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August 9, 1982

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Station Units 1 and 2
Braidwood Station Units 1 and 2
Pipe Support Anchor Plates
NRC Docket Nos. 50-454, 50-455, 50-456 and 50-457

Reference (a) July 6, 1982 letter from B. J. Youngblood to L. O. DelGeorge

Dear Mr. Denton:

This is to provide advance copies of responses to FSAR questions regarding the flexibility of baseplates for pipe supports at Byron and Braidwood. This information will be included in the FSAR at the next amendment.

Enclosed with this letter are responses to questions 110.71 and 110.72 which were transmitted in reference (a). NRC review of this information should close Outstanding Item 5 of the Byron/Braidwood FSAR.

Please direct further questions regarding this matter to this office.

One signed original and fifteen (15) copies of this letter are provided for your review.

Very truly yours,

T. R. Tramm

T. R. Tramm
Nuclear Licensing Administrator

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Response 110.71

The Commonwealth Edison Company has accounted for the effects of the baseplate flexibility on forces in the expansion anchors by extensive finite element studies. The flexible plate was modeled by plate elements and the anchors were modeled by truss elements. A bilinear load displacement curve for the anchors idealizing the load displacement behavior observed in tests was used in the analysis. The supporting concrete was modeled by one way compression springs. Nonlinearity was introduced in the analysis by the nonlinear behavior of the concrete springs and the bilinear load displacement behavior of the expansion anchors. A constant stiffness method was used to solve this nonlinear problem. The details of this analysis procedure are discussed in Reference 1. The following discussion briefly summarizes how the effect of plate flexibility was considered in the design.

There are two possible effects of the baseplate flexibility on the forces in the expansion anchors as follows:

(1) Prying action

(2) Unequal distribution of forces among anchors based on the geometric configuration of anchors with respect to the applied loads.

Commonwealth Edison Company's analysis procedure has considered the effect of both these factors on the forces in expansion anchors.

As a result of this analysis, amplification factors for use in the design of expansion anchor plates were developed. These amplification factors correlate the anchor forces determined by the nonlinear flexible plate analysis to the forces determined by a conventional rigid plate analysis.

The amplification factors were computed as follows:

(1) Pure tension and pure moment was applied on the anchor plate assembly so that at least one anchor was stressed to its ultimate load capacity, Pu. A nonlinear approach described above accounting for plate flexibility was used for the analysis.

(2) For the same plate assembly and same load, the anchor force was calculated using a rigid plate analysis.

(3) The ratio of the anchor force obtained by the nonlinear finite element approach to that obtained by the rigid plate analysis approach is defined as the amplification factor.

The amplification factors were determined for the Byron/ Braidwood specific plates varying the expansion anchor configuration and the plate size. The loading conditions considered were the direct tension and pure moment in the critical direction. An enveloping value of the amplification factors for each plate size and anchor configuration thus obtained was used in the design. A separate study had confirmed that the amplification factors for a combination of direct tension and moment will fall within the enveloping value of amplification factors.

The flexible plate test program which was conducted by Wiss, Janney, Elstner & Associates indicated an amplification factor of 1.15 to 1.20. These amplification factors were reported at ultimate load. The analytical assessment for the same assemblies predicted the amplification factor to be 1.0. The residual load of 15 to 20% which was observed during the WJE test is not attributed to base plate flexibility or prying action effects because the plate corner displacements which were monitored during the tests showed that the corners had lifted and were not in contact with concrete at ultimate load. Thus amplification of anchor force due to plate flexibility or prying action is not possible. This residual in anchor load measurement is attributed to the behavior of the testing equipment at the ultimate load levels. The tests did establish that prying action in base plate assemblies with expansion anchors is insignificant as compared to plate assemblies with rigid bolts. According to analytical studies reported in Reference 1, the amplification factor was expected

to be 2.1 with rigid bolts. The test results have substantiated that the rigid bolt behavior is not the true behavior and that the prying effect is relieved due to the flexible load-displacement characteristics of expansion anchors.

Reference

(1) "Evaluation of Analysis Procedures for the Design of Expansion Anchored Plates in Concrete," May 31, 1979. Part of Commonwealth Edison Company's response to IE Bulletin 79-02 transmitted by C. Reed to J. G. Keppler dated July 5, 1979.

Response 110.72

Examples of three expansion anchor plate assemblies are provided. The square plates are with four and eight anchors and the rectangular plate is with six anchors. The maximum applied load on the assemblies and the corresponding anchor forces obtained by the rigid plate analysis and the flexible plate analysis are tabulated. The amplification factors as defined in response to Question 110.71 are also tabulated. The larger of the computed amplification factors for each plate assembly is used as the design amplification factor.

AMPLIFICATION FACTORS FOR TYPICAL EXPANSION ANCHOR BASE PLATES WITH WEDGE TYPE ANCHORS

Plate No.	Anchor Assembly	Load	Max. Anchor Reaction (Flexible Plate Analysis)	Max. Anchor Reaction (Rigid Plate) Analysis)	Amplification Factor
1	12x12x1/2 in	33.6 k (tension)	8.4	8.4	1.0
	4 anchors 1/2"	159.2 in-k (moment)	7.43	8.4	1.0
2	9x15x1/2 in	33.7 k (tension)	7.0	5.62	1.25
	6 anchors 1/2"	199 in-k (moment)	7.0	6.62	1.06
3	21x21x7/8 in	114 k (tension)	16.0	14.25	1.12
	8 anchors 3/4"	900 in-k (moment)	16.0	14.7	1.09

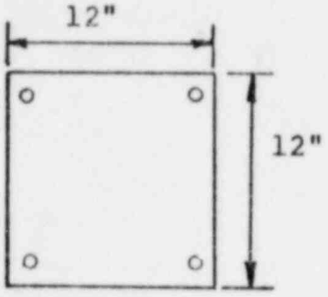

Plate No. 1
12x12x3/4 in
4 anchors 3/4"

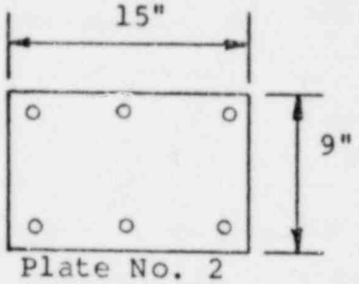

Plate No. 2
9x15x1/2 in
6 anchors 1/2"

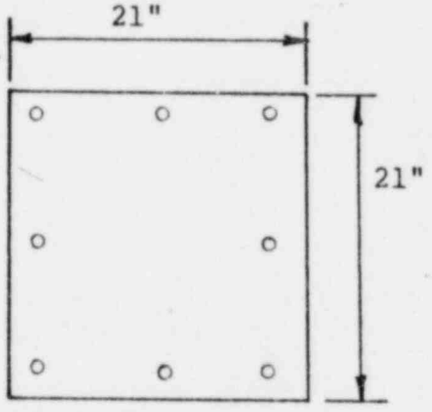

Plate No. 3
21x21x7/8 in
8 anchors 3/4"