ENCLOSURE

WATTS BAR NUCLEAR PLANT UNITS 1 AND 2
TENSILE ANCHOR CAPACITIES LOWER THAN ASSUMED IN DESIGN ALLOWABLES
NCR CEB 79-6
10 CFR 50.55(e)
FINAL REPORT

Description of Deficiency

Progressive cracking of the heat affected zone of welded stud anchors in flexible plate connections has occurred in TVA general research and development program tests. This results in lower tensile anchor capacities than assumed in establishing design allowables.

Safety Implications Statements

Based on the results and conclusions of the testing program, a review of welded anchorages found the anchorages were adequate and would perform as designed under design loadings. Therefore, had the deficiency gone uncorrected, it would not have adversely affected plant safety.

Corrective Action

When this problem was discovered, a testing program was initiated to qualify the effect of plate flexibility on stud capabilities to withstand design loadings. The results of the tests are contained in CEB Report 79-18 (Attachment 1). Based on the results of this report, guidelines were provided to evaluate and qualify the welded stud anchorages at Watts Bar Nuclear Plant (Attachment 2). A review of anchorages in safety applications was conducted in accordance with these recommendations and guidelines. This review determined the anchorages were adequate.

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ATTACHMENT 2

TVA 64 (08-9-63)

UNITED STATES GOVERNMENT

Memorandum

CEB 790710 007

TENNESSEE VALLEY AUTHORITY

79071780241 (37)

TO : Those listed

FROM : R. G. Domer, Chief, Civil Engineering Branch, W9D224 C-K

DATE : July 16, 1979

SUBJECT: ALL PROJECTS - WELDED STUD ANCHORAGES - QUALIFICATION OF DESIGN TO ACCOUNT FOR REDUCED STUD CAPACITIES DUE TO PLATE FLEXIBILITY

CEB Report No. 79-18 "Effect of Plate Flexibility on Stud Capacity" is attached. It contains the results of our testing of welded studs in flexible plates, our evaluation of the results, and our recommendations for design.

The recommendations of the report were further substantiated in tests performed at UT on June 28, 1979. A 1-inch-thick plate 16 inches square with 9-3/4-inch studs spaced 6 inches on centers was tested to failure. The attachment was a 7-x 7-x 1/2-inch tube section with the tensile flange located 3-1/2 inches below the tope line of anchors. The minimum estimated failure load using the recommendations of 79-18 in a flexible analysis was 920 inch kips. The peak moment attained at initial anchor failure was 1070 inch kips. In the UT tests a controlled loading rate is only possible within the 1/2-inch deflection range of the LVDT. After removal of the LVDT the rate of loading is very rapid. Under controlled loading the peak moment could conceivably have been even less. All three modes of failure were present in this test. The center stud which apparently failed first, failed at the top of the ferrule in the stud. One top corner stud pulled a slight depression out of the plate. The other corner stud appeared to fail in a straight line across the bottom of the plate. The interior anchor which had e/t of approximately 2 failed by a traditional tensile neck down of the stud.

For design qualifications it does not appear reasonable to require a higher safety factor for reduced capacities than was originally required. Civil Design Standard DSC6.1 required a maximum safety factor of 2.5 for service load conditions as applied to a minimum 60-ksi tensile strength requirement for stud material. This should therefore be the maximum safety factor used in comparing designs with anchorage capacities of flexible connections.

If we assume the attachment and attachment plates are both stressed to their full service load allowables of 0.55 fy and apply a factor of 2.5 to establish minimum ultimate requirements for the anchorage, then significant nonlinear straining of attachment, attachment plates, and anchors will occur prior to failure of the anchorage. Any nonlinearity which occurs in the system will subdivide the energy in the system decreasing the energy in the fundamental mode and thereby restricting the maximum loading which any anchorage can see. It therefore appears that any ductile anchorage that can sustain the initial peak loading condition without failure will not fail under seismic

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loading. Under these conditions there appears to be no need to require anchorage capacities equal to or greater than attachment capacities. It should only be necessary to apply a sufficient safety factor to assure that the anchorage capacity will sustain the initial peak loading condition.

Note: Exhibits 16-21 are contained in CEB Report 79-18 as exhibits 16-21.

Recommendations for conservative estimation of anchorage capacities are contained in attached CEB Report No. 79-18. Also attached are copies of exhibits 16-21 on which we have shown tube section limitations based on a safety factor of 2.5 for service loading. For any given attachment width and plate thickness the design is automatically qualified if the anchorage capacity exceeds the tube section limits shown. When the tube section limits exceeds the anchor capacity for a given attachment width and plate thickness then stiffners are required to match the tube section limits. This can be determined by following the tube section lines to the proper plate thickness and reading the out-to-out width requirements for the stiffners.

Where the need for stiffners is indicated and cannot be provided then anchor capacities within 80 percent of the indicated tube section limitations may be assumed as acceptable. For the larger tube sections even this reduction may not be sufficient to qualify the attachment without stiffners. Under these conditions a reanalysis of the peak seismic loading accounting for the effect of base rotation on attachment response may reduce loads sufficiently to provide a minimum factor of safety of two. For those attachments that cannot be stiffened or qualified by the above methods it may be necessary to instigate a testing program to verify design conservatisms or to establish the maximum seismic loads which can be developed through connections undergoing nonlinear strains.

When the spacing limitations of CEB Report No. 79-18 for attachments cannot be met, the two attachments may be tied together with bracing so that neither attachment is dependent on the questionable anchors which are between the attachments.

We are available at any time to meet with project personnel to discuss our recommendations and to assist in establishing whatever corrective action appears needed to qualify designs effected by plate flexibility. Ron Guthrie will contact you to establish a time table for disposition of project NCR's on the subject and to arrange for any needed meetings for discussions.

R. G. Domer

R. M. Hodges, W7C126 C-K
R. M. Pierce, 204 GB-K (2)
H. C. Russell, W5C126 C-K
J. P. Vineyard, W6D224 C-K

RGD:RWC:EES
Attachment

cc: MEDS, E4B37 C-K - w/attachment