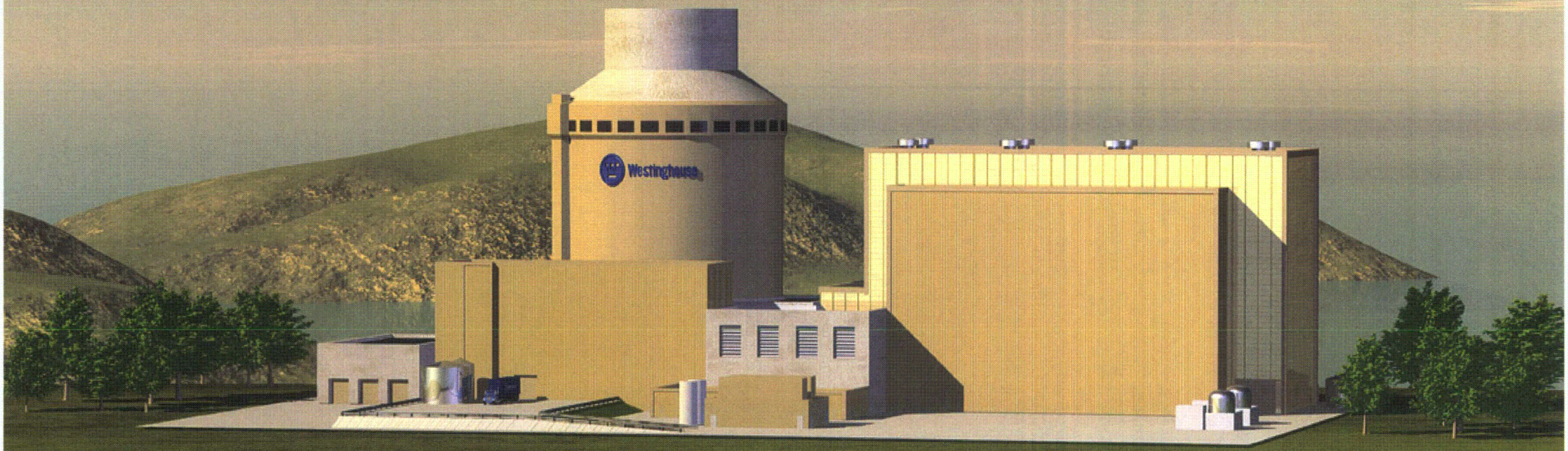
ENCLOSURE 4

Presentation Slides "AP1000 Shield Building Design," Meeting with NRC Staff, April 12, 2011

(Non-Proprietary)

AP1000 Shield Building Design



Thermal + SSE

Rockville, Md

April 12, 2011

Problem Statement

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- Westinghouse design analysis of the shield building did not [ ]a,c
  - Westinghouse followed our Design Guidance Methodology which establishes when the designer [ ]a,c
  - Table 3.2-7 in Shield Building report implies an [ ]a,c
- NRC is requesting
  - Justification of the Westinghouse approach to [ ]a,c
  - Clarification of the table

Topics to be Covered Today

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- Introduction
- Shield Building Design
- [ ]a,c
- Out-of-Plane Shear
- Table 3.2-7
- Summary and Conclusion

Shield Building Design

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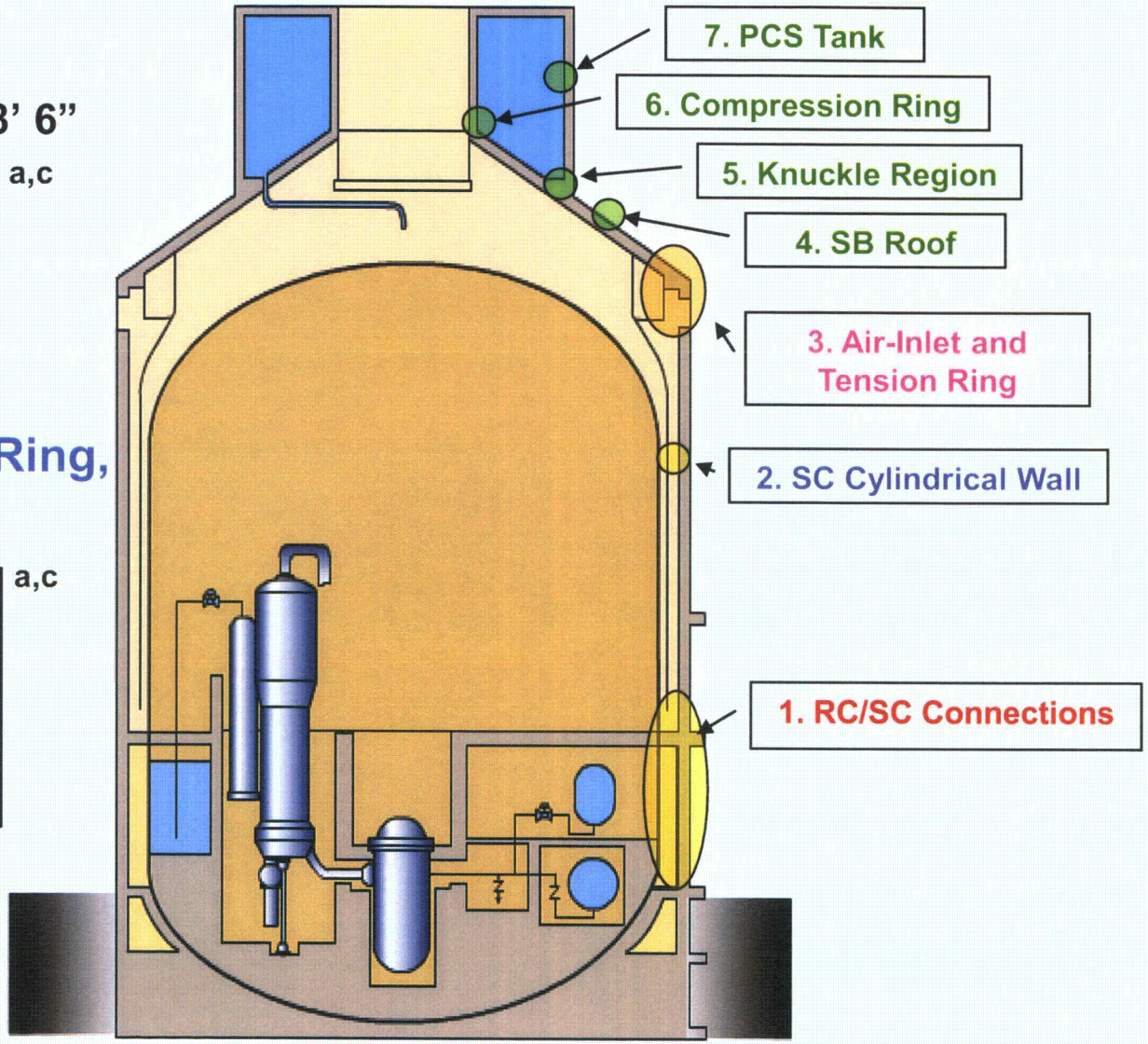
1, 2 RC/SC Connections

SC Cylindrical Wall–Up to Elev 248' 6"

[ ] a,c

3, 4,5,6 &7 Air Inlet & Tension Ring, Roof, etc.

[ ] a,c



Westinghouse

Ambient conditions

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- [ ]a,c
  - Minimum safety air temperature of -40°F
  - Minimum normal air temperature -10°F represents [ ]a,c exceedance value (air temperature exceeds -10°F [ ]a,c
  - [ ]a,c
  - DCD subsection 3.9.3.1.1 states: "The safe shutdown earthquake is analyzed in combination with those operating modes that occur more than 10 percent of the time."
- Minimum safety air temperature of -40°F results in temperature difference across external walls of 110°F.
- [ ]a,c

ACI 349-01

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- RA.1.2 The procedures discussed in Appendix A and this commentary are valid for all of the temperature conditions described above. The designer, however, should consider the following when using these procedures:
  1. Linear thermal strain causes stress only under conditions of restraint and a portion of such stress may be self-relieving. Mechanisms for such relief are: cracking, yielding, relaxation, creep, and other time-dependent deformations;

Design of Concrete Structures for Thermal

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- Mechanical loads are primary, thermal loads are secondary
- Reinforcement is required to control cracking under ambient and operating thermal conditions
- Strength is required to resist primary loads under SSE
- AISC N690-94 (paragraph Q1.5.7.2) does not require the evaluation of secondary stresses with SSE provided that the resultant deformations do not exceed specified ductility limits.
- [ ]a,c
  - [ ]a,c
  - [ ]a,c

Effect of thermal membrane forces on SSE overturning strength

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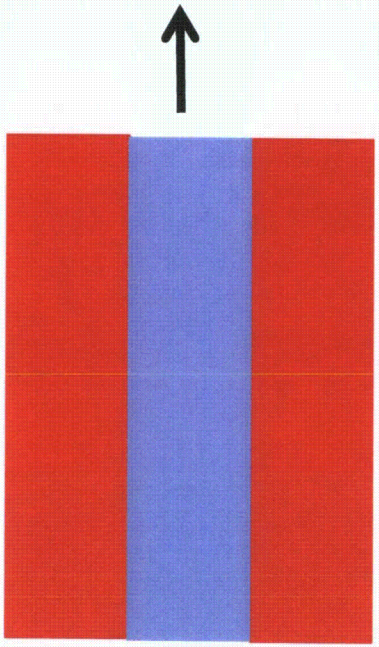
- For average temperature reduction of 50°F thermal strain = [ ]a,c
- If blue zone is cold relative to red zone, there will be axial tension in the blue zone and compression in the red zone.
- If both zones are subject to axial tension force due to seismic overturning, both zones will crack. The cold zone will have additional strain of [ ]a,c in the reinforcement.
- As load is increased reinforcement in cold zone reaches yield first, but total strength [ ]a,c
- [ ]a,c



Rollout of SB

a,c

Thermal Gradient

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- Out-of-plane bending and shear
- Thermal member forces reduced by factor of [

]a,c

[ ]a,c

Mid Surface Thermal

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- Membrane forces, TX, TY, TXY
- Thermal member forces reduced by factor of [ ]a,c

[ ]a,c

Effect of Cracking on Axial Stiffness

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a,c

Fig. 4.2 – Tensile load versus strain diagrams based on CEB and effective cross-sectional area expressions

Thermal + SSE

AP1000

a,c

Thermal + SSE

AP1000

a,c

Thermal + SSE

AP1000

a,c

Westinghouse

Conclusion

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- Review of effect of cracking and yield leads WEC to consider [ ]a,c
- [ ]a,c Assessment confirms WEC approach in Shield Building Wall

Shield Building
Out of Plane Shear Summary

Shield Building Rollout

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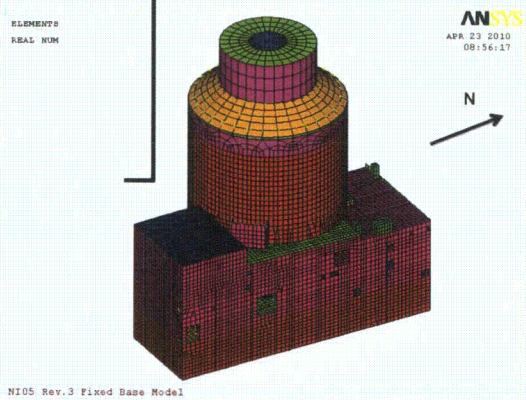
a,c

Annulus Seal



Middle to Upper Annulus Transition - Thermal Input

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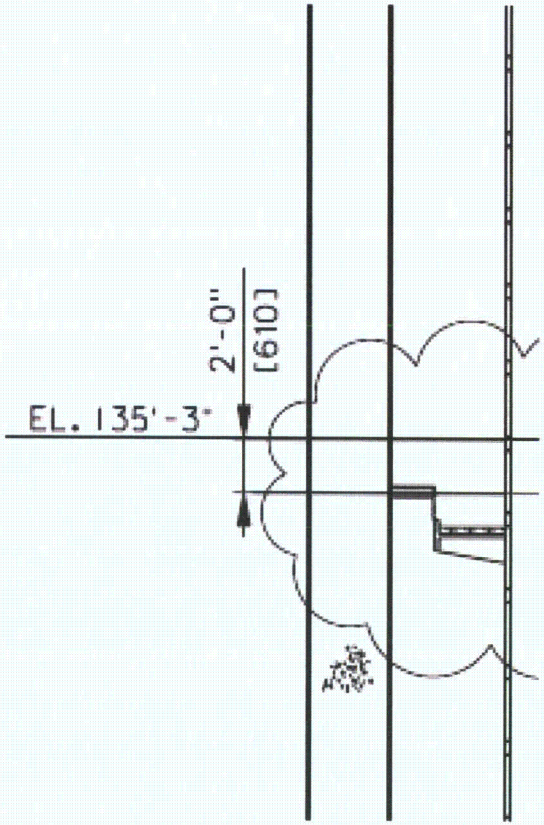
- [

-

-

-]a,c



Load Combinations

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a,c

where,

D	=	dead load
L	=	live load
Es	=	SRSS (member forces are positive) of the SSE loads
E's	=	Es with all member forces except axial forces (TX, TY) reversed to negative
Pa	=	accident pressure load
α	=	reduction factor for the self-relieving effect (based on ratio of cracked to uncracked stiffness)
To	=	normal thermal load

Table 3.2-7

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- Table 3.2-7 of Rev 3 of the Shield Building Report, contained [ ]a,c

- The Revised table shows the [ ]a,c

Table 3.2-7 Rev3 Shield Building Report

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a,c

Table 3.2-7 Revision

Considering Element Averaging

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a,c

a,c

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Westinghouse

a,c

AP1000

Westinghouse

a,c

AP1000

Westinghouse

Design of Walls and Slabs

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- The design of walls in ACI349-01 is described in Section 11.10 which directs the reader to 11.12 Special Provisions for Slabs and Footings. In section 11.12.1.1, the code states that:
  - "Beam action where each critical section to be investigated extends in a plane across the entire width."
- For a slab the critical section for shear should be averaged over the length of the slab, therefore for the cylindrical wall it is reasonable to average over smaller lengths of only about 4 times the wall thickness (12ft).

Member Force

17inx17in Tiebar Zone

AP1000

a,c

Backups.....

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Applied Temperature

AP1000

a,c