SEISMIC AND STRUCTURAL ANALYSIS

FOR THE

LACROSSE BOILING WATER REACTOR

SHUTDOWN CONDENSER PLATFORM

CONTROLLED COPY
VALID ONLY IF THIS STAMP IS RED

Prepared For

Dairyland Power Cooperative

Project Application 5101	Prepared By N. Ravishankar, R. Kumpf	Date 1/19/82
	APPROVALS	
TITLE/DEPT.	SIGNATURE	DATE
Manager, Structural Engineering	Afzal Husain	1-19-82
General Manager, General Engineering Services	[signature]	1-19-82
Project Engineer	Craig F. Finnan	1/19/82
V.P. Engineering Service Operations	[signature]	1/19/82
Quality Assurance Manager	[signature]	1/20/82

8208170121 820722
PDR ADOCK 05000409
P PDR

nes

REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 81A0045

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL

FORM # NES 206 2/80

TABLE OF CONTENTS

		Page
1.	SUMMARY	4
2.	INTRODUCTION	5
3.	DESCRIPTION OF THE SHUTDOWN CONDENSER PLATFORM	6
4.	APPLICABLE CODES, STANDARDS AND SPECIFICATIONS	7
5.	LOADING CRITERIA	8
6.	STRUCTURAL ACCEPTANCE CRITERIA	9
7.	ANALYTICAL METHODS	10
	7.1 Mathematical Model	10
	7.2 Mathematical Formulation of Static Analysis	10
	7.3 Method of Analysis	11
8.	DISCUSSION OF RESULTS	14
	Table I	16
	Table II	17
	Table III	18
9.	CONCLUSIONS AND RECOMMENDATIONS	19
10.	REFERENCES	20
11.	FIGURES	21
	APPENDIX	

1. SUMMARY

This report, prepared for Dairyland Power Cooperative, presents the results of seismic and stress analyses of the Shutdown Condenser Platform for the LACBWR Nuclear Power Station. The seismic and stress analyses are performed in accordance with the requirements of US NRC Standard Review Plan, Section 3.8.3. Based on the results of a preliminary analysis, it was concluded that the existing platform would require additional members and supports. With these additional members, stresses due to seismic, dead weight and live load, are within the design requirements.

2. INTRODUCTION

At the LACBWR, the shutdown condenser system provides a backup heat sink for the reactor steam in the event that the reactor is isolated from the main condenser. The shutdown condenser rests on two saddles, which in turn are supported by a structural steel platform. The platform is supported by the containment building wall and from the columns which are supported at the operating floor.

The shutdown condenser system (Figure 1) has been designated as a safe shutdown system and, as such, it must be capable of operating during and after a seismic event. In order to assure the proper functioning of the shutdown condenser system under a seismic event, it is necessary that the supporting platform maintain its structural integrity under such an occurrence.

A preliminary analysis was performed to ascertain the capability of the shutdown condenser platform to withstand a seismic event and it was concluded that the existing platform required modification. Additional stiffness can be furnished by providing additional bracings and supports. The existing and the modified platforms are shown in Figures 2 and 3 respectively.

Section 3 of this report describes the physical and geometrical properties of the shutdown condenser platform. The applicable codes, standards and specfications used in the analysis are given in Section 4. The loading criteria, and the design criteria used in the analysis are given in Sections 5 and 6 respectively. In this analysis, the dynamic loads due to seismic event are substituted by equivalent static loads. A detailed method of analysis is presented in Section 7. The results of the analysis are discussed in Section 8. The conclusions and recommendations are summarized in Section 9.

3. DESCRIPTION OF THE SHUTDOWN CONDENSER PLATFORM

The shutdown condenser platform is located an elevation of 711 feet. (See Figure 1). The platform consists of a structural steel frame supported by the containment building walls and by the columns supported at an elevation 701 feet. The shutdown condenser saddles rest on two W 10x33 wide flange beams and the remainder of the platform is covered with steel grating. Figure 2 gives the plan arrangement of existing structural members.

Preliminary analysis indicate that certain structural members would be overstressed during the postulated SSE event. Consequently, the following changes have been suggested to strengthen the platform:

1. Additional bracings have to be provided. 3x3x1/4 angles are used to add stiffness in the the horizontal plane of the platform.

2. An additional column has to be provided to increase the support of the platform.

3. Additional lateral support has to be provided for some beams. The modified platform showing required additional members is shown in Figure 3.

4. APPLICABLE CODES, STANDARDS AND SPECIFICATIONS

The following specifications, Regulatory Guides and Codes have been used in the analysis of the shutdown condenser platform.

1. American Institute of Steel Construction, Manual of Steel Construction, Eighth Edition.

2. U.S. Nuclear Regulatory Commission Regulatory Guide 1.122, "Development of Floor Design Response Spectra for Seismic Design of Floor Supported Equipments or Components".

3. U.S. Nuclear Regulatory Commission, Regulatory Standard Review Plan, Section 3.8.3 "Concrete and Steel Internal Structures or Concrete Containments".

4. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.92 "Combining Modal Response and Spatial Components in Seismic Response Analysis".

5. U.S. Nuclear Regulatory Commission, NUREG/CR-0098 "Development of Criteria for Seismic Review of Selected Nuclear Power Plants".

5. LOADING CRITERIA

The following load cases and load combinations have been considered in the analysis in accordance with the requirements of US NRC Standard Review Plan Section 3.8.3.

1. Dead Load and Live Load

   The platform has been designed to support a live load of 100 pounds per square foot (Reference 6). The dead and the live loads acting on the platform are lumped at the nodes.

2. Seismic Loading

   A static analysis is performed on the platform to determine the horizontal and vertical stiffnesses and the corresponding frequencies (Section 7). Using the SSE seismic acceleration floor spectra for LACBWR plant (Reference 1), the equivalent static loads on the platform are established. The horizontal response spectrum is taken at the upper floor elevation at a damping value of two percent and the vertical response spectrum for the SSE loading is taken as 2/3 of the horizontal SSE upper floor response spectra (NUREG/CR-0098). The applicable response spectra used in the analysis are shown in Figure 4.

In the present report, seismic analysis has been performed for SSE seismic event only since it is more limiting compared to OBE. The magnitude of SSE acceleration is twice the OBE acceleration value for the same frequency, whereas the allowable stress values according to Standard Review Plan 3.8.3 are only 60 percent higher than that allowed for the OBE event.

The loads imposed on the shutdown condenser by the 6 inch main steam line in case of a postulated seismic event (Reference 2) have also been imposed on the shutdown condenser. The individual connections in the shutdown condensor platform have not been analysed individually since they were assumed to satisfy the requirements of AISC specifications.

6. STRUCTURAL ACCEPTANCE CRITERIA

The following allowable stress limits constitute the structural acceptance criteria used for each of the loading combinations presented in Section 5. These stress limits are based on the requirements for acceptability of Standard Review Plan 3.8.3.

Load	Limit
D + L	S
D + L + E'	1.6S but no greater than Fy

Where: D = Dead Load
L = Live Load
E' = SSE Seismic Load
Fy = Yield Stress of Steel

S is the required section strength based on the applicable sections of the AISC specification for the design, fabrication and erection of structural steel for buildings.

7. ANALYTICAL METHODS

7.1 MATHEMATICAL MODEL

In order to perform a stress analysis of the shutdown condenser platform, it is modeled as an assemblage of elastic structural beam elements interconnected at discrete nodal points (Figure 5). Each nodal point has six degrees of freedom (three translations and three rotations are permitted at each nodal point). Stiffness characteristics of the elements are related to the moment of inertia, area, and thickness properties of the structural members they represent. In this analysis, solution has been obtained using the computer program STARDYNE (Reference 3).

7.2 MATHEMATICAL FORMULATION OF STATIC ANALYSIS

The static analysis of the finite element model has been performed using the stiffness method of structural analysis. If the force displacement relationship of each of the discrete elements is known, then force-displacement relationship of the entire structure can be assembled using standard matrix methods as shown below. For each element:

$$ku = f \qquad (1)$$

Where:

k = Element stiffness matrix
u = Element nodal displacement vector
f = Element nodal force vector

For the idealized system, the equation of equilibrium may be written, in matrix form as follows:

$$KU = F \qquad (2)$$

K = Assembled stiffness matrix for the system
U = Nodal displacement vector for the system
F = External force vector

If sufficient boundary conditions are specified on U to guarantee a unique solution, equation (2) can be solved for the nodal displacement knowing the assembled stiffness matrix of the system and the external force matrix. In this analysis, the solution has been obtained by using the computer program STARDYNE.

7.3 METHOD OF ANALYSIS

Static methods have been employed in the seismic analysis of the structure and the analysis has been performed in the following sequence:

1. Determination of platform stiffness along X_1, X_2, and X_3 directions.

   A. Unit loads along X_1 direction are applied at nodes 18 and 22 and the structure is analyzed and the maximum displacement d_{x1} is calculated.

      Unit loads along X_1 direction are applied at nodes 18 and 22 only, even though the shutdown condenser saddle is bolted to the platform at nodes 18, 22, 27, and 29. The other nodes (27 and 29) represent supports at which the movement is unrestricted along X_1 direction. At these nodes, slotted holes have been provided (slots along X_1) and consequently, no reaction will be induced.

   B. Unit loads are applied along X_2 direction at shutdown condenser nodes 18, 22, 27, and 29 and the maximum displacement d_{x2} is calculated.

C. The dead load analysis is performed on the platform and the average of vertical displacements d_{x3} at nodes 18, 21, 27, and 29, is calculated.

2. Determination of saddle stiffness along X_1, X_2 and X_3 directions.

In order to evaluate the frequency of the entire system, it is essential to evaluate the stiffness of the shutdown condenser saddle as well as stiffness of the platform. The stiffness of the entire system is a combination of the stiffness of the platform and the saddle. Figure 6 shows the details of the saddle and in calculation of the stiffness of the saddle, it is assumed that the shutdown condenser is rigid, whereas the saddle is flexible.

The stiffness calculation is shown in the Appendix and the summarized results are as follows:

Along X_1 direction = 378.4 Kip/in.
Along X_2 direction = 7947 Kip/in.
Along X_3 direction = 606.4 Kip/in.

3. The frequencies along the three directions are calculated:

Horizontal frequency along X_1 direction = 10.93 CPS
Horizontal frequency along X_2 direction = 50.1 CPS
Vertical frequency along X_3 direction = 13.83 CPS

4. The horizontal acceleration values for SSE loading are obtained from the acceleration spectra at crane support level (Figure 4). The vertical acceleration is assumed to be 2/3 the horizontal acceleration from the corresponding vertical frequency. In calculating the acceleration values from the spectra, the recommendations of NUREG/CR0098 have been followed and the calculated SSE acceleration values are as follows:

Horizontal SSE accn. along X_1 = 0.573g
Horizontal SSE accn. along X_2 = 0.437g
Vertical SSE accn. along X_3 = 0.25g

It is emphasized here that the analysis is performed for SSE accelerations only since it is more limiting than the OBE. The magnitude of SSE acceleration for a particular frequency is twice the OBE acceleration value for a corresponding frequency whereas, according to Standard Review Plan Section 3.8.3, the allowable stresses are only 60 percent higher than that allowed for the OBE.

5. The forces acting on the platform due to the seismic event are evaluated from the acceleration values calculated earlier. The force acting at each of the nodes along any direction is a product of the lumped mass at that node and the acceleration in the corresponding direction.

6. The forces calculated above are imposed on the platform structure along X_1, X_2 and X_3 directions individually and the deflections, moments and stresses due to the corresponding loading are determined.

7. The combined seismic response of the three spatial components of the earthquake is obtained by taking the square root of the sum of the squares of the corresponding maximum response values due to the three components calculated independently. (Reg. Guide 1.92)

8. The response of the platform structure due to the combination of dead load and the seismic loading is calculated by summing absolutely the deflections, moments and stresses due to the dead load (as determined in step 1(c)) and the combined seismic response (as determined in step 7).

8. DISCUSSION OF RESULTS

A preliminary seismic analysis of the shutdown condenser platform with its present configuration indicated that the stresses due to SSE would be greater than the allowable stress values. In order to ensure the ability of the platform to withstand the postulated seismic event, the following modifications to the existing structure are recommended (Refer to Figure 3):

1. Provide additional angle braces between nodes 17 and 52, 17 and 30, 23 and 26, 23 and 34, 30 and 24, 25 and 26. The intersecting angle braces have to be connected at the point of intersection.

2. Provide an additional column (W8x24) to support the platform at node 23. The other end of the column is anchored at the operating floor.

3. Provide additional beam between nodes 16 and 53.

4. Provide additional vertical support at node 26.

5. Provide additional beam (W10x33) between nodes 52 and 26.

6. Provide additional beam between nodes 38 and A.

The results of the analysis presented in this section correspond to the modified structure. As stated earlier in the report, static methods have been followed in the seismic analysis of the platform structure and a summary of the stiffness, frequency and acceleration values employed in the seismic analysis of the platform are presented in Table 1.

The results of the platform structural analysis under the combination of dead load and live load, combination of dead load, live load and seismic loads (Reference 4) are presented in Tables 2 and 3 respectively. The maximum stresses are given for each type of platform member Stresses in members where unsupported length or support conditions limit the allowable stress values are also included. The allowable stress values have been calculated according to Section 6 of this report and the applicable provisions of the AISC specification.

TABLE 1

STIFFNESS CHARACTERISTICS OF SHUTDOWN CONDENSER PLATFORM

	X_1-Direction (Horizontal)	X_2-Direction (Horizontal)	X_3-Direction (Vertical)
Platform Stiffness (Kip/in)	392.16	8510.6	606.4
Saddle Stiffness (Kip/in)	10768	120,000	Very Stiff (Rigid)
Combined Stiffness (Kip/in)	378.4	7947	606.4
Frequency (cps)	10.93	50.1	13.83
SSE Accn. Values (g's)	0.573	0.437	0.25

TABLE 2
RESULTS OF SHUTDOWN CONDENSER PLATFORM STRESS ANALYSIS
DEAD LOAD + LIVE LOAD

Beam	Element Number	Axial Stress (ksi)		Bending About Major Axis (ksi)		Bending About Minor Axis (ksi)		Shear Stress (ksi)		Combined* Stress Ratio
		f_a	F_a	f_{bx}	F_{bx}	f_{by}	F_{by}	f_t	F_t	$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}}$
C10x15.3	51	--	--	4.62	10.4	--	27	3.03	14.4	0.44
W10x21	13	--	--	4.36	24.00	--	27	0.09	14.4	0.18
W8x10	32	--	--	5.08	12.6	--	27	0.00	14.4	0.40
W10x11.5	17	--	--	6.76	16.8	--	27	0.00	14.4	0.40
W10x33	35	--	--	6.40	23.76	--	27	0.07	14.4	0.27
W8x24	74	2.604	15.95	--	--	--	27	--	--	0.16
L3x3x1/4	--	--	--	--	--	--	--	--	--	--

* Must be $\leq$ 1.0 for acceptability according to AISC.

TABLE 3
RESULTS OF SHUTDOWN CONDENSER PLATFORM STRESS ANALYSIS
DEAD LOAD + LIVE LOAD + SSE SEISMIC LOAD

Beam	Element Number	Axial Stress (ksi)		Bending About Major Axis (ksi)		Bending About Minor Axis (ksi)		Shear Stress (ksi)		Combined* Stress Ratio
		f_a	F_{ae}^{**}	f_{bx}	F_{bxe}^{**}	f_{by}	F_{bye}^{**}	f_t	F_{te}^{**}	$\frac{f_a}{F_{ae}} + \frac{f_{bxe}}{F_{bxe}} + \frac{f_{by}}{F_t}$
C10x15.3	51	2.42	19.52	4.49	28.93	10.24	34.6	0.00	23.04	0.57
W10x21	12	0.21	32.1	5.97	36	4.49	36	1.65	23.04	0.3
	33	0.67	23.5	4.38	30.3	3.55	36	0.23	23.04	0.27
W8x10	43	0.37	28.05	6.61	36	16.69	36	0.74	23.04	0.66
	49	1.15	25.5	7.9	32.26	5.11	36	3.55	23.04	0.43
W10x11.5	17	0.113	24.75	13.02	26.88	6.39	36	0.00	23.04	0.67
W10x33	35	1.55	30.45	15.51	36	12.86	36	0.8741	23.04	0.84
W8x24	74	5.36	25.5	0.00	36	0.00	36	0.00	23.04	0.21
L3x3x1/4	65	5.45 (Tension)	16.86 (Tension)	—	--	--	--	--	--	0.32

* Must be $\leq$ 1.0 for acceptability according to AISC

** Allowable stresses are 1.6 times the stresses allowed under the combination of dead load and live loads or Fy whichever is lower.

9. CONCLUSION AND RECOMMENDATIONS

" ‹ previously discussed, modifications are necessary to strengthen the structure. The recommended modifications are as follows (Refer to Figure 3):

1. Provide additional L3x3x1/4 braces between nodes 17 and 52, 17 and 30, 23 and 26, 23 and 34, 30 and 24, and 25 and 26. The intersecting angle braces have to be connected at the point of intersection.

2. Provide a column (W8x24) to support the platform at node 23, other end of the column to be anchored to the operating floor.

3. Provide additional beam between nodes 16 and 53.

4. Provide additional support at node 26.

5. Provide additional beam (W10x33) between nodes 52 and 26.

6. Provide additional beam between nodes 38 and A.

It is concluded that with the modifications recommended in the report, the shutdown condenser platform will be capable of withstanding the loads during and after the SSE seismic event without exceeding the appropriate allowable stresses.

REFERENCES

1. Gulf United Services Report No. SS-1162 "Seismic Evaluation of the LaCrosse Boiling Water Reactor, dated January 11, 1974.

2. NES Report, Document 81A0044, Seismic and Structural Analysis for the LACBWR Shutdown Condenser, Nuclear Energy Services, Danbury, Conn., November, 1981.

3. MRI/STARDYNE 3 - Static and Dynamic Structural Analysis Systems User's Information Manaual, Control Data Corporation 1976.

4. LACBWR Shutdown Condenser Platform Structural Analysis, Project 5101, Task 060, NES Computer Output Binder S-44, November, 1981.

5. DWG. No. 41-503480, REV.K - Reactor Containment Vessel Gallery Framing Plans. LACBWR Project Reactor Plant, US Atomic Energy Commission, Genoa, Wisconsin. Dated Dec 26, 1968.

6. DWG. NO. 41-503477 REV.B - Floor loading diagram, LACBWR Project Reactor Plant, US Atomic Energy Commission, Genoa, Wisconsin. Dated Dec 26, 1968.

7. ALLIS-CHALMERS specification 41-493-0S-LACBWR-19. Outline specification for building work. LACBWR Project Reactor Plant. Dated Aug 30, 1963.

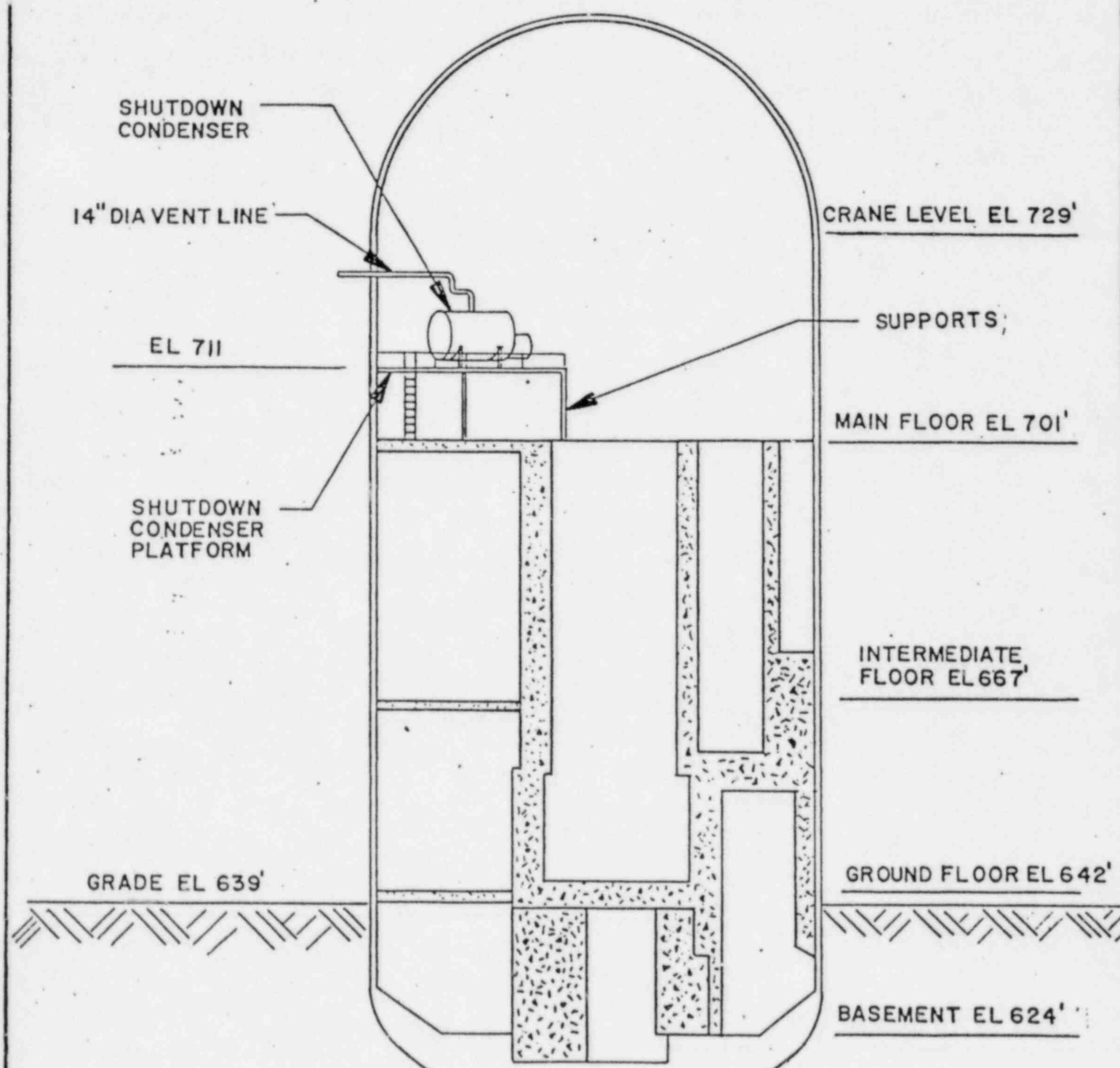


FIGURE 1. REACTOR CONTAINMENT BLDG.

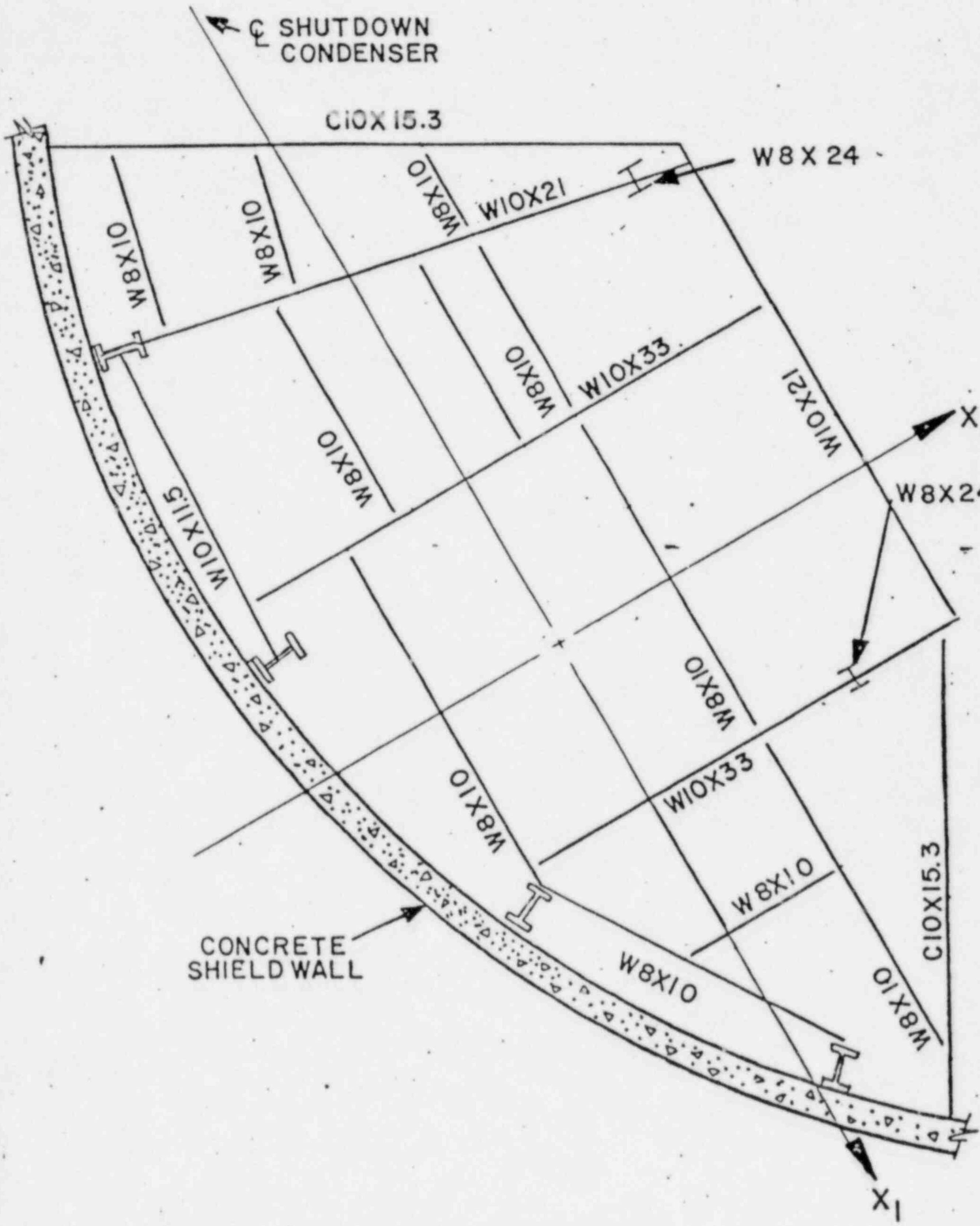
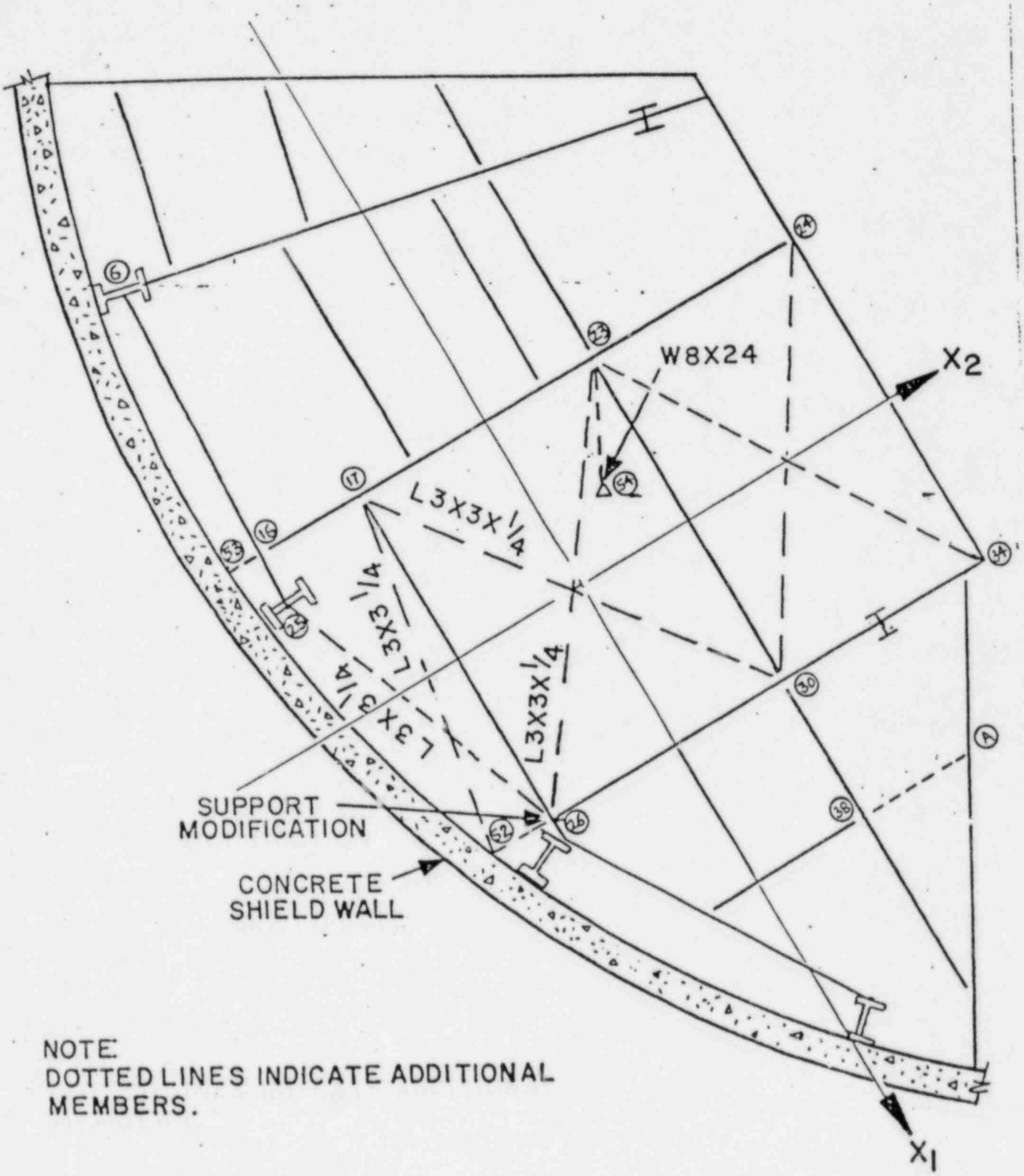


FIG.2. SHUTDOWN CONDENSER PLATFORM - PRESENT CONFIGURATION



NOTE:
DOTTED LINES INDICATE ADDITIONAL MEMBERS.

FIG.3. SHUTDOWN CONDENSER PLATFORM-MODIFIED CONFIGURATION

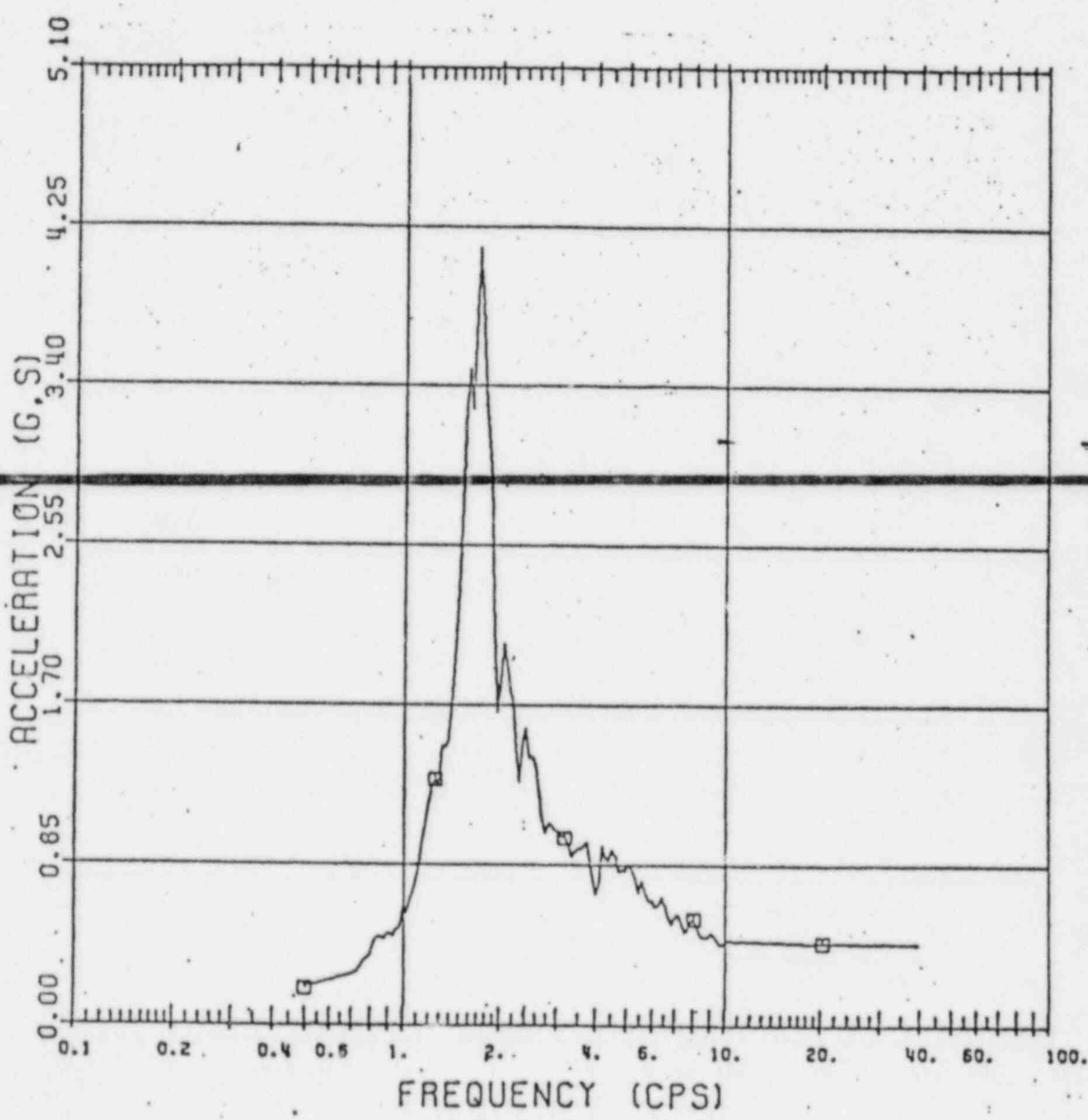


FIGURE 4 - UPPER FLOOR SPECTRA, SSE SEIMIC INPUT

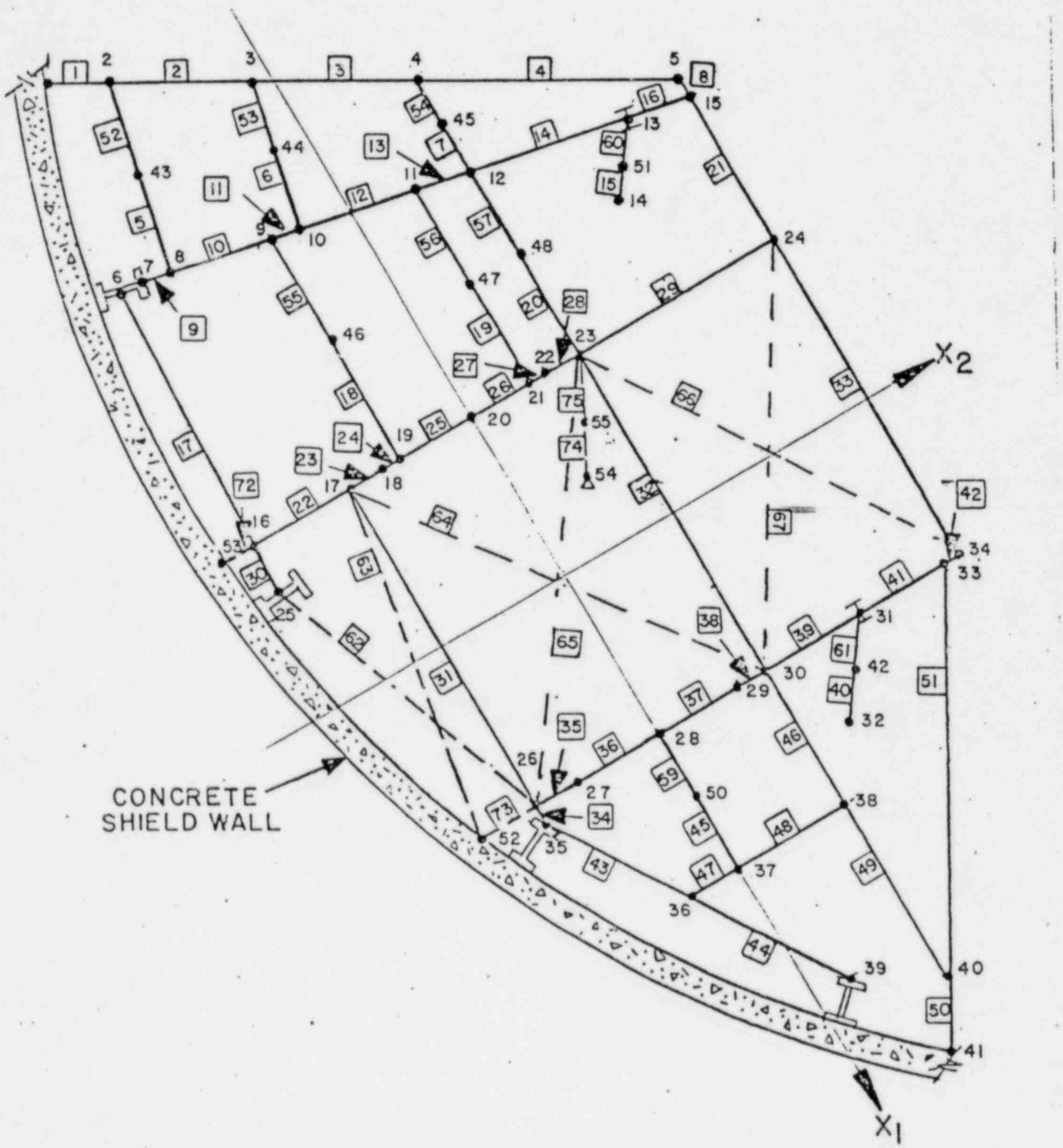


FIG.5. STARDYNE MODEL OF SHUTDOWN CONDENSER PLATFORM

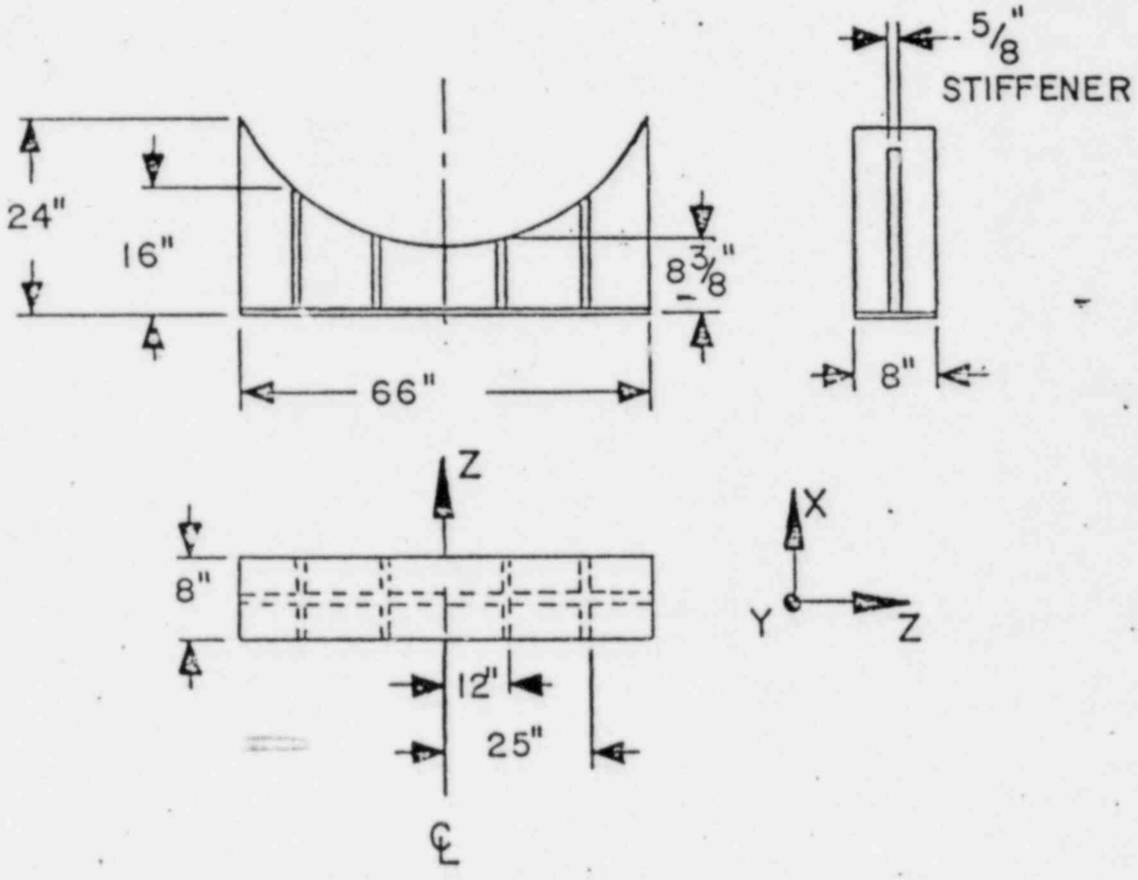


FIG.6. SADDLE DETAILS

APPENDIX

CALCULATION OF STIFFNESS.	REF.

REFERENCE — ALL VALUES FOR STRESS, LOADS AND DEFLECTIONS ARE TAKEN FROM COMPUTER PROGRAMS S4400ZB & S4400SY STARDYNE MODEL — REF. 4

DEFLECTION AT NODE 20 $\delta_{HORIZ\,X1} = 0.0051$ IN FOR THE 1[K] LATERAL LOAD AT NODES 18 & 22. ✓

$\delta_{HORIZ\,X2}$ = 0.00062 @ NODE 22
0.00031 @ NODE 29

$\frac{0.00093}{2} = 0.00047$ IN AVERAGE FOR 1[K] LATERAL LOAD AT NODES 18, 22, 27 & 29 ✓

FLOOR STIFFNESS $K_{X1} = \frac{2^K}{0.0051\,in} = 392.16$ K/IN ✓

FLOOR STIFFNESS $K_{X2} = \frac{4^K}{0.00047} = 8510.6$ K/IN ✓

FLOOR STIFFNESS $K_{VERT} = \frac{P}{\delta_{AVG}}$

FROM COMPUTER PRINTOUT S4400SY
$\delta_{18} = 0.0847$ ✓ $\delta_{29} = 0.0526$ ✓
$\delta_{21} = 0.0495$ ✓ $\delta_{27} = 0.01781$ ✓
$\delta_{VAVE} = 0.0511$ ✓ DUE TO 31K LOAD

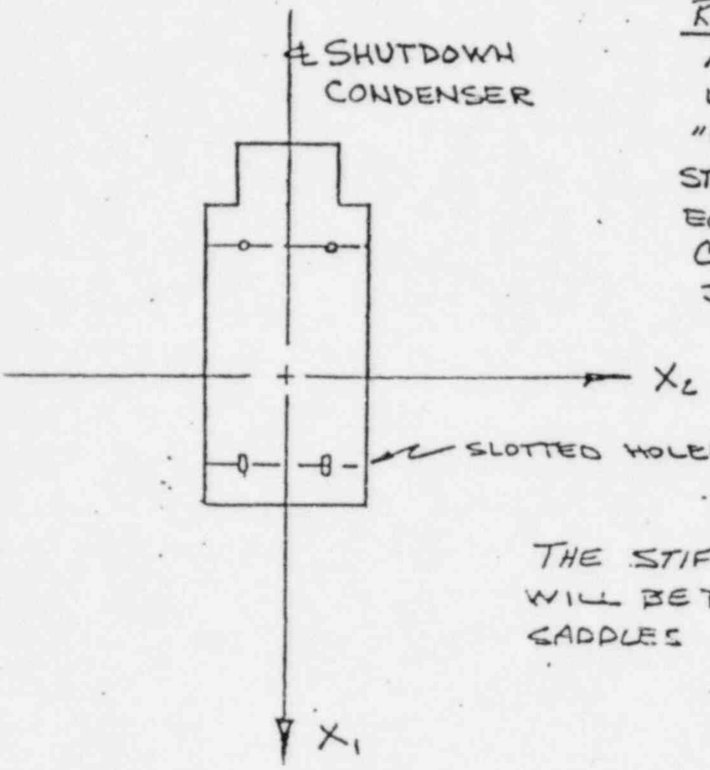
$K_{VERT} = \frac{31}{.0511} = 606.39$ K/in ✓

VERTICAL FREQUENCY $= \frac{1}{2\pi}\sqrt{\frac{K}{M}} = \frac{1}{2\pi}\sqrt{\frac{606.4 \times 386.4}{31}}$

$f_{VERT} = 13.83$ CPS ✓

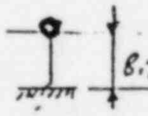
	REF.

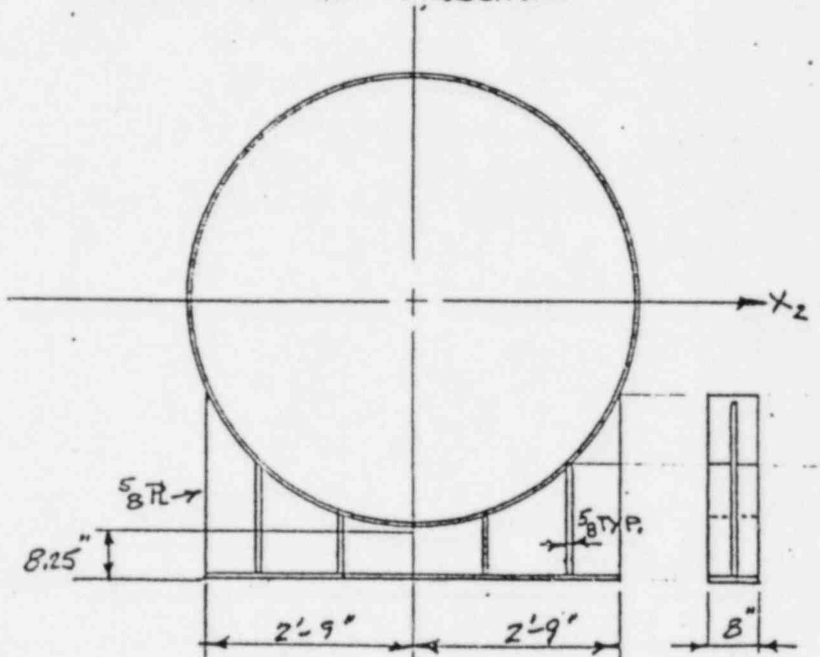
SHUTDOWN CONDENSER STIFFNESS



REFERENCE: ALL DIMENSIONS AND MATERAL THICKNESSES WERE TAKEN FROM. "OPERATION AND MAINTENANCE OF STRUTHERS WELLS HEAT TRANSFER EQUIPMENT", STRUTHERS WELLS CORP. WARREN, PENNSYLVANIA. JAN, 1965

THE STIFFNESS IN THE X_2 DIRECTION WILL BE THAT OF THE SUPPORT SADDLES IN THAT DIRECTION.





ASSUMING THE WEBS OF THE SADDLES ARE EFFECTIVE RESISTING THE LOAD.

$$K_{SHEAR} = \frac{\bar{A}G}{H}$$

$\bar{A} = 2 \times \frac{5}{8}" \times 66 = 82.5\,in^2$

$G = 12{,}000\,ksi$

$H = 8.25\,in$

$$K = \frac{82.5 \times 12{,}000}{8.25} = 120{,}000\ k/in$$

	REF.

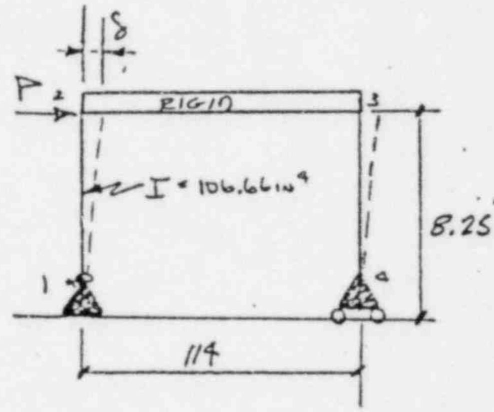
COMBINING THE STIFFNESSES OF THE FLOOR (EL 711) AND THE SHUT DOWN CONDENSER IN THE X_2 DIRECTION

$$K_{EQ\,X_2} = \frac{1}{\frac{1}{K_{X_2\,floor}} + \frac{1}{K_{X_2\,Shutdown}}} = \frac{1}{\frac{1}{8510.6} + \frac{1}{120,000}} = 7947 \text{ k/in}$$

$$f_{X_2} = \frac{1}{2\pi}\sqrt{\frac{K}{M}} = \frac{1}{2\pi}\sqrt{\frac{7947 \times 386.4}{31}} = \underline{50 \pm \text{ CPS}}$$

CONDENSER STIFFNESS IN X_1 DIRECTION

ASSUME THAT THE SHUT DOWN CONDENSER IS RIGID AND THE SADDLE IS FLEXIBLE



THE I OF THE 8 STIFFNERS WILL BE EFFECTIVE

$$4\,I_{LEG} = 4 \times \frac{5}{8}\frac{(8)^3}{12} = 106.66 \text{ in}^4$$

$$\bar{A} = 4 \times \frac{5}{8} \times 8 = 20 \text{ in}^2$$

$$K = \frac{P}{\delta} \quad \frac{3EI}{\ell^3}$$

BENDING STIFFNESS $K_B = \dfrac{3 \times 30000 \times 106.66}{8.25^3}$

$$K_B = 17,096.0 \text{ k/in}$$

SHEAR STIFFNESS $= K_s = \dfrac{\bar{A}\,G}{H} = \dfrac{20 \times 12000}{8.25} = 29091 \text{ k/in}$

COMBINING THE SHEAR & BENDING STIFFNESSES

$$K_{EFF} = \frac{1}{\frac{1}{K_B} + \frac{1}{K_S}}$$

$$K_{EFF} = \frac{1}{\frac{1}{17,096} + \frac{1}{29091}} = 10768.0 \text{ k/in}$$

	REF.

USING THE FREQUENCIES CALCULATED AND THE APPROPRIATE SPECTRA FROM THE GULF UNITED REPORT "SEISMIC EVALUATION OF THE LACROSSE BOILING WATER REACTOR" JAN 11, 1974., THE ACCELERATION CANBE FOUND.

COMBINING THE FLOOR STIFFNESS AND THE HORIZONTAL SADDLE STIFFNESS IN THE X_1 DIRECTION

$$K_{eq} = \frac{1}{\frac{1}{392.16} + \frac{1}{10768}} = 378.40 \text{ K/in} ✓$$

$$\text{HORIZONTAL FREQUENCY } X_1 = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{378.40 \times 386.4}{31}}$$

$$F_{H_1} = 10.93 \text{ CPS} ✓$$

CRANE SUPPORT LEVEL

HORIZONTAL ACC VALUE FOR SSE (FIG G-14) — REF.

HORIZ X_1 DIRECTION (10.93 CPS) /	HORIZ X_2 DIRECTION (50.10 CPS).	VERTICAL X_3 (13.83 CPS)

USING THE GREATER G-VALUE FOR 10% ±

	9.84 CPS	12.02 CPS	45.09	55.11	12.447	15.213
FLOOR	0.437	0.437	0.437		2/3 (0.38)	(0.38)
SUPPORT	0.786	0.629	0.437		0.25 G	
	0.612 >	0.533	0.437			

AVERAGE $\frac{0.612 + 0.533}{2} = 0.573$ ✓

HORIZ $X_{1\,ACC} = 0.573g$ /

HORIZ $X_{2\,ACC} = 0.437g$ /

VERT $X_{3\,ACC} = 0.25g$