LONG ISLAND LIGHTING COMPANY

SHOREHAM NUCLEAR POWER STATION

P.O. BOX 618, NORTH COUNTRY ROAD • WADING RIVER, N.Y. 11792

SNRC-458

January 14, 1980

Mr. Boyce Grier, Director
Office of Inspection and Enforcement
Region 1
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, Pa 19406

I&E Bulletin 79-02
Shoreham Nuclear Power Station - Unit 1
W. O. 44430/48923

Dear Mr. Grier:

Enclosed is the revised response to I&E Bulletin 79-02 concerning base plate designs using concrete expansion anchor bolts. The report responds to all inquiries described in I&E Bulletin 79-02 including Revisions 1 and 2.

If you require any further information regarding the enclosed report, we will be pleased to discuss it with you.

Very truly yours,

J. P. Novarro
Project Manager
Shoreham Nuclear Power Station

CKS:mc

cc: Mr. Victor Stello, Dir
Office of Inspection & Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

J. Higgins, NRC Site

FC-8935

8003050137

## RESPONSE TO I&E BULLETIN NO. 79-02 REVISION 2

## PIPE SUPPORT BASE PLATE DESIGN USING DRILLED-IN ANCHORS

I&E BULLETIN 79-02 (Revision 2) raises questions with regard to pipe support base plate design. The following items are in response to inquiries concerning base plate flexibility, anchor bolt design loads and their factors of safety, cyclic loading, and Q.C. documentation for installation and inspection of base plates.

ITEM (1) "Verify that pipe support base plate flexibility was accounted for in the calculation of anchor bolt loads".

The component support base plates are analyzed by modifying the simplified method of column base plates (Reference 3) with a load factor to determine the maximum bolt tension due to direct loads and prying effects of plate deformation. The load factors were determined from the proprietary parametric studies of rectangular and square plates, using the elastoplastic finite element analysis computer program ANSYS (Reference 4). Plate flexibility, anchor stiffness, stiffening effect on member attached to the plate, as well as concrete flexibility, are represented in the model. The contact boundary conditions at the interface of the plate and concrete and plate and drilled-in anchors are satisfied in the solution.

The ANSYS 3 finite element package was used for analysis. The element model considers pure plate bending, appropriate for the analysis of flexible base plates. The concrete and drilled-in anchors are both modelled with the "combination" gap elements which both model the stiffness of these components as well as represent the contact boundary conditions discussed previously. Finally, forces are applied as couples and axial forces distributed to nodes of the attached member.

The bolt patterns and plate thickness are variables in the parametric study, and the load factor is the ratio of the highest tension bolt load computed by finite element analysis to the maximum bolt tension load obtained from the simplified method. The parametric study showed that the simplified method for column base plates (Reference 3) was conservative for low span to thickness ratios and unconservative for larger ratios where prying actions became significant. Plates with low ratios were conservatively assumed rigid, while load factors were applied to plates with large span to thickness ratios. Based upon results of the above parametric studies, an acceptance criteria to determine whether the base plate should be considered flexible, more realistic than that presented in I&E Bulletin No. 79-02 (Revision 2), is used.

ITEM (2) "Verify that the concrete expansion anchor bolts have the following minimum factor of safety between the bolt design load and the bolt ultimate capacity determined from static load tests..."

The anchor bolts used for component supports in the LILCO-Shoreham plant are the "wedge" type concrete anchor bolts. The **holding** capacity of these anchor bolts is derived from the expansion of steel wedges against the sides of holes drilled in concrete (eg., Hilti Kwik-Bolts). The tension/shear interaction diagram used for the anchor bolt design is shown in Figure 1, based upon the criteria given in Reference 1. The allowable tension loads for all anchor bolts are based upon the test results for Hilti Kwik-Bolts from an independent laboratory provided by the manufacturer (Reference 2), using a minimum safety factor of 4.0 on pullout. In addition to the use of Hilti Kwik-Bolts, Phillips Red Head and Universal Thunderstuds are also used. Manufacturer's data shows that generally the Phillips Red Head bolts have a higher pullout capacity than the Reference 2 data. The data available for the Thunderstud type bolts indicates that the loads are lower than those defined in the Reference 2 data for selective bolts sizes. Based on a concrete compressive strength of 4,000 psi, the factor of safety against pullout for these selective bolt sizes would be a minimum of 3.0. This is in agreement with the design requirements of ACI 349-76 "Code Requirements for Nuclear Safety Related Concrete Structures", Appendix B, Section B.7.2. The balance of Thunderstuds and all other wedge-type anchor bolts used in the Shoreham Plant have a minimum factor of safety against pull-out of 4.0.

A recent test program to determine actual in-place concrete compressive strengths of Seismic Category I structures has been completed. The test results show that 100% of the concrete represented by these tests has a compressive strength in excess of 5,000 psi. Therefore, as noted above, an additional conservatism has been applied to the stated factors of safety by the utilization of a design compressive strength of 4,000 psi.

In the design of anchor bolts for the Shoreham plant, specifications of minimum embedment, minimum spacing, minimum edge distance, and minimum concrete compressive strength ($f_c$) are incorporated to provide assurance that use of these allowable tension loads will maintain the minimum factors of safety as outline above. If these specifications cannot be met, allowables are reduced linearly with respect to the reduced dimension (embedment depth, bolt spacing, etc.).

ITEM (3) "Describe the design requirements, if applicable, for anchor bolts to withstand cyclic loads..."

Industry test results of concrete anchor bolts subjected to cyclic loadings conclude that bolt integrity is unaffected by cyclic loadings as long as bolts are properly "set" during installation. The bolt "set" and a resulting bolt preload is achieved by applicantion of the installation torques specified in SNPS-1 procedures.

ITEM (4) "Verify from existing QC documentation that design requirements have been met..."

4 (a) Cyclic loadings have been addressed in Item (3) above. Verification that installation requirements are met is accomplished as described in Item 4 (b).

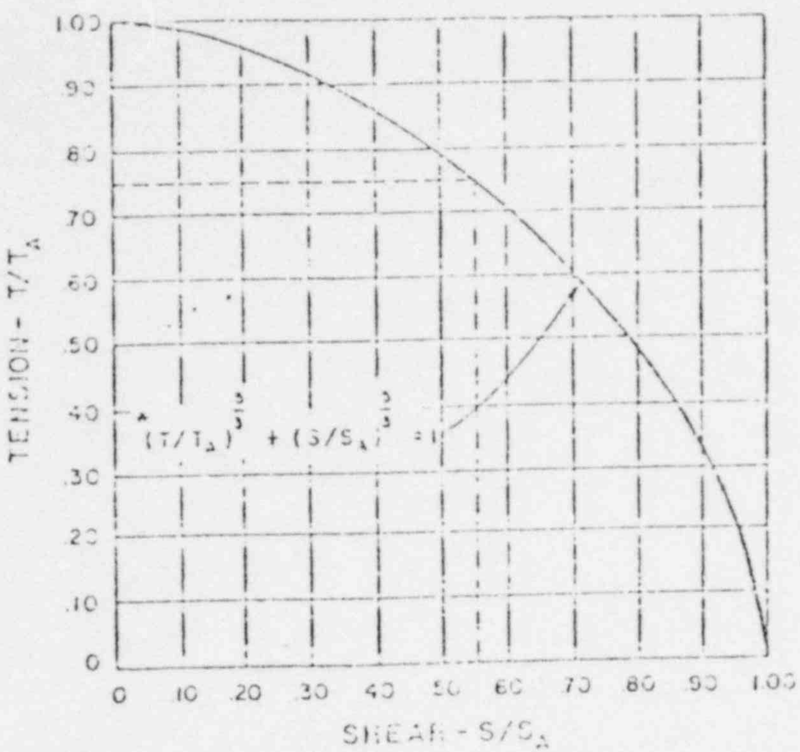
4 (b) Field Quality Control Procedure QC-11.4 requires inspection of anchor bolts for Category I pipe supports and restraints. The inspection ensures that bolt diameter and length, embedment depth, and installation torque (and thus cyclic load capacity) are in accordance with design requirements. This procedure has been implemented for all Category I anchor bolt installations, thus verifying the design requirements are met.

ITEM (5) "Determine the extent that expansion anchor bolts were used in concrete block (masonrey) walls to attach piping systems..."

A review of Seismic Category I and other safety related piping systems has indicated that <u>none</u> of these systems are attached to concrete block walls.

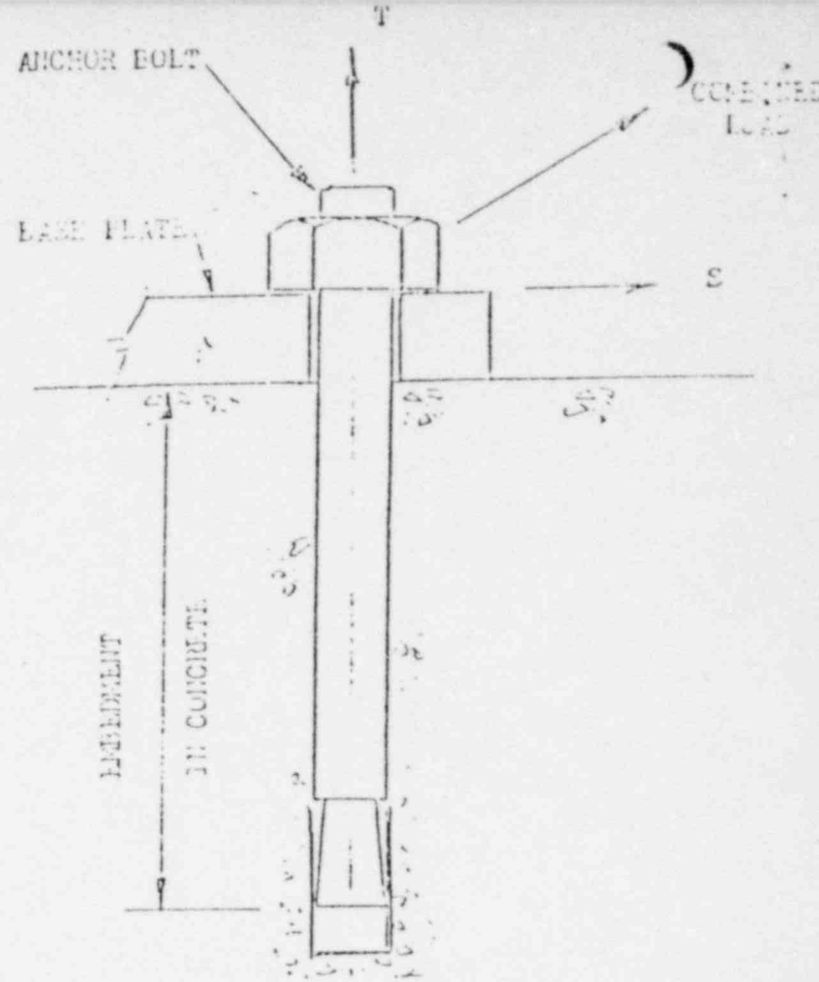
ITEM (6) "Determine the extent that pipe supports with expansion anchor bolts used structural steel shapes instead of base plates."

Use of expansion anchors in structural steel shapes other than base plates in Seismic Category I piping systems is limited to small bore (2 inch and under) piping systems. A Stone & Webster technical guideline, containing several standard, pre-qualified designs of supports for small bore piping, includes a support of the type described in Item (6) of I&E 79-02, Revision 2. This standard support consists of a 5" x 9" channel secured to concrete by 3/4 inch wedge-type anchor bolts through the channel web and equally spaced along the longitudinal center line. It is the only pipe support type involving the use of anchor bolts in structural members other than base plates in Seismic Category I piping systems. This standard pipe support was reviewed in accordance with existing approved methods for base plate stiffness evaluations as discussed in Item (1) above and found to be satisfactory.




COMBINED LOAD

TO DETERMINE COMBINATION OF SHEAR AND TENSION ON EACH BOLT, ENTER CHART WITH THE RATIO OF ACTUAL TENSION TO ALLOWABLE TENSION AND FIND THE RATIO OF ACTUAL SHEAR TO ALLOWABLE SHEAR




T = APPLIED TENSION PER BOLT (LBS)
S = APPLIED SHEAR PER BOLT (LBS)
$T_A$ = ALLOWABLE TENSION PER BOLT (LBS)
$S_A$ = ALLOWABLE SHEAR PER BOLT (LBS)

FIGURE 1

TENSION - SHEAR INTERACTION DIAGRAM

SHOREHAM NUCLEAR POWER STATION - UNIT 1

REFERENCES:

1. McMackin, P. J. Slutter, R. C., Fisher, J. W., "Headed Steel Anchor Under Combined Loading", AISC Engineer Journal, Second Quarter, 1973.

2. Abbot A. Hawks Testing Laboratories, Report No. 878JR "Summary Report - KWIK-Bolt Testing Program", Mark, 1977.

3. Blodgett, O. W., "Design of Welded Structures", The James F. Lincoln Welding Foundation, 1972.

4. DeSalvo, G. J., and Swanson, J. A., "ANSYS User's Manual", Swanson Analysis System, Inc., 1972.