ENCLOSURE 4

Westinghouse Non-Proprietary Class 3

Presentations and Actions for WEC Meeting with NRC June 9 through June 11 - (Non-Proprietary)

Attachment to DCP_NRC_002995

This attachment represents the Westinghouse responses to NRC staff comments from the June 9-11, 2010, meetings in Rockville, Maryland. The staff comments were generated in response to review of the Westinghouse Design Report for the AP1000 Enhanced Shield Building, (APP-1200-S3R-003, Revision 2) from May 2010.

1.0 Item 1

1.1 1-A Demand

Westinghouse Position

Westinghouse states that capacity is greater than demand. In Appendix F, WEC shows contour plots of member forces for load combination 6 (for the SC wall).

NRC Understanding

Although Appendix F contains force contours, the plots are insufficient for full understanding of the design demands and related design capacities.

Staff believes that it is necessary to know the magnitude of demands (required bending moment, shear, and torsion), and of the capacity of the member with respect to bending moment, shear, and torsion. This is usually presented by plotting the magnitude of demands and capacities along the entire length of the member. However, these plots are absent in the report.

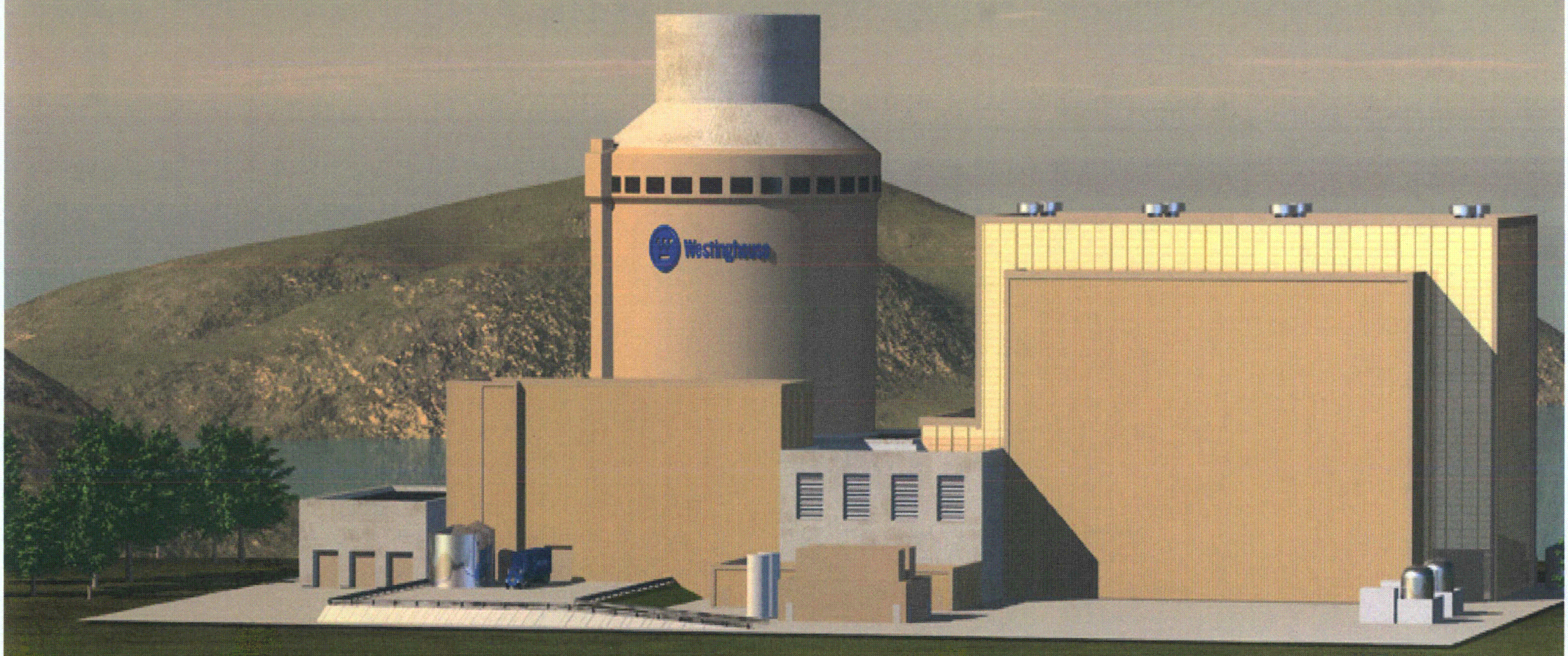
NRC Question

Provide the calculated demands and capacities in a form that permits the full and ready understanding of the design demands and related design capacities?

For example, provide information, i.e., plots for OOPS (wall, roof, and PCS tank) , in-plane shear (wall), torsion (wall), bending moment (wall, roof, and PCS tank). Also, include plots of capacity with only the steel contribution to the OOPS (SC wall) capacity and identify locations where the steel contribution alone would be insufficient to meet demands.

The following pages are the presentation slides for Demand and Capacity as presented to the NRC during the June9-11, 2010, meetings.

Shield Building Demand vs Capacity



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Introduction

AP1000

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Westinghouse

Westinghouse approach to address NRC concern

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Westinghouse Non-Proprietary Class 3

Shield Building Wall Design Process

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Load Combinations

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Locations of Comparisons

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Governing Load Case – In plane Shear

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Governing Load Case – Axial Load

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LC6 Along west side
Demand vs Capacity- In plane shear

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LC6 Along west side
Demand vs Capacity- Axial

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LC6 Along west side

Demand vs Capacity- out of plane shear

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LC6 Along west side
Moment Demand vs Moment Capacity

AP1000

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LC17 Along west side
Moment Demand vs Moment Capacity

AP1000

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Locations of Comparisons

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LC6 Along north-east side
Demand vs Capacity- In plane shear

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LC6 Along north-east side Demand vs Capacity- Axial

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LC6 Along north-east side
Demand vs Capacity- out of plane shear

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LC6 Along North-East Side
Demand vs Capacity- Out of Plane Shear

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LC6 Along south side
Demand vs Capacity- out of plane shear

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LC6 Along north-east side
Moment Demand vs Moment Capacity

AP1000

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Summary

AP1000

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WESTINGHOUSE NON-PROPRIETARY CLASS 3

Maximum Out of Plane Shear in 17" x 17' Tie Region

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Shield Building Report Rev 2 Table 3.2-7

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Spacing of Tie bars

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Nuclear Island FE Model

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Figure 3.3-15 Design Surface Temperatures of Shield Building Wall

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Element results
NY shear LC15 (thermal)

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Out of Plane Shear Design

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Horizontal path at distance "d" above top of walls

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1.1.1 Action 1

Westinghouse Understanding

Westinghouse will provide contour plots, demand Vd/Phi*Vs and Vd/Phi* (Vc+Vs) on unfolded SC Wall

Response

Questions 1 and 2 are a combined response listed in Section 1.1.2.

1.1.2 Action 2

Westinghouse will review current analysis to determine if Phi*Vs is exceeded and provide a justification.

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1.1.3 Action 3

Westinghouse will provide an assessment on minimum notch toughness and detailing to mitigate premature fracture under SSE earthquake for significant welds

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1.1.4 Action 4

Westinghouse will assess the effects of cracking, show that the in-plane shear distribution near the base of the West Wall and right above the roof at the Auxiliary Building at [1 SSE]^{a,c} and show that the maximum in-plane shear remains within the code allowable. Westinghouse will utilize [ANSYS] ^{a,c} for NI05 and [LS-DYNA (elastic) and (cracked)]^{a,c}

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1.2 1B- Out-of-plane (OOP) Shear Capacity

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Westinghouse Position

Out-of-plane shear strength is adequately predicted by the test results shown in Figure 7.7-7, p 7-18 and Figure 7.11-16, p 7-110 of the Design Report for the AP1000 Enhanced Shield Building.

NRC Staff Understanding

For a/d=3.5, the test indicate a brittle failure mode for tie bars at 17 inches. For a/d=2.5, the cyclic tests indicate significant degradation and failure at cyclic load levels only slightly beyond yield (brittle failure).

The staff understood that despite brittle OOPS behavior of the SC module with ties at 17 inches, Westinghouse would demonstrate that the Shield Building would have a ductile failure mode.

However, the adequacy of the results of the analysis is in question.

NRC Question

Based on the indicated brittle failure in the OOPS test of the specimen, as provided under Figure 7.7-7 pg. 7-18, and given that Westinghouse indicated that they will demonstrate ductile failure, justify how the resultant brittle failure demonstrates safety in the Shield Building structure

The following pages are the presentation slides for the Out-of-Plane Shear Capacity and for the Maximum Out-of-Plane Shear in the 17 x 17" Tie Region as presented to the NRC during the June 9-11, 2010, meetings.

1.2.1 Action 5

Westinghouse will provide stress/strain test data for the tie bars with [ ]^{a,c} and the ASTM specifications used for the construction material.

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Designation: A 496/A 496M – 07

Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement[1]

This standard is issued under the fixed designation A 496/A 496M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers deformed steel wire which has been cold-worked by drawing, rolling, or both drawing and rolling, to be used as produced, or in fabricated form, for the reinforcement of concrete in sizes having nominal cross-sectional areas not less than 6.45 mm^2[0.01 $in.^2$].

1.2 Supplement S1 describes high-strength wire, which shall be furnished when specifically ordered. It shall be permissible to furnish high-strength wire in place of regular wire if mutually agreed to by the purchaser and manufacturer.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. (The inch-pound units are shown in brackets except in Table 1).

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 497/A 497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

E 83 Practice for Verification and Classification of Extensometer Systems

2.2 *Military Standards:*[3]

MIL-STD-129 Marking for Shipment and Storage

2.3 *Federal Standard:*[3]

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)

2.4 *ACI Standard:*[4]

ACI 318 Building Code Requirements for Structural Concrete

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *deformed steel wire for reinforcement—as used within the scope and intent of this specification*, shall mean any cold-worked, deformed steel wire intended for use as reinforcement in concrete construction, the wire surface having deformations that: (*1*) inhibit longitudinal movement of the wire in such construction; and (*2*) conform to the provisions of Section 5. It shall be permissible for the deformations to be raised or indented.

3.1.2 *size number—as used in this specification*, refers to the numerical designation of the wire as tabulated in Table 1 and Table 2 under the column headed Deformed Wire Size Number, or a number indicating the nominal cross-sectional area of the deformed wire in square millimeters [hundredths of a square inch].

4. Ordering Information

4.1 When deformed wire is ordered by size number, the dimensional requirements shall be as given in Table 1. When deformed wire is ordered to dimensions other than the sizes shown, the nominal dimensions shall be developed from the applicable unit mass per meter [weight per foot] of the section.

4.2 It shall be the responsibility of the purchaser to specify all requirements that are necessary for the manufacture and delivery of the wire under this specification. Such requirements to be considered include, but are not limited to, the following:

4.2.1 Quantity (mass [weight]),

4.2.2 Name of material (deformed steel wire for concrete reinforcement),

4.2.3 Wire diameter (see Table 1 and Table 2),

4.2.4 Yield strength measurement (see 8 and 13.3),

4.2.5 Packaging (see Section 17), and

4.2.6 ASTM designation and year of issue.

4.2.7 Special requirements, if any. (See Supplement S1.)

NOTE 1—A typical ordering description is as follows: 50 000 lb

[1] This specification is under the jurisdiction of ASTM A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of A01.05 on Steel Reinforcement.

Current edition approved Sept. 1, 2007. Published October 2007. Originally approved in 1964. Last previous edition approved in 2005 as A 496/A 496M-05.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

[4] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.aci-int.org.

*A Summary of Changes section appears at the end of this standard.

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TABLE 1 Dimensional Requirements for Deformed Wire for Concrete Reinforcement in SI Units

Deformed Wire Size[A,B,C]	[D in.²] [× 100]	Nominal Dimensions: Unit Wt. kg/m	Unit Wt. [lbs/ft.]	Diameter[D] mm	Diameter[D] [in.]	Cross-Sectional Area[B,E] mm²	Cross-Sectional Area[B,E] [in.²]	Deformation Requirements: Perimeter mm	Perimeter [in.]	Spacing, Maximum mm	Spacing, Maximum [in.]	Spacing, Minimum mm	Spacing, Minimum [in.]	Min. Avg. Height of Deformations mm[F]	Min. Avg. Height of Deformations [in.]
MD 25	[D 3.9]	0.196	[0.132]	5.64	[0.222]	25	[0.039]	17.7	[0.698]	7.24	[0.285]	4.62	[0.182]	0.252	[0.010]
MD 30	[D 4.7]	0.235	[0.158]	6.18	[0.243]	30	[0.047]	19.4	[0.764]	7.24	[0.285]	4.62	[0.182]	0.279	[0.011]
MD 35	[D 5.4]	0.275	[0.185]	6.68	[0.263]	35	[0.054]	21.0	[0.826]	7.24	[0.285]	4.62	[0.182]	0.302	[0.012]
MD 40	[D 6.2]	0.314	[0.211]	7.14	[0.281]	40	[0.062]	22.4	[0.883]	7.24	[0.285]	4.62	[0.182]	0.320	[0.013]
MD 45	[D 7.0]	0.353	[0.237]	7.57	[0.298]	45	[0.070]	23.8	[0.936]	7.24	[(0.285]	4.62	[0.182]	0.342	[0.014]
MD 50	[D 7.8]	0.392	[0.264]	7.98	[0.314]	50	[0.078]	25.1	[0.987]	7.24	[0.285]	4.62	[0.182]	0.360	[0.014]
MD 55	[D 8.5]	0.432	[0.290]	8.37	[0.329]	55	[0.085]	26.3	[1.04]	7.24	[0.285]	4.62	[0.182]	0.378	[0.015]
MD 60	[D 9.3]	0.471	[0.316]	8.74	[0.344]	60	[0.093]	27.5	[1.08]	7.24	[0.285]	4.62	[0.182]	0.392	[0.015]
MD 65	[D 10.1]	0.510	[0.343]	9.10	[0.358]	65	[0.101]	28.6	[1.13]	7.24	[0.285]	4.62	[0.182]	0.455	[0.018]
MD 70	[D 10.9]	0.549	[0.369]	9.44	[0.372]	70	[0.109]	29.7	[1.17]	7.24	[0.285]	4.62	[0.182]	0.470	[0.018]
MD 80	[D 12.4]	0.628	[0.422]	10.1	[0.397]	80	[0.124]	31.7	[1.25]	7.24	[0.285]	4.62	[0.182]	0.505	[0.020]
MD 90	[D 14.0]	0.706	[0.475]	10.7	[0.421]	90	[0.140]	33.6	[1.32]	7.24	[0.285]	4.62	[0.182]	0.535	[0.021]
MD 100	[D 15.5]	0.785	[0.527]	11.3	[0.444]	100	[0.155]	35.4	[1.40]	7.24	[0.285]	4.62	[0.182]	0.565	[0.022]
MD 120	[D 18.6]	0.942	[0.633]	12.4	[0.487]	120	[0.186]	38.8	[1.53]	7.24	[0.285]	4.62	[0.182]	0.620	[0.024]
MD 130	[D 20.2]	1.02	[0.686]	12.9	[0.507]	130	[0.202]	40.4	[1.59]	7.24	[0.285]	4.62	[0.182]	0.645	[0.025]
MD 200	[D 31.0]	1.57	[1.05]	16.0	[0.628]	200	[0.310]	50.1	[1.97]	7.24	[0.285]	4.62	[0.182]	0.800	[0.031]
MD 290	[D 45.0]	2.28	[1.53]	19.2	[0.757]	290	[0.450]	60.4	[2.38]	7.24	[0.285]	4.62	[0.182]	0.961	[0.0379]

[A] The number following the prefix indicates the nominal cross-sectional area of the deformed wire in square millimeters.
[B] For sizes other than those shown above, the Size Number shall be the number of one hundredths of a square inch in the nominal area of the deformed wire cross section, prefixed by the letters MD.
[C] These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 1–mm² [0.0015–in.²] increments.
[D] The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same mass per metre as the deformed wire.
[E] The cross-sectional area is based on the nominal diameter. The area in square millimetres [inches] is calculated by dividing the unit mass [weight] in kg/mm [lbs./in.] by 7×10^{-6} (mass of 1 mm³ of steel [0.2833 weight of 1 in.³ of steel]) or by dividing the unit mass [weight] in kg/m [lbs./ft.] by 0.007849 (mass of steel 1 mm square and 1 m long) [3.4 (weight of steel 1in. square and 1 ft. long)].
[F] The minimum average height of the deformations shall be determined from measurements made on not less than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentation as described in 7.7.

A 496/A 496M – 07

TABLE 2 Dimensional Requirements for Deformed Steel Wire for Concrete Reinforcement—US Customary Units Wire Sizes[A]

	Nominal Dimensions			Deformation Requirements			
Deformed Wire Size Number[B,G]	Unit Weight, lb/ft [kg/m]	Diameter, in. [mm][D]	Cross-sectional Area, in.^{2}[mm^2][E]	Perimeter, in. [mm]	Maximum Spacing, in. [mm]	Minimum Spacing, in. [mm]	Minimum Average Height of Deformations, in. [mm][F,G]
D-1	0.034 [0.051]	0.113 [2.87]	0.010 [6.45]	0.354 [9.00]	0.285 [7.24]	0.182 [4.62]	0.0045 [0.114]
D-2	0.068 [0.101]	0.160 [4.05]	0.020 [12.9]	0.501 [12.7]	0.285 [7.24]	0.182 [4.62]	0.0063 [0.160]
D-3	0.102 [0.152]	0.195 [4.96]	0.030 [19.4]	0.614 [15.6]	0.285 [7.24]	0.182 [4.62]	0.0078 [0.198]
D-4	0.136 [0.202]	0.226 [5.73]	0.040 [25.8]	0.709 [18.0]	0.285 [7.24]	0.182 [4.62]	0.0101 [0.257]
D-5	0.170 [0.253]	0.252 [6.41]	0.050 [32.3]	0.793 [20.1]	0.285 [7.24]	0.182 [4.62]	0.0113 [0.287]
D-6	0.204 [0.304]	0.276 [7.02]	0.060 [38.7]	0.868 [22.1]	0.285 [7.24]	0.182 [4.62]	0.0124 [0.315]
D-7	0.238 [0.354]	0.299 [7.58]	0.070 [45.2]	0.938 [23.8]	0.285 [7.24]	0.182 [4.62]	0.0134 [0.304]
D-8	0.272 [0.405]	0.319 [8.11]	0.080 [51.6]	1.00 [25.5]	0.285 [7.24]	0.182 [4.62]	0.0143 [0.363]
D-9	0.306 [0.455]	0.339 [8.60]	0.090 [58.1]	1.06 [27.0]	0.285 [7.24]	0.182 [4.62]	0.0152 [0.386]
D-10	0.340 [0.506]	0.357 [9.06]	0.100 [64.5]	1.12 [28.5]	0.285 [7.24]	0.182 [4.62]	0.0160 [0.406]
D-11	0.374 [0.557]	0.374 [9.51]	0.110 [71.0]	1.18 [29.9]	0.285 [7.24]	0.182 [4.62]	0.0187 [0.475]
D-12	0.408 [0.607]	0.391 [9.93]	0.120 [77.4]	1.23 [31.2]	0.285 [7.24]	0.182 [4.62]	0.0195 [0.495]
D-13	0.442 [0.658]	0.407 [10.3]	0.130 [83.9]	1.28 [32.5]	0.285 [7.24]	0.182 [4.62]	0.0203 [0.516]
D-14	0.476 [0.708]	0.422 [10.7]	0.140 [90.3]	1.33 [33.7]	0.285 [7.24]	0.182 [4.62]	0.0211 [0.536]
D-15	0.510 [0.759]	0.437 [11.1]	0.150 [96.8]	1.37 [34.9]	0.285 [7.24]	0.182 [4.62]	0.0218 [0.554]
D-16	0.544 [0.810]	0.451 [11.5]	0.160 [103]	1.42 [36.0]	0.285 [7.24]	0.182 [4.62]	0.0225 [0.572]
D-17	0.578 [0.860]	0.465 [11.8]	0.170 [110]	1.46 [37.1]	0.285 [7.24]	0.182 [4.62]	0.0232 [0.589]
D-18	0.612 [0.911]	0.479 [12.2]	0.180 [116]	1.50 [38.2]	0.285 [7.24]	0.182 [4.62]	0.0239 [0.607]
D-19	0.646 [0.961]	0.492 [12.5]	0.190 [122]	1.55 [39.2]	0.285 [7.24]	0.182 [4.62]	0.0245 [0.622]
D-20	0.680 [1.01]	0.505 [12.8]	0.200 [129]	1.59 [40.3]	0.285 [7.24]	0.182 [4.62]	0.0252 [0.604]
D-21	0.714 [1.06]	0.517 [13.1]	0.210 [135]	1.62 [41.3]	0.285 [7.24]	0.182 [4.62]	0.0259 [0.658]
D-22	0.748 [1.11]	0.529 [13.4]	0.220 [141]	1.66 [42.2]	0.285 [7.24]	0.182 [4.62]	0.0265 [0.673]
D-23	0.782 [1.16]	0.541 [13.7]	0.230 [148]	1.70 [43.2]	0.285 [7.24]	0.182 [4.62]	0.0271 [0.688]
D-24	0.816 [1.21]	0.553 [14.0]	0.240 [154]	1.74 [44.1]	0.285 [7.24]	0.182 [4.62]	0.0277 [0.704]
D-25	0.850 [1.26]	0.564 [14.3]	0.250 [161]	1.77 [45.0]	0.285 [7.24]	0.182 [4.62]	0.0282 [0.716]
D-26	0.884 [1.32]	0.575 [14.6]	0.260 [167]	1.81 [45.9]	0.285 [7.24]	0.182 [4.62]	0.0288 [0.732]
D-27	0.918 [1.37]	0.586 [14.9]	0.270 [174]	1.84 [46.8]	0.285 [7.24]	0.182 [4.62]	0.0293 [0.744]
D-28	0.952 [1.42]	0.597 [15.2]	0.280 [180]	1.88 [47.6]	0.285 [7.24]	0.182 [4.62]	0.0299 [0.759]
D-29	0.986 [1.47]	0.608 [15.4]	0.290 [187]	1.91 [48.5]	0.285 [7.24]	0.182 [4.62]	0.0304 [0.772]
D-30	1.02 [1.52]	0.618 [15.7]	0.300 [193]	1.94 [49.3]	0.285 [7.24]	0.182 [4.62]	0.0309 [0.785]
D-31	1.05 [1.57]	0.628 [16.0]	0.310 [200]	1.97 [50.1]	0.285 [7.24]	0.182 [4.62]	0.0314 [0.798]
D-45	1.53 [2.28]	0.757 [19.2]	0.450 [290]	2.38 [60.4]	0.285 [7.24]	0.182 [4.62]	0.0379 [0.961]

[A] In this table only, inch-pound units are regarded as standard and SI units are shown in brackets.

[B] The number following the prefix indicates the nominal cross-sectional area of the deformed wire in square inches [square millimeters].

[C] For sizes other than those shown above, the Size Number shall be the number of one hundredths of a square inch in the nominal area of the deformed wire cross section, prefixed by the letter D.

[D] The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire.

[E] The cross-sectional area is based on the nominal diameter. The area in square inches [millimeters] is calculated by dividing the unit weight [mass] in lbs./in. [kg/mm] by 0.2833 (weight of 1 in.^{3} of steel) [7 × 10^{-6}(mass of 1 mm^3 of steel)], or by dividing the unit weight [mass] in lbs./ft. [kg/m] by 3.4 (weight of steel 1 in. square and 1 foot long) [0.007849 (mass of 1 mm square and 1 m long)].

[F] The minimum average height of the deformations shall be determined from measurements made on not less than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentation as described in 6.2.

[G] These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 0.0015–in^2 [1–mm^2] increments.

deformed steel wire for concrete reinforcement, size No. MD80 [D12.4], in 800 kg [2000 lb] secured coils, to ASTM A 496/A 496M –____ .

5. Materials and Manufacture

5.1 The steel shall be made by one of the following processes: open-hearth, electric furnace, or basic oxygen.

5.2 The deformed steel wire shall be produced from rods or bars that have been hot rolled from billets.

6. Requirements

6.1 Deformations shall be spaced along the wire at a substantially uniform distance and shall be symmetrically dispersed around the perimeter of the section. The deformations on all longitudinal lines of the wire shall be similar in size and shape. A minimum of 25 % of the total surface area shall be deformed by measurable deformations.

6.2 Deformed wire shall have two or more lines of deformations.

6.3 The average longitudinal spacing of deformations shall be not less than 3.5 nor more than 5.5 deformations per 25.4 mm [1 in.] in each line of deformations on the wire.

6.4 The minimum average height of the center of typical deformations based on the nominal wire diameters shown in Table 1 and Table 2 shall be as follows:

Wire Sizes	Minimum Average Height of Deformations, Percent of Nominal Wire Diameter
MD20 [D3] and smaller	4
Larger than MD20 [D3] through MD65 [D10]	4 ½
Larger than MD65 [D10]	5

6.5 The deformations shall be placed with respect to the axis of the wire so that the included angle is not less than 45°; or if deformations are curvilinear, the angle formed by the transverse axis of the deformation and the wire axis shall be not less than 45°. Where the line of deformations forms an included

TABLE 3 Tension Test Requirements

	MPa [psi] min
Tensile strength	585 [85 000]
Yield strength	515 [75 000]

angle with the axis of the wire from 45 to 70° inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the included angle is greater than 70°, a reversal in direction is not required.

7. Dimensions

7.1 The average spacing of deformations shall be determined by dividing a measured length of the wire specimen by the number of individual deformations in any one row of deformations on any side of the wire specimen. A measured length of the wire specimen shall be considered the distance from a point on a deformation to a corresponding point on any other deformation in the same line of deformations on the wire.

7.2 The minimum average height of deformations shall be determined from measurements made on not less than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentations.

8. Mechanical Property Requirements

8.1 *Tension Tests*:

8.1.1 When tested as described in Test Methods and Definitions A 370, the material, except as specified in 8.1.2 shall conform to the tensile property requirements in Table 3, based on the nominal area of wire.

8.1.2 When required by the purchaser, yield strength shall be determined using a Class B-1 extensometer as described in Practice E 83. The yield strength shall be determined as described in Test Methods and Definitions A 370 and an extension of 0.5 % of gage length. It shall be permissible to remove the extensometer after the yield strength has been determined. The wire shall meet the requirements of Table 3 or 4, whichever is applicable.

8.1.3 For material to be used in the fabrication of welded wire reinforcement, the tensile and yield strength properties shall conform to the requirements given in Table 4, based on the nominal area of the wire.

8.1.4 The material shall not exhibit a definite yield point as evidenced by a distinct drop of the beam or halt in the gage of the testing machine prior to reaching ultimate tensile load.

8.2 *Bend Test*—The bend test specimen shall withstand being bent at room temperature through 90° without cracking on the outside of the bent portion, as prescribed in Table 5.

9. Permissible Variation in Mass [Weight]

9.1 The permissible variation in mass [weight] of any deformed wire shall be ±6 % of its nominal weight. The theoretical masses [weights] shown in Table 1, or similar calculations on unlisted sizes, shall be used to establish the variation.

10. Workmanship, Finish, and Appearance

10.1 The wire shall be free of detrimental imperfections and shall have a workmanlike finish.

TABLE 4 Tension Test Requirements (Material for Welded Wire Reinforcement)

	MPa [psi] min
Tensile strength	550 [80 000]
Yield strength	485 [70 000]

TABLE 5 Bend Test Requirements

Size Number of Wire	Bend Test
MD39 [D6] and smaller	Bend around a pin the diameter that is equal to twice the diameter of the specimen
Larger than MD39 [D6]	Bend around a pin the diameter that is equal to four times the diameter of the specimen

10.2 Rust, surface seams, or surface irregularities shall not be a cause for rejection provided the requirements of 10.3 are met, and the minimum dimensions and mechanical properties of a hand wire-brushed test specimen meet the requirements of this specification.

10.3 Wire intended for welded wire reinforcement shall be sufficiently free of rust and drawing lubricant, so as not to interfere with electric resistance welding.

11. Sampling

11.1 Test specimens for testing mechanical properties shall be full wire sections and shall be obtained from the ends of the wire product as drawn or rolled, or both drawn and rolled. The specimens shall be of sufficient length to perform testing described in 8.1 and 8.2.

11.2 Any test specimen exhibiting obvious isolated imperfections that are not representative of the product shall be discarded and another specimen substituted.

12. Number of Tests

12.1 One tension and one bend test shall be made from each 9000 kg [10 tons] or less of each size of wire or fraction thereof in a lot, or a total of seven samples, whichever is less. A lot shall consist of all the coils of a single size offered for delivery at the same time.

13. Inspection

13.1 The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's facilities that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification.

13.2 Except for yield strength, all tests and inspections shall be made at the manufacturer's facilities prior to shipment, unless otherwise specified. Such tests shall be so conducted as not to interfere unnecessarily with the operation of the manufacturer's facilities.

13.3 The purchaser shall have the option to require a yield strength measurement to determine compliance with yield strength requirements in 8.1, and shall specify that the measurements be performed by the manufacturer at the manufacturer's facilities, a recognized laboratory, or the purchaser's representative at the manufacturer's facilities. Such measurements shall be conducted without unnecessarily interfering with manufacturing operations.

13.4 *For U.S. Government Procurement Only*—Except as otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract, the contractor shall have the option to use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time of purchase. The purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

14. Rejection

14.1 Material that shows detrimental imperfections subsequent to its acceptance at the manufacturer's facilities shall be rejected, and the manufacturer shall be notified.

14.2 Failure of any of the test specimens to comply with the requirements of this specification shall constitute grounds for rejection of the lot represented by the specimen.

14.3 Any rejection based on tests made in accordance with this specification shall be reported to the manufacturer within two weeks of the date of inspection or test. The material shall be adequately protected and correctly identified such that the manufacturer is able to make a proper investigation.

15. Rehearing

15.1 Rejected material shall be preserved for a period of not less than two weeks from the date of inspection, during which time the manufacturer shall have the option to make claim for a rehearing and retesting.

15.2 The manufacturer shall have the option to resubmit the rejected lot for re-inspection or retesting by inspecting or testing every coil for the property in which the specimen failed and sorting out non-conforming coils.

16. Certification

16.1 When specified in the purchase order or contract, the purchaser shall be furnished with the manufacturer's written certification that the material was manufactured, sampled, tested, and inspected in accordance with, and meets the requirements of, this specification. When specified in the purchase order or contract, a report of the test results shall be furnished. The certification shall include the specification number, year-date of issue and revision letter, if any.

16.2 A Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the manufacturer. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

NOTE 2—The industry definition as invoked here is: EDI is the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

17. Packaging and Marking

17.1 The size of the wire, ASTM designation, and name or mark of the manufacturer shall be marked on a tag securely attached to each coil of wire.

17.2 Unless otherwise specified, packaging, marking, and loading for shipment shall be in accordance with Practices A 700.

17.3 When specified in the contract or order, and for the direct procurement by or direct shipment to the U.S. government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for U.S. military agencies and in accordance with Fed. Std. No. 123 or U.S. government civil agencies.

18. Keywords

18.1 concrete reinforcement; deformations (indentations); steel wire

SUPPLEMENTARY REQUIREMENTS

S1. High-Strength Wire

S1.1 *Scope*—This supplement delineates only those details that are relative to high-strength wire and to the mechanical requirements for wire having properties generally as described in this specification.

NOTE S1.1—Building codes, for example, ACI 318 permit the use of reinforcement with a yield strength up to 550 MPa [80 000 psi]. For compatibility with the codes' design provisions for high-strength reinforcement, this supplement prescribes requirements for the mechanical properties of wire that exceed the minimum values for yield strength and tensile strength in Table 3 and Table 4 of this specification

S1.2 *Mechanical Property Requirements:*

S1.2.1 Minimum yield strength shall be specified in the purchase order in increments of 17.5 MPa [2500 psi]. When tested the yield strength shall be determined at an extension under load of 0.35 %.

NOTE S1.2—To conform to the limit on yield strength in building codes, the minimum yield strength specified in the purchase order should not be greater than 550 MPa [80 000 psi].

S1.2.2 Minimum tensile strength shall be 70 MPa [10 000 psi] greater than the minimum specified yield strength.

NOTE S1.3—A typical order entry line for minimum yield strength is, "72 500 psi minimum yield strength" or "500 MPa minimum yield strength."

S1.3 *Certification*—Certification for material produced to this supplement shall include a report of the test results for yield strength, tensile strength, and bend tests. Frequency of testing shall conform to Section 12 of this specification and Section 12 of Specification A 497/A 497M as applicable.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 496/A 496M–05) that may impact the use of this standard.

(*1*) Removed reference to MIL-STD-163.

1.3 1C- Global Stability

Westinghouse Position

In report section 3.3.1, Westinghouse addresses local buckling of the Shield Building, but does not address global buckling.

NRC Understanding

ACI 334.1R-92 (reapproved 2002), "Concrete Shell Structures Practice and Commentary," Chapter 5-stability, states "In common with other structures, shell should be investigated for buckling...Poor correlation between the results of theory and experiment exists when both principal membrane forces are compressive, as in the case of: 1. Cylindrical shells under axial compressive load; 2. Cylindrical shells under distributed load normal to the surface, which causes bending; and 3. Domes under inward radial pressure. In extreme cases, the buckling load obtained experimentally has been found to be as little as 10% of that predicated by the small deflection theory."

NRC Question

Given the uniqueness of the Shield Building design, with a significant concentrated load at the top of the structure (i.e., PCS tank), how does Westinghouse address concerns with global stability, such as that provided for under the ACI 334.1R-92, or justify why it is not required?

1.3.1 Action 6

Westinghouse will provide buckling justification and the tolerances. a,c

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2.0 Item 2 (RC/SC Connection)

2.1 2A- RC/SC Connection, Load Path

Westinghouse Position

Westinghouse's proposed connection between the SC and RC as shown in Figure D.1-5 p D6 and Figure 4.1-2.p 4-6.

NRC Understanding

The proposed connection between the SC and RC transfers loads from the steel faceplates to a horizontal steel plate, which is welded to the faceplates and supported by a gusset plate. The horizontal steel plate supports the vertical rod by a nut on top of the plate. The rod passes through the interface between the SC module and the RC module and is threaded to a mechanical connector in the RC. Such a connection is unconventional.

The staff has identified the following concerns: (1) possibility for an alternative load path for shear friction at the interface above the mechanical couplers when the steel faceplates bear on the concrete; (2) possible ineffective bond between the tie rods and the concrete that may reduce the shear friction of the same joint; (3) lack of qualification and production criteria and programs for the mechanical splice; and (4) that the concrete below the anchor plates may not be in close contact with these plates.

NRC Questions

(1) How does Westinghouse address the effects of a possible alternative load path for shear friction at the joint above the mechanical couplers when the steel faceplates bear on the concrete?

(2) How does Westinghouse address the effects of ineffective bond between the tie rods and the concrete on the shear friction behavior of the interface above the mechanical couplers?

(3) What are the qualification and production criteria and programs for the mechanical splices?

(4) How does Westinghouse address the concern that the concrete below the anchor plates may not be in close contact with these plates (lack of contact would affect the transmission of compressive forces)?

The following pages are the presentation slides for the RC/SC Connection and for the RC/SC Connection Force and Moment Transfer topics as presented to the NRC during the June9-11, 2010, meetings.

SC/RC Connection Force and Moment Transfer

SC/RC Connection Detail

AP1000

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Westinghouse

SC/RC Connection Detail

AP1000

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SC/RC Connection Tension

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SC/RC Connection Tension

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SC/RC Connection Tension

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SC/RC Connection Tension

AP1000

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SC/RC Connection Compression

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Westinghouse

SC/RC Connection Moment

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SC/RC Connection In-Plane Shear

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SC/RC Connection In-Plane Shear

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SC/RC Connection In-Plane Shear

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2.1.1 Action 7

Westinghouse will clarify the design approach and the load path for the RC/SC connection. Westinghouse will walk through individual components and the load path and confirm its strengths. Westinghouse will also describe any design changes to the RC/SC connection (i.e., possible replacement of [ ]a,c

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2.1.2 Action 8

Westinghouse will provide justification that voids in the RC/SC region will not affect load path in compression.

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2.2 2B- RC/SC Connection, Bonding of Rods and Concrete

The following pages are the presentation slides for the Shear Friction Behavior topic as presented to the NRC during the June9-11, 2010, meetings.

WESTINGHOUSE NON-PROPRIETARY CLASS 3

Shear Friction Behavior

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Code Limits on Shear Friction

AP1000

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References

a,c

Shear Transfer Mechanisms

AP1000

a,c

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Westinghouse

Effect of Crack Width

(maintained constant during test)

AP1000

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Westinghouse

Cyclic Load

AP1000

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Westinghouse

Shear Friction Strength of Cracked Concrete

AP1000

a,c

Westinghouse

Shear friction strength

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Shear Friction Behavior and Strength of Concrete

AP1000

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Westinghouse

2.2.1 Action 9

Westinghouse will verify the [ ]^{a,c} shear friction was used and the basis for acceptability when using [ ]^{a,c}. Additionally, Westinghouse will address the limiting failure mode and check to ensure this is in the [ ]^{a,c}. If changes are made from [ ]^{a,c}, Westinghouse will provide details of those changes. In addition, Westinghouse will provide the technical justification [ ]^{a,c} for a higher shear friction capacity factor to be used for purposes of beyond design basis.

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The major mechanisms affecting the transfer of stresses across cracks in reinforced concrete are:

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2.2.2 Action 10

Westinghouse will clarify use of SCC and the specific locations where it will be used for the Shield Building.

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2.3 2C- Qualification of Mechanical Splices

2.3.1 Action 11

Westinghouse will consider use of ACI 318, Chapter 21 and will indicate the specific type of concrete used for the Shield Building. If it is type 1, Westinghouse will provide justification, qualification, and production criteria.

a,c

3.0 Item 3 (Ring Girder)

3.1 Ring Girder

Westinghouse Position

Table 5.2.6 on page 5-25 of the Shield Building report indicates that the stress for the tie bar from the confirmatory [ ]^{a,c} analysis is about one-third of that from the ANSYS analysis, and the stress for vertical and circumferential stresses from [ ]^{a,c} is about one-fifth of that from the [ ]^{a,c} analysis.

NRC Understanding

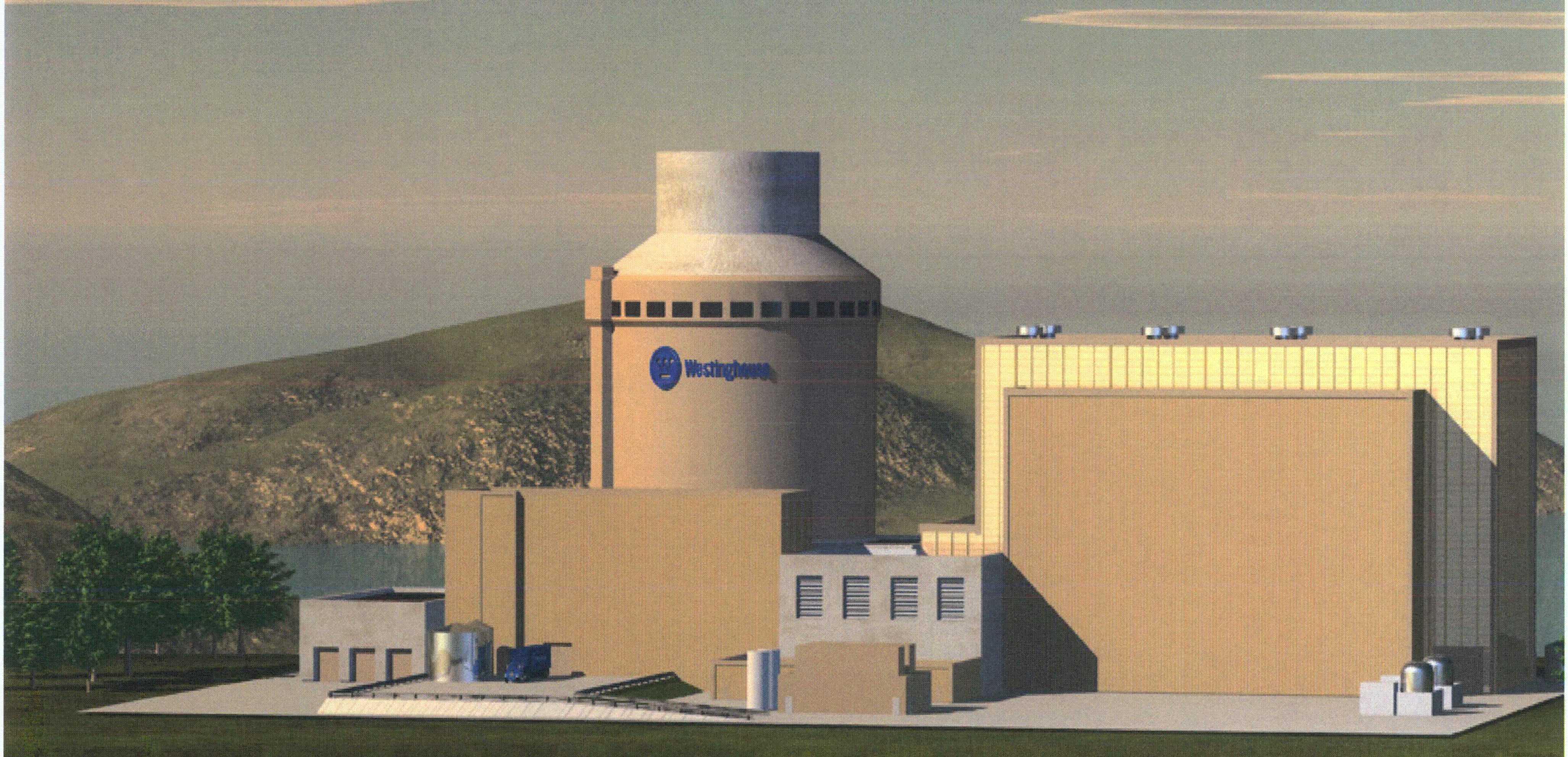
Westinghouse used [ ]^{a,c} to confirm a level of conservatism in the design of the ring girder. However, differences as large as those shown in the table indicate that such reductions in stresses may not be achievable.

NRC Question

Explain the reasons for the differences between the results in the [ ]^{a,c} and [ ]^{a,c} analyses and describe the implications on the design of the structure.

WESTINGHOUSE NON-PROPRIETARY CLASS 3

Shield Building ANSYS to LS-DYNA Comparisons



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AP1000

NRC Staff Concern:

a,c

Westinghouse

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Westinghouse approach to address NRC concern

AP1000

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Westinghouse

AP1000

Table 5.2-6 Correction

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Post - Processing

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Elastic ANSYS F/E Analyses

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Four Critical Response Locations

a,c

Tension Ring Sectional Cuts

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Air Inlets Vertical Sectional Cuts

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Air Inlets Horizontal Sectional Cuts

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Conservative Tension Ring Stress Calculations

AP1000

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Westinghouse

Air Inlet Structure – Pipe Openings

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Conservative Air Inlets Stress Calculations for Vertical Cuts

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Conservative Air Inlets Stress Calculations for Horizontal Cuts

a,c

Conclusions

a,c

Westinghouse

The following pages are the presentation slides for the [ ]^{a,c} to [ ]^{a,c} Comparison topic as presented to the NRC during the June 9-11, 2010, meetings.

3.1.1 Action 12

Westinghouse will provide a typical load case at SSE to show that the cross sectional forces for both the [Standard (ANSYS) and confirmatory (LS-DYNA)]a,c analyses.

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3.1.2 Action 13

Westinghouse will perform a calculation to address shear friction loads at the air inlets connection and construction joint in the tension ring.

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3.1.3 Action 14

Westinghouse will show a calculation of the capacity of the shear ties to show that they are adequate to address the transition from a [ ]^{a,c} wall.

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4.0 Item 4 (Other)

4.1 Issue 1- Benchmarking and System Ductility

Westinghouse Position

(1) In Figure 8.7-7 (Page 8-28 of the Shield Building), the experimental load displacement curve indicates that specimen OOPV-3.5 shows a brittle failure mode. The specimen failed at a 1.5-inch deflection. This specimen was also benchmarked by four different concrete models in the [ ]^{a,c} computer code. The predicted results from these four different concrete models in the [ ]^{a,c} computer code indicate that the specimen behaves in a ductile manner with no sign of failure at 3-inch deflection and keep going strong. Also, as stated on page 10-49, "A hand-off procedure is used to compare the analysis results from the [ ]^{a,c} models to the detailed [ ]^{a,c} models for the critical regions of the Shield Building. These regions are Wall Q, the west wall, air inlets, and Wall 5."

(2) Westinghouse stated that [ ]^{a,c} would be benchmarked.

(3) Westinghouse uses displacements for the [ ]^{a,c} "handoff."

(4) Page 10-48 of the report states "The results, shown in Table 10.2-4, indicate that the building has sufficient system ductility (> 3.5)."

NRC Understanding

(1) The staff is concerned that all the four concrete models in the [ ]^{a,c} computer code over predicted the ductility of the AP1000 Shield Building SC wall by a significant amount. Therefore, the adequacy of the results is questionable.

(2) The report does not describe how the [ ]^{a,c} code, used for [ ]^{a,c}, was benchmarked to experimental results. Further, the report does not provide any assessment of the mesh size sensitivity for the [ ]^{a,c} model.

(3) Staff is concerned that the handoff from [ ]^{a,c} would underestimate demands if the [ ]^{a,c} model is too stiff.

(4) Table 10.2-4 only shows loads and stresses, and no deformations and ductility are reported.

NRC Questions

(1) Given that all four concrete models in the [ ]^{a,c} over predicted the ductility of the AP1000 Shield Building SC wall by a significant amount (i.e.,

does not predict failure), how does Westinghouse ensure the adequacy of the [ ]^{a,c}

(2) Given that the report does not describe how the[ ]^{a,c} code, used for [ ]^{a,c} was benchmarked to experimental results, and does not provide any assessment of the mesh size sensitivity for the [ ]^{a,c} model, how does Westinghouse justify the adequacy of the [ ]^{a,c}

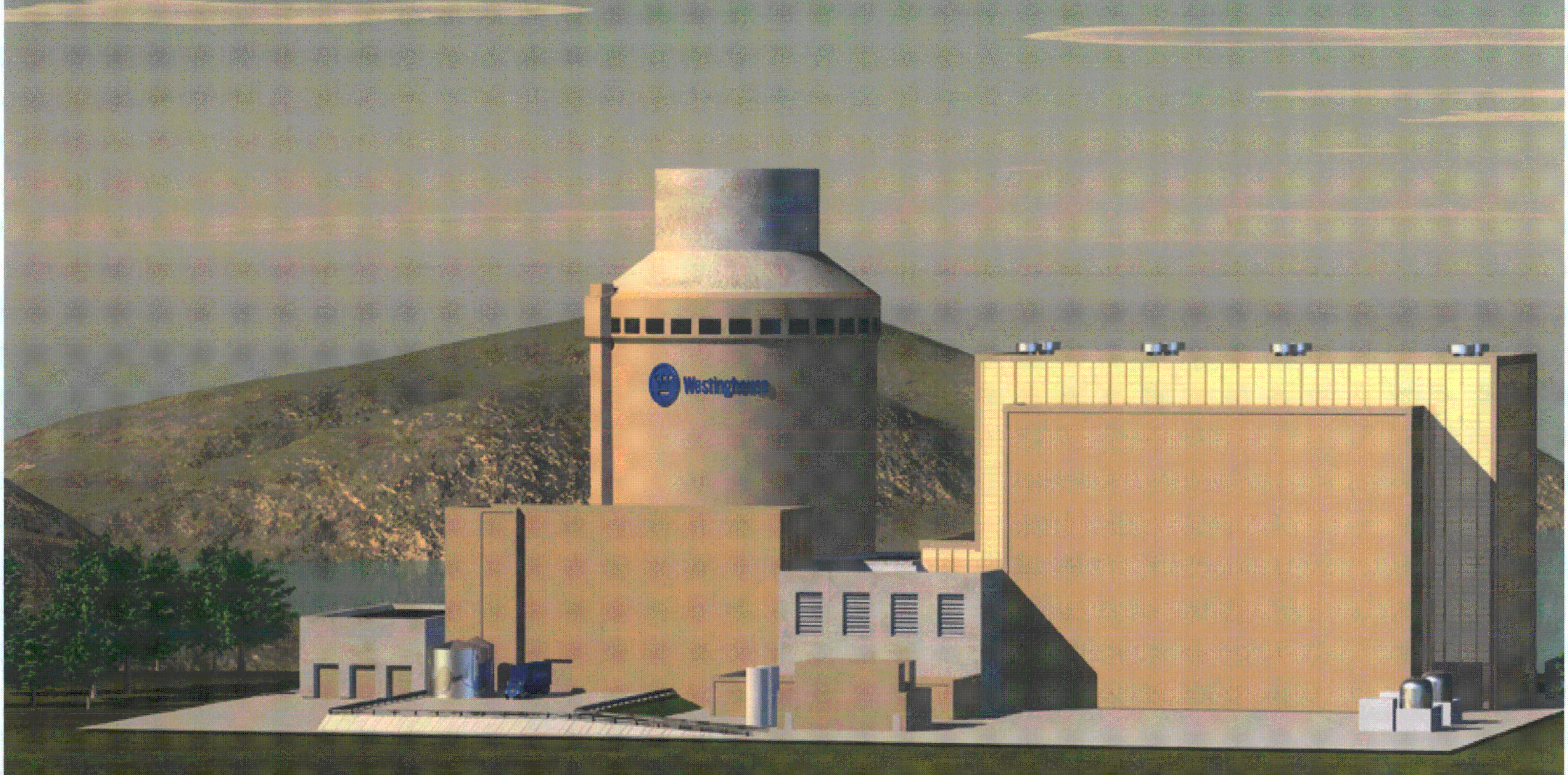
(3) In addition given that the handoff from [ ]^{a,c} would underestimate demands if the [ ]^{a,c} is too stiff, how does Westinghouse verify adequacy of the handoff procedure that was used?

(4) Given that Table 10.2-4 only shows loads and stresses, and that no deformations and ductility are reported, how did Westinghouse use these results to make an evaluation of system ductility? What is the basis for [ ]^{a,c} being designated as sufficient system ductility?

The following pages are the presentation slides for Benchmarking and System Ductility topic as presented to the NRC during the June 9-11, 2010, meetings.

WESTINGHOUSE NON-PROPRIETARY CLASS 3

Shield Building Benchmarking and System Ductility



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AP1000

NRC Staff Concern:

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Westinghouse

AP1000

NRC Staff Understanding

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AP1000

NRC Staff Questions:

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Westinghouse

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Westinghouse approach to address NRC concern

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NRC Staff Questions:

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Level 3 ABAQUS Benchmarking

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Failure Criteria

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Failure Criteria

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NRC Staff Questions:

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NRC Staff Questions:

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Level 2 LS-DYNA Benchmarking

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Westinghouse

In-plane Shear – SC Wall

AP1000

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Westinghouse

SC Wall LS-DYNA Model

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SC Wall LS-DYNA Model

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Steel Plate Material Properties

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Concrete Material Properties

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LS-DYNA ANALYSIS RESULTS - Force vs Shear Strain

a,c

Westinghouse

AP1000

Shear Strain Calculations

a,c

Westinghouse

Contours of Von Mises Stresses in Plates

a,c

Principal Stress Vectors for Steel Plate – S1, S3

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Principal Strain Vector for Concrete after Yield

a,c

Principal Strain Vectors for Steel Plate – After Yield

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AP1000

In-plane Shear – RC Wall

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LSDYNA MODEL FOR FLANGED SHEAR WALL STEEL REINFORCEMENTS

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Steel Reinforcements Plastic Strain Vs. Stress

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Concrete Properties

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Boundary Conditions

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University of Toronto Flanged Shear Wall Test Results vs LSDYNA Analysis

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Out Of Plane Benchmarking

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Out Of Plane Shear Benchmarking

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Westinghouse

OOP BENCHMARKING – TEST VS. ANALYSIS

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OOP BENCHMARKING – TEST VS. ANALYSIS

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West Wall Level 2 vs Level 3 Stiffness Comparison

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LEVEL 2 vs. LEVEL 3 In-Plane Shear Comparison of West Wall

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LEVEL 2 vs. LEVEL 3 Tension Comparison of West Wall

AP1000

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Westinghouse

LEVEL 2 vs. LEVEL 3 Out Of Plane Shear Of West Wall

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Nuclear Island Shield Building
Level 3 Detail Modeling & Analysis

Wall-5 Benchmarking and Contrasting

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June 5, 2010

Westinghouse

Wall 5

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AP1000

Conclusions

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Westinghouse

AP1000

Comparison of Wall-5

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Westinghouse

Wall-5 Level-3 Model Description

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Wall-5 Level-3 Model Description

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Wall-5 Level-3 Model Description

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Loading Conditions of Level-3

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Wall-5 Level-2 Model Description

AP1000

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Westinghouse

Loading Conditions of Level-2 Model

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FEA Contrasting of Level-2 and Level-3

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Comparison of In-Plane Shear

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Westinghouse

Comparison of Out-of-Plane

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Comparison of Tension-Z

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Westinghouse

Air Inlet Level 3 Model Comparison

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Air Inlet Level-2 Model Description

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Air Inlet Level-3 Model Description

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Air Inlet Level-3 Model Description

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Comparison of Air Inlet In-plane Shear

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AP1000

NRC Staff Questions:

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Westinghouse

Drift Ratio

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Drift Ratio

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AP1000

Conclusions

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Westinghouse

4.1.1 Action 15 [ ]^{a,c}

Westinghouse will present an analysis of test specimens, using material [ ]^{a,c}, and indicate strain limits and the points where a [ ]^{a,c} would occur.

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4.1.2 Action 16 [ ]^{a,c}

Westinghouse will provide the benchmarking of the [ ]^{a,c} model to the staff.

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4.1.3 Action Item 17 [ ][a,c]

Provide the handoff procedure from the [ ][a,c].

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4.1.4 Action 18 (Out-of-Plane Shear Capacity for Tie Bars)

For tie bars, Westinghouse will determine whether [ ]^{a,c}.

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4.2 Issue 2 [

]^{a,c}

Westinghouse Position

Tie bars are spaced at 6 inches, 8 inches, and 17 inches as stated on page 4-1, and 7 inches on page 4-2, but only 6-inch and 17-inch spacings have been tested.

NRC Understanding

The staff does not know the strength (capacity) for tie bars spaced at 7 inches and 8 inches, because there is no test for them.

NRC Question

How does Westinghouse compute the out-of-plane shear strengths for the Shield Building with tie bars spaced at 7 inches and 8 inches?

4.2.1 Action 19

Westinghouse will provide the calculation basis for the tie bar spacing other than those that were explicitly tested [ ]^{a,c} Westinghouse will identify the regions where these nonstandard spacings were used, and demonstrate the capacity versus the demand in these regions and whether it is large.

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4.3 Issue 3 (Thermal Cracking Problem)

Westinghouse Position

The analysis results indicate that thermal cycling will cause vertical concrete cracking in the SC wall (page 3-50).

NRC Understanding

Westinghouse did not address effects of cracking on Shield Building design capacity.

NRC Staff

Given that Westinghouse has predicted vertical concrete cracks due to thermal cycling, what is the effect on the Shield Building design and capacity?

4.3.1 Action 20

Westinghouse will review the crack width assumption calculation used to evaluate the effect on design, including: cement content, coefficient of thermal expansion, and concrete volumetric expansion.

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4.3.2 Action 21

PCS Tank Design

1. What is the maximum height of the sloshing wave? How was it calculated? How much freeboard is provided?

2. How is the hydrodynamic pressure that is used in designing the tank walls calculated?

    a. Describe how impulsive and convective loads are calculated and applied in the Shield Building roof design
    b. Provide floor response spectra at top and bottom of the PCS tank
    c. Provide typical floor response spectra at PCS tank elevation extending down to 0.1 Hz (to show that spectra at roof elevation at this frequency are similar to the ground input motion).

3. What is the maximum deflection of the W36 x 393 beam? Provide mid-span deflection relative to ends of beam.

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