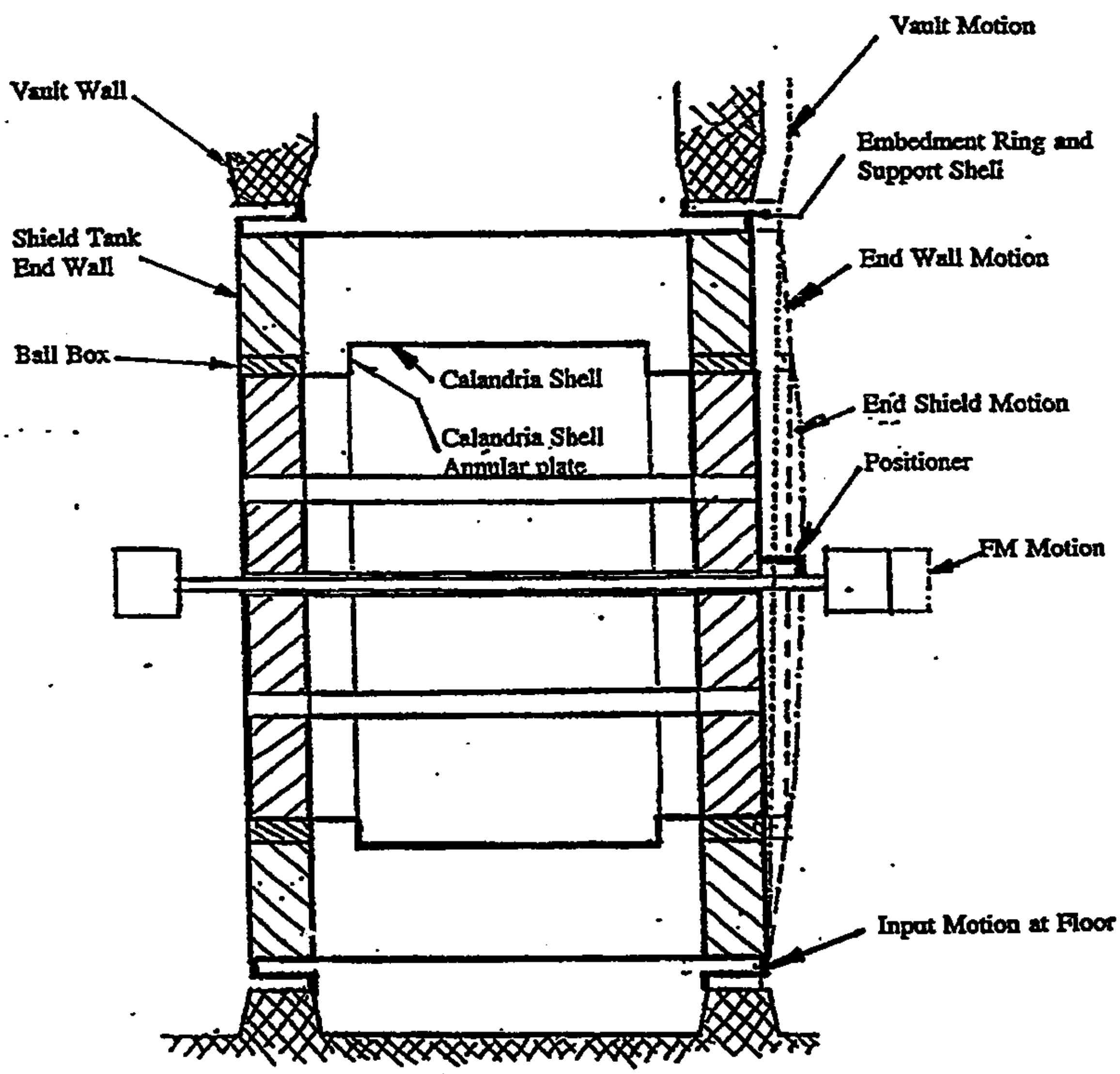


 Figure 3-1 Schematic of CANDU 9 Support System

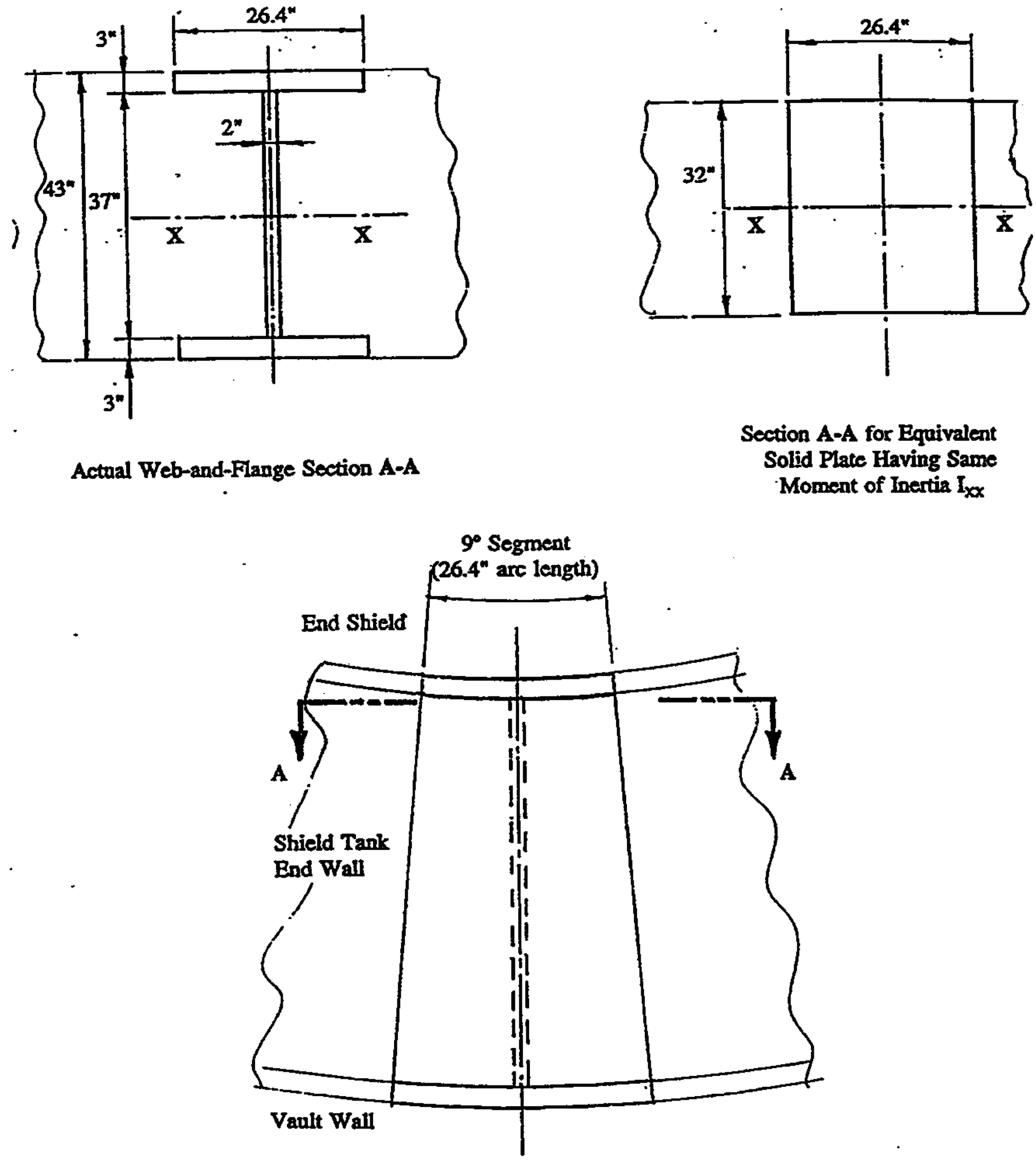


Figure 3-2 Section of Segment of Shield Tank End Wall used to Compare Edge Fixing Concepts

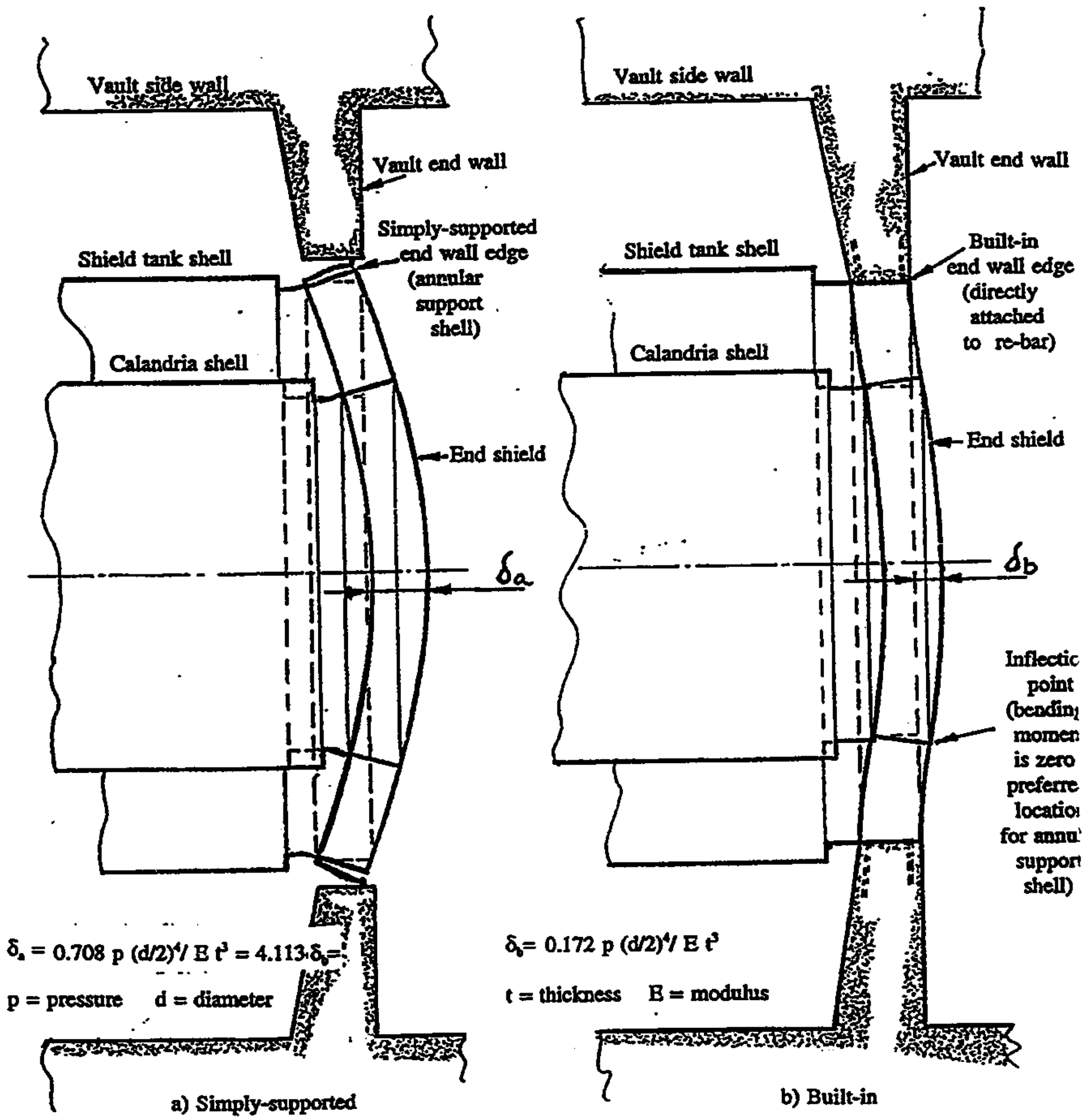


Figure 3-3 Comparison of Deflected Shapes and Magnitude for Simply-Supported and Built-In Flat Plates

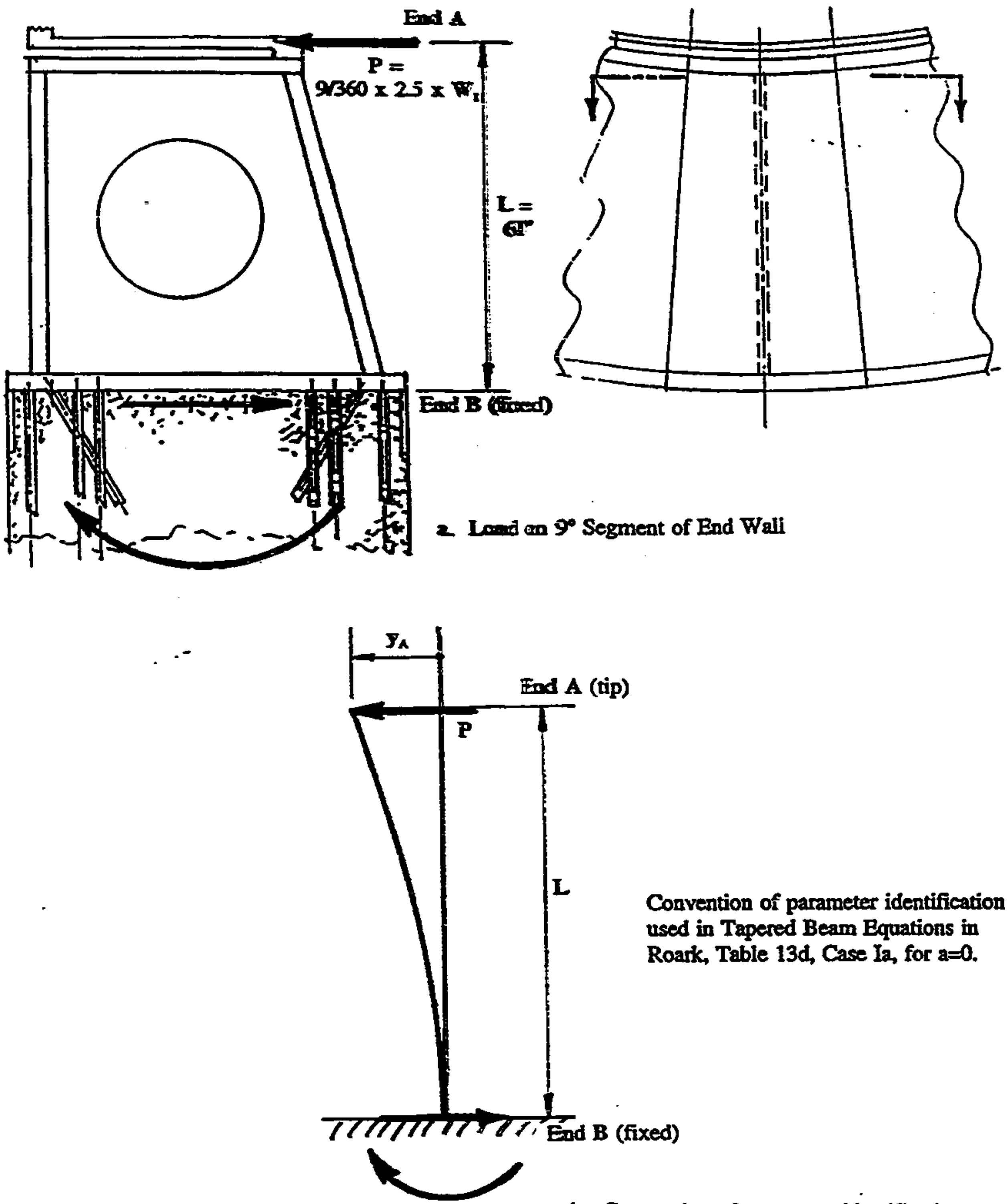


Figure 3-4 Deflections and Stiffness of Built-In End Wall Design

SUMMARY OF

DIFFERENCES IN DESIGN
- BY RULE
- BY ANALYSIS

- MATERIALS
- MANUFACTURING
- INSPECTION
- STRESS LIMITS

BY RULE - 3100	BY ANALYSIS - 3200
- BASED ON MAXIMUM STRESS VALUE	- BASED ON MAXIMUM STRESS INTENSITY
- S_A: HIGHER FACTOR OF SAFETY 5/8 Y.S. OR 1/4 UTS	- S_M: LOWER FACTOR OF SAFETY- MIN. OF 2/3 Y.S. OR 1/3 UTS
- SIMPLE ANALYSIS	- DETAILED ANALYSIS
- SIMPLE SERVICE CONDITIONS	- SEVERE OPERATING CONDITIONS
- LIMITED DESIGN CONFIGURATIONS	- NO LIMIT ON DESIGN CONFIGURATIONS

Figure 3-5 Allowable Stresses for Design-by-Rule & Design-by-Analysis Methods

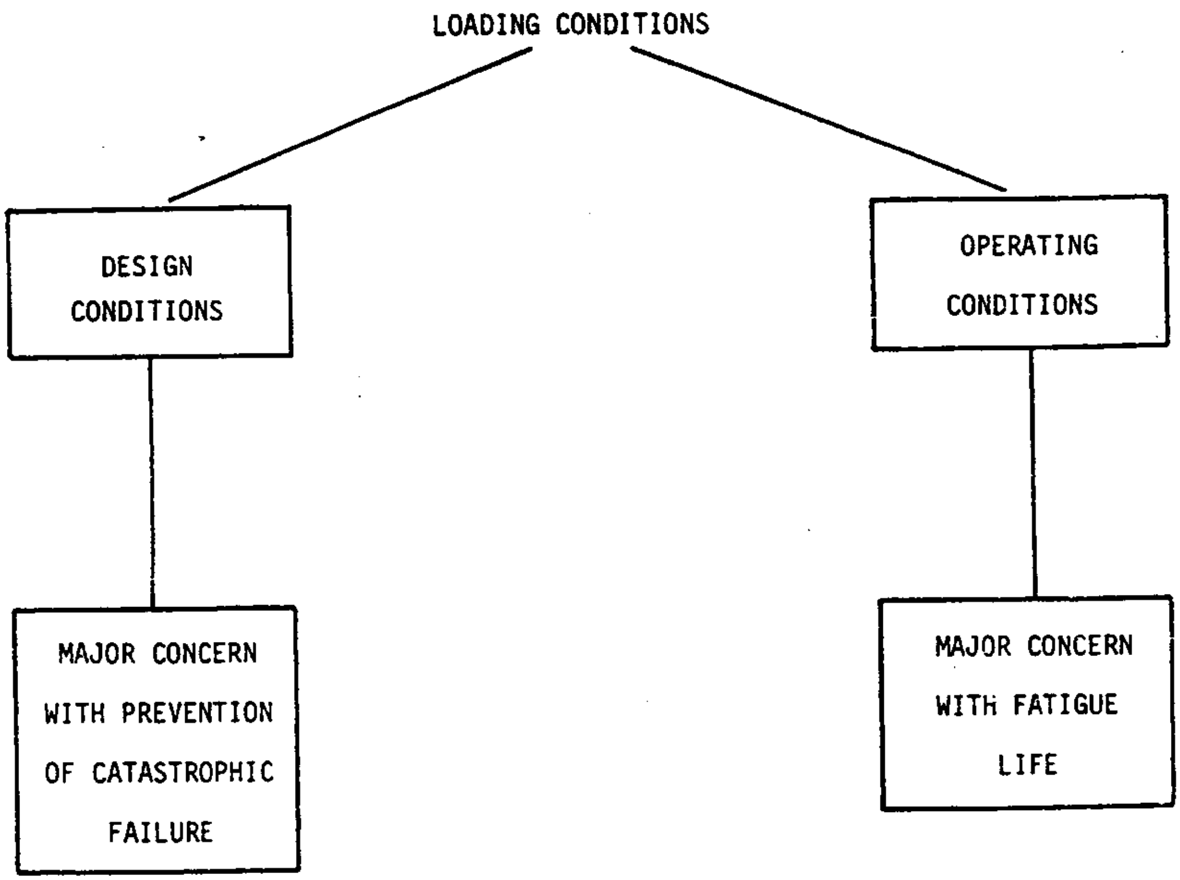


Figure 3-6 Two Main Categories of Loading Conditions

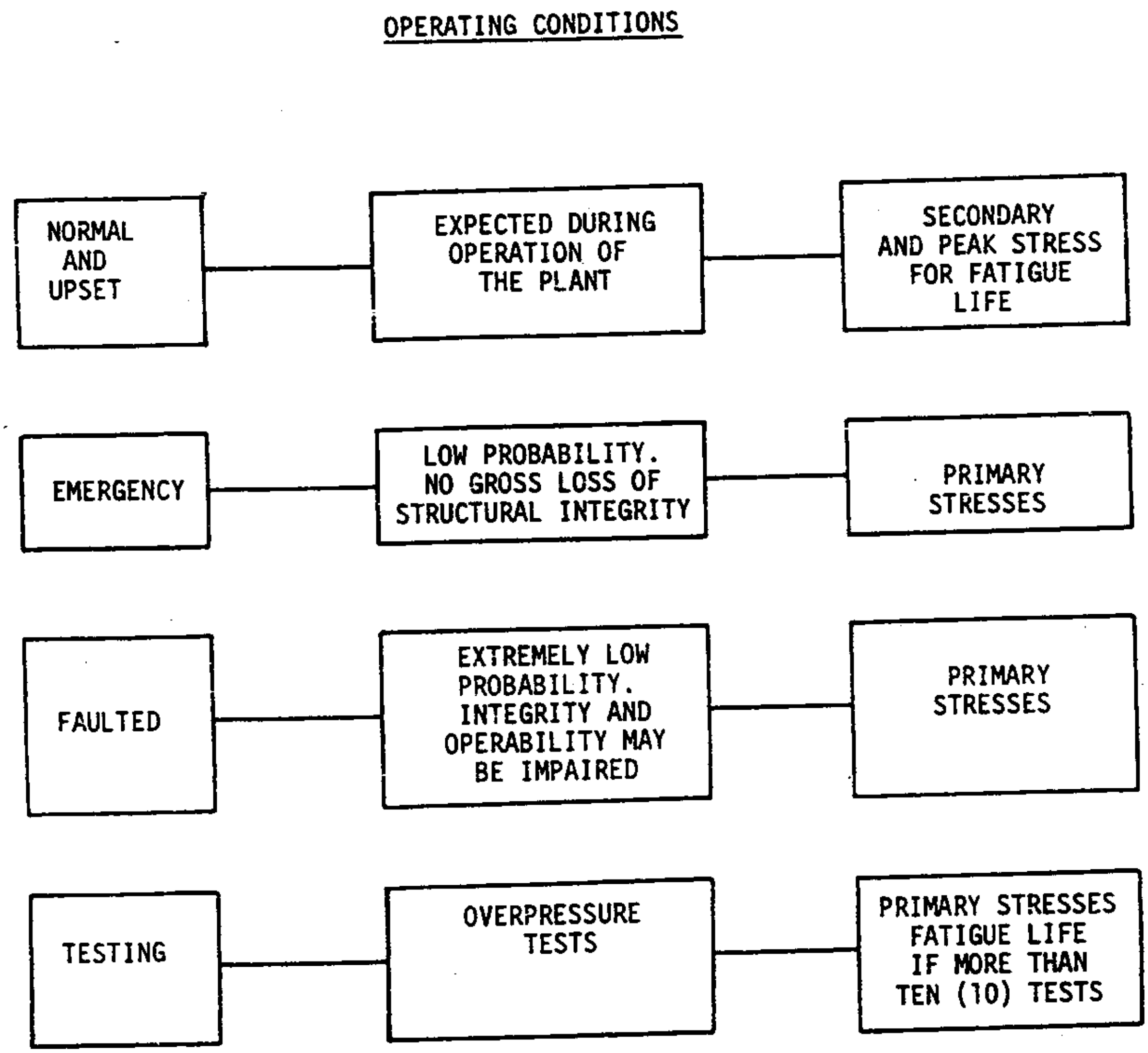


Figure 3-7 Operating Conditions

OPERATING OR SERVICE LEVELS

NORMAL OPERATION SERVICE LEVEL A AND B

SERVICE LEVEL 'A' AND 'B' LIMITS ARE PROVIDED TO EVALUATE COMPONENT STRESSES AND EFFECT OF SYSTEM OPERATING LOADS ON THE FATIGUE LIFE OF THE COMPONENT (FIGURE 6).

SERVICE LEVEL C OR EMERGENCY

THESE LEVELS ARE PROVIDED IN ORDER TO EVALUATE THE EFFECT OF PLANT OPERATING LOADS ON THE STRUCTURAL INTEGRITY OF A COMPONENT FOR SITUATIONS WHICH ARE NOT ANTICIPATED TO OCCUR FOR A SUFFICIENT NUMBER OF TIMES TO AFFECT THE FATIGUE LIFE AND FOR WHICH LARGE DEFORMATIONS IN THE AREA OF DISCONTINUITIES ARE NOT OBJECTIONABLE. UNDER THIS CONDITION REACTOR IS SHUT DOWN AND THE VARIOUS COMPONENTS ARE INSPECTED FOR DAMAGE AND THE COMPONENTS MAY BE REMOVED FOR REPAIRS

SERVICE LEVEL D OR FAULTED CONDITION

THIS LIMIT IS PROVIDED IN ORDER TO EVALUATE THE EFFECT OF PLANT OPERATING LOADS ON THE STRUCTURAL INTEGRITY OF A COMPONENT FOR SITUATIONS IN WHICH GROSS GENERAL DEFORMATIONS, LOSS OF DIMENSIONAL STABILITY AND DAMAGE REQUIRING REPAIR, EXCLUDING LOSS OF PRESSURE RETAINING FUNCTION ARE NOT OBJECTIONABLE.

REQUIRES SAFE SHUTDOWN.REACTOR AND COMPONENTS MAY BE A WRITE OFF.

DESIGN AND TEST LOADS

SPECIAL LIMITS APPLY TO DESIGN AND TEST LOADS. BUT ONE CAN CONSERVATIVELY CHOOSE TO APPLY SERVICE LEVEL 'A' LIMITS FOR THE DESIGN AND TEST LOADS.

 Figure 3-8 Definition of Service Level Categories

SUMMARY OF OPERATING CONDITIONS IN OLD AND NEW CODE

PRE 1974 CODE LOADING CONDITION	POST 1974 CODE SERVICE LEVEL
DESIGN CONDITION	CONSERVATIVELY WE CHOOSE TO APPLY LEVEL A
NORMAL OPERATION	LEVEL A OR LEVEL B
UPSET CONDITIONS	LEVEL B
EMERGENCY CONDITION	LEVEL C
FAULTED CONDITION	LEVEL D
TEST CONDITIONS	CONSERVATIVELY WE CHOOSE TO APPLY LEVEL A

Figure 3-9 Service Level Category Definitions before and after 1974

Stress Category	Primary		
	General Membrane	Local Membrane	Bending
Description (For examples, see Table NB-3217-1)	Average primary stress across solid section. Excludes discontinuities and concentrations. Produced only by mechanical loads.	Average stress across any solid section. Considers discontinuities but not concentrations. Produced only by mechanical loads.	Component of primary stress proportional to distance from centroid of solid section. Excludes discontinuities and concentrations. Produced only by mechanical loads.
Symbol	P_m	P_L	P_b

Combination of stress Components and Allowable Limits of Stress Intensities.

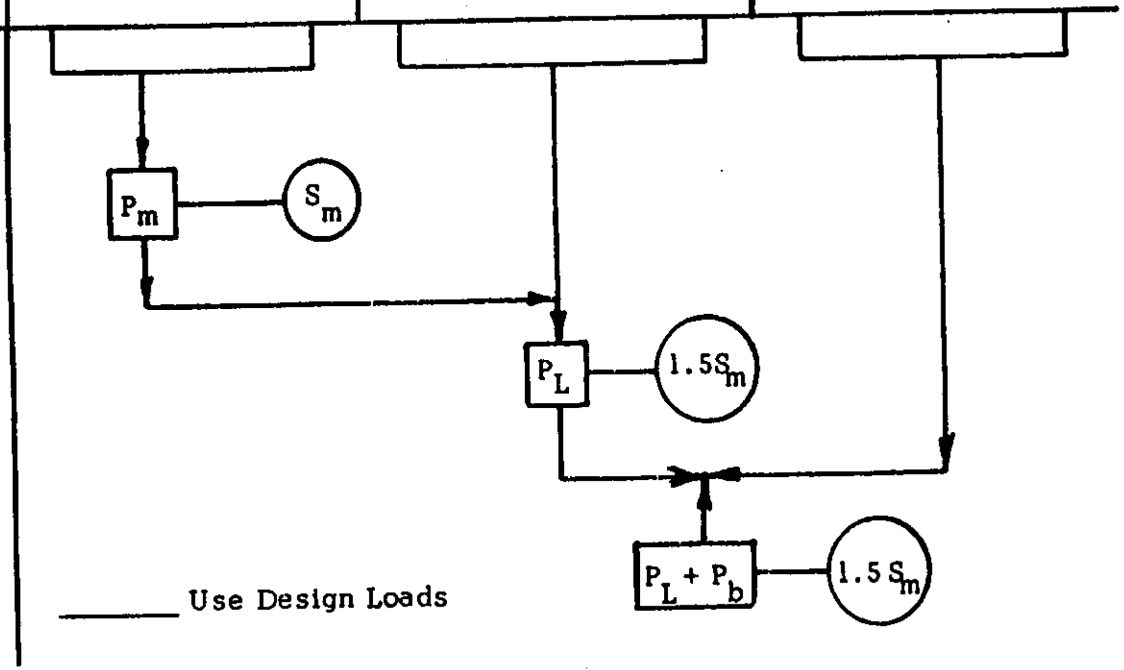


Figure 3-10 Allowable Stress Intensities for Design Condition

Stress Category	Primary			Secondary		
	General Membrane	Local Membrane	Bending	Expansion	Membrane Plus Bending	Peak
Description (for examples see Table NB-3217-2)	Average primary stress across solid section. Excludes effects of discontinuities and concentrations. Produced by pressure and mechanical loads.	Average stress across any solid section. Considers effects of discontinuities but not concentrations. Produced by pressure and mechanical loads, including inertia earthquake effects.	Component of primary stress proportional to distance from centroid of solid section. Excludes effects of discontinuities and concentrations. Produced by pressure and mechanical loads, including inertia earthquake effects.	Stresses which result from the constraint of "free end displacement" and the effect of anchor point motions resulting from earthquakes. Considers effects of discontinuities but not local stress concentration, (not applicable to vessels)	Self-equilibrating stress necessary to satisfy continuity of structure. Occurs at structural discontinuities. Can be caused by pressure, mechanical loads, or by differential thermal expansion. Excludes local stress concentrations.	(1) Increment added to primary or secondary stress by a concentration (notch). (2) Certain thermal stresses which may cause fatigue but not distortion.
Symbol	P_m	P_L	P_b	P_e	Q	F
Combination of stress components and allowable limits of stress intensities						

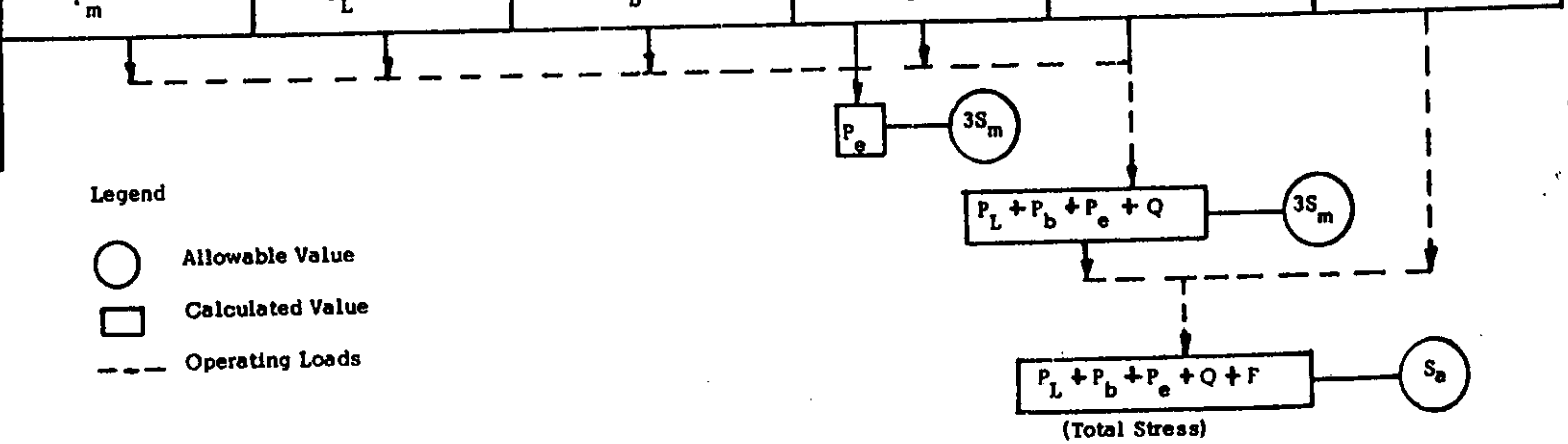
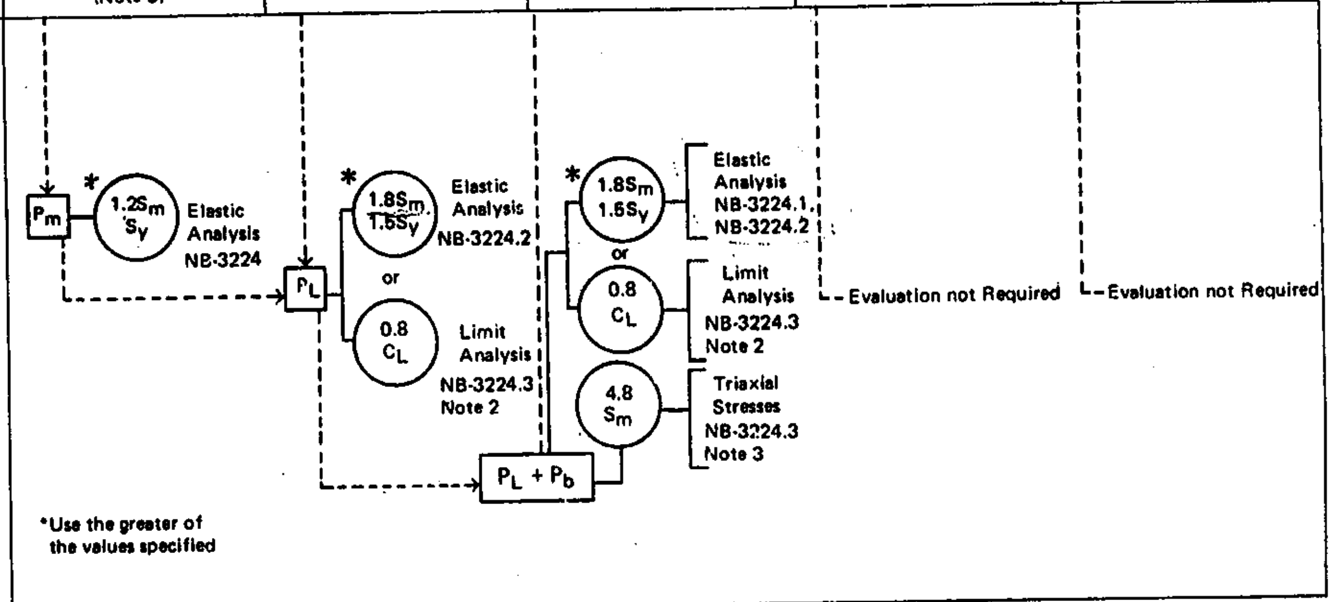


Figure 3-11 Allowable Stress Intensities for Normal & Upset Operating Conditions

Stress Category	Primary Stresses (Notes 1 & 4): General Membrane	Primary Stresses (Notes 1 & 4): Local Membrane	Primary Stresses (Notes 1 & 4): Bending	Secondary Stresses (Note 1): Membrane & Bending	Peak Stresses (Note 1)
Description (For examples see Table NB-3217-1)	Average primary stress across solid section. Excludes discontinuities and concentrations. Produced only by mechanical loads.	Average stress across any solid section. Considers discontinuities but not concentrations. Produced only by mechanical loads.	Component of primary stress proportional to distance from centroid of solid section. Excludes discontinuities and concentrations. Produced only by mechanical loads.	Self-equilibrating stress necessary to satisfy continuity of structure. Occurs at structural discontinuities. Can be caused by mechanical load or by differential thermal expansion. Excludes local stress concentration.	(1) Increment added to primary or secondary stress by a concentration (Notch) (2) Certain thermal stresses which may cause fatigue but not distortion of vessel shape.
Symbol (Note 1)	P_m NB-3213.6 & .8 (Note 5)	P_L NB-3213.10	P_b NB-3213.7 & .8	Q NB-3213.9	F NB-3213.11

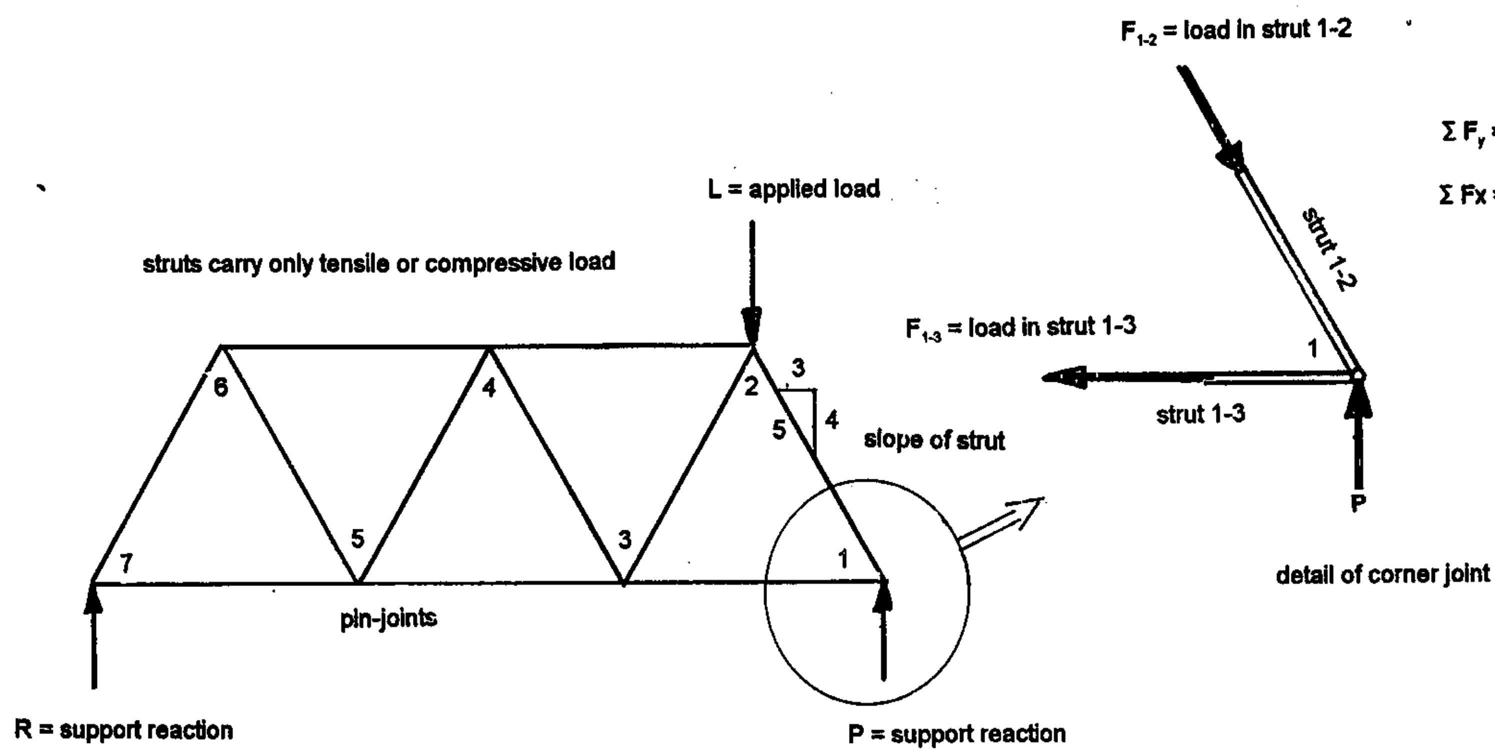
Combination of Stress Components and Allowable Limits of Stress Intensities — For Level C Service Limits



NOTES:

1. The symbols P_m, P_L, P_b, Q, and F do not represent single quantitites, but rather sets of six quantities representing the six stress components σ_t, σ_l, σ_r, τ_{lt}, τ_{lr}, and τ_{rt}.
2. C_L the collapse load calculated on the basis of the lower bound theorem of limit analysis and yield strength values specified in Table I-2.1 or I-2.2 (NB-3213.22).
3. The triaxial stresses represent the algebraic sum of the three primary principal stresses ($\sigma_1 + \sigma_2 + \sigma_3$) for the combination of stress components.
4. For configurations where compressive stresses occur, the stress limits shall be revised to take into account critical buckling stresses (NB-3211(c)).
5. The limits shown are for stresses resulting from pressure in combination with other mechanical loads. For ferritic materials, the P_m elastic analysis limits for pressure loadings alone shall be equal to the greater of $1.1S_m$ or $0.9S_y$. For the P_L and P_b limits, a factor of 1.5 shall be applied to the P_m limits.

Figure 3-12 Allowable Stress Intensities for Level C Conditions



Solution:

$\Sigma F_y = 0$: $4/5 \times F_{1-2} = P$

$\Sigma Fx = 0$: $3/5 \times F_{1-2} = F_{1-3}$

Figure 3-13 Simple Pin-Jointed Truss

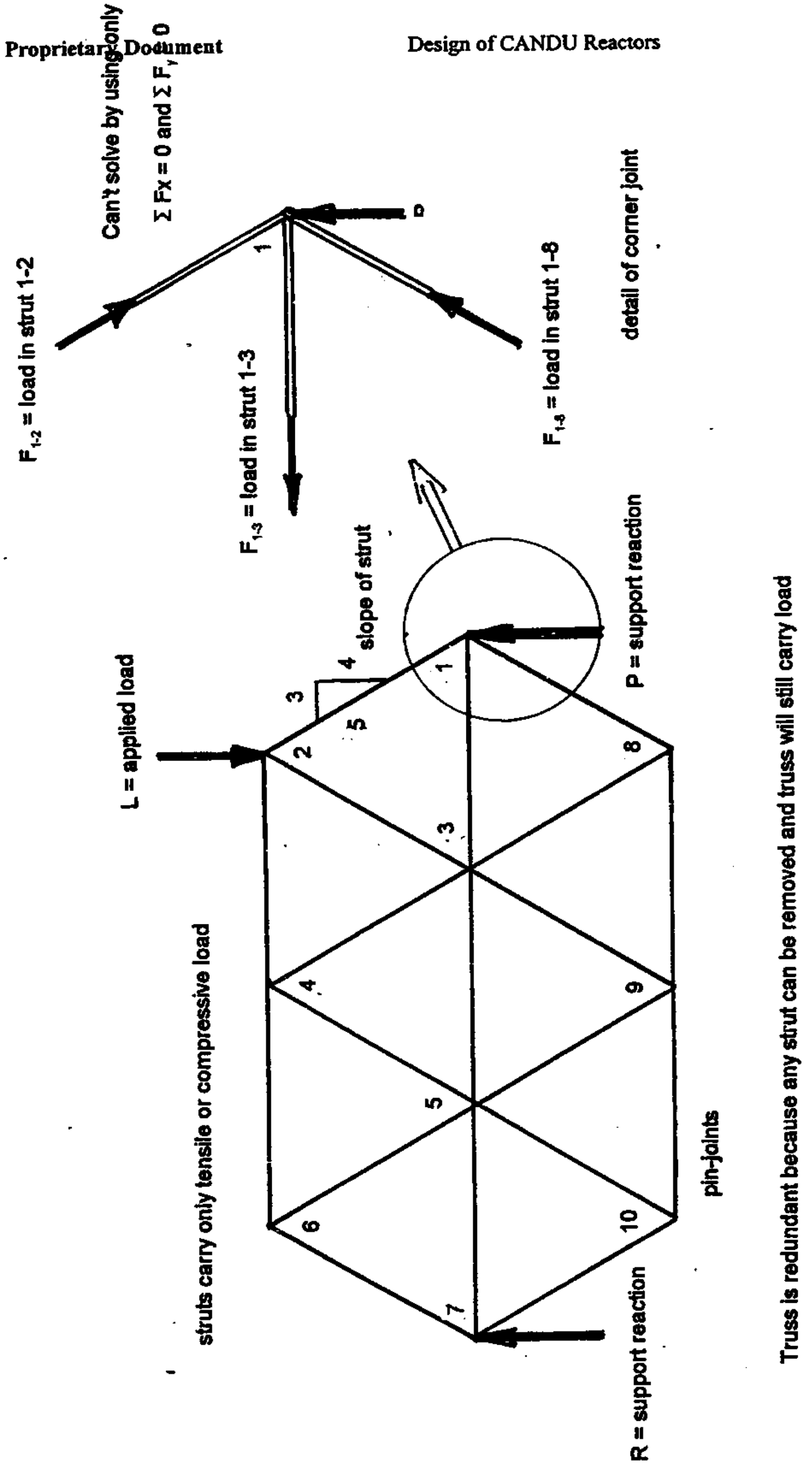


Figure 3-14 Redundant Pin-Jointed Truss

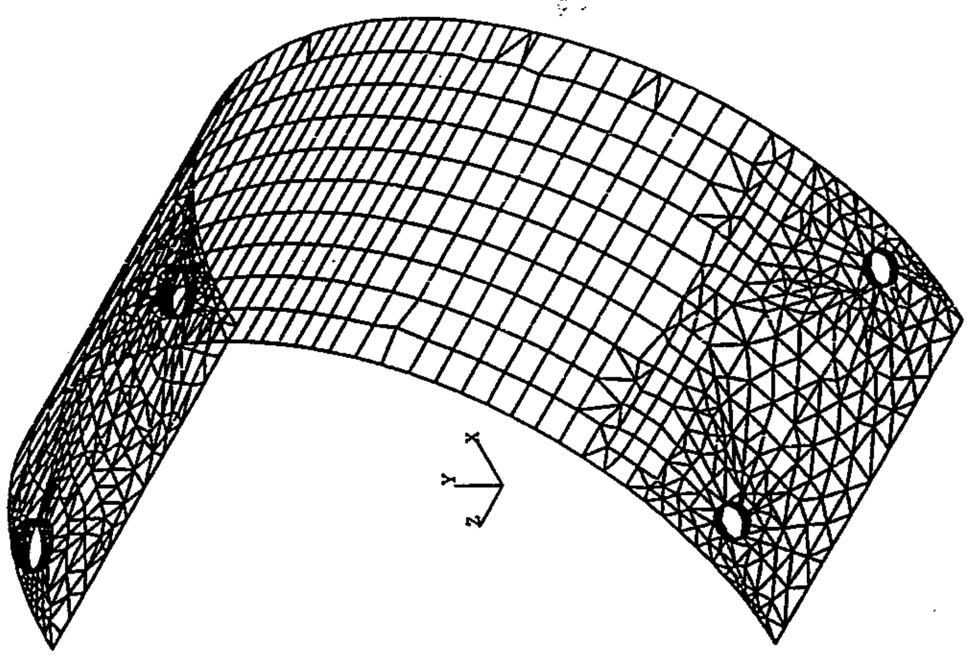


Figure 3-15 Finite Element Model for a CANDU Reactor Calandria Shell

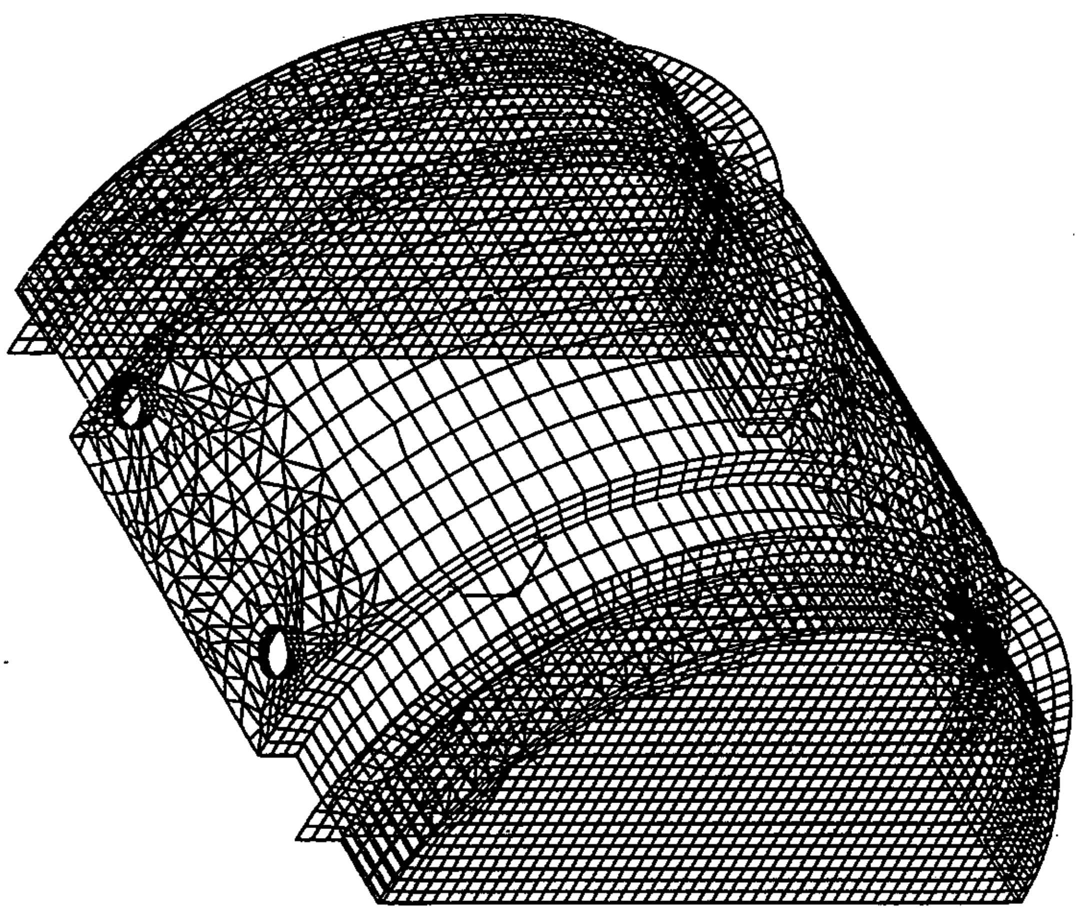


Figure 3-16 Finite Element Model for a CANDU Reactor Structure

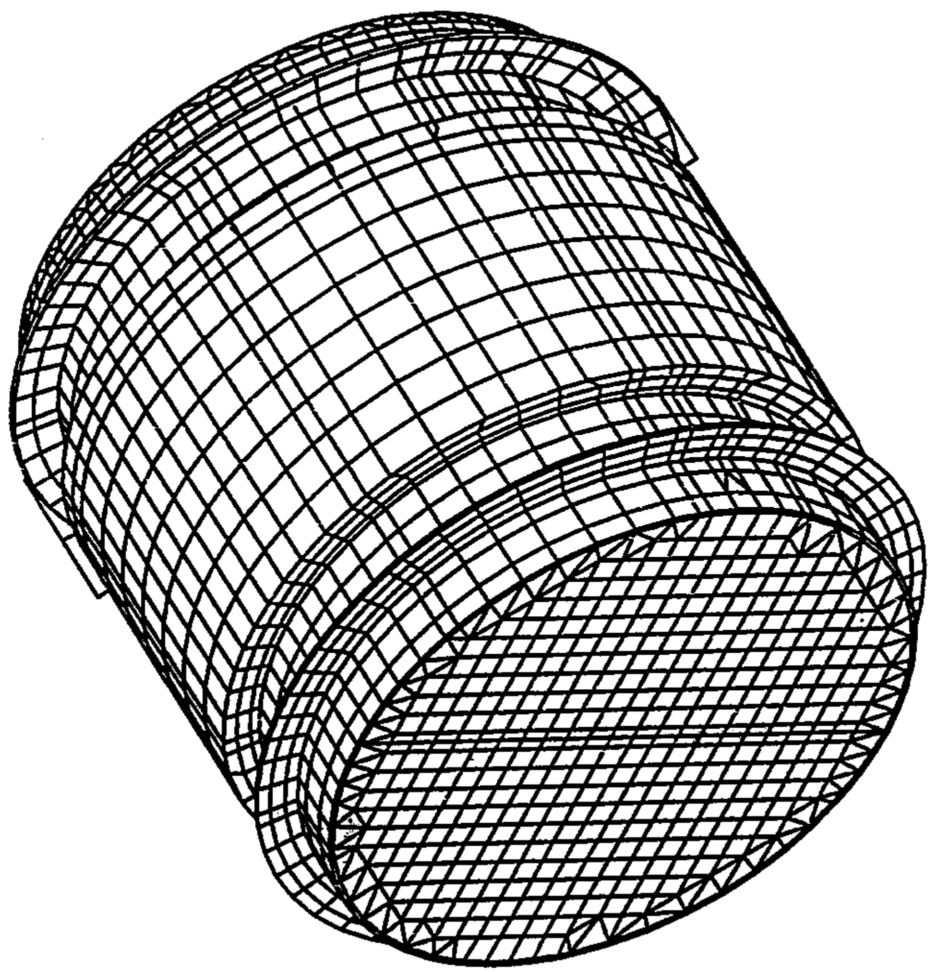


Figure 3-17 Seismic Finite Element Model for a CANDU Calandria Structure Assembly

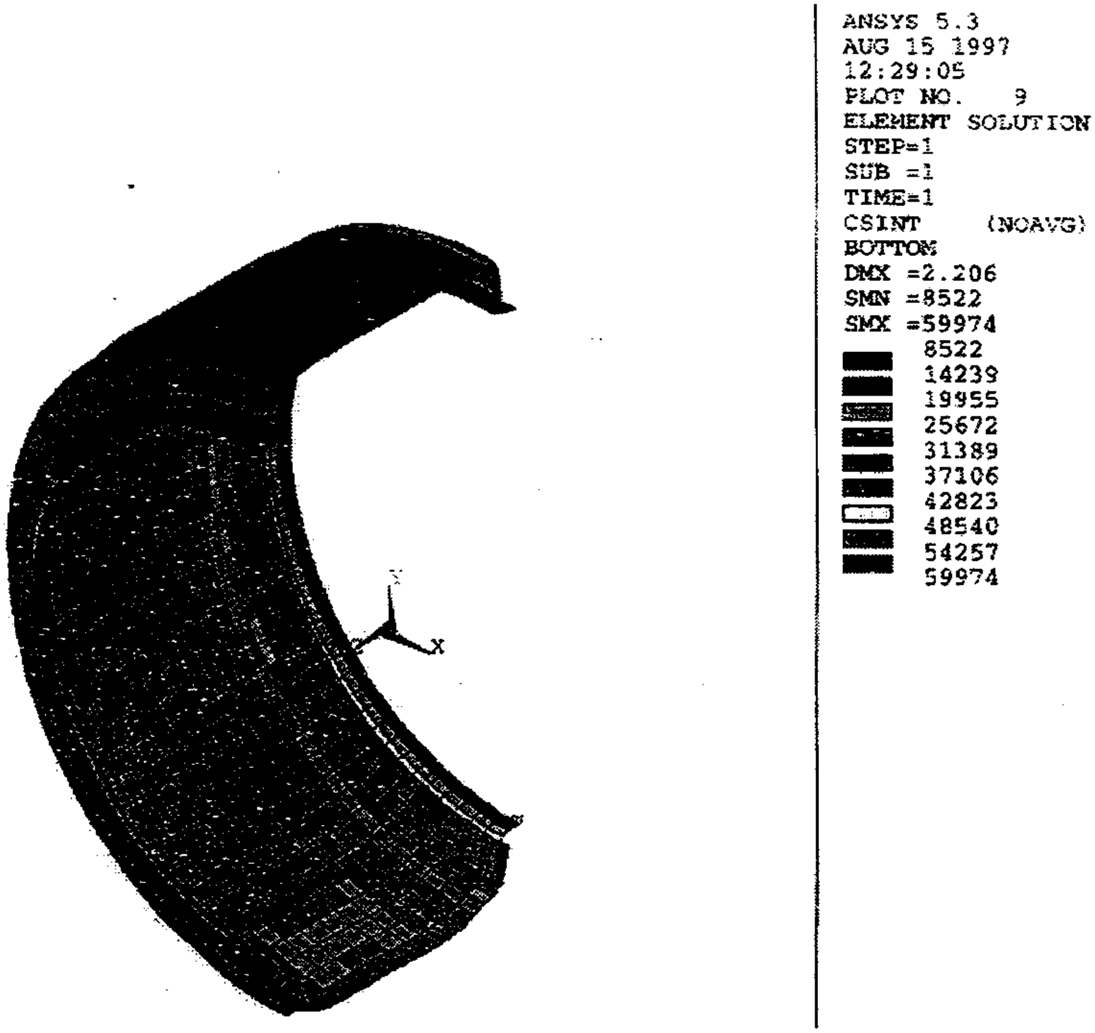


Figure 3-18 Graphical Display of Stresses for a CANDU Reactor Structure

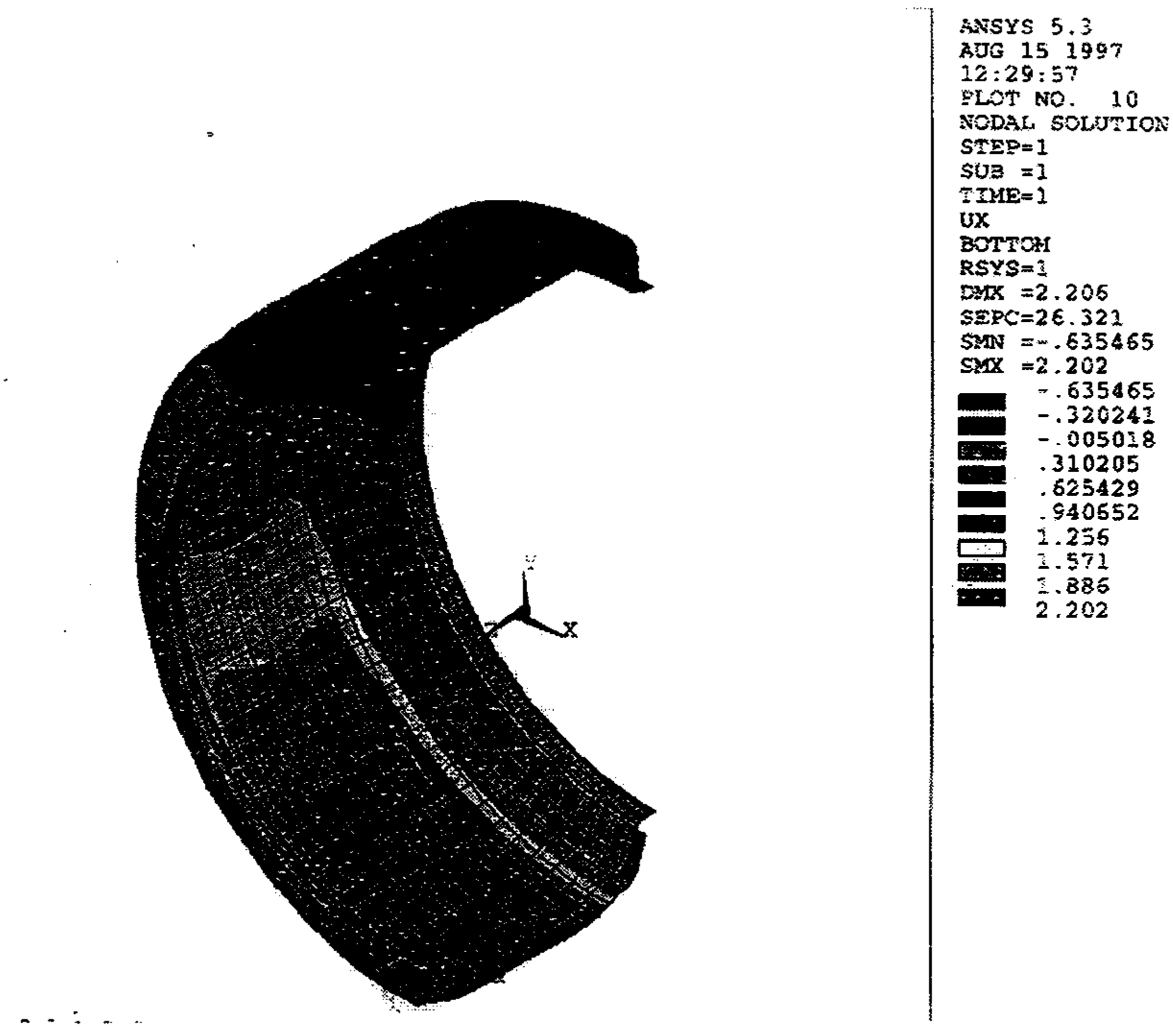


Figure 3-19 Graphical Display of Deflections for a CANDU Reactor Structure