UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FEB 8 1982

Docket Nos. 50-329/330 OM, OL

APPLICANT: Consumers Power Company

FACILITY: Midland Plant, Units 1 and 2

SUBJECT: SUMMARY OF JANUARY 13, 1982 MEETING ON BORATED WATER STORAGE TANKS

On January 13, 1982, the NRC staff met in Bethesda, Maryland, with Consumers Power Company, Bechtel and several consultants to discuss several recent submittals to the NRC regarding cracking of the foundations of the Midland Borated Water Storage Tanks. This subject relates to a 10 CFR 50.55(e) report first issued February 20, 1981, enclosing MCAR-48. Meeting attendees are listed as Enclosure 1.

Summary

The background documents providing the basis for this meeting had been submitted to the NRC by coverletters dated November 10, 13 and 24, 1981. Testimony of Robert P. Kennedy of Structural Mechanics Associates (SMA), Inc., a general consultant for the applicant, presented during the December 1-3, 1981 session of the OM, OL hearing also provided relevant background information.

Based upon review of the above documents, questions had been submitted by telephone to the applicant by the U.S. Army Corps of Engineers (NRC geotechnical consultant) (Enclosure 2) and by the NRC's Structural Engineering Branch (Enclosure 3). Responses to these questions were made during the meeting.

The applicant stated that the NRC would be receiving shortly a letter dated January 11, 1982, forwarding a report by SMA on the results of a BWST finite element analysis performed to verify the integrity of the tanks. A summary of that report was provided by Mr. Cambell using the viewgraph slides of Enclosure 4. The report demonstrates that the tanks were not permanently damaged as a result of the ring wall foundation cracking. The report does note that one bolt chair (at bolt location 27) may have yielded to a small degree and recommended that it be dye penetrant tested. The applicant stated that the dye penetrant test had been performed and all the welds of the bolt chair had passed.

The applicant also stated that the tank vendor, the Graver Company, had dropped its N stamp and was no longer in the nuclear business. The applicant plans to meet with RECO on January 15, 1982, to discuss techniques of re-establishing a level base for the tanks after removal of the surcharge from the BWST valve pits. The staff will be advised of the technique selected, once that is known.

The applicant will provide a letter summarizing the results of the surcharge program for the BWSTs. The applicant also stated that all cracks with a width in excess of 10 mils in the existing ring foundation will be sealed before the new ring beam is constructed around the existing ring.

/S/
Darl Hood, Project Manager
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Division of Licensing

Enclosures:
As stated

cc: See next page

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JANUARY 13, 1982

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NSWC/WO (NRC Consultant)

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R. Campbell

ENCLOSURE 2

Handout for 01/13/82 Meeting

January 8, 1982

Subject: Midland Project, Corps of Engineers review comments on Design Report for the Borated Water Storage Tank Foundations, Report Transmitted November 13, 1981 in letter from J. Cook to H. Denton.

Q.1, Sect. 3, Page 2.

Since the loads (weight of water) are applied uniformly through the flexible bottom of the tanks, and the foundations of the ring walls and valve pits are not involved in spreading the load on the ground underneath, there is no reason for differential settlement to occur unless the underlying soil mass has varying engineering properties. Please discuss what caused the differential settlements.

Q.2, Sect. 3.2, Page 2.

How are the tanks' loads imposed on the ring beams when the static load is directly transmitted to the ground through the flexible tanks' bottom.

Q.3, Deleted.

Q.4, Sect. 5b, Page 3.

What do the roof loads include? If this includes the dead load of the roofs, why not combine with the dead load.

Q.5, Deleted.

Q.6, Deleted

Q.7, Sect. 6.1, Page 4.

The settlements of the foundation soils under the tanks and under the ring wall footings have been caused by the water load directly applied on the soil surface under the flexible tank bottom, very little water load has been transmitted to the soil through the ring beam footings, therefore, there is no assurance that deflection of the ring beams bottom and the settlement underneath the footings at all points are compatible. Provide discussion on this aspect.

Q.8, Sect. 6.1.2, Page 5.

Between elevations 635 and 629, the continuity of the soil media has been interrupted by the ring walls and their foundations, however, the finite element model (Figure 6) indicates continuity of the soil more than 80' from the center of the tanks in all directions. Discuss the effects of the discontinuity on the results of the finite element solutions.

Q.9, Sect. 6.2, Page 5.

The settlements of the soil under the tanks' foundations are produced by the water load directly applied at the soil, therefore, more bearing areas of ring wall footings will have practically no effect in reducing the settlements as claimed by the applicant. Please discuss how the wider ring beam will reduce the settlement.

Q.10. It is our understanding that ongoing load tests of the soil under the tanks' foundations is being performed by filling the tanks with water. Please discuss what would be the difference in loadings when the tanks are filled with borated water. Also, what additional permanent loads or semi-permanent loads other than weight of the borated water, which will contribute to the settlements, are expected to act on the tanks. If the actual load on the tanks' foundations during their operational period is more than the pressure created by water during the load tests, the compressibility parameters determined by the load tests may not predict the future settlements of the tanks accurately under the actual loadings.

Q.11, Sect. 6.3.1, Page 6.

Provide justification for values of Modulus of Elasticity which have been used in evaluation of long term settlements and shown in Figure 9. What method or methods, assumptions, and tests have been used to determine the long term Modulus of Elasticity?

Q.12, Sect. 6.4.3, Page 7.

Load combinations 1 thru 8 include permanent loads, therefore, use of the short-term model described in subsection 6.4.2 is not appropriate. The short-term model uses the values of Youngs Moduli, which are applicable to seismic events or machine vibration where the magnitude of strains are in range of $10^{-3}\%$ or less.

Q.13, Sect. 6.5.1b, Page 7.

Table 5 does not provide summary of loads.

Q.13a, Sect. 8, Page 8.

The finite element analyses are based on questionable inputs concerning soil compressibility, therefore, existence of compression under the foundation soil, under the dead loads, and live loads are questionable. Therefore, there is no assurance that the footings of the ringwalls and the soil underneath are displacing in compatible manner.

Q.14, Deleted

Q.15, Sect. 8a, Page 8.

Provide the magnitude of dead loads and live loads used to compute foundation pressures which resulted in 2.0 ksf of soil pressure.

Q.16, Sect. 8, Page 9.

Bearing capacity and factor of safety provided on page 9 are not appropriate. The soil shear strength in the area of Unit 1 is not identical with Unit 2, therefore, bearing capacity of foundation soils under each unit should be determined using the shear parameters pertinent to their respective area.

ENCLOSURE 3

01/03/82

CIVIL/STRUCTURAL QUESTIONS ON BWST

1) Where are the construction details shown for the new ring fix?

2) What is your rationale for applying a load factor of unity (1.0) to dead load in load combinations 9 through 12?

3) Was the eccentricity of the new ring beam included in the final ring beam design?

4) How is shear between the new and old ring beam calculated anl transferred?

5) How will you treat cracks in the existing concrete in the shear transfer process?

ACCEPTANCE CRITERIA

SETTLEMENT PROBLEM NOT COVERED BY GOVERNING DESIGN CODE.

THREE ACCEPTANCE CRITERIA CONSIDERED

1) NO YIELD

2) CODE STRESS LEVELS APPLICABLE TO SERVICE LEVELS THAT IMPLY REPEATED LOADING WITH NO SUBSEQUENT INSPECTION (UPSET OR TESTING CONI

3) LEVEL C SERVICE (EMERGENCY EVENTS) WITH SUBSEQUENT NDE.

CRITERION 1 MET FOR ALL BUT BOLT CHAIR TOP PLATE (MAX BOLD LOAD CASE)

CRITERION 3 APPLIED TO WORST CASE BOLT CHAIR

MIDLAND BWST

FOUNDATION SETTLEMENT EVALUATION

STATEMENT OF PROB

SOIL SETTLEMENT HAS RESULTED IN DISTORTION OF RING WALL TOP SURFACE

SUPPORT OF BWST WALLS IS NON-UNIFORM

ANCHOR BOLT LOADING IS NON-UNIFORM

CONCERN REGARDING STRESS LEVELS INDUCED IN TANK WALL, ANCHOR BOLTS AND BOLT CHAIRS

TWO TANKS CONSIDERED BUT TANK IT-60 IS GOVERNING CASE

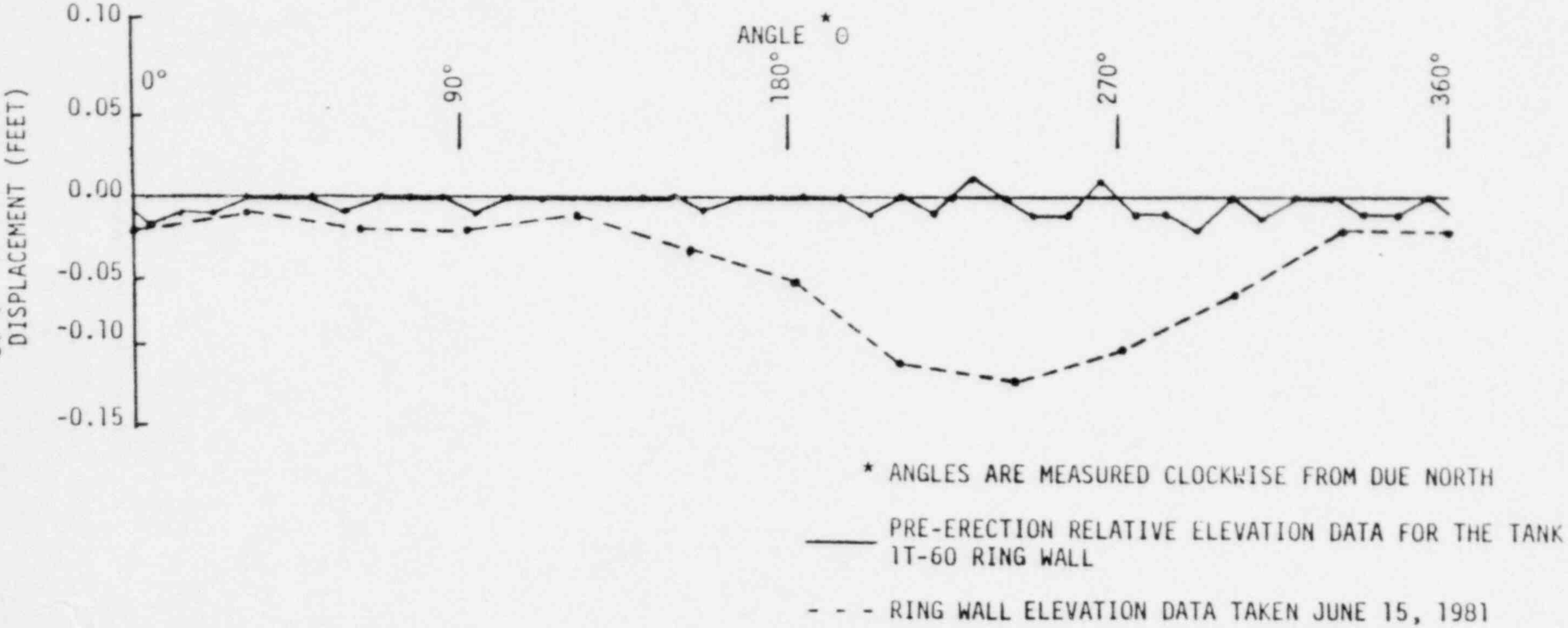


FIGURE 1-3. COMPARISON OF TANK 1T-60 RING WALL RELATIVE ELEVATIONS BEFORE AND AFTER THE GROUND SETTLEMENT

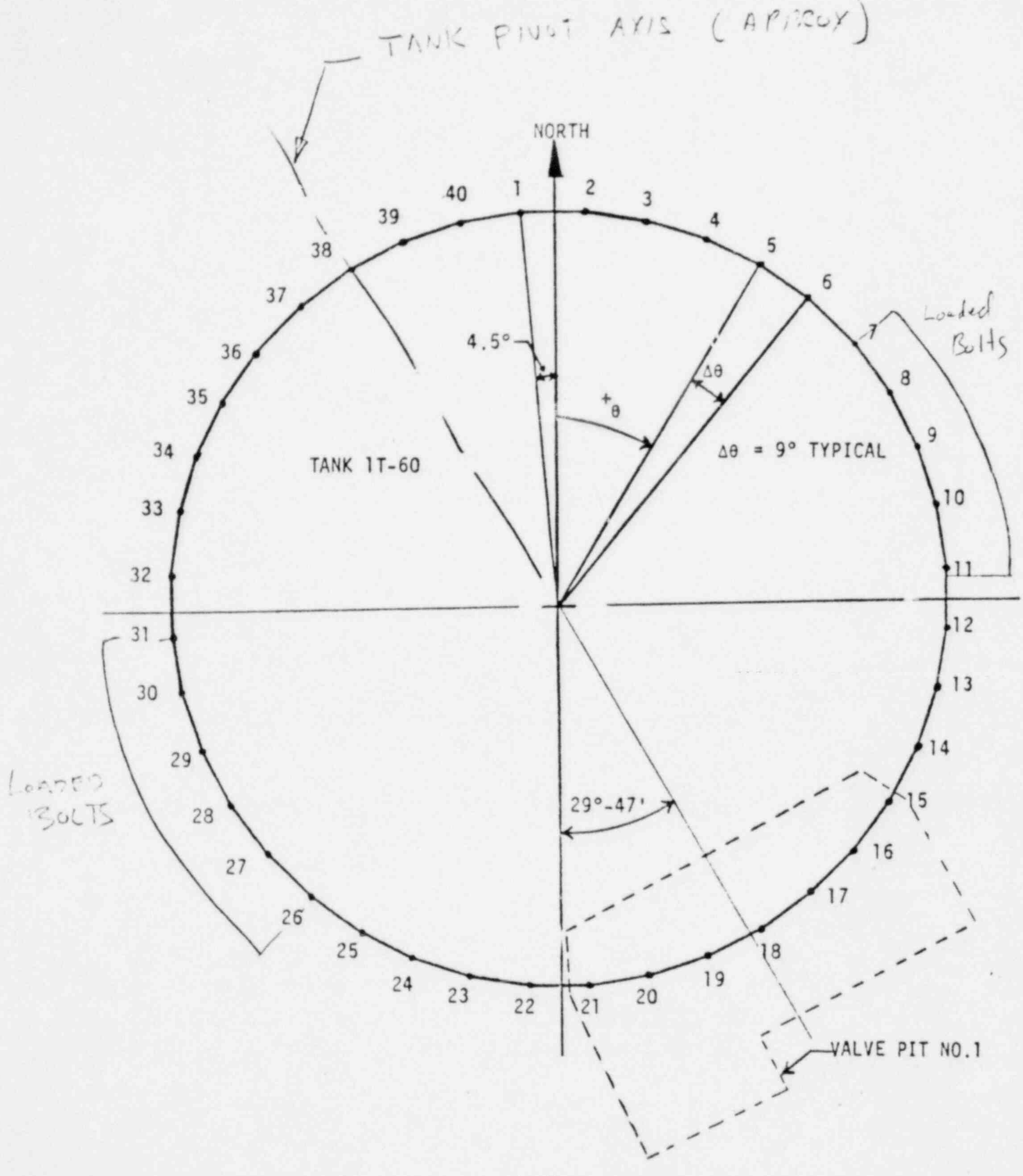


FIGURE 1-1: PLAN VIEW OF TANK 1T-60 IDENTIFYING BOLT NUMBERS AND LOCATION ANGLE θ

TABLE 1-3

MEASURED LOADS IN BOLTS ANCHORING TANK TT-60

BOLT NUMBER*	LOAD (KIPS)	BOLT NUMBER*	LOAD (KIPS)
1	0.0	21	0.0
2	0.0	22	0.0
3	0.0	23	0.0
4	0.0	24	0.0
5	0.0	25	0.0
6	0.0	26	16.44
7	17.83	27	31.31
8	14.02	28	16.10
9	21.32	29	10.13
10	22.51	30	0.02
11	16.46	31	2.32
12	0.0	32	0.0
13	0.0	33	0.0
14	0.0	34	0.0
15	0.0	35	0.0
16	0.0	36	0.0
17	0.0	37	0.0
18	0.0	38	0.0
19	0.0	39	0.0
20	0.0	40	0.0

*BOLT LOCATIONS CORRESPONDING WITH THESE BOLT NUMBERS ARE LISTED IN TABLE 1-1

TANK GEOMETRY & MATERIALS

DIA = 52'
HEIGHT = 32'

SHELL THICKNESS -

3/8" FOR BOTTOM 8'
1/4" FOR UPPER 24'

BOTTOM- 1/4" FLAT PLATE, 1/8 IN/FT DEADRISE

ROOF - UMBRELLA TYPE

TANK MATERIAL - 304 L SS
S_y = 25 KSI

ANHCOR BOLTS - $1\frac{1}{2}$" DIA. A-36 STEEL
S_y = 36 KSI

BOLT CHAIRS - 304 L SS MATERIAL
5/8" THICK TOP PLATE
1/2" THICK GUSSET PLATES

RING WALL - REINFORCED CONCRETE
1'6" WIDTH, 4' WIDTH FOOT AT BOTTOM
6' DEPTH

BOTTOM SUPPORT - OIL IMPREGNATED SAND

ASPHALT IMPREGNATED FIBER BOARD BETWEEN TANK BOTTOM AND RING WALL

ANALYSIS METHOD

MODEL

3 DIMENSIONAL FINITE ELEMENT MODEL OF TANK WALL

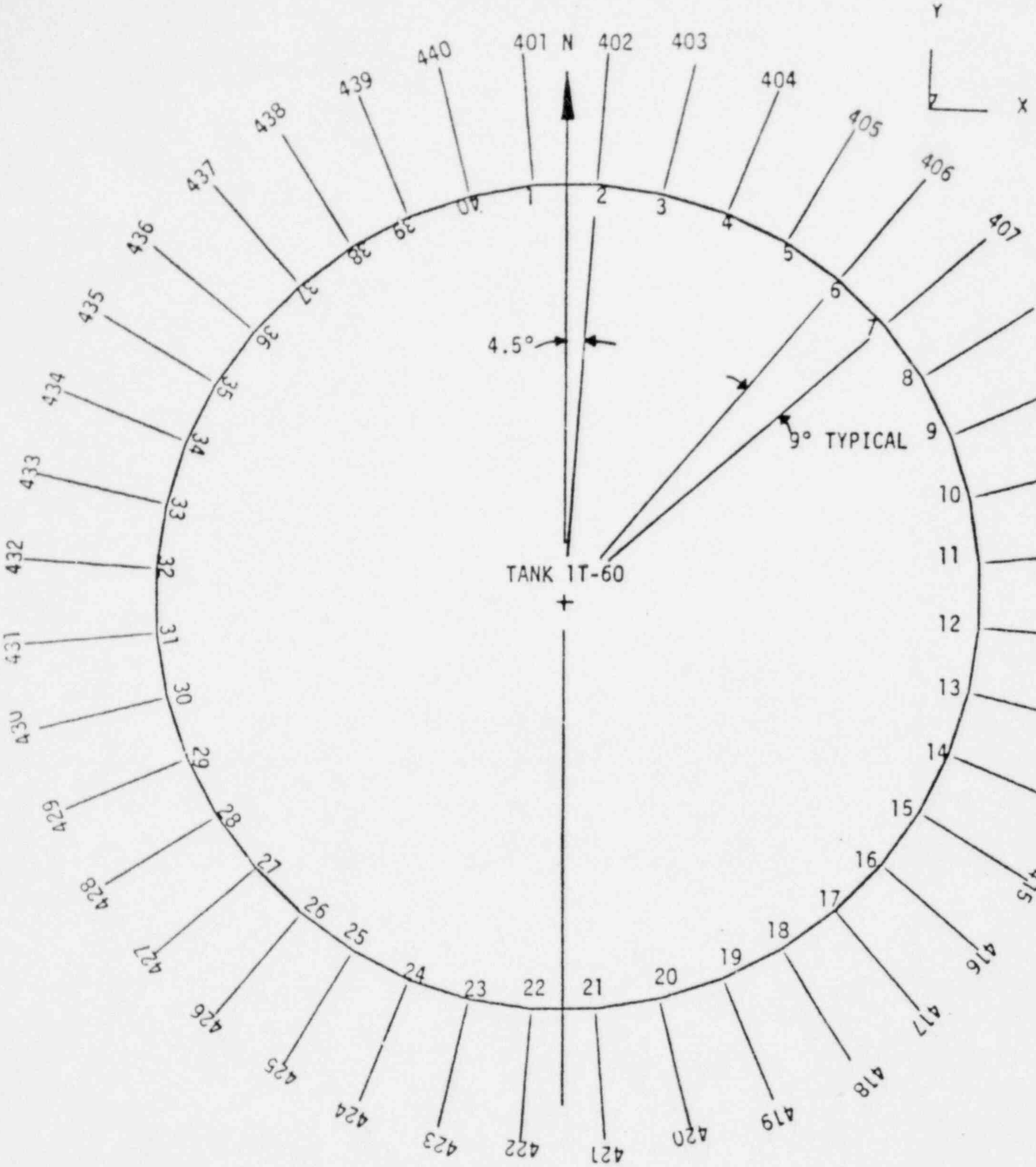
- RING WALL CONSIDERED RIGID BOUNDARY
- GAP ELEMENTS USED TO REPRESENT
  - BOUNDARY BETWEEN TANK BOTTOM AND RING WALL

LOADING

- HYDROSTATIC PRESSURE
- DEAD WEIGHT OF TANK WALL AND ROOF
- BOLT LOADS (FROM STRAIN GAGE MEASUREMENTS

MODEL BOUNDARY CONDITIONS

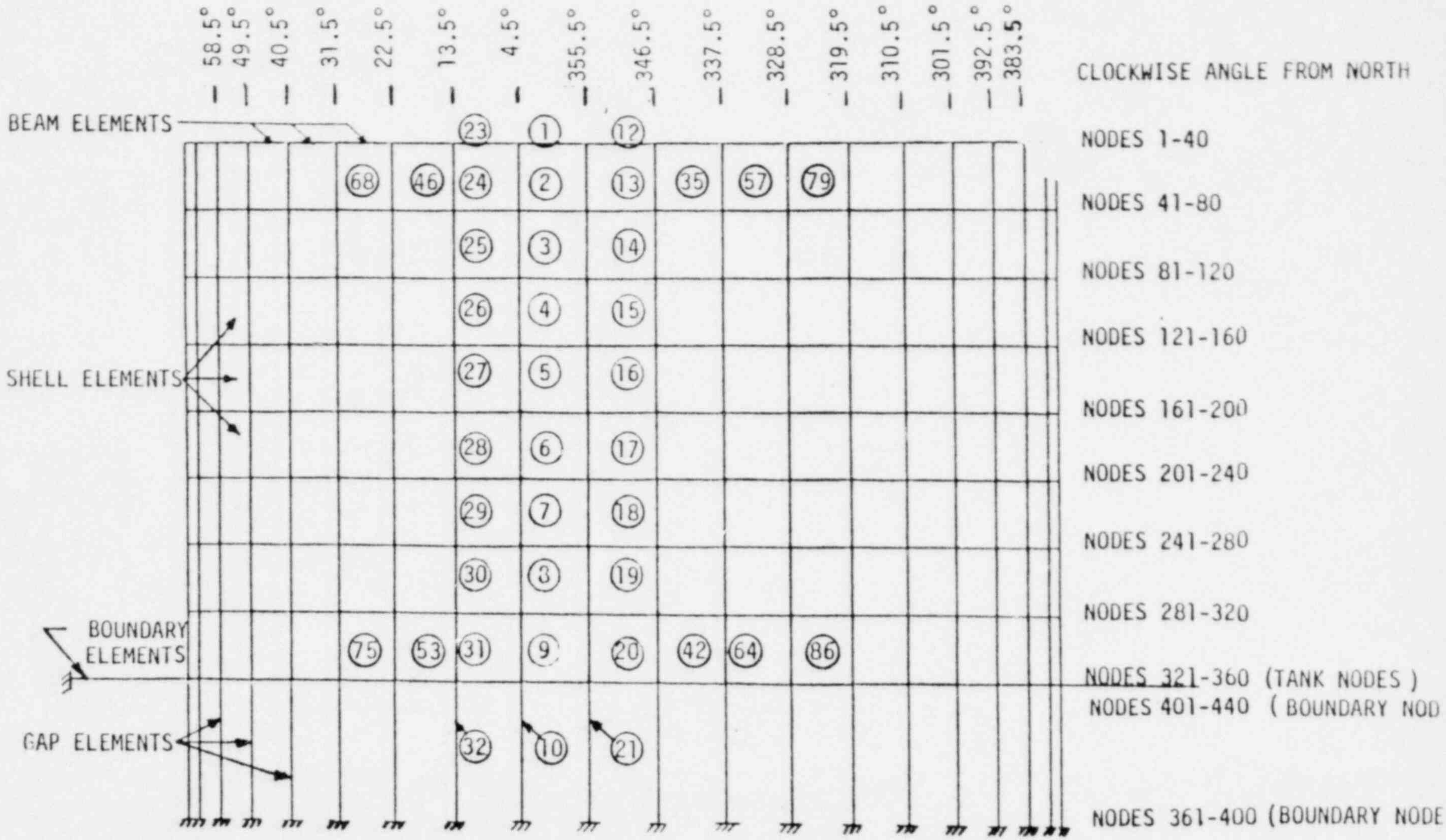
- RADIAL BEAM ELEMENTS REPRESENT BOTTOM STIFFNESS
- BEAM ELEMENT RING GIRDER FOR ROOF STIFFNESS
- GAP ELEMENTS REPRESENT CONTOUR OF
  - RING WALL TOP SURFACE AND
  - COMPRESSIBILITY OF ASPHALT IMPREGNATED FIBER BOARD



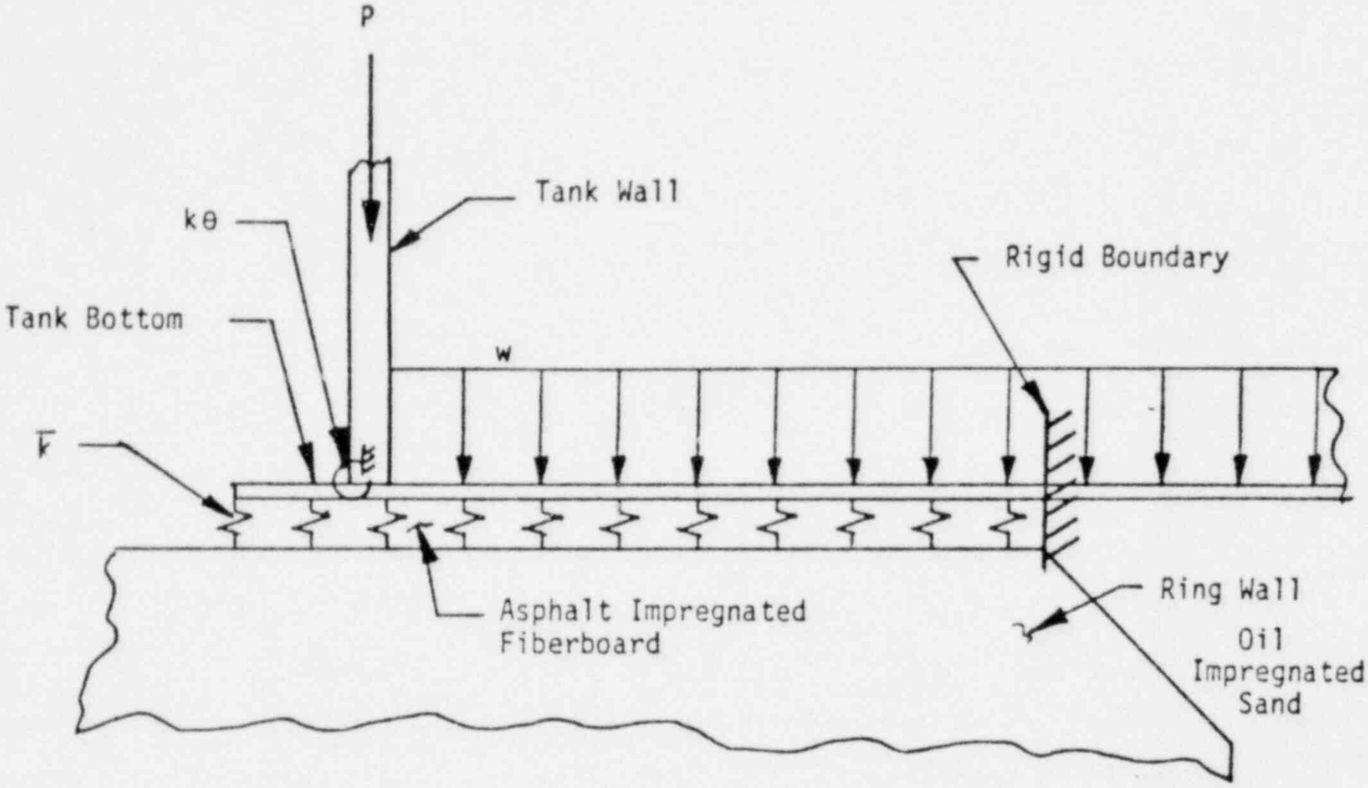
NOTE: INNER CIRCLE OF NUMBERS REPRESENT NODES ON THE TOP OF THE TANK. OUTER CIRCLE OF NUMBERS REPRESENT NODES AT THE OUTER END OF THE BOUNDARY ELEMENTS AT THE TANK BOTTOM.

FIGURE 2-1. PLAN VIEW OF TANK MODEL

BORATED WATER STORAGE TANKS AT MIDLANDS



(xx) - Represent Element Numbers



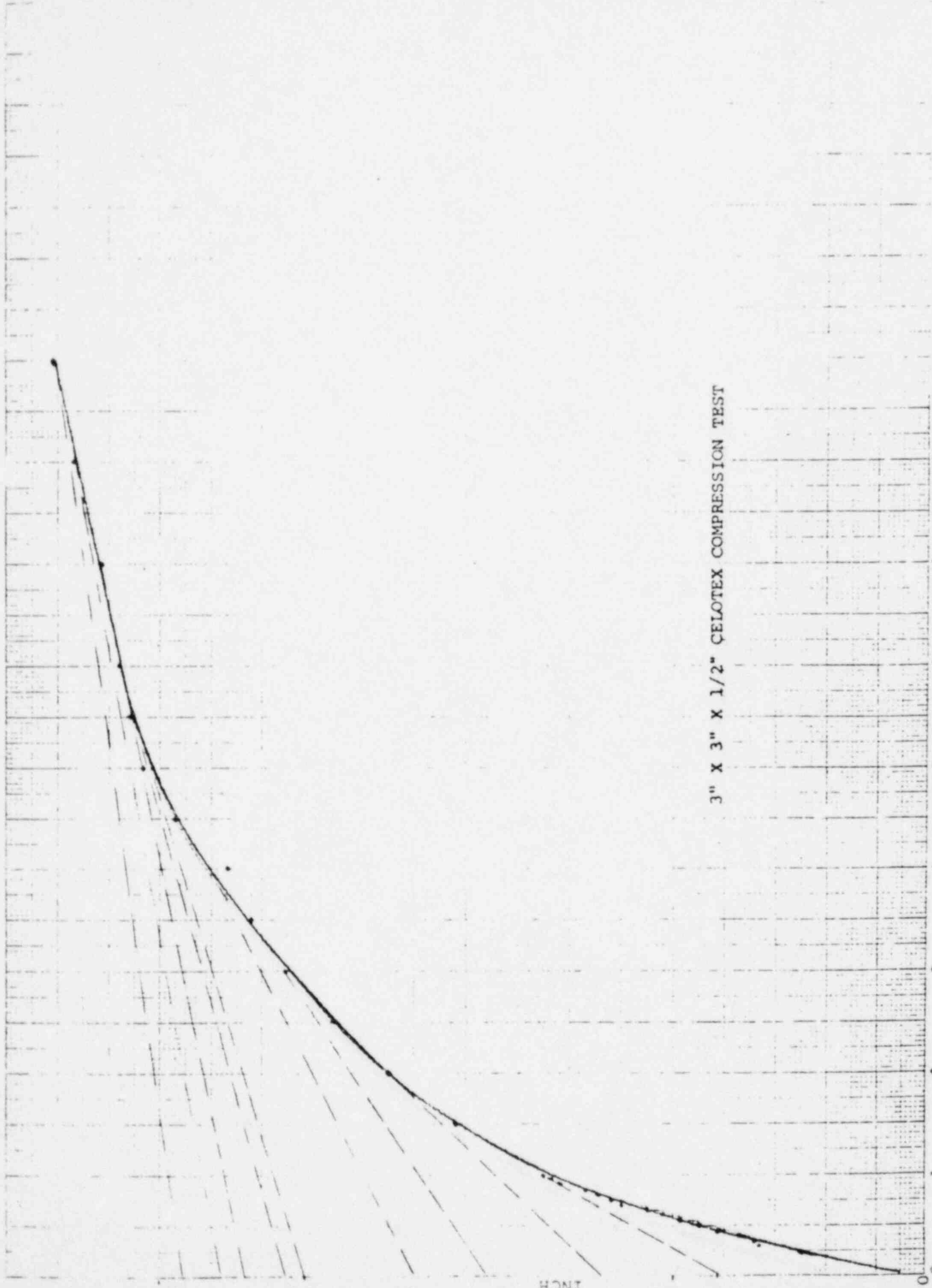
$\bar{k}$ = average spring rate of asphalt impregnated fiberboard over finite deflection range, lbs/in/unit width

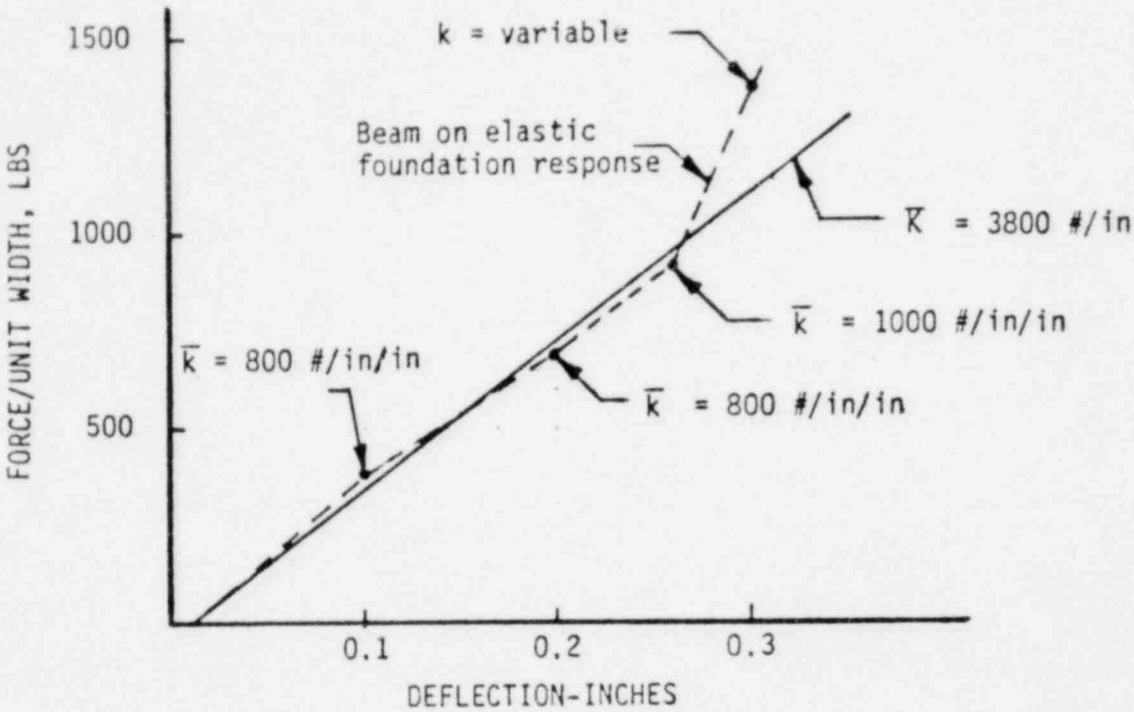
w = water force, lbs/in/unit width

P = Load into tank/unit width

$k\theta$ = Rotational stiffness of tank wall

FIGURE 4-1. BEAM-ON-ELASTIC-FOUNDATION MODEL

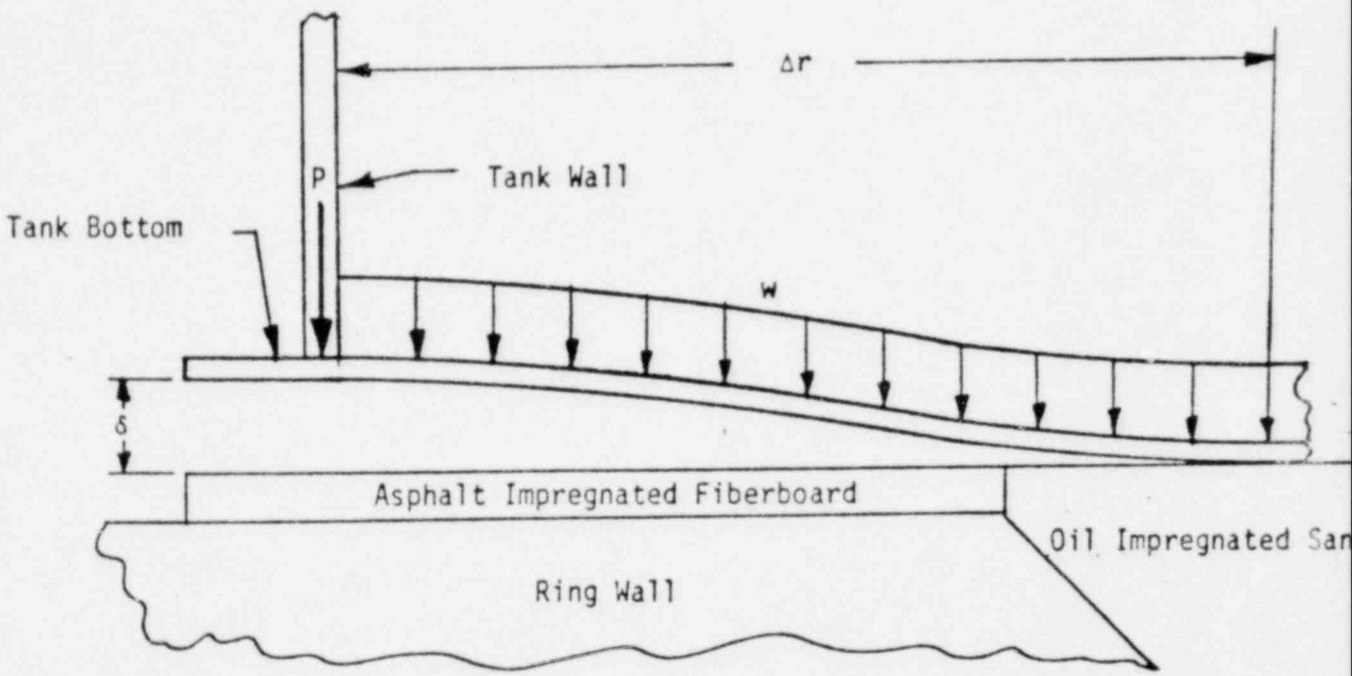

3" X 3" X 1/2" CELOTEX COMPRESSION TEST
DEFORMATION, INCH
0.3
0.2
0.1
0
1
2
3
4
5
6
7
8
9
10



$\overline{k}$ = Average spring rate at asphalt impregnated fiberboard over finite deflection range, lbs/in/in/unit width

$\overline{K}$ = Average spring rate of tank support, lbs/in/unit width

FIGURE 4-2. LINEARIZATION OF BOUNDARY SPRINGS



w = water force, lbs/in/unit width

P = tank and roof weight, lbs/unit width

δ = gap between tank bottom and asphalt impregnated fiberboard, in.

Δ_r = effective width of water annulus, in.

FIGURE 4-3. EFFECTIVE WATER ANNULUS

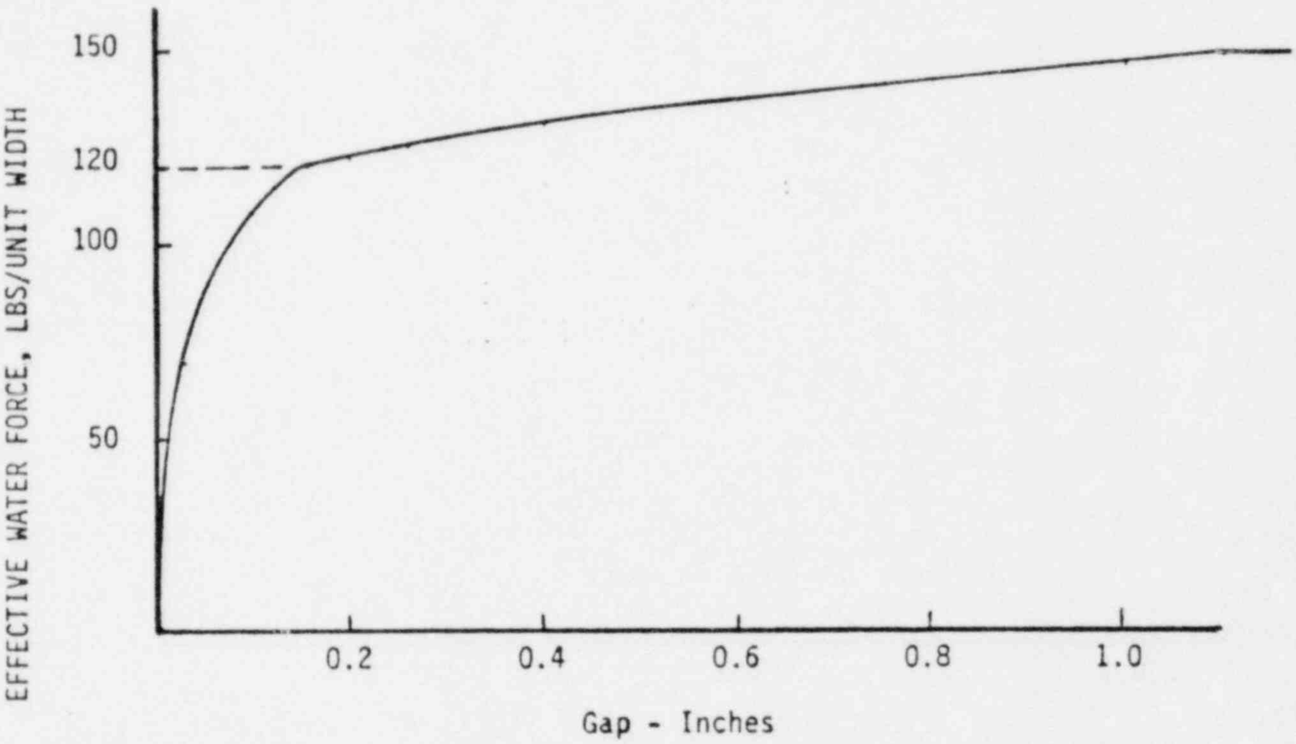


FIGURE 4-4. EFFECTIVE WATER FORCE/UNIT WIDTH OF CIRCUMFERENCE VS GAP

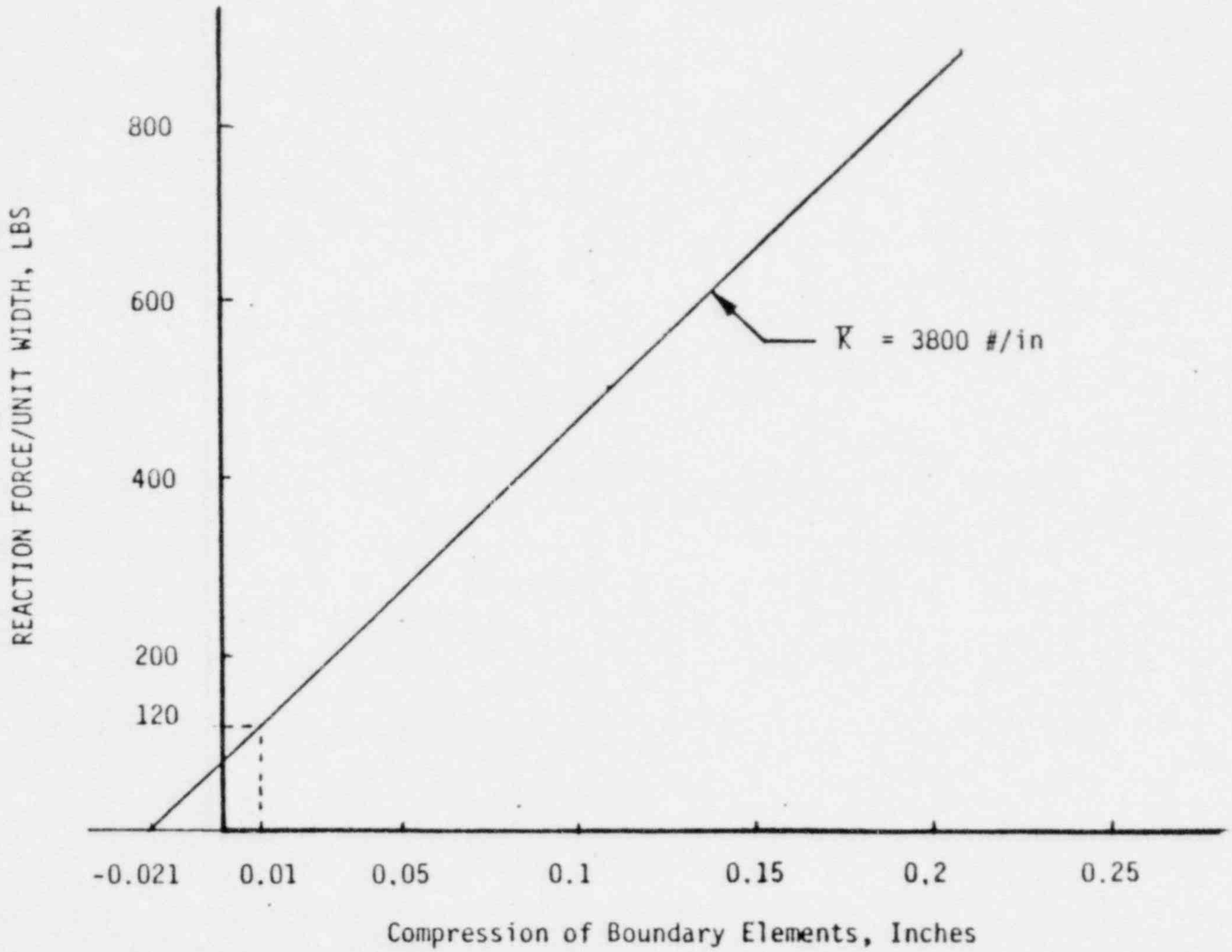
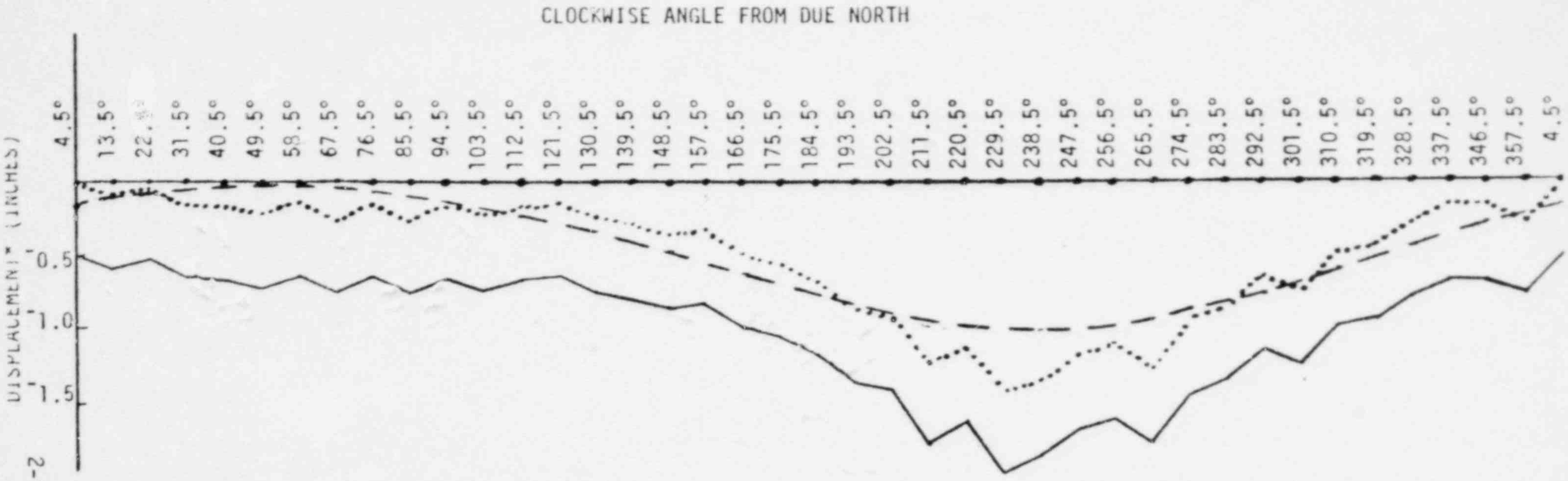


FIGURE 4-5. FORCE VS DEFLECTION AT BOUNDARY ELEMENTS



* DISPLACEMENT RELATIVE TO THE AS BUILT TOP OF THE CELOTEX IN THE UNLOADED CONDITION

——— RINGWALL CONTOUR AFTER GROUND SETTLEMENT

······ TOP OF CELOTEX CONTOUR IN THE UNLOADED CONDITION AFTER GROUND SETTLEMENT (UNLOADED CONDITION = 1/2 INCH ABOVE RING WALL CONTOUR)

– – – – TANK BOTTOM CONTOUR IN LOADED CONDITION AFTER GROUND SETTLEMENT

FIGURE 2-3. DISPLACEMENT OF TANK BOTTOM RELATIVE TO RINGWALL AND CELOTEX CONTOURS AFTER GROUND SETTLEMENT

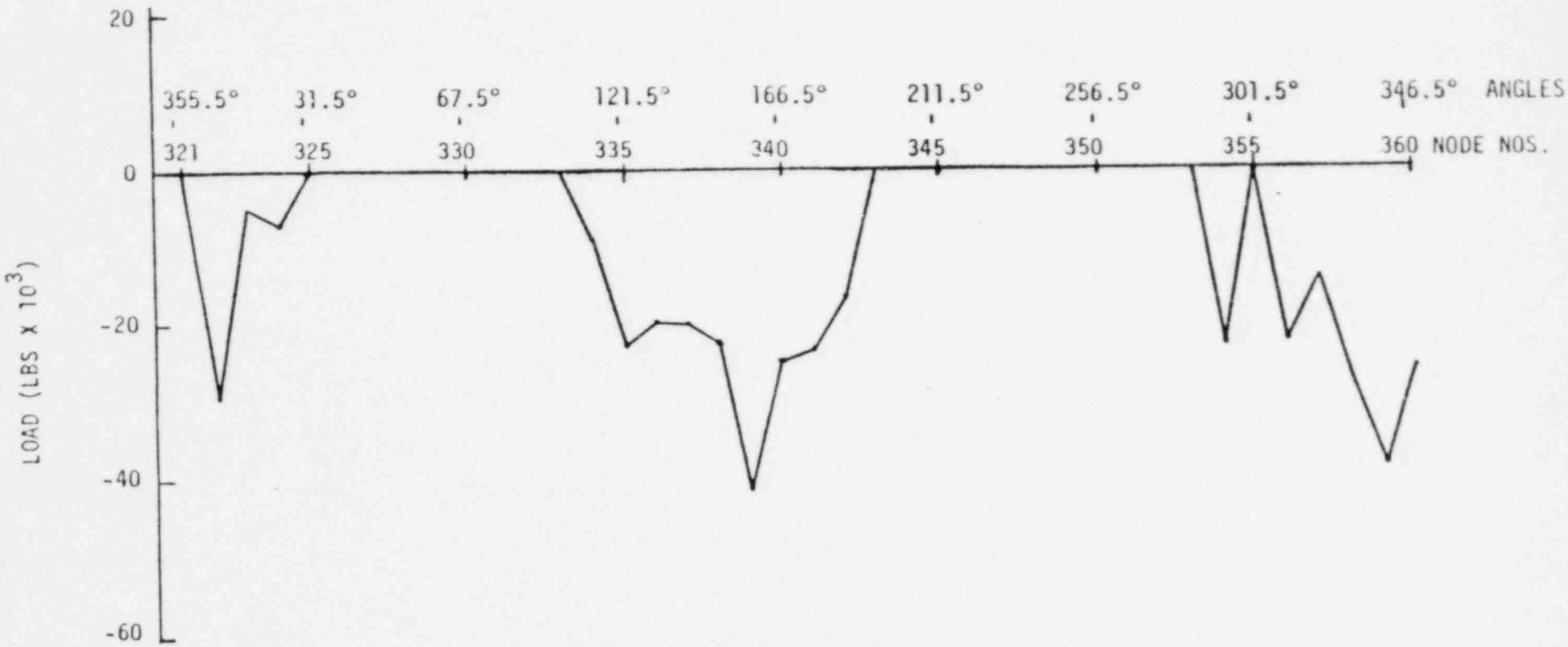


FIGURE 2-4. COMPRESSIVE LOADS AT TANK BOTTOM (SEE TABLE 5-3)

SHELL RESULTS

P_M IN SHELL = 12495 PSI ← Press. [illegible] = 10570

F.S. ON YIELD = 2.0

LOCATION - 8' ABOVE BASE IN 1/4" SHELL

MAX COMPRESSIVE STRESS = -1930 psi

F.S. ON BUCKLING = 2.46

LOCATION - 8' ABOVE BASE IN 1/4" SHELL

P_L IN SHELL AT BOLT CHAIR = 19590 PSI ← MAX. BOLT LOAD

F.S. ON YIELD = 1.28

P_L+P_b+Q IN SHELL AT BOLT CHAIR = 48.32 KSI ← [illegible]

F.S. ON SHAKEDOWN = 1.03

ANCHOR BOLT RESULTS

MAXIMUM BOLT STRESS (THREADS) = 22320 PSI

F.S. ON YIELD = 1.61

F.S. ON PULL OUT = 2.87

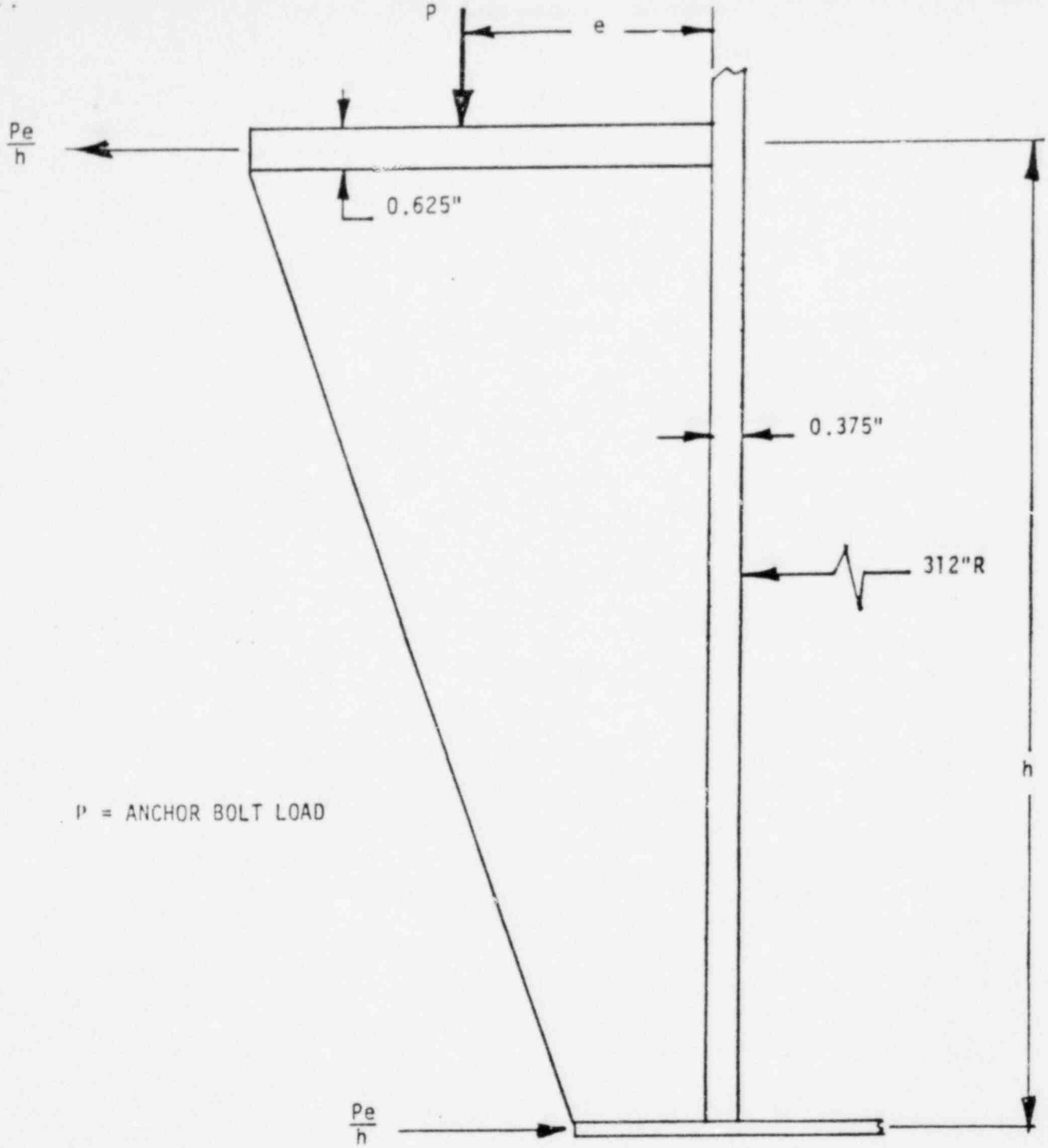


FIGURE 4-8. ANALYSIS MODEL FOR LOCAL MEMBRANE STRESSES IN SHELL DUE TO ANCHOR BOLT LOADING

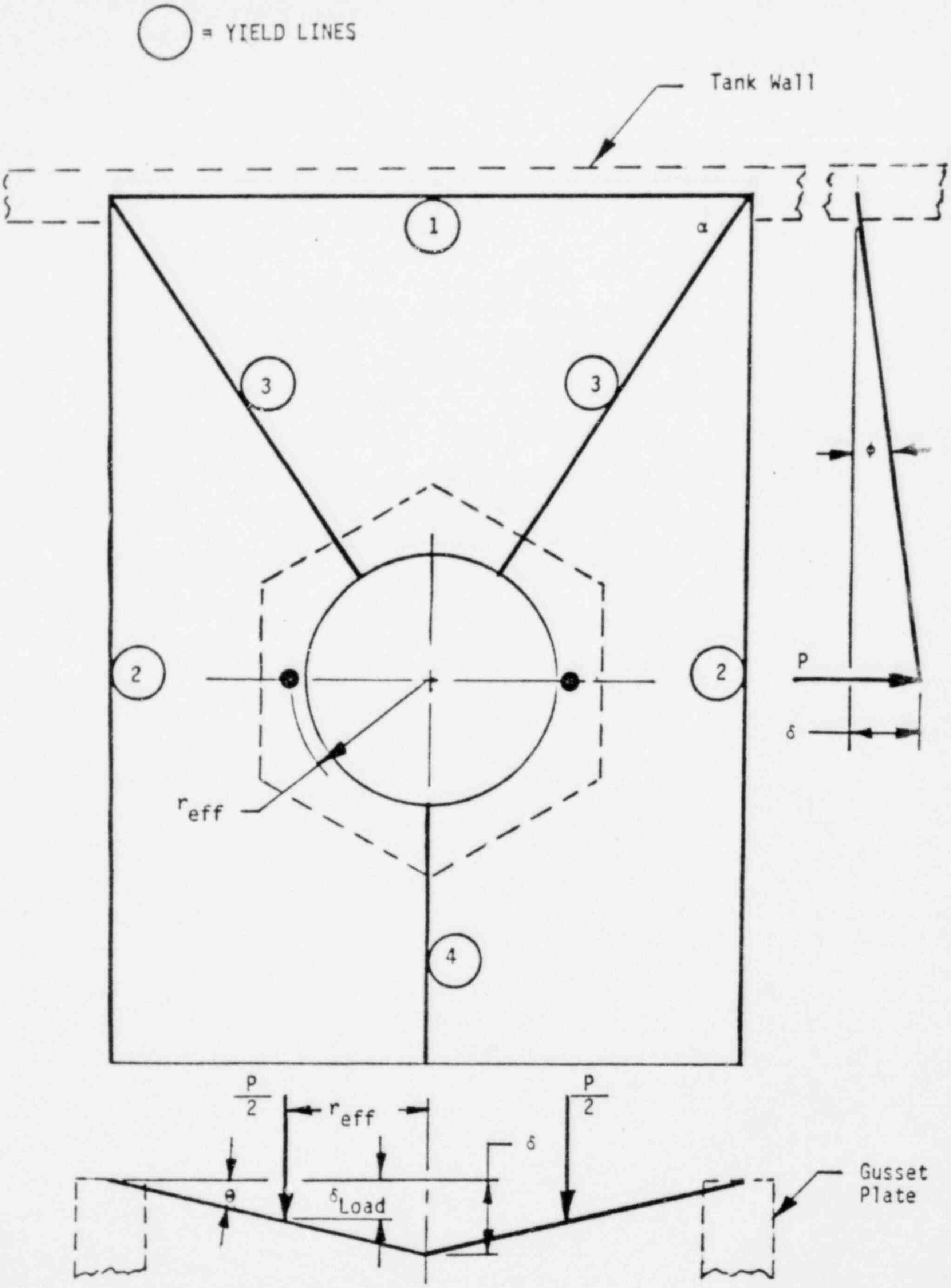


FIGURE 4-7. YIELD LINE MODEL FOR BOLT CHAIR

BOLT CHAIR RESULTS

LIMIT (YIELD LINE) ANALYSIS USED

MAX. BOLT LOAD (MEASURED) = 31.31 KIPS

ALL OTHER LOADS BELOW 22.5 KIPS

LOWER BOUND LIMIT LOAD = 39.95 KIPS

F.S. ON LOWER BOUND COLLAPSE = 1.28

CODE PHILOSOPHY WOULD ALLOW 0.8X
LOWER BOUND COLLAPSE LOAD FOR LEVEL C SERVICE (EMERGENCY COND).

CODE PHILOSOPHY SATISFIED

RECOMMEND DYE PENETRANT EXAMINATION OF BOLT CHAIR FILLET WELDS ON MAXIMUM LOADED BOLT

MEETING SUMMARY DISTRIBUTION

Docket File 50-329 OM, OL
330
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