SUBJECT: "GAS BOTTLE ANALYSIS". DATED 12·3·'84.

1-2 TELECON DATED 12/27/'84 FROM D.R. (G&H.) TO. T.S. (AIR PRODUCTS) SUBJECT: "GAS BOTTLE SHAPES".

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

Gibbs & Hill, Inc. Job No. 3544 Client PP&L.

Subject D/G E BLDG. - REMOVABLE WALL SECTION.

Calculation Number SC-DB-076 Sheet No. 47.

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #			1								
Preparer				4·24·85							
Checker			SKS	6/6/85							

FROM REF. 1-1., FOLLOWING GAS BOTTLE MISSILES ARE IDENTIFIED AS MOST CRITICAL MISSILES:

No	MISSILE	DIAMETER INCH.	WEIGHT lbs.	VELOCITY FPS *
G1	OXYGEN BOTTLE	9	143	262
G2	ACETYLENE "	12	198	179
G3	ZERO GAS "	7	70	342

* VELOCITIES GIVEN ARE HORIZ. VELOCITIES.

∴ VERTICAL VELOCITY = 0·8 × HORIZ. "

PLATE PERFORATION:

FROM SH. NO. 7 $T = \dfrac{\left(\frac{MV_s^2}{2}\right)^{2/3}}{672D}$

FOR G1 $M = 143/32.2 = 4.44 \ \# sec^2/ft.$

$V_s = 262$ f/sec.

$D = 9$ IN.

$T_{G1} = 0.47$ IN.

FOR G2 $M = 198/32.2 = 6.15 \ \# sec^2/ft.$

$V_s = 179$ f/sec.

$D = 12''$

$T_{G2} = 0.26$ IN.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client FP&L

Subject D/G & BLDG. - REMOVABLE WALL SECTION.

Calculation Number SC-DB-076 Sheet No. 48.

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #										
Preparer				5/24/85						
Checker			JKS	6/6/85						

FOR G3 : $M = 70/32.2 = 2.17 \ \# sec^2/ft.$

$V_s = 343 \ ft/sec.$

$D = 2 \ IN$

$\underline{TG3 = 0.537 \ IN.}$

MIN. THICKNESS REQ'D TO PREVENT PERFORATION

$= 1.25 \times 0.537 = 0.67^{IN} << 2.5''$ PROVIDED.

VERIFY OVERALL EFFECT : PLATE DESIGN.

FROM SH. NO. 13 $E_{s_{TARGET}} = 667 \ K \cdot IN.$

FROM SH. NO. 14 $E_{s_{REQD}} = \frac{M_m^2 \cdot V_s^2}{2[M_m + M_e]}$ $M_e = \frac{39.67}{g}[D_x + 5]$

$$= \frac{W_m^2 V_s^2}{2 \times 32.2[W_m + 39.67(D_x+5)]}$$

FOR G1 $W_m = 143 \#$ $V_s = 262 ft/sec$, $D_x = 9 \ IN$

$E_{s_{REQD \ G1}} = 31,210 \ lb \cdot Ft = 374 \ k \cdot IN < 667$

$\therefore$ $\boxed{\text{RESPONSE IS ELASTIC.}}$

FOR G2 $W_m = 198 \#$; $V_s = 179 \ ft/sec.$, $D_x = 12 \ IN.$

$E_{s_{REQD \ G2}} = 22,358 \ lb \cdot ft = 268 \ K \cdot IN < 667 \ K \cdot IN.$

$\therefore$ $\boxed{\text{RESPONSE IS ELASTIC}}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544. Client PP&L

Subject D'G E BLDG. - REMOVABLE WALL SECTION.

Calculation Number SC-DB-07b Sheet No. 49

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #											
Preparer				4/24/85							
Checker			JKS	6/6/85							

FOR G.3 : $W_m = 70$ lbs ; $V_s = 342$ ft/sec. ; $D_x = 7^{IN.}$

$$\therefore E_{s\ REQ'D\ G3} = 16{,}298\ \#\,Ft = 196\ k\cdot IN < 667\ k\cdot IN$$

$\therefore$ $\boxed{\text{RESPONSE IS ELASTIC}}$

VERIFY OVERALL EFFECT: GIRDER DESIGN

FROM SH. NO. 21. $E_{s\ TARGET} = 650\ k\cdot IN.$

FROM SH. NO. 22. $E_{s\ REQD} = \dfrac{M_m^2 V_s^2}{2(M_m + M_e)}$ $M_e = \dfrac{25}{g}[D_x + 32]$.

$$= \frac{W_m^2 \cdot V_s^2}{64.4\,[W_m + 25(D_x + 32)]}$$

FOR G1 $E_{s\ G1\ REQ'D} = 18{,}661\ \#\cdot Ft = 224\ k\cdot IN. < 650\ k\cdot IN.$

$\therefore$ $\boxed{\text{RESPONSE IS ELASTIC.}}$

FOR G2 $E_{s\ G2\ REQ'D} = 15{,}027\ \#\cdot Ft = 180\ k\cdot IN < 650\ k\cdot IN$

$\therefore$ $\boxed{\text{RESPONSE IS ELASTIC}}$

FOR G3 $E_{s\ G3\ REQD} = 8{,}516\ \#\cdot Ft = 102\ k\cdot IN < 650.\ k\cdot IN$

$\therefore$ $\boxed{\text{RESPONSE IS ELASTIC}}$

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544. Client PPEL

Subject D/G E BLDG. - REMOVABLE WALL SECTION.

Calculation Number SC-DB-07b. Sheet No. 50.

Revision	Original Issue	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date	
Checking Method #		☒		☒		☒		☒		☒	
Preparer				4/24/85							
Checker			AKS	6/6/85							

MAXIMUM DELIVERABLE IMPACT FORCE ON RIGID TARGET

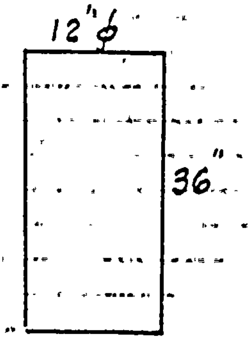
FROM SH. NO. 26

$$F = P_c + mV^2$$

$$= f_{CR} \times A + \frac{WV^2}{g \times l}$$

MOST CRITICAL IS MISSILE G2 BECAUSE OF LARGE CROSS SECTION.

$l = 36" . 3'0"$



CALCULATE CROSS SECTION.:

$$\left[\pi \cdot 12 \times t \times 36 + \frac{2 \times \pi \cdot 12^2 \times t}{4}\right] \times \frac{490}{1728} = 198^{\#}$$

$t = 0.44$ IN.

$A = \pi \cdot 12 \cdot t = 16.59 \text{ IN}^2$

$$F = 66 \times 16.59 + \frac{198 \times 179^2}{32.2 \times 3 \times 1000}$$

$= 1095 + 66$

$= 1,161^k < 1204^k$ FOR MISSILE G ∴ OK.

CONCLUSION: DESIGN OF REMOVABLE SECTION OF WALL IS ADEQUATE TO WITHSTAND THE SITE PROXIMITY GAS BOTTLE MISSILES AS WELL.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared.
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 3544 Client P.P.&L.

Subject D/G 'E' BLDG. REMOUABLE WALL SECTION

Calculation Number SC-DB-076. Sheet No. 51

Revision	Original Issue	Date	Rev.	Date	Rev. 2	Date	Rev.	Date	Rev.	Date	
Checking Method #					1						
Preparer						8/8/85					
Checker					R.S.	8.8.85					

PURPOSE: NPSI (FABRICATOR OF REMOUABLE WALL SECTION) REQUESTED FOLLOWING MODIFICATIONS FOR THE CENTER BOX GIRDER [SEE REF. # 2-1]

(a.) INCREASE LOWER HORIZ. PLATE THICKNESS TO 2½" AND REDUCE LENGTH OF VERTICAL PLATES BY ½ IN TO MANTAIN OVERALL DEPTH OF GIRDER

(b) CHANGE FULL PENETRATION WELDS BETN WEBS AND FLANGES OF GIRDER TO 1¾" PARTIAL PENETRATION WELD.

PERFORM CALCULATIONS TO VERIFY GIRDER DESIGN ADEQUACY WITH THESE MODIFICATIONS.

REF. 2-1 - TELECOPY FROM NPSI TO GH RECEIVED 8/2/85

MODIFICATION a.

INCREASE IN THICKNESS OF ONE OF THE PLATES OF THE GIRDER WILL MAKE THE SECTION SLIGHTLY UNSYMETRICAL HOWEVER THE CAPACITY OF THE GIRDER WILL NOT BE IMPAIRED. AND THEREFORE THIS CHANGE IS ACCEPTABLE

NOTE: YIELD STRENGTH FOR 2½" PL IS SAME AS FOR 2" PLATE (100 ksi).

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

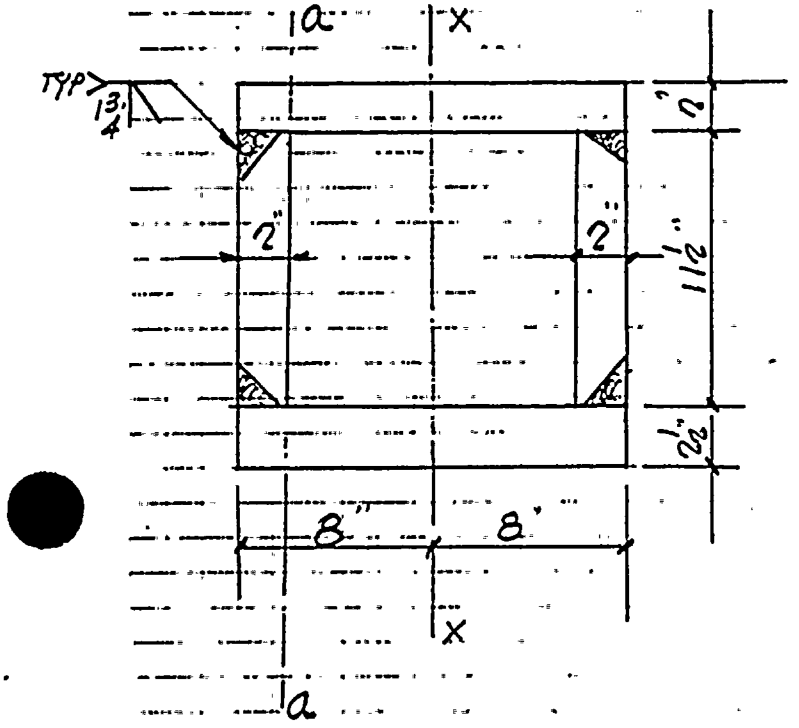
Gibbs & Hill, Inc. Job No. 3644. Client P.P.&L.

Subject P/G E BLDG. - REMOVABLE WALL SECTION.

Calculation Number SC-DB-076. Sheet No. 52.

Revision	Original Issue	Date	Rev.	Date	Rev. 2	Date	Rev.	Date	Rev.	Date	
Checking Method #		☒		☒	1	☒		☒		☒	
Preparer						8/8/85					
Checker					R.S.	8.8.85					

MODIFICATION. 6.



$$I_{xx.} = \frac{2 \times 16^3}{12} + \frac{2.5 \times 16^3}{12} + 11.5 \times 4 \times 7^2$$

$$= 3790 \text{ IN}^4$$

$$Q_{a-a} = 11.5 \times 2 \times 7 = 161 \text{ IN}^3$$

MAX.M SHEAR IN GIRDER

$= 428^k$ SH. NO. 33.

HORIZ. SHEAR ON WELDS

$$= \frac{VQ}{I} = \frac{428 \times 161}{3790} = 18.18 \text{ k/in.}$$

$$\text{SHEAR/WELD} = \frac{18.18}{2} = 9.09 \text{ k/IN.}$$

ALLOWABLE SHEAR ON WELD:

ELECTRODE E11018 M TENSILE STRENGTH = 115,000 psi.

$0.3 \times 115 = 34.5$ ksi.

BASE METAL A514 GR F. $F_y = 100$ ksi.

$0.4 \times 100 = 40$ ksi. WELD STRESS GOVERNS.

EFFECTIVE THROAT = $1.75 - 0.125 = 1.625$ IN

ALLOWABLE SHEAR = $34.5 \times 1.625 = 56.05$ k/IN >> 9.09 k/in.

THEREFORE $1\frac{3}{4}$" PARTIAL PENETRATION WELD IS ACCEPTABLE

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

ATTACHMENT 3

REF. 1
FSAR REV.
1.1 – 2.4

1.2.2.4.16 Standby ac Power Supply

The Standby ac Power Supply System consists of four diesel-generator sets. The diesel-generators are sized so that three diesels can supply all the necessary power requirements for one unit in the design basis accident condition, plus the necessary required loads to effect the safe shutdown of the second unit. The diesel generators are specified to start up and attain rated voltage and frequency within 10 seconds. Four independent 4 kV engineered safety feature switchgear assemblies are provided for each reactor unit. Each diesel-generator feeds an independent 4 kV bus for each reactor unit.

Each diesel-generator starts automatically upon loss of off-site power or detection of a nuclear accident. The necessary engineered safety feature system loads are applied in a preset time sequence. Each generator operates independently and without paralleling during a loss of off-site power or LOCA signal.

1.2.2.4.17 dc Power Supply

Each reactor unit is provided with four independent 125 V and two independent 250 V dc systems. Each dc system is supplied from a separate battery bank and battery charger. The 125 V dc systems are provided to supply station dc control power and dc power to four diesel generators and their associated switchgears. The 250 V dc systems are provided to supply power required for the larger loads such as dc motor driven pumps and valves.

The 125/250-V dc System is designed to supply power adequate to satisfy the engineered safety feature load requirements of the unit with the postulated loss of off-site power and any concurrent single failure in the dc system.

1.2.2.4.18 Residual Heat Removal Service Water System

A Residual Heat Removal Service Water System is provided to remove the heat rejected by the Residual Heat Removal System during shutdown operation and accident conditions.

1.2.2.4.19 Emergency Service Water System

The Emergency Service Water System supplies water to cool the standby diesel-generators and the ECCS and Engineered Safety Features equipment rooms, and other essential heat loads.

Additionally, a fifth diesel generator is provided which has the capability of the emergency loading for any one of the four diesel generators after manual realignment.

Power from the generators is stepped up from 24 kV to 230 kV on Unit No. 1 and from 24 kV to 500 kV on Unit No. 2 by the unit main transformers and supplied by overhead lines to the 230 kV and 500 kV switchyards, respectively.

1.2.2.6.2 Electric Power Distribution Systems

The electric power distribution system includes Class IE and non-Class IE ac and dc power systems. The class IE power system supplies all safety related equipment and some non-class IE loads while the non-Class IE system supplies the balance of plant equipment.

The Class IE ac system for each unit consists of four independent load groups. Two independent off-site power systems provide the normal electric power to these groups. Each load group includes 4.16 kV switchgear, 480 V load centers, motor control centers and 120 V control and instrument power panel. The vital ac instrumentation and control power supply systems include battery systems, static inverters. Voltages listed are nominal values, and all electrical equipment essential to safety is designed to accept a range of ±10 percent in voltage.

Four independent diesel generators are shared between the two units. Each diesel generator is provided as a standby source of emergency power for one of the four Class IE ac load groups in each unit. Assuming the total loss of off-site power and failure of one diesel generator, the remaining diesel generators have sufficient capacity to operate all the equipment necessary to prevent undue risk to public health and safety in the event of a design basis accident on one unit and a forced shutdown of the second unit.

SEE INSERT A →

The non-Class IE ac system includes 13.8 kV switchgear, 4.16 kV switchgear, 480 V load centers and motor control centers.

Four independent Class IE 125 Vdc batteries and two independent Class IE 250 Vdc batteries and associated battery chargers provide direct current power for the Class IE dc loads of each unit. Power for non-Class IE dc loads is supplied from the Class IE 125 and 250 V batteries through an additional circuit breaker for redundant fault protection.

SEE INSERT B →

These systems are discussed in Chapter 8.

Insert "A" (to page 1.2-26)

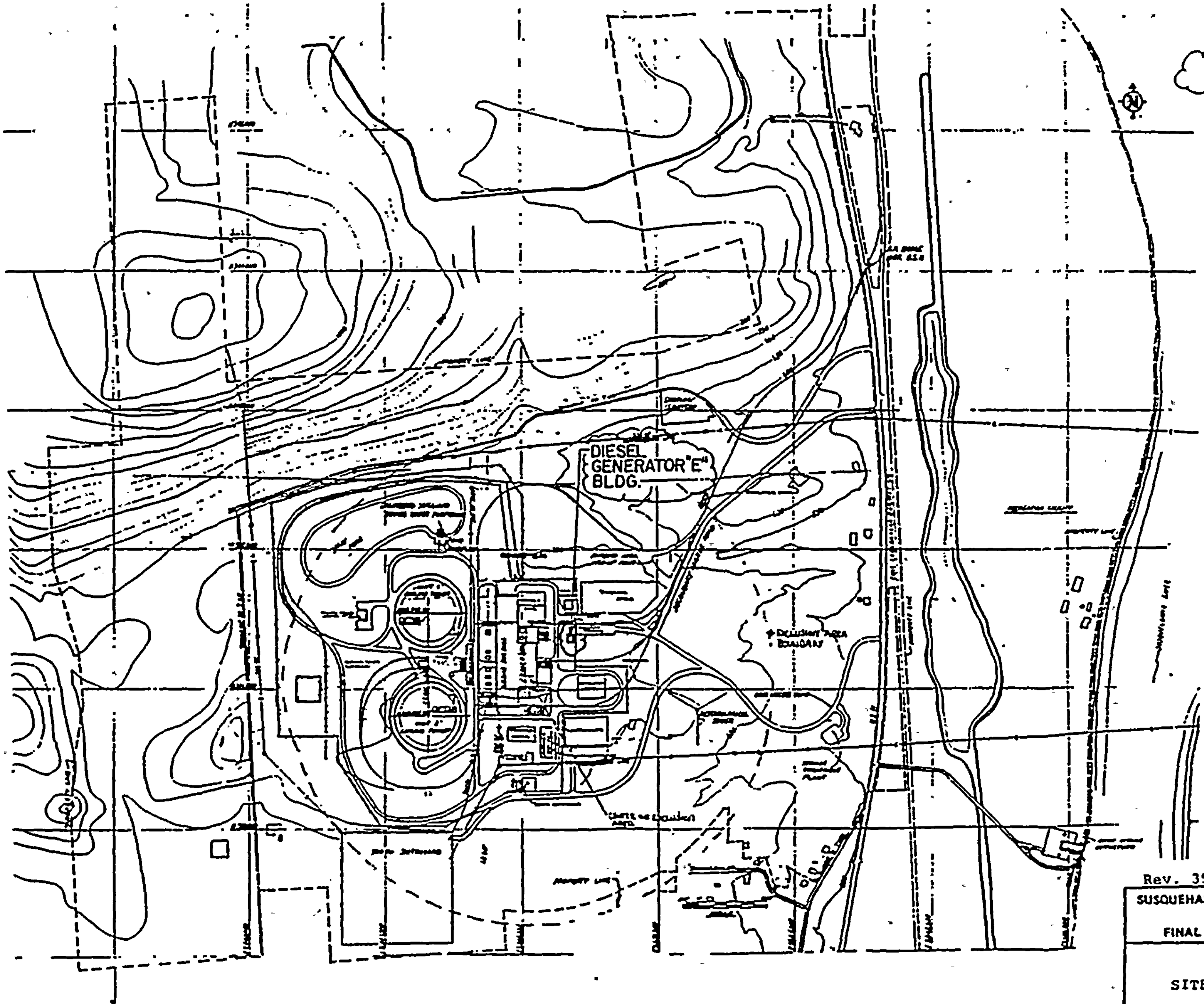
Additionally, a fifth diesel generator is provided which has the capability of the emergency loading for any one of the four diesel generators after manual realignment

INSERT "B" (to page 1.2-26)

A separate Class 1E, 125 V DC Subsystem is provided for the fifth standby diesel generator.

DRAFTING NOTE

(cloud) = G&H Change

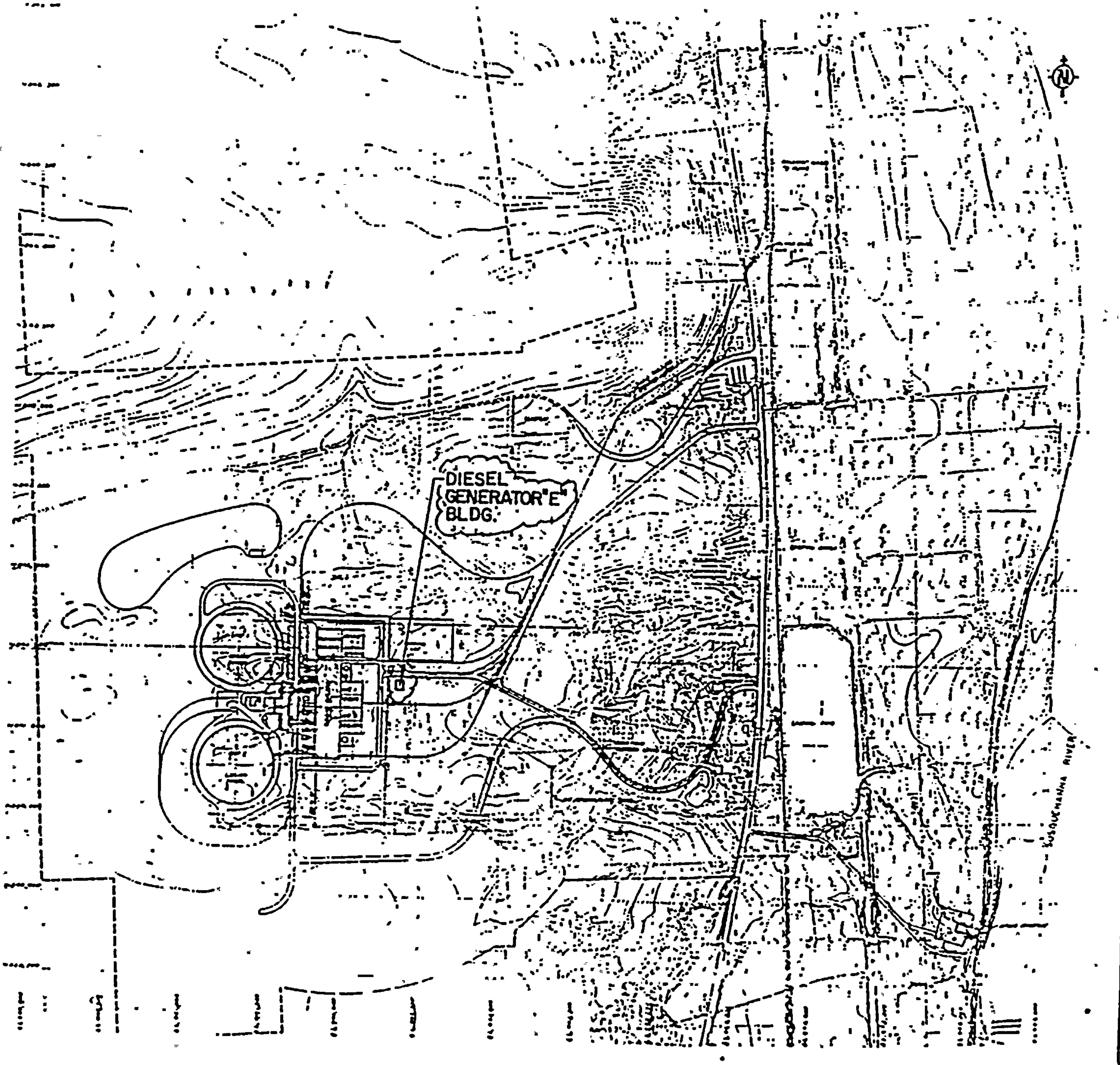


Rev. 35, 07/84

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

SITE FACILITIES PLAN

FIGURE 2.1-2

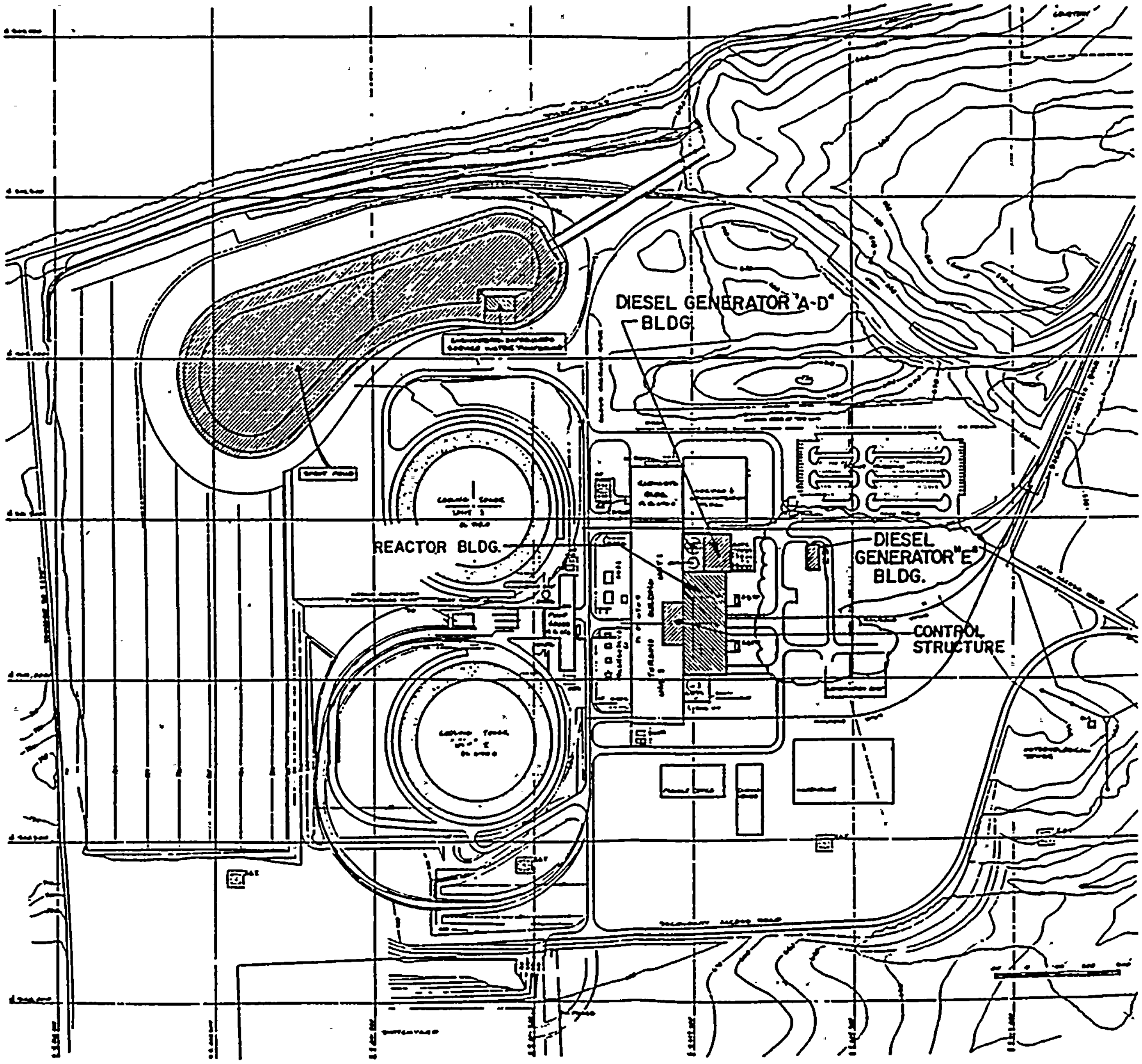


Rev. 35, 07/84

SUSQUEHANNA STEAM ELECTRIC STA
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

SITE LOCATION WITH RESPEC
TO SURROUNDING TOPOGRAPHY

FIGURE 2.4-1

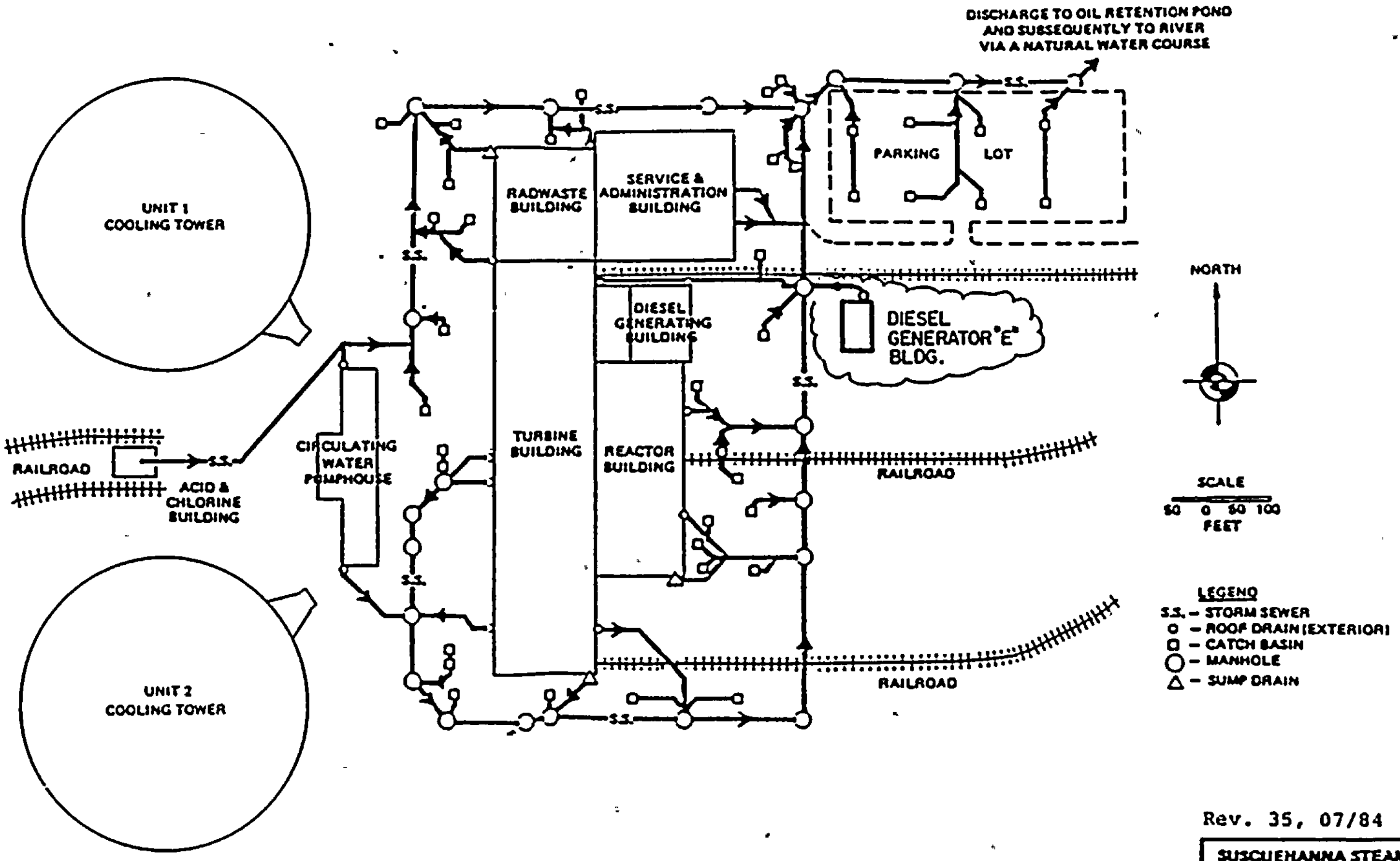


Rev. 35, 07/84

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

PLAN SHOWING SAFETY RELATED FACILITIES ON PLANT SITE

FIGURE 2.4-2



Rev. 35, 07/84

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

PLANT COMPLETE SHOWING STORM DRAIN PIPE LAYOUT

FIGURE 2.4-3

REF. 1
FSAR REV.
2.5

the north and west branches of the Susquehanna River. Post-Olean advances did not reach the site vicinity (Ref. 2.5-5 and 2.5-6).

Peltier (Ref. 2.5-5) mapped discontinuous kame terraces along the Susquehanna River in the site vicinity. The highest such terrace formed by ice marginal streams occurs at about 650 feet above sea level at the site. Ref.er to Subsections 2.5.1.2.2 and 2.5.1.2.3.3 for further discussion of Pleistocene erosion and deposition at the site.

Since the retreat of the Wisconsinan ice sheets from the region, broad regional uplift appears to have occurred, probably at least in part as a result of crustal rebound subsequent to the removal of ice load. Erosion has continued and soil profiles have formed.

2.5.1.2.5 Engineering Geology Evaluation

Site subsurface exploration is described and discussed in Subsection 2.5.4.3. Laboratory tests of foundation materials, and in situ geophysical tests of the foundation materials are discussed in Subsections 2.5.4.2 and 2.5.5. Geologic mapping of the final foundations is described in Subsections 2.5.1.2.2, 2.5.1.2.3 and 2.5.4.1.3. It was concluded from these studies and evaluations that the site geologic and foundation conditions are entirely suitable for the construction and operation of the plant.

2.5.1.2.5.1 Geologic Conditions Under Category 1 Structures

All Seismic Category 1 plant facilities, except the spray pond, ~~and~~ the Engineered Safeguard Service Water (ESSW) pumphouse and pipeline, and diesel fuel tank for diesel generator 'E' building are founded on bedrock. The ESSW pipeline trench is excavated partly in soil and partly in rock. The location of these facilities is shown on Figure 2.5-24.

The foundation rock is a hard, indurated siltstone, a member of the Devonian Mahantango Formation. In the foundations area it is quite massive and lithologically homogeneous, with bedding generally not well defined, and lacking the bedding plane fissility usually associated with less well indurated shaly siltstones and silty shales. In places the rock exhibits a slaty cleavage, further evidence of its indurated nature. All Category 1 rock foundations were excavated to unweathered bedrock. Geologic maps and sections of the Category 1 excavations in rock are shown in Figures 2.5-18 and 2.5-19. More detailed discussion of the foundation geologic conditions is contained in Subsections

2.5.1.2.2 and 2.5.1.2.3. Engineering properties of the foundation rock are described in Subsection 2.5.4.

The spray pond is situated over a glacial or preglacial, east-west trending bedrock valley as outlined by contours on top of bedrock (Figure 2.5-17). The valley is filled with dense gravelly and sandy glacial outwash and till deposits which attain a maximum thickness of about 110 feet adjacent to the spray pond area. They were deposited no later than the Olean substage (early Wisconsinan) of the Wisconsinan glaciation which occurred over 50,000 years ago. In general, the deposits are permeable and consist of a sequence of sand, gravel, and boulders overlain by sand and gravel, overlain in turn by silty sand. The entire sequence is highly variable in grain size distribution and sorting, and contains discontinuous pockets of similar materials. As a rule, grain size decreases and sorting increases toward the top of the sequence.

The southwestern tip of the spray pond is cut into bedrock while the remainder was excavated in these permeable glacial materials. The thickness of the glacial deposits beneath the bottom of the spray pond ranges from zero at the rock contact to 93 feet at the eastern end of the pond. The spray pond is lined to minimize seepage losses to the underlying permeable glacial deposits. The foundation of the pumphouse structure located at the southeastern corner of the pond is underlain by 35 to 60 feet of glacial material. The ESSW circulation pipelines between the pumphouse and the plant intersect bedrock at an elevation of 668 feet, approximately 260 feet southeast of the pumphouse (refer to Figure 2.5-17A). A geologic map of the spray pond area is presented on Figure 2.5-15. Further discussion of conditions at the ESSW pumphouse and spray pond are contained in Subsections 2.5.1.2.2, 2.5.3 and 2.5.5.

2.5.1.2.5.2 Landslide Potential

Natural slopes adjacent or close to the principal plant structures are relatively flat. Most of these slopes are composed of soil; few rock slopes occur (Figure 2.5-17 shows areas of rock outcrops).

North of the spray pond the Trimmers Rock Formation forms a relatively steep ridge rising approximately 380 ft. above the pond. The south-facing slope of this ridge is essentially a rock slope underlain by flaggy, resistant sandstone thinly mantled with soil and rock fragments. The closest approach of this slope to the spray pond is along the northern perimeter of the pond; the toe of the slope, at elevation 710-720 feet, is 250 feet or more from the edge of the pond (at elevation 679 feet). The maximum slope along the ridge is about 2 horizontal to 1

The area underlying the diesel fuel tank for diesel generator 'E' building consists of a dense to very dense glacial outwash and till deposit. The deposit consists of a sequence of sand, gravel, cobbles, and boulders overlain by sand and gravel.

1,000 ft. This rock contains no unstable minerals and provides highly stable foundation conditions.

Soils at the site are glacial in origin, deposited mostly by flowing glacial meltwater, much under torrential conditions. The soil is noncalcareous. Most of the rock fragments consist of indurated sandstones. The origin and mineralogy of these soils is such that they present no hazardous conditions (refer to Subsection 2.5.1.2.5.7).

2.5.4.2 Properties of Subsurface Materials

A few of the safety-related principal plant structures are founded on soil. These structures consist of the Engineered Safeguard Service Water (ESSW) pumphouse, the spray pond, and portions of the Seismic Category I pipeline linking the reactor building to the spray pond. and diesel fuel tank for diesel generator 'E' building Most other plant structures are founded on rock. The location of these structures is shown on Figure 2.5-24; soil and rock foundations are identified on Figure 2.5-17A.

The static and dynamic engineering properties of the site bedrock and overburden soils were determined by field investigation and laboratory testing. The results of laboratory testing of the materials sampled from the project site are covered in two reports (Ref. 2.5-97 and 2.5-98).

A detailed study of the soil properties at the site of the spray pond and ESSW pumphouse is given in Subsection 2.5.5.

2.5.4.2.1 Properties of Foundation Rock

The Category I reactor buildings and diesel generator building, as well as the non-Category I turbine and radwaste buildings (see Figure 2.5-24) are founded on unweathered siltstone bedrock. The siltstone, a member of the Mahantango Formation of Devonian age, is hard and indurated, and in the foundations area is lithologically homogeneous with bedding generally not well defined, and lacking the bedding plane fissility usually associated with less well indurated shaly siltstones and silty shales. In places the rock exhibits cleavage, further evidence of its indurated nature.

In the area of the principal plant structures, bedrock bedding where observed generally dips gently (less than 10°) south; locally, such as north of the circulating water pumphouse, beds dip slightly north. At the north end of the radwaste building and the north side of the Unit 1 cooling tower, bedding dips more

steeply north. The cleavage is steeply inclined to the south. Minor slickensided bedding plane shears and joint planes occur in the foundations as described in Subsections 2.5.4.1 and 2.5.1.2.3. All such shears beneath the principal plant foundations are fully healed with unweathered calcite and quartz mineralization and do not adversely affect the strength and competence of the foundation rock. Further evidence of the healed nature of these shears is furnished by the RQD values and core recovery rates in borings that penetrated bedding plane shear A (refer to Figure 2.5-18 and discussion in Subsection 2.5.4.1) at elevations below the bottom of the foundation of the principal plant structures, such as in borings 302, 309, and 314. In all cases RQD values are above 35 percent through the shear plane; in most cases, RQD values exceed 80 or 90 percent and core recovery was close to 100 percent (Further information on foundation geologic conditions is presented in Subsection 2.5.4.1).

Typical values of unconfined compressive strength of unweathered siltstone underlying the principal plant foundations range from 3,650 to 16,000 psi (see Table 2.5-3). The modulus of deformation determined from these laboratory tests on core samples ranges from 3.1×10^6 to 9.4×10^6 psi. These values indicate strong, competent rock.

P-wave measurements were made by Dames and Moore in the laboratory on individual core specimens. The cores were from borings 303, 314, and 315 which are located, respectively, near the Unit 1 turbine building condensate pump pit at the center of the Unit 1 reactor, and at the center of the Unit 2 reactor. The average seismic P-wave velocity determined for 10 samples at or below foundation grade beneath power block structures is 13,236 fps. For three samples from boring 303 in the Unit 1 turbine building, the average Vp value is 14,272 fps, or approximately 14,000 fps. These determinations are listed in Tables 2.5-4 and 2.5-5.

Rock quality designation (RQD) measurements made by Dames and Moore on rock cores from below the foundation elevations in the reactor, turbine, radwaste, diesel generator, and circulating water pumphouse foundations exceed 80 percent (refer to boring logs, Ref. 2.5-97).

In the reactor area, cross-hole and down-hole measurements of in situ seismic velocities show high values. The measurements were made by Weston Geophysical Engineers, Inc., June 8 - August 6, 1971 using boreholes 105, 303, 307, 314, 315, and 316 (refer to Figure 2.5-29). Values obtained from the cross-hole array for the elevation interval 550-640 ft MSL are 16,000 fps for the P-wave velocity and 7500 fps for the S-wave velocity in the reactor area (design elevation of bottom of reactor foundations, 639 ft MSL). The results of the down-hole measurements yield values

that are slightly lower, by a factor of about 15 percent; that is, a V value of about 14,000 fps and V of about 6,200 fps. These in site results are in good agreement with the laboratory determinations. Additional cross-hole and up-hole in situ seismic velocity measurements were made in the spray pond area (Ref. 2.5-99). Results of the cross-hole explorations at the site are further discussed in Subsections 2.5.4.2.2 and 2.5.4.4.

Plate load tests were carried out on sound rock near the center of the Units 1 and 2 reactor building excavation in the vicinity of boring 105 (refer to Figure 2.5-18). Plates 24, 13.5, and 8 in. in diameter were subjected to successively increasing total loadings of 7, 22, and 60 tons per square foot (tsf), respectively. A total deflection of .062 in. occurred when the 24 in. plate was loaded to a maximum of 7 tsf. An additional deflection of 0.036 in. was recorded on subsequent loading to 22 tsf, and another 0.036 in. of deflection on application of the 60 tsf maximum load, producing a total settlement of 0.134 in. for the three-stage loading to 60 tsf. Recovery of the rock by elastic rebound upon release of these loads was substantial: 68, 75, and 80 percent repeatable elastic recovery of the total deflections were recorded after release of the 7, 22, and 60 tsf loadings, respectively. Additional deflections due to cyclic loading were small. Application of 14 cycles of load at 7, 15, and 30 tsf resulted in additional settlements of only 0.012, 0.003, and 0.002 in., respectively, over the corresponding single loadings. These results are consistent with the high modulus values and seismic velocities of the foundation rock, and indicate structurally strong, competent material for foundations in unweathered rock.

It is concluded from the engineering properties of the unweathered bedrock of the Mahantango Formation that the rock provides adequate support for the major plant structures under both static and dynamic conditions. Settlement of structures under static loading is insignificant. It consists of pseudo-elastic compression of the underlying rocks and occurs essentially upon load application. Moreover, the bedrock will undergo no loss of strength and will experience negligible additional settlement under earthquake loading.

A summary of the properties of the foundation rock is compiled in Table 2.5-5.

2.5.4.2.2 Properties of Foundation Soils

The results of detailed exploration of the soils in the spray pond area are given in Subsection 2.5.5. Only information on the properties of the pumphouse and diesel fuel tank for diesel generator 'E' building foundation soils is given in this subsection.

and fuel tank for diesel generator 'E' building

The natural soils at the pumphouse site are normally consolidated and consist predominantly of sand, gravel, cobbles, and boulders. The soils are poorly stratified, starting as sand or sandy gravel at the surface and grading to mostly cobbles and boulders near bedrock. The depth of the soil deposit below foundation grade ranges from about 35 ft at the south end of the pumphouse to about 60 ft at the north end. A subsurface cross-section through the pumphouse site is shown on Figure 2.5-30, cross-section D-D. The soils below the foundation level are predominantly sandy gravels with large amounts of cobbles and boulders. The properties of these sandy and gravelly soils are as follows:

Approximately eight (8) feet and twenty (20) feet of sand, gravel, and boulders are below the foundation grade of diesel fuel tank for diesel generator 'E' building at the north end and south end respectively.

a) Grain Size Distribution

Grain size distribution tests were made on most of the split spoon samples for classification purposes. Sieve and hydrometer analyses were performed according to ASTM Procedure D-422. The range of grain size curves is shown on Figure 2.5-31. The mean grain size (D50) of the gravelly soils, which are the predominant material below the pumphouse, was found to be in the range of 4.5 to 25.0 mm. Wherever the sand is present below the pumphouse, the D50 size is in the range of 0.14 to 3.0 mm.

and diesel fuel tank for diesel generator 'E' building

b) Relative Density

Relative density data were derived from standard penetration test results using the Gibbs and Holtz procedure (Ref. 2.5-100). This procedure is valid for normally consolidated sands.

Values of relative density obtained in this way are summarized on Figure 2.5-32. A direct comparison of relative density from 'N' values given in Figure 2.5-32 and from undisturbed samples and/or in site density tests cannot be made because no relative density tests were made. The soil deposits are glacial in nature. The deposits are quite variable in particle size and sorting and contain discontinuous sand pockets and gravel pockets. Grain size in general increases with depth. At the foundation level of the pumphouse, the maximum sizes of the particles are in the range of 3 to 12 inches. Undisturbed tube samples could not be obtained in the gravelly soils. The gravel also will influence the results of in site density tests so that they may not represent the in site condition as a whole. The Standard Penetration resistance versus elevation is given on Figure 2.5-33. The 'N' values will be

and diesel fuel t[illegible]
for diesel generator [illegible]
building.

㊼

influenced by gravel. Because of this the higher blowcounts were not considered representative of site conditions. A value of N = 40 was selected for design. Of the 49 standard penetration tests made beneath the foundation level at the ESSW Pumphouse, and four (4) standard penetration tests beneath the diesel fuel tank for the diesel generator 'E' building, ~~43~~ exceeded 40 blows per foot. Of the 6 values that were less than 40 blows per foot only one was less than 30 blows per foot.

c) Static and Dynamic Shear Strength

Undisturbed sampling of gravelly soils was not possible. Therefore, shear strength testing was conducted only on the sands. The shear strength of the gravelly soils was then conservatively assumed to be equal to that of the sands.

The details of the testing procedures and selection of design strengths are given in Subsection 2.5.5. The effective angle of internal friction was selected from the test data to be 35° (Figure 2.5-34). The cyclic shear stress ratios at the two effective consolidation pressures 1.0 ksf and 6.0 ksf were determined to be 0.320 and 0.260, respectively, for 5 loading cycles (Figure 2.5-35, Subsection 2.5.5). A linear relationship was assumed in computing cyclic shear stress ratios at other effective consolidation pressures.

d) Shear Wave Velocity and Shear Moduli

Cross-hole shear wave velocity measurements were performed by Weston Geophysical Engineers, Inc. (ref. 2.5-99). Compressional and shear wave velocities obtained from the measurements are given on Figure 2.5-36.

Shear moduli were computed from the values of shear wave velocity:

$$G = \frac{\gamma}{g} V_S^2$$

Where:

G = shear modulus, psf

γ = unit weight, pcf

g = gravitational acceleration, ft/sec^2

V = shear wave velocity, fps

A discussion on how the shear modulus is influenced by the confining pressure, the strain amplitude, and the relative density is given in Subsection 2.5.5.2.

2.5.4.3 Exploration

The location of all field explorations is shown on the plot plan, Figure 2.5-22.

A total of approximately 250 exploratory borings was made in soil and rock at the site. Borings were logged in detail; boring logs are contained in Ref.s. 2.5-97, 2.5-98 and 2.5-99 and Appendix 2.5C. The soils were classified in accordance with the Unified Soil Classification System. Rock logs include RQD (rock quality designation) values. Coring in rock was performed using NX double-tubed coring equipment.

Drilling was conducted in late 1970 (100 and 200 series borings) to establish general geologic relationships over the site area and to determine general soil and rock conditions at the site. A more intensive program (300 series borings) was conducted in the Spring of 1971 to define foundation conditions in the principal plant structures area. Four 45-degree angle holes were drilled in the reactor area. Additional exploration drilling was necessary to locate the site for the Susquehanna River intake and discharge structures (700-800 series borings), to define soil and rock conditions at the spray pond and ESSW pumphouse site (1100 series and some 400 series borings), and to investigate foundation conditions for the cooling towers (borings B1 to B10) and the railroad spur and bridge over State Highway 11 (borings 417 to 455 and 929 to 940). Because of the safety-related (Category I) function of the spray pond, ~~and~~ ESSW pumphouse, the exploration program for these facilities was comprehensive and included split spoon and undisturbed samples, laboratory testing, hydrologic surveys, permeability tests, and seismic cross-hole and up-hole surveys. After completion of geologic borings, static water levels were measured in some of the borings drilled on the site. Perforated plastic pipes were installed in a number of the borings to allow collection of future water level data. These borings are denoted on the plot plan, Figure 2.5-22.

An investigation program (Borings 1 thru 7) was conducted in 1983 to determine soil and rock conditions in the diesel generator 'E' building area. Boring logs are contained in Appendix 2.5.C

and diesel generator fuel tank for diesel generator 'E' building,

Forty-seven test pits were excavated by backhoe at selected locations to observe soil and rock conditions. Two north-south trenches totalling over 700 ft in length were excavated to obtain information on physical properties, structure, and variability of the near-surface materials at the site. Logs of the test pits and trenches are compiled in Appendix 2.5C.

2.5.4.5.2 Excavation Methods and Dewatering

2.5.4.5.2.1 Excavations in Rock

All Seismic Category I rock foundations were carried to or well below unweathered bedrock. Rock foundations for the turbine and radwaste buildings, although they are not Seismic Category I structures, were prepared according to the same general procedures and criteria used in preparing the Seismic Category I rock foundations.

Excavation of rock proceeded by initial ripping of any weathered surficial rock material followed where necessary by line blasting and presplitting in holes drilled to provide slopes of 1 horizontal to 4 vertical. Essentially vertical slopes in unweathered rock proved stable throughout the duration of construction and no special protective measures were required. Weathered rock was cut on slopes of 1 horizontal to 2 vertical. In a few places, wire mesh was used for protection of higher weathered rock slopes that were exposed for extended periods.

The surface of the excavated foundation rock was scaled to remove loose debris and jetted with water or air to remove loose fragments and to prepare the surface for concrete. Before placement of structural concrete or concrete backfill to design elevation, all Seismic Category I foundations were inspected by an engineering geologist to verify the suitability of the rock and its proper surface preparation to receive concrete. All foundation rock bearing a Seismic Category I structure was geologically mapped (see Figure 2.5-18).

Foundations for each of the cooling towers (nonseismic-Category I structures) consist of 40 individual pedestals supporting the columns and extended to bedrock. Excavation proceeded by cutting a ring trench and preparing for each pedestal a suitable surface in unweathered or partly weathered bedrock by ripping or blasting as necessary, followed by scaling and jetting.

During construction of principal plant structures founded on rock, excavations extended below the water table and some dewatering was required. Due to the low permeability of the rock, groundwater inflow was small. Dewatering was accomplished by surface drains and sumps.

2.5.4.5.2.2 Excavations in Soil

The excavation for the spray pond, ~~and~~ ESSW Pumphouse and diesel fuel tank for diesel generator 'E' building was predominantly in soils. Excavation proceeded initially by using

large earth moving equipment, then finished by using more refined procedures. On completion of excavation, the surface layer of the natural soil formation was recompacted as follows:

a) For soils having not more than 12 percent passing the No. 200 sieve size, 80 percent relative density as determined by ASTM D2049

b) For all other soils, 95 percent of maximum dry density as determined by ASTM D1557

Test Results are included in Appendix 2.5C. The location of test specimens with respect to the spray pond is shown on Figure 2.5-59. A statistical analysis of the test results was made and is summarized on Figure 2.5-60. The required compaction was met or exceeded.

A protective concrete mat was immediately placed over the compacted soil under the ESSW Pumphouse and a minimum of 5 in. thick reinforced concrete liner placed over the entire spray pond area.

All temporary slopes in soil were formed at a maximum slope of 1 1/2 horizontal to 1 vertical. The temporary slopes in the vicinity of the ESSW Pumphouse were protected with a 3 in. layer of concrete to maintain the natural soil formation intact. All permanent slopes in soil were formed at a slope of 3 horizontal to 1 vertical.

The excavation for the Seismic Category 1 pipelines in soil was carried out similarly. All slopes were cut at a maximum of 1 1/2 horizontal to 1 vertical. The minimum clearances were 1 ft beneath the pipe and 2 ft to the sides.

SEE INSERT A →

2.5.4.5.3 Backfill and Compaction

Generally, the excavated area, for a minimum distance of 10 ft surrounding the major structures, was backfilled with a non-corrosive lean mix concrete known as sand-cement-flyash backfill. A minimal amount of backfilling has taken place using granular backfill, with the exception of the spray pond and vicinity addressed later in this section.

SEE INSERT B →

The Seismic Category I pipelines were generally backfilled with the sand-cement-flyash; otherwise granular material was used.

Buried Seismic Category I electrical ductbanks are composed of reinforced concrete encasements around plastic or metal ducting; the concrete encasement being cast directly against the excavated

INSERT A

The excavation for diesel generator E building was carried to unweathered bedrock using soldier beams and laggings. All timber laggings were treated with preservative by pressure process. The soldier beams and laggings were left in place. The disturbed soils adjacent to the soldier beams and laggings were densified by compaction grouting. The results of compaction grouting were verified by standard penetration tests. The standard penetration test results indicate that the blow count numbers are equal to or exceed those of original soils.

The excavation for diesel fuel tank for diesel generator E building was carried out in open cut. All slopes were cut at a maximum of 1½ horizontal to 1 vertical

INSERT B

The excavated area for diesel fuel tank for diesel generator E building was backfilled with sand-cement-flyash to two (2) feet below finished grade.

grade. Granular or sand-cement-flyash backfill was used the same as for buried pipes.

The properties of these respective backfills were as follows:

a) Sand-Cement-Flyash

Weight	-	110 lb/cu ft minimum
Slump	-	3 in. minimum
	-	6 in. maximum
Strength	-	40 psi minimum at 28 days

b) Granular

Granular backfill was well-graded, sound, dense, and durable material. It consisted of sand, gravel or crushed rock and did not contain any topsoil, humus, brush, roots, peat, sod, cinders, shale, rubbish or other perishable materials, or portions of clay, waste concrete, trash, or frozen material. No more than five percent by weight passed the No. 200 sieve. The maximum size of the material was 4 in. in confined areas where hand tamping was required and 6 in. in other areas.

The placement specification of these respective backfills was as follows:

a) Sand-Cement-Flyash

Sand-cement-flyash backfill was either mixed at the batch plant or obtained from an offsite source, conveyed to the point of placement by truck, and placed in lifts not exceeding 30 in. in height. The maximum rate of pour did not exceed 4 ft/hr. It was vibrated in place with approved equipment. It was protected from freezing temperatures for a minimum of 3 days.

b) Granular

Granular backfill was placed in maximum 8 in. loose horizontal layers, moisture conditioned, and compacted to at least 80 percent relative density as determined by ASTM D2049.

Backfill material within 2 ft of structures and in areas where large construction equipment could not be used or where there was a danger of damage to structures was compacted to the specified density by hand operated equipment.

Small areas resulting from dental excavation beneath the spray pond concrete liner received a shallow leveling course. The

material and placement specification for this type of fill (arbitrarily designated Fill Type A) was as follows:

Fill Type A, Material

The maximum size of this material was 4 inches and no more than 5 percent by dry weight passed the No. 200 sieve.

Fill Type A, Placement

Fill Type A was placed in maximum 6 inch uncompacted layers, moisture conditioned, and compacted to at least 80 percent relative density as determined by ASTM D2049.

The area to the south and south-east of the spray pond was filled in a controlled manner. The material and placement specification for this type of fill (arbitrarily designated Fill Type 'B') was as follows:

Fill Type B, Material

The maximum size of this material was 12 inches and no more than 35 percent by dry weight passed the No. 200 sieve.

Fill Type B, Placement

Fill Type B was placed in a 15 inch maximum uncompacted layer thickness, moisture conditioned, and compacted to satisfy both of the following requirements:

a) At least 80% relative density as determined by ASTM D2049 for material having not more than 12% passing the No. 200 sieve or 90% of maximum dry density as determined by ASTM D1557 for all other material.

b) Irrespective of the compacting effort required to satisfy part a) above, the fill was compacted in one of the following manners as a minimum effort:

   i) Using a crawler tractor having a weight at least equal to that of a D8 Caterpillar tractor with bulldozer blade. Each track overlapped the preceding track by not less than four inches. When the tractor has made one entire coverage of an area in this manner, it was considered to have made one pass. Each fill lift was compacted with four passes.

   ii) Using a vibratory roller of minimum weight 20,000 pounds having a roller width of approximately 78 inches and a diameter of approximately 60 inches. The roller had a vibrator frequency range of

between 1100 and 1600 vibrations per minute and had a minimum vibratory dynamic force of 40,000 pounds. The roller speed did not exceed 3 mph and each track overlapped the preceding one by at least 4 inches. When the roller had made one entire coverage of an area in this manner, it was considered to have made one pass. Each fill lift was compacted with four complete passes.

iii) Using a hand controlled vibratory compactor in locations inaccessible by tractor or vibratory compactors was on the basis of the demonstrated ability of the compactor to compact the material to the same density as the contiguous backfill.

Test results are included in Appendix 2.5.C. The location of test specimens with respect to the spray pond is shown on Figure 2.5-59. A statistical analysis of the test results was made and is summarized on Figure 2.5-60. The required compaction was met or exceeded.

To compute the lateral pressures acting on subterranean walls, all backfill was conservatively assumed to be granular. The static and dynamic engineering properties of this granular backfill was assumed as follows:

Bulk unit weight, γ_b = 135 pcf

Saturated unit weight, γ_s = 140 pcf

Coefficient active earth pressure, K_A = 0.30

Coefficient earth pressure "at-rest", K_o = 0.70

The computation of static and dynamic lateral soil pressures acting on subterranean walls is addressed in Subsection 2.5.4.10.2.

2.5.4.5.4 Bedding Material for Seismic Category I Pipes and Electrical Duct Banks

The bedding material was sand-cement-flyash as defined in Section 2.5.4.5.3 of the FSAR.

The excavation was made to original ground or in sand-cement-flyash backfill to required bedding subgrade. The bedding subgrade was inspected and verified to be sound and dense meeting visual requirements for backfill adequate for support of bedding

material, thus meeting specification intent. The subgrade was also inspected for unsuitable material such as water, frozen, organic or deleterious material. Such material, when found, was removed.

The sand-cement-flyash bedding material was either mixed at the batch plant or obtained from an approved offsite source. The sand-cement-flyash was then placed in lifts not exceeding 30 inches in height nor 4 feet per hour. For pipes the pour was brought to the pipe spring line and was allowed to set. For duct banks the bedding was not placed until the duct bank concrete reached the required strength. Sand-cement-flyash was then poured to the top of the duct bank and allowed to set.

Analysis of the relevant field tests for bedding material is included in the summary given in Table 2.5-61.

2.5.4.6 Groundwater Conditions

Special measures for control of groundwater levels beneath Seismic Category I plant structures founded on rock are not required. However, control of groundwater levels and seepage is needed at the spray pond; discussion of design criteria for stability of the spray pond is presented in Subsection 2.5.5.

Periodic water level readings were obtained in the vicinity of the principal plant (power block) structures between December 1970 and August 1972. Groundwater fluctuations ranged from 1.5 ft in drill holes 209, 311, to 6.2 ft in drill hole 213.

The maximum groundwater level measured in the plant structures area during this preconstruction period ranged from approximately 690 ft at the west edge of the site of the turbine building, to about 655 ft at the east edge of the site of the reactor buildings (refer to Figure 2.5-55). These levels were obviously influenced by the topographic high of 749 ft just west of the site of the power block structures. However, subsequent excavation and grading in these areas preclude water levels from rising to this height in the future.

During construction, the area just west of the power block structures was graded to elevation 710 ft or less. Excavations for the foundations of the principal plant structures extended below the water table and some minor dewatering was required. Due to the low permeability of the rock, groundwater inflow was small and was confined to seepage from fractures. Dewatering was accomplished by pumping from low areas and sumps. Where seeps were noted issuing from fractures in the rock, holes were drilled into the fractures and pipes caulked in the holes to control water while the mudmat was placed. In the foundation for the

reactor building (elevation 639 ft) and in the turbine condensate pump pit (at elevation 635 ft), hydrostatic pressure caused lifting of small areas of the 3 inch thick concrete mudmat that had been placed over the impervious membrane. Approximately 20 relief wells drilled through the mudmat released the pressure and allowed the mat to settle back to its original position. The weight of the structural concrete slab subsequently placed on this mudmat was more than sufficient to resist any uplift pressures.

The highest seeps noted in the foundation rock during construction were at elevation 642 ft in the radwaste building excavation and at about the same elevation in the pipe trench in the southern part of the Unit 2 turbine building. Some seeps were also noted in the foundation rock for the reactor buildings at elevation 639 ft and in sumps below this. To the west of the turbine building in the circulating water pumphouse excavation, water was noted to enter the excavation to an elevation of approximately 660 ft. Hydrostatic lifting (described above) of the impervious membrane did not occur at foundation elevations above 640 ft.

SEE INSERT C

Additional information with regard to groundwater monitoring and water table fluctuations in the principal plant structures area is provided in Subsection 2.4.13 and Tables 2.4-31 and 2.4-32.

At the spray pond, water level information taken between July 29, 1974 and August 4, 1975, and from January through March 1977, indicate a minimum water level fluctuation of 4.0 ft recorded at observation wells 1111 and 1113, and a maximum fluctuation of 7.0 ft in 1115. Additional discussion of groundwater fluctuations in the spray pond area can be found in Subsection 2.5.5. Because groundwater levels at the pond will be higher than the maximum projected flood elevation (refer to Figure 2.5-38 and Subsection 2.4.3, respectively), flooding conditions will not significantly affect the groundwater levels.

Local wells within two miles of the plant site were inventoried and the information is given in Table 2.4-22.

Groundwater flows away from the principal plant structures area to the north, east, and south. However, the predominant direction of flow is to the east and southeast at gradients of 0.05 and 0.06, respectively. The flow rate in bedrock is estimated to be less than 1 ft per day as discussed in Subsection 2.4.13. Groundwater contours at the site are shown on Figure 2.5-38.

Permeability of the intact bedrock at the site is less than 1 ft/year. The average permeability of the glacial materials at the spray pond is 2,000 ft/year; however, this value has been considerably exceeded in some tests. For a complete description

of permeability at the spray pond and plant structures areas, consult Subsections 2.5.5 and 2.4.13, respectively. Measured permeability values may be found in Table 2.4-33 and 2.4-34.

2.5.4.7 Response of Soil and Rock to Dynamic Loading

2.5.4.7.1 Response of Rock to Dynamic Loading

Rock at the site would be unaffected by dynamic loading from earthquakes. During historical time, no Pennsylvania earthquakes have been felt at the site. Approximately 14 earthquakes originating outside Pennsylvania could have been felt at the site, but with a probable maximum intensity of only IV on the Modified Mercalli Scale. Ground motion at this intensity would have had no effect on the site.

The compressional and shear wave velocities of sound, unweathered foundation rock in the reactor area (V_p = 14,000 to 16,000 fps; V = 6,200 to 7,500 fps) indicate that the rock possesses a high rigidity and provides effective resistance against dynamic loads for all structures founded upon it (refer to Table 2.5-5). Such rock will not be subject to any loss of strength under earthquake loadings.

2.5.4.7.2 Response of Soil to Dynamic Loading

The analysis of earthquake-induced soil strain and settlement of the spray pond and ESSW pumphouse are given in Subsection 2.5.5. If the sands at the site behave like dry sand during an earthquake, the settlement will be less than 0.05 in. If the sand deposits are saturated and excess pore pressures develop, they will reconsolidate following the earthquake and settlements up to 1.2 in. at the east end of the pond and up to 1.0 in. at the ESSW pumphouse may be expected.

The bearing capacity of the pumphouse mat footing was evaluated by the following equation (Ref. 2.5-115):

$$q'_d = 1/2\, B\gamma N_\gamma + D_f (N_q - 1)$$

Where:

q'_d = ultimate bearing capacity

B = width of the footing

γ = unit weight of the soil

Insert "C"

Excavation for diesel generator "E" building extended below the water table and some minor dewatering was required. The groundwater which seeped into the excavation area was diverted to a sump at a low point and was removed by pumping.

D = depth of surcharge

N , N = bearing capacity factors

This equation was derived for the static condition; however, a conservative evaluation of the bearing capacity for the dynamic condition can be made by assuming that, during dynamic loading, the footing has an effective width equal to 1/3 of the actual footing (Ref. 2.5-115). Substituting all values given in Subsection 2.5.4.10.2 into the equation but using B=21.3 ft instead of 64 ft, the ultimate bearing capacity was calculated to be 52 kips/sq ft. The corresponding factor of safety against bearing failure is 17.

2.5.4.7.3 Soil Structure Interaction

Soil structure interaction has been addressed in Subsection 3.7.2.4. The analysis and design of buried pipelines has been addressed in Subsection 3.7.3.12.

2.5.4.8 Liquefaction Potential

For the soil supported spray pond, ESSW pumphouse and Seismic Category I pipelines, the liquefaction potential was evaluated. The soil underneath these structures is predominantly sand, gravel, cobbles, and boulders.

The liquefaction potential of the soils beneath the spray pond and the ESSW pumphouse is discussed in detail in Subsection 2.5.5. The minimum factor of safety against liquefaction for these structures was found to be 1.26, which is larger than the minimum acceptable factor of safety of 1.20.

The soil supported Seismic Category I pipelines are underlain by the same glacial deposits as the spray pond area and the maximum predicted water level below the pipelines is lower than that under the pond. Hence, liquifaction potential of the soils beneath the seismic Category I pipelines is no greater than that of soils beneath the spray pond.

2.5.4.9 Earthquake Design Bases

The design bases for the SSE and OBE are addressed in Subsections 2.5.2.6 and 2.5.2.7.

2.5.4.10 Static Stability

2.5.4.10.1 Static Stability of Safety-Related Structures Supported on Rock

The reactor buildings, control structure, and the diesel generator building, all of which are Seismic Category I structures, are founded on sound, unweathered siltstone bedrock. The Seismic Category I pipelines linking the reactor buildings with the spray pond are trenched partly in soil and partly in bedrock.

The strength of the unweathered bedrock amply accommodates the loads of the plant providing highly stable foundation conditions. As measured in the Seismic Category I reactor area, compressional velocities are in the range of 14,000 to 16,000 fps; shear wave velocity ranges between 6,200 and 7,500 fps. Static deformational moduli as measured on rock cores vary between 3.1 to 9.4×10^6 psi (refer to Table 2.5-3). Measurements of unconfined compressive strength of unweathered foundation rock from the vicinity of the principal plant structures were between 3,650 and 16,000 psi (Table 2.5-3). Static properties of the foundation rock are summarized in Table 2.5-5. Loads induced by the plant structures are less than the allowable bearing pressure of the rock and far below the ultimate bearing capacity. The structural loads will produce no significant total or differential settlement of the foundations.

Safety-related structures founded on rock were designed for a hydrostatic groundwater loading caused by a maximum groundwater level of 665 ft. This is higher than the expected maximum water level, as discussed in Subsection 2.4.13.

2.5.4.10.2 Static Stability of Safety-Related Structures Supported on Soil

The mat footing of the ESSW pumphouse is 112 ft long, 64 ft wide, and 3 ft thick. The total dead and live loads are 20,000 kips and 2,100 kips, respectively. The corresponding unit pressures are 2.80 ksf and 0.30 ksf, respectively. The bottom of the mat is at elevation 657 ft.

The ultimate bearing capacity of the mat can be estimated by the following equation (Ref. 2.5-115):

$$q'_d = 1/2\ B\gamma\ N_\gamma + D_f\ (N_q - 1)$$

Where:

q'_d = ultimate bearing capacity

B = width of the mat = 64 ft

γ = unit weight of the soil = 130 pcf

D_f = depth of surcharge, conservatively assumed to be zero

N_γ, N_q = bearing capacity factors

= 38, and 33, respectively (Ref. 2.5-115) corresponding to $\phi = 35°$ (Subsection 2.5.4.2.2)

The ultimate bearing capacity of the mat foundation was found to be 158 kips/sq ft. The factor of safety was computed to be 51, which indicates no danger in overstressing the supporting granular soil. Therefore, the allowable bearing pressure and settlement of the mat footing were evaluated by the method of limiting settlements suggested by Peck, Hanson, and Thornburn (Ref. 2.5-116). The allowable bearing pressure for a maximum settlement not to exceed 2 in. was computed by the formula:

$$q_a = 0.22\ C_n\ C_w\ N$$

Where:

q_a = allowable bearing pressures, tsf

N = number of blows per foot in the standard penetration test

C_n, C_w = correction factors for "N", for the effects of overburden pressure and location of groundwater surface

A conservative N value of 40 was selected to represent the soils below the mat foundation (Elevation 657 ft, Figure 2.5-38). The Standard Penetration Tests below the foundation level were made at an average overburden pressure of about 6,000 psf (Figure 2.5-39); the corresponding correction factor C_n was obtained from Figure 19.6 of Ref. 2.5-115 to be 0.63. Assuming that the groundwater surface is at 7 ft below the mat and no surcharge, the correction factor C_w was computed to be 0.55 by equation 19.4 of Ref. 2.5-115.

The allowable bearing pressure was computed to be 6.0 kips/sq ft based on the values of N, C_n , and C_w given above. At this bearing pressure, the settlement of the mat foundation should be less than 2 in. and the differential settlement should be less than 3/4 in. Therefore, by proportion, for a design total pressure of 3.1 kips/sq ft, the corresponding maximum and

differential settlements would be less than 1 in. and 1/2 in., respectively. Settlement in sand and gravel deposits occurs almost simultaneously with the application of load. Since more than 80 percent of the total load is dead load, then less than 0.2 in. of settlement is expected after the completion of the construction.

SEE INSERT D →

The structural stability of the ESSW pumphouse is discussed in Subection 3.8.4 and 3.8.5.

The sustained load from the spray pond is less than the weight of overburden removed; therefore, there is an adequate factor of safety against overstressing the underlying soil. Soil rebound during excavation in granular soils of the type found at the spray pond is insignificant.

The maximum predicted elevation of the water table is below the base of the spray pond and ESSW pumphouse; therefore, hydrostatic water loadings were not considered in the design of these structures. A full discussion of the water table in this vicinity is in Subsection 2.5.5.

The lateral earth pressure acting on subterranean walls of Seismic Category I structures was computed assuming granular backfill having the properties stated in Subsection 2.5.4.5.3. The coefficient of earth pressure "at-rest" was used. Additionally, the walls were designed for surcharge loadings and dynamic soil pressures as appropriate. The typical pressure diagrams and combinations are shown on Figure 2.5-39.

Water levels in the spray pond area are discussed in Subsection 2.5.5.1.2. Contours of the groundwater table in the spray pond area are shown on Figure 2.5-38. Profiles of measured and projected profiles of the groundwater table beneath the spray pond are shown on Figure 2.5-40.

2.5.4.11 Design Criteria

2.5.4.11.1 Design Criteria of Safety-Related Structures on Rock

The plant structures founded on rock are designed for a maximum acceleration of 0.10g from an occurrence of the SSE event. From consideration of its engineering properties, it is evident that the foundation rock will not be measurably affected by seismic loadings, and negligible additional foundation settlement will accompany these maximum potential dynamic loads. The maximum contemplated total static and dynamic loads of 40 tsf are only a

Insert "D"

The same equations and procedures can be applied to compute the ultimate bearing capacity of the foundation soils and the allowable bearing pressure for a maximum settlement not to exceed 2 inches.

The foundation mat for the diesel fuel Tank for diesel generator "E" building is 17 feet wide, 57 feet long and 5 feet thick. The total dead and live loads are 111.4 kips and 684.8 kips respectively. The corresponding unit pressures are 0.12 ksf and 0.71 ksf respectively. The bottom of the foundation mat is at elevation 645.0 ft.

The ultimate bearing capacity of the foundation soils was found to be 42.0 ksf. The factor of safety against shear failure was computed to be 50 which indicates that there is ~~no~~ no danger of shear failure.

The allowable bearing pressure was found to be 12.0 ksf for a maximum settlement not to exceed 2 inches. By proportion, the maximum and differential settlement corresponding to a design total pressure of 0.83 ksf would be less than 1/8 in. and 1/16 in. respectively.

2.5-115 Peck, R.B., Hanson, W.E., and Thronburn, T.H., 1974, Foundation Engineering, 2nd Ed., John Wiley & Sons, Inc.

2.5-116 GIBBS & HILL, INC., Report on Subsurface Investigation for New Emergency Diesel Generator Facility, Susquehanna Steam Electric Station Units 1 & 2, January, 1984.

2.5-117. DAMES & MOORE, Geologic Map of The Emergency Diesel Generator Foundation, Susquehanna Steam Electric Plant, August, 1984.

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Emergency Service Water System (ESWS)

The ESWS is designed to

a) Supply cooling water to the RHR pumps and their associated room coolers during the several non-emergency modes of RHR pump operation such as fuel pool cooling, normal shutdown, and hot standby

b) Supply cooling water to the various diesel generator heat exchangers, RHR pumps, room coolers, RBCCW and TBCCW heat exchangers during emergency shutdown conditions such as a LOCA.

The ESWS pumps are located in the ESWS pumphouse with the RHRSW pumps. The ESWS pumphouse is designed as Seismic Category I and the ESWS consists of two redundant loops (denoted A and B) each capable of providing 100 percent of the cooling water required by all the ESF equipment of both Units 1 and 2 simultaneously. The system is designed so that no single active or passive component failure will prevent it from achieving its safety related objective.

The system starts automatically on a diesel start signal.

For additional discussion, see Subsection 9.2.5.

Diesel Generators

The four diesel generators are housed in a Seismic Category I structure. They are separated from each other by concrete walls which provide missile protection. Loss of one diesel generator will not impair the capability to safely shutdown both units, since this can be done with three diesel generators. For additional discussion, see Subsection 8.3.1.4.

Additionally, a fifth diesel generator is provided as a replacement for any one of the four. This unit is housed in a separate Seismic Category I Building

For descriptions of the Diesel Generator Fuel Oil System, Cooling Water System, Air Starting System, Lube Oil System, and the Intake and Exhaust Systems see Subsections 9.5.4, 9.5.5, 9.5.6, 9.5.7, and 9.5.8 respectively.

For missile protection see Subsection 3.5. Separation is discussed in Sections 3.12 and 8.3.

Ultimate Heat Sink (Spray Pond)

The spray pond provides the water for both the ESWS system and the RHRSW systems. It is the ultimate heat sink for both Units 1 and 2. The return lines from the ESWS and the RHRSW are combined and the total quantity of water from both these systems is discharged through spray networks, which dissipate the heat back

following a loss-of-coolant accident to assure that core cooling, containment integrity, and other vital safety functions are maintained.

Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

Design Conformance

Two offsite power transmission systems and four onsite standby diesel generators A,B,C&D with their associated battery systems are provided. Either of the two offsite transmission power systems or any three of the four onsite standby diesel generator systems have sufficient capability to operate safety related equipment for cooling the reactor core and maintaining primary containment integrity and other vital functions in the event of a postulated accident in one unit with a safe shutdown of the other unit.

SEE INSERT K

The two independent offsite power systems supply electric power to the onsite power distribution system via the 230 kV transmission grid. Each of the offsite power sources is supplied from a transmission line which terminates in switchyards (or Substations) not common to the other transmission line. The two transmission lines are on separate rights-of-way. These two transmission circuits are physically independent and are designed to minimize the possibility of their simultaneous failure under operating and postulated accident and environment conditions.

Each offsite power source can supply all Engineered Safety Feature (ESF) buses through the associated transformers. Power is available to the ESF buses from their preferred offsite power source during normal operation and from the alternate offsite power source if the preferred power is unavailable. Each diesel generator A,B,C&D supplies standby power to one of the four ESF buses in each unit. Loss of both offsite power sources to an ESF bus results in automatic starting and connection of the associated diesel generator A,B,C or D within 10 seconds. Loads are progressively and sequentially added to avoid generator instabilities.

There are four independent ac load groups provided to assure independence and redundancy of equipment function. These meet the safety requirements assuming a single failure since any three of the four load groups have sufficient capacity to supply the minimum loads required to safely shut down the unit. Independent routing of the preferred and alternate offsite power source circuits to the ESF buses are provided to meet the single failure safety requirements.

INSERT K

Additionally, a fifth diesel generator 'E' with its associated battery system is provided as a replacement, and has the capability of supplying the emergency loading for any one of the other four diesel generators (A, B, C or D). Diesel generator 'E' is not designed to automatically replace any one of the other four diesel generators in the event of a failure.

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
Pump motors, fuel oil system		P/PL/GH	O,G,G5	NA	3	IEEE-323/344	I	Y	
Diesel generators		P/PL	G,G5	NA	3	IEEE-387	I	Y	
Electrical modules with safety functions		P/PL	G,G5	NA	3	IEEE-279/323	I	Y	
Cable, with safety functions		P/GH	G,G5	NA	3	IEEE-279/323/383	NA	Y	15
Diesel fuel storage tanks		P	O	C	3	III-3	I	Y	
Diesel lube oil system piping and valves		P	G	C	3	B31.1	I	Y	
Heat exchangers: jacket water and lube oil		P	G	C	3	III-3/TEMA C	I	Y	
Filter housings		P	G	C	3	VIII/NA	I	Y	
Lube oil heater		P	G	NA	Other	NONE	NA	N	
Lube oil circulating pump		P	G	D	Other	NA	NA	N	24
Diesel starting air system piping and valves from downstream of tee following compressor discharge to engine skid		P	G	C	3	III-3	I	Y	
Piping and valves, others		P	G	D	Other	B31.1.0	NA	N	
Air receivers		P	G	C	3	III-3	I	Y	
Compressors		P	G	D	Other	NA	NA	N	
Jacket cooling water piping		P	G	D	Other	B31.1	NA	N	
Cooling jacket water heater		P	G	NA	Other	NA	NA	N	
Cooling jacket water heater pump		P	G	D	Other	NA	NA	N	24
Air Intake & exhaust piping (except mufflers and expansion joints)		P	G	C	3	III-3	I	Y	
Dirty lube oil drain tank		P	G	NA	Other	NONE	NA	N	
Heating, Ventilating and Air Conditioning Systems									
Control Structure	9.4.1								
Control Room & Computer Room HVAC									
Motors		P	CS	NA	3	NEMA MG1 IEEE-344/323	I	Y	

* Refer to the General Notes at the end of this table.

TABLE 3.2-1 (Continued)

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
Instrumentation Associated with Other Systems Required for Safety	7.6								
Spent fuel pooling cooling system		P	R	NA	2	IEEE-279	I	Y	
Fuel handling area ventilation isolation system		P	R	NA	2	IEEE-279	I	Y	
Control room panels		P	CS	NA	2	IEEE-279	I	Y	
Local instrument racks associated with safety related equipment		P	ALL	NA	2	IEEE-279	I	Y	
Instrumentation Associated with Systems Not Required for Safety	7.7								
Seismic instrumentation		P	ALL	NA	Other	NA	I	Y	
Area radiation monitoring		P	ALL	NA	Other	NA	NA	N	
Leak Detection Instrumentation									
Temperature elements		GE	C,R,T	NA	2	IEEE-323	I	Y	39
Differential temperature switch		GE	C,R	NA	2	IEEE-323	I	Y	39
Differential flow indicator		GE	CS	NA	2	IEEE-323	I	Y	39
Pressure switch		GE	C,R	NA	2	IEEE-323	I	Y	39
Differential pressure indicator switch		GE	CS	NA	2	IEEE-323	I	Y	39
Differential flow summer		GE	CS	NA	2	IEEE-323	I	Y	39
Process Radiation Monitors									
Electrical modules, main steam line and reactor building ventilation monitor		GE	R	NA	2	IEEE-323	I	Y	
Cable, main steam line and reactor building ventilation monitors		P	R	NA	2	IEEE-279/323/383	NA	Y	15
Electric Systems	8								
Engineered Safety Features AC Equipment	8.3								
4.16 kV switchgear		P/GH	0,65	NA	2	IEEE-308/323/344	I	Y	

* Refer to the General Notes at the end of this table.

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
480 V load centers		P	0,GS	NA	2	IEEE-308/ 323/344	I	Y	
480 V motor control centers		P/GH	0,GS	NA	2	IEEE/308/ 323/344	I	Y	
4.16KV -480V Transformer - D/G 'E'			O	NA	2	IEE/308/ 323/344	I	Y	
Engineered Safety Features DC Equipment	8.3								
125 V and 250 V station batteries and racks, battery chargers		P	CS,GS	NA	2	IEEE-308/ 323/344	I	Y	
125 V switchgear and distribution panels		P/GH	CS	NA	2	IEEE-308/ 323/344	I	Y	
125 V Motor Control center - D/G 'E'		GH	GS	NA	2	~~IEEE~~ 308/ 323/344	I	Y	
120 V Vital AC System Equipment	8.3								
Static inverters		P	CS	NA	2	IEEE-308/ 323/344	NA	Y	
120 V distribution panels		P	CS,R	NA	2	IEEE-308/ 323/344	I	Y	
Electric Cables for ESF Equipment	8.3								
5 kV power cables		P,GH	ALL	NA	2	IEEE-323/ 383	NA	Y	15
600 V power cables		P,GH	ALL	NA	2	IEEE-323/ 383	NA	Y	15
Control and instrumentation cables		P,GH	ALL	NA	2	IEEE-323/ 383	NA	Y	15
Miscellaneous Electrical	8								
Primary containment building electrical penetration assemblies		P	C	NA	2	IEEE-317/ 344/383	I	Y	
Conduit supports, safety related		P,GH	ALL	NA	2	IEEE-344	I	Y	15
Tray + Tray supports, safety related		P,GH	ALL	NA	2	IEEE-344	I	Y	15
Emergency lighting systems		P,GH	ALL	NA	2	IEEE-344	I	Y	
Emergency communications systems		P,GH	ALL	NA	Other	NONE	NA	N	
Diesel generator		P/PL	G	NA	2	IEEE-387	I	Y	
Transfer Panels - D/G 'E'		GH	GS	NA	2	IEEE 323/344	I	Y	
Termination Cabinets - D/G 'E'		GH	GS	NA	2	IEEE 323/344	I	Y	

* Refer to the General Notes at the end of this table.

TABLE 3.2-1 (Continued)

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
Demineralized Water Makeup System	9.2.9								
Tanks		P	CW	D	Other	VIII-1	NA	N	
Pumps		P	CW	D	Other	B31.1.0/ Hyd.I	NA	N	24
Motors		P	CW	NA	Other	NEMA MG1	NA	N	
Piping and valves		P	ALL	D	Other	B31.1.0	NA	N	
Buildings									
Reactor Building		P	R	B	2	ACI/AISC	I	Y	
Pressure resistant doors		P	R	B	2	ASTM/AWS AISC	NA	Y	
Watertight door		P	R	B	2	ASTM/AWS	NA	Y	
R. B. Equipment door		P	R	B	2	ASTM/AWS	NA	Y	
Primary Containment		P	C	B	2	ACI/AISC/ III	I	Y	27,30
Access hatches/locks/doors		P	C	B	2	III-MC	I	Y	
Liner plate		P	C	B	2	III-MC	I	Y	
Penetration assemblies		P	C	B	2	III-MC	I	Y	29
Vacuum relief valves		P	C	B	2	III-2	I	Y	
Downcomers		P	C	B	2	III-2	I	Y	44
Downcomer Bracing		P	C	B	2	AISC	I	Y	
Diesel generator building		P	G	NA	2	ACI/AISC	I	Y	
Control structure		P	CS	NA	2	ACI/AISC	I	Y	
Radwaste and offgas building		P	RW	NA	Other	ACI/AISC	NA	N	22
Turbine building		P	T	NA	Other	ACI/AISC	NA	N	21
Administration building		P	O	NA	Other	ACI/AISC	NA	N	
Circulating water pump house		P	O	NA	Other	ACI/AISC	NA	N	
ESSW pumphouse		P	O	NA	3	ACI/AISC	I	Y	
Low Level Radwaste Holding Facility		P	O	NA	Other	ACI/AISC/ UBC	NA	N	
DIESEL GENERATOR 'E' BUILDING		GRH	DG'E'	NA	2	ACI/AISC	I	Y	
Structures									
Roof Scuppers and Parapet Openings		P	R,CS,G	NA	2	ACI/AISC	NA	Y	
Spray pond & Emergency Spillway		P	O	NA	3	ACI	I	Y	
Condensate storage tank		P	O	D	Other	D100	NA	N	
Spent fuel pool		P	R	NA	2	ACI/AISC	I	Y	
Spent fuel pool liner		P	R	NA	2	ACI/AISC	I	Y	
Refueling water storage tank		P	O	D	Other	D100	NA	N	
Pipe Whip Restraints		P	R,C	NA	3	AISC	I	Y	

* Refer to the General Notes at the end of this table.

TABLE 3.2-1 (Continued)

Principal Components (34*)	FSAR Section	Source of Supply (1)*	Location (2)*	Quality Group Classification (3)*	Safety Class (4)*	Principal Construction Codes and Standards (5)*	Seismic Category (6)*	Quality Assurance Requirement (7)*	Comments *
Missile Barriers for safety related equipment		P	C,R,CS,SW,G	NA	Other	ACI/AISC	I	Y	
Biological shielding within Primary containment, reactor Building and control building		P	C,R,CS	NA	Other	ACI/AISC	I	Y	42
Safety related masonry walls		P	R,G,CS	NA	Other	ACI/UBC	I	Y	

②

* Refer to the General Notes at the end of this table.

TABLE 3.2-1

SSES DESIGN CRITERIA SUMMARY (Continued)

General Notes and Comments

1) GE = General Electric

PL = Pennsylvania Power & Light

P = Bechtel as agents for Pennsylvania Power & Light

NA = Not Applicable, see comments

GH = GIBB & HILL & DCI AS AGENTS FOR PENNSYLVANIA POWER & LIGHT

2) Location

C	Part of or within primary containment
R	Reactor Building
T	Turbine Building
CS	Control Structure
RW	Radwaste and Offgas Building
G	Diesel Generator A, B, C & D Building
I	Intake Structure
A	Administration Building
CW	Circulating Water Pumphouse
SW	Engineering Safeguards Service Water (ESSW) Pumphouse
CA	Chlorine and Acid Storage Building
O	Outdoors, Onsite
G5	DIESEL GENERATOR "E" BUILDING

3) A,B,C,D - Quality group classification as defined in Regulatory Guide 1.26. The equipment shall be constructed in accordance with codes listed in Tables 3.2-2, 3.2-3, and 3.2-4.

NA - Not applicable to quality group classification

4) 1,2,3,4, other = safety classes defined in ANSI-N212 and Section 3.2.3.

NA - Not applicable to safety classification

③

TABLE 3.2-1

SSES DESIGN CRITERIA SUMMARY (Continued)

General Notes and Comments

1) GE = General Electric

PL = Pennsylvania Power & Light

P = Bechtel as agents for Pennsylvania Power & Light
G&H = GIBBS & HILL, INC. " " " "
NA = Not Applicable, see comments

2) Location

C	Part of or within primary containment
R	Reactor Building
T	Turbine Building
CS	Control Structure
RW	Radwaste and Offgas Building
G	Diesel Generator Building
DG'E'	DIESEL GENERATOR 'E' BUILDING
I	Intake Structure
A	Administration Building
CW	Circulating Water Pumphouse
SW	Engineering Safeguards Service Water (ESSW) Pumphouse
CA	Chlorine and Acid Storage Building
O	Outdoors, Onsite

3) A,B,C,D - Quality group classification as defined in Regulatory Guide 1.26. The equipment shall be constructed in accordance with codes listed in Tables 3.2-2, 3.2-3, and 3.2-4.

NA - Not applicable to quality group classification

4) 1,2,3,4, other = safety classes defined in ANSI-N212 and Section 3.2.3.

NA - Not applicable to safety classification

3.3 WIND AND TORNADO LOADINGS

3.3.1 WIND LOADINGS

All exposed structures are designed for wind loading.

3.3.1.1 Design Wind Velocity

The design wind velocity for all structures is 80 mph at 30 ft above ground for a 100-year recurrence interval. The design wind velocity is based on Figure 5 of Reference 3.3-1. (References are listed in Subsection 3.3.3).

The vertical velocity distribution is based on Table 1(a) of Reference 3.3-2. The velocity distribution is tabulated in Table 3.3-1.

A gust factor of 1.1, as given in Reference 3.3-2, is used.

3.3.1.2 Determination of Applied Forces

The procedure used to transform the wind velocity into an effective pressure applied to exposed surfaces of structures is as described in Reference 3.3-2 and is summarized as follows:

The dynamic pressure is given by:

$q = 0.002558 V^2$ where,

q = Dynamic pressure in psf

V = Wind velocity in mph (design wind velocity x gust factor).

The local pressure at any point on the surface of a building is equal to:

$q \times C_p$ where

C_p = Pressure coefficient

The total pressure on a building is equal to:

$q \times C_D$ where,

C_D = Shape coefficient.

The Susquehanna SES structures have sloping roofs with a pitch less than 20 degrees. The following are values for Cp and C_D: (See Reference 3.3-2, p. 1151 and Figure 7)

Cp for windward wall = 0.8 (pressure)

Cp for leeward wall = -0.5 (suction)

Cp for windward slope = 0

Cp for leeward slope = -0.6 (suction)

C_D = 1.3 (pressure).

Wind loads on structures are tabulated in Table 3.3-1.

Exposed tanks are designed to resist a minimum wind load of 30 psf on the vertical projection, based on Reference 3.3-3. For cylindrical tanks, wind is considered acting on six-tenths of the vertical projection. No increases in allowable working stresses are permitted for these structures for loading conditions involving wind.

3.3.2 TORNADO LOADINGS

Table 3.3-2 lists the systems that are protected against tornadoes and the enclosures which provide this protection. This table is based on NRC Regulatory Guide 1.117 (Reference 3.3-4).

3.3.2. Applicable Design Parameters

The following design parameters are used for the design of tornado-resistant structures and are based on Reference 3.3-5:

a) Dynamic Wind Loading (FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDING)

Tangential speed: 300 mph

Translational speed: 60 mph

⑥

b) Pressure Differential Between the Inside and Outside of a Building (FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDIN

A pressure drop of 3 psi at the rate of 1 psi per second.

c) Tornado-Generated Missiles

These are discussed in Subsection 3.5.1.4.

→ INSERT 'A'

3.3.2.2 Determination of Forces on Structures

The following procedures are used to transform the tornado loadings into effective loads on structures:

a) Dynamic Wind Loading

A procedure the same as the one utilized to transform the wind velocity into an effective pressure, as described in Subsection 3.3.1.2, is used with the following exceptions:

1) Velocity and velocity pressure are assumed not to vary with height.

2) The gust factor is taken as unity.

As shown in Figure 5 of Reference 3.3-5, and as explained therein, the equivalent uniform tornado wind velocity on the building due to a tangential component of 300 mph and a translational component of 60 mph is 220 mph. On Susquehanna SES the pressure loads are calculated on the basis of a uniform 300 mph wind velocity and are as follows FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDING:

		FOR DG 'E' BLDG
Windward pressure on walls:	185 psf	266 psf
Leeward suction on walls:	115 psf	166 psf
Total design pressure:	300 psf	432 psf
Suction (uplift) on roof:	140 psf.	199 psf

"The turbine building is designed to resist the tornado loading assuming 2/3 of the metal siding and the roof deck being blown away. However, all the frames are designed for the full tornado loading.

The metal siding and the roof deck of all structures are not designed to resist full tornado loading."

b) Differential Pressure Loading

Differential pressure loading is calculated using the following pressure-time function:

The differential pressure is assumed to vary from zero to 3 psi at the rate of 1 psi/sec, remain at 3 psi for 2 seconds and then return to zero at 1 psi/sec.

INSERT 'B' Blowout panels are used as necessary on safety related structures to minimize differential pressure.

c) Tornado-Generated Missiles

Tornado-generated missiles are classified as given in Tables 3.5-4 AND The barrier design procedures are described in Subsection 3.5.3. 3.5-4a.

Loadings a), b), and c) are combined in the following manner to obtain the total tornado loading:

(i) $W' = Ww$

(ii) $W' = Wp$

(iii) $W' = Wm$

(iv) $W' = Ww+0.5Wp$

(v) $W' = Ww+Wm$

(vi) $W' = Ww+0.5Wp+Wm$

where,

W' = Total tornado load

Ww = Tornado wind load

Wp = Tornado differential pressure load, and

Wm = Tornado missile load

3.3.2.3 Effect of Failure of Structures or Components Not Designed for Tornado Loads

Structures not designed for tornado loads are checked to ensure that during a tornado they will not generate missiles that have more severe effects than those listed in Table 3.5-4.

The modes of failure of these structures are analyzed to verify that they will not collapse on safety related structures.

3.3.3 REFERENCES

3.3-1. H.C.S. Thom, "New Distributions of Extreme Winds in the United States", Journal of the Structural Division, ASCE (July 1968), pp 1787.

3.3-2. "Wind Forces on Structures", ASCE Paper No. 3269, Transactions, Volume 126, Part II (1961), p 1124.

3.3-3. "Steel Tanks, Standpipes, Reservoir, and Elevated Tanks for Water Storage", AWWA Standard, D100-73.

3.3-4. "Tornado Design Classification", US NRC Regulatory Guide 1.117, (June 1976).

3.3-5. J.A. Dunlap and Karl Wiedner, "Nuclear Power Plant Tornado Design Considerations",Journal of the Power Division, ASCE, (March 1971).

INSERT 'A'

d) Dynamic wind loading (for Diesel Generator 'E' Building).

Tangential Speed: 360 mph
Translational Speed: 70 mph

e) Pressure differential between the inside and outside of diesel generator 'E' building.

A pressure drop of 3 psi at the rate of 2 psi per second.

INSERT 'B'

The differential pressure is assumed to vary from zero to 3 psi at the rate of 2 psi/sec, remain at 3 psi for 2 seconds and then return to zero at 2 psi/second. (FOR DIESEL GENERATOR 'E' BUILDING)

⑩

TABLE 3.3-2

TORNADO WIND PROTECTED SYSTEMS AND TORNADO RESISTANT ENCLOSURES

(Pg. 1 of 2)

	Protected System	Tornado Resistant Enclosure
1.	Reactor coolant pressure boundary	Reactor Building
2.	Reactor core and reactor vessel internals	Reactor Building
3.	Systems or portions of systems required for	
	a) Reactor shutdown	Reactor Building
	b) Residual Heat Removal	Reactor Building
	c) Cooling the spent fuel storage pool	Reactor Building
	d) Makeup water for primary system	Reactor Building
	e) Systems necessary to support service water, cooling water source, and component cooling	ESSW Pumphouse and Reactor Building
4.	Reactivity control systems	Reactor Building and Control Building
5.	Control room	Control Building
6.	Monitoring, actuating, and operating systems important to safety	Reactor Building and Control Building
7.	Electric and mechanical devices and circuitry between the process sensors and the input terminals of the actuator systems involved in generating signals that initiate protective action	Reactor Building, Diesel Generator Building, and ESSW Pumphouse DIESEL GENERATOR 'E' BUILDING,

⑪

TABLE 3.3-2 (Continued)

(Pg. 2 of 2)

	Protected System	Tornado Resistant Enclosure
8.	Long-term emergency core cooling system	Reactor Building, Diesel Generator Building, DIESEL GENERATOR 'E' BUILDING and ESSW Pumphouse
9.	Class 1E electric systems	All Seismic Category I structures

0

3.4 WATER LEVEL (FLOOD) DESIGN

As discussed in Section 2.4, all Seismic Category I structures are secure against flooding due to probable maximum flood (PMF) of the Susquehanna River or probable maximum precipitation (PMP) on the area surrounding the plant. Therefore, special flood protection measures are unnecessary. The Seismic Category I structures have, however, been designed for hydrostatic loads resulting from groundwater, as discussed in Section 3.8. The groundwater table is at elevation 665 MSL in the main plant area.

A postulated break in the cooling tower basins or of the water delivery pipes to the basin could result in a build-up of water against the walls of either or both of the ESSW pumphouse and the turbine building. In the event of such water build-up breaching the turbine building wall, water that would not be intercepted by the floor drains or grilles and thus would flow through the turbine building to the reactor building would be prevented from endangering equipment in the latter by means of watertight doors. Flood water building up against the ESSW pumphouse would also be prevented from entering the building by means of watertight doors. Impact forces and water pressure due to flood water will not endanger the integrity of the ESSW pumphouse.

All safety-related systems are located in the Reactor Building, Diesel Generator Building, Control Structure and the Engineered Safeguard Service Water (ESSW) Pumphouse.

DIESEL GENERATOR 'E' BUILDING

Sufficient physical separation between these buildings is provided to prevent internal spreading of any floods from one building to another.

Redundant Engineered Safety Features, pumps and drives, heat exchangers and associated pipes, valves and instrumentation in the reactor building subject to potential flooding, are housed in separate watertight rooms, with the exception of HPCI and RCIC rooms in Unit 2. Seismic Category I level detectors trip alarms in the main control room when the water level in any room exceeds the set point. Isolation of the floor drainage lines from these rooms is provided by outside manual valves.

All other rooms in the reactor building and control structure containing safety related equipment which are subject to potential flooding by process fluid leakage or fire protection water are provided with at least one open floor drain.

Floods in excess of the approximately 80 gpm floor drain capacity increase the water level in the affected area and are released through the door-to-floor clearance of these rooms.

Refer to Subsection 9.3.3 for a detailed description of the reactor building and control structure drainage system.

The four diesel generator sets are housed in individual water tight compartments within the diesel generator building. Floor drain line branches from each of these compartments are equipped with check valves to prevent backflooding from the common sump.

The ESSW pumphouse is divided into two redundant compartments. Flooding from internal leakage would, therefore, only affect one of the redundant pump sets. The control and electrical panels are mounted on minimum 4 inch high concrete pads or structural supports. Operating floor openings allow drainage of any leakage to the ESSW pump suction space below or to a reserve sump space that could be emptied with a portable pump.

The HPCI and RCIC rooms in Unit 2 are interconnected through a vent plenum which leads to the common blowout panel. Flooding in either room could potentially spill over to the other via the vent path. The vent path is 10'-8" above the floor. A moderate energy pipe break in each room has been postulated and analyzed in consistence with BTP APCSB3-1. It is conservatively estimated, without taking credit for floor drain capacity, that it will take approximately 13 hours for the maximum moderate energy pipe crack leakage in the RCIC room to overflow into the HPCI room, and 5 hours from HPCI room to RCIC room. The maximum moderate energy pipe crack leakage that cannot be isolated from outside these pump rooms will take approximately 23 hours to overflow from RCIC room to the HPCI room and 6 hours to overflow from HPCI room to RCIC room. There is sufficient time to identify the pipe failure and take appropriate action to mitigate the consequence of pipe failure prior to overflow occurred between those two interconnected rooms.

IN THE CASE OF DIESEL GENERATOR 'E' BUILDING, FLOOR DRAINS AT EL. 656'-6" ARE EQUIPPED WITH CHECK VALVES TO PREVENT BACKFLOODING FROM THE BUILDING SUMP. ALL FLOORS OF THE DIESEL GENERATOR 'E' BUILDING WHICH ARE SUBJECT TO POTENTIAL FLOODING BY FIRE PROTECTION WATER ARE PROVIDED WITH FLOOR DRAINS.

Commercial Aircraft

In V-232 18,000 movements x 0.12 x 10^{-11}/mi^2 x .04 mi^2 = .09 x 10^{-8} per year.

In V-106 3,000 movements x 1.9 x 10^{-11}/mi^2 x .04 mi^2 = .23 x 10^{-8} per year.

The sum of these event probabilities at the Susquehanna SES site is about 9.3 x 10^{-8}.

3.5.2 SYSTEMS TO BE PROTECTED

3.5.2.1 Missile Protection Design Philosophy

Systems that are reviewed for missile protection are listed in Subsection 3.12.2.

For internally generated missiles, protection is provided through basic station component arrangement so that, if equipment failure occurs, the missile does not cause the failure of a Seismic Category I structure or any safety related system. Where it is impossible to provide protection through station layout, suitable physical barriers are provided whose function is either to isolate the missile or to shield the critical system or component. In addition, redundant Seismic Category I components are suitably protected so that a single missile cannot simultaneously damage a critical component and its backup system.

3.5.2.2 Structures Designed to Withstand Missile Effects

Seismic Category I structures are designed to withstand postulated external or internal missiles which may impact them. Table ' 3-2 is a list of the structures designed to withstand external tornado generated missiles, and the safety related equipment which they protect. The missiles are listed in TableS 3.5-4 AND 3.5-4a for Structures other than Diesel Generator 'E' BUILDING and the Diesel Generator 'E' BUILDING respectively.

3.5.3 BARRIER DESIGN PROCEDURES

The structures and barriers are designed in accordance with the procedures detailed in Reference 3.5-5. The procedures include:

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a) Prediction of local damage (penetration, perforation, and spalling) in the impact area including estimation of the depth of penetration

b) Estimation of barrier thickness required to prevent perforation

c) Prediction of the overall structural response of the barrier and portions thereof to missile impact.

The use of a ductility ratio higher than 10 but less than the allowables given in Reference 3.5.5 will be governed by the following conditions:

(1) Reinforced concrete barriers

The allowable displacement of reinforced concrete flexure members can be based on an upper limit for plastic hinge rotation $r\theta$ as follows:

$$r\theta = 0.0065 \frac{d}{c} \leq 0.07$$

where

d = distance from compression face to centroid of tensile steel reinforcement (inch)

c = distance from compression face to the neutral axis at ultimate strength (inch)

This condition is given in section C.3.5 of Appendix C and commentary to Appendix C of ACI 349-~~76~~80

(2) Steel barriers

To insure the ability of a steel beam to sustain fully plastic behavior and thus to possess the assumed ductility at plastic hinge formation, it is necessary that the elements of the beam section meet minimum thickness requirements sufficient to prevent local buckling failure.

The conditions to preclude local buckling as given in AISC Manual are satisfied.

⑤

3.5.4 REFERENCES

3.5-1. GE Memo Report "Hypothetical Turbine Missile Data - 38 inch Last Stage Bucket Units" (March 16, 1973).

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3.5-5. "Design of Structures for Missile Impact", BC-TOP-9A, Rev. 2, Bechtel Power Corporation, San Francisco, California (September 1974).

3.5-6. U.S. Army, "Structures to Resist the Effects of Accidental Explosions", Dept. of the Army, Navy, and Air Force, (1969).

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3.5-8 Solomon, K.A., "Hazards Associated with Aircraft and Missiles", presented at American and Canadian Nuclear Society Meeting, Toronto, Canada, (June, 1976).

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3.5-11 Chelapati, C.V., Kennedy, R.P., and Wall, I.B., Probabilistic Assessment of Aircraft Hazard for Nuclear Power Plants, Nuc. Eng. Design 19,336 (1972).

3.5-12 Barber, R. B., Steel Rod/Concrete Slab Impact Test (Experimental Simulation), Bechtel Corp., (October, 1973).

3.5-13 Vasallo, F. A., Missile Impact Testing of Reinforced Concrete Panels, Prepared for Bechtel Corp., Calspan Corp., (January, 1975).

3.5-14 National Defense Research Committee, Effects of Impact and Explosion, Summary Technical Report of Division 2, Volume 1, Washington, DC, 1946

3.5-15 Gwaltney, R. C., Missile Generation and Protection in Light-Water-Cooled Power Reactors, ORNL NSIC-22, Oak Ridge National Laboratory, Oak Ridge, Tennessee, for the U.S.A.E.C., (September, 1968).

3.5-16 U.S. NUCLEAR REGULATORY COMMISSION "STANDARD REVIEW PLAN 3.5.1.4 REV.2" NUREG-0800 (JULY 1981)

3.5-17 U.S. NUCLEAR REGULATORY COMMISSION "STANDARD REVIEW PLAN 3.5.3 REV.1" NUREG-0800 (JULY 1981)

⑧

TABLE 3.5-4a

Tornado-Generated Missile Parameters for Diesel Generator 'E' Building.

Missile	Weight (lb)	Impact Velocity (fps)
A) Wood plank, 4 in. x 12 in. x 12 ft., traveling end-on	108	440
B) Steel pipe, 3 in. dia., Schedule 40, 10 ft. long, traveling end-on	72	147
C) Steel pipe, 6 in. dia., Schedule 40, 15 ft. long	285	170
D) Steel pipe, 12 in. dia., SCHEDULE 40, 15 FT. long	750	155
E) Steel rod 1-inch dia. x 3 ft. long	8	317
F) Automobile flying through the air at not more than 25 ft. above the ground and having contact area of 20 sq. ft.	4000	195
G) Utility pole 13.5 in. dia, 35 ft. long	1490	211

Note:

The vertical velocities will be considered equal to 80 percent of the horizontal velocities mentioned above.

⑦

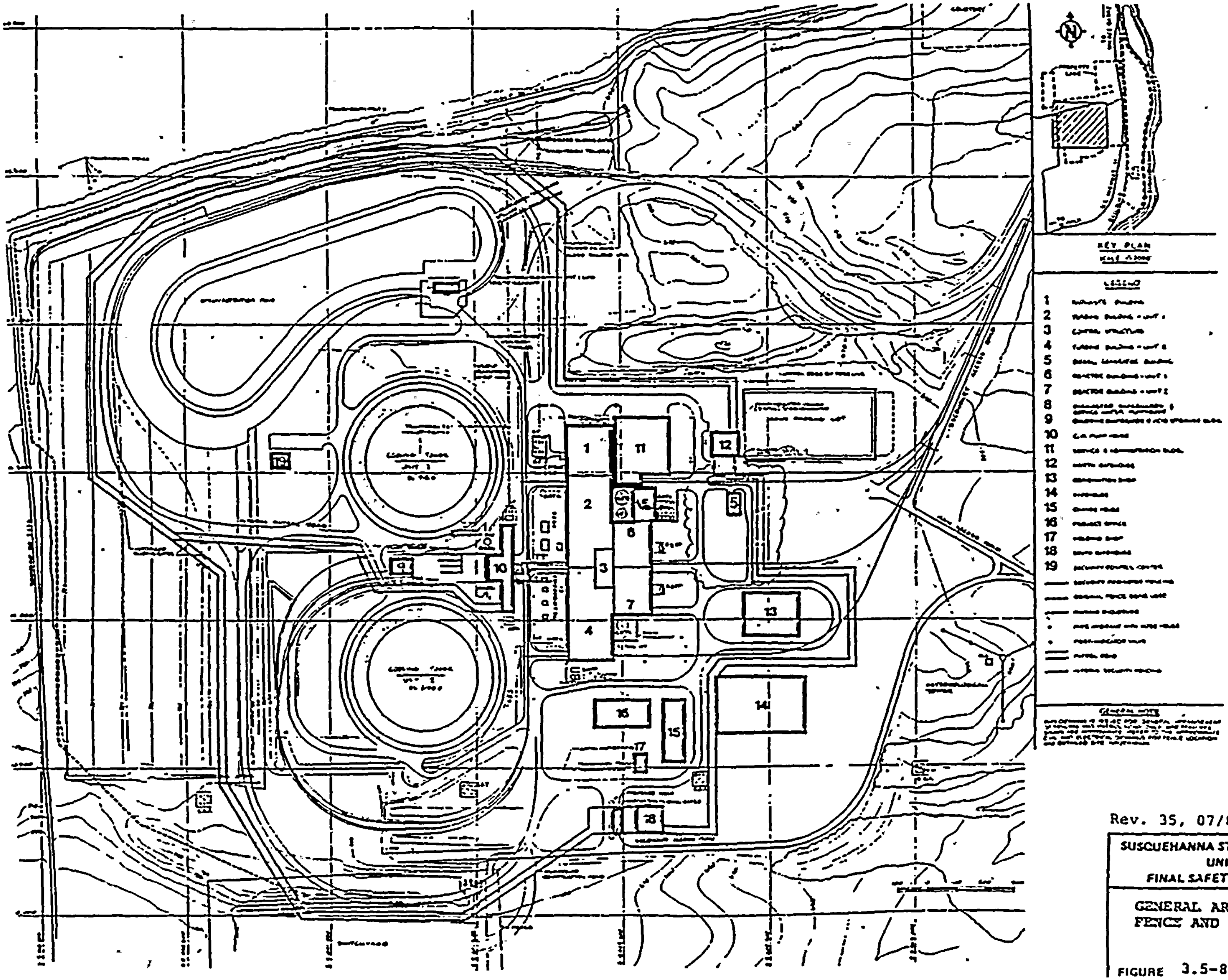
TABLE 3.5-4

TORNADO-GENERATED MISSILE PARAMETERS
(FOR STRUCTURES OTHER THAN DIESEL GENERATOR 'E' BUILDING)

Missile	Weight (lb)	Velocity (mph)
Wood plank, 4 in. x 12 in. x 12 ft, traveling end-on	108	300
Steel pipe, 3 in. dia., Schedule 40, 10 ft long, traveling end-on	76	100
Automobile flying through the air at not more than 25 ft above the ground and having contact area of 20 sq ft.	4000	50
Steel rod 1-inch diameter x 3 feet long	8	216
Utility pole 13-1/2 inch diameter, 35 feet long acting not more than 30 feet above the ground	1490	144

NOTE:

The vertical velocities will be considered equal to 80% of the horizontal velocities mentioned above.



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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

GENERAL ARRANGEMENT
FENCE AND PATROL ROAD

FIGURE 3.5-8

REF. 1
FSAR REV.
3.7b

3.7b SEISMIC DESIGN

This section describes the seismic design requirements and methods used for Susquehanna SES and the seismic design and analysis of non-NSSS equipment. Seismic design of NSSS equipment is described in Section 3.7a.

3.7b.1 SEISMIC INPUT

3.7b.1.1 Design Response Spectra

The site design response spectra for rock founded structures except diesel generator 'E' facility are illustrated on Figures 3.7b-1 and 3.7b-2 for the horizontal components of the Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) respectively. The diesel generator 'E' facility site horizontal design spectra has been scaled down from those given in Regulatory Guide 1.60, Rev. 1. (Refer to Figures 3.7b-102 thru 3.7b-105). The design earthquake is assumed to be the free field motion at the base mat of the structure without the effect of the structure. For all Seismic Category I structures founded on rock the horizontal ground acceleration values are 5 and 10 percent of gravity for OBE and SSE respectively (refer to Subsections 2.5.2.6 and 2.5.2.7). However, Seismic Category I structures founded on soil, and the spray pond have been designed for ground accelerations of 8 percent (OBE) and 15 percent (SSE) of gravity. The maximum ground displacement is taken proportional to the maximum ground acceleration and is set at 40 in. 36 in. for the diesel generator 'E' facility for a ground acceleration of 1.0 gravity.

The base diagram of all design spectra consists of three parts: the maximum ground acceleration line on the left part, the maximum ground displacement line on the right part, and the middle part depends on the maximum pseudo-velocity.

For various damping values, the numerical values of design displacements and accelerations for the horizontal component design response spectra are obtained by multiplying the values of the maximum ground displacement and acceleration by the corresponding factors given in Table 3.7b-1. For the diesel generator 'E' facility the numeric values for corresponding horizontal component follow Regulatory Guide 1.60, Rev. 1. ~~The~~ For all Seismic Category I Structures, except the diesel generator E facility, the acceleration lines of the design response spectra are drawn parallel to the maximum ground acceleration line between the frequency lines of 6.67 cps (control point B of Figures 3.7b-1 and 3.7b-2) and 2 cps (control point C). The acceleration lines converge at the junction of the maximum ground acceleration line and the 33 cps frequency line (control point A). For frequencies higher than 33 cps, the maximum ground acceleration line represents the design response spectra. The displacement lines

For the diesel generator 'E' facility, Regulatory Guide 1.60, Rev. 1 is followed.

are drawn parallel to the maximum ground displacement line. The maximum pseudo-velocity is assumed to be constant. Lines were drawn parallel to the constant velocity lines connecting the acceleration lines at control point C and the displacement lines.

For all Seismic Category I structures, except the diesel generator 'E' facility,

~~D~~design response spectra values for the vertical component of the earthquake are taken as 2/3 of the corresponding values of the horizontal component of the earthquake. For the diesel generator 'E' facility, Regulatory Guide 1.60, Rev. 1 is followed. The vertical ground acceleration values are the same as the horizontal ground acceleration values described above.

~~T~~the site design spectra deviate from those suggested in Regulatory Guide 1.60. Figures 3.7b-102 through 3.7b-105 provide comparison of the two. The damping values for the NRC spectra are those specified by Regulatory Guide 1.61 for reinforced concrete structures. For the diesel generator 'E' facility, Regulatory Guides 1.60, Rev.1 and 1.61, Rev. 0 are followed.

3.7b.1.2 Design Time History

A synthetic time history motion, for all Seismic Category I structures, except the diesel generator E' facility is generated by modifying the actual records of the 1952 Taft earthquake according to the techniques proposed in Reference 3.7b-1. Figure 3.7b-3 shows the normalized synthetic time history motion. The duration of the time history is 20 sec. The time interval of the time history is 0.005 sec.

Figures 3.7b-4 and 3.7b-5 show a comparison of the time history response spectra and the design response spectra for 2, 3, 5, and 7 percent damping values. The spectra are computed at the following frequency values (in cps):

0.2 to 1.0 (increment of 0.05)

1.0 to 10.0 (increment of 0.1)

10.0 to 30.0 (increment of 1.0)

Figure 3.7b-6 shows a comparison of the time history response spectra and the design response spectra for 2 and 5 percent damping values for a frequency range between 0.2 and 1.0 cps, with intervals of 0.0125 cps. All the above figures show that the time history response spectra envelop the design response spectra.

For the diesel generator 'E' facility, the horizontal and vertical synthetic time history motions are shown in Figures 3.7b-107 and 3.7b-108 respectively. The duration of these time histories is 25 seconds. The time interval of these time histories is 0.01 seconds. Figures 3.7b-109 thru 3.7b-114 show a comparison of the time history response spectra and the design response spectra for 2, 5 and 7 percent damping values. The spectra are computed at the frequencies suggested in Standard Review Plan 3.7.1, July 1981. All of the above figures show that the time history response spectra meet the acceptance criteria described in the same Standard Review Plan

3.7b.1.3 Critical Damping Values (Non-NSSS)

Table 3.7b-2 summarizes the damping values used on Susquehanna SES except for the diesel generator E facility. They are expressed as a percentage of critical damping and are based on Reference 3.7b-2. For the diesel generator 'E' facility, the damping values are taken from Regulatory Guide 1.61, Rev.0 and are summarized in Table 3.7b-7.

The ESSW pumphouse, piping to the reactor building and the spray pond and the diesel fuel tank for the diesel generator 'E' facility are the only Seismic Category I structures and systems founded on soil. The equivalent spring constants and the soil damping coefficients used in the analysis of the ESSW pumphouse are shown in Table 3.7b-3. These values are based on formulae contained in Table 3-2 of Reference 3.7b-3. A lumped representation of soil structure interaction was used.

Soil structure interaction is also considered in the generation of the response spectra for the containment. As in the ESSW pumphouse, a lumped representation of the soil structure interaction is considered. Table 3.7b-3 shows the equivalent spring and damping coefficients used in the containment model.

3.7b.1.4 Supporting Media for Seismic Category I Structures

All Seismic Category I structures, with the exception of ESSW pumphouse and the spray pond, and its pipe supports are founded on rock. For the structural analysis of the rock based structures, soil structure interaction is considered to be negligible due to the high stiffness of the rock which has a modulus of elasticity of approximately 3.0×10^6 psi. However, the response spectra of the containment are derived from a model that considers the flexibility of the rock.

The properties of the rock and soil supporting the ESSW pumphouse are shown in Table 3.7b-4. Discussion of the embedment of structures in soil will be limited to the ESSW pumphouse, since all the other structures are founded on rock.

The ESSW pumphouse is 59 ft high and rests on a 64 ft x 112 ft reinforced concrete mat foundation. The embedment depth of the foundation is 29 ft. The depth of soil below the mat foundation varies from 35 to 60 ft. The soil is predominantly sand, gravel, cobbles, and boulders. Near the surface, the soil is primarily sand and sandy gravel. With increasing depth, the soil changes to more cobbles and boulders. Near bedrock, the soil is mostly cobbles and boulders.

The site geology is discussed in detail in Section 2.5.

3.7b.2 SEISMIC SYSTEM ANALYSIS

Section 3.2 identifies Seismic Category I structures, systems, and components. Seismic Category I structures are considered seismic systems and are discussed here. Seismic Category I systems and components are considered seismic subsystems and are discussed in Subsection 3.7b.3. Seismic systems are analyzed for both the OBE and SSE.

3.7b.2.1 Seismic Analysis Methods

The response spectrum method, as described in Section 4.2.1 of Reference 3.7b-3, is used for seismic analysis of Seismic Category I structures. Separate lateral and vertical analyses of structures are performed. The responses are then combined to predict the total response of the structure.

A time history analysis of the Seismic Category I structures is done to generate the response spectra at the various mass points of the model.

The mathematical models used for these analyses are lumped mass, stick models. The same models were used for both the response spectrum and time history analyses with the exception of containment. In this case, the time history analysis used the flexible base models shown in Figures 3.7b-7 and 3.7b-8, whereas the structural analysis used a fixed base model. The fixed base model differs from the flexible base only in that the soil springs and dampers are assumed to be infinitely rigid, which results in a fixed base. The equivalency of the two models determined by comparing their dynamic characteristics is discussed in answer to NRC Question 130.20 in Volume 16 of FSAR.

The mathematical models of the reactor and control building are shown on Figures 3.7b-9 through 3.7b-11.

For all models, the masses are located at elevations of mass concentrations, such as floors and roofs. However, in the case of the containment which is a structure of continuous mass distribution, masses are lumped at approximately 15 ft intervals along the containment shell and reactor pedestal. These methods of mass distribution are in accordance with the procedures of Section 3.2 of Reference 3.7b-3 to provide an adequate number of masses.

The reactor and control buildings act as a single structure due to the monolithic construction. The entire reactor and control

building structure is shown as a single unit in Figure 3.7b-12. Both the control building and the line 29 wall of the reactor building are connected to the P-line wall, which is common to both the reactor and control buildings. In the east-west direction, the control building and the line 29 wall are considered to respond as a single unit.

The horizontal mathematical models are shown on Figures 3.7b-9 and 3.7b-10. The sticks represent shear walls located at the base mat elevation in the reactor building in the direction of the earthquake motion. In the east-west model (Figure 3.7b-9), the control building is lumped entirely on the line 29 stick. The entire control building is considered to contribute to the stiffness of the line 29 stick. In the north-south direction, the control building has its own stick connected to the P-line wall by springs.

The springs between the sticks represent the flexibility of the floor slab connecting each stick. Since these springs act in the direction of the earthquake motion, the model allows relative displacement between sticks.

Figure 3.7b-11 shows the vertical earthquake model of the reactor and control buildings. The left stick represents the steel columns. The right stick represents the shear walls of both the reactor and control buildings. The floors are represented by lumped masses and beam elements with the appropriate stiffness to capture the out of plane flexural vibration. Vertical translational coupling springs are provided to represent the coupling stiffness of the floor slab between the wall and column sticks. Mass numbers 8, 55, and 57 represent the fuel pool girder masses. Mass numbers 34, 35, 41, 43, 44, 46, 53 and 54 represent the floors between the fuel pool girders and columns/walls. Figure 3.7b-13 shows the correlation between the model mass points and the actual structure.

To more accurately determine the dynamic characteristics of the mathematical models the modulus of elasticity for concrete used in the analysis, is determined based on test results of concrete samples obtained from the plant site. The modulus value used is 720,000 ksf.

SEE INSERT A →

The seismic analysis of the Seismic Category I structures considers all modes whose frequencies are less than 33 cps. However, if a structure has only one or two modes with a natural frequency below 33 cps, then the three lowest modes are used. If a structure has three or less degrees of freedom, then all modes are considered in the analysis. For the diesel generator 'E' facility and its pedestal, all modes were considered.

The Seismic Category I structures are supported by continuous base mats; therefore, relative displacement of supports is not a consideration.

Nonlinear responses are not considered since the Seismic Category I structures are designed to remain elastic.

3.7b.2.2 Natural Frequencies and Response Loads

The natural frequencies of the containment and the reactor and control building below 33 cps are shown in Tables 3.7b-5 and 3.7b-6 respectively. The first seven frequencies of the reactor and control building in the east-west direction are dependent upon the location of the reactor building cranes.

The significant mode shapes of the containment and the reactor and control building are shown on Figures 3.7b-14 through 3.7b-43. The mode shapes for containment are for the horizontal and vertical directions. The reactor and control building mode shapes are for each of the three principal directions: east-west, north-south, and vertical. As with the frequencies, the first seven mode shapes of the reactor and control building in the east-west direction depend on the location of the cranes. Figures 3.7b-20 through 3.7b-26 show that it is the superstructure of the reactor building that is excited at these low frequencies. The location of the cranes is noted on the figures.

Figures 3.7b-44 through 3.7b-57 show the response (i.e., displacements, accelerations, shear forces, bending moments, and axial forces) of the containment for both OBE and SSE. The response of the reactor and control building is shown on Figures 3.7b-58 through 3.7b-79.

Response spectra at critical locations are shown on Figures 3.7b-80 through 3.7b-101. The curves are shown for each of the three principal directions at the damping values used for each design earthquake (see Subsection 3.7b.2.15 for further discussion of damping values). A brief description of the location of each series of curves is provided below with the corresponding figure numbers.

Figures 3.7b-80 through 3.7b-83	RPV Pedestal
Figures 3.7b-84 through 3.7b-89	Refueling Area
Figures 3.7b-90 through 3.7b-95	Diesel Generators A thru D Pedestal

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The DG "E" Building was represented by a horizontal and a vertical model (Figures 3.7b-119A and 3.7b-119B) to evaluate the seismic responses due to the horizontal and vertical seismic excitations, respectively. The horizontal model has four lumped masses, one at each floor elevation. The asymmetry in the building is accounted for by considering the eccentricity of each lumped mass location. The vertical model is the same as the horizontal model except that a vertical translational spring with a mass has been added at each mass location to account for the flexibility of each floor.

A finite element model consiting of beam and plate elements was generated for the DG "E" Building to evaluate its stiffness matrix at each lumped mass location.

The DG "E" Pedestal was represented by a stick model (Figure 3.7b-120) having three lumped masses, mass 1 located at C.G of the the Diesel engine and generator assembly, mass 2 and 3 at top and mid-height of the pedestal, respectively.

The modulus of elasticity of 4000 psi Concrete used in the DG "E" Building analysis has been taken as 3.6×10^6 psi

SEE INSERT B

Figures 3.7b-96 through 3.7b-101	Operating Floor of ESSW Pumphouse

3.7b.2.3 Procedure Used for Modeling

Seismic systems and subsystems were defined in Subsection 3.7b.2.

All equipment, components, and piping systems are lumped into the supporting structure mass except for the reactor vessel, which is analyzed using a coupled model of the containment structure and the reactor vessel (refer to Figures 3.7b-7 and 3.7b-8). See Section 3.2 of reference 3.7b-3 for the criteria of lumping the equipment, components and piping systems into the supporting structure mass.

Adequacy of the number of masses and degrees of freedom is discussed in Subsection 3.7b.2.1.

Each Seismic Category I structure is considered to be independent because of a gap between adjacent structures. For example, there is a 2 in. horizontal gap between the reactor and control building and the containment above the foundation mat.

To form these gaps rodofoam material (Ref. 3.7b-12) was used. Rodofoam was left in place in the following areas:

(1) Joints where the provided actual gap is 0-5 inch greater than that originally specified on the civil drawings.

(2) Joints where the interaction forces between structures due to presence of rodofoam cause insignificant effect on shear and moment.

3.7b.2.4 Soil Structure Interaction

All Seismic Category I structures, except the ESSW pumphouse and spray pond, are founded on rock. The seismic analysis of these structures is done assuming a fixed base. As stated in Subsection 3.7b.2.1, the containment response spectrum curves are generated from a flexible base model. The rock is assumed to be a homogeneous material comprising an entire elastic half-space. The soil springs and dampers used to represent the effect of the soil are discussed in Subsection 3.7b.1.3.

The FSSW pumphouse is supported by natural soil formation; consequently, soil structure interaction has been considered in the analysis of the pumphouse. Information regarding soil characteristics, foundation embedment, etc., is contained in Subsection 3.7b.1.4. The soil structure interaction analysis is performed using the lumped spring approach. The soil is considered a homogeneous material. The equivalent spring constants and the soil damping coefficients are discussed in Subsection 3.7b.1.3.

The seismic analysis of the spray pond is discussed in Subsection 2.5.5.

3.7b.2.5 Development of Floor Response Spectra

A time history analysis is used to develop the floor response spectra. The mathematical models used for this analysis are discussed in Subsections 3.7b.2.1, 3.7b.2.3, and 3.7b.2.4.

The floor response spectra are calculated at the frequencies listed in Table 5-1 of Reference 3.7b-3. Structural frequencies up to 33 cps are used.

For the diesel generator 'E' facility, the floor response spectra were generated at the frequencies per Regulatory Guide 1.122, Rev. 1

3.7b.2.6 Three Components of Earthquake Motion

Independent analyses are done for the vertical and two horizontal (east-west and north-south) directions. For design purposes, the response value used is the maximum value obtained by adding the response due to vertical earthquake with the larger value of the response due to one of the horizontal earthquakes by the absolute sum method. For the diesel generator E facility, the responses due to three simultaneous orthogonal components of an earthquake are combined by the square root of the sum of the squares method per Regulatory Guide 1.92, Rev. 1.

3.7b.2.7 Combination of Modal Responses

The modal responses, i.e., shears, moments, deflections, accelerations, and inertia forces, are combined by either the sum of the absolute values method or by the square root of the sum of the squares method. When the latter method is used, the absolute values of closely spaced modes for each group are added first and then combined with the other modes or groups of closely spaced modes by the square root of the sum of the squares method. Two consecutive modes are defined as closely spaced when their frequences differ from each other by 0.5 cps or less.

SEE INSERT C →

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The natural frequencies and corresponding participation factors for the DG "E" Building and its Pedestal are shown in Tables 3.7b-8 and 3.7b-9, respectively.

The response spectra generated for all floor elevations of the DG "E" Building are given in Project ~~in~~ Specification C-1041, Rev. 1. These curves were prepared for three orthogonal directions at damping values 1, 2, 3, 4, 5 and 7 percent for the SSE and 0.5, 1, 2, 3, 4 and 5 percent for the OBE.

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For the DG "E" ~~Building~~ Facility, the total response is obtained by combining the absolute values of all closely spaced modal responses with the square root of the sum of squares of the remaining modal responses. Two consecutive modes are defined as closely spaced when their frequencies differ from each other by 10 percent or less.

3.7b.2.8 Interaction of Non-Category I Structures with Seismic Category I Structures

Non-Category I structures that are close to Seismic Category I structures, viz., the turbine and radwaste buildings, have been designed to withstand an SSE. Dynamic analyses of these structures were done by the response spectrum method.

The remaining non-Category I structures were designed for seismic loads according to the UBC (Ref. 3.7b-4). The collapse of any of these remaining non-Category I structures will not cause the failure of a Seismic Category I structure.

Structural separations have been provided to ensure that interaction between Category I and non-Category I structures does not occur. The minimum separation at any point is maintained at one and a half times the absolute sum of the predicted maximum displacements of the two structures.

The rodofoam material which was used to form the separation gaps was left in place in some areas as mentioned in Section 3.7b.2.3.

3.7b.2.9 Effects of Parameter Variations on Floor Response Spectra

To account for variations in the structural frequencies owing to uncertainties in the material properties of the structure and to approximations in the modeling techniques used in the seismic analysis, the computed floor response spectra are smoothed and peaks associated with each of the structural frequencies are broadened. The parameters, which are considered variable, are the masses, the modulus of elasticity of the material, and the cross-sectional properties of the members. In addition, variation in the structural frequency is also taken into account because the base of the structures may not be fully fixed as assumed in the analysis.

Let

nf = Natural frequency of the building at a peak value of the floor response spectra

Δnf = Total variation in nf

Δnf_m = Variation in nf due to variation in the mass

Δnf_e = Variation in nf due to variation in the modulus of elasticity of the material

Δnf_s = Variation in nf due to variation in the cross-sectional properties of the members

A factor of 0.05 is used to account for the decrease in nf due to the possibility that the base of the structures may not be fully fixed.

Since it is highly improbable that the maximum variations in the individual parameters would occur simultaneously, Δnf is determined by the square root of the sum of the squares of the individual variations as follows:

The maximum increase in nf is given by:

$$+\Delta nf = \left[(\Delta nf_m)^2 + (\Delta nf_e)^2 + (\Delta nf_s)^2\right]^{1/2}$$

$$-\Delta nf = \left[(\Delta nf_m)^2 + (\Delta nf_e)^2 + (\Delta nf_s)^2 + (0.05)^2\right]^{1/2}$$

For all Seismic Category I structures, excluding the diesel generator E facility

~~On Susquehanna SES,~~ the following values of ± Δnf are used:

$+\Delta nf = 0.12\ nf$

$-\Delta nf = -0.14\ nf$

3.7b.2.10 Use of Constant Vertical Static Factors

Constant vertical static factors are not used in the seismic design of Seismic Category I structures. The methodology used for the vertical seismic analysis is similar to the horizontal analysis.

For the diesel generator 'E' facility, the computed floor response spectra were smoothed and peak width associated with each structural frequency was increased by ± 15 percent.

3.7b.2.11 Methods Used To Account for Torsional Effects

Torsional effects for the diesel generator building and ESSW pumphouse are accounted as follows:

A static analysis was done to account for torsion on these two structures. For the ESSW pumphouse the eccentricity was determined by the distance between the center of mass and the center of rigidity of the structure. The inertia force from the response spectrum analysis was applied at the center of mass. The resulting torsional moment is equal to the inertial force times the eccentricity. The shear forces due to the torsional moment were then distributed to the walls. The torsional shear forces are distributed according to the method described in Section 3.4 of Reference 3.7b-5.

In the diesel generator building, torsion is considered due to the eccentricity caused by the difference in rigidities of the east and west shear walls. The torsional shear forces are assumed to be taken entirely by east and west walls only.

Torsional effects are negligible for the containment because of the symmetry of the structure.

The reactor/control building is modeled for horizontal dynamic analysis as multiple sticks coupled by springs representing the shear stiffness of the floor slabs. Each stick represents a major structural shear wall. The mass and stiffness distribution of the structural walls is such that torsional effects are properly represented in the dynamic analysis.

Torsional effects for the diesel generator building, ESSW pumphouse, and reactor/control building are also discussed in response to NRC questions 130.21 and 130.22.

SEE INSERT E →

3.7b.2.12 Comparison of Responses

Figures 3.7b-4 through 3.7b-6 show that the response spectra of the time history envelop~~e~~ the design response spectra at all frequencies. The time history has been used to generate response spectra in the structures but has not been used to calculate forces in the structures. Response in containment, a typical Category I Structure, obtained from the response spectrum analysis compare closely with those obtained from time history analysis based on studies comparing displacements and accelerations obtained by the two methods. For the diesel generator 'E' facility, the above two comparisons are shown in Figures 3.7b-109 thru 3.7b-118.

3.7b.2.13 Methods for Seismic Analysis of Dams

Dams are not provided on Susquehanna SES.

3.7b.2.14 Determination of Seismic Category I Structure Overturning Moments

For the diesel generator E facility, the total acceleration at each floor elevation, due to an earthquake component resulting from the modal combination described in Subsection 3.7b.2.7 are used to compute the overturning moment.

excluding the diesel generator 'E' facility

The overturning moments for Seismic Category I structures is the sum of the moments at the base of each stick of the mathematical model. For each stick, the moment at the base is determined by combining the model overturning moments. The moments are combined by the methods described in Subsection 3.7b.2.7.

The components of the earthquake motion used are the same as those discussed in Subsection 3.7b.2.6.

Subsection 3.8.5 discusses the factor of safety against overturning for several loadings which include seismic loads.

3.7b.2.15 Analysis Procedure for Damping

except the diesel generator 'E' facility

The structures consist of reinforced concrete and welded/bolted structural steel. Damping values for these materials are shown in Table 3.7b-2. However, in the seismic analysis of the structures, damping values of 2 and 5 percent are used for OBE and SSE respectively for reinforced concrete, as well as welded/bolted structural steel. Therefore, analysis of composite model damping is not necessary.

All Seismic Category I structures except the ESSW pumphouse and spray pond and its pipe supports are founded on rock. Consequently, soil damping values are calculated for the ESSW pumphouse as described in Appendix D of Reference 3.7b-3.

The interaction damping values for the time history analysis of the containment are also calculated by the method described in Appendix D of Reference 3.7b-3.

For the diesel generator E facility, the damping values for various materials are shown in Table 3.7b-7. For a structural system consisting of various components having different materials, composite modal damping is computed in accordance with Standard Review Plan, Rev. 1, Sheet 3.7.2.11, equation (4).

Ⓔ

For the DG "E" Building, the torsional effects due to its asymmetry are accounted for by lumping the floor masses at their respective CG's in the mathematical model of the building discussed in Section 3.7b.2.1. The stiffness matrix is calculated at these mass points and thus reflects the actual asymmetrical building configuration including the various wall openings. To account for accident torsion, an additional torsional moment, produced by an eccentricity of ± 5 percent of the maximum building dimension, is added to the gross torsional moment obtained from the dynamic analysis of the above mathematical model.

3.7b.3 SEISMIC SUBSYSTEM ANALYSIS

As explained in Subsection 3.7b.2, this section discusses the seismic analysis of subsystems, i.e., equipment, piping, Class IE cable trays and supports for Seismic Category I HVAC ducts and cable trays.

3.7b.3.1 Seismic Analysis Methods

3.7b.3.1.1 Equipment

Seismic qualification of equipment is performed by using one of the following methods:

a) Analysis

b) Dynamic testing

c) Combination of analysis and dynamic testing

3.7b.3.1.1.1 Analysis

Seismic qualification of equipment is performed by analysis when the equipment can be adequately represented by a model and the analysis can determine its structural and functional adequacy. The analysis can either be an equivalent static analysis or a dynamic analysis.

Equivalent static analysis is described in Subsection 3.7b.3.5.

Dynamic analysis can be classified into three cases according to the relative rigidity of the equipment based on the magnitude of the fundamental natural frequency. Dynamic Analysis refer to Seismic Loads only, a discussion of the Hydrodynamic Load can be found in the DAR Subsection 7.1.7.

For structurally simple equipment, which can be represented by a one degree of freedom system, the dynamic load consists of a static load obtained as the equipment weight time the acceleration corresponding to the equipment's natural frequency. It the fundamental frequency is not know, the peak acceleration from the response spectra is taken.

For rigid equipment having a fundamental frequency greater than 33 Hz, the dynamic load consists of a static load obtained as the equipment's weight times the acceleration corresponding to 33Hz.

For structurally complex equipment, which cannot be classified as structurally simple or rigid, the equipment is idealized by a mathematical model and dynamic analysis is performed using standard analytical procedures. An alternative method used for verifying structural integrity of members physically similar to beams and columns is the static coefficient method. In this method no determination of natural frequency is made. Dynamic forces are calculated as product of the weight and peak acceleration of response spectra multiplied by a static coefficient of 1.5.

Damping values used are given in Table 3.7b-2 and 3.7b-7

3.7b.3.1.1.2 Dynamic Testing

Dynamic testing is performed when analysis is insufficient to determine either the structural or functional adequacy of the equipment or both. Typical test methods used are as follows:

a) Single frequency sine beat test

b) Single frequency dwell test

c) Multifrequency test

All seismic qualification tests subject the equipment to excitation for at least 30 seconds.

3.7b.3.1.1.3 Combination of Analysis and Dynamic Testing

Certain equipment is qualified by a combination of analysis and dynamic testing.

3.7b.3.1.2 Piping Systems

BP-TOP-1, Rev. 3 (Ref. 3.7b-6) and AEG-502, Rev.0 (Ref. 3.7b-14) describes the methods used for seismic analysis of piping systems found in all Seismic Category I structures, excluding the diesel generator 'E' facility. Reference 3.7b-6 is followed on Susquehanna SES with the following exceptions:

In seismic analysis the modal responses are combined by SRSS and lower damping values than specified in Reference 3.7b-6 are used.

See Subsection 3.7b.3.7.

AEG-502, Rev. 0 (Ref. 3.7b-14) describes the methods used for seismic analysis of piping systems found in the diesel generator 'E' facility.

3.7b.3.1.3 Class IE Cable Trays

The cable trays are seismically qualified by the capacity evaluation method which consists of the following:

a) Calculation of the fundamental frequency of the cable tray based on the tray properties obtained from static tests

b) Seismic load computation based upon the tray frequency, the possible support frequencies and the design spectra

c) Calculation of the tray allowable capacity

d) Evaluation of the tray capacity by interaction formulae

For the diesel generator E facility equivalent static analysis is used in lieu of steps (a) and b).

3.7b.3.1.4 Supports for Seismic Category I HVAC Ducts

The supports of HVAC ducts are analyzed by the response spectrum method.

3.7b.3.1.5 Concrete Block Masonry Structures (Blockwalls)

The dynamic analysis of safety related concrete masonry blockwalls in Class I structures is performed by the response spectrum method. Response spectrum for the lower floor has been used for vertical motion and for walls, cantilevered from the floor. For horizontal motion, the acceleration of the lower floor or average of the lower and upper floor, whichever is greater, is used in determining inertia loads. Frequency calculations for blockwalls supporting class I attachments or located in areas of class I equipment are based on either cracked section, partially cracked section, or uncracked section properties; whichever represents the condition based upon the calculated loads.

Partially cracked section analysis is based on the following ACI 318 (Ref. 10A of Table 3.8-1) formula

$$I_e = (M_{cr}/M_a)^3\ I_g + (1 - (M_{cr}/M_a)^3)\ I_{cr}$$

where,

I_e = effective moment of inertia of cracked Section

I_{cr} = moment of inertia of cracked Section

M_a = bending moment applied to the blockwall

I_g = Gross section moment of inertia (uncracked)

M_{cr} = cracking bending moment = $\frac{fr\ I_g}{yt}$

fr = modulus of rupture for masonry = 50 psi

modulus of rupture for concrete = 6 f' c psi

Y_t = distance from centroid axis of gross section to the extreme fiber in tension.

For assessing the effects of frequency variations on the responses, the variable items such as boundary conditions, mass, modulus of elasticity, cracking moment are considered. Damping values used are in accordance with Table 3.7b-2. The response of attachments to blockwalls is determined as described in Subsection 3.7b.3.1.1.1.

The three components of earthquake motion are combined in accordance with Subsection 3.7b.2.6.

3.7b.3.1.6 Supports of Seismic Category I Electrical Raceway Systems

This section defines the procedures used for the design of the supports of electrical raceway systems, i.e., cable tray, conduit, and wireway gutter systems, subject to the seismic and other applicable loads. The raceway support system usually consists of raceways, horizontal and vertical support members and lateral and longitudinal bracing members.

3.7b.3.1.6.1 Loading Combinations

In all Seismic Category I structures, except the diesel generator 'E' facility, the ~~The~~ adequacy of raceway systems to withstand seismic and other applicable static loads is determined according to the loading combinations and allowable responses given below:

Equation	Condition	Load Combination	Allowable Response
1	Normal	D + L	F - See note 4
2	Normal/Severe	D + L + E	See Notes 2 & 4
	(Equation 2 applies only to connections for fatigue considerations.)		
3	Abnormal/Extreme	D + E'	See Notes 2, 3, & 4

Notes:

1. For notations, see Table 3.8-2.
2. The following equation is applicable for bending in overhead connections:

$$\frac{5n_{EQ}}{N_{OBE}} + \frac{n_{EQ}}{N_{SSE}} \leq 1.0$$

where:

n_{EQ} = Total number of load/stress cycles per earthquake.

N_{OBE} = Allowable number of load/stress cycles per OBE event.

N_{SSE} = Allowable number of load/stress cycles per SSE event.

3. The following criteria are used for checking the members. In no case shall the allowable stress exceed 0.90F in bending, 0.85F in axial tension or compression, and 0.50F in shear. Where the design is governed by requirements of stability (local or lateral buckling), the actual stress shall not exceed 1.5F .
4. Allowable shear and normal loads in connections are determined from the manufacturers' data or from code allowable stresses whichever is applicable.

The allowable values are increased 50% for load combination equation 3.

SEE INSERT G

3.7b.3.1.6.2 Analytical Techniques

In all Seismic Category I structures, except the diesel generator 'E' facility either ~~Either~~ of two methods of analysis is used. Method 1 is a simplified method of analysis which determines the fundamental frequency of braced supports using two dimensional analysis. Frequencies are determined in each of three principal directions. Then loads are determined by taking the spectral accelerations times the weight; and stresses are determined from static analysis. All members and connections are checked using stress criteria.

Method 2 uses a three dimensional computer analysis and includes springs to represent joint stiffnesses. Response spectrum analyses are done to determine stresses and deformations. The number of stress cycles is determined by multiplying the time of maximum earthquake motion by the natural frequency of the system. The allowable number of cycles is taken from Reference 3.7b-8 for the joint rotations calculated. Only overhead connections are checked for fatigue since the test results (ref. 3.7b-8, pg. 7-19) demonstrate that failures occur only in overhead connections.

The basis for the design criteria and analysis method 2 is the "Cable Tray and Conduit Raceway Test Program" (references 3.7b-7 through 3.7-10).

SEE INSERT H

3.7b.3.1.6.3 Damping

In all Seismic Category I structures, except the diesel generator 'E' facility damping ~~Damping~~ of 7% of the critical is used for the design of all raceway systems. The test program demonstrates that for cable tray systems damping is, in general, much higher than 7%. Reference 3.7b-7 recommends using 20% but values up to 50% are reported. The recommended damping values, developed from the test program and based on lower bound values, are shown in Figure 3.7b-106. Damping is amplitude dependent, i.e., it increases with increasing amplitude of input motion. For conduit systems the damping increases with increasing amplitude, but is much lower than for cable tray systems. This 7% is a realistic value for input motion exceeding 0.1g for conduit systems. Wireway gutters were not tested; however, the manner in which they are constructed - with more bolted connections and more cables than conduit - provides more damping mechanisms that are present in conduit systems so that 7% is a conservatively low damping value.

For diesel generator 'E' facility a damping value of 3 percent for OBE conditions and 5 percent for SSE conditions were used for cable tray supports. In case of conduit supports, 2% damping was used for OBE conditions and 3 percent for SSE conditions, in order to ensure the design is conservative.

INSERT 'G'

DIESEL GENERATOR 'E' BUILDING.

The loading combinations and the allowable stresses for the design of cable tray supports in the Diesel Generator 'E' Building are as follows:

SERVICE LOAD.

1. S = D + L
2. S = D + E

FACTORED LOAD.

1. 1.6 S = D + E'

The definitions of terms S, D, L, E and E' are as per table 3.8-9a.

INSERT 'H'

DIESEL GENERATOR 'E' BUILDING.

Static coefficient method of analysis is used for the design of cable tray supports. In this method, the acceleration response of the cable tray is assumed to be the peak of the response spectrum at the damping values described in Section 3.7b.3.1.6.3. This response is then multiplied by a static coefficient of 1.5 to take into account the effects of both multifrequency excitation and multimode response

3.7b.3.1.6.4 Operating Basis Earthquake (OBE)

The OBE is considered in the load combinations only for the overhead connections which are checked for fatigue. The OBE stresses are not checked during design for two reasons: first, raceway systems do not fail in a brittle or catastrophic mode as demonstrated by the test program in which such failures did not occur and the electrical systems were able to continue to function in all cases. Thus, there is no need to limit the OBE stresses to the low levels usually used to preclude such failures. Second, the OBE stresses will always be less than the SSE stresses as demonstrated below.

In all cases the ZPA values are high enough to use 7% damping based on Figure 3.7B-106 since they all exceed 0.1g. A comparison of response spectra for corresponding damping values demonstrates that for all response spectra the OBE acceleration values are less than the corresponding SSE acceleration values. (See References 3.7b-8 and 3.7b-10) Thus, the OBE acceleration response and stresses are below the SSE acceleration response and stresses.

3.7b.3.2 Determination of Number of Earthquake Cycles

In general, the design of the equipment is not fatigue controlled because the equipment is elastic and the number of cycles in an earthquake is low.

Equipment that is qualified by analysis is designed to remain elastic during the earthquake. Any fatigue effects in tested equipment are accounted for by performing extended duration test on selected specimens. Consequently, the number of cycles of the earthquake has been accounted for.

In order to conduct a fatigue evaluation for nuclear Class I piping, the number of cycles for a given load set is obtained. This is done by considering ten maximum stress cycles per earthquake and five OBE's and one SSE to occur within the life of the plant.

3.7b.3.3 Procedure Used for Modeling

The models are developed to represent the equipment. Two or three dimensional models are used depending on the complexity of the equipment. The boundary conditions are modeled to reflect

the in-plant mounting conditions. The equipment is represented by lumped mass models. Massless elastic members are used to connect the masses.

Supports for HVAC ducts are modeled as two dimensional, lumped mass, plane frame models. The masses are lumped at the center of the ducts. The cable tray support analytical techniques are discussed in Subsection 3.7b.3.1.6.2. The cable tray properties are determined from the load deflection tests (see Reference 3.7b-11).

Sections 2.0 and 3.0 of Reference 3.7b-6 discuss the techniques and procedures used to model piping other than the buried type.

3.7b.3.4 Basis for Selection of Frequencies

The natural frequencies of components are calculated. If the natural frequency of the component falls within the broadened peak of the response spectrum curve, then it is designed to withstand the peak acceleration.

3.7b.3.5 Use of Equivalent Static Load Method of Analysis

The equivalent static load method of analysis is used when the natural frequency of the equipment is not determined. If the equipment can be adequately represented by a single degree of freedom system, then the applied inertia load is equal to the weight of the equipment times the peak value of the response spectrum curve. If the equipment requires more than one degree of freedom for an adequate representation, then a factor of 1.5 is applied to the peak of the response spectrum curve.

Section 2.3.2 and Appendix D of Reference 3.7b-6 discuss the use of equivalent static load method of analysis as applicable to piping.

3.7b.3.6 Three Components of Earthquake Motion

For equipment, cable trays, and supports for cable trays and HVAC ducts, the three spatial components of the earthquake are considered in the same manner as for structures (described in Subsection 3.7b.2.6).

The criteria used for combining the results of horizontal and vertical seismic responses for piping systems are described in Section 5.1 of Reference 3.7b-6.

3.7b.3.7 Combination of Modal Responses

The modal responses of equipment (excluding the equipment in the Diesel Generator "E" Build are combined by the square root of the sum of the squares method. The absolute values of two closely spaced modes are added first before combining with the other modes by the square root of the sum of the squares method. Two consecutive modes are defined as closely spaced when their frequencies differ from each other by 10 percent or less. For equipment located in the Diesel Generator "E" Building, the modal responses are combined using the criteria presented in Regulatory Guide 1.92.

Procedures given in Regulatory Guide 1.92 for combining modal responses, when closely-spaced modes are present, are not complied with in the seismic response spectra analysis for piping, except for piping within the DG "E" facility. All modal responses are combined by square root of sum of squares (SRSS) in the response spectra method of modal analysis for seismic loading (OBE and SSE). Seismic response spectra used in the piping analysis corresponds to conservative damping values of 1/2% for OBE and 1% for SSE. The damping values used for the DG "E" facility correspond to those presented in Regulatory Guide 1.61.

The procedures used in evaluating the piping system for hydrodynamic loads (SRV and LOCA) by response spectra method is in compliance with Regulatory Guide 1.92. The modal responses in this case are combined in accordance with section 5.2 of BP-TOP-1, Rev. 3, which has been accepted by the NRC staff, per the letter dated September 29, 1976, from Karl Kniel, Chief Light Water Reactors Branch No. 2, Division of Project Management to Burton L. Lex, Bechtel Power Corporation.

The criteria used for piping systems are described in Sections 5.1 and 5.2 of Reference 3.7b-6

3.7b.3.8 Analytical Procedures for Piping

The design criteria and the analytical procedures applicable to piping systems are as described in Section 2.0 of Reference 3.7b-6. The methods used to consider differential piping support movements at different support points are as described in Section 4.0 of Reference 3.7b-6.

3.7b.3.9 Multiply Supported Equipment and Components with Distinct Inputs

For cable trays and ducts whose supports have two distinct inputs, a response spectrum curve is used that envelopes the curves at the two locations. Section 4.0 of Reference 3.7b-6 discusses the methods used for the analysis of multiple supported piping systems.

3.7b.3.10 Use of Constant Vertical Static Factors

Constant vertical static factors are not used in the seismic design of subsystems.

3.7b.3.11 Torsional Effects of Eccentric Masses

The torsional effects of valves and other eccentric masses are considered in the seismic analysis of piping by the techniques discussed in Section 3.2 of Reference 3.7b-6.

3.7b.3.12 Buried Seismic Category I Piping Systems and Tunnels

Buried Seismic Category I piping has been analyzed and designed for seismic effects in accordance with Section 6.0 of Reference 3.7b-3, and Reference 3.7b-13 for the DG "E" Facility.

The majority of the anticipated settlement due to static loading of the ESSW Pumphouse will have occurred prior to connecting the piping to the building. During a SSE event, the differential settlement between the pumphouse and the surrounding soil which supports the piping, will be less than one inch (see Subsection 2.5.4.7 for further discussion of settlements). This movement will be accommodated by the piping without exceeding code allowable stresses.

Tunnels on the Susquehanna SES are non-Seismic Category I.

3.7b-12 Rodofoam II manufactured by W. R. Grace & Co. or equivalent equal.

3.7b-13 M.A. Iqbal and E.C. Goodling, "Seismic Design of Burried Pipes," Presented at the 2nd ASCE Specialty Conference on Structural Design of Nuclear Plant Facilities at New Orleans, Louisiana December, 1975

3.7b-14 "Seismic Analysis of Piping Systems in Nuclear Power Plants", AEG-502, Rev. 0, Gibbs and Hill, Inc., New York, New York (June 1981)

SSES— FSAR

TABLE 3.7b-8

MODAL FREQUENCIES AND PARTICIPATION FACTORS FOR DIESEL GENERATOR "E" BUILDING SEISMIC MODELS

Horizontal Model

Freq. (Hz)	γ_x	γ_z
7.17	−0.10	−15.36
9.75	−15.29	0.11
14.46	−0.05	0.94
22.28	−0.28	−7.06
22.70	1.80	−1.07
25.25	−6.79	−0.04
30.80	0.05	−5.53
33.89	0.21	1.23
36.42	−1.52	0
38.13	−0.68	−0.02
38.34	−5.72	0.02
45.26	0.36	0.04
49.84	−0.90	0.01
52.85	−0.11	0.07
61.02	−0.13	0.03
62.85	−0.03	0.01
68.42	−0.49	−0.05
72.29	−0.07	0.42
75.26	−0.14	−0.14
77.85	−0.40	
83.21	−0.02	−0.08
83.83	−0.03	0.28
98.42	0.03	0.01
113.94	0	0.02

Vertical Model

Freq. (Hz)	γ_y
7.17	−0.04
9.75	0.41
13.93	−3.77
14.14	5.17
14.46	0.02
15.08	−3.10
22.29	−0.53
23.83	12.73
25.46	−6.41
30.80	0.14
33.89	0.23
36.17	3.35
38.11	0.60
38.27	0.57
43.78	1.65
45.26	0.04
49.85	−0.05
52.85	0.05
62.84	−0.28
65.02	5.47
68.99	−1.32
72.47	−0.52
77.43	4.02
78.72	0.96
83.70	1.19
84.01	0.82
103.20	−0.37
113.96	0

NOTE :

γ_x = PARTICIPATION FACTOR IN X (N-S) DIRECTION
γ_y = " " Y (VERTICAL) "
γ_z = " " Z (E-W) "

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TABLE- 3.7b-7

DAMPING VALUES FOR NON-NSSS MATERIALS FOR DG "E" FACILITY

(Percent of Critical Damping)

Structure or Component[3]	Operating Basis Earthquake (OBE)[1]	Safe Shutdown Earthquake (SSE)
Equipment and large-diameter piping systems[2], pipe diameter greater than 12 in.	2	3
Small-diameter piping systems, diameter equal to or less than 12 in.	1	2
Welded steel structures . . .	2	4
Bolted steel structures . . .	4	7
Reinforced concrete structures	4	7

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[1] In the dynamic analysis of active components as defined in U.S. NRC Regulatory Guide 1.48, these values should be used for the SSE.

[2] Include both material and structural damping. If the piping system consists of only one or two spans with little structural damping, use values for small-diameter piping.

[3] If the maximum combined stresses due to static, seismic, and other dynamic loading are significantly lower than the yield stress and 1/2 yield stress for SSE and OBE, respectively, in any structure or component, damping values lower than those specified above should be used for that structure or component to avoid underestimating the amplituide of variations or dynamic stresses.

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TABLE 3.7b-9

FREQUENCIES AND MODAL PARTICIPATION FACTORS
FOR DIESEL GENERATOR "E" PEDESTAL SEISMIC MODEL

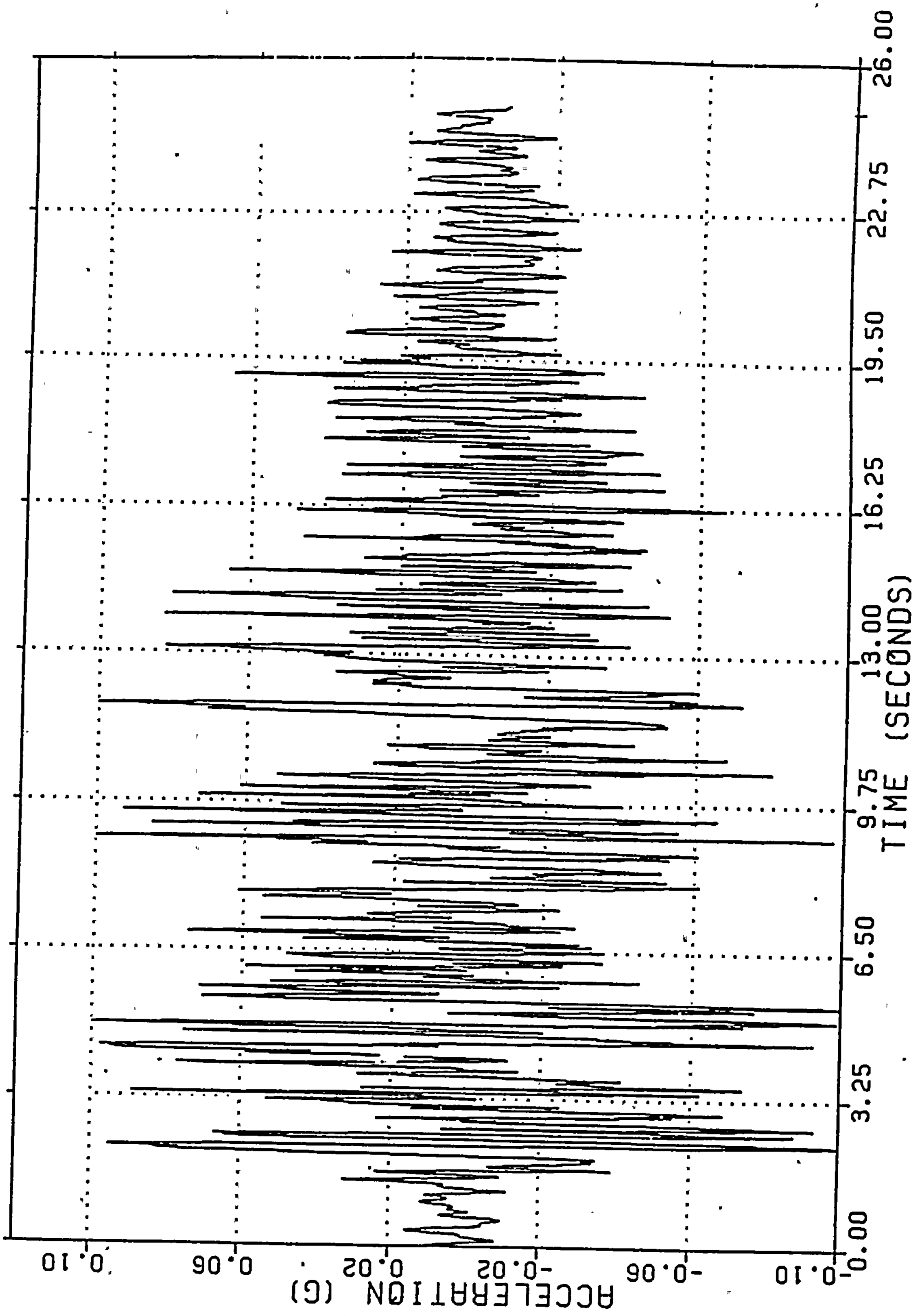
Freq. (Hz)	γ_x	γ_y	γ_z
1844	0	0	4.11
27.81	1.39	0	0
29.94 *	0	0	0
32.24	0	3.14	0
37.72	0	0	-2.38
50.59	-4.78	0	0
77.36 *	0	0	0
101.09	0	0	-2.45
129.49	-2.11	0	0
132.54	0	-4.35	0
150.07 *	0	0	0
162.63	0	0	-0.71
183.03	-0.30	0	0
234.87	0	0	0.52
256.81	0	0	-0.12
304.22	0.17	0	0
317.88	0	-0.79	0
345.58	0.01	0	0

* Torsional mode

NOTE:

γ_x = PARTICIPATION FACTOR IN X (N-S) DIRECTION
γ_y = " " Y (VERTICAL) "
γ_z = " " Z (E-W) "

20



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UNITS 1 AND 2
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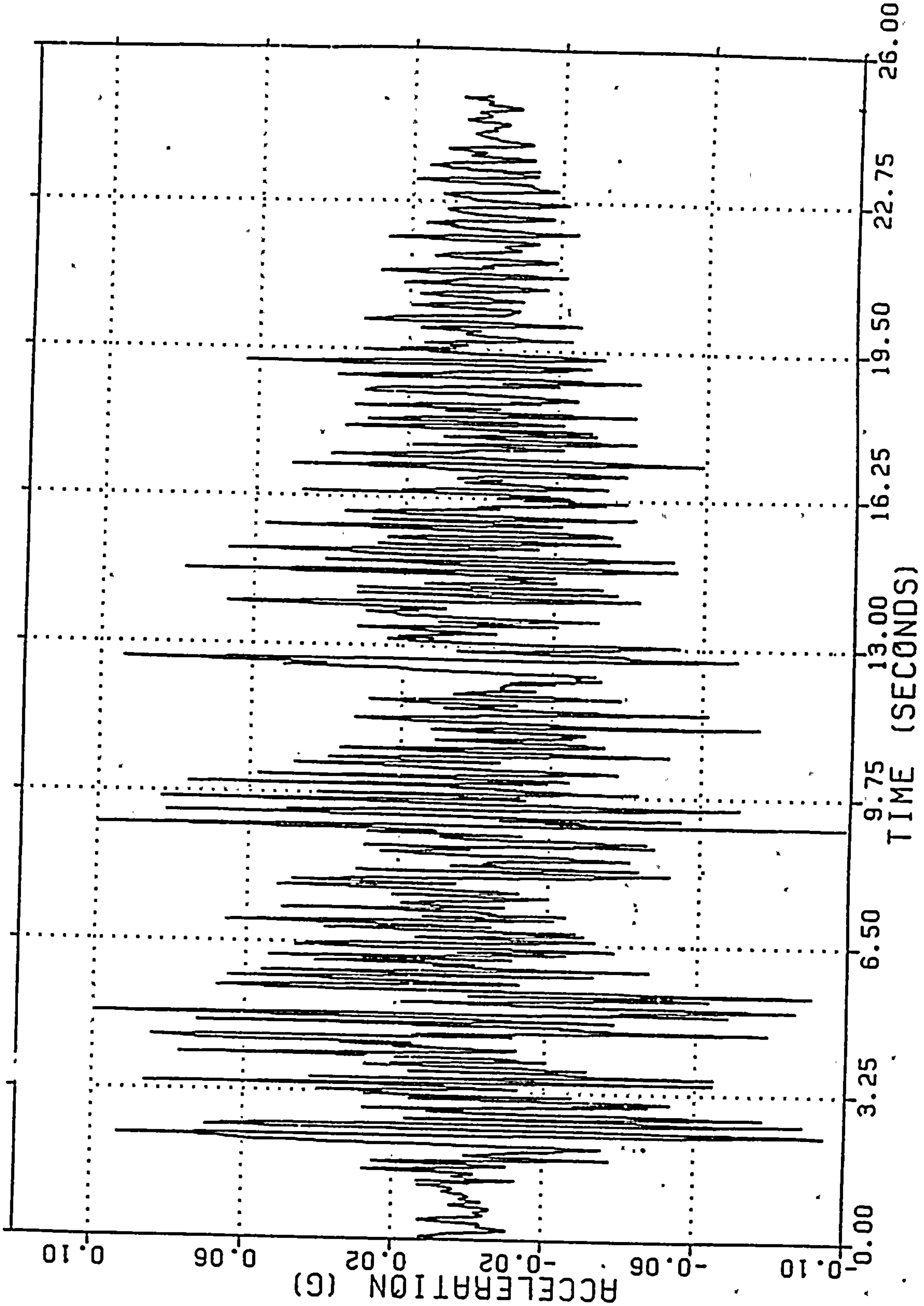
DIESEL GENERATOR "E" FACILITY
HORIZONTAL SYNTHETIC TIME
HISTORY NORMALIZED TO 0.1 G

FIGURE 3.7b-107



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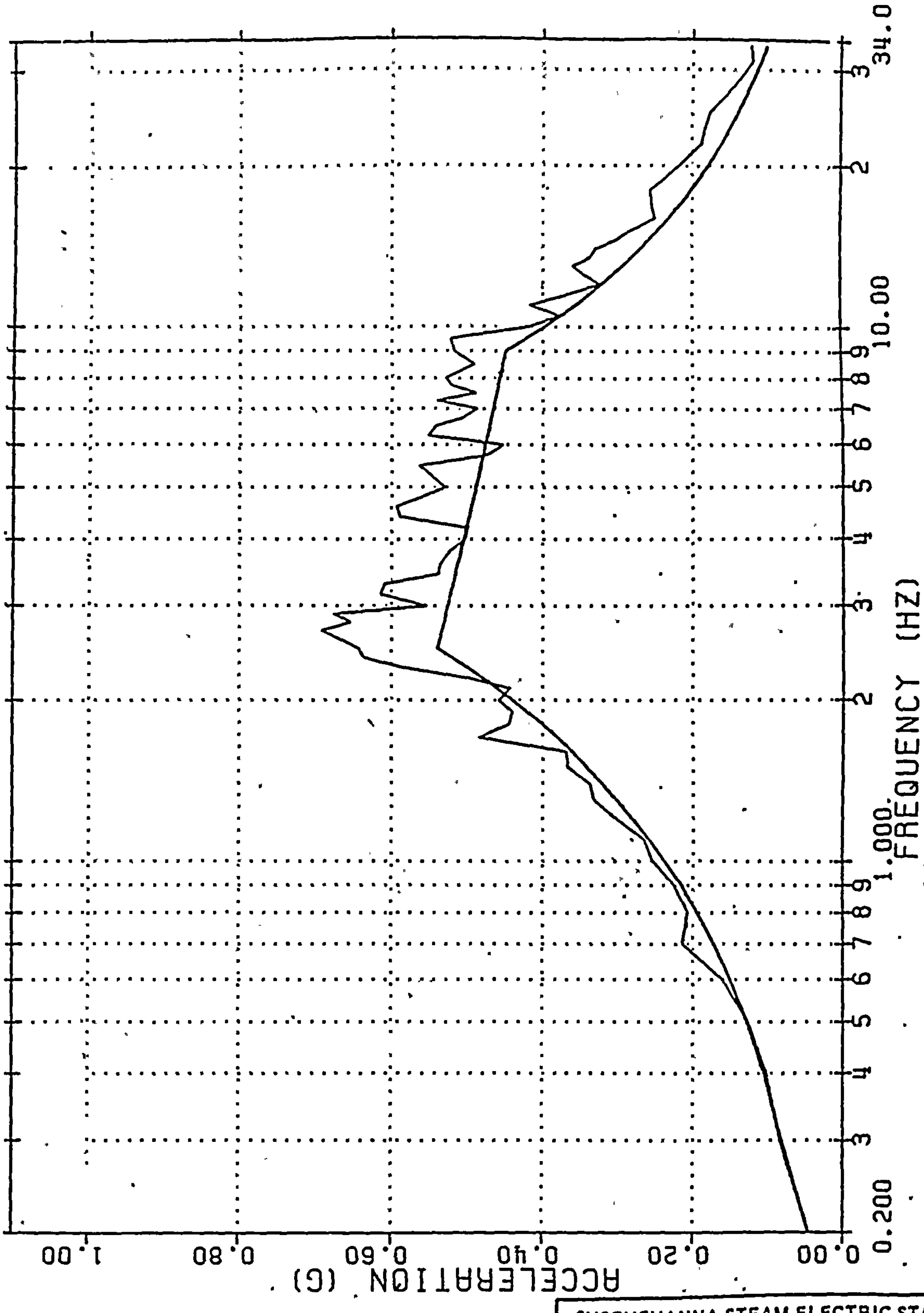
DIESEL GENERATOR "E" FACILITY
VERTICAL SYNTHETIC TIME
HISTORY NORMALIZED TO 0.1G

FIGURE 3.7b-108

2



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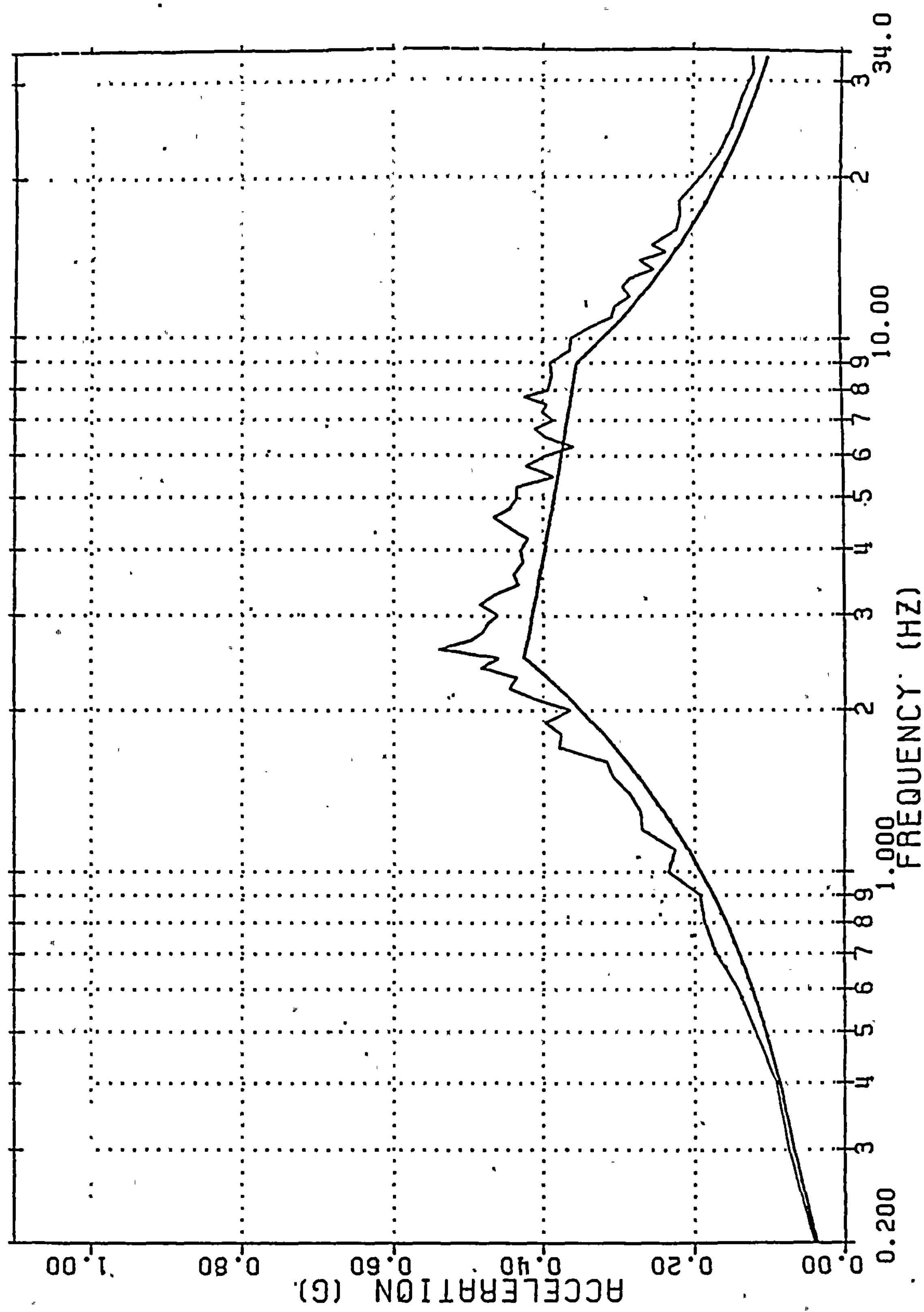
DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY
RESPONSE SPECTRUM AND HORIZ. DESIGN
RESPONSE SPECTRUM — 1 % DAMPING

FIGURE 3.7b-109



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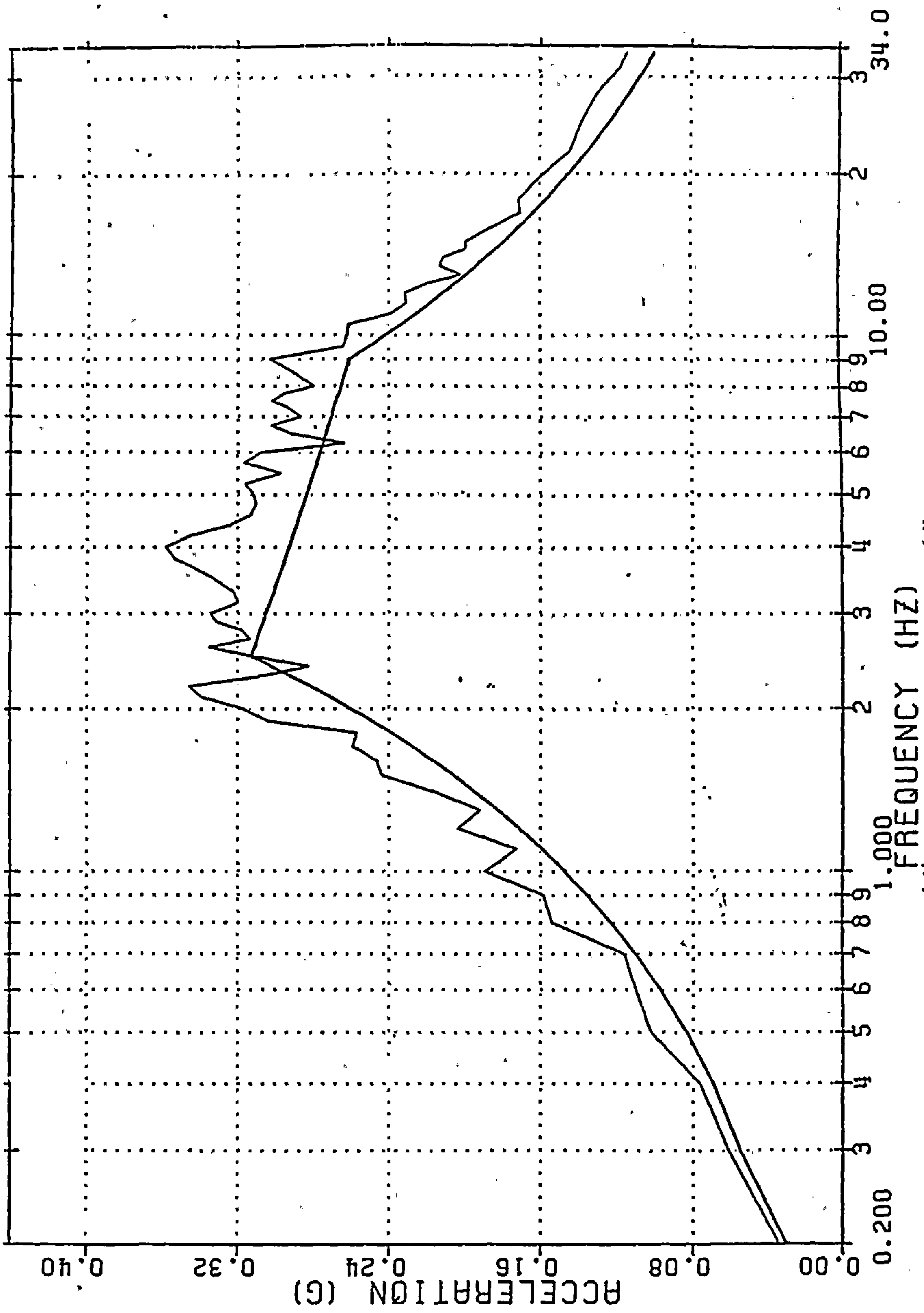
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY
RESPONSE SPECTRUM AND HORIZ. DESIGN
RESPONSE SPECTRUM — 2 % DAMPING

FIGURE 3.7b-110



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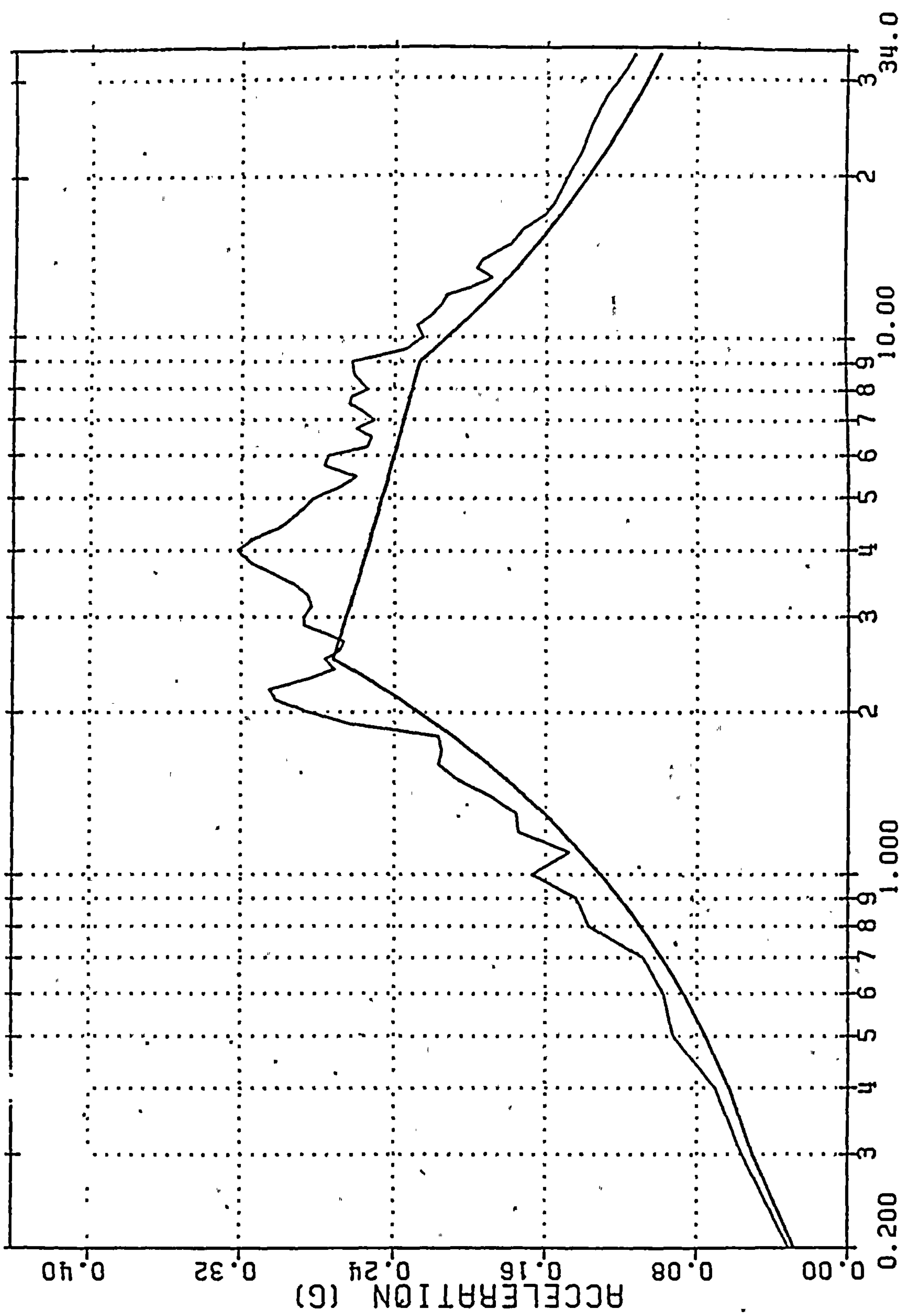
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY
RESPONSE SPECTRUM AND HORIZ. DESIGN
RESPONSE SPECTRUM — 5 % DAMPING

FIGURE 3.7b-111



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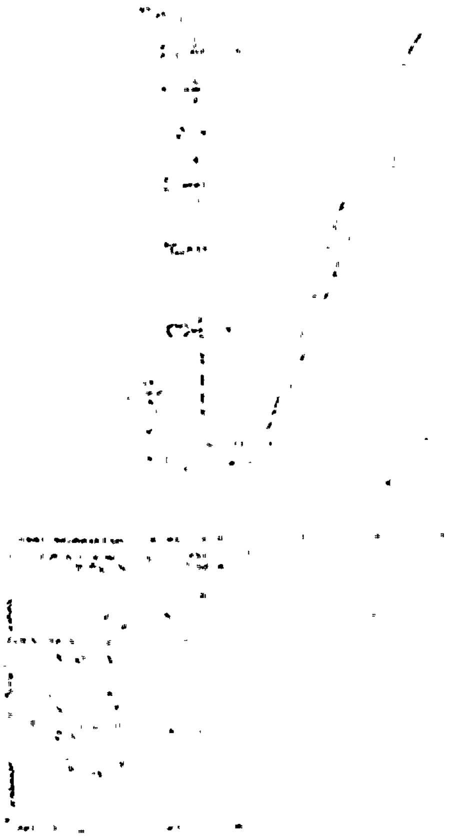
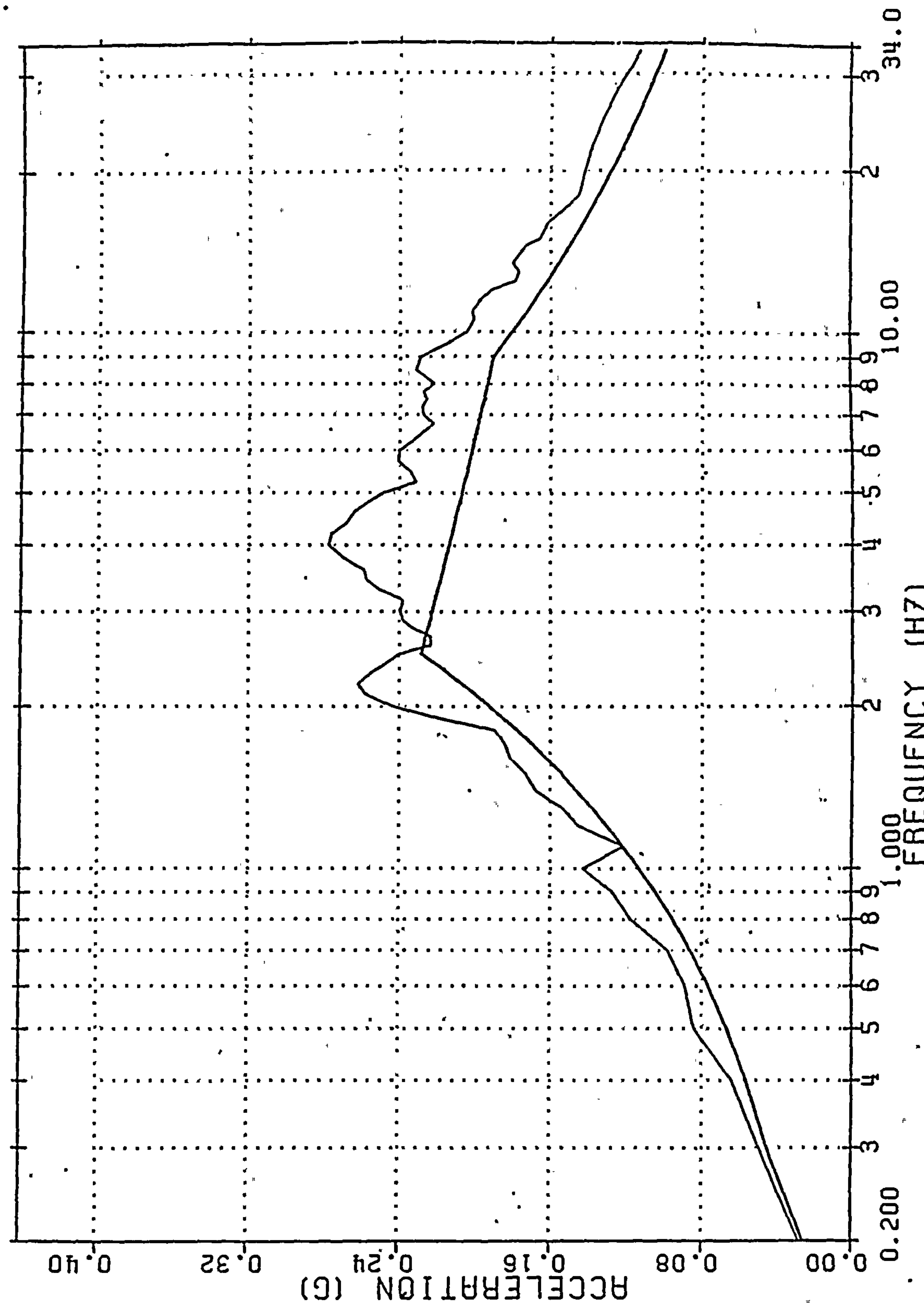
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY
RESPONSE SPECTRUM AND HORIZ. DESIGN
RESPONSE SPECTRUM — 7 % DAMPING

FIGURE 3.7b-112





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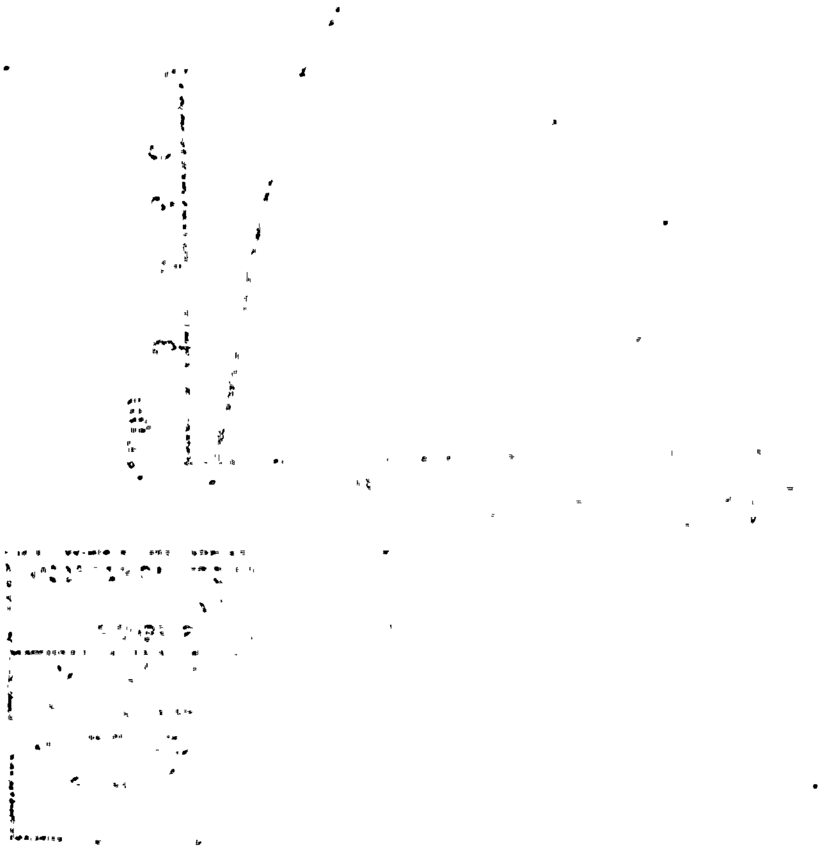
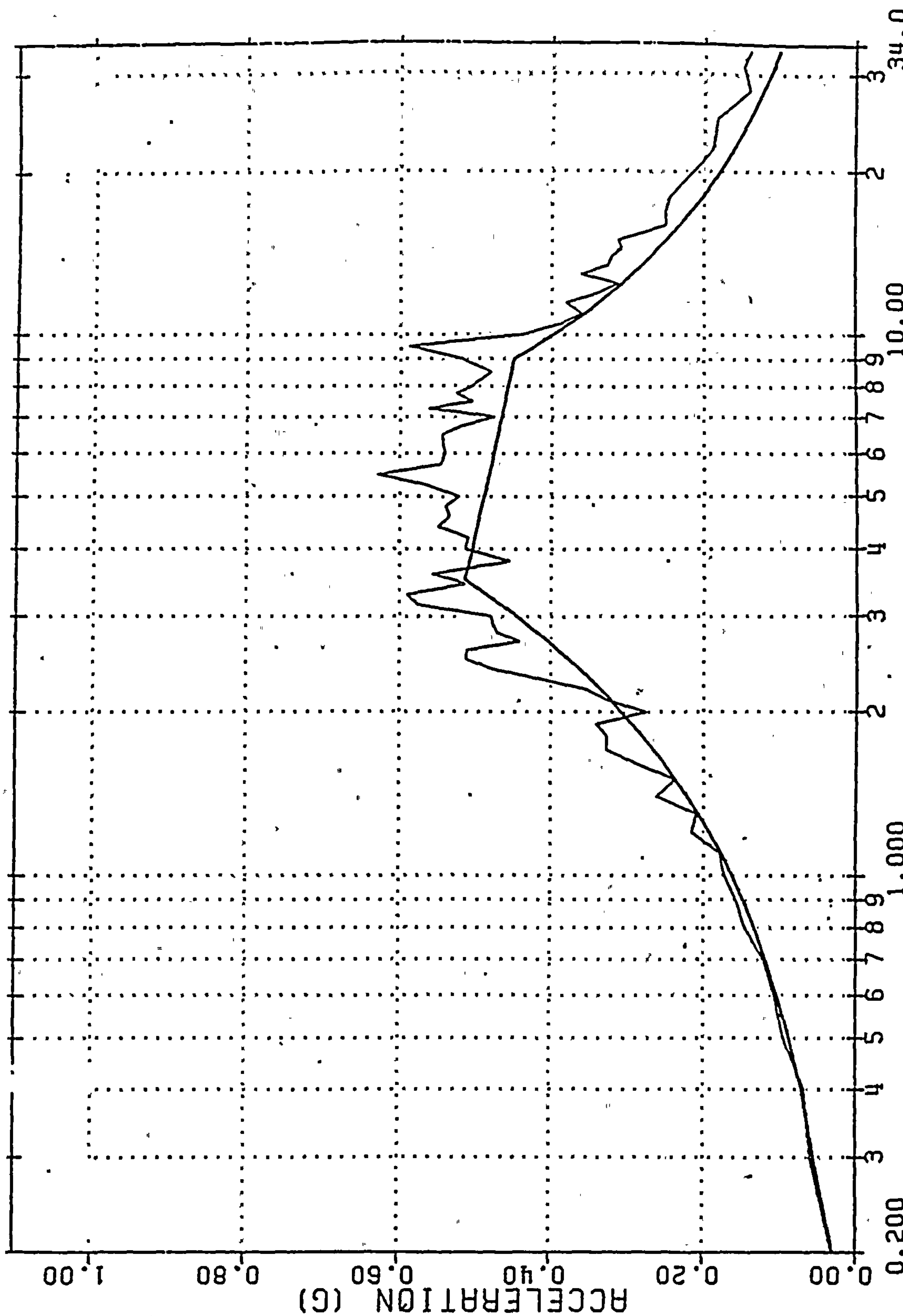
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

DIESEL GENERATOR "E" FACILITY
COMPARISON OF HORIZ. TIME HISTORY
RESPONSE SPECTRUM AND HORIZ. DESIGN
RESPONSE SPECTRUM — 10 % DAMPING

FIGURE 3.7b-113





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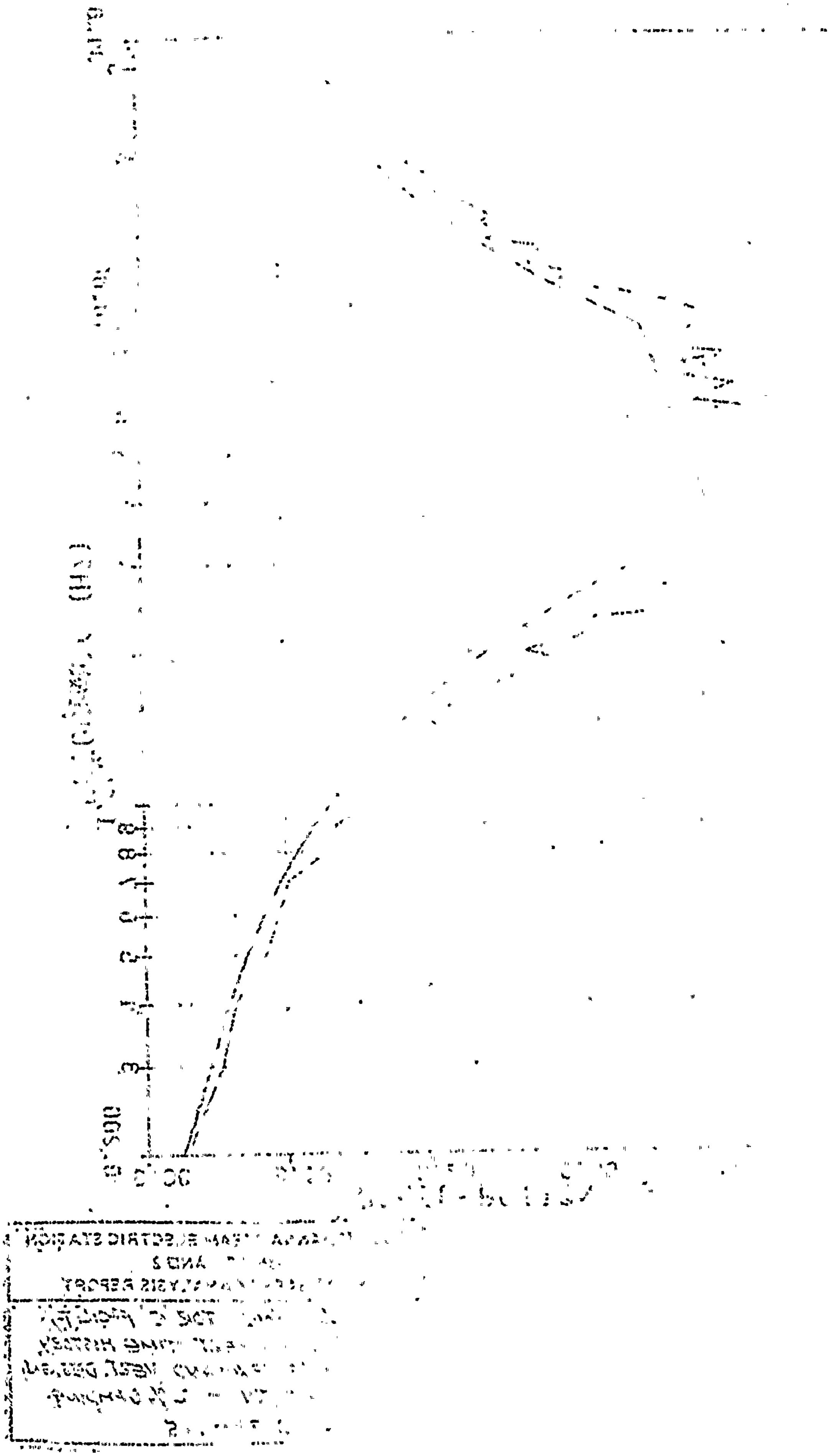
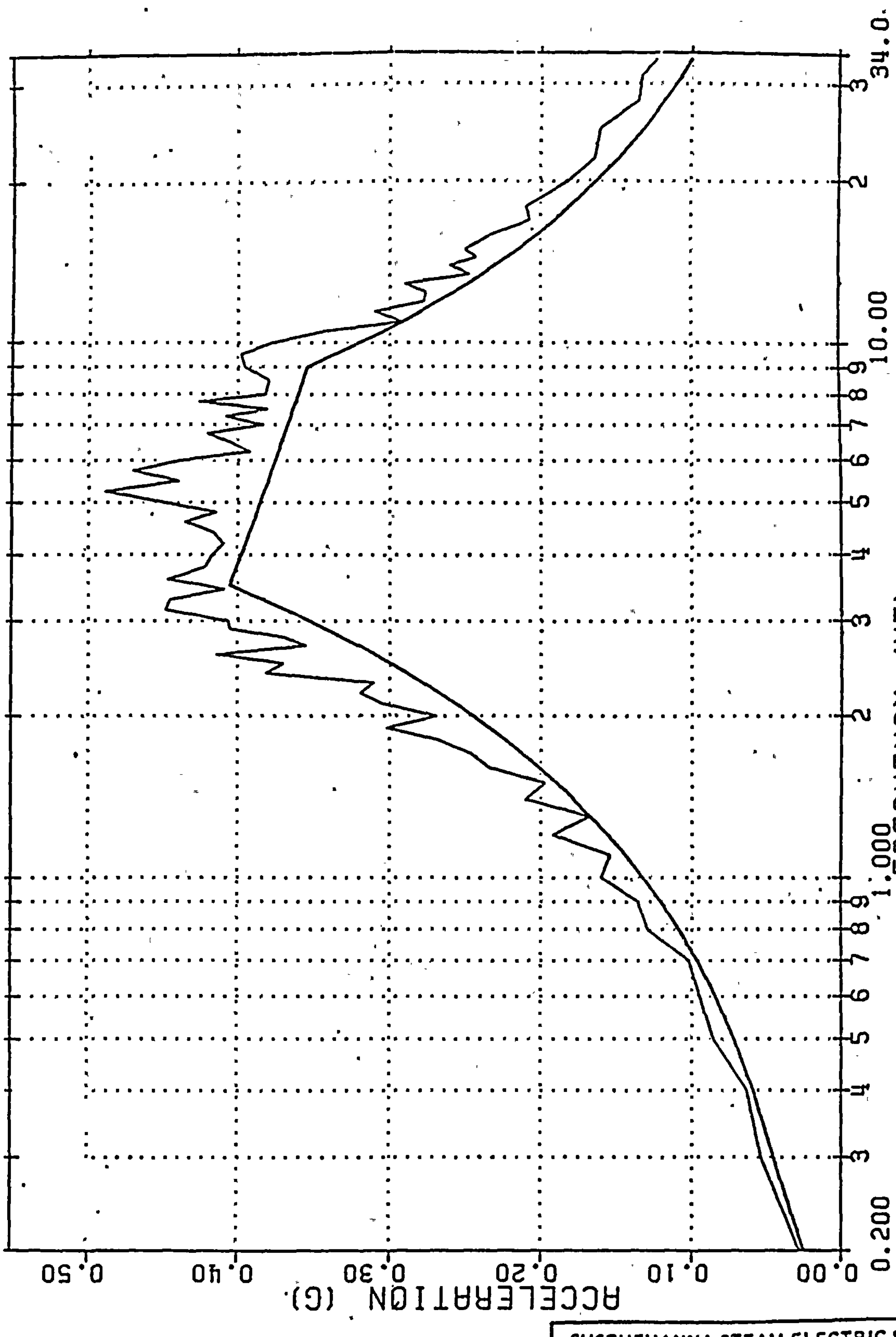
DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 1 % DAMPING

FIGURE 3.7b-114





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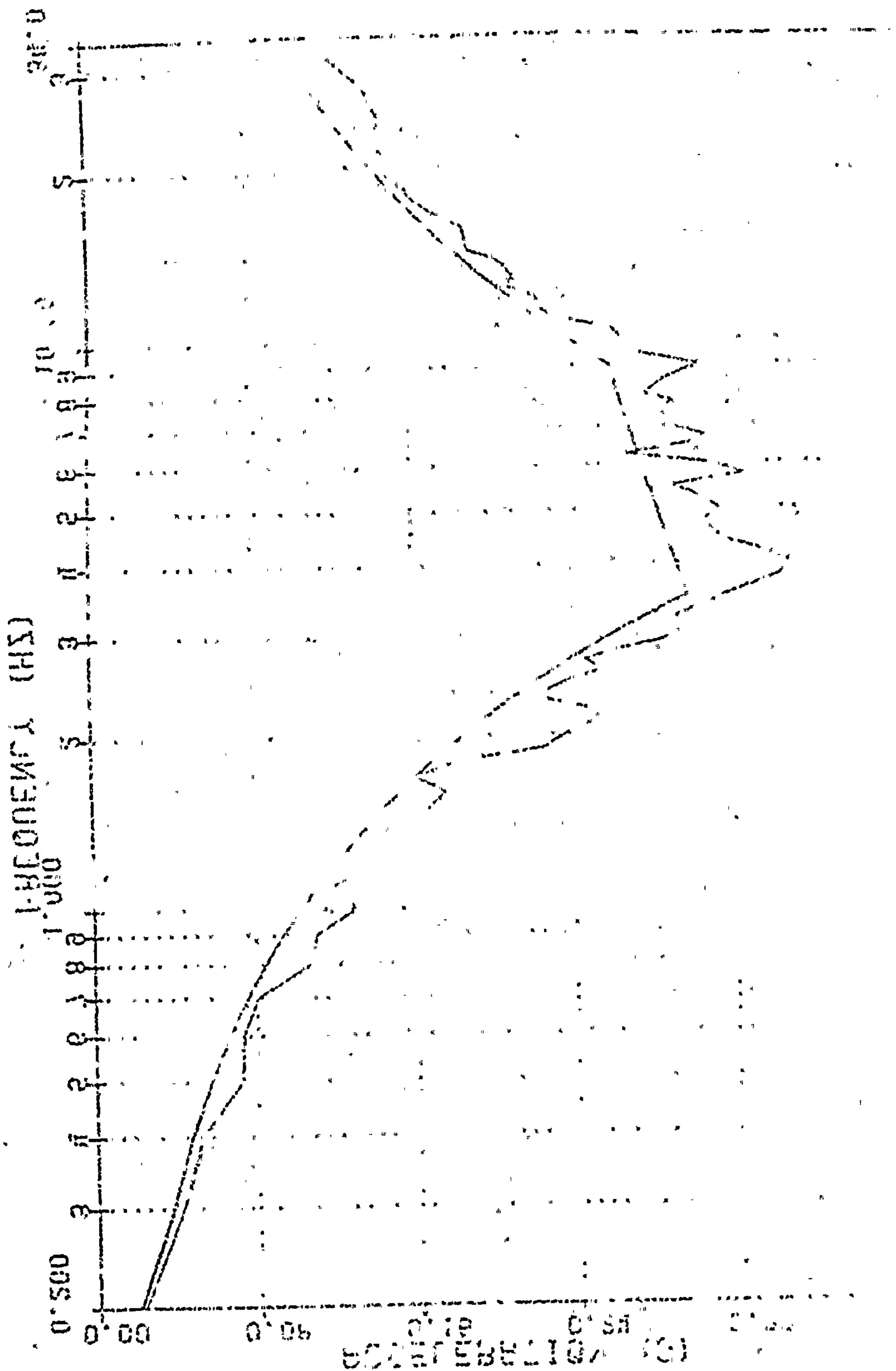
DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 2 % DAMPING

FIGURE 3.7b-115



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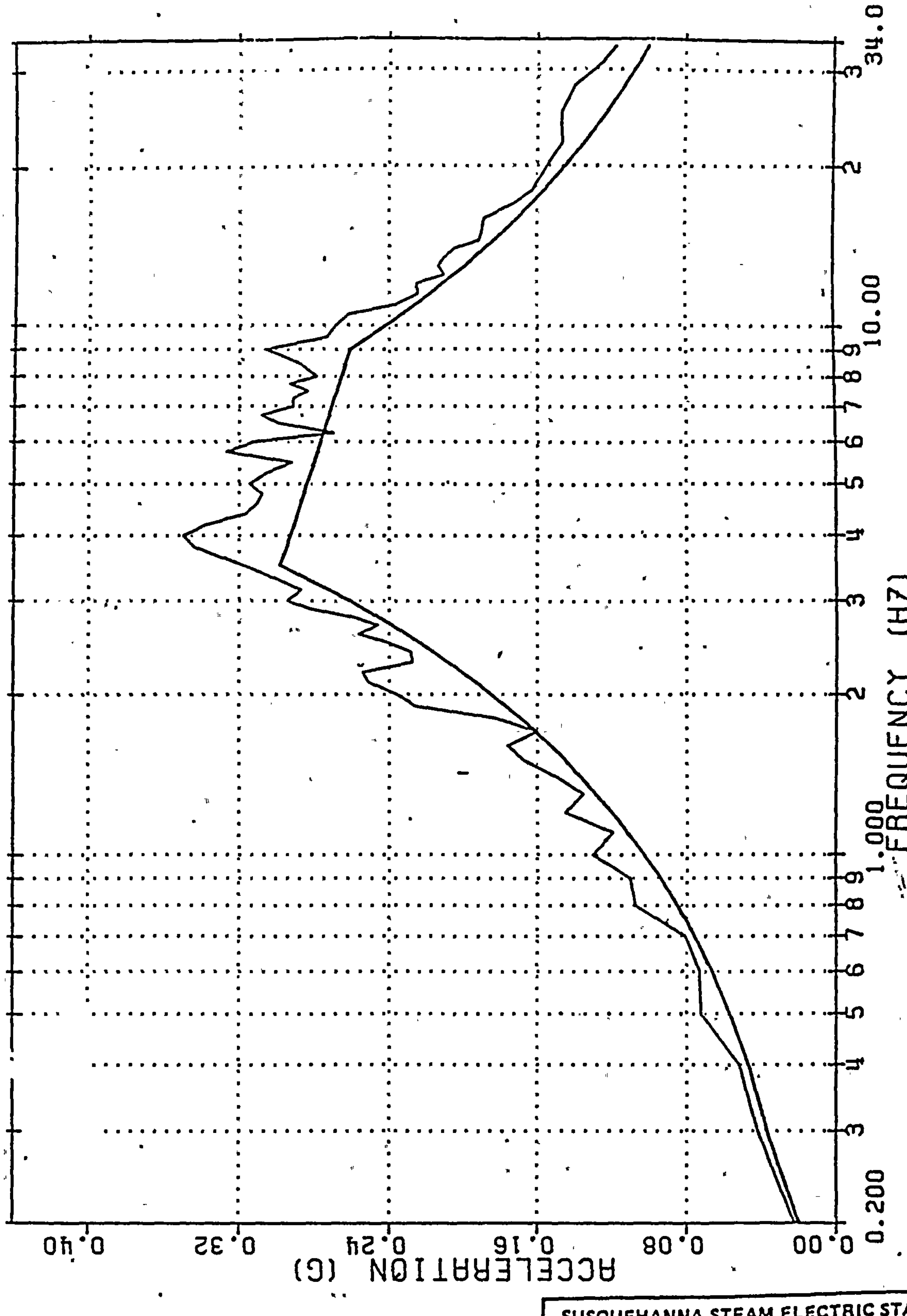
[illegible] DIESEL GENERATOR 'E' FACILITY
[illegible] BASED ON VERT. TIME HISTORY
[illegible] SPECTRUM AND VERT. DESIGN
[illegible] SPECTRUM — 5% DAMPING
[illegible] 3.7b-116



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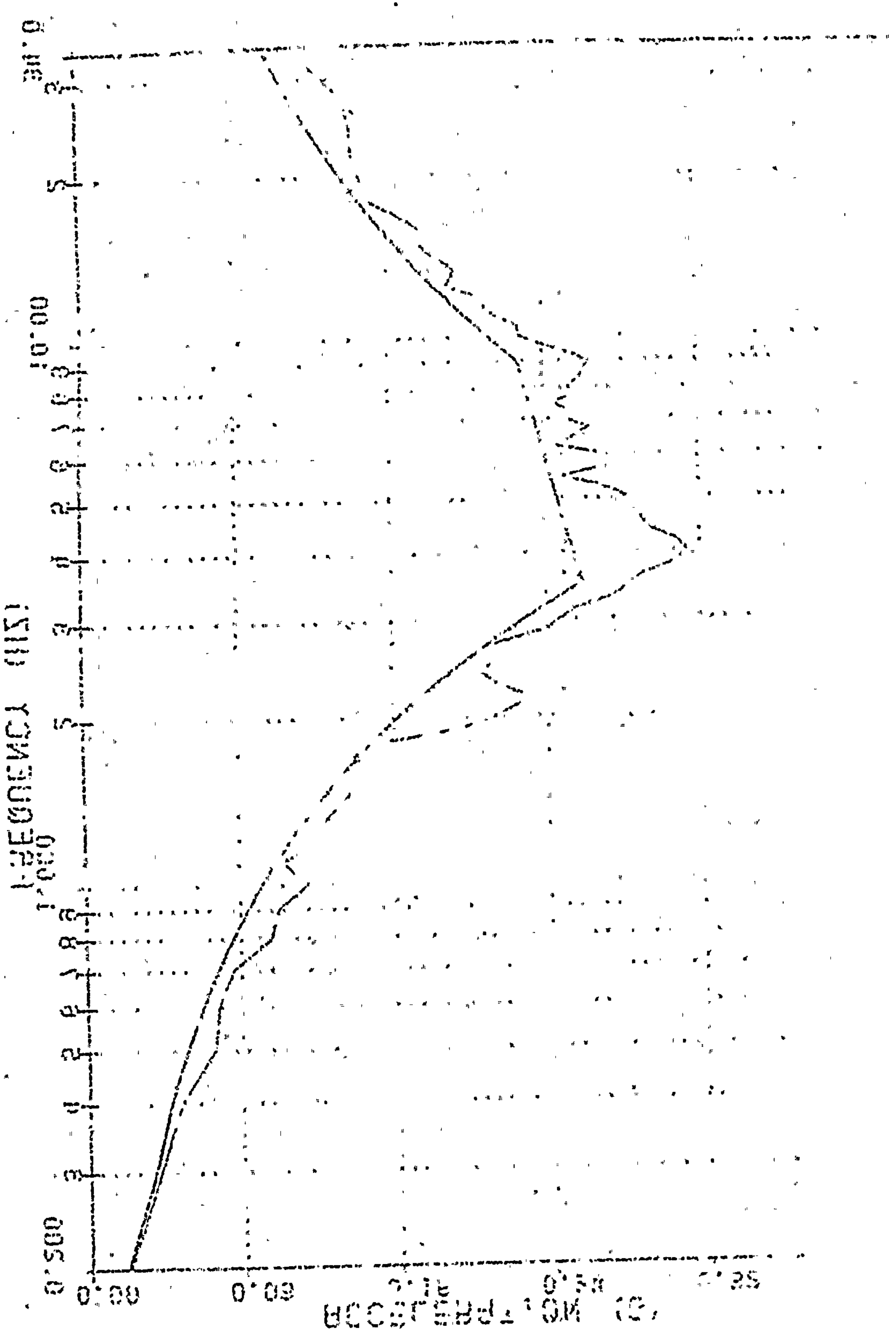
DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 5% DAMPING

FIGURE 3.7b-116



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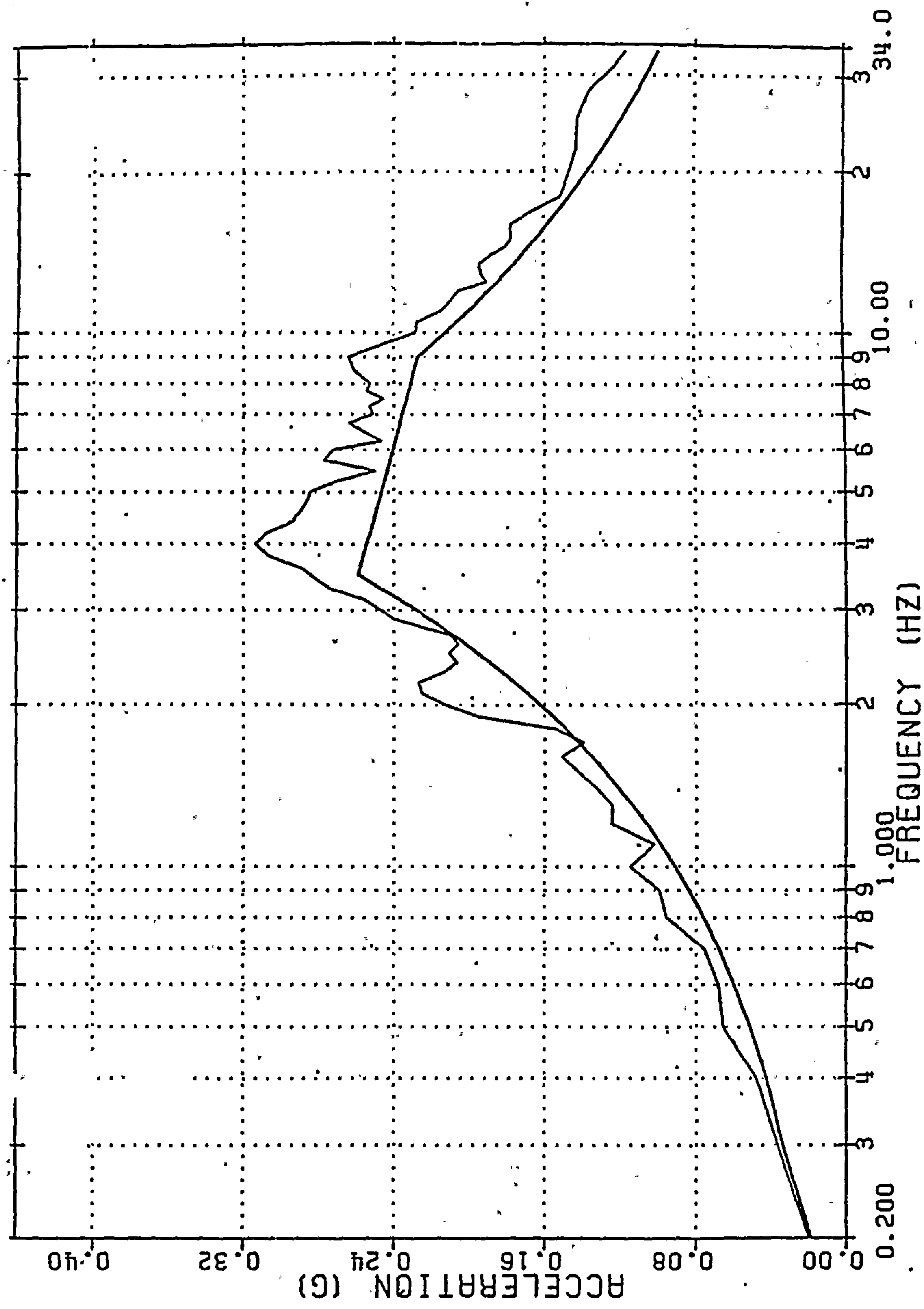
Diesel Generator "E" Facility
Comparison of Vert. Time History
Response Spectrum and Vert. Design
Response Spectrum — 7% Damping
Figure 3.7b-117



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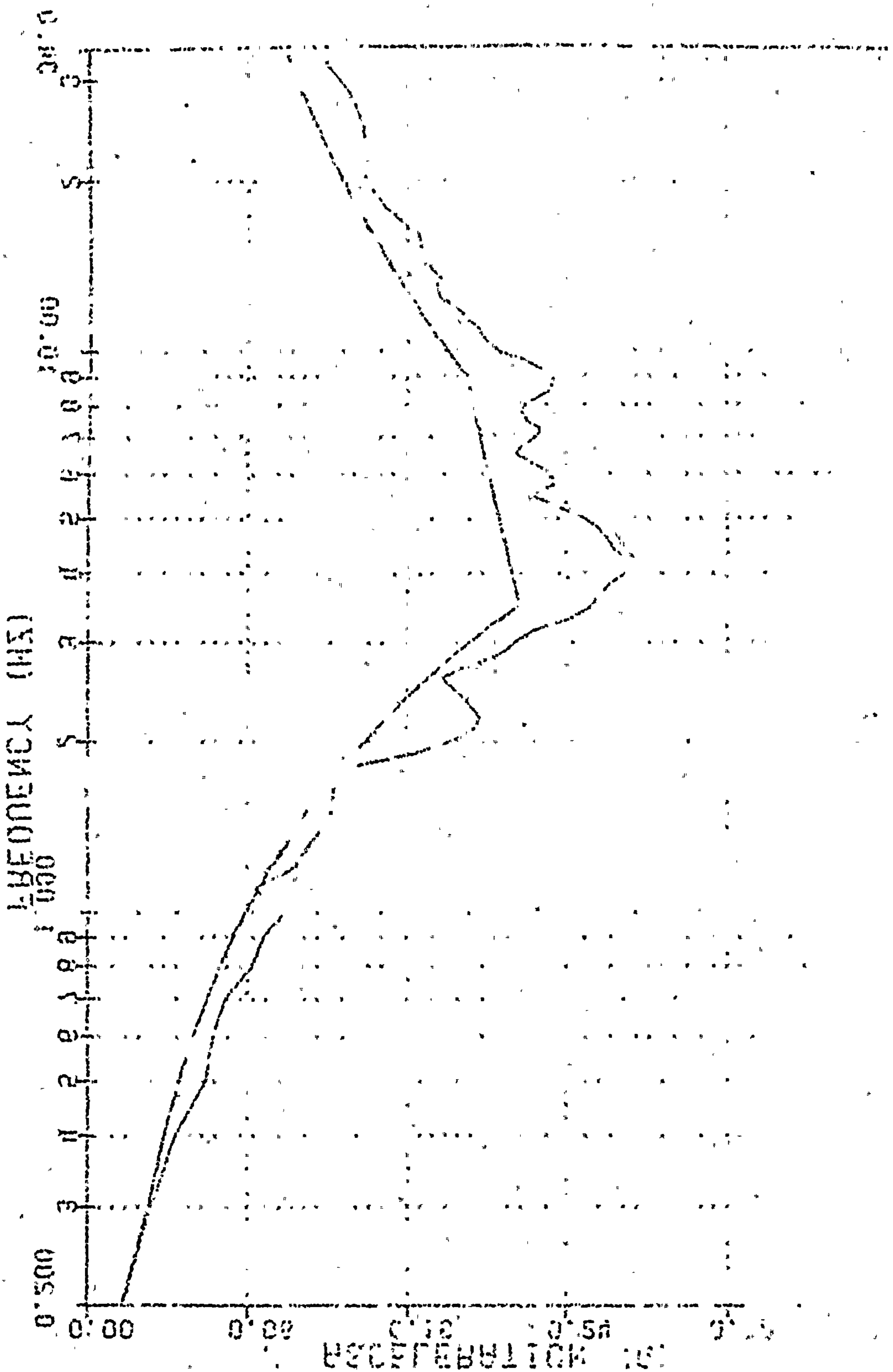
DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 7% DAMPING

FIGURE 3.7b-117



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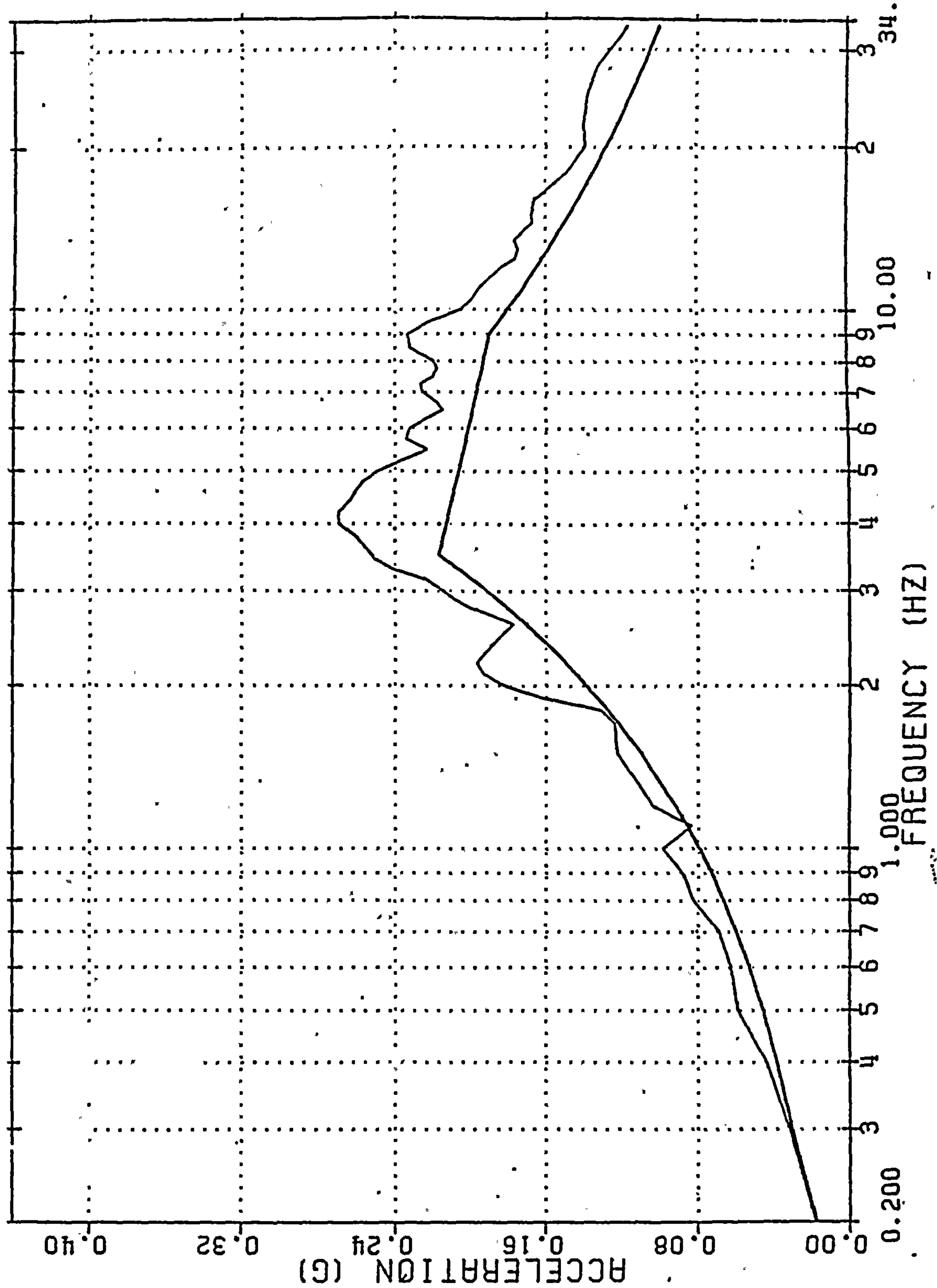
DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 10% DAMPING
FIGURE 3.7b-115



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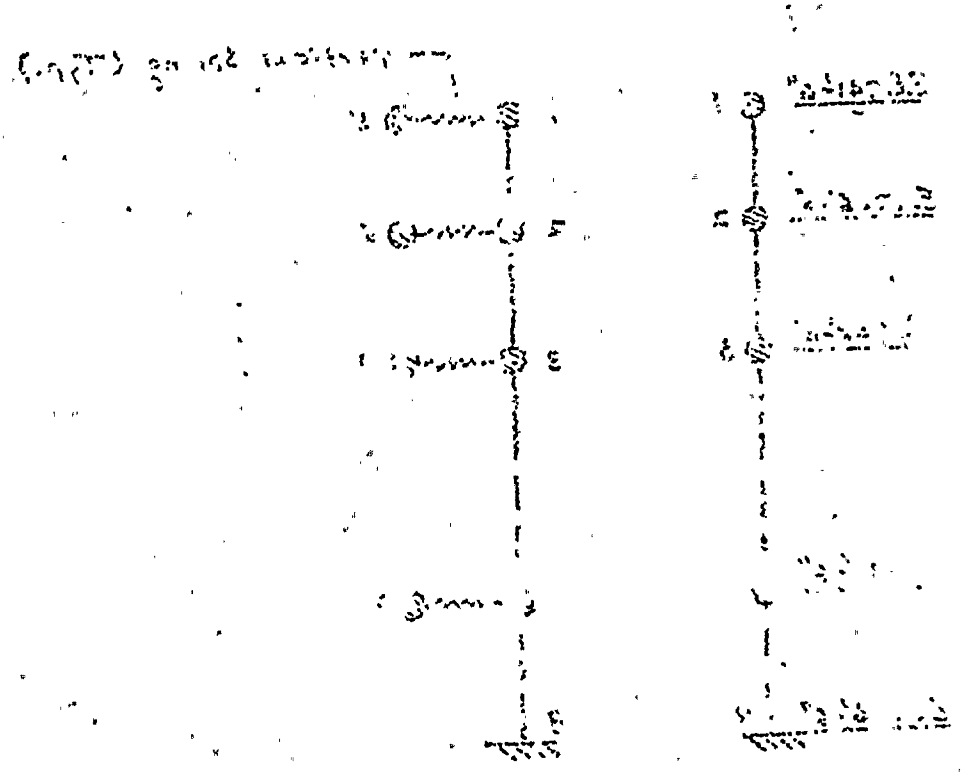
DIESEL GENERATOR "E" FACILITY
COMPARISON OF VERT. TIME HISTORY
RESPONSE SPECTRUM AND VERT. DESIGN
RESPONSE SPECTRUM — 10 % DAMPING

FIGURE 3.7b-118



b. VERTICAL MODEL

a. HORIZONTAL (N-S & E-W) MODEL

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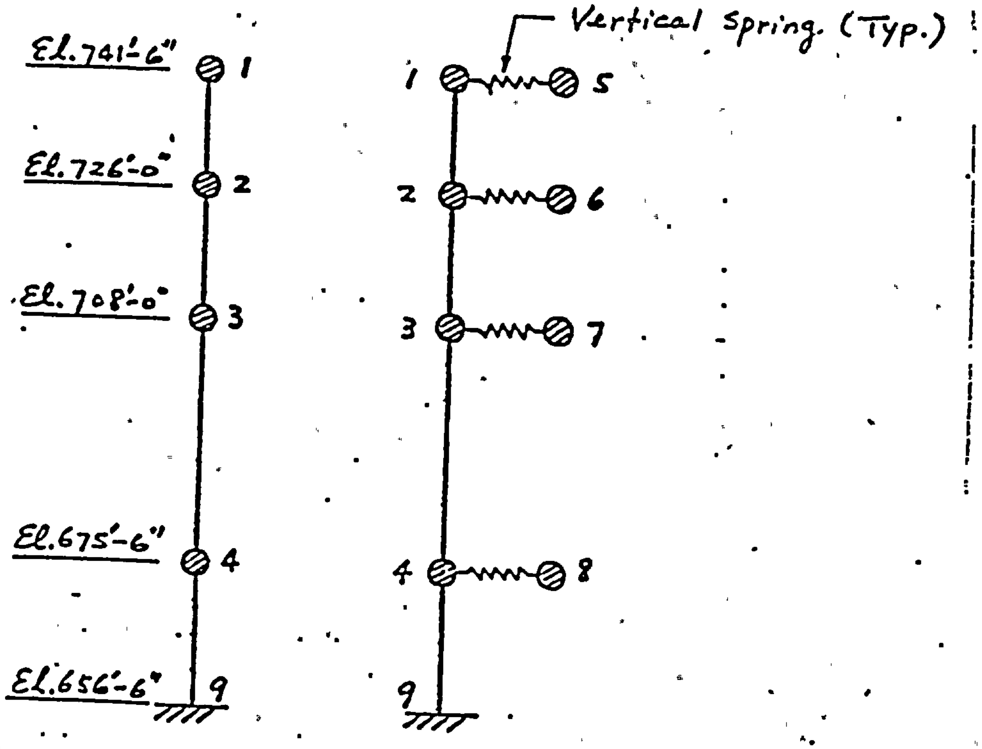
DIESEL GENERATOR "E" BUILDING
HORIZONTAL AND VERTICAL
DYNAMIC MODELS

FIGURE 3.7b-119



A. HORIZONTAL (N-S AND E-W) MODEL

B. VERTICAL MODEL

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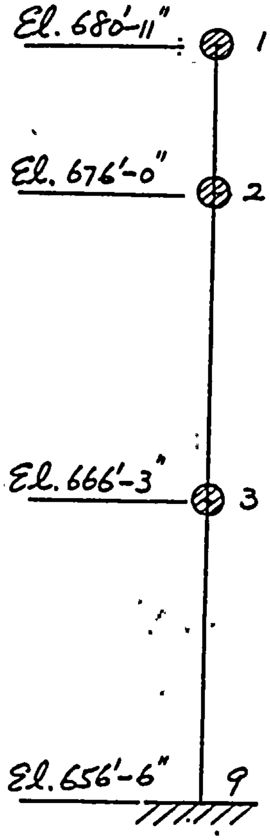
DIESEL GENERATOR "E" BUILDING
HORIZONTAL AND VERTICAL
SEISMIC MODELS

FIGURE 3.7b-119



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DIESEL GENERATOR "E" PEDESTAL SEISMIC MODEL

FIGURE 3.7b-120