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EISENHUT,D.G. Division of Licensing

SUBJECT: Forwards responses to Matls Engineering Branch request for addl info re loose parts monitoring sys & concrete expansion anchor design.Responses will be incorporated into FSAR in future amend.

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P.O. BOX 529100 MIAMI, FL 33152

FPL

FLORIDA POWER & LIGHT COMPANY

September 16, 1981
L-81-408

Office of Nuclear Reactor Regulation
Attention: Mr. Darrell G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Eisenhut:

Re: St. Lucie Unit 2
Docket No. 50-389
Final Safety Analysis Report
Requests for Additional Information

Attached are Florida Power & Light Company (FPL) responses to NRC staff requests for additional information which have not been formally submitted on the St. Lucie Unit 2 docket. These responses will be incorporated into the St. Lucie Unit 2 FSAR in a future amendment.

Very truly yours,

Robert E. Uhrig
Vice President
Advanced Systems & Technology

REU/TCG/jhs

Attachments

cc: J. P. O'Reilly, Director, Region II (w/o attachments)
Harold F. Reis, Esquire (w/o attachments)

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Attachments to L-81-408
September 16, 1981

A. Loose parts monitoring system.

B. MEB request for additional information (concrete expansion anchor design).

FLORIDA POWER & LIGHT COMPANY
ST LUCIE PLANT - UNIT NO. 2
MEB REQUEST FOR ADDITIONAL INFORMATION

The following are our responses to the additional questions on concrete expansion anchor design, received from the MEB on August 31, 1981:

Question 1

In Section 5 of the Design Criteria for Concrete Expansion Type Anchors define and indicate the method for determining the dimension "d" in the formula using the applied moment. Provide the derivation of this formula.

Response

The parameter "d" used in the applied moment prying formula is defined as the dimension of the attachment in the direction of the moment. For example, in the case of a wide-flange member welded to a base plate and bent about the strong axis, "d" would equal the depth of the member.

See the attached sheets for the derivation of the formulas for α and Q.

Question 2

a. Indicate the condition under which α could be greater than one for a perfectly plastic material.

b. The statement that "if α is less than zero there is no prying force" is not correct. It indicates that α cannot be calculated by assuming a plastic hinge at the flange. Provide the information which is used if the base plate remains entirely elastic.

Response

a. For design purposes, the value of α is not permitted to exceed 1.0 as this constitutes the limiting state, wherein plastic hinges form in the base plate at the bolt line and at the face of the attachment. The value of α which depends on (among other parameters) the thickness of the base plate and the distance between the attachment and the bolt line, can be controlled by adjusting the configuration of the base plate/anchorage detail.

b. The approach to prying force determination utilized in St Lucie 2 design assumes a plastic hinge in the base plate at the point of attachment. This is a convenient assumption to give us a value for σ to use in the equation for α. It seems reasonable in view of the fact that the flexural deformation of the base plate must be large compared to the elongation of the anchors in order for prying action to be realized. A value of α of zero or less implies single curvature bending of the base plate, i.e. no prying.

This approach is based on the method presented by Fisher and Struik in "Guide to Design Criteria for Bolted and Riveted Joints" (Wiley, 1974) which also forms the basis for the AISC formula for prying action which is widely used in design. This method cannot be used with the assumption of a fully elastic condition in the base plate, Question 3

Provide the physical basis for reducing σ_y, a material property, under combined tension and bending, in each of the two formulas and then adding them so that the sum is less than σ_y. Justify the entire procedure in view of the fact that superposition of responses is not permissible under elastic or plastic deformation if the base plate is assumed to be deformable.

Response

σ_y in this procedure does not represent a "material property," but rather an assumed level of stress in the base plate. Simultaneous equations are solved to determine what portion of this stress each loading component contributes. The total of the tributary stresses adds up to σ_y.

Please refer to the sample calculation previously submitted, wherein 4 simultaneous equations are solved for each of the three components of σ_y and for α.

Superposition of responses is permissible since the load-stress relationship is linear up to a stress value of σ_y.

Question 4

Provide the basis for calculating the total prying force in two-way bending of the base plate as the SRSS combination of prying forces due to bending in each direction.

Response

The value of the prying force depends directly on the distance of the attachment from the anchor. In the simple formula for one-way bending, this is expressed as "b", defined as the distance from the face of the attachment to the centerline of the anchor minus ½ the anchor diameter, and is measured perpendicular to the bolt line. In the case of two-way bending, this distance should more properly be measured diagonally from the face of the attachment to the nearest bolt. Since the prying force for the two-way case is developed from a one-way calculation in each direction, the calculated forces should be summed by SRSS to approximate the effect of a "b" which is the SRSS of the two component "b's".

Question 5

Indicate how bolt preload is included in these calculations.

Response

The allowable loadings for expansion anchors are established such that the design load is never permitted to exceed the preload. The preload is verified by in-place testing of installed anchors. Thus separation of the base plate and wall never occurs.

Externally applied loads mainly change the contact pressure between the base plate and the wall. Very little additional anchor elongation is introduced. Hence there is only a minor change in anchor tension, and thus bolt preload does not enter into the design calculations.

Question 6

Provide the formulas for calculating the bolt loads. The formulas shown indicate the prying forces only.

Response

The applied load per bolt is calculated by conventional statics methods. Please refer to the sample calculation previously submitted for determination of "P" and "H" which are then increased by the appropriate load factors. The total bolt load is the applied load per bolt plus the prying force per bolt.

Question 7

Indicate specifically how the effect of close spacing is included in calculating the anchor tensile and shear capabilities.

Response

Please refer to Paragraph 4 of the Design Criteria which states, "if the center-to-center anchor spacing is less than 12 anchor diameters, the ultimate capacity shall be reduced linearly to 50 percent capacity at the minimum center-to-center anchor spacing of 6 anchor diameters."

Question 8

Provide a description of the field testing program to determine expansion anchor ultimate capabilities.

Response

Field test programs were performed on site by qualified manufacturers to determine a) compliance with Engineering acceptance criteria, as established in "Drilled-In Expansion Type Anchor In Concrete", Specification FLO 2998.469, b) installation procedures, including installation torque, and ultimate load capacities based upon actual structural concrete used on site, and c) acceptance criteria for static tensile test load and test torque.

The tests were conducted by manufacturer's representatives in the presence of FP&L Construction Engineers and with the assistance of construction personnel. Testing followed the applicable recommendations contained within ASTM E-488, "Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements". Following are the tests performed during the program:

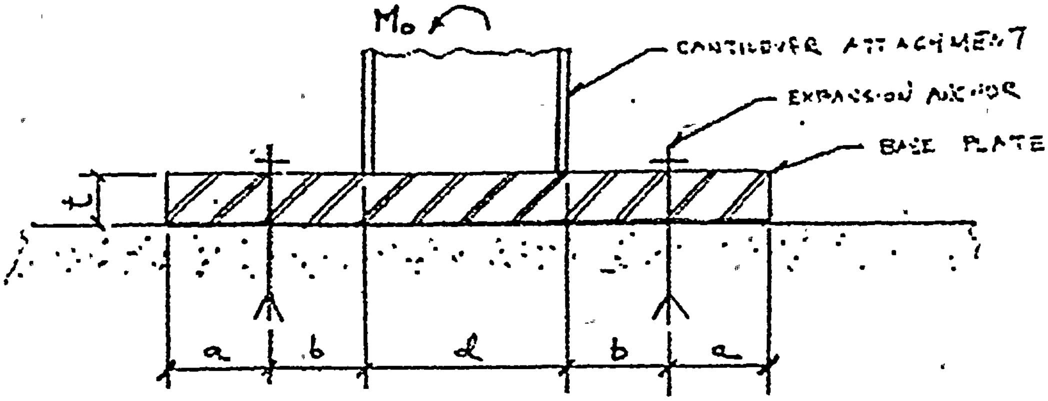
1 - Tension Testing

- a. Determination of Torque vs Tension
- b. Determination of Slip vs Load
- c. Determination of "Slip Load" at Set Torque
- d. Determination of Ultimate Capacity
- e. Determination of Edge Distance Effects
- f. Determination of Torque Relaxation

2 - Shear Testing

- a. Determination of Ultimate Shear Capacity

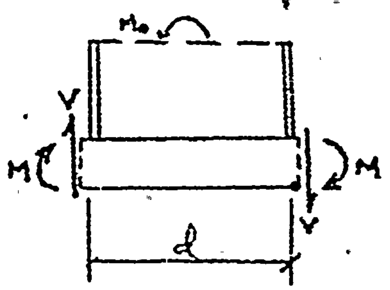
SUBJECT Concrete Expansion Anchors - Formula for Prying Force with Applied Moment



Let $\delta = \dfrac{\text{net area of base PL cross-section at bolt line}}{\text{gross area of base PL cross-section at bolt line}}$

Let $\alpha = \dfrac{\text{moment in base PL at tension bolt line per unit width}}{\text{moment in base PL at face of cantilever member per unit width}}$

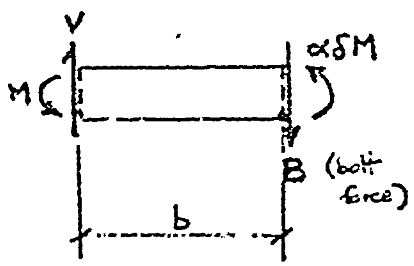
Taking a free body of the base plate near the cantilever attachment:



$\Sigma M = 0; \quad 2M + Vd - M_o = 0$

$$V = \frac{M_o - 2M}{d} \qquad (1)$$

Taking a free body of the base plate from the face of the cantilever member to the tension bolt line:



$\Sigma M = 0; \quad Vb - M - \alpha\delta M = 0$

$Vb - M(1 + \alpha\delta) = 0$

$$M = \frac{Vb}{1 + \alpha\delta} \qquad (2)$$

Combining equations (1) and (2):

$$M = \left(\frac{M_o - 2M}{d}\right)\frac{b}{1+\alpha\delta}$$

$$\frac{Md}{b}(1+\alpha\delta) = M_o - 2M$$

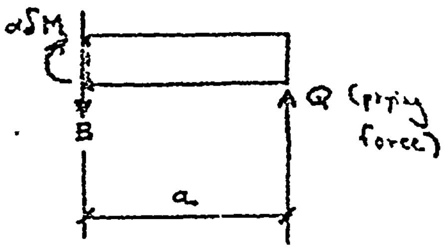
$$M = \frac{M_o}{\frac{d}{b}(1+\alpha\delta)+2} \qquad (3)$$

Assuming a plastic hinge forms in the plate at the face of the [illegible] member, M is the full plastic moment;

$$M = \frac{1}{4} w t^2 \sigma_y \qquad (4)$$

where w is the width of the plate contributing to each bolt and σ_y is the yield stress for the plate material.

Taking a free body of the base plate from the tension bolt line to the edge of the plate:



$$\Sigma M = 0, \quad \alpha\delta M = Qa$$

$$Q = \frac{\alpha\delta M}{a} \qquad (5)$$

Combining equations (3) and (4):

$$\frac{1}{4} w t^2 \sigma_y = \frac{M_o}{\frac{d}{b}(1+\alpha\delta)+2}$$

$$\frac{d}{b}(1+\alpha\delta)+2 = \frac{4M_o}{w t^2 \sigma_y}$$

$$1+\alpha\delta = \frac{4M_o b}{w t^2 \sigma_y d} - \frac{2b}{d}$$

$$\boxed{\alpha = \frac{1}{\delta}\left(\frac{4M_o b}{w t^2 \sigma_y d} - \frac{2b}{d} - 1\right)}$$

Combining equations (3) and (5):

$$\boxed{Q = \frac{\alpha\delta}{a}\,\frac{M_o}{\frac{d}{b}(1+\alpha\delta)+2}}$$ (prying force)

Force in the tension bolt exclusive of prying = T

$$T = \frac{M_o}{2b+d}$$

Total force in the tension bolt $B = T + Q$

$$B = \frac{M_o}{2b+d} + \frac{\alpha\delta}{a}\,\frac{M_o}{\frac{d}{b}(1+\alpha\delta)+2}$$

$$\boxed{B = M_o\left[\frac{1}{2b+d} + \frac{\alpha\delta b}{a}\,\frac{1}{d(1+\alpha\delta)+2b}\right]}$$

LOOSE PARTS MONITORING SYSTEM

Flordia Power & Light Co. commits to submittal of the training program for NRC review 30 days prior to the inssuance of operating license. This submittal addresses the operation of LPMS hardware and implementation of the LPMS program.