

Bechtel Associates Professional Corporation

Attachment to

Howe-312-79

SUBJECT: MCAR 34 (issued 8/21/79) Drop-In Anchors

603505

FINAL REPORT

DATE: November 30, 1979

PROJECT: Consumers Power Company
Midland Plant Units 1 & 2
Bechtel Job 7220

Introduction

As requested in MCAR 34, this report summarizes project engineering's evaluation and action regarding the failure of the drop-in anchors to meet the tension testing criteria furnished by project engineering. This report completes project engineering's action.

Description of Deficiency

Specification 7220-C-305, Section 6.2.2 requires tension testing of drop-in anchors to meet the values indicated in Table 3.2 of that specification. Inprocess inspection of drop-in anchor installation is also required in Specification 7220-C-305. However, when it was learned that this inspection at the time of installation was not being done at all times, testing was requested by project engineering on August 21, 1978, and again on May 18, 1979, to verify the adequacy of past installation.

For the testing results to be acceptable, it was necessary that a sample of 60 randomly selected anchors be tested with no failures. According to Specification 7220-C-305, the anchor is considered acceptable if a test load equal to twice the design allowable tensile load is applied and the concrete does not break out; the anchor does not break, distort, or deform; and the anchor does not slip excessively or become loose. Excessive slippage is evident when the washer between the nut and the concrete can be rotated by hand. However, upon completing tension tests on 32 drop-in anchors involving four different bolt diameters, nine anchors did not pass the test. A nonconformance report (NCR) has been generated to identify them. Approximately 900 drop-in anchors had been installed as of August 17, 1979, when project engineering requested that drop-in anchor installation be suspended until further notice. Subsequently, the testing was completed and results indicated 13 out of 66 anchors did not meet the specification requirements.

Investigation

To investigate the problem with the drop-in anchors, project engineering met with a representative of Hilti, the manufacturer of the anchor, at the Midland site to witness testing and installation practices used for the drop-in anchors. The Hilti representative verified that the testing procedure used is consistent with Hilti's own test procedure. He emphasized

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that if the plug which expands the anchor is driven in completely with the Hilti tool, the full capacity will be attained. The design of the Hilti drop-in anchors and the method of setting are illustrated in Figure 1. Based on a preliminary investigation on August 23, 1979, some of the installed plugs were found to be not fully driven into the anchor; however, the extent to which this contributed to the cause of the anchor failures was not established. It was determined that further testing would be needed to establish the specific cause(s) and extent of the anchor's failure to pass the test.

Project engineering requested that additional testing be performed as indicated in Specification 7220-C-305 on a random sampling of 100 drop-in anchors to establish the portion which had not been completely set and the failure rate for anchors that are completely set. Results of the requested testing are as follows.

1. Of 101 anchors, 20 were found to be properly set.
2. It was possible to complete the setting of an additional 24 of the remaining 81 anchors which had not been completely set when first installed.
3. The 44 anchors which were completely set were tension tested and one anchor failed by slippage.
4. The remaining 57 anchors which could not be set further were also tension tested and one anchor failed by slippage. The distance the anchor plug lacked from being completely set varied from 1/16 to 1/4 inch.

Additional information was requested to adequately evaluate 5/8-inch diameter drop-in anchors because only a very small sample was tested previously. Eight properly set drop-in anchors were tension tested with four anchors failed by slippage. Combined with the 44 completely set anchors of the previous sample, this totalled 52. Of these 52 anchors, 5 did not meet the criteria established in Specification 7220-C-305.

Additional testing of the five anchors which did not meet the criteria indicated that the anchors do not reach their predicted ultimate capacities if they slip at or below the test load.

The field verified that all attempts to completely set the remaining 57 drop-in anchors were unsuccessful. The manufacturer and construction have not determined the reason some anchors previously installed incompletely cannot be completely set at a later date.

Investigation revealed that drop-in anchor installations were not being verified by a quality control representative as prescribed in Specification 7220-C-305.

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Evaluation Criteria

Project engineering divided the average ultimate load capacity determined by Hilti by five to arrive at the allowable design load. This is consistent with what is required by NRC IE Bulletin 79-02, which requires that a safety factor of five be used for final design and installation objectives. To be considered acceptable, drop-in anchors must be installed according to the manufacturer's recommendations. In that case only, will the basis of the design load be justified.

Investigation Conclusions

Quality control has indicated that it has not implemented the specification inspection requirements for drop-in anchors because of the large number of anchors installed. Inspections at the time of installation and testing for Q-listed anchors were not performed as required by Specification 7220-C-305. Results of the additional testing indicate that drop-in anchor capacity is very sensitive to proper installation. It is difficult to ensure correct installation even under controlled conditions. It is not practical to provide the required 100% inprocess inspection at the time of installation and the testing program needed to verify correct installation without this inspection is costly. Therefore, it is not cost effective to continue the use of drop-in anchors when equivalent alternatives are available which have easier verification processes and are therefore more economical.

To verify the acceptability of existing drop-in anchors, a testing program simulating existing conditions is needed to establish ultimate capacities for the majority of the anchors. After the modified ultimate capacities are obtained, a check against design conditions will be performed to determine anchor acceptability.

Corrective Actions (recommended)

Project engineering recommends that installed Q-listed drop-in anchors be dealt with in the following manner.

1. A testing program is to be established at the jobsite to develop ultimate loads for drop-in anchors which are not completely set. This testing program will also establish a torque-tension relationship for all drop-in anchors.

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2. All drop-in anchors which are not set to at least the acceptable values determined by testing shall be either reset to at least those values or be replaced with appropriate stud or grouted anchors.
3. Each drop-in anchor which is set to at least the values determined by testing shall be inspected to all of the applicable requirements of Specification 7220-C-305, up through SCN 9013, except complete setting of the plug is not required. In addition, a gap between the shell and the bearing surface shall be verified during the test load noted in Step 4.
4. The modified design allowable loads will be one fifth of the ultimate loads established in Step 1. Each drop-in anchor shall be tested to two times the modified design allowable loads. Testing may be by the tensioner or torque method. Torque values will be based on the tests performed in Step 1.
5. Engineering is to review the design for all drop-in anchors to assure that the modified design allowable loads exceed the actual design loadings. Those anchors not meeting the modified design allowable loads will be replaced with appropriate stud or grouted anchors.

The use of drop-in anchors has been discontinued for all installations. Project engineering has issued a specification change notice to delete the Hilti drop-in anchors from the specification.

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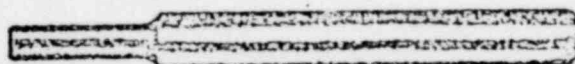
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POOR ORIGINAL



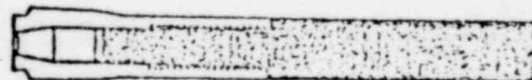
TYPICAL HILTI DROP-IN ANCHOR



HILTI SETTING TOOL



BEFORE EXPANSION



AFTER EXPANSION

(PER HILTI ANCHOR AND FASTENER DESIGN MANUAL)

FIGURE 1.

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