TVA

Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381

William J. Museler
Site Vice President
Watts Bar Nuclear Plant

JUL 27 1992

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

WATTS BAR NUCLEAR PLANT (WBN) - UNITS 1 AND 2 - RESPONSE TO NRC OPEN ITEMS FROM IN-OFFICE AUDIT OF CIVIL CALCULATIONS (TAC NOS. 500514, M73097, AND M73098)

References: 1. TVA letter dated April 1, 1992, WBN Responses to NRC Information Request (TAC R00514, M73097, M73098), J. H. Garrity to USNRC Document Control Desk

2. NRC letter dated May 26, 1992, In-Office Audit of Civil Calculations (TAC Nos. R00514, M73097, and M73098), Peter Tam to M. O. Medford

NRC conducted an in-office audit of submitted Watts Bar civil calculations (Reference 1) during the month of April 1992. Results of that review are documented in the NRC audit report dated May 26, 1992 (TAC Nos. R00514, M73097, and M73098). (Reference 2)

Four items were identified as remaining open upon conclusion of that in-office review. The purpose of this submittal is to provide TVA responses to those open issues.

Issue 1 - NRC Audit Report Section 2.1.1.1 - Validity of Reaction Forces and Adequacy of the Finite Element Model at Boundary of the Slab - Item No. AU-10

TVA Response: Enclosure 1 provides further clarification which confirms the acceptability of the reaction forces along column line "t" as requested by the staff.

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Issue 2 - Audit Report Section 2.5.4 - Inclusion of Vertical Earthquake in the Slope Stability Analysis Adjacent to the Intake Channel

TVA Response: Enclosure 2 provides discussion of the slope stability analysis along the intake channel which confirms the adequacy of the original analyses.

Issue 3 - Audit Report Section 2.5.2.4 - Shear Stress in Soils within Sheetpile Walls at the Intake Pumping Station

TVA Response: Enclosure 3 is the calculation for "Frequency Dependent Dynamic Shear Stresses in the Earthfill Between Sheetpiles at the Intake Pumping Station." This calculation demonstrates that the stresses meet acceptable levels. The original calculation "Seismic Analysis of Earthfill Contained by Sheetpile Walls at the Intake Pumping Station" has been revised to reference this new calculation.

Issue 4 - Audit Report Section 2.8 - Above Ground Vertical Steel Tank

TVA Response: Enclosure 4, revision to calculation WCG-ACQ-0275, provides the interaction effect from the 6" diameter nozzle on the 8" diameter nozzle. Effects are demonstrated to be acceptable.

If you have any questions, please contact P. L. Pace at (615) 365-1824.

Sincerely,

W.J. Museler

William J. Museler

Enclosures
cc (Enclosures):

NRC Resident Inspector
Watts Bar Nuclear Plant
P.O. Box 700
Spring City, Tennessee 37381

Mr. P. S. Tam, Senior Project Manager
U.S. Nuclear Regulatory Commission
One White Flint, North
11555 Rockville Pike
Rockville, Maryland 20852

Mr. B. A. Wilson, Project Chief
U.S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

ENCLOSURE 1

VALIDITY OF REACTION FORCES AND

ADEQUACY OF THE FINITE ELEMENT MODEL

AT THE BOUNDARY OF THE SLAB

ITEM NO. AU-10

The arrangement of the equipment and the positioning of the columns supporting the one foot slab at elevation 737, as shown on the sketch of attachment for AU-10 sheet 2, was expected to result in the worst slab loading in the region between the Component Cooler Water Heat Exchangers, to the north and south of column line s. The slab model boundaries therefore were extended sufficiently away from the column line s, to column lines "r" and "t". The boundary conditions along the column line "r" are reflecting the presence of a large continous concrete beam, and the nodes are vertically restrained along this line.

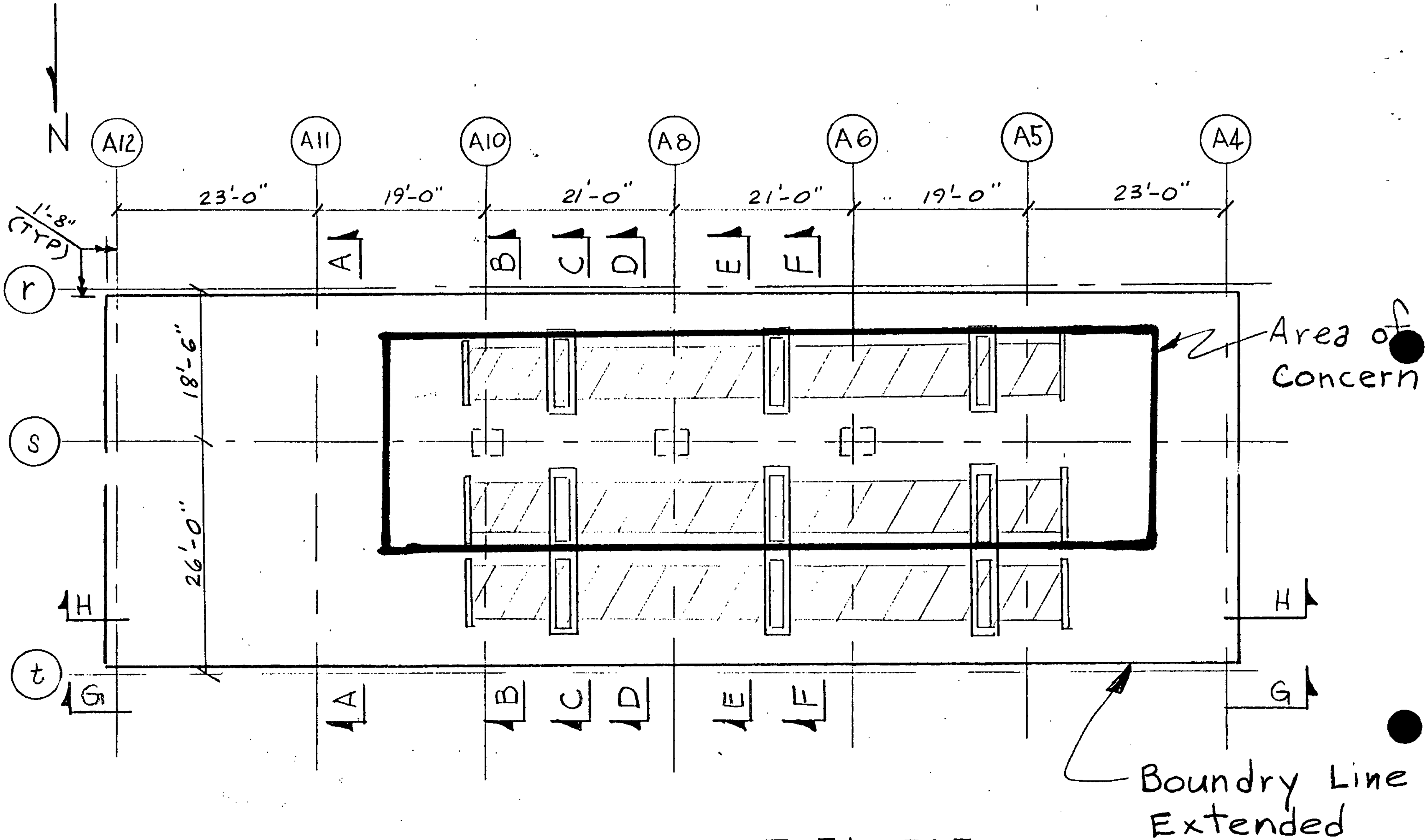
The conditions along the column line t however, consist of a series of slabs of different thicknesses, intersecting walls and drop panels with columns, as shown on the sketch of attachment for AU-10 sheet 3. Conservative idealization of the model was performed at this complex boundary. All but one foot thick slab sections were restrained in the vertical direction, and the one foot slab was freed for conservatism, neglecting the resistance in vertical direction inherent in continuous slabs.

The CCW Heat Exchanger pedestals are relatively close to the free boundary, resulting in heavy dead as well as moment loads from seismic effects.

The idealization of the boundary as discribed above, resulted in the reaction patterns, which include irregular downward and some upward reactions in the vicinities of the free slab boundaries, is reflective of a "continuous beam" behavior imposed by the boundary model.

The AU-10 sheet 4 sketch shows a plot of deflections along the boundary, which is reflective of the above phenomena, and the AU-10 sheet 5 sketch provides the reactions along the same boundary. The effects of the idealized model boundary are localized largely in the vicinity of the boundary, and rapidly attenuate with distance. The AU-10 sheet 6 sketch provides a deflected shape along the boundary line at an offset of approximately 4'-0 distance.

In contrast and as expected the structural behavior of the slab away from the boundary line and in the areas of expected high stress is realistic and accurate. Sheets 7 thru 11 of attachment for AU-10 which provide deflection profiles between column lines "t" and "r", demonstrate this fact.



PLAN OF SLAB AT EL 737

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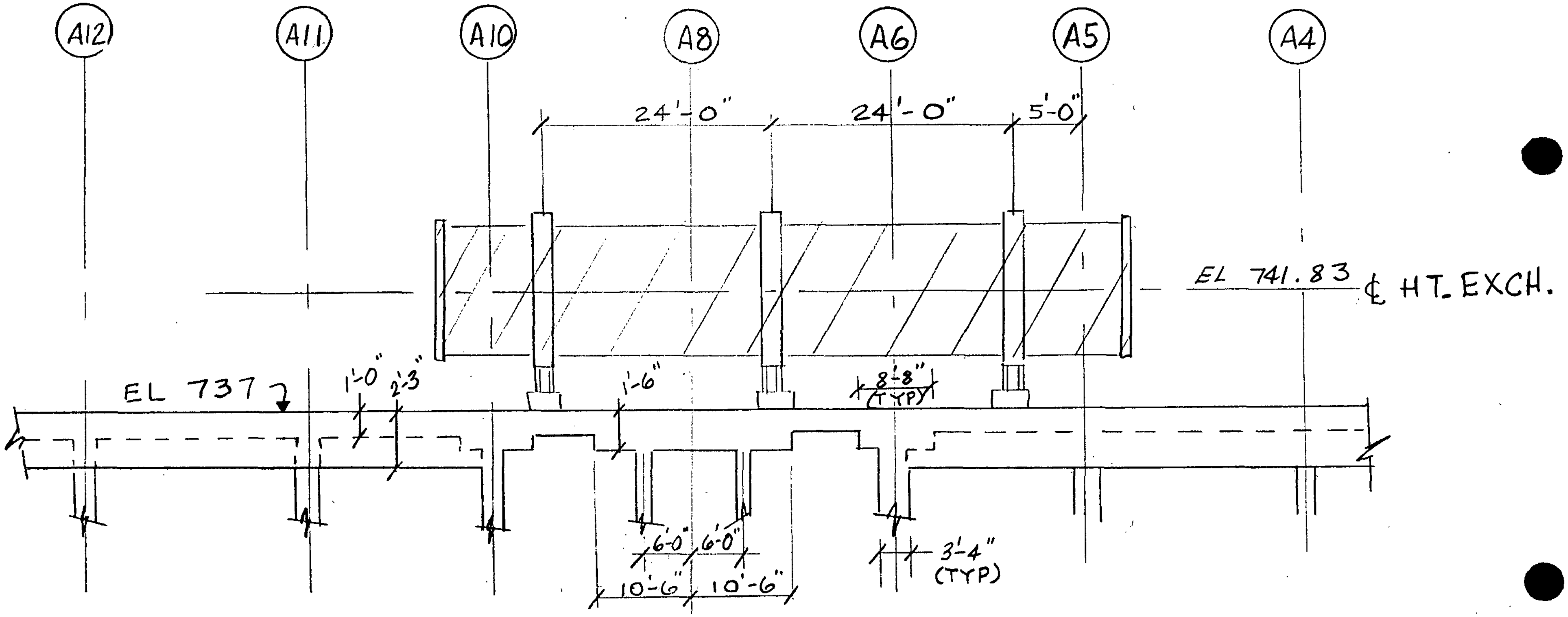
Sheet 2 of 11



SECTION THRU (t)

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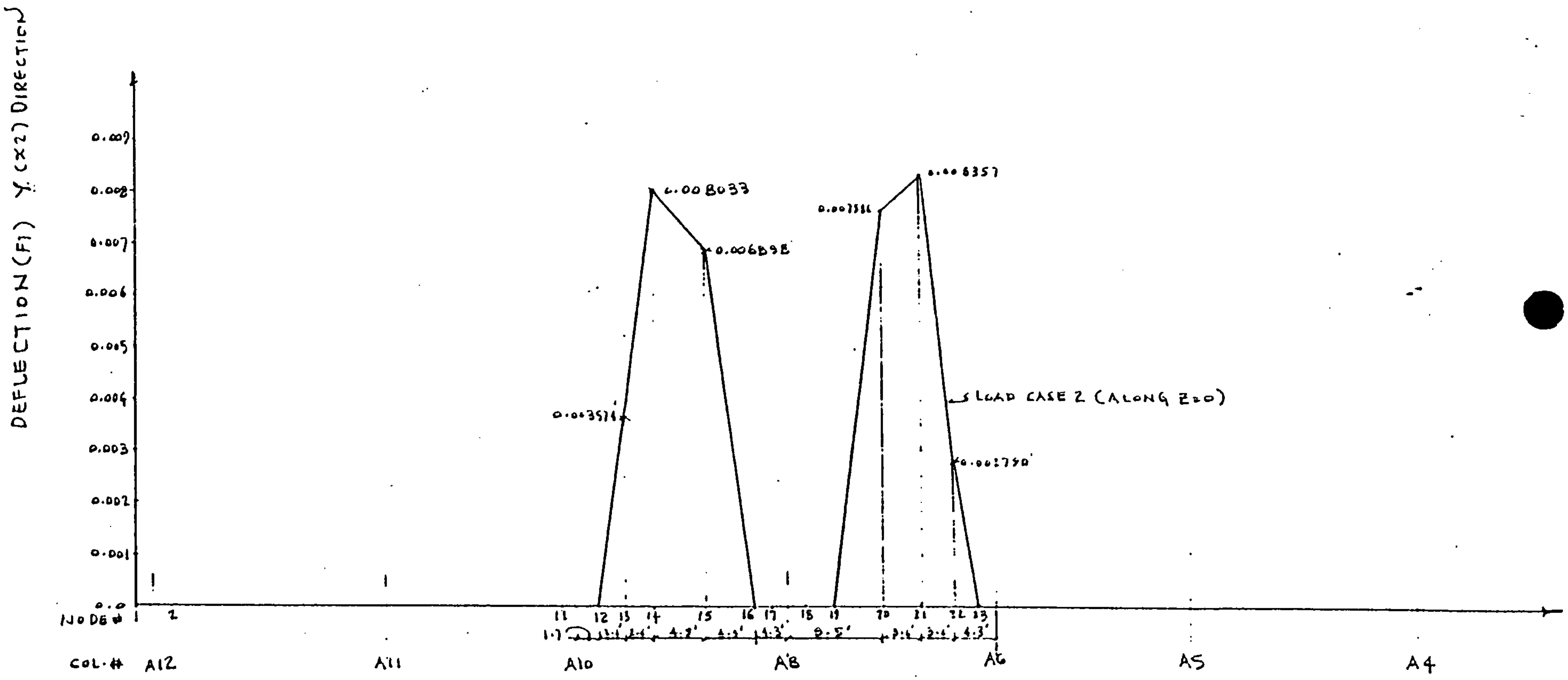
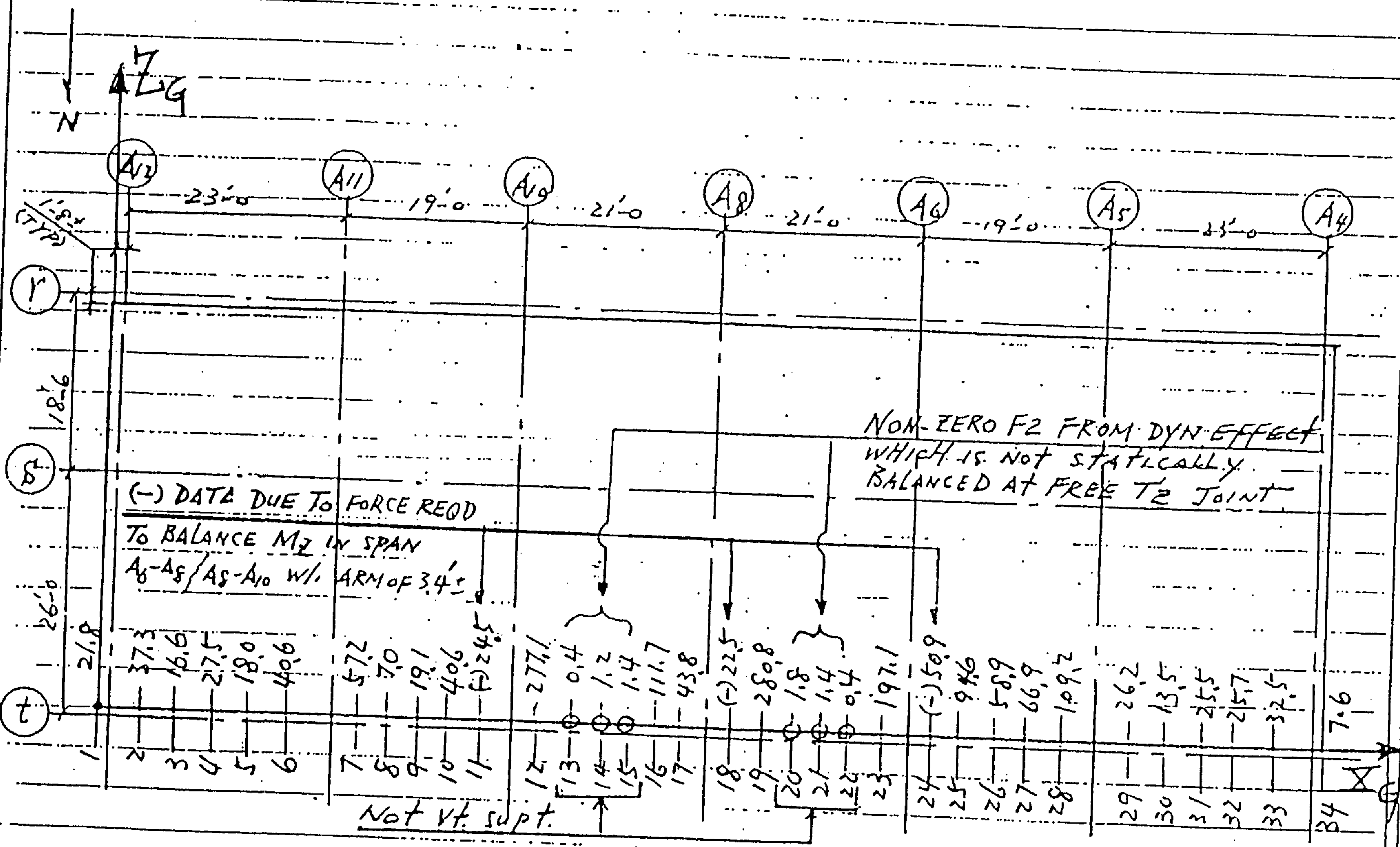
Sheet 3 of 11



SECTION G-G.

NOTE:
CHART SHOWING DEFLECTION ALONG EAST-WEST DIRECTION (FOR NODES 1 THRU 34) AT DISTANCE 1.7 FT. SOUTH OF COL. LINE "E" FOR LOAD CASE 2 WHICH IS CRITICAL. FOR VALUES SEE P.33 OF 60 ATTACHEMENT "G-4".

Item No. AU-10
Sheet 4 of 11



PLAN SHOWING EQUILIBRIUM CHECK F2

DATA OF JOINTS ALONG NORTH BOUNDARY

REF ATTACHMENT C-4, SH. 47.

ALL JOINTS ARE VERT. SUPTS EXCEPT NOTED & MARKED "ϕ".

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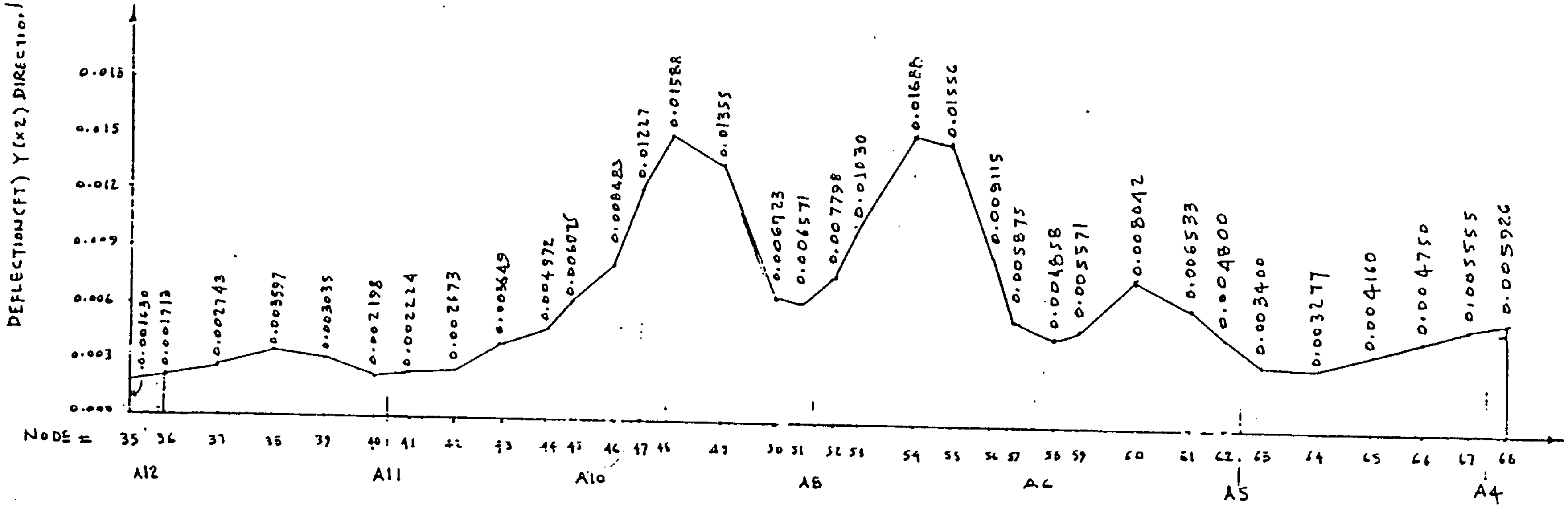

SECTION H-H.

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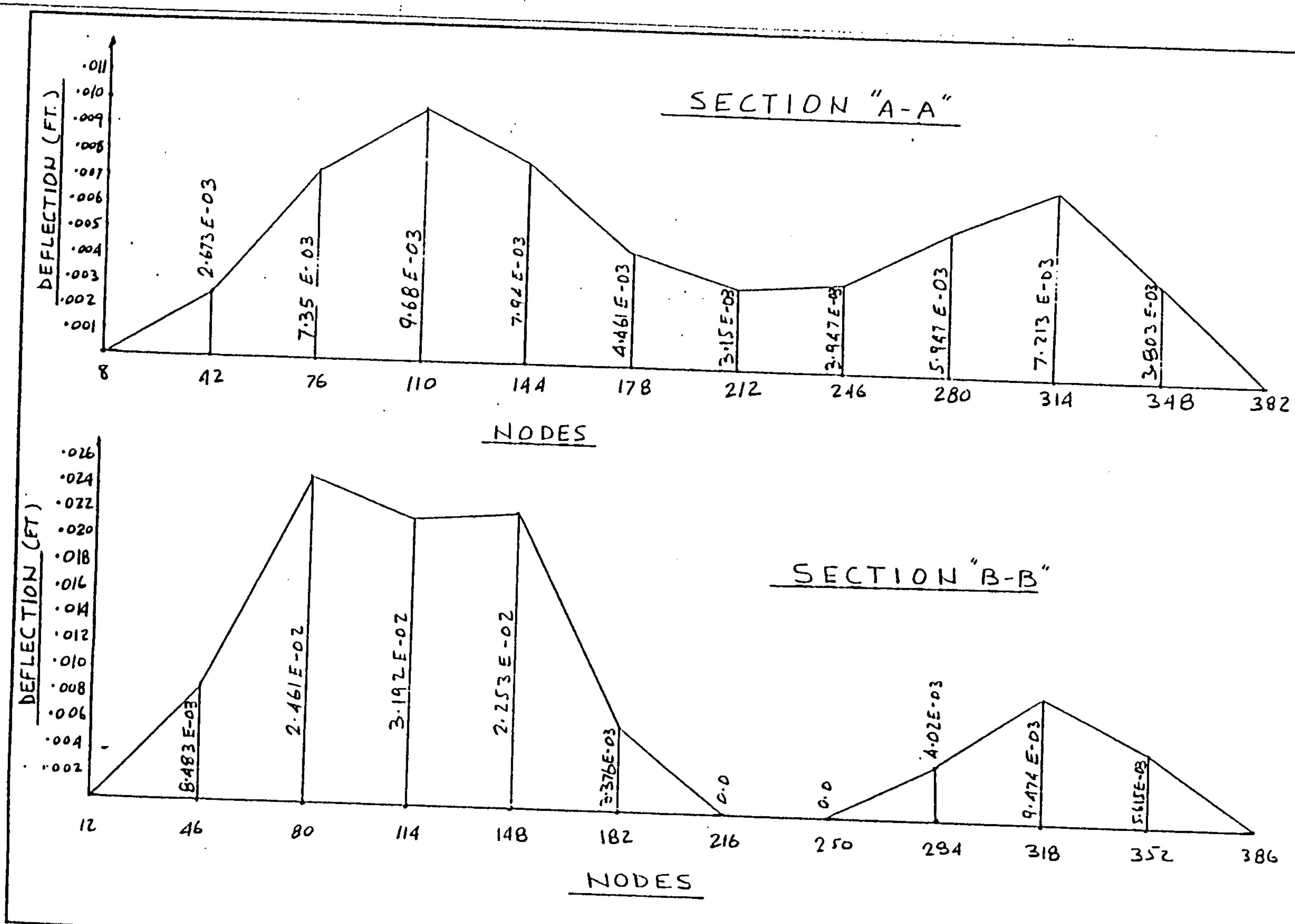
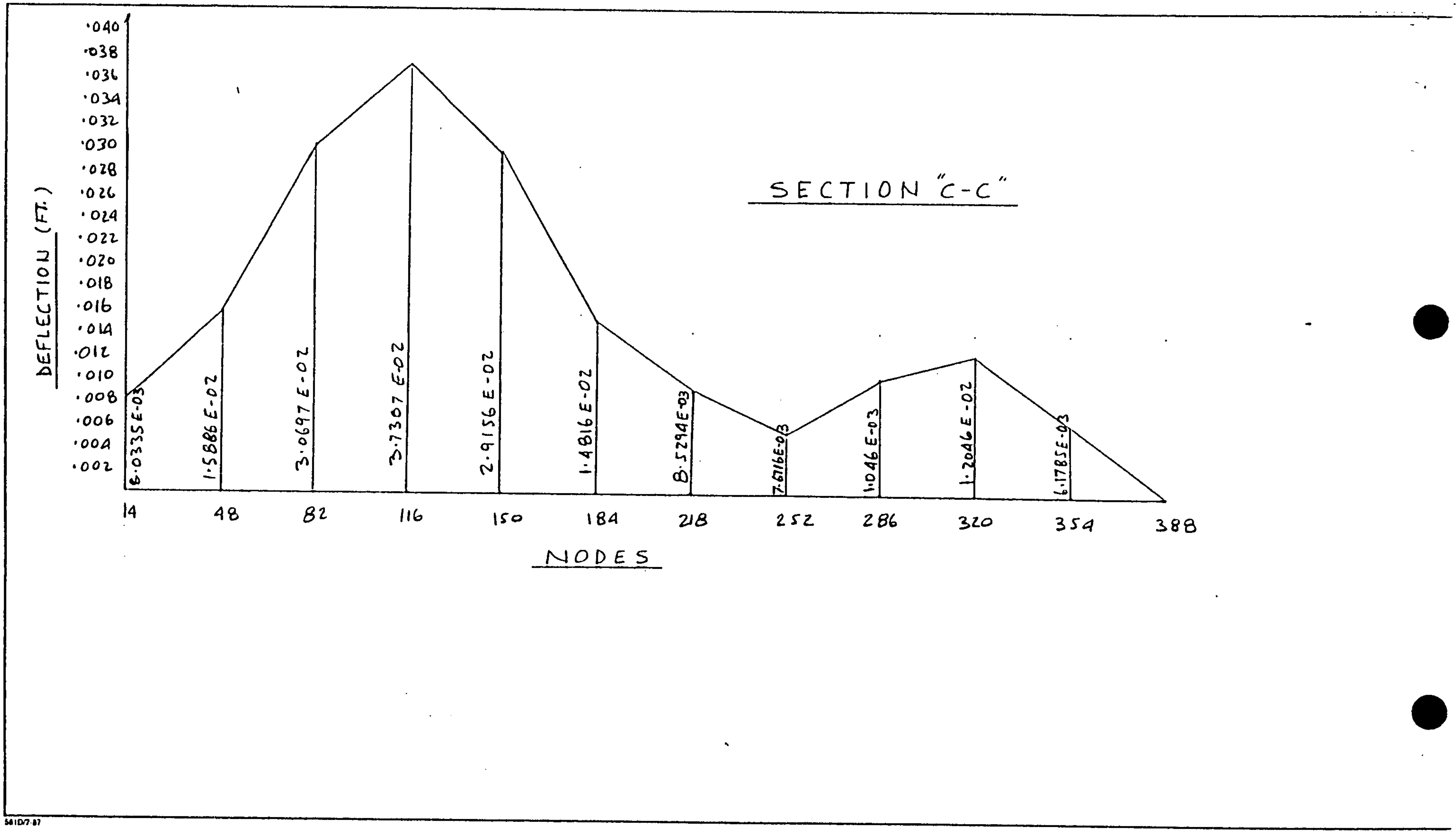


Item No. AU-10
Sheet 7 of 11



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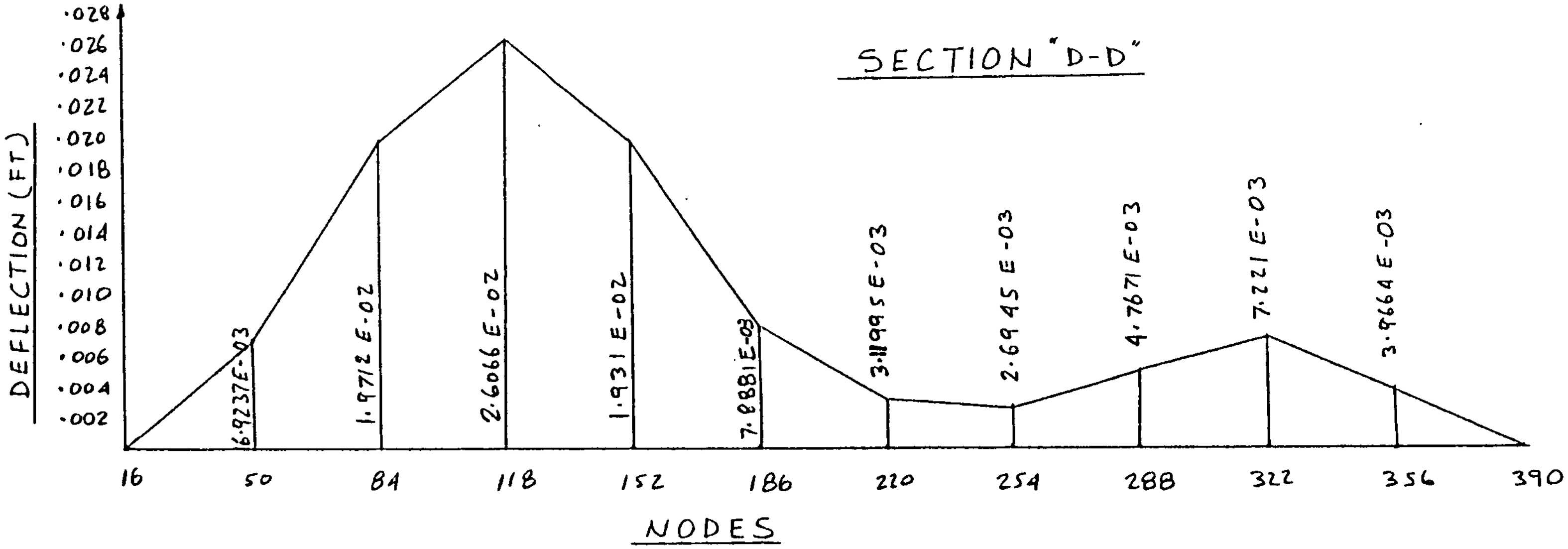
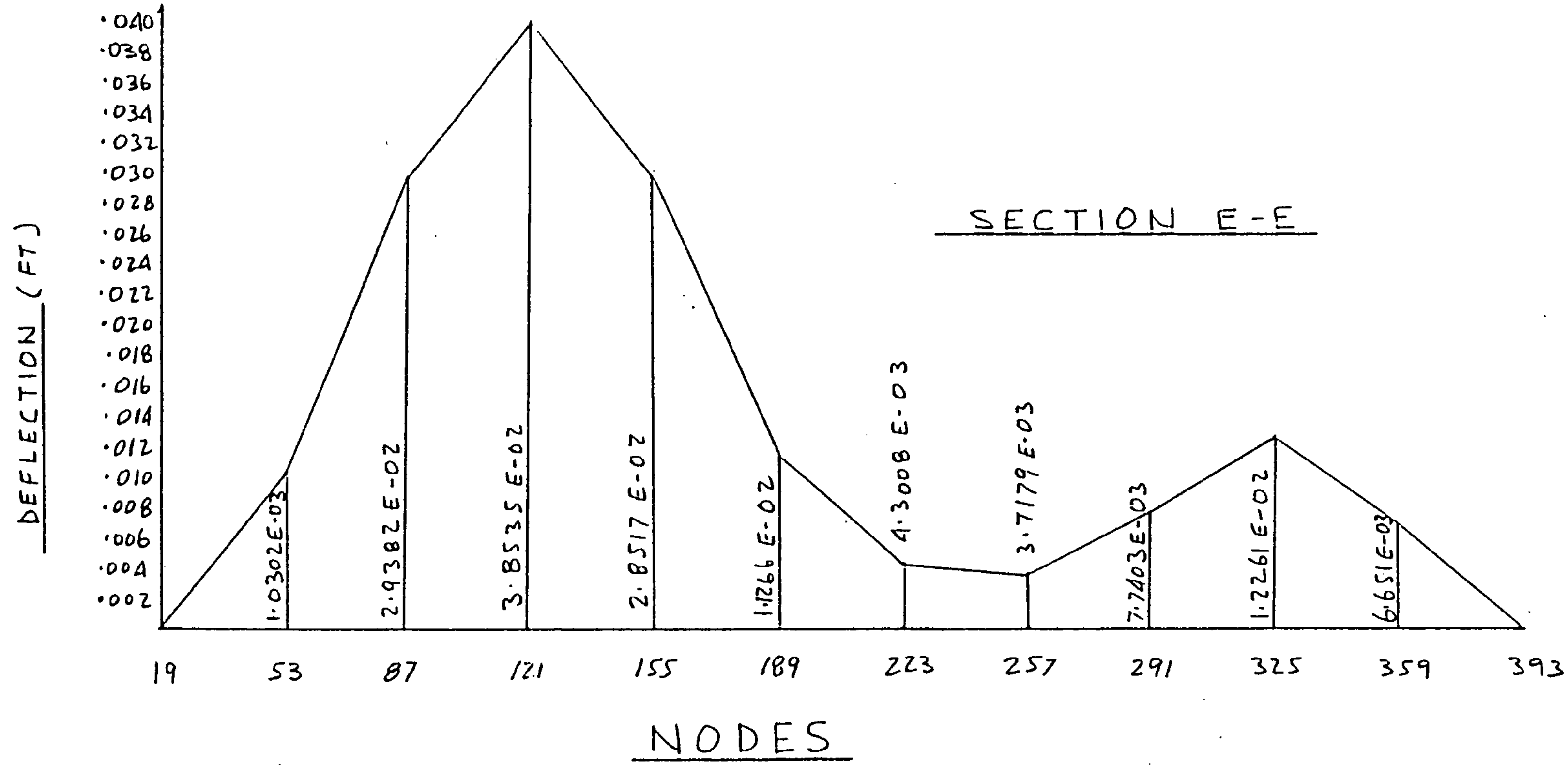


Item No. AU-10
Sheet 9 of 11



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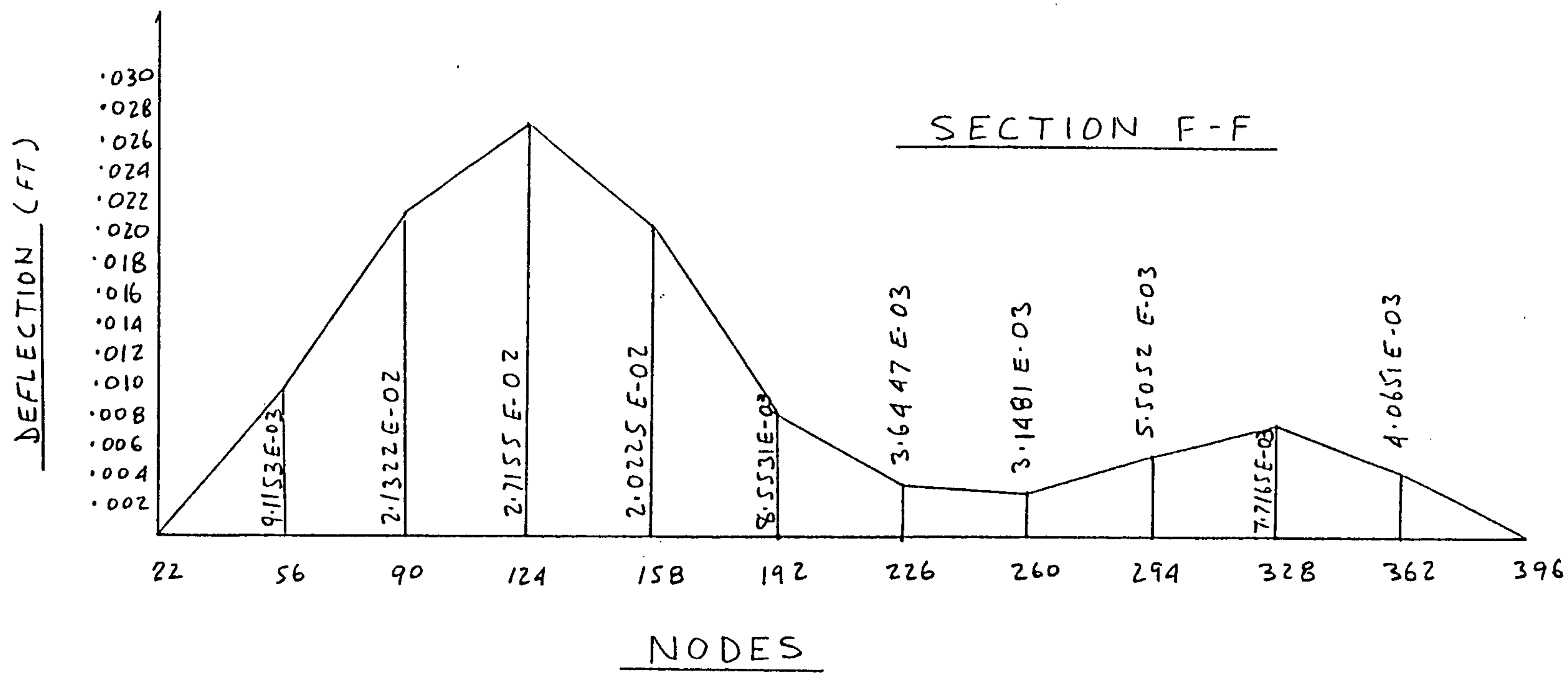

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ENCLOSURE 2

INCLUSION OF VERTICAL EARTHQUAKE IN THE SLOPE STABILITY ANALYSIS ADJACENT TO THE INTAKE CHANNEL

ENCLOSURE 2

INCLUSION OF VERTICAL EARTHQUAKE IN THE SLOPE STABILITY ANALYSIS ADJACENT TO THE INTAKE CHANNEL

Actual forces induced by earthquakes act randomly and instantaneously in all directions - constantly and quickly changing directions during the several seconds of strong earthquake ground motion. Therefore, the application of both horizontal and vertical earthquake components as permanent static forces (in the direction of least stability) produces unrealistic and very conservative results. For this reason, only horizontal seismic coefficients were used in slope stability analyses. Additional justification is provided by the following:

1. Subsection 2.5.5.2 of the Standard Review Plan (SRP) Section 2.5.5, Stability of Slopes states ". . . No single method of analysis is entirely acceptable for all stability assessments; thus, no single method of analysis can be recommended. Relevant manuals issued by public agencies (such as the U.S. Navy Department, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation) are often used in review to ascertain whether the analyses performed by the applicant are reasonable (References 22, 26, and 32)."

   None of the following public agency or professional documents explicitly prescribe the use of a vertical seismic coefficient.

   SRP Reference 22 - Corps of Engineers, "Engineering and Design Stability of Earth and Rock-Fill Dams," Manual EM 1110-2-1902, Office of the Chief of Engineers, Dept. of the Army (1970).

   SRP Reference 26 - Bureau of Reclamation, "Earth Manual," First Edition, U.S. Dept. of the Interior (1968).

   SRP Reference 32 - Corps of Engineers, "Procedures for Foundation Design of Buildings and Other Structures (Except Hydraulic Structures)," Tech. Report TM 5-818-1 (formerly EM 1110-345-147), Office of the Chief of Engineers, Dept. of the Army (1965).

   Design of Small Dams, U.S. Dept. of Interior, Bureau of Reclamation, Second Edition, 1973 (Revised Reprint 1977).

   Dams and Public Safety, U.S. Dept. of Interior, Water and Power Resources Service (Bureau of Reclamation).

   Safety of Existing Dams: Evaluation and Improvement, National Research Council, National Academy Press, 1983.

   Handbook of Dam Engineering, Alfred R. Golze, Van Nostrand Reinhold Co., 1977.

2. Pseudo-static slope stability analysis, using an "amplified" peak horizontal seismic coefficient to compute an equivalent horizontal force and apply it as a static force is very conservative. Reference 3 states

> "Some engineers believe that the product of the seismic coefficient and the weight of the potential sliding mass represents the maximum inertia force developed on the mass during the design earthquake. If this is so, then the application of this force (which might actually act for a fraction of a second) as a static force is extremely conservative-other things being equal. Clearly, a large force can develop for an extremely short period of time without causing significant deformations. Because time is an essential factor in the development of deformations, the application of a transient force as a static force would grossly overestimate its effects."

3. Sarma (Reference 4, page 759) showed that consideration of some angle of incidence of an earthquake acceleration (to create both horizontal and vertical inertial forces) with the base of an embankment would not provide much difference in resultant factors-of-safety, and concluded that use of only horizontal acceleration could be adopted for stability analysis calculations.

4. TVA studied 40 strong motion (actual) earthquake accelerograms (References 5 and 6) with three mutually perpendicular recording axes (2 horizontal and 1 vertical). There were only two instances where the peak horizontal (either axis) and vertical acceleration components occurred at the same time (one acting vertically upward and the other vertically downward). It is unrealistic to assume these peak acceleration components simultaneously occur in the direction of least stability.

   Therefore, TVA concluded that analysis predicated on the use of horizontal seismic coefficients applied to peak ground acceleration for pseudo-static analysis are sufficiently conservative to compensate for refinements which would attempt to predict the instantaneous effects of combined horizontal and vertical accelerations.

   To address the open item in Reference 2, TVA additionally performed a study calculation using a vertical earthquake component for the area in question adjacent to the intake channel. The study calculation utilized "as constructed" configuration geometry, lower bound soil strengths (C=450 PSF, PHI=5 degrees) for the silty sand, a vertical acceleration of 0.2g (2/3 of the horizontal component), and a simultaneous horizontal acceleration of 0.3g. The resultant safety factor was 1.03 which exceeds the minimum acceptable value of 1.0. The study calculation therefore demonstrates the adequacy of the conservatism in the original calculation and that the slope is stable with simultaneous application of horizontal and vertical acceleration components.

REFERENCES:

(3) Seed, H.B., and Martin, G. R. (1966), "The Seismic Coefficient in Earth Dam Design," JSMFD, ASCE, Volume 92, Number SM3, May, pages 25-58

(4) Sarma, S. K. (1975), "Seismic Stability of Earth Dams and Embankments," Geotechnique 25, Number 5, pages 743-761

(5) "Strong Motion Earthquake Accelerograms," Cal. Inst. of Tech. EERL 71-50, September 1971, Pasadena, California.

(6) "Strong Motion Earthquake Accelerograms," Cal. Inst. of Tech. EERL 72-50, February 1973, Pasadena, California.