Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-8555
USA

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

Direct tel: 412-374-6206
Direct fax: 724-940-8505
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: DCP_NRC_002810

March 5, 2010

Subject: AP1000 Response to Request for Additional Information (TR 85)

Westinghouse is submitting responses to NRC requests for additional information (RAI) on Technical Report No. 85. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-TR85-SEB1-29 R1

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on Technical Report No. 85

D063
NRO

0461ljb.doc

cc:	D. Jaffe	-	U.S. NRC	1E
	E. McKenna	-	U.S. NRC	1E
	B. Gleaves	-	U.S. NRC	1E
	T. Spink	-	TVA	1E
	P. Hastings	-	Duke Power	1E
	R. Kitchen	-	Progress Energy	1E
	A. Monroe	-	SCANA	1E
	P. Jacobs	-	Florida Power & Light	1E
	C. Pierce	-	Southern Company	1E
	E. Schmiech	-	Westinghouse	1E
	G. Zinke	-	NuStart/Entergy	1E
	R. Grumbir	-	NuStart	1E
	D. Lindgren	-	Westinghouse	1E

ENCLOSURE 1

Response to Request for Additional Information on Technical Report No. 85

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-29
Revision: 1

Question: (Revision 0)

Once the various load combinations are obtained, describe how the design of the basemat is performed in accordance with ACI 349-01. Include in the description whether every 3D ANSYS finite element is designed for the resultant forces in accordance with the ACI 349 Code. Is this process automated by using a computer code or by hand calculations? Provide one example for the most critical concrete section in the mat for bending/membrane and one example for shear.

Additional Question: (Revision 1)

An additional question on the MACRO issue was sent by e-mail from B. Gleaves (NRC) to R. Sisk (Westinghouse) on 12/11/09 that stated in part, "It was brought to my attention by our contractor thru the NRC tech. staff that we have identified a potential issue with an output of WEC software. I will turn your attention to page 421 of your AP1000 Enhanced Shield Building report (the 1200-S3R report), at the top of the page, a negative Vc is calculated, resulting in a value of required Vs that exceeds Vu. This error highlights the need to review your software and identify if any generic concerns on its use should be brought to the attention of the NRC."

The question was answered by e-mail on 12/17/09 and 2/12/10; and on 2/24/10 the NRC requested that this information be submitted as an RAI response.

Westinghouse Response: (Revision 0)

The design procedure is described in APP-1010-CCC-005-rev.1 Section 4.2 "Calculation Approach / Methodology", which is shown below in the following pages. The calculation process is automated by an ANSYS macro; alternatively an Excel macro is also prepared. These macros are verified by APP-1000-CCC-001-Rev.2 "Verification of Design Macro for Reinforced Concrete Walls and Floors". Examples of element 4225 and 4526 for bending/membrane and for shear are shown below.

Maximum Axial-flexure rebar at element 4225 (Load Case 17)

Member Force Data at Load Case 17

ELEM	TX	TY	MX	MY	TXY	MXY	NX	NY
4225	0.1406E+03	-0.5063E+02	0.2716E+03	0.2106E+02	0.1226E+02	0.8734E+02	-0.2637E+01	0.1754E+02

Rebar ~~Calulaiton~~Calculation Data (by rebar calc macro)

ELEM AXTOP AXBOT AYTOP AYBOT AXYSH AXSHE AYSHE AXSUM AYSUM SHEAR
4225 0.2569E+01 0.1329E+01 0.1089E+01 0.1329E+01 0.0000E+00 0.0000E+00 0.0000E+00 0.2569E+01 0.1329E+01 0.0000E+00

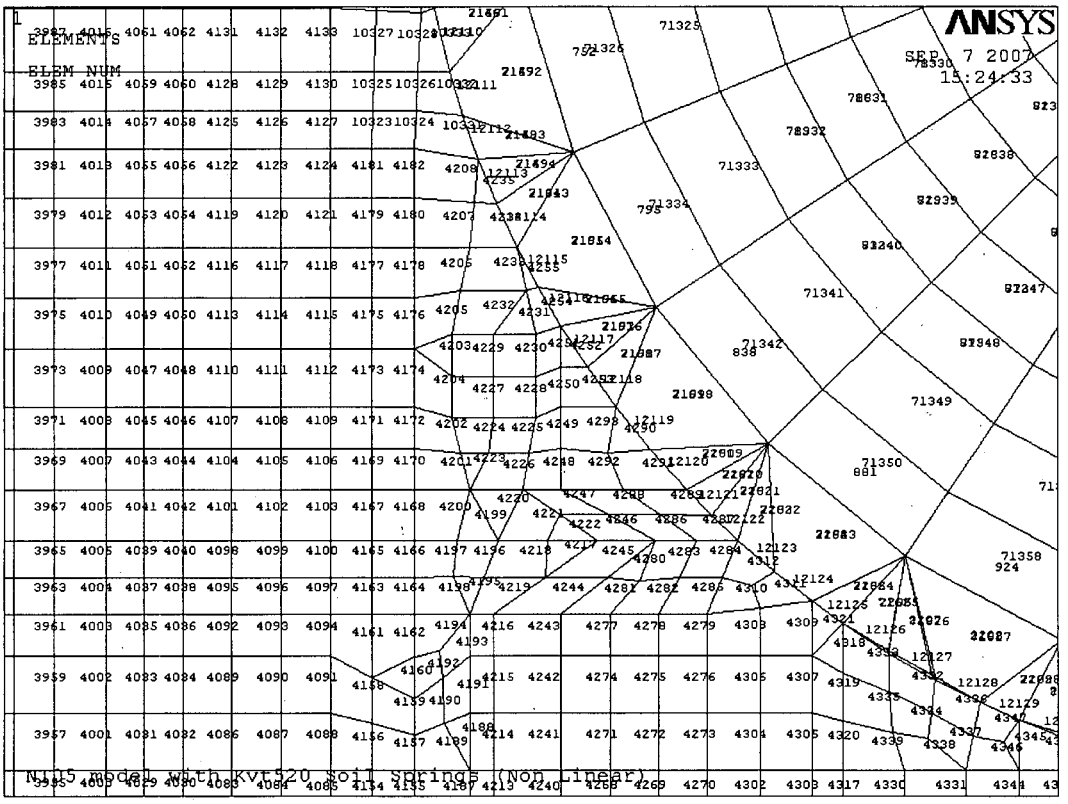
Final Design of elem 4225
ELEM EVXTP EVXBT EVYTP EVYBT
4225 0.3083E+01 0.2339E+01 0.2250E+01 0.7956E+00

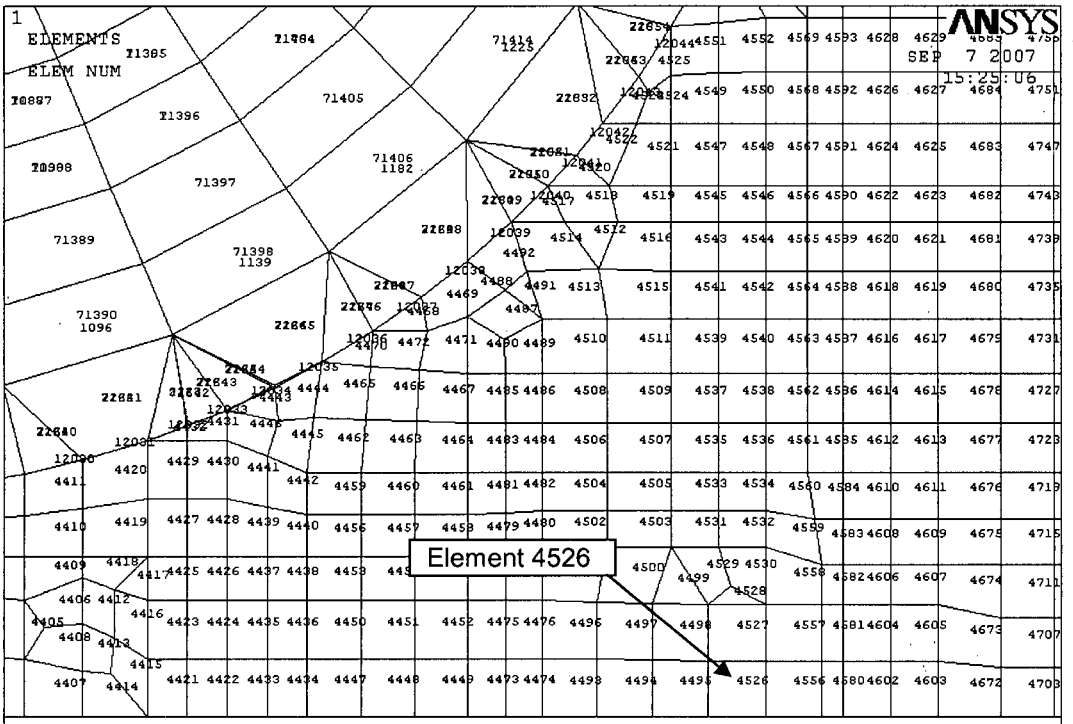
Maximum Shear rebar at element 4526 (Load Case 12)

20% increased ~~ember~~member Force Data at Load Case 12
ELEM TX TY MX MY TXY MXY NX NY
4526 -0.3479E+02 -0.1653E+02 0.5239E+01 -0.5769E+01 -0.3016E+02 -0.1140E+02 -0.7234E+01 0.6763E+02

Rebar ~~Calulaiton~~Calculation Data (by rebar calc macro based on the 20% increased ~~menber~~member force)
ELEM AXTOP AXBOT AYTOP AYBOT AXYSH AXSHE AYSHE AXSUM AYSUM SHEAR
4526 0.2592E+00 0.2592E+00 0.2592E+00 0.2592E+00 0.1359E+00 0.0000E+00 0.0000E+00 0.3272E+00 0.3272E+00 0.9618E+00

Final Design of elem 4526
ELEM EVSHR
4526 0.9618E+00


ELEMENTS
ELEM NUM
ANSYS
SEP 7 2007
15:24:33
N105 model with KVT520 soil springs (Non Linear)



NI05 model with Kvt520 Soil Springs (Non Linear)

[From APP-1010-CCC-005-rev.1]

4.2 Calculation Approach / Methodology

4.2.1 Calculation Procedures

The major loads (Dead, Live and SSE loads) are included in the FEM analyses. Firstly, member forces given from the FEM analyses are used to have a required reinforcement. Then, the effect to the reinforcement design by lateral earth pressure loads is to be evaluated. Table 4-1 shows the design procedure.

Table 4-1 Design Procedure for 6' basemat

Step 1	Calculate required reinforcement by the load combinations of 1.4x(LC1)+1.7x(LC2) and LC3-01 thru LC3-16 (shown as "LC3-**"). All cases' results are enveloped (see 4.2.6 for the method of enveloping) to define one map for required reinforcement.		by FEM analysis results Shown in6.1
Step 2	1a.	Select the critical lateral earth pressure case	by hand calculation shown in 6.2.1
	3a.	Evaluate the effect of the critical lateral earth pressure to the design given in Step 1.	
Step 3	Check compression and shear forces in critical elements to satisfy design requirement.		by hand calculation Shown in 6.2.2 thru 6.2.4

4.2.2 Calculation Parameters

The required reinforcement is calculated under the following conditions.

Compressive strength of concrete f'c = 4,000 psi or 576 ksf [27.6 Mpa]

Yield strength of reinforcement fy = 60,000 psi or 8640 ksf [414 Mpa]

Location of rebar on top face dtop = 2.0" + 1.5 x 1.693" = 4.540" [115.3 mm]

i.e. #14 rebar at the second layer with 2.0" cover

Location of rebar on bottom face dtop = 3.0" + 1.5 x 1.693" = 5.540" [140.7 mm]

i.e. #14 rebar at the second layer with 3.0" cover

The out-of-plane shear reinforcement is calculated with beam action per Section 3.3.2 of Reference 2. The beam action is more conservative for design of rebars.

4.2.3 Design Load

The following individual design load applicable to the basemat below Auxiliary Building is considered for use in the required reinforcement calculation as a part of load combinations specified in Table 3 of Reference 1. A unique LC number is assigned to each design load to be identified in the load combinations shown in Section 4.2.4.The following individual design load applicable to the basemat below Auxiliary Building is considered for use in the required reinforcement calculation as a part of load combinations

specified in Table 3 of Reference 1. A unique LC number is assigned to each design load to be identified in the load combinations shown in Section 4.2.4.

4.2.3.1 Dead Load and Live Load

The dead load and live load computed without liftoff in Reference 8 are used. These are single loads given from the linear analyses from Reference 8. These are numbered as follows.

LC1 Dead Load (D)

LC2 Live Load (L)

4.2.3.2 Wind and Tornado Loads

As all basemat areas are under the ground level and not exposed to the exterior, wind and tornado loads are not governing. Hence, Load Combinations 2, 4 and 8 of Civil/ Structural Design Criteria (Reference 1) are excluded.

4.2.3.3 Safe Shutdown Earthquake Loads

The equivalent static SSE member forces computed in Reference 8 are used. As a liftoff of the basemat may occur, SSE loads are combined with Dead and Live load in order to get the balanced liftoff condition. The follwoing16 cases for the 1.0-0.4-0.4 method from Reference 8 are used.

LC3-01: D+ L+ Es, Es=1.0xSns+0.4xSew+0.4xSvt
LC3-02: D+ L+ Es, Es= 1.0xSns+0.4xSew-0.4xSvt
LC3-03: D+ L+ Es, Es= 1.0xSns-0.4xSew+0.4xSvt
LC3-04: D+ L+ Es, Es= 1.0xSns-0.4xSew-0.4xSvt
LC3-05: D+ L+ Es, Es= -1.0xSns+0.4xSew+0.4xSvt
LC3-06: D+ L+ Es, Es=-1.0xSns+0.4xSew-0.4xSvt
LC3-07: D+ L+ Es, Es= -1.0xSns-0.4xSew+0.4xSvt
LC3-08: D+ L+ Es, Es= -1.0xSns-0.4xSew-0.4xSvt
LC3-09: D+ L+ Es, Es= 0.4xSns+1.0xSew+0.4xSvt
LC3-10: D+ L+ Es, Es= 0.4xSns+1.0xSew-0.4xSvt
LC3-11: D+ L+ Es, Es= 0.4xSns-1.0xSew+0.4xSvt
LC3-12: D+ L+ Es, Es= 0.4xSns-1.0xSew-0.4xSvt
LC3-13: D+ L+ Es, Es= -0.4xSns+1.0xSew+0.4xSvt
LC3-14: D+ L+ Es, Es= -0.4xSns+1.0xSew-0.4xSvt
LC3-15: D+ L+ Es, Es= -0.4xSns-1.0xSew+0.4xSvt
LC3-16: D+ L+ Es, Es= -0.4xSns-1.0xSew-0.4xSvt

4.2.3.4 Normal Thermal Load

As stated in Reference 1, operating thermal loads are not specifically included as a design load for the 6' basemat. This is consistent to Reference 3, where basemat is not listed as structures most subject to

potentially significant temperature effects.

4.2.3.5 Accident Pressure and Thermal Loads

Accident pressure loads inside containment are associated with a design basis accident. The containment design pressure (Pd) of 59 psig is applied with the consideration of Reference 1.

However there are no high stresses by Pd in the lower level of the auxiliary building, that is outside of the containment boundary, and no significant force is induced to 6' basemat by Pd. Therefore accident pressure loads are not included.

4.2.3.6 Lateral Earth Pressure Loads

The lateral earth pressure load is simply added as a combination of bending moment and axial load at the edge of the 6' thick basemat. The applied moment and axial load are based on the analysis results of Reference 9 to envelope the analysis results along the corresponding areas. The types of earth pressure loads are classified as follows; those are defined in Reference 10.

LC4: Ground water (to be included as a part of Live Load, L)
LC5: At rest earth pressure (Earth Pressure Load, H)
LC6: Passive earth pressure (to be included as a part of SSE Load, Es)
LC7: Dynamic earth pressure (to be included as a part of SSE Load, Es)
LC8: Static surcharge (to be included as a part of Dead Load, D)
LC9: Dynamic surcharge (to be included as a part of SSE Load, Es)

As the moment due to the lateral earth pressure is mostly affecting at the edge beneath the exterior walls of the basemat, the critical conditions of these elements under combined earth pressure loads are evaluated by the following method.

Extract the bending moment and out-of-plane shear force in vertical direction at the bottom elements of exterior walls calculated in Reference 9.

- Select a critical earth pressure load combination and select typical elements for the evaluation.
- Apply the forces to the elements in addition to the FEM analysis results. The out-of-plane shear force at the exterior wall is considered to be an axial force to the basemat.
- Evaluate the member force by the earth pressure and compare the design results of "without earth pressure case" and "with earth pressure case".

4.2.4 Load Combination

In accordance with the previous section, the following load combinations have been selected for the required reinforcement calculation. The first digit of the load combination number shown below is the

corresponding load combination number specified in Table 3 of the Civil/ Structural Design Criteria (Reference 1). In brackets [#] is applied sequential number for use in ANSYS analyses.

1a. 1.4x(LC1+LC8)+1.7x(LC2+LC4+LC5) [1]

3a. LC3-01+(LC8+LC4+LC5)+(LC7+LC9) [2]
LC3-02+(LC8+LC4+LC5)+(LC7+LC9) [3]
LC3-03+(LC8+LC4+LC5)+(LC7+LC9) [4]
LC3-04+(LC8+LC4+LC5)+(LC7+LC9) [5]
LC3-05+(LC8+LC4+LC5)+(LC7+LC9) [6]
LC3-06+(LC8+LC4+LC5)+(LC7+LC9) [7]
LC3-07+(LC8+LC4+LC5)+(LC7+LC9) [8]
LC3-08+(LC8+LC4+LC5)+(LC7+LC9) [9]
LC3-09+(LC8+LC4+LC5)+(LC7+LC9) [10]
LC3-10+(LC8+LC4+LC5)+(LC7+LC9) [11]
LC3-11+(LC8+LC4+LC5)+(LC7+LC9) [12]
LC3-12+(LC8+LC4+LC5)+(LC7+LC9) [13]
LC3-13+(LC8+LC4+LC5)+(LC7+LC9) [14]
LC3-14+(LC8+LC4+LC5)+(LC7+LC9) [15]
LC3-15+(LC8+LC4+LC5)+(LC7+LC9) [16]
LC3-16+(LC8+LC4+LC5)+(LC7+LC9) [17]

3b. LC3-01+(LC8+LC4)+(LC6+LC9) [18]
LC3-02+(LC8+LC4)+(LC6+LC9) [19]
LC3-03+(LC8+LC4)+(LC6+LC9) [20]
LC3-04+(LC8+LC4)+(LC6+LC9) [21]
LC3-05+(LC8+LC4)+(LC6+LC9) [22]
LC3-06+(LC8+LC4)+(LC6+LC9) [23]
LC3-07+(LC8+LC4)+(LC6+LC9) [24]
LC3-08+(LC8+LC4)+(LC6+LC9) [25]
LC3-09+(LC8+LC4)+(LC6+LC9) [26]
LC3-10+(LC8+LC4)+(LC6+LC9) [27]
LC3-11+(LC8+LC4)+(LC6+LC9) [28]
LC3-12+(LC8+LC4)+(LC6+LC9) [29]
LC3-13+(LC8+LC4)+(LC6+LC9) [30]
LC3-14+(LC8+LC4)+(LC6+LC9) [31]
LC3-15+(LC8+LC4)+(LC6+LC9) [32]
LC3-16+(LC8+LC4)+(LC6+LC9) [33]

9 is virtually same as 1 (as Pd is not considered)

10 is virtually same as 3 (as Pd is not considered)

4.2.5 Design Margin

As stated in 3.1, the calculated reinforcement (required amount) is increased to be 20% more for the axial-flexure reinforcements, and the member force from the analyses is increased to be 20% more for the design of shear reinforcement design. Therefore, in addition to the above load combinations ([1] to [33]), another set of load combinations is analyzed for shear reinforcement calculation where all loads are 1.2 times larger. The other set of load combination (only for the shear reinforcements) has the same load combination number as the above load combinations.

4.2.6 Required Reinforcement Calculation

At the Step 1 calculation shown in Table 4-1, the required reinforcement is calculated by each load combination using the ANSYS design macro from Reference 4. The overall reinforcement requirement is given from the following procedures. Calculation results are shown in Appendix D (for Step2) and "rebar_data.xls" in the attached zip file (for Step1 and Step2).

- Step1: Calculate top and bottom reinforcement separately. The design summaries (AXSUM and AYSUM) by the ANSYS design macro are prepared for walls and floor slabs where design reinforcements at both sides are the same. However this condition is not appropriate for the basemat because of expected difference of design reinforcement between top and bottom sides at the basemat. Therefore, the following calculation (given from section 3.4 of Reference 2) is added to get top and bottom reinforcement separately.

Axtop = Greater of Axtopaxial or (Axtopaxial+flexure + Axbotaxial+flexure + Axyshear + Axshear)/2
Axbot = Greater of Axbotaxial or (Axtopaxial+flexure + Axbotaxial+flexure + Axyshear + Axshear)/2
Aytop = Greater of Aytopaxial or (Aytopaxial+flexure + Aybotaxial+flexure + Axyshear + Ayshear)/2
Aybot = Greater of Aybotaxial or (Aytopaxial+flexure + Aybotaxial+flexure + Axyshear + Ayshear)/2
AStirrup = Axtransverse shear + Aytransverse shear

- Step2: The above calculation is one of design results usable, but the following adjustment is done in the 6' basemat where the same or more reinforcements are kept. This adjustment is intended to reduce the topside of the reinforcement within structurally reasonable. This step is not applied for the topside rebars of the four pit areas are where the Step 1 results are used. Bottom side rebars of the pit areas uses Step 2 where the Step1 results are confirmed to be enveloped.

Ax'top = Greater of 2.25 or Axtop - Axyshear /2
Ax'bot = Greater of 2.25 or Axtop + Axbot - Ax'top

Ay'top = Greater of 2.25 or Aytop - Axyshear /2
Ay'bot = Greater of 2.25 or Aytop + Aybot - Ax'top

- Step3: Envelope the calculated reinforcement requirement (Ax'top, Ax'bo, Ay'top, Ay'bot, and AStirrup) at all load combinations.

Westinghouse Response: (Revision 1)

The structural manager confirms that four different people have confirmed that the EXCEL spreadsheet that the NRC has commented on is correct. Westinghouse can explain and clarify what NRC perceives to be an error.

The following information and response was e-mailed from S. Altmayer (Westinghouse) to B. Gleaves (NRC) on 12/17/09 and on 2/12/10. Westinghouse looked into the subject concern of the NRC staff and discussed it with our technical experts who summarized their explanation in the specific **"MACRO Technical Response Details"** reprinted below.

We also discussed this proposed clarification and action briefly with NRC staff B. Thomas and D. Jaffe on the 12/17/09 shield building status call. We would point NRC to the references in SB Design Report Rev. 0 (pg. 50, pg. 60, pg. 299: Ref. 3-2 (APP-GW-S1-008, Rev. 1), Ref. 3-3 (APP-1000-CCC-001, Rev. 3), and Ref. 3-4 (APP-1000-CCC-002, Rev. 0)) as the explicit approved/validated basis for why the issues raised are not an error or oversight. These calculations and basis documents represent validated/verified MACROs. Earlier revisions of some of these calculations have been audited by NRC in the past and found acceptable. We believe them to be accurate and error-free as documented through our quality assurance system and document control program. Westinghouse suggests that NRC consider making this an action item for more detailed review by NRC during the next audit in 2010.

MACRO Technical Response Details:

Subject: Potential 10 CFR Part 21–Type Reportable Defect

Reference: Bill Gleaves (NRC Senior Project Manager) e--mail to Rob Sisk (December 11, 2009 2:34 PM)

In the referenced email, the NRC informed Westinghouse that the NRC staff thought there was an error in the Westinghouse 'EXCEL Macro to Size Reinforcement'. (Note: This macro was included in the WEC 'Enhanced Shield Building Design Report', APP-1200-S3R-003, as Appendix D). The referenced email indicated that on page 421 of the report, a negative value of Vc was inappropriate.

Westinghouse Response:

The segment of the macro on page 421 of 'Enhanced Shield Building' report (APP-1200-S3R-003, Rev 0)

was reviewed. It was determined that there is no error in this segment of the output of this software.

(a) A negative value of Vc indicates that the macro has detected that concrete is in tension with tension greater than 500 psi. Therefore, the macro does not use the strength provided by concrete as explained below.

- The macro calculates the shear force (fi Vs) as [Vu - MAX(0,fi Vc)]. This MAX (0,fi Vc) is included in the Excel cell but not shown in the descriptive text.

- For a negative Vc, MAX (0,fi Vc) is zero. The strength provided by concrete is ignored.

(b) It may be noted that the Westinghouse EXCEL macro gives the same results as a similar ANSYS macro. The text for the ANSYS macro is shown below.

```
! IN-PLANE SHEAR REINFORCEMENT FOR FLOOR SLABS
! documented in APP-1000-CCC-001, Rev 4
! by Obayashi Corporation

 fi=0.85
 VU=ABS(TXY)

 NU=-TX   ! NU to be negative in tension

 *IF,TX,LT,TY,THEN
  NU=-TY
 *ENDIF

! Shear strength provided by concrete

 *IF,NU,GT,0,THEN
  VC=2*SQRT(fc)*h*b
 *ELSE
  VC=2*(1+NU/(500*h*b))*SQRT(fc)*h*b
  *IF,VC,LT,0,THEN
   VC=0.0
  *ENDIF
 *ENDIF

! Required shear strength provided by reinforcement

 VS=(VU-fi*VC)/fi
 *IF,VS,LT,0,THEN
  VS=0.0
 *ENDIF

! Required shear reinforcement

 ASHEAXY=VS/fy
```

Conclusion:
- The two macros are consistent.
- There is no error in the segment of the output of this software (identified by the NRC for review).

A brief explanation of the calculation on page 421 of 'Enhanced Shield Building' report (APP-1200-S3R-003, Rev 0)

3.2 In-plane shear:

In-plane shear reinforcement required = Vu / Φ

= 216601 / 0.85

= 254825 lb. (1)

In-plane shear strength provided = Vn

= Vc + Vs
(Provided by concrete) + (Provided by reinforcement)

= 0 + 254825 lb. (2)

Therefore, when Vc is negative (-58965 lb), the macro considers the shear strength provided by concrete as zero. The in-plane shear strength demand is fully met by the reinforcement area.

Required area of reinforcement Av = 254825 lb / 65000 lb/ in^2
= 3.9204 in^2

References:

1. APP-1010-CCC-005 Rev 1
2. APP-1000-CCC-001 Rev 2

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None