50-280

INFORMATION CONCERNING HIGH DENSITY SPENT FUEL STORAGE RACKS....INS RESPONSE TO NRC QUESTIONS SUBMITTED BY LTR DTD 8/25/77..............

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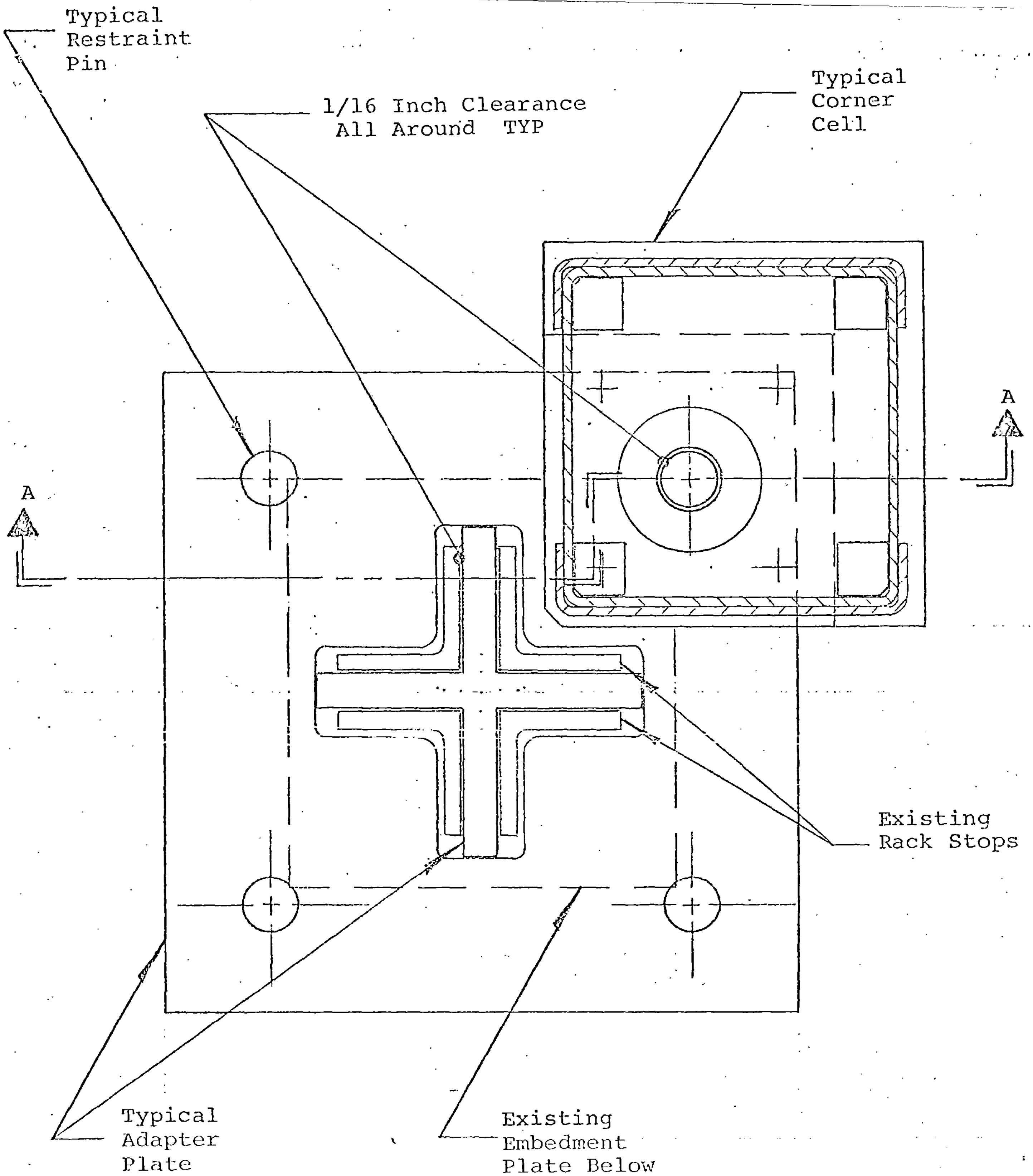
Question 1: Provide clear sketches indicating the connection between the corner storage cells and the spent fuel pool floor pads at their mating surfaces. If the corner cells simply rest on the pads, a detailed description should be provided as to how the effect of possible sliding of the rack modules and potential impact between the inner cells and the floor pads are incorporated in the design. Also discuss how the various tools and the gates in storage within the pool interact with the new rack system in a seismic environment.

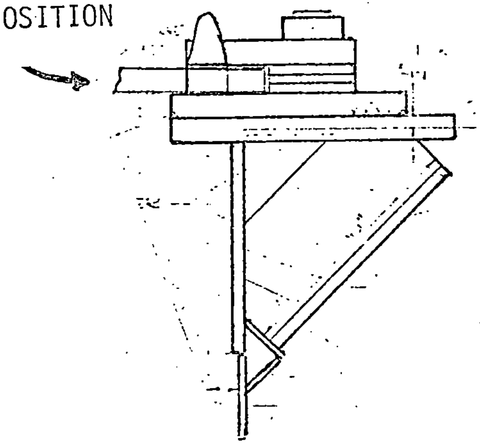
Response: The corner storage cells do not just simply rest on the fuel pool floor pads. The corner cells rest on adapter plates as shown in Figures 1-1 and 1-2. The adapter plates are keyed to the existing rack stops and the corners of the fuel storage cells are keyed to the adapter plates through 1-5/8" diameter restraint pins. For installation purposes a nominal clearance of 1/16 inch is provided all around between the restraint pin hole in the corner storage cells and the restraint pin, and between the clearance cut-outs in the adapter plates and the existing rack stops. The clearance also provides sufficient allowance for thermal expansion. The horizontal seismic loads are transmitted from the rack structure to the existing rack stops at each corner of the rack through the adapter plates and pins. The racks cannot slide during any design basis seismic events.

The new high density spent fuel racks will replace the existing racks on a one for one basis and will occupy the same space as the existing spent fuel racks. Therefore, there will be no interferences between the new spent fuel storage racks and the gates and tools in storage within the pool. All of the equipment stored within the fuel pool, except the fuel pool gates, weighs less than a fuel assembly. Therefore, any possible interaction between these tools and the fuel racks would be less severe than interaction between a fuel assembly and the spent fuel storage racks, which has been analyzed. The fuel pool gates, however, weigh 3300 pounds, which is more than a fuel assembly. These gates are stored in such a manner as they are captured at both the top and the bottom making interaction between the gate and the spent fuel storage racks very unlikely. This is shown in Figure 1-3.



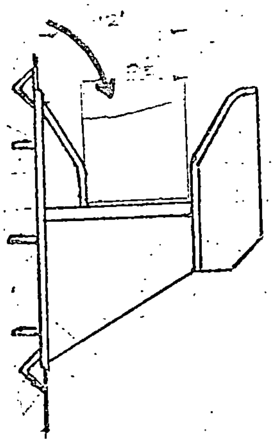
FUEL RACK ADAPTER PLATE
FIGURE 1-1

TOP OF GATE IN
STORAGE POSITION



Tabs on top of gate
fit over two pins on
the pool side. An arm
locks them in position.

BOTTOM OF GATE IN
STORAGE POSITION



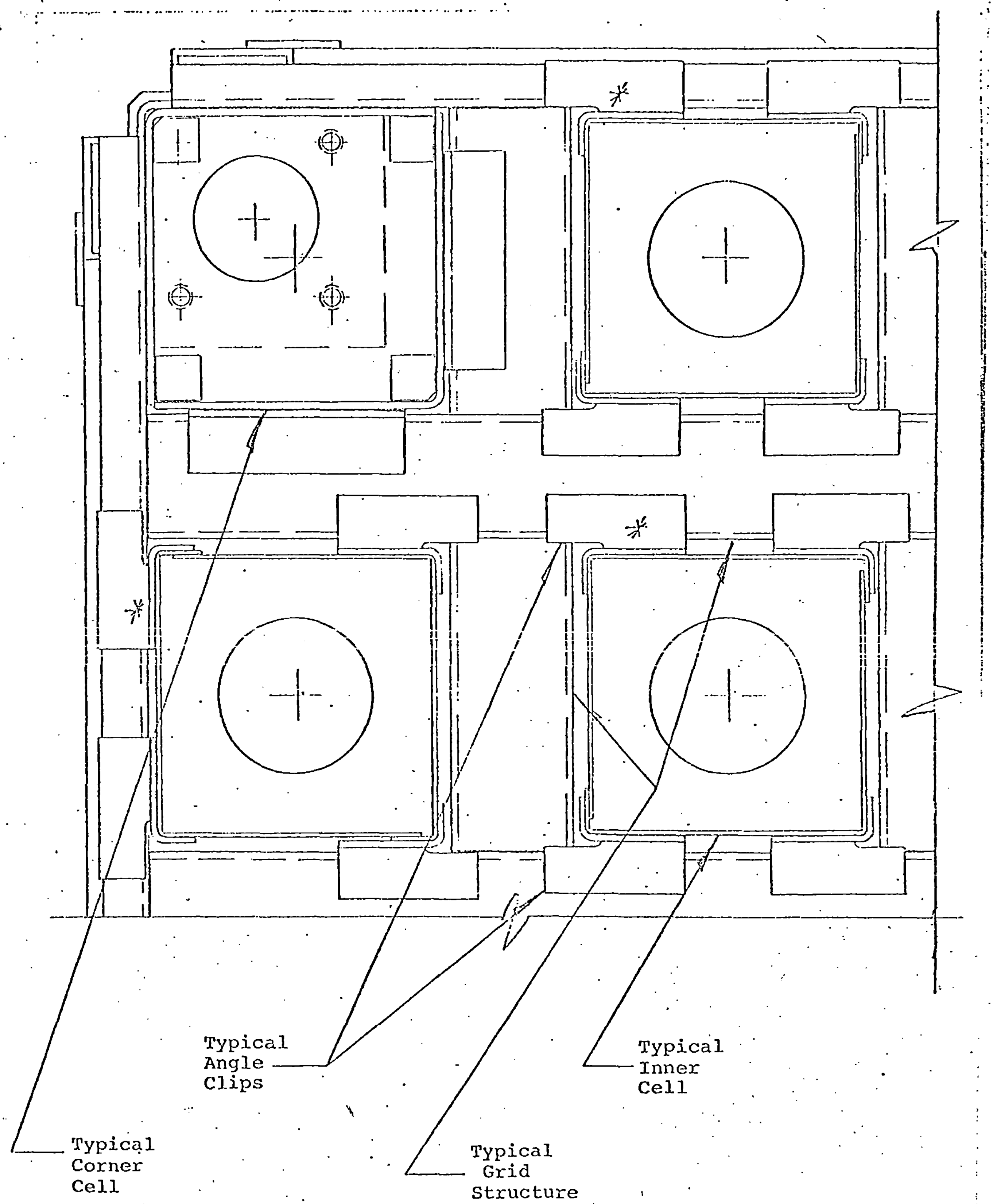
Gate is keyed into
position such that
the bottom is not
free to move.

FUEL POOL GATE
STORAGE DETAILS
FIGURE 1-3

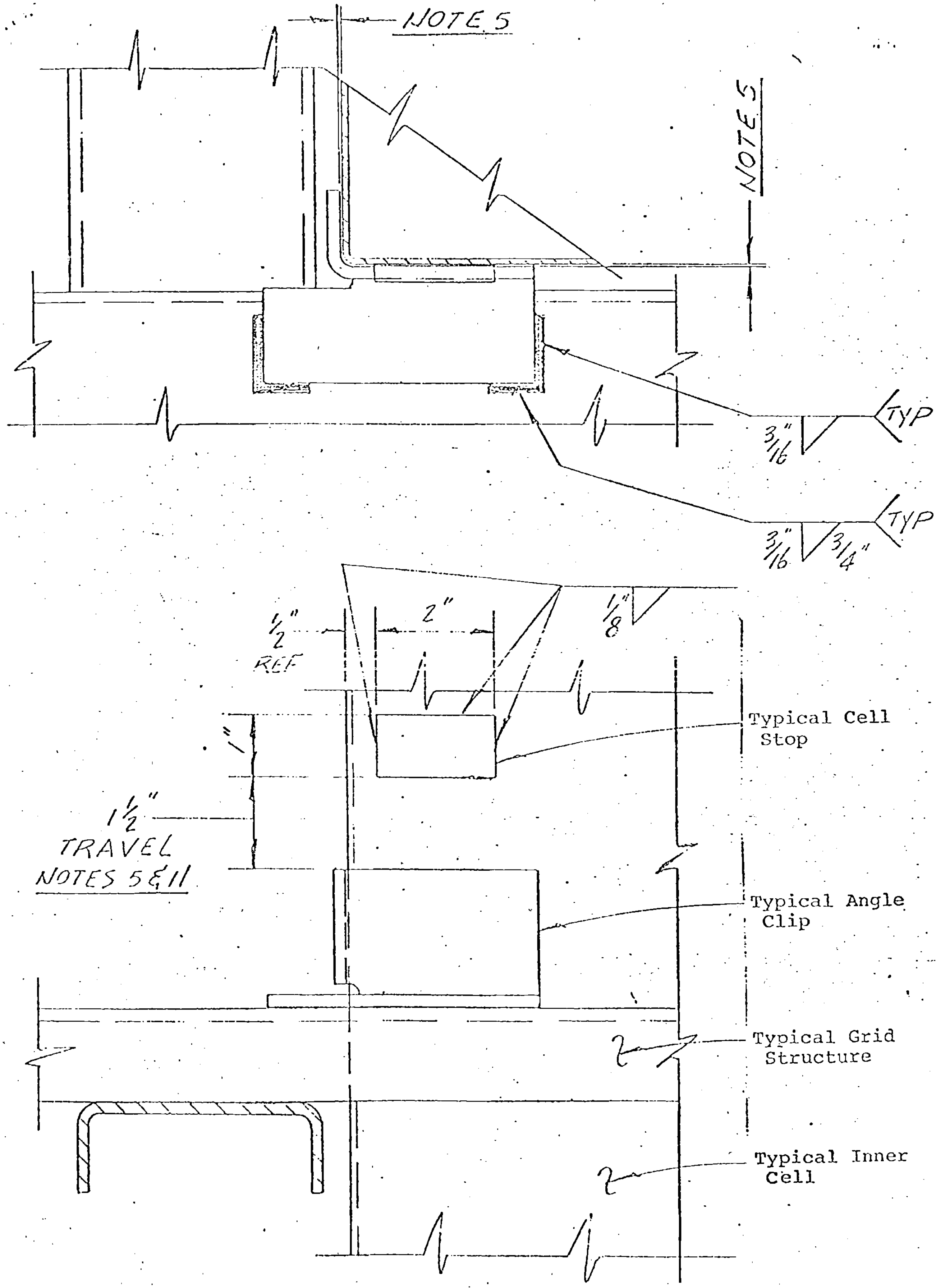
Question 2: Provide a complete description of the connection between the inner cells among each other, and among them and the corner cells indicating how the potential impact between adjacent inner cells and the corner cells are accounted for in the design. Also indicate how the stresses due to the 1" vertical deformation of the inner cells to accommodate the unevenness of the floor were accounted for by stating the specific load combinations utilized.

Response: The rack grids maintain the horizontal position of the inner cells relative to each other and the corner cells such that impact between inner cells and/or corner cells is not possible. Each grid consists of welded 4-inch by 1-1/2 inch x 3/16 inch channels forming square openings in which the inner cells are placed. The grids are welded to the top and bottom ends of the heavy wall (1/4 inch thick) corner storage cells to form the basic rack structure. Diagonal bracing welded to the corner storage cells completes the rack structure and provides the lateral and torsional rigidity to accommodate seismic and installation loads.

Figures 2-1 and 2-2 show the specific method of retaining the inner cells within the grid openings. At each grid elevation four angle clips capture the corners of each inner cell. These clips are welded to the channel members of each grid to maintain pitch and vertical plumbness. A slight clearance is provided between the clips and the cells (1/64 inch maximum for each clip) to facilitiate fabrication and to permit vertical movement of the inner cells. Such vertical movement does not introduce any stresses/deformations in the rack structure or the inner storage cells since each inner cell can move freely past the grid retaining clips to sit directly on the pool floor. The design permits the vertical loads for each inner cell to be transmitted to the pool floor. It is necessary to limit the vertical travel of the inner storage cells to prevent (1) removal of a cell during fuel handling operations (e.g. stuck fuel assembly load case) and (2) a cell dropping out of the rack during rack installation/removal. Mechanical stops welded to each inner cell limit the total vertical travel to about 2 inches (+ 1 inch). These stops will support the weight of the fuel cell plus a fuel assembly if necessary.



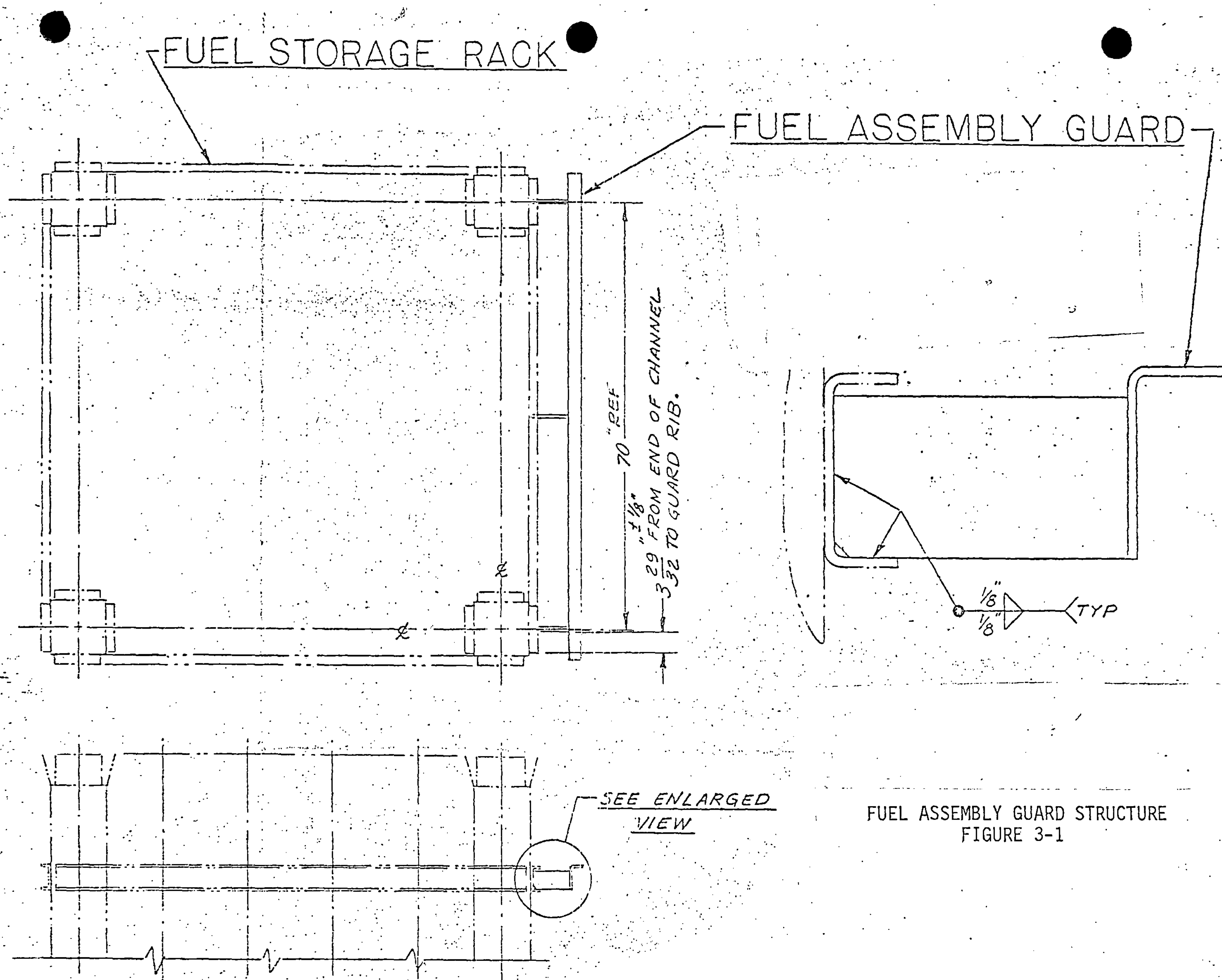
FUEL STORAGE CELL INTERCONNECTION
FIGURE 2-1



FUEL STORAGE CELL INTERCONNECTION
FIGURE 2-2

Question 3: On the top of page 28 a reference is made to a "structure". It is quite unclear as to how this structure functions. Provide a detailed discussion indicating the function and the physical nature of the "structure".

Response: The purpose of the fuel assembly guard structure is to prevent a fuel assembly from being brought up against the side of the peripheral fuel racks wherever the space between the fuel racks and the fuel pool walls is sufficient to insert an assembly. The structure is a 4-inch by 2-inch by 3/16 inch angle welded to the outside channel of the upper grid. The location and configuration of the guard structure is shown in Figure 3-1. With this structure in place it will not be possible to move a fuel assembly closer than ~8 inches to stored fuel thereby maintaining a pitch in excess of 17 inches for this condition. The guard structures are required on the east and west sides of the storage rack array and on the two racks adjacent to the Unit 2 refueling canal. The space between the fuel racks and the north or south walls is not sufficient to insert a fuel assembly.



FUEL ASSEMBLY GUARD STRUCTURE
FIGURE 3-1

Question 4: In Section 6.3.1.1 it should be clearly stated (SIC) which ground response spectra and amplified floor response spectra were used for this modification indicating the appropriate SSE and OBE values. Also indicate how the allowable stress values for stainless steel at various design temperature were obtained.

Response: The amplified response spectra used in the design of the spent fuel racks are shown in Figures 4-1 through 4-6. The ground acceleration values in section 2.5 of the Surry 1 and 2 FSAR were used to generate these curves. A dynamic model representing the fuel building structure and the subgrade was prepared. This model was used to calculate amplified response spectra (ARS) due to the specified earthquake. ARS were generated for both the Safe Shutdown Earthquake (SSE) and the Operational Basis Earthquake (1/2 SSE) at the mat surface, the top of the concrete structure, and the roof of the steel superstructure. The response spectra of the design earthquakes used are consistent with the requirements set forth by NRC Regulatory Guide 1.60, and the damping levels are from NRC Regulatory Guide 1.61.

The dynamic analysis was performed for a range of subgrade properties to account for uncertainties in soil parameters. The ARS provided are the result of enveloping the response spectra obtained from these analyses. They also include the design ground response spectrum.

The various load combinations considered in the design of the High Density Fuel Storage Racks and the allowable stress values for these load combinations are given in Tables 4-1 and 4-2 respectively. The yield stress value for stainless steel used in calculating the section strength for all the load combinations was taken as 30.0 ksi.

VEPCO, SURRY 1-2 , DYNAMIC ANALYSIS OF FUEL BUILDING , JOB NO 12496.26
ELEVATION 6.83 VERT DIRECTION.1/2 SSE. VERT. DIR. JUNE 14, 1976.PAUL MARTIN
FLOOR RESPONSE SPECTRUM, 1/2 SSE. NRC REG. 1.60 UNE 18, 1976. T.P.LEE

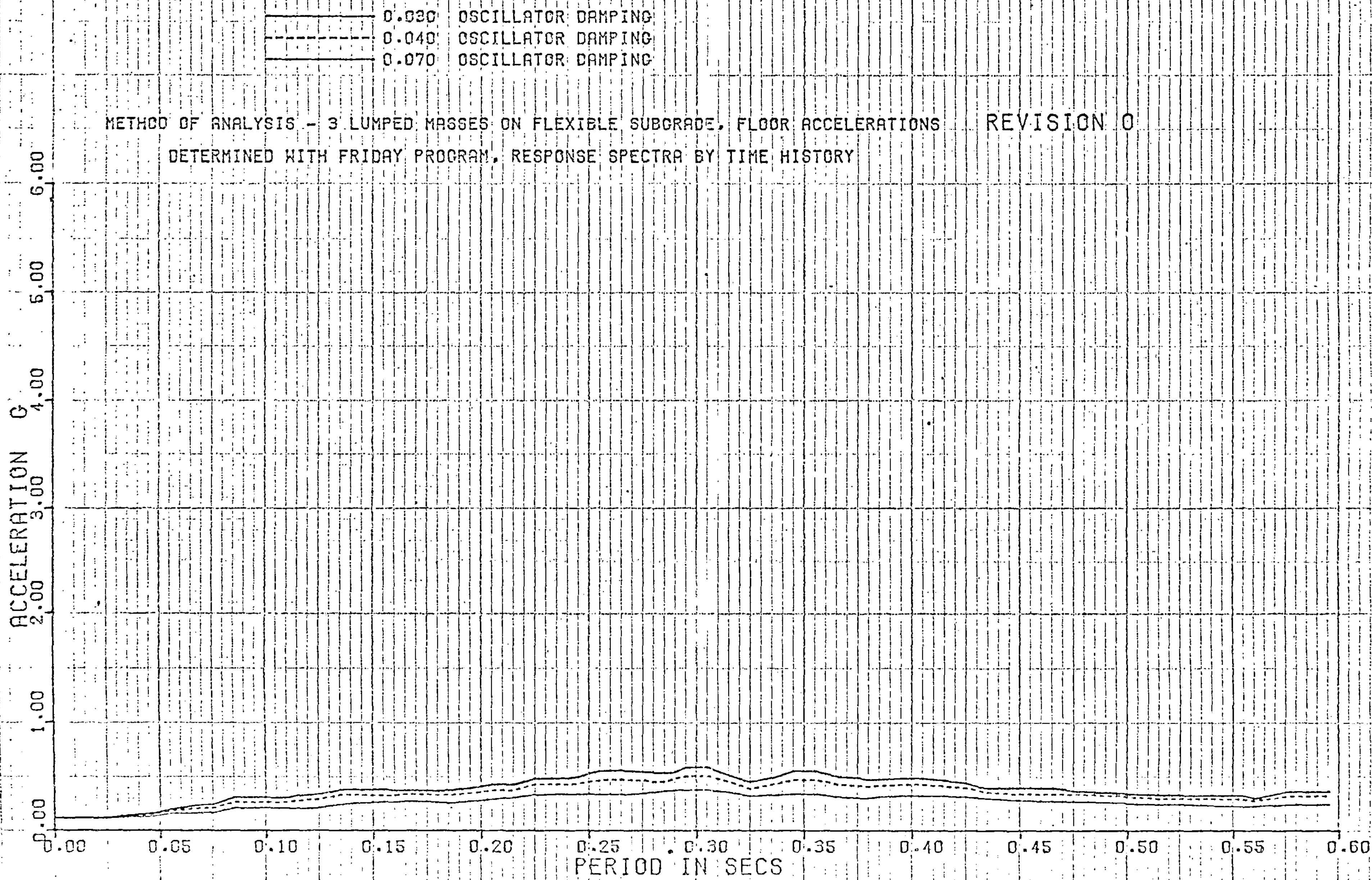


FIGURE 4-1

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ELEVATION 6.83 E-W DIRECTION,1/2 SSE, HORZ. DIR. JUNE 14, 1976,PAUL MARTIN
FLOOR RESPONSE SPECTRUM, 1/2 SSE, NRC REG. 1.60 JUNE 18, 1976, T.P.LEE

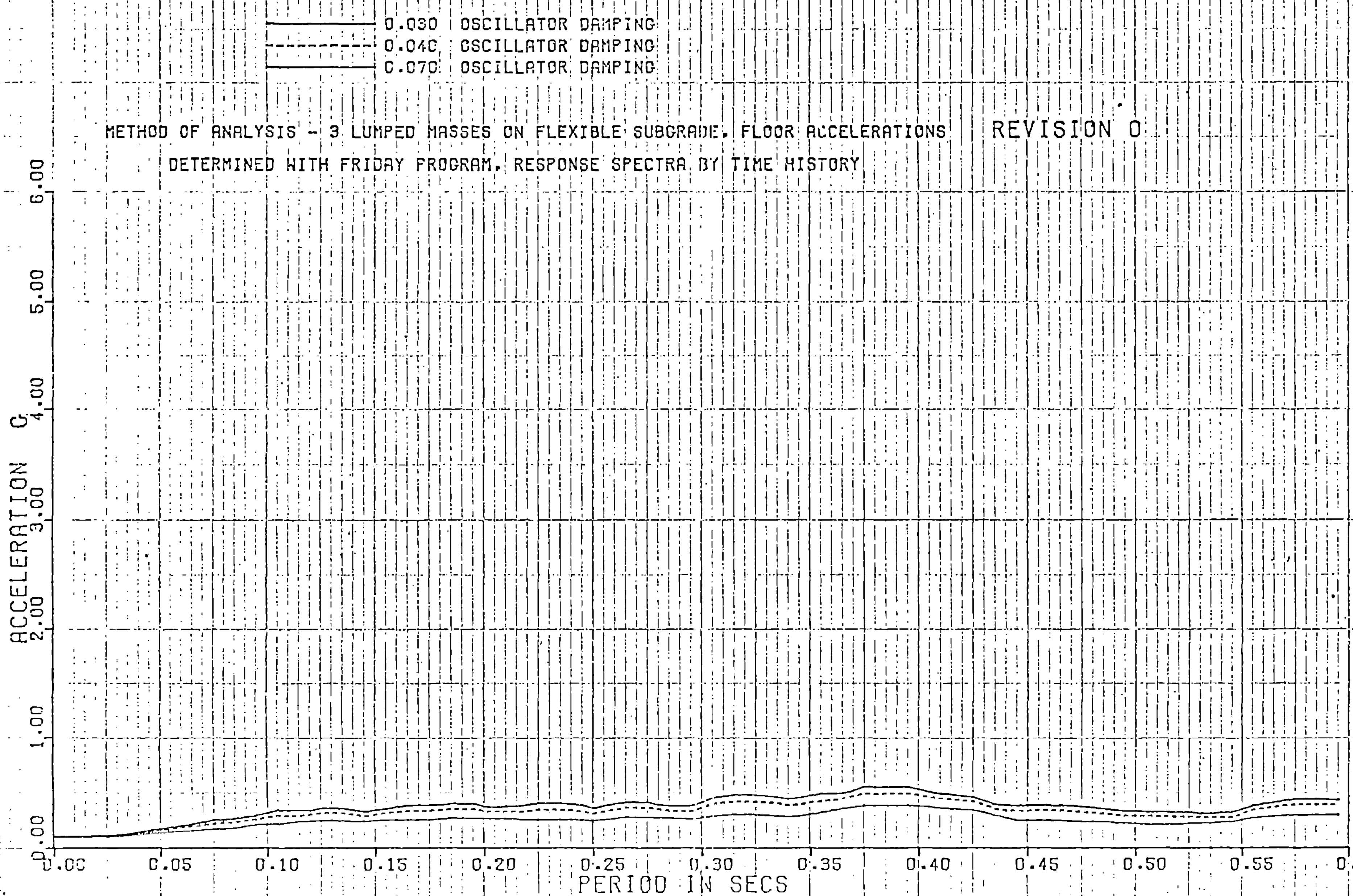

FIGURE 4-2

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ELEVATION 6.83 N-S DIRECTION,1/2 SSE, HORZ. DIR.
FLOOR RESPONSE SPECTRUM, 1/2 SSE, NRC REG. 1.60

JUNE 14, 1976,PAUL MARTIN
UNE 18, 1976, T.P.LEE

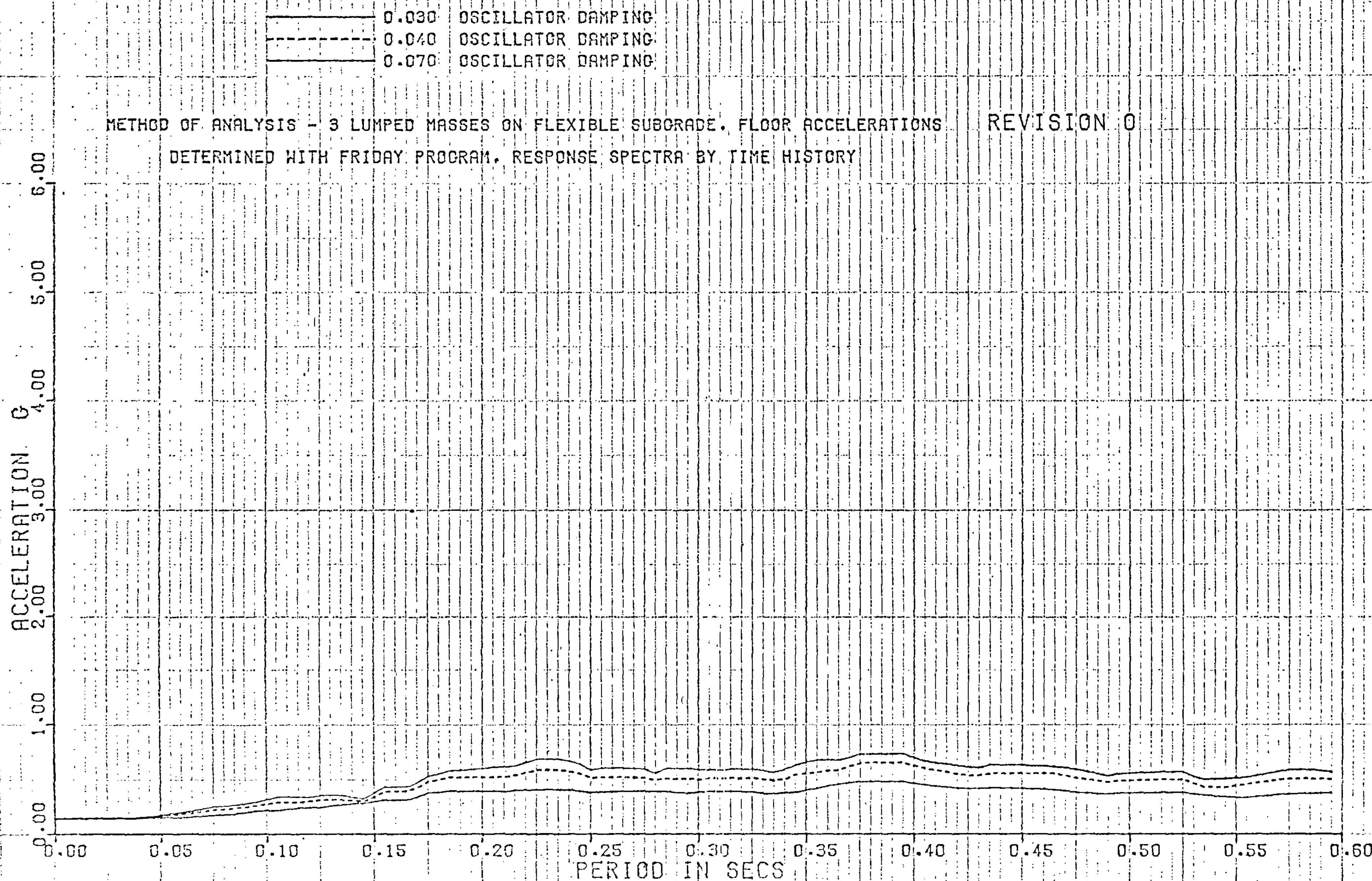

FIGURE 4-3

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FLOOR RESPONSE SPECTRUM, SSE, NRC REG. 1.60 UNE 18, 1976, T.P.LEE

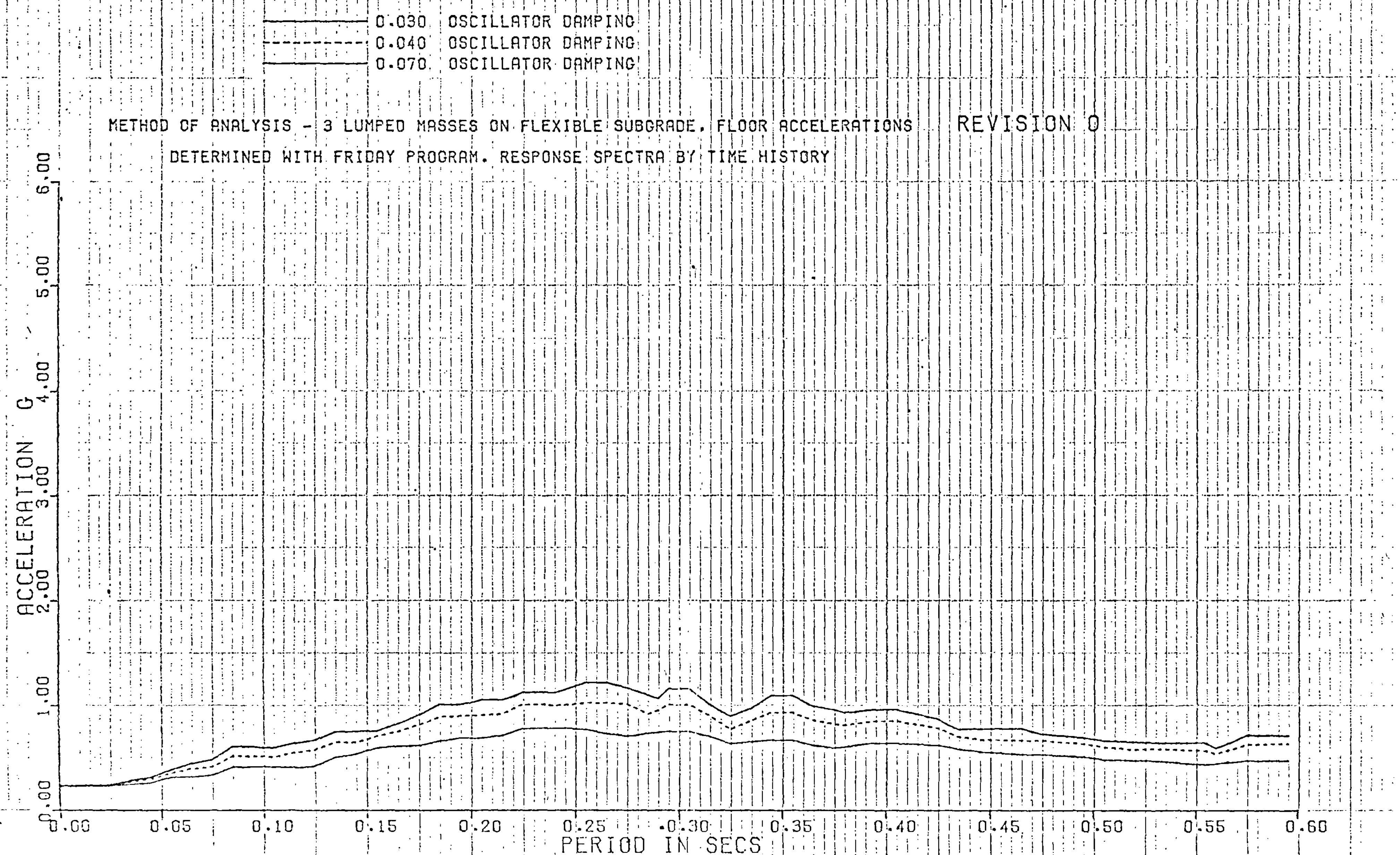

FIGURE 4-4

VEPCO, SURRY 1-2 , DYNAMIC ANALYSIS OF FUEL BUILDING , JOB NO 12496.26
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FLOOR RESPONSE SPECTRUM, SSE, NRC REG. 1.60 UNE 18, 1976. T.P.LEE

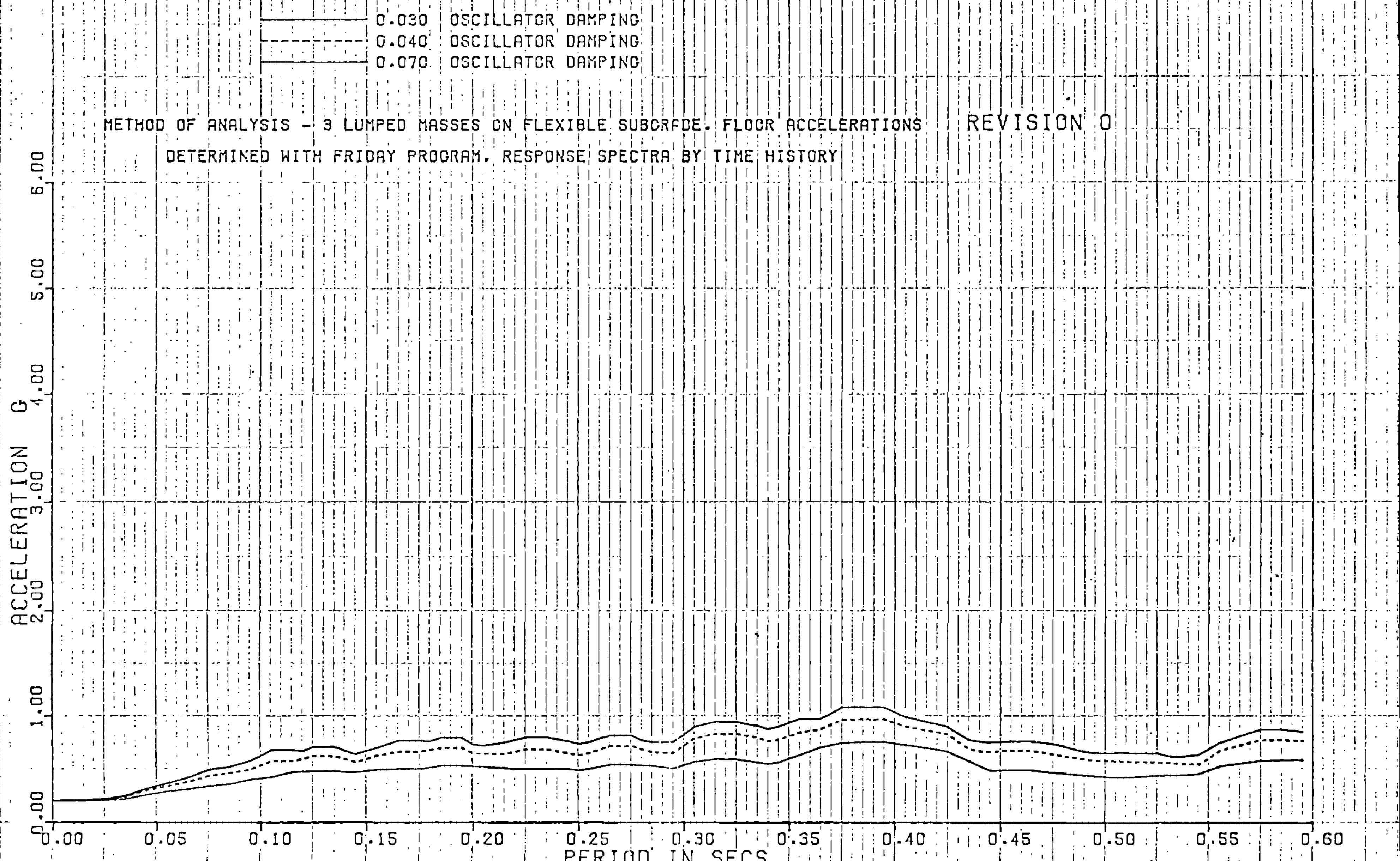


FIGURE 4-5

VEPCO, SURRY 1-2 , DYNAMIC ANALYSIS OF FUEL BUILDING , JOB NO 12496.26
ELEVATION 6.83 N-S DIRECTION, SSE, HORZ. DIR. JUNE 14, 1976,PAUL MARTIN
FLOOR RESPONSE SPECTRUM, SSE, NRC REG. 1.60 UNE 18, 1976, T.P.LEE

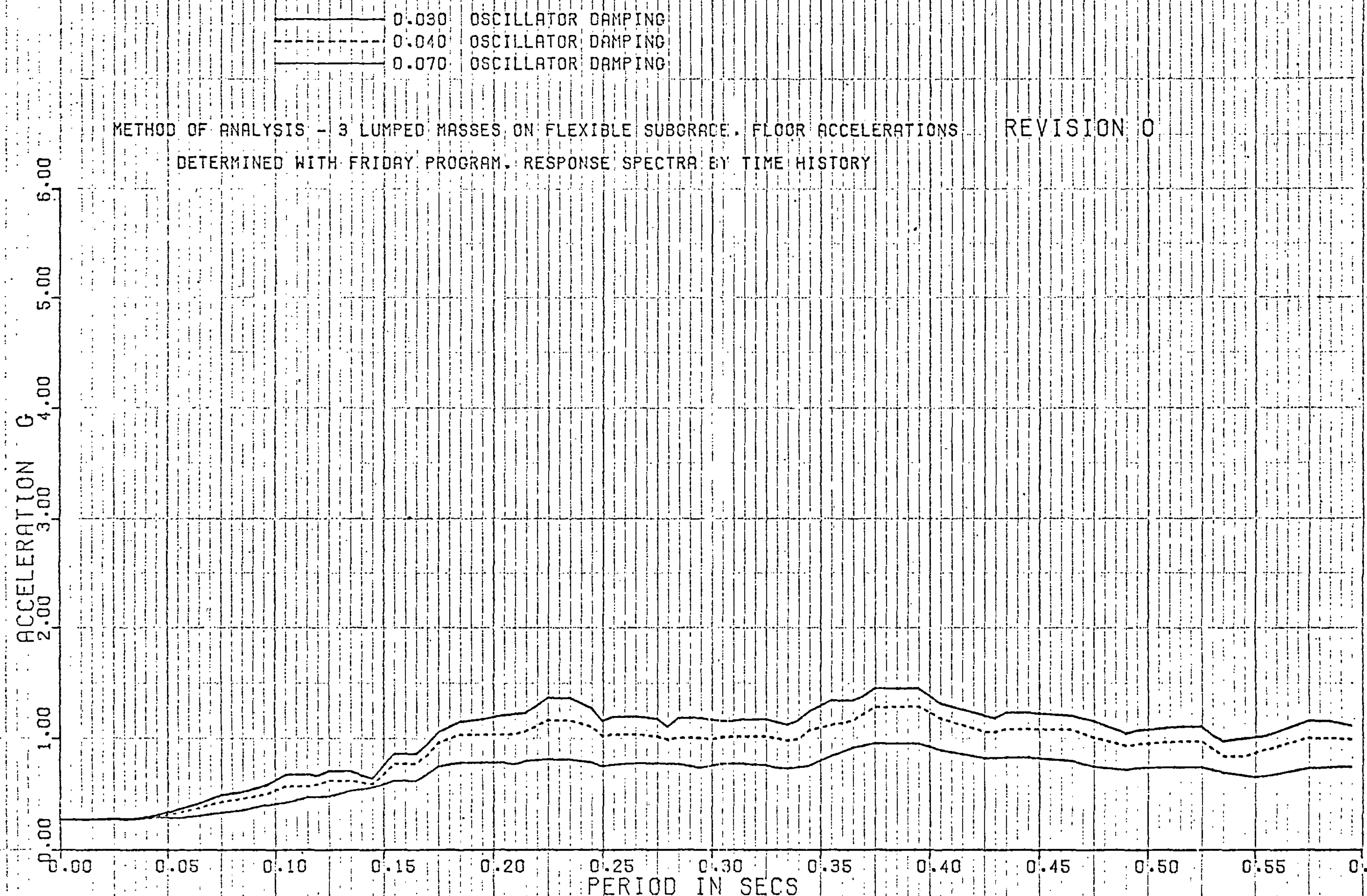


FIGURE 4-6

TABLE 4-1

LOADING CONDITIONS

The following load cases and load combinations have been considered in the analysis in accordance with the requirements of USNRC Standard Review Plan, Section 3.8.4.

Load Cases:

Load Case 1a - Dead Weight of Rack Plus Corner Fuel Assemblies, D + L (Normal Load)

Under normal operating conditions the rack is subjected to the dead weight loading of the rack structure itself plus the loads resulting from four fuel assemblies stored in the four structural corner cells. The loads resulting from the individual storage cells and contained fuel assemblies are not considered since these transmit their load directly to the pool floor and not through the structure.

Load Case 1b - Dead Weight of Rack and Storage Cells, D + I.L. (Normal Load)

During installation the rack is subjected to the loading resulting from its own structural weight plus the weight of the empty storage cells.

Load Case 2 - Operating Basis Earthquake, E (Severe Environmental Load)

The rack, fuel assemblies, and virtual water mass react to the simultaneous loading of the horizontal and vertical components of the sismic response acceleration spectra specified for the Operating Basis Earthquake in the Surry 1 and 2 Seismic Design Specifications (see Figures 4-2, 4-3, and 4-4). The seismic loading is applied to two storage conditions: a fully loaded rack and one partially loaded with 21 fuel assemblies.

Load Case 3 - Safe Shutdown Earthquake, E' (Extreme Environmental Load)

Same as Load Case 2 except that the seismic response acceleration spectra corresponding to the Safe Shutdown Earthquake was used in the analysis (see Figures 4-5, 4-6 and 4-7).

Load Case 4 - Uplifting Load, U.L. (Abnormal Load)

The possibility of the fuel handling bridge fuel hoist grapple getting hooked on a fuel storage cell was considered. The uplift force considered for this load case was 2400 pounds which corresponds to a specified 4000 lbs. uplift load less the weight of the storage cell and contained fuel assembly. This load is conservative considering that the hoist has a load-limit cell set at ~2000 pounds resulting in an actual uplift force of 350 lbs. when the assembly is present.

Load Case 5 - Assembly Drop Impact Load, (Abnormal Load)

The possibility of dropping a fuel assembly on the rack from the highest possible elevation during spent fuel handling was considered. A 1500 pound weight was postulated to drop on the rack from a height of 24 inches.

Thermal Loading, T (Normal Load)

The stresses and reaction loads due to thermal loadings are insignificant since clearances are provided at the base attachments to allow unrestrained growth of the racks for the maximum expected temperature differential.

Load Combinations:

(a) For service load conditions, the following load combinations are considered using elastic working stress design methods of AISC:

(1a) D + L

(1b) D + I.L.

(2) D + L + E

(b) For factored load conditions, the following load combinations are considered using elastic working stress design methods of AISC"

(3) D + L + E'

(4) D + U L

TABLE 4-2

STRUCTURAL ACCEPTANCE CRITERIA

The following allowable limits constitute the structural acceptance criteria used for each of the loading combinations presented in Table 4-1.

Load Combinations	Limit
1	S
2	S
3	1.6S
4	1.6S

Where S is the required section strength based on the elastic design methods and the allowable stresses defined in Part 1 of the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Building", February 12, 1969. The yield stress value for stainless steel is taken at 30.0 ksi.

The acceptance criteria for Load Case 5, accidental fuel assembly drop onto the rack, is that the resulting impact will not adversely affect the leak-tightness integrity of the fuel pool floor and liner plate and that the deformation of the impacted storage cells will not adversely affect the value of k_{eff}.

Question 5: Thermal loads should be included for the service load combinations, and for the factored load combinations per Section 3.8.4.II.3 of the Standard Review Plan. Provide stress summaries for all load combinations including those that were omitted in this report.

Response: Th maximum thermal growth of the fuel storage racks would be 0.11 inches for a fuel pool bulk water temperature change from 70°F to 210°F (84" x 9.35 x 10^{-6} in./in./°F x (210 - 70°F). Sufficient clearance between the fuel storage rack and the pool floor support pads (0.125 inches minimum) has been provided to eliminate any potential interference between the rack and the support pads caused by thermal expansion. The installation approach permits those clearances to be achieved during the wet installation of the Surry fuel racks. Since there will not be any interferences between the rack and its support points, the stresses and reaction loads due to thermal loadings would be insignificant. Furthermore, there will not be any local stresses due to thermal gradients across the fuel storage rack structural members, since significant increases in pool water bulk temperature occur very gradually (a change from 70°F to 210°F would take ~20 hours).

The maximum stress values for all load combinations except fuel assembly drop are given in Table 5-1. The stress values for the fuel assembly drop are presented in the response to Question No. 7.

TABLE 5-1

COMBINED STRESS SUMMARY

LOAD COMBINATION	ELEMENT NO./TYPE	COMBINED STRESS (ksi)* CALCULATED	ALLOWABLE	COMBINED** STRESS RATIO
1a) D + L	74/Beam	1.70	18.5	-
	158/Beam	1.78	18.5	-
	48/Plate	1.17	16.8	-
1b) D + I.L.	77/Beam	15.52	18.5	-
	48/Plate	1.24	16.8	-
2) D + L + E (Fully Loaded Rack)	2/Beam	5.56	-	0.32
	74/Beam	6.85	-	0.54
	158/Beam	5.18	-	0.36
	164/Beam	4.97	-	0.29
	48/Plate	9.17	16.8	-
3) D + L + E' (Fully Loaded Rack)	2/Beam	9.66	-	0.35
	74/Beam	10.51	-	0.59
	158/Beam	7.67	-	0.37
	164/Beam	8.51	-	0.32
	48/Plate	16.22	26.9	-
4) D + U.L.	70/154/Beams	16.93	29.6	-
	53/Plate	0.85	26.9	-

* Maximum Total Stress P/A + $\underline{M_2C_3}$ + $\underline{M_3C_2}$ for Beams. Max Von Mises for Plates. Allowable stresses are flexural for beams and tensile for plates.

** Combined axial compression plus bending stress requirement per AISC Specification Section.

Question 6: On page 29 under load case 4 indicate the consequences of malfunction of the load limit cell.

Response: The uplift load case which was analyzed did not take credit for the operation of the load limit cell. The uplift load applied to the fuel storage rack was based on the stall load developed by the fuel handling bridge hoist (4000 pounds) less the weight of the jammed fuel assembly and the fuel storage cell (a combined weight of ~1650 pounds). Consequently the malfunction of the load limit switch will not affect the results of the analysis.

Question 7: On page 29 under load case 5 indicate by reference to clear sketches that the maximum drop height is indeed 24". Discuss the effects of a drop for the cases of (a) straight drop on top of storage cans at the weakest edge of a can, (b) an inclined drop maximumizing the kinetic energy, and (c) a straight drop through a storage can and impacting on the liner. Also indicate the local and overall effects of these postulated impact loads.

Response: The actual maximum drop height is actually 23 1/4" inches, 24 inches was therefore used conservatively. This is shown in Figure 7-1 which shows the elevation of the bottom of the fuel pool to be 6'10" and the bottom of a fuel assembly during transfer to be a elevation 23'2". The high density spent fuel racks are 14' 4 3/4" in height.

<u>Case (a)</u> Straight Drop on Top of Storage Cans at the Weakest Edge of a Can

The results of the fuel assembly drop analysis using energy balance methods are summarized in Table 7-1. From Table 7-1 it can be seen that the maximum stress in the fuel storage cell is greater than the dynamic yield stress for stainless steel, thus indicating that the fuel storage cell may undergo some local permanent deformation, however, the cell will not collapse during such an accident event. From Table 7-1 it can also be seen that the maximum shearing stress in the weld between the cell legs and the cell, and the maximum bearing stress on the concrete floor under each leg exceed the allowable values, thus indicating that during the fuel drop accident event, the weld between the legs and the cell may partially shear off and the concrete may crumble locally under each leg. The external kinetic energy of the dropped fuel will be absorbed in the local deformation of the flare at the top of the fuel storage cell, in the partial shearing of the cell leg weld, in the local crumbling of the concrete, and in the minor deformation of the liner plate under each leg.

For conservatism, it has also assumed that the cell leg welds shear completely in order to assess the effects of a free fall of the dropped assembly and the storage cell from a height of 5.00 inches above the liner plate. This condition was analyzed using empirical missile equations (the Ballistic Research and Stanford Research Institute Formulae). The results of the analysis indicates that the maximum thickness of steel plate that could be perforated by such a missile is 0.070 inches which is far less than the 0.25 inch thickness of the liner plate.

It has, therefore, been concluded that neither the initial impact of the dropped fuel assembly on a storage cell nor the unlikely subsequent free fall of the fuel cell will damage the pool floor liner sufficiently to affect its leak-tight integrity.

Case (b) Inclined Drop Maximumizing the Kinetic Energy

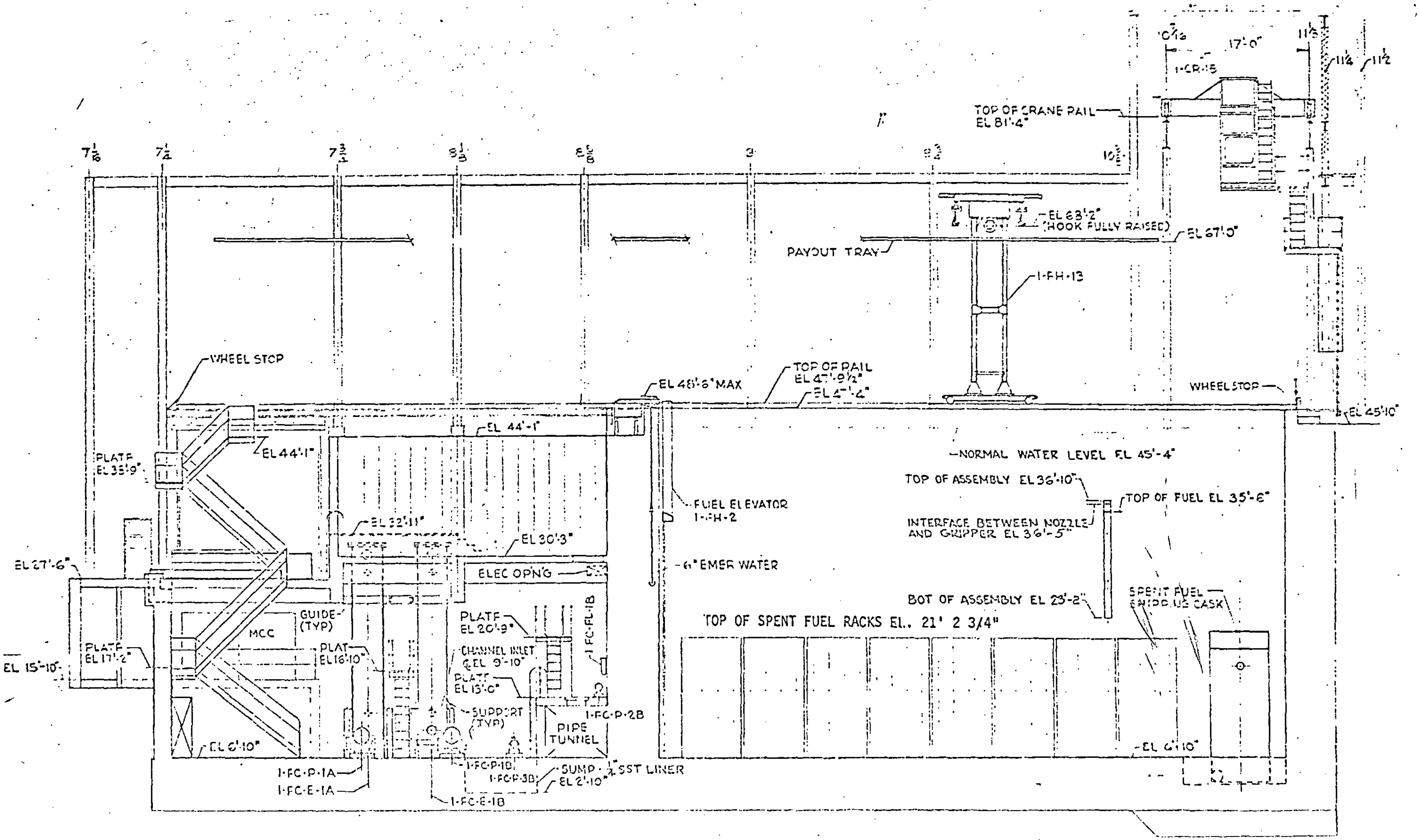
The maximum kinetic energy of the fuel assembly for an inclined drop is in the order of 156.6 in.k. Assuming this kinetic energy and that the entire fuel assembly falls on the minimum number of storage cells (8 storage cells if the assembly falls on the diagonal). The maximum kinetic energy that will be asborbed by the individual can will be in the order of 32.9 in.-kips. This value is lower than the kinetic energy of 34.8 in.-kips for the vertical drop of fuel assembly (Case a). Therefore, the resulting consequences of the inclined drop of fuel assembly would be less severe than that of the vertical drop (Case a).

Case (c) Straight Drop Through a Storage Can and Impacting on the Liner

If a fuel assembly were to drop straight through a storage can, it would not impact on the fuel pool liner but would impact on the bottom of the storage can. The case of a fuel assembly dropped directly on the pool floor is discussed in Section 14.4 of the Surry 1 and 2 FSAR. The consequences of a straight drop through a storage can would be less severe than those of a free fall of a fuel assembly directly to the pool floor for the following reasons.

1. The total frontal impact area of the four 1.5" x 1.5" legs at the corner of each storage cell is greater (9.0 square inches) than the impact area of the fuel assembly (6.0 square inches).

2. Due to the relatively small clearances between the fuel assembly and the storage cell, the drag resistance will be larger for a drop through the storage cell than for the free fall of fuel assembly directly to the pool floor.



FUEL BUILDING ARRANGEMENT
FIGURE 7-1

TABLE 7-1

RESULTS OF ACCIDENTAL FUEL ASSEMBLY DROP (LOAD CASE 5)

		ALLOWABLE VALUE
Weight of Fuel Assembly, kip	1.45	
Maximum Drop Height, in	24.0	
Kinetic Energy of Drop to be Absorbed, in-kip	34.8	
Maximum Strain in Storage Cell in/in	0.00227	0.485
Ductility Ratio	1.135	
Maximum Cell Deformation, in	0.372	
Maximum Stress in Cell (ksi)	44.61	41.4[1]
Maximum Transmitted Reaction Load per Leg, kip	36.25	19.2[2]
Maximum Stress in the Weld Between the Leg and the Cell (ksi)	102.53	19.2
Maximum Local Bearing Stress on Concrete Floor *under each leg) ksi	5.04	3.57[3]
Maximum Free-Fall Impact Velocity of Cell on Liner Plate (after Leg Weld is sheared) ft/sec	5.178	
Maximum unsupported Plate Thickness That May be Perforated by Missile Free Fall Velocity, in		
BRL Formula	0.070	0.25
Stanford Research Institute Formula	0.070	0.25

1. The allowable stress value represents dynamic stress for stainless steel.

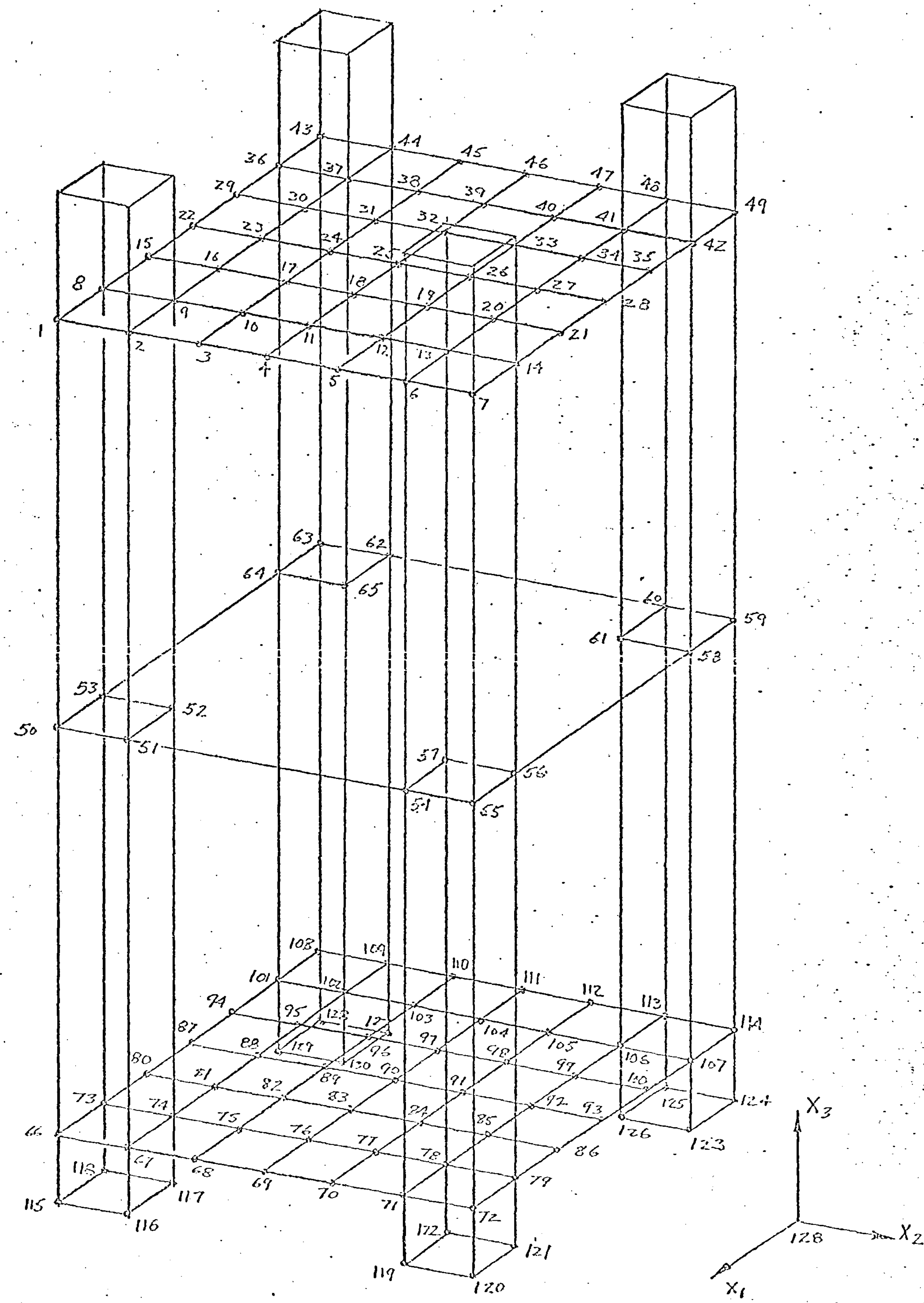
2. Allowable stress in the weld = $1.6 \times 0.4\ f_y = 1.6 \times .4 \times 30 = 19.2$ ksi

3. Based on Paragraph 10.14 of ACI of ACI 318-71. There will be local crumbling of concrete under each leg but the steel liner will not be perforated.

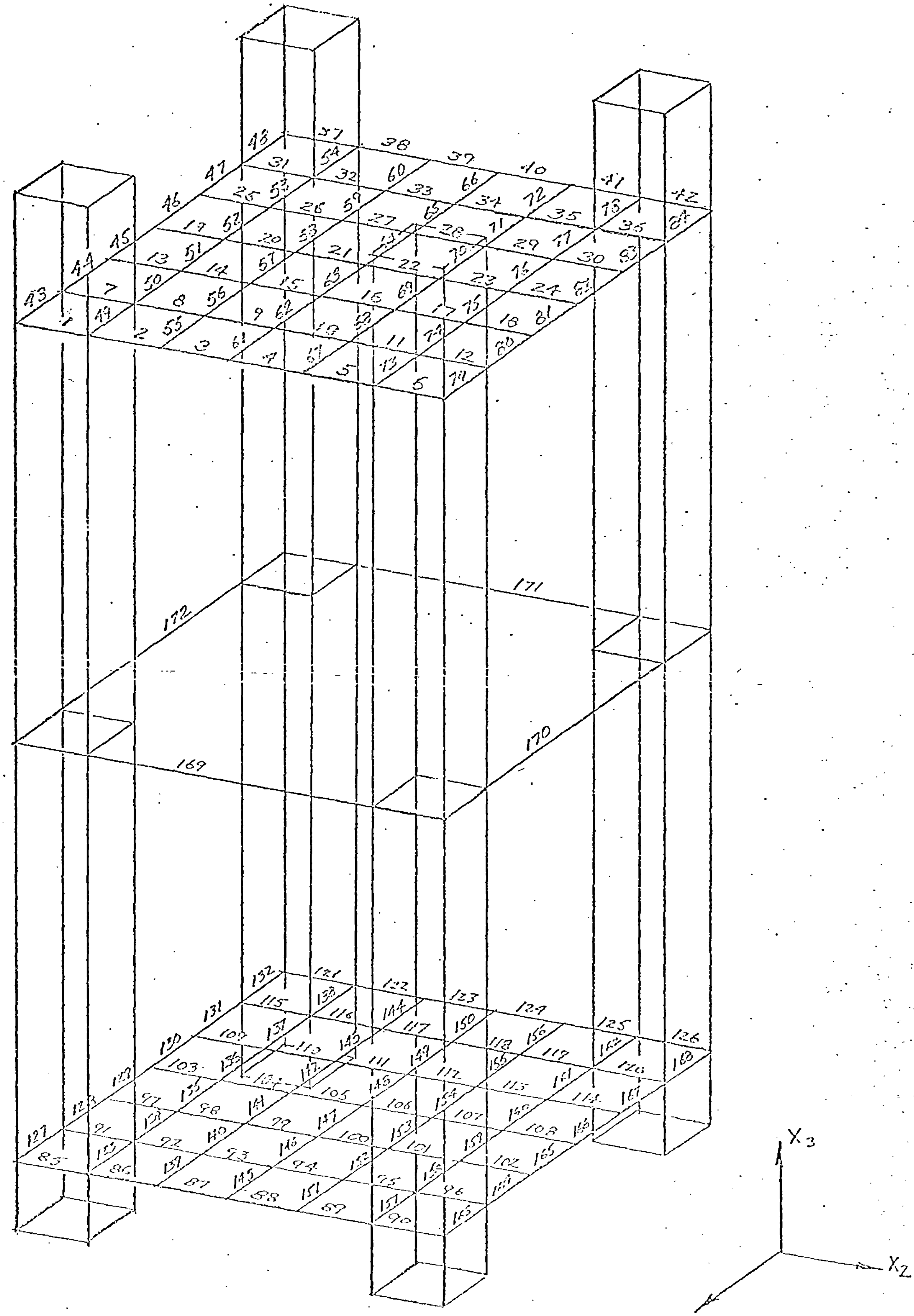
Question 8: Provide a description of the dynamic model of the rack, fuel pool system clearly showing the boundary conditions. Also indicate the damping values used in your analysis. Since the proposed rack system is inherently weak in torsion discuss what considerations were given to obtain the highest torsional effects due to possible non-uniform mass distribution.

Response: For the dynamic analysis, the fuel storage rack structure has been mathematically modeled as a three dimensional finite element structure consisting of discrete three dimensional elastic beam and plate elements interconnected at a finite number of model points as shown in Figures 8.1 through 8.4. Figures 8.5 and 8.6 show the model boundary conditions and the lumped mass distribution used in the seismic analysis of the fully loaded and partially loaded fuel storage racks respectively. The damping values used in the seismic analysis of the high density fuel storage racks are four percent for the Operating Basis Earthquake (OBE) and six percent for the Safe Shutdown Earthquake (SSE). The NRC Regulatory Guide 1.61 permits damping values of two percent for OBE and four percent for SSE for welded steel structures functioning in air. These damping values are increased by two percent since the fuel storage racks are welded stainless steel structures completely submerged in water. This two percent increase in damping value for submerged structures is based on Section 6.4 of "Fundamentals of Earthquake Engineering" by N. M. Newmark, and E. Rosenblueth.

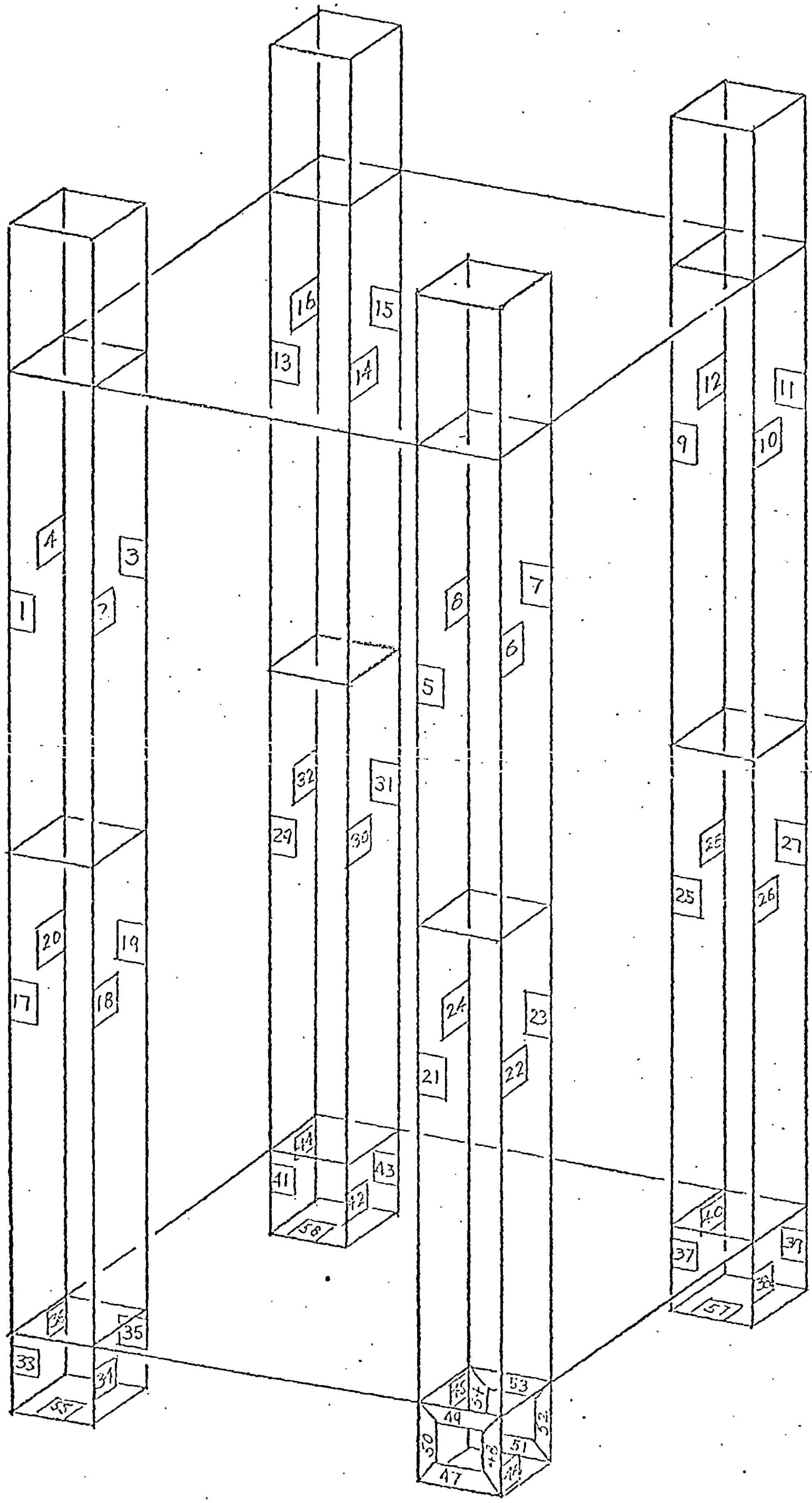
The fuel storage rack (six by six array of fuel storage cells) consists of upper and lower grid structures connected to each other by means of four corner cells and the diagonal bracing members. The fuel storage rack thus structurally becomes equivalent to a box shaped structure which is inherently strong in torsion. The torsional effects due to possible non-uniform mass distribution are considered in the analysis by analyzing the partially loaded rack. (Figure 8-6).



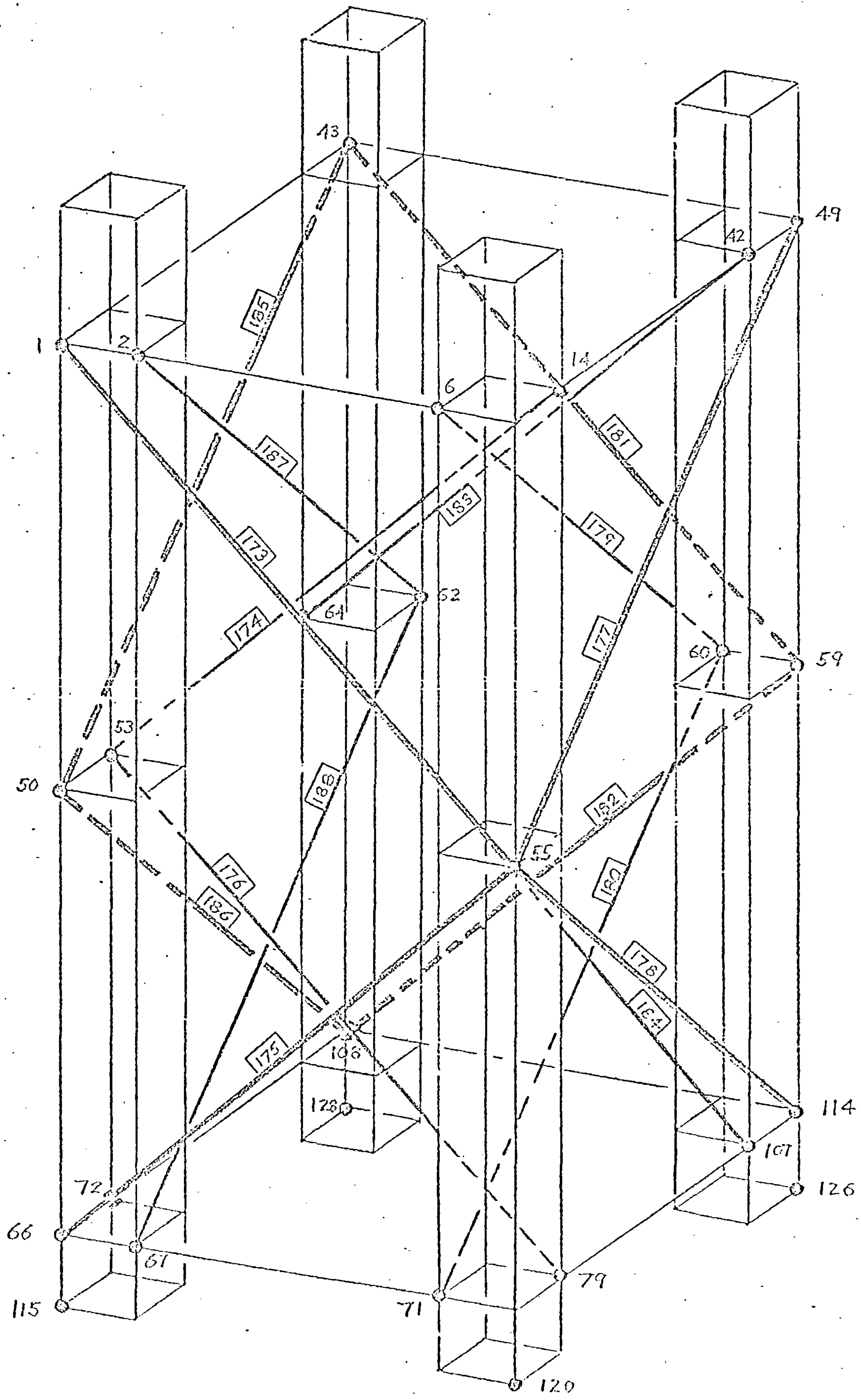
FINITE ELEMENT MODEL NODE NUMBERING
FIGURE 8-1



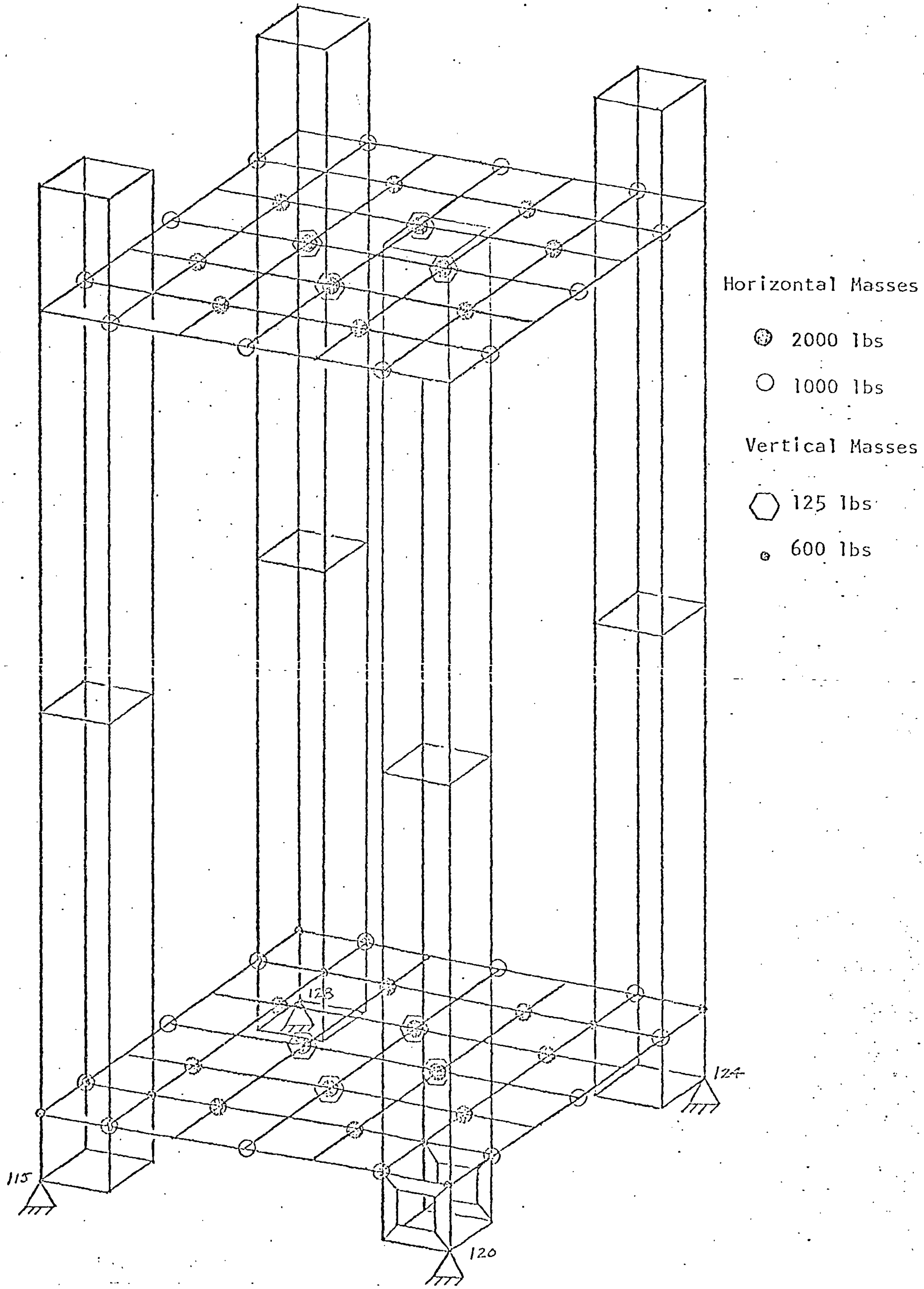
FINITE ELEMENT MODEL BEAM ELEMENT NUMBERING
FIGURE 8-2



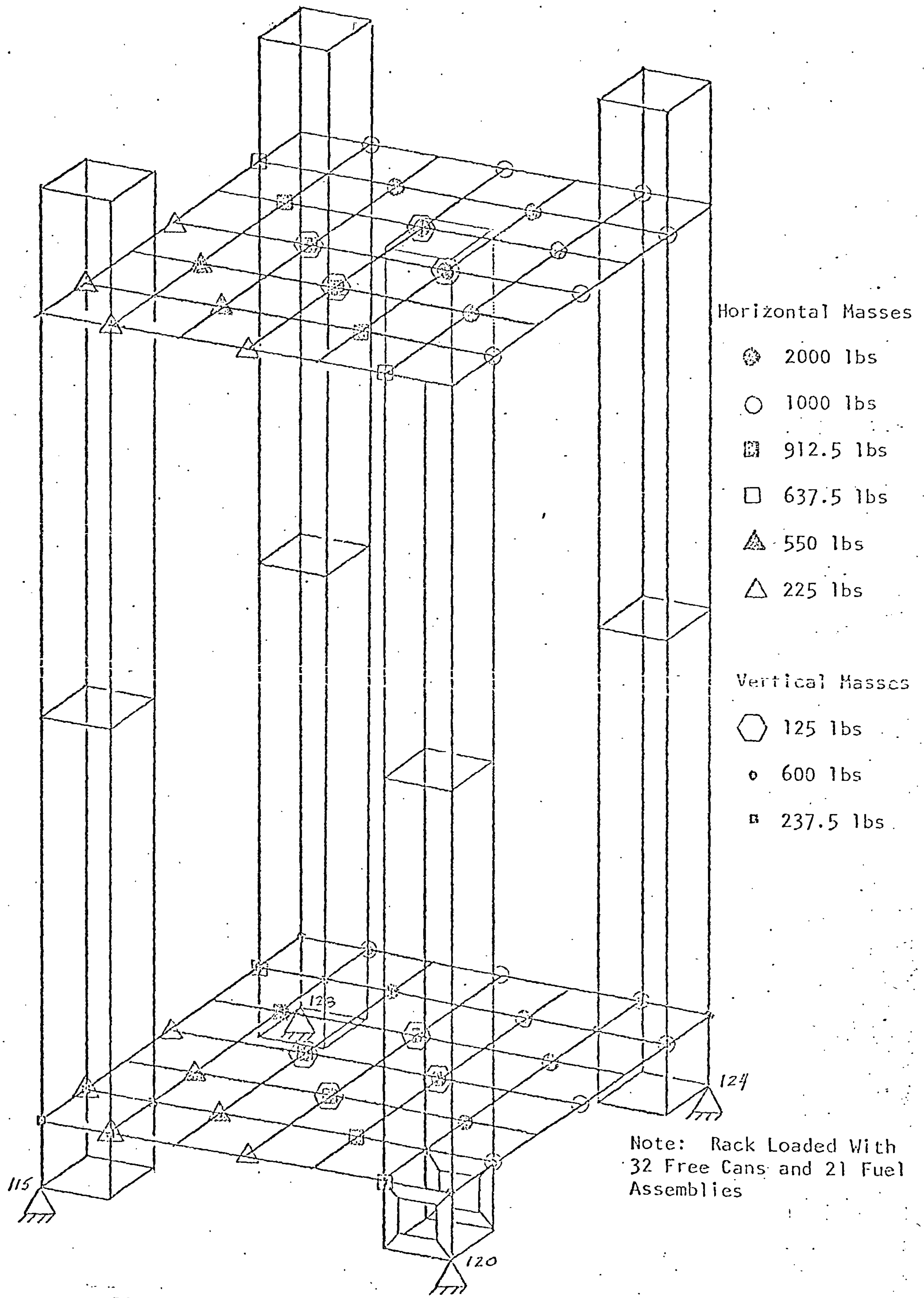
RACK FINITE ELEMENT MODEL PLATE ELEMENT NUMBERING
FIGURE 8-3



RACK FINITE ELEMENT MODEL CROSS BRACING
FIGURE 8-4



BOUNDARY CONDITIONS AND LUMPED MASSES
LOAD CASES 2 AND 3
SEISMIC ANALYSIS OF FULLY LOADED RACK
FIGURE 8-5



BOUNDARY CONDITIONS AND LUMPED MASSES
LOAD CASES 2 AND 3
SEISMIC ANALYSIS OF PARTIALLY LOADED RACK
FIGURE 8-6

Question 9: On page 31 in the first paragraph it is stated that the equivalent load due to fuel bundle impact against the can combined with the seismic loading is equivalent to 1.4 times the seismic inertia load combined from the seismic analysis of the rack system in which the fuel bundle mass is lumped with the rack mass along with the appropriate mass of water. Clearly state whether or not the equivalent loading was considered for overall effects such as total base shear or loading on the bracing system.

Response: The equivalent loading (1.4 times the seismic inertia loads to account for fuel assembly impact effects) was considered for local effects as well as overall effects on the structural members of the rack, the rack/floor pad connection plates, and the floor pads.

Question 10: On page 32 in the first paragraph, provide a summary of your analyses indicating such parameters as kinetic energy at impact (refer to the three cases indicated in Q7), ductility ratios utilized in each material behavior mode to absorb the kinetic energy, predicted penetration of the pool liner.

Response: The results of the accidental straight drop of a fuel assembly (Case (a) of NRC Question 7) are summarized in Table 7-1. The consequences of the inclined drop of a fuel assembly (Case (b) of NRC Question 7) are less severe than those for Case (a). The results of the straight drop of a fuel assembly through the storage cell (Case c) are less severe than that for the free fall of fuel assembly anywhere in the storage pool.

Question 11: On page 38 in Section 7.1 provide a summary of stresses of the supporting pool structure indicating the load combinations and the corresponding acceptance criteria. Indicate whether or not the maximum temperature or the thermal gradient in the pool walls and the base slab as originally designed are exceeded as result of this proposed expansion.

Response: A summary of stresses of the supporting pool structure is provided in Table 11-1. The points given are in the regions where the maximum stresses occur as shown in Figure 11-1.

The following load combination were considered:

1. Hydrostatic + Dead Load + Live Load
2. Hydrostatic + Dead Load + Live Load + OBE
3. Hydrostatic + Dead Load + Live Load + SSE
4. Hydrostatic + Dead Load + Live Load + High Density Racks

The allowable stresses are based on the minimum sampled coupon strength of 43,600 psi and the acceptance criteria stated in ACI 318-63. It should be noted that with the new high density spent fuel storage racks, the mat loadings are lower than those originally calculated. This is due to the different analytical model used. For the high density spent fuel storage rack loadings, the model accounted for the detailed location of both the pilings and the fuel rack embedments in the mat. This resulted in a significant portion of the load due to spent fuel to be transmitted to the pilings without inducing mat bending. In the analysis for the original loading the rack loads were spread uniformly over the mat, and the pilings were lumped at discrete locations which were further apart than the actual pile spacing. The method used to calculate the mat loadings from the new high density spent fuel storage racks represents the as built conditions at Surry.

As given in Section 7.2 of the Surry 1 and 2 High Density Spent Fuel Storage Rack Submittal, the spent fuel pool temperature will be maintained at or below the original limits of 140°F (normal case) and 170°F (abnormal case). Therefore, the maximum temperature or the thermal gradient in the pool walls and the base slab as originally designed will not be exceeded.

TABLE 11-1

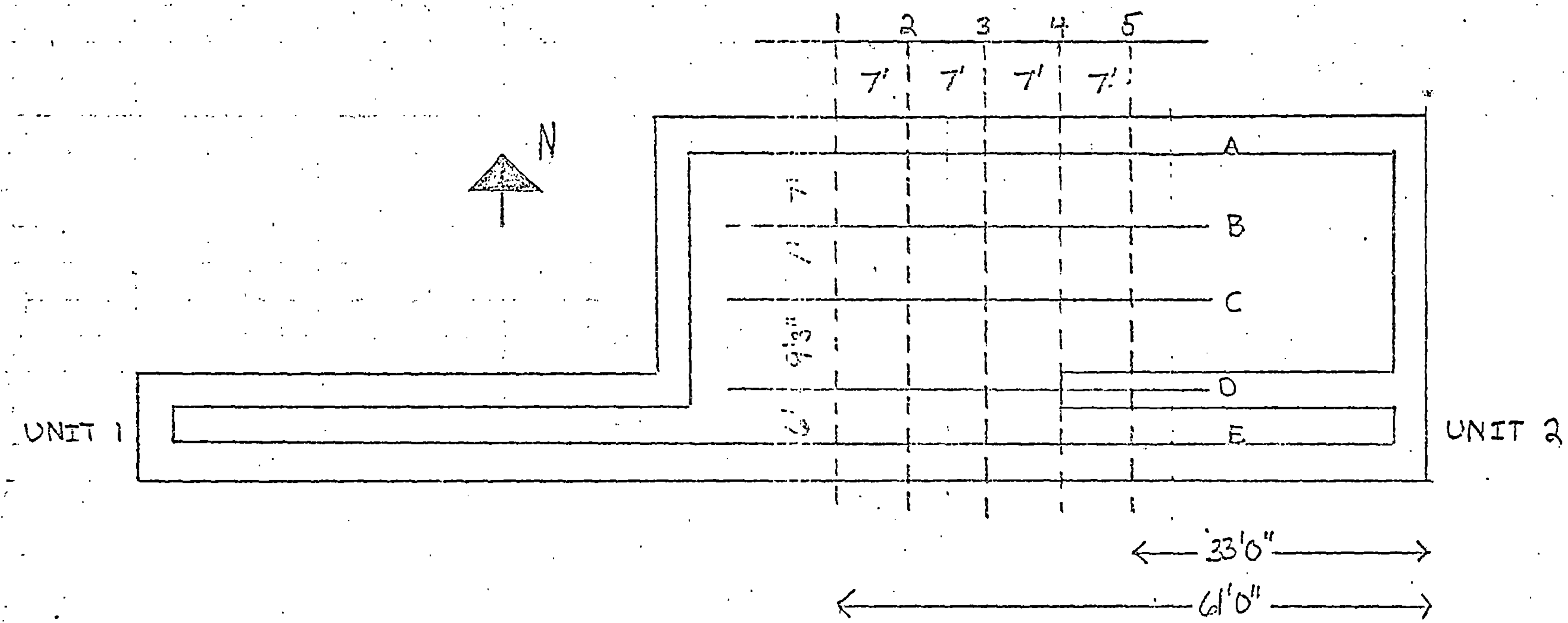
SUMMARY OF STRESSES (Ksi)

Location	Hydrostatic + Dead + Live	Hydrostatic + Dead + Live + OBE	Hydrostatic + Dead + Live + SSE	Hydrostatic + Dead + High Density Racks
4A	21.4	27.8	34.1	----
4B	21.4	26.7	32.0	----
4C	20.7	25.1	29.5	----
4E	18.1	23.6	29.1	----
3A	20.9	27.1	33.3	17.7
3B	19.8	24.8	29.8	14.9
3D	19.8	25.2	30.7	17.5
3E	21.4	27.8	34.1	20.9
2A	19.0	----	----	----
2E	21.7	----	----	20.9
Allowable Stress	f_s 21.8	$4/3\ f_s$ 29.0	$0.9\ f_y$ 39.0	f_s 21.8

Allowable stress based on minimum coupon strength sample.

$f_y = 43.6$ ksi $\quad f_s = 0.5\ f_y$

Note: Columns 1, 2, and 3 are the original loads in the fuel building structure and column 4 shows the change with the addition of the high density spent fuel racks.



FUEL POOL STRESS POINT
LOCATIONS FOR TABLE 11-1
FIGURE 11-1