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July 21, 1983
ANPP-27346-BSK/RQT

REGION V

U. S. Nuclear Regulatory Commission
Region V
Creekside Oaks Office Park
1450 Maria Lane - Suite 210
Walnut Creek, CA 94596-5368

Attention: Mr. D. M. Sternberg, Chief
Reactor Projects Branch 1

Subject: Final Report - DER 82-56
A 50.55(e) Report Relating to Condensate Storage Tank Was Scaled-Down Without New Calculations For Seismic Response.
File: 83-019-026; D.4.33.2

Reference: A) Telephone Conversation between J. Eckhardt and G. Duckworth on October 15, 1982
B) ANPP-22179, dated November 1, 1982 (Interim Report)
C) ANPP-22696, dated January 11, 1983 (Time Extension)
D) ANPP-22845, dated January 27, 1983 (Time Extension)
E) ANPP-23276, dated March 17, 1983 (Time Extension)
F) ANPP-23467, dated April 12, 1983 (Time Extension)
G) ANPP-23868, dated May 24, 1983 (Time Extension)
H) ANPP-24175, dated June 27, 1983 (Time Extension)

Dear Sir:

Attached is our final written report of the deficiency referenced above, which has been determined to be Not Reportable under the requirements of 10CFR50.55(e).

Very truly yours,

E E Van Brunt

E. E. Van Brunt, Jr.
APS Vice President,
Nuclear Projects Management
ANPP Project Director

EEVBJr./RQT:ru

Enclosure

cc: See Page 2

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IE27

cc: Richard DeYoung, Director
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Washington, D. C. 20555

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FINAL REPORT - DER 82-56
DEFICIENCY EVALUATION 50.55 (e)
ARIZONA PUBLIC SERVICE COMPANY (APS)
PVNGS UNITS 1, 2, & 3

I. Condition Descritpion

This report was intitated as a result of the Torrey Pines Technology Independent Evaluation of PVNGS which requested that the design of the Condensate Storage Water Tank (CST) be reevaluated.

The CST is required to be designed to resist stresses resulting from operating and extreme environment/accident loads. The analysis and design of the CST (Calculation 13-CC-CT-010) was based on the design of the Refueling Water Tank (Calculation 13-CC-CT-015) without detailed engineering calculations. Due to the similarities in the geometry, the tank-wall reinforcement of the CST was scaled down from the reinforcement used in the RWT design due to the decreased height and mass of the CST. However, the review by Torrey Pines Technology indicated that the scaling approach may not be conservative because the CST is only embedded 4.5 feet into the soil while the RWT is embedded 15 feet. The CST, with the reduced embedment, has more flexible soil springs and less soil damping than that of the RWT, which could result in greater seismic response.

II. Analysis of Safety Implications

This condition is evaluated as not reportable. Based upon a detailed analysis of the CST (separate from the Refueling Water Tank analysis) performed by Bechtel Engineering, the existing design for the CST has been determined to be adequate for all load combination specified in the project Design Criteria (see attached report). Therefore, a safety significant condition does not exist, hence the subject condition is not reportable under the requirements of 10CFR50.55(e)

III. Corrective Action

1. Bechtel Engineering has performed a detailed analysis of the CST, independently from the Refueling Water Tank design calculation, per Revision 1 of Calculation 13-CC-CT-010. Details of the analysis are presented in the attached report "Engineering Evalution of the Design of the Condensate Water Storage Tank and the Refueling Water Tank", dated May, 1983. Based upon the results of the detailed analysis, it has been determined that the local yielding of some of the inside-face vertical rebar at the wall basemat junction occurs for the CST under certain load conditions. The 1/4 inch stainless steel liner plate, attached to the inside surface of the tank, ensures the leak tight integrity of the structure. Under the extreme loading condition that might locally crack the concrete at the wall-basemat junction, the strain in the liner will remain well below allowable strain for stainless steel based upon ASME Section III Division 2 Code. Therefore, it has been demonstrated that this local yielding of the rebar in no way impairs the design function of the tank or poses any threat to any other Category I structure or equipment.

2. For the CST, Safety Analysis Report Change Notice 1100 is being issued to revise Section 3.8.4.1.7 (subtitled "Condensate Storage Tank") of the FSAR. This revision clarifies the following of the CST: a) the concrete shell and the Seismic Category I stainless steel wall liner will retain the hydrostatic pressure; and b) the welded stainless steel liner ensures the leak tight integrity of the structure.

DEFICIENCY EVALUATION REPORTS 82-56 AND 82-63

ENGINEERING EVALUATION FOR THE DESIGN OF THE CONDENSATE WATER STORAGE TANK AND THE REFUELING WATER TANK

PALO VERDE NUCLEAR GENERATING STATION

JOB NUMBER 10407
BECHTEL POWER CORPORATION
NORWALK, CALIFORNIA

Revision 1
May 1983

I

DEFICIENCY EVALUATION REPORTS 82-56 AND 82-63

ENGINEERING EVALUATION FOR THE DESIGN OF THE CONDENSATE WATER STORAGE TANK AND THE REFUELING WATER TANK

PALO VERDE NUCLEAR GENERATING STATION

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Revision 1
May, 1983

REVIEWED AND
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JOB NUMBER 10407
BECHTEL POWER CORPORATION
NORWALK, CALIFORNIA

Revision 1
May 1983

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1

FIGURES

Figure

1 PROBLEM INTRODUCTION

1.1 DESIGN CRITERIA

The Refueling Water Tank (RWT)[1] and the Condensate Water Storage Tank (CST)[2] shall be designed as Seismic Category I structures in accordance with PVNGS Project Design Criteria, Volume III, Civil/Structural, Structures and Systems, page CT.2-1 and ZY-1.

The Refueling Water Tank shall house and protect the 750,000 gallons of borated water against adverse environmental occurrences including the safe shutdown earthquake (SSE) and tornados.

The Condensate Water Storage Tank shall house and protect the 550,000 gallons of condensate water for the steam generators against adverse environmental occurrences including the safe shutdown earthquake (SSE) and tornados.

Both tanks shall consist of a reinforced concrete cylindrical shell supported on a square reinforced concrete mat foundation. The roof is supported by structural steel beams. The inside of the tanks are lined with a stainless steel liner plate.

1.2 DISCOVERY OF PROBLEM

In September 1982, Torrey Pines Technology conducted an independent evaluation of the Refueling Water Tank and the Condensate Water Storage Tank design calculations[3,4].

A Potential Finding Report was written on the design of the Condensate Water Storage Tank because the analysis and the design of the CST was based on the analysis of the RWT without detailed engineering calculations. Due to the similarities in the geometry, the tank-wall reinforcing of the CST was scaled down because of its decreased height and mass from the reinforcement used in the RWT design. However, the review by Torrey Pines Technology questioned that the scaling may not be conservative because the CST was only embedded 4.5 feet into the soil while the RWT was embedded 15 feet. Therefore, the CST with the reduced soil embedment, had more flexible soil springs and also less soil damping than that determined for the RWT. DER No. 82-56 was initiated because a preliminary engineering review indicated that the scaling approach used may not be appropriate.

In October 1982, during further review of the RWT calculation package by Bechtel Engineering, an error was discovered in the determination of the tank-wall bending moment at the junction of the basemat. The correction of this error in the calculation without a more detailed three-dimensional finite element analysis resulted in calculated stresses in some of the inside-face vertical rebar of the tank-wall that exceeded the Design Criteria allowables. Consequently, DER NO. 82-63 was initiated.

1.3 ENGINEERING ACTION

Upon the discovery of the above stated problems, a detailed analysis of the Condensate Water Storage Tank[4,] and the Refueling Water Tank[3,] was initiated to more accurately determine the stresses in the tanks.

2 SUMMARY AND CONCLUSION

The Refueling Water Tank and the Condensate Water Storage Tank were initially designed using simplified hand calculations. After extensive review of the design assumptions and hand calculations employed, it was determined that a more detailed analysis of both tanks was required to accurately determine the state of stress in the corresponding reinforcement. Three-dimensional finite element models were therefore developed for each tank. These models were extensively analyzed for the various load combinations specified by the Project Design Criteria.

The tanks were originally modeled with the base of the tank-wall rigidly connected to the basemat (i.e. fixed). The results of the analysis indicated that local yielding of some of the inside-face vertical rebar at the wall-basemat junction might occur for either tank under certain extreme load conditions. To investigate the effects of the local yielding, the tanks were then modeled with a pin connection at the wall-basemat junction. This analysis was performed in order to determine the performance of the tank in the event that portions of the tank-wall underwent local yielding at the basemat junction.

The results of the analysis of the pinned-base models of both tanks demonstrated that any high stress levels occurring at the base of the tank-walls would redistribute after local yielding occurred up into the lower stressed regions of the tank-wall. This would result in stress levels throughout the balance of the tank falling within Design Criteria allowables. The local yielding of the rebar at the wall-basemat junction, if it does occur, would not jeoparidze the structural integrity of either tank. In addition, the 1/4-inch stainless steel liner attached to the inside surface of the two tanks ensures the leak tight integrity of the 1
structures. Even under extreme loading conditions that might locally crack the concrete at the wall-basemat junction, the strain in the liner will remain well below the allowable strain for stainless steel based upon the ASME Section III, Division 2 Code. Therefore, the Refueling Water Tank and the Condensate Water Storage Tank are adequately designed to meet their design functions for the primary plus secondary (thermal) loads specified by the Project Design Criteria.

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3 DISCUSSION OF THE ANALYSIS

3.1 PURPOSE

The purpose of the detailed analysis of the RWT and the CST was to verify the structural adequacy of the existing design per Project Design Criteria.

3.2 GENERAL

The method of analysis used for the RWT and the CST was identical, therefore, the following discussion of the analysis will be described without reference to a particular tank unless a significant difference requires identification.

3.3 BRIEF DESCRIPTION OF THE ANALYSIS

The following analysis required the formulation of two mathematical models for each tank. The first mathematical model was a two-dimensional beam stick model that was used to determine the dynamic response of the tank. The second model was a three-dimensional finite element model that was used to determine the local section forces and moments.

The response spectrum analysis was performed on the CST and the RWT which were modeled as two-dimensional lumped-mass beam sticks (figures 1 and 6). The models considered hydrodynamic effects calculated according to TID-7024[6]. The soil springs and damping values were calculated per Design Guide C2.44[7].

The three-dimensional finite element models (figures 5 and 10) were developed to determine section forces and moments in the tank-walls and basemats. The equivalent static analysis included the results of the response spectrum analysis of the beam stick model by representing the seismic loading as equivalent nodal loads. The soil structure interaction effects were approximated by developing a system of discrete springs that were attached to the basemat nodes. The effects of the various possible directions of seismic input motion on the square basemat were investigated.

3.4 BEAM STICK MODEL

Each tank was modeled as a two-dimensional lumped-mass beam stick. The location of the lumped-masses were chosen to reflect the hydrodynamic as well as the structural effects calculated according to the TID-7024[6]. The two-dimensional stick models for the CST and the RWT are shown in figures 1 and 6 respectively.

3.4.1 DYNAMIC ANALYSIS

The following outline provides the procedure used for the dynamic analysis:

A. The fixed-base two-dimensional lumped-mass stick model was input into the BSAP program. The program calculated the natural frequencies and the mode shapes for the fixed-base model.

B. The fixed-base frequencies were used to calculate the initial soil springs and damping values per Design Guide C2.44[7].

C. The BSAP DYNAM program used the mode shapes provided by the fixed-base model with the soil springs and damping values calculated in step B) to determine the flexible-base frequencies and modal damping ratios.

D. The flexible-base frequencies developed by DYNAM were used to calculate new soil springs and damping values as in step B.

E. Steps C) and D) were repeated until the frequencies used to calculate the soil springs and damping values were the same as the final flexible-base frequencies. The final soil springs and damping values along with the corresponding modal frequencies and modal damping ratios are shown in figures 2 and 7.

F. The BSAP program, using the mode shapes and modal damping ratios developed by DYNAM, was used to perform a response spectrum analysis. The response spectrum curves were per the USNRC REG. GUIDE 1.60 and the structural damping conformed to USNRC REG. GUIDE 1.61. The free field acceleration values for the analysis were 0.25g for SSE and 0.13g for OBE. The results of the response spectrum analysis for the CST and the RWT are shown on figures 3, 4, 8 and 9.

3.5 THREE-DIMENSIONAL FINITE ELEMENT MODEL

The concrete wall and basemat of the tanks were modeled using BSAP LCCT9 finite elements for the three-dimensional analysis (figures 5 and 10). The steel roof structure was not modeled as a structural element because it is very flexible relative to the tank-walls and the roof design was not a part of the DER. However, the effects of the roof structure were considered in the computation of the dead loads. Vertical and horizontal springs representing the soil stiffness were connected to each node of the basemat of the three-dimensional model. The vertical springs were determined considering the average of the vertical spring (K_{yy}) and the rocking spring ($K_{\theta\theta}$) provided by the flexible-base modal analysis of the two-dimensional stick model. Horizontal springs for the three-dimensional model were determined considering the horizontal spring (K_{xx}) of the stick model. The magnitude of each soil spring attached to the basemat was proportional to its nodal tributary area. The soil around the RWT wall due to embedment reduces tank-wall stresses because it provides resistance against internal hydrostatic pressure. However, the resistance was very small and was conservatively neglected in the three-dimensional model. The three-dimensional finite element model representing the CST and the RWT are shown in figures 5 and 10 respectively.

3.5.1 LOADING

3.5.1.1 DEAD LOAD

The dead load effects of the roof structure, tank-wall, basemat and water (hydrostatic) were determined by conventional methods. These forces were applied either as nodal loads, mass density or pressure loads on the three-dimensional model.

3.5.1.2 SEISMIC LOADING

3.5.1.2.1 VERTICAL

Vertical accelerations were obtained from the response spectrum analysis of the two-dimensional stick model (figures 4, 9). The vertical seismic forces for the tank-walls were applied as nodal loads. The basemat forces were modeled as the product of mass density and an appropriate vertical acceleration and the water (hydrostatic) forces were modeled using pressure loads.

3.5.1.2.2 HORIZONTAL

Shear forces were obtained from the beam-end-forces output of the response spectrum analysis of the beam stick model (figures 4, 9). The shear force was separated into a water contribution and a tank-wall contribution. The shear contributed by the water was modeled as pressure loads and the shear contributed by the tank-wall was modeled as nodal loads on the three-dimensional model. The horizontal seismic force on the basemat was modeled as the product of the mass density and an appropriate horizontal acceleration.

3.5.1.3 THERMAL LOADS

Seasonal temperature gradients were established using meteorological data for Phoenix, Arizona. The gradients were directly applied in the three-dimensional model developed for the BSAP program and the resulting elastic thermal forces for the uncracked sections were calculated. Later, these thermal forces were relaxed by the OPTCON module of the BSAP-POST program to obtain the final relaxed thermal loads on the cracked sections.

3.5.1.4 LOAD COMBINATIONS

The load combinations for SSE, OBE and thermal were per Project Design Criteria sections as follows:

3.6.4 LOAD COMBINATIONS

3.6.4.1 Seismic Category I Structures (Concrete)

A. Normal operating loads

U = 1.4D + 1.7L + 1.9E
U = 0.75 (1.4D + 1.7L + 1.9E + 1.7To)
U = 0.75 (1.4D + 1.7L + 1.7To + 1.7Ro)

B. Extreme environmental/accident loads

U = D + L + To + E'

D = Dead load (including hydrostatic loads)
L = Live load (including soil pressure)

To = Thermal loads (operating or shutdown)
Ro = Pipe reactions (operating or shutdown)
E = Seismic loads due to operating basis earthquake (OBE)
E' = Seismic loads due to safe shutdown earthquake (SSE)

Seismic loading was applied to the three-dimensional model in three orthogonal directions (horizontal X and Y, and vertical Z) by the following method:

E or E' = [1.0 Horizontal (X) + 0.4 Horizontal (Y) $\pm$ 0.4 Vertical (Z)]
E or E' = [0.4 Horizontal (X) + 0.4 Horizontal (Y) $\pm$ 1.0 Vertical (Z)]

The above combinations were repeated for two possible basemat orientations to the seismic motion. The above variations were sufficient to evaluate the many possible seismic variations because of the symmetry of the geometry.

3.5.2 PRIMARY LOADING (DL AND SEISMIC) - EQUIVALENT STATIC ANALYSIS

Dead load and equivalent three directional seismic forces were applied to the three-dimensional finite element model as static loads using the BSAP program. During the SSE load combinations, horizontal seismic forces produced tension in some vertical soil springs indicating that the basemat was not in contact with the soil at those locations.

The vertical springs in tension were removed from the model by setting their stiffness close to zero (note horizontal springs attached to the same node as a vertical spring in tension were also removed). The static analysis was then repeated. This procedure was continued until all vertical springs in tension were removed.

During the OBE load combination, the entire basemat remained in contact with the soil (no vertical springs were in tension). The load factors of unity were used to calculate soil pressures for the OBE load combination. However, the concrete design load factors were used to determine the final design forces in the tank.

Because the tanks were designed with a square basemat, the effects of the direction of the earthquake had to be considered on the soil-structure interaction. Hence, two seismic directions were considered for the primary horizontal excitation:

1. Parallel to the sides of the basemat

2. Parallel to the diagonal of the basemat.

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3.5.3 SECONDARY LOADING (THERMAL) - EQUIVALENT STATIC ANALYSIS

Temperature gradients were input as individual load cases in the three-dimensional model using the BSAP program. Thermal stresses were then combined with primary stresses using the BSAP-POST, OPTCON program. OPTCON investigated the cracking effect of the concrete and the yielding effects of the reinforcement in order to determine the final cracked-section stresses. OPTCON then determined whether the reinforcement provided was adequate for the final stresses.

4 RESULTS OF ANALYSIS

4.1 DYNAMIC ANALYSIS RESULTS OF THE BEAM STICK MODEL

The results of the SSE and OBE response spectrum analysis for the lumped-mass beam stick model are shown in figures 3, 4, 8, and 9.

4.2 EQUIVALENT STATIC ANALYSIS RESULTS - PRIMARY LOADING

4.2.1 TANK-WALL

4.2.1.1 ANALYSIS OF VERTICAL REINFORCING STEEL

The output for the LCCT9 elements used to model the tank-walls and basemat provided axial forces and moments at the midpoint of the element. Because the highest vertical moment occurred at the wall-basemat junction (along an element edge), it was necessary to determine the moment at the base of the lowest vertical element. The bending moment curve was plotted for the first three vertical elements. The equation of a second degree curve was developed analytically based on an assumed parabolic shape and the moment at the wall-basemat junction was determined.

The vertical bending moments were calculated for the six most highly stressed tank-wall elements at the basemat junction. Three elements were chosen on the compression side of the tank and three on the tension side. The bending moments and axial forces were plotted on an OPTCON interaction diagram. The OPTCON interaction diagrams were a plot of the maximum allowable resistance of a section for moments and axial forces using ACI 318-71 criteria.

The vertical tank-wall stresses of the CST fell within the boundaries of the OPTCON interaction diagrams. Therefore, the CST vertical wall reinforcement is adequate for the moments and axial forces resulting from primary load combinations.

Some elements of the RWT along the wall-basemat junction were stressed slightly beyond design allowables. This overstress is considered in section 4.3, PRIMARY PLUS SECONDARY THERMAL LOADING.

4.2.1.2 ANALYSIS OF HOOP REINFORCING STEEL

The hoop moments and axial forces of the highest stressed elements were plotted on the appropriate OPTCON interaction diagram.

The stresses in two elements of the RWT and three elements of the CST plot slightly outside of the OPTCON interaction boundaries. However, these stresses were found to be acceptable after considering the effects of the liner plate and that the actual strength of the reinforcing steel used for construction is normally greater than that used in design.

The horizontal reinforcing steel of the CST and the RWT is adequately designed for hoop stresses resulting from primary load combinations.

4.2.1.3 RADIAL SHEAR

The maximum radial shear occurred at the wall-basemat junction and is equal to the slope of the vertical moment diagram. Radial shear was determined for the six highest stressed elements considered in the analysis of the vertical steel. Radial shear was checked considering axial tension or compression on the section per ACI code provisions as specified by the Project Design Criteria.

All element shear stresses are within design allowables, therefore the CST and the RWT are adequately designed for radial shear stresses resulting from primary load combinations.

4.2.1.4 TANGENTIAL SHEAR

Tangential shear forces were provided by the BSAP LCCT9 element output. Several elements having the highest tangential shear were checked per ACI code provisions.

All element shear stresses are within design allowables, therefore the CST and the RWT are adequately designed for tangential shear stresses resulting from primary load combinations.

4.2.2 BASEMAT

4.2.2.1 ANALYSIS OF BASEMAT REINFORCING STEEL

OPTCON interaction diagrams were developed and the highest stressed elements under moment and axial forces are plotted on the appropriate diagram.

The basemat stresses of both tanks fell within the OPTCON interaction boundaries. Therefore, the basemat reinforcing steel for the CST and the RWT is adequately designed for primary load combinations.

4.2.2.2 SOIL PRESSURES

BSAP BOUNDARY elements representing soil springs provided output for soil spring compression forces. Soil pressures were calculated by dividing the spring compression force by the appropriate nodal tributary area.

The maximum soil pressures for the CST and the RWT are within Design Criteria allowables.

4.3 EQUIVALENT STATIC ANALYSIS RESULTS - PRIMARY PLUS SECONDARY THERMAL LOADING

4.3.1 INTRODUCTION

During the SSE primary load combination (DL and seismic) analysis of the RWT, it was determined that some of the inside-face vertical wall reinforcement was stressed slightly beyond design allowables. This overstress would increase with the addition of secondary thermal loading. Thus, under the given load conditions, some yielding would occur in the RWT inside-face vertical reinforcement at the wall-basemat junction.

To determine the effects of the yielded condition of the RWT vertical reinforcement, the primary plus secondary load combination was applied to the tank with a pinned-connection conservatively modeled at the wall-basemat junction. The pin condition was investigated to demonstrate that if the inside-face vertical reinforcement yielded all around the wall-basemat junction, which will not happen, the forces are redistributed to other parts of the tank-wall and the tank structural integrity is still maintained.

Although the vertical reinforcing steel of the CST remained within design allowables with a rigid connection at the base during primary load combinations, yielding occurred at the wall-basemat junction when secondary thermal stresses were applied. Therefore, the CST was also conservatively modeled with a pinned-connection at the wall-basemat junction to investigate the effects of primary plus secondary loading.

4.3.2 PROCEDURE

The following outline provides the procedure used for the primary plus secondary thermal loading analysis:

A. Run the BSAP program considering primary loading and secondary thermal loading on the pinned-base model.

B. Run BSAP-POST, OPTCON program to determine the utilization factors (ratio of the actual moment to the allowable resisting moment for a given axial load) of all elements under primary loading for the pinned-base model. Locate the elements with the highest utilization factors to be checked with thermal loading.

C. Run OPTCON for the highest stressed elements under primary loading along with the corresponding secondary elastic thermal stresses developed in the BSAP run. OPTCON will calculate the cracked-section stresses and determine the final utilization factors.

4.3.3 TANK WALL

4.3.3.1 ANALYSIS OF VERTICAL AND HOOP REINFORCING STEEL

The highest-stressed elements under primary loads for the pinned-base model were input into OPTCON with elastic thermal stresses. All element stresses remained within design allowables.

Therefore, the tank-wall reinforcement of the CST and the RWT is adequately designed for moment and axial forces under all load combinations when analyzed with a pinned-connection at the wall-basemat junction.

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4.3.3.2 RADIAL SHEAR

Radial shear was determined by conservatively summing the shear developed on the fixed-base model resulting from primary loading with the elastic (uncracked) shear developed on the pinned-base model resulting from thermal loading. All radial shear stresses remained within design allowables.

The CST and RWT are adequately designed for radial shear stresses under all load combinations when analyzed with a pinned-connection at the wall-basemat junction.

4.3.3.3 TANGENTIAL SHEAR

Thermal loads had very little effect on tangential shear stresses.

Thus, the CST and the RWT are adequately designed for tangential shear stresses under all load combinations when analyzed with a pinned-connection at the wall-basemat junction.

4.3.4 BASEMAT

4.3.4.1 ANALYSIS OF BASEMAT REINFORCING STEEL

The highest stressed elements of the basemat under primary loading for the pinned-base model were input into OPTCON with elastic thermal stresses. The results show that all reinforcing steel stresses remain within allowables.

Therefore, the basemat reinforcing steel of the CST and the RWT is adequately designed for all load combinations when analyzed with a pinned-connection at the wall-basemat junction.

4.3.5 LINER PLATE

4.3.5.1 LINER PLATE STRAINS

Based upon the results of the detailed analysis, it was determined that local yielding of some of the inside face vertical rebar at the wall-basemat junction occurs under certain load conditions. This condition 1 might cause the concrete to crack. However for all loading conditions, the liner plate will still remain intact and will ensure the leak tight integrity of the structure. To demonstrate this the strain in the liner plate at the critical locations at the wall-basemat junction was determined. The strain was found to be well below the allowable strain for stainless steel based upon the ASME Section III, Division 2 Code. Therefore, the liner plate is adequately designed for all loading combinations.

5 REFERENCES

1. RWT Reference Drawing 13-C-ZYS-706

2. CST Reference Drawing 13-C-CTS-703

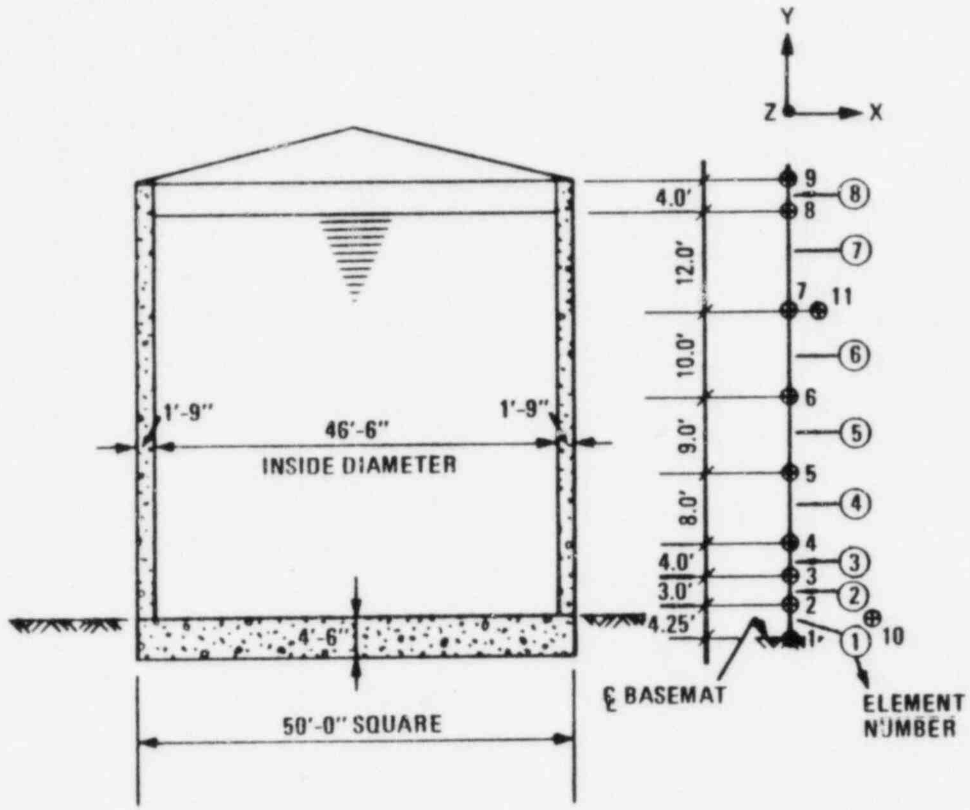
3. Calculations 13-CC-CT-015: REFUELING WATER TANK

4. Calculations 13-CC-CT-010: CONDENSATE WATER STORAGE TANK AND PUMPHOUSE

5. Potential Finding Report PVNGS Quality Assurance Verification. PFR No. 2426-021, Revision Issue A.

6. TID 7024, Nuclear Reactors and Earthquakes, U.S. Department of Commerce

7. Design Guide C2.44, Seismic Analysis of Structures and Equipment for Nuclear Power Plants



NODE NUMBER	ELEVATION (FEET)	MASS PROPERTIES		
		Mx (KSEC^2/FT)	My (KSEC^2/FT)	Mφz (KSEC^{2}xFT)
1	2.25	56.90	211.60	11,844.00
2	2.00	11.40	3.10	2,005.00
3	5.00	15.95	4.32	2,811.00
4	8.00	27.35	7.41	4,869.00
5	17.00	33.27	10.50	6,914.00
6	26.00	37.20	11.74	7,756.00
7	36.00	43.06	13.59	9,047.00
8	48.00	26.00	9.88	2,868.00
9	52.00	5.71	5.71	722.00
11	36.00	24.30	–	–

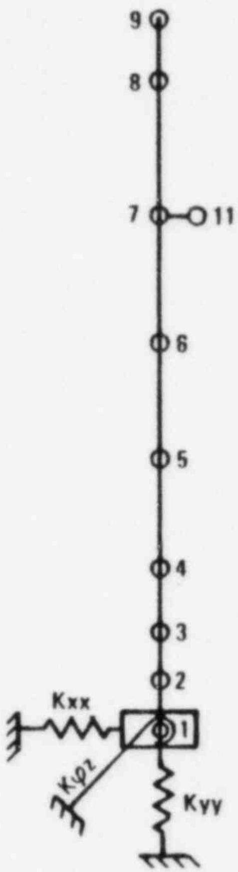
FIXED-BASE STICK MODEL

CONDENSATE WATER STORAGE TANK

Figure 1

SUMMARY OF SOIL SPRINGS & DAMPING

	SOIL SPRINGS			SOIL DAMPING KFT/RAD		
	Kxx(K/FT)	Kyy(K/FT)	Kφz (K-FT/RAD)	Cxx (K-SEC/FT)	Cyy (K-SEC/FT)	Cφz (K-SEC/RAD)
SSE	486.00	53,800	3.04×10^8	9,005	15,648	1.20×10^6
OBE	60,300	70,500	3.90×10^8	10,026	17,094	0.78×10^6

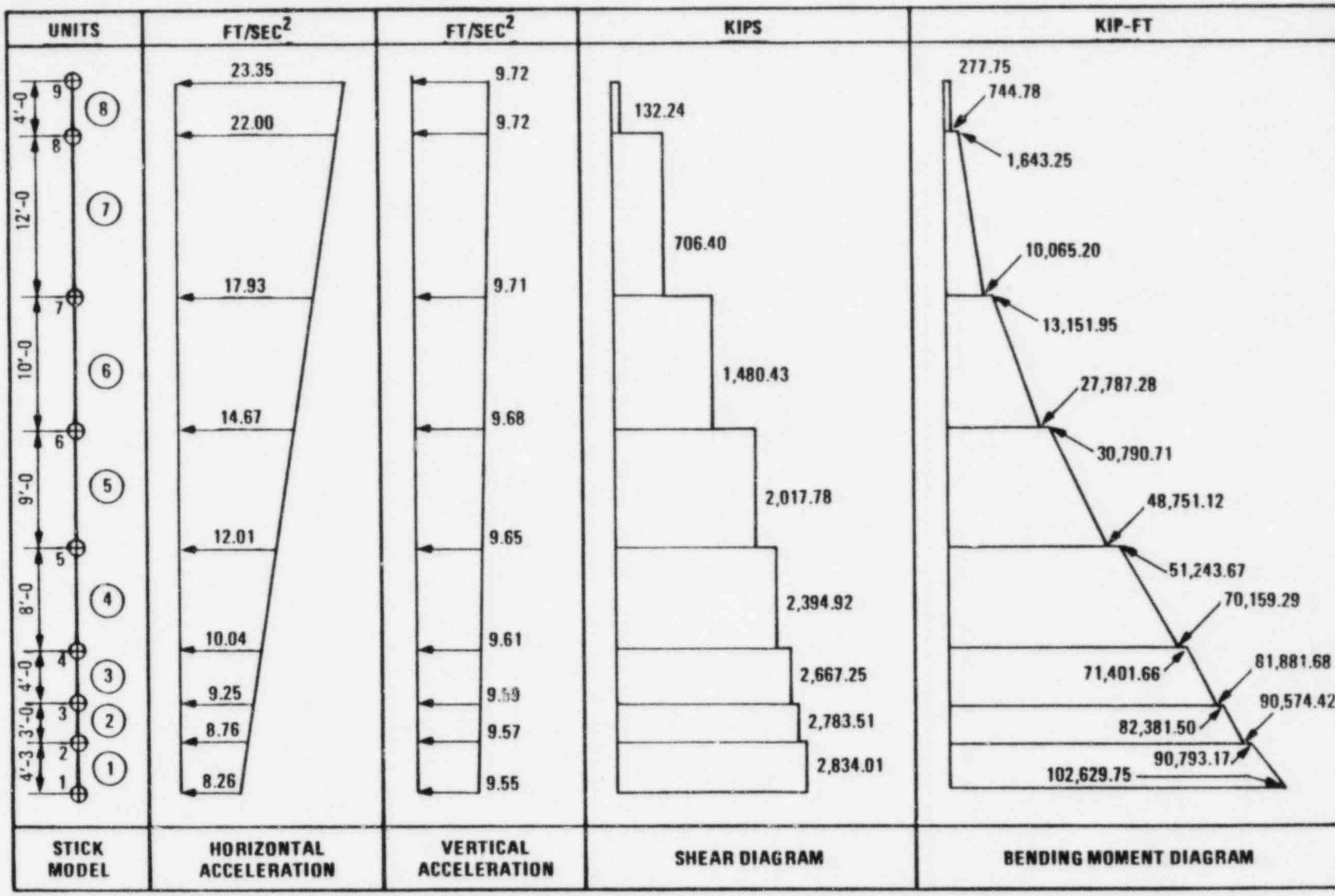


SUMMARY OF MODAL FREQUENCIES & DAMPING RATIOS

MODE NO.	SSE		OBE		
	FREQUENCY (CPS)	DAMPING (%)	FREQUENCY (CPS)	DAMPING (%)	
1	0.26	0.5	0.26	0.5	SLOSHING WATER
2	4.49	11.8	4.99	10.2	STRUCTURAL MODES
3	6.99	63.7	8.00	60.7	
4	11.12	46.1	12.37	43.5	
5	42.90	22.3	43.28	15.0	
6	47.32	14.2	47.58	10.3	

FLEXIBLE-BASE STICK MODEL
CONDENSATE WATER STORAGE TANK

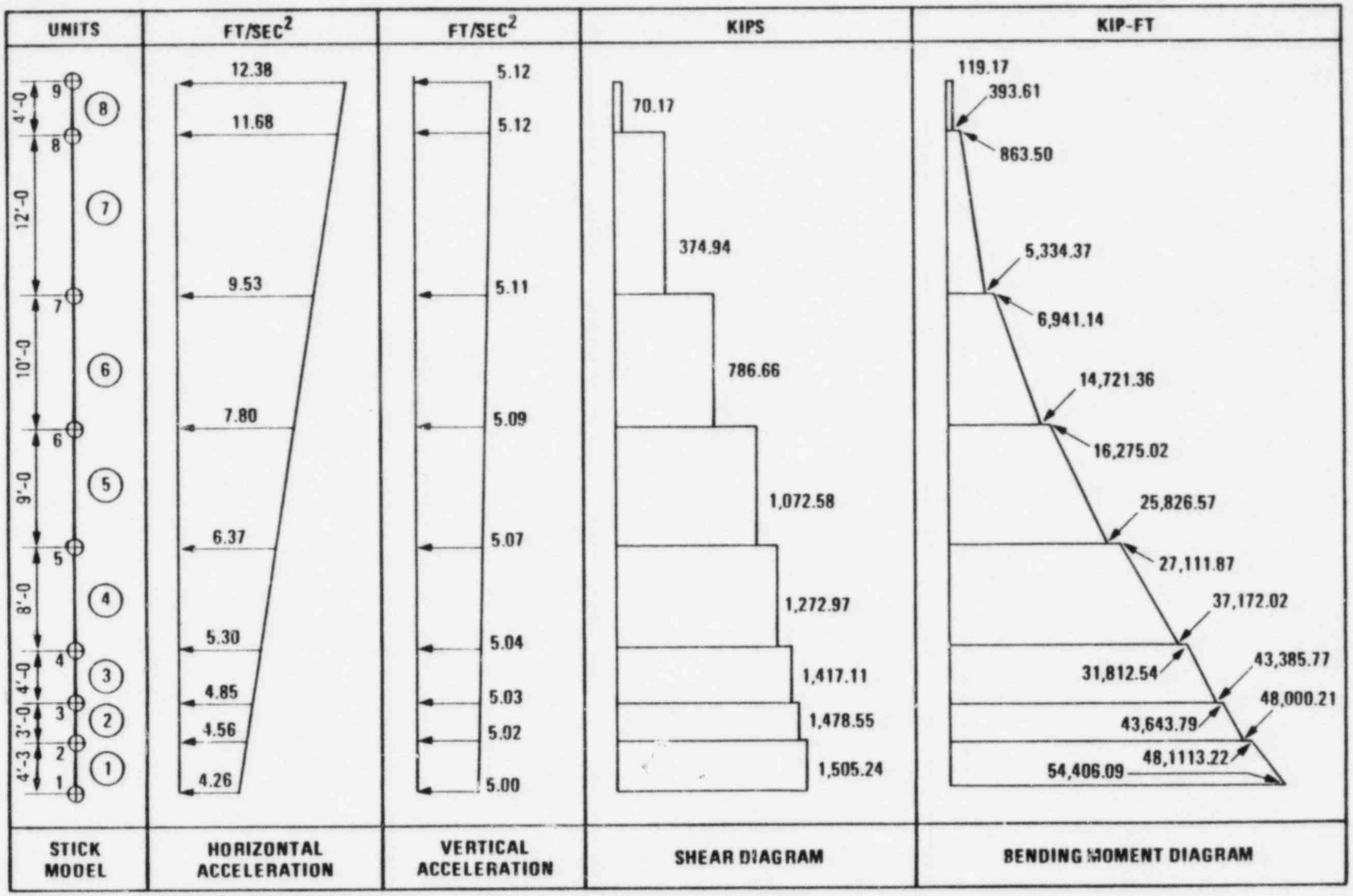
Figure 2



STICK MODEL SSE RESPONSE SPECTRA ANALYSIS RESULTS

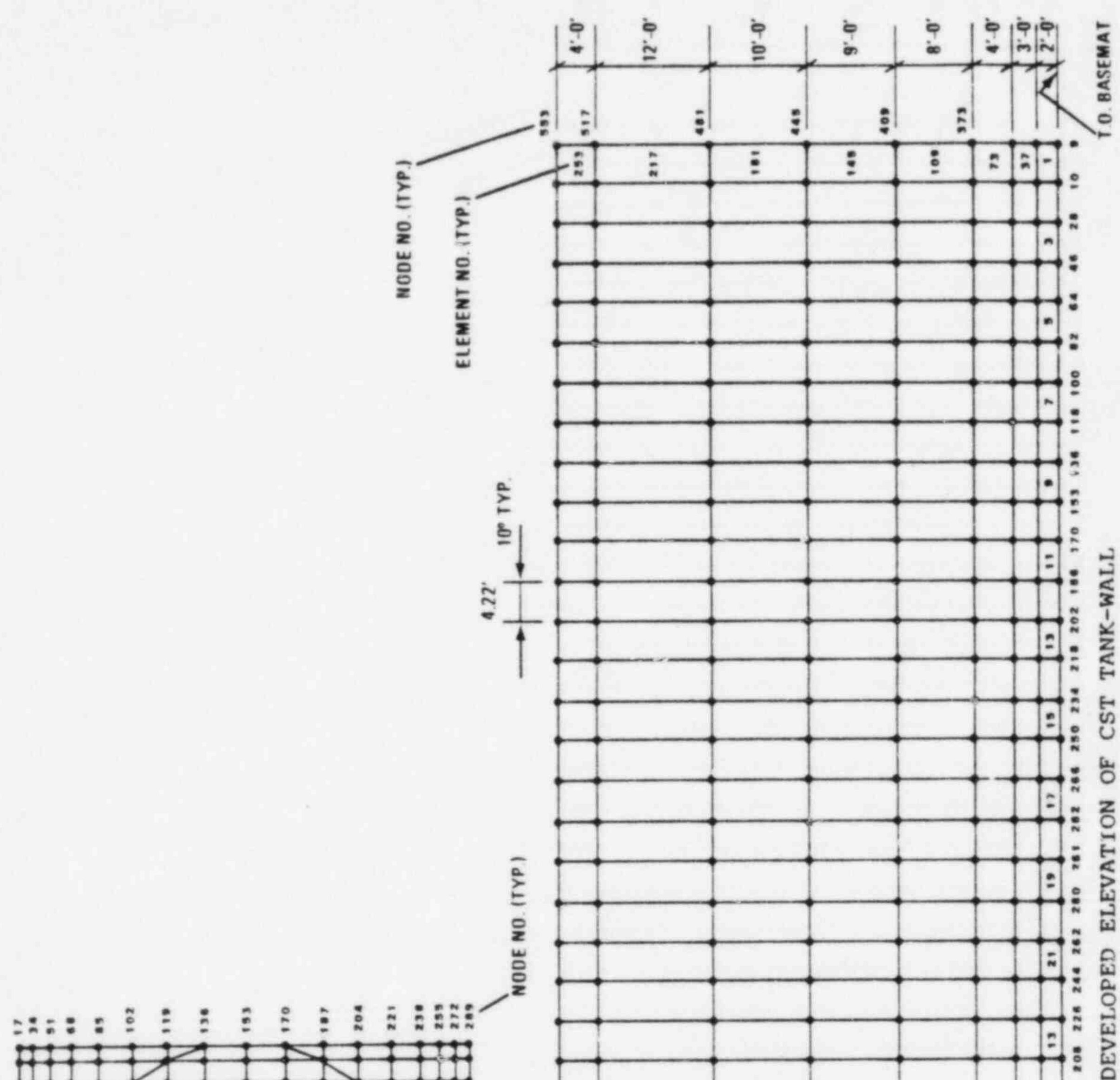
CONDENSATE WATER STORAGE TANK

Figure 3



STICK MODEL OBE RESPONSE SPECTRA ANALYSIS RESULTS
CONDENSATE WATER STORAGE TANK

Figure 4

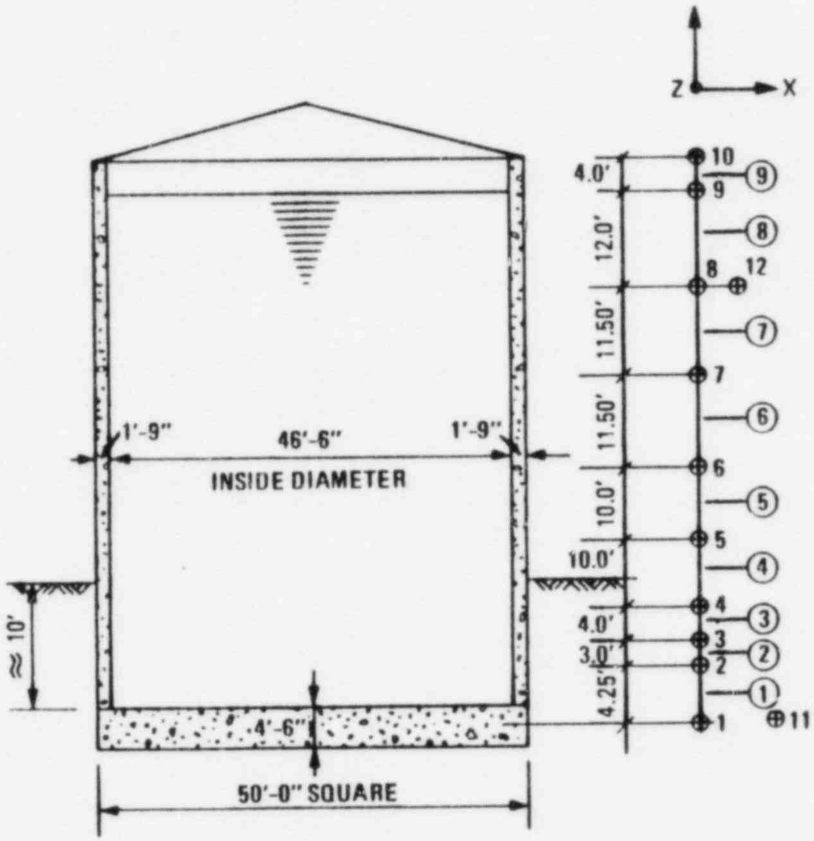


DEVELOPED ELEVATION OF CST TANK-WALL

3-D FINITE ELEMENT MODEL

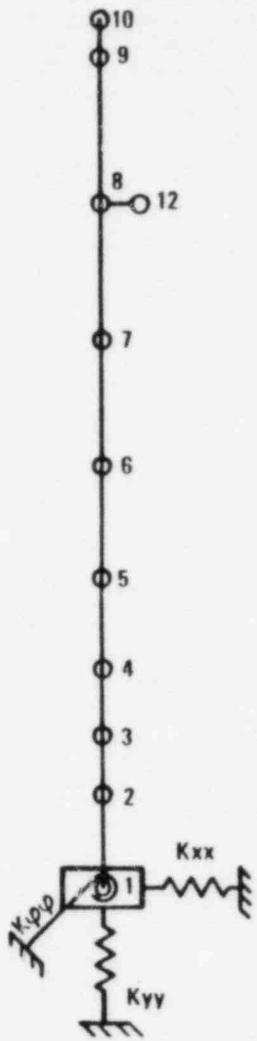
CONDENSATE WATER STORAGE TANK

Figure 5



NODE NUMBER	ELEVATION (FEET)	MASS PROPERTIES		
		M_x (HORZ) ($KSEC^2/FT$)	M_y (VERT) ($KSEC^2/FT$)	$M\varphi_z$ (ROTL) ($KSEC^2xFT$)
1	-2.25	57.20	264.30	11,840.00
2	2.00	11.37	3.11	2,028.00
3	5.00	15.87	4.32	2,841.00
4	9.00	31.80	8.66	5,824.00
5	19.00	45.40	12.36	8,330.00
6	29.00	43.20	13.29	8,990.00
7	40.50	41.00	14.22	9,854.00
8	52.00	41.89	14.53	7,901.0[illegible]
9	64.00	2[illegible].85	9.88	2,923.00
10	68.00	5.71	5.71	727.00
12	52.00	24.40	–	–

FIXED-BASED STICK MODEL
REFUELING WATER TANK
Figure 6



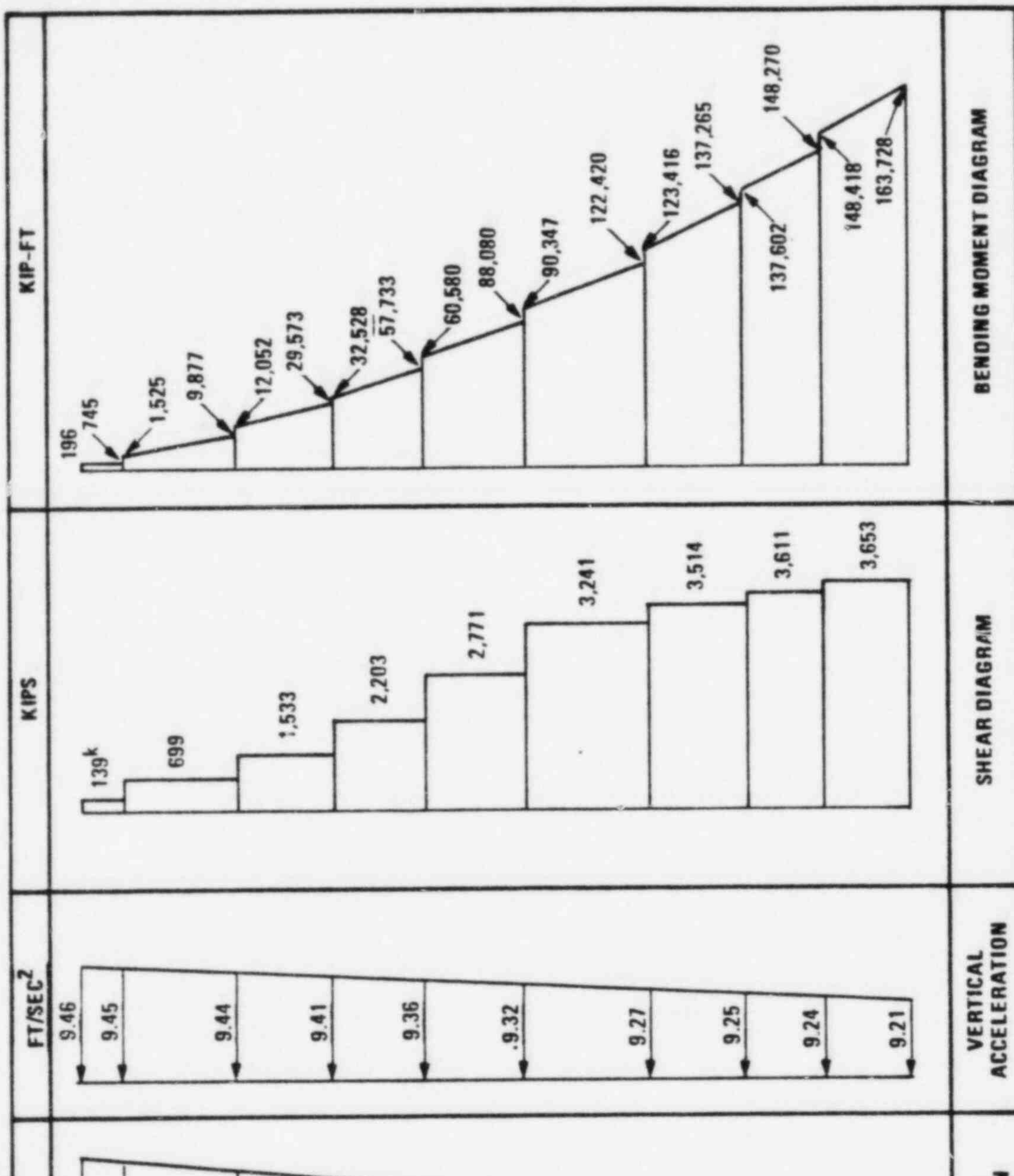
SUMMARY OF SOIL SPRINGS & DAMPING

	SOIL SPRINGS			SOIL DAMPING		KFT/RAD
	K_{xx}(K/FT)	K_{yy}(K/FT)	$K_{\varphi\varphi}$ (K-FT/RAD)	C_{xx} (K-SEC/FT)	C_{yy} (K-SEC/FT)	$C_{\varphi\varphi}$ (K-SEC/RAD)
SSE	51,100	56,700	4.49×10^8	13,340	20,066	2.16×10^6
OBE	65,200	73,500	5.71×10^8	14,999	22,498	2.55×10^6

SUMMARY OF MODAL FREQUENCIES & DAMPING RATIOS

MODE NO.	SSE		OBE		
	FREQUENCY (CPS)	DAMPING (%)	FREQUENCY (CPS)	DAMPING (%)	
1	0.26	0.5	0.26	0.5	SLOSHING WATER
2	3.87	12.6	4.28	11.8	STRUCTURAL MODES
3	6.38	70.7	7.26	69.5	
4	10.55	61.5	11.74	59.8	
5	35.84	21.6	36.12	20.1	
6	40.54	23.2	41.11	16.3	

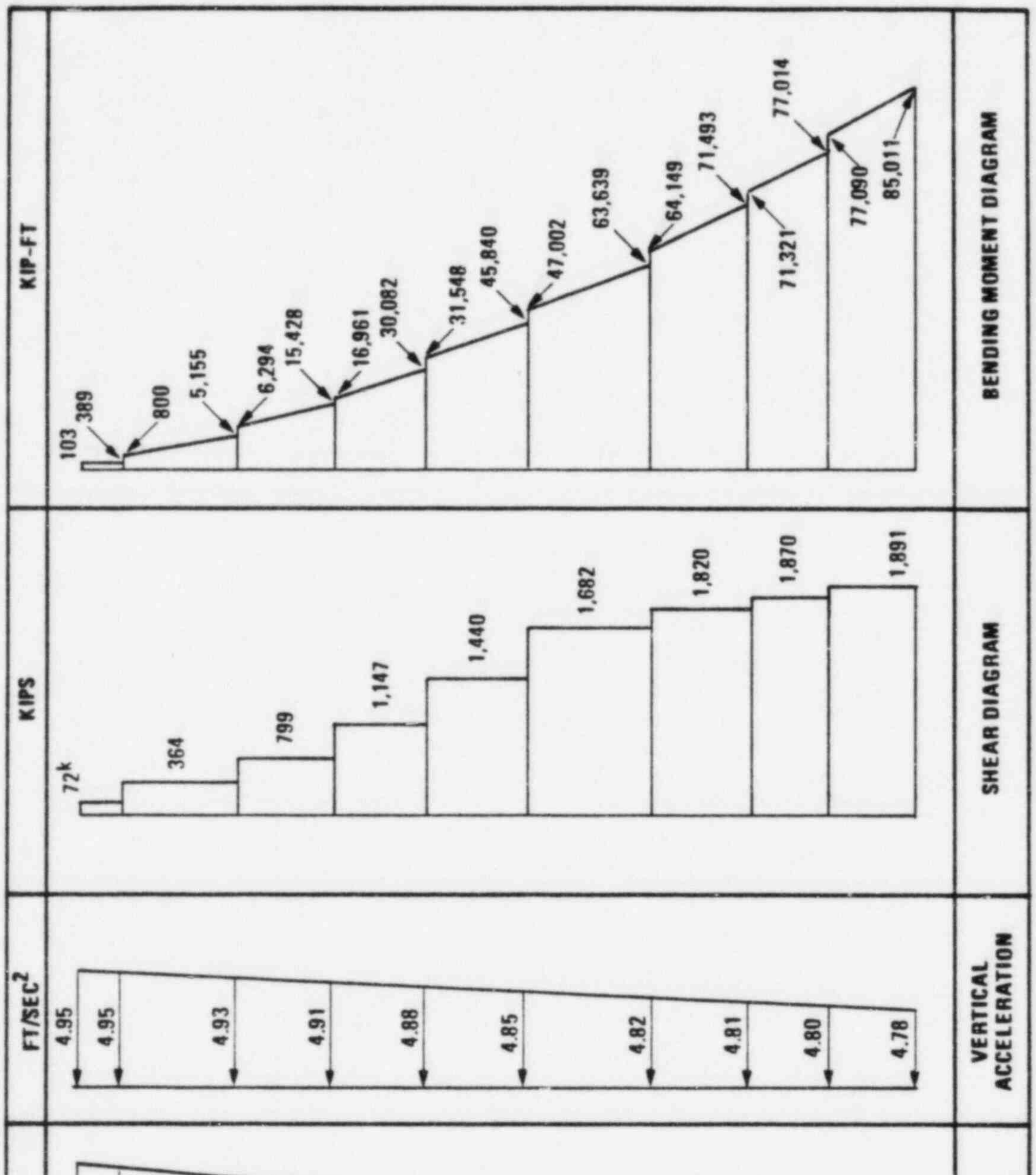
FLEXIBLE-BASE STICK MODEL
REFUELING WATER TANK
Figure 7



STICK MODEL SSE RESPONSE SPECTRA ANALYSIS RESULTS

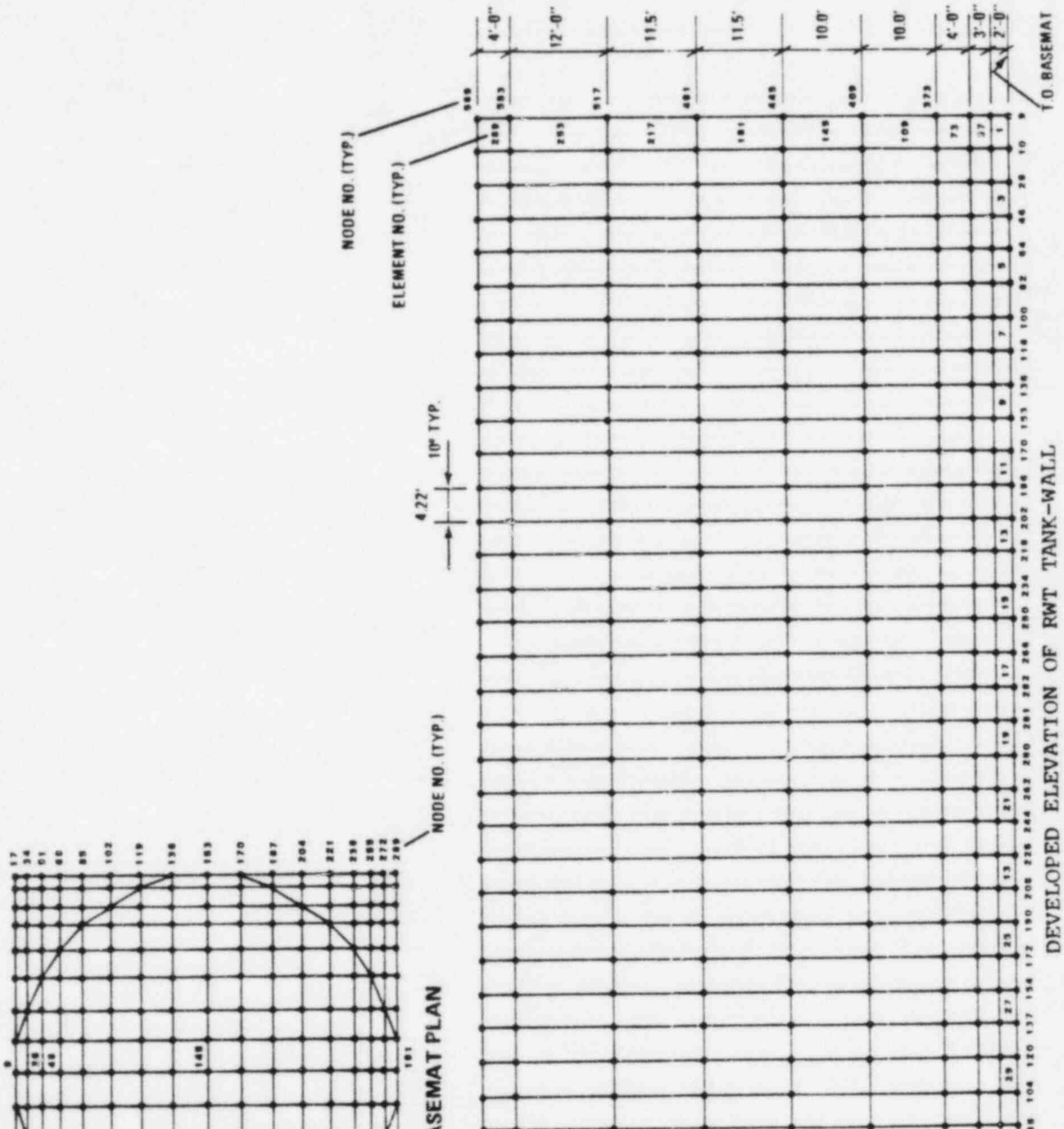
REFUELING WATER TANK

Figure 8



STICK MODEL OBE RESPONSE SPECTRA ANALYSIS RESULTS
REFUELING WATER TANK

Figure 9



DEVELOPED ELEVATION OF RWT TANK-WALL

3-D FINITE ELEMENT MODEL

REFUELING WATER TANK

Figure 10