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John H. Garrity
Vice President, Watts Bar Nuclear Plant

APR 30 1992

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

Gentlemen:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

WATTS BAR NUCLEAR PLANT (WBN) - UNITS 1 AND 2 - RESPONSE TO STAFF REQUEST FOR ADDITIONAL INFORMATION (RAI) - SHEAR TESTING OF SHALLOW UNDERCUT ANCHORS

Reference: TVA Letter from J. H. Garrity to USNRC Document Control Desk dated October 16, 1991, "WBN Test Program for the Evaluation of Shear Capacity of Shallow Undercut Anchors - Summary Report"

During a teleconference on March 31, 1992, the NRC requested the following additional information relative to the shear testing program for shallow undercut anchors (see referenced summary report):

1. Basis for the allowable shear loads for shallow undercut anchors.
2. Information on the interaction requirements for shallow undercut anchors.
3. If available, shear load/deflection test data for cast-in-place anchors for comparison to the shallow undercut anchor test results.

RESPONSE

Item 1

TVA Civil Design Standard DS-C1-7.1 provides the allowable shear loads for the shallow undercut anchors. The allowable shear loads for the 1/2-, 5/8-, and 3/4-inch diameter anchors are 5.0, 7.9, and 11.7 kips, respectively. These allowable loads are based on 0.33 Fy and apply to all loading conditions. The factor of safety for these allowable loads is not specifically stated in the design standard since a designer will use the allowable stress provided. The intent was to apply a factor of safety of 2 for the steel shear failure mechanism. The factor of safety from the tests exceeds 2 for all sizes. The enclosed pages (6, 16, and 17) from the design standard show the allowable anchor stress and allowable loads.

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Item 2

The enclosed pages (33 and 34) from the design standard provide the requested interaction equation information.

Item 3

Compatible shear load/deflection test data for cast-in-place anchors is not available. TVA's shear load/deflection data for cast-in-place anchors is for anchors preloaded to yield. The shallow undercut anchors were tightened snug tight. Preloaded anchors are stiffer than anchors tightened snug tight.

If you have further questions this subject, please telephone P. L. Pace at (615) 365-1824.

Sincerely,

John H. Garrity

John H. Garrity

Enclosure
cc (Enclosure):
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2.0 DUCTILE ANCHORS (Continued)

Table 1

Ductile and Undercut Anchor Design Data

Type of Anchor	Allowable Service Load Stress F_{sa} (k/in^2)	Minimum Yield Stress F_y (k/in^2)	Minimum Tensile Stress F_{ut} (k/in^2)
A307 and A36 Bolts	20.0	36.0	60.0
A325 Bolts (1/2 through 1 inch)	51.0	92.0	120.0
A325 Bolts (1-1/8 through 1-1/2)	45.0	81.0	105.0
A108 Welded Studs	See subsection 2.3.1	44.0	60.0
A193 Undercut Anchors	52.5	105.0	125.0

For welded studs, the allowable service load stress shall be determined from equation 2 or 3. (Reference: CEB Report 79-18).

$$F_{sa} = 0.55\ F_y - 6.0\sqrt{e/t - 2} \quad \text{for } e/t > 2 \quad \text{(equation 2)}$$

or

$$F_{sa} = 0.55\ F_y \quad \text{for } e/t \leq 2 \quad \text{(equation 3)}$$

where:

e = The minimum clear distance between the attachment welded to the embedded plate and the centerline of the welded stud (inches).

t = The plate thickness (inches).

When welded studs stresses are determined using the Baseplate II computer program, equation 2 does not apply and the allowable welded stud stresses shall be determined using equation 3 for all values of e/t [see calculation CSG-87-120 (B41 870828 004)]. RS

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TABLE 3a

UNDERCUT ANCHOR LOAD TABLE

Size	Max Allowable Load (Kips)	
	T_o [4]	V_o [5]
1/4	1.7	1.1
3/8	4.1	2.7
1/2	7.5	5.0
5/8	11.9	7.9
3/4	17.5	11.7
1	31.8	21.2
1-1/4	52.5	35.0

Notes for Table 3 and 3a:

1. All dimensions in inches.
2. Length equals the total length of the anchor. The minimum length anchor which provides the required capacity should be used to reduce drilling
3. Embedment depth equals the sleeve length for Type I installations. For Type II installations, embedment depth equals the sleeve length minus the attachment thickness. If design output documents allow baseplate or attachment thickness to be increased by the installer, the tolerance must be deducted from the embedment for Type II installations. Grout, if any, must be included in the attachment thickness.
4. T_o is calculated in accordance with equation 4 which assumes ductile steel failure. These values are for evaluation of steel capacity using Equation 8. In many cases, anchor failure will be a non-ductile concrete failure due to spacing, embedment, or edge conditions. The ultimate tensile capacity of the concrete must be checked in accordance with Section 7 and 8 in all cases.

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5. V_o is calculated as $\frac{A_{st} \times F_{sa}}{R}$, where R is assumed to be 1.5. These values are for evaluation of steel capacity using Equation 8. For other plate configurations (grouted plates, etc.) the V_o value must be adjusted using the appropriate R-value given in Section 5.3. For UC anchors adjacent to a concrete edge, the shear capacity may be controlled by non-ductile concrete capacity. The ultimate shear (push-off) capacity of the concrete must be checked in accordance with Section 8 in all cases.

6. Minimum concrete thickness is 4/3 of the anchor embedment.

7. Minimum concrete thickness may be decreased by 4/3 times the actual attachment thickness for Type II installations (see G-66).

8. Minimum spacing is the recommended minimum spacing. Smaller or larger spacings may be used as necessary. Concrete pullout capacity must be evaluated for all installations regardless of spacing (see Note 4).

9. Minimum edge distances are the minimum recommended edge distances. Concrete shear (push-off) capacity must be evaluated for all installations adjacent to an edge (see Note 5).

10. Maximum attachment thickness for Type I UC anchors is equal to the (length) - (sleeve length) - (2 bolt diameters). If design output documents provide the field a tolerance for increasing the plate thickness, the tolerance must be subtracted from the tabulated value unless actual plate thickness is known.

5.0 ANCHOR DESIGN (Continued)

3. Determine the tensile loads in the individual anchors in accordance with subsection 5.1. Revise the number, size, and location of the anchors if necessary to optimize the design or reduce anchor stresses or loads.

4. Determine the frictional resistance between the baseplate and the concrete in accordance with subsection 6.1. If the frictional resistance is greater than the applied shear, the connection meets the requirements for a friction connection and no additional computations are required. If the frictional resistance is less than applied shear, the connection is a bearing connection and shear must be distributed to the anchors in accordance with subsection 5.3 or shear lugs must be provided in accordance with subsection 5.4. If the moment about an axis parallel to the anchors (torsion) is significant, the connection should be considered to be a bearing connection.

5.3 <u>Distribution of Shear to Anchor for Bearing Connection</u>

For bearing connections where the applied shear load passes through the centroid of the anchor group, the shear on each anchor shall be determined by dividing the load by the number of anchors. For bearing connections with moments about an axis parallel with the anchors (torsion), the shear on each anchor shall be determined using classical structural steel connection design techniques.

The combined effect of shear and tension shall be evaluated using equation 7 for ductile anchors and equation 8 for expansion anchors, undercut anchors, and strip inserts.

$$\frac{T_i + R\,V_i}{T_o} \leq 1.0 \qquad \text{(equation 7)}$$

$$\left(\frac{T_i}{T_o}\right) + \left(\frac{R\,V_i}{1.5\,V_o}\right) \leq 1.0 \qquad \text{(equation 8)}$$

where:

T_i = the calculated tensile load on the anchor

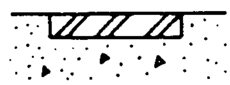
V_i = the calculated shear load on the anchor

T_o = the allowable tensile load on the anchor for tensile loading only

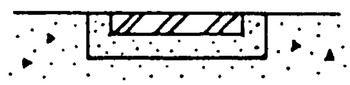
V_o = the allowable shear load on the anchor for shear loading only

5.0 ANCHOR DESIGN (Continued)

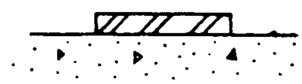
R = 1.10 for embedded plates with the exposed surface of the steel coincidental with the concrete surface. (If free concrete edge less than 4 inches from edge of embedded plate, use R = 1.5)



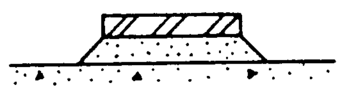
R = 1.25 for plates with recessed grout pads with exposed surface of the plate coincidental with the concrete surface



R = 1.5 for surface mounted plates



R = 1.85 for plates supported on a grout pad with the contact surface exterior to the concrete surface



When shear is directed toward a free edge, the capacity of the concrete shall be evaluated in accordance with Section 8.0.

For evaluation of expansion anchors, UC anchors and strip inserts for existing supports, the combined effects of shear and tension may be evaluated using the following equation:

$$\left(\frac{T_i}{T_o}\right)^{1.7} + \left(\frac{R\,V_i}{1.5V_o}\right)^{1.7} \leq 1.0$$

For evaluation of ductile anchors for existing supports, the combined effects of shear and tension may be evaluated using the following equation:

$$\left(\frac{T_i}{T_o}\right)^{1.7} + \left(\frac{R\,V_i}{T_o}\right)^{1.7} \leq 1$$

Note: The above equation should be utilized to evaluate existing supports however it may be used to reduce the anchor size in a new installation. RS