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April 18, 1984

Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

Re: Catawba Nuclear Station
Units 1 and 2
Docket Nos. 50-413 and 50-414

Dear Mr. O'Reilly:

Please find attached an amended final report describing corrective actions taken on Significant Deficiency No. SD 413-414/82-23. This report includes the results of additional tests performed to address NRC Inspector W. B. Ang's questions concerning soundness of anchoring material and the potential influence of repairs on the ultimate capacity of expansion anchors.

Very truly yours,

H.B. Tucker 4/18/84

Hal B. Tucker

LTP/php

Attachment

cc: Director
Office of Inspection & Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

NRC Resident Inspector
Catawba Nuclear Station

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REPORT NUMBER: SD 413-414/82-23

REPORT DATE: April 18, 1984

FACILITY: Catawba Nuclear Station - Units 1 and 2

IDENTIFICATION OF DEFICIENCY: Approved Construction Procedures for mixing and placing SikaTop 122 were violated during repair of abandoned drill holes.

INITIAL REPORT: On November 8, 1982, J. Bryant, NRC Region II, Atlanta, Georgia was notified of the deficiency by W. O. Henry, I. W. Pearce and J. A. Lee of Duke Power Company, Charlotte, NC.

COMPONENT AND/OR SUPPLIER: Abandoned drill hole repairs made with SikaTop 122 from the Sika Corporation.

DESCRIPTION OF DEFICIENCY:

One of the materials approved for repairing abandoned drill holes is SikaTop 122 from the Sika Corporation. This material is a two-component cementitious system generically classified as a latex modified mortar. Construction procedures require that this material be mixed and placed in accordance with the manufacturer's instructions. The material was approved for use on April 30, 1982, and was the material typically used to repair abandoned drill holes after that date.

During drilling of holes for an anchor in the Auxiliary Building it was necessary to partially drill into an abandoned drill hole which had been repaired with SikaTop 122. The repair material was found to be weak and would not support torquing of the anchor to required load. QA personnel investigated and determined that craft personnel making repairs were not following approved construction procedures. Nonconforming item report 15679 was initiated and Duke Power reported the deficiency to the NRC, Region II, on November 8, 1982.

ANALYSIS OF SAFETY IMPLICATIONS:

Anchor capacity could be adversely affected if the anchor is located partially in or near weak repairs made with SikaTop 122.

CORRECTIVE ACTION:

QA Department investigation discovered that craft personnel making repairs were using only the quantity of liquid component A necessary to achieve a dry pack consistency and not the total quantity specified by the construction procedures. The following tests were then performed to determine the quality of repair which would result when SikaTop 122 was mixed to and placed at a dry pack consistency:

1. Several holes 5/8 inch, 1 inch, and 2 inches in diameter were drilled into a test slab and dry packed with SikaTop 122. Repairs were performed on October 28, 1982, and left to air cure. On November 5, one inch and 5/8 inch diameter holes were drilled at locations varying from completely within a repair to tangent to a repair. During drilling of these holes, the repair material did not ravel and the drill did not drift. Expansion anchors were

then installed into the holes drilled into the larger repairs and axially loaded to failure. In each case, failure resulted in a conical fracture extending from the base of the anchor through the repair material and into the concrete. The anchor capacities achieved correlated well with the capacities anticipated in sound concrete. The repaired areas were therefore found to have negligible effect on the ultimate capacity of the anchors.

2. Two inch cube specimens were cast for testing at 3, 7, 14, 28, 56 and 90 days. Specimens were cast with material mixed to a dry pack consistency and with material mixed with the total quantity of liquid component to a trowelable consistency. The placing and tamping of the dry pack specimens simulated actual field conditions. The specimens cast with material at the trowelable consistency were molded in accordance with ASTM C109-80. All specimens were cured with wet burlap for 24 hours and then stored in air in the laboratory until time of test. Half of the specimens were removed from their molds 24 hours after casting while the other half remained in their molds until immediately before testing. Typically, the average strength of the dry pack specimens was greater than the average strength of the ASTM C109 molded specimens at all ages of test. The 90-day compressive strengths of the dry pack specimens and the ASTM C109 molded specimens averaged 10750 psi and 10400 psi, respectively. Test results indicate that the SikaTop 122 material will have acceptable strength when properly mixed and placed as both a dry pack and a trowelable mortar.

The above investigations further indicated that hand mixing of SikaTop 122 to a dry pack consistency is difficult and that the material dries quickly once mixed. Based on these observations, we concluded that the cause of the faulty repair which initiated our concerns was either the use of dry material which had not been sufficiently combined with the liquid component or the use of mixed material which had been allowed to dry out before using. Such material would have been weak and would not have allowed torquing of the anchor. The following test programs were therefore initiated to determine the likelihood of other weak repairs existing which could affect anchor performance:

1. Tension tests were performed on in-place anchors. A list of hangers whose anchors were likely installed in or near repairs made with SikaTop 122 was compiled by reviewing the documentation forms for abandoned drill holes repaired during the months of May 1982 through September 1982. Each of these hangers was assigned a number. A statistical sampling approach was then used to determine within a 95% confidence level that less than 5% of the anchors installed could be significantly affected by a repair made with SikaTop 122. The Random Numbers Table from CRC Standard Math Tables, 24th Edition was used to generate random numbers. Hangers corresponding to the random numbers selected comprised our random sample population. Test procedures

required that at least one anchor on a minimum of 74 hangers be tested. If a hanger was inaccessible, it was eliminated from the sample population and the next hanger on the sample list tested. Anchors were tested by a calibrated center-hole hydraulic jack, pressurized by a hand actuated pump. Anchors were loaded to 125% of their design capacity and held for 60 seconds before unloading. A total of 119 anchors on 74 hangers were tested and found to hold the imposed load verifying that anchors were installed into sound material and that any possible detrimental affect of repairs on anchor design performance was negligible.

2. Swiss hammer tests were performed to determine the soundness of typical repairs made in the field with SikaTop 122 and the potential effect that repairs could have on expansion anchors located in their vicinity. Criteria for evaluating tests results were established as follows:

   1) Anchors located in sound repairs should not experience a reduction in ultimate capacity. A repair is judged to be sound if a rebound reading is obtained that is greater than the rebound corresponding to the required compressive strength of concrete.

   2) Based on the results published by Burdette, Sen and Ismen in their paper "Effect of Abandoned Holes on Capacity of Wedge Bolts," ASCE, Vol. 108, April 1982, it is concluded that no reduction in pullout capacity need be considered for an anchor located a clear distance greater than 1/2 the anchor diameter from the edge of a repair if the repair has a minimum rebound/strength of 3000 psi.

   All Swiss hammer tests were performed by a single operator using one hammer. The test hammer was calibrated to the SikaTop 122 material for horizontal and overhead hammer positions. Holes 3/4 inch in diameter were drilled 3 inches deep into concrete members in the Unit 2 Turbine Building. These holes were repaired with SikaTop 122 at a dry pack consistency. Two inch cube specimens were dry packed with SikaTop 122 in a similar manner to simulate the repair of the test holes. At designated ages, 15 repaired test holes were tested with the Swiss hammer and 3 cube specimens representing the repairs were broken. Graphs were then developed showing compressive strength versus rebound for horizontal and vertical hammer positions. These graphs indicated that hammer position had a minor influence on rebound readings. Correlation data for horizontal and overhead positions were therefore used to develop a single curve for compressive strength versus rebound which best fit all data points and could be used for all tests.

   Documentation forms for abandoned drill hole repairs were reviewed by Construction personnel. Two hundred and three abandoned drill holes

repaired with SikaTop 122 were located for testing. Seventy-eight of these repairs were located in ceilings and one hundred and twenty-five were located in walls. These repairs were judged to be typical of repairs made during this time period with SikaTop 122. Swiss hammer data obtained for these repairs were analyzed in accordance with the guidelines found in ACI 214-77, "Recommended Practice for Evaluation of Strength Test Results of Concrete." This analysis indicates that repairs made in the field with SikaTop 122 should have an average rebound/compressive strength of 25.2/6200 psi. The analysis further indicates that there is a 99% probability that repairs will exceed 3300 psi and an 82% probability that repairs will exceed 5000 psi. The capacity values for anchors found in Specification No. CNS-1206.00-04-0001, "Design Specification for Nuclear Safety Related Pipe Supports," are based on a 3000 psi concrete strength and are the maximums used in 99% of all pipe support calculations and in 50% of all pipe rupture restraint calculations. Therefore, requiring a 5000 psi strength and conservatively assuming that a 50% probability exists for an anchor to be located partially into a repair results in a 96% probability that the anchor will develop its ultimate capacity. If an anchor is located a minimum clear distance of 1/2 its diameter from the edge of a repair, a 99% probability exists that the anchor will develop its ultimate capacity.

In summary, the following conclusions are drawn:

1. When SikaTop 122 is properly blended and placed as a dry pack, the repair will have acceptable strength and will not affect the ultimate capacity of anchors.

2. The root cause of the weak repair that was discovered was either the use of dry material which was not sufficiently combined with the liquid component or the use of mixed material which was allowed to dry out before using.

3. The weak repair which initiated concerns was an isolated case. The probable occurrence of poor repairs is low.

4. Tests on in-place anchors indicate to a 95% confidence level that anchors are properly installed into sound material and that design requirements will be met.

5. Tests of field repairs indicate a 96% probability that repairs are sufficiently sound such that no reduction in pullout capacity need be considered to account for the possible presence of repairs.

To ensure that SikaTop materials are properly mixed and placed, craft personnel have been retrained in the proper methods for mixing and placing. Construction Procedure 447, "Proprietary Materials for Concrete Repair," has been replaced

with CP330, "Use of Sika Proprietary Materials for Various Concrete Repair Applications." The following additional guidance in mixing and placing has been incorporated into this procedure:

1) SikaTop materials shall be mixed until all components are thoroughly combined. Mixing time shall be 3 to 5 minutes.

2) Combined SikaTop shall be placed within 15 minutes after mixing.

3) Reduction of the powder "B" component into smaller units shall be accomplished in a manner similar to Method A - Mechanical Splitter of ASTM C702-80.

These requirements will help to ensure that the material is properly mixed to a more uniform consistency and is used before it dries significantly.