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Docket No. 50-423
B15850

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Millstone Nuclear Power Station, Unit No. 3
Additional information Related to the Issue of
Cement from the Millstone Unit No. 3 Containment Mat

During a teleconference on August 2,1996, the NRC Staff requested that Northeast Nuclear Energy Company (NNECO) provide test results of one aspect of the ongoing porous concrete mock-up testing. Specifically, the Staff requested the results of the mock-up test conducted to determine the impact on the simulated containment basemat concrete at the interface with the nine inch porous concrete layer. The third and final phase of the mock-up testing program is scheduled to be completed by the end of 1996.

Attachment 1 provides the results of the basemat/porous concrete interface mock-up test, and it's impact on the simulated containment basemat concrete.

Should the NRC Staff have questions regarding the material provided, please contact Mr. R. T. Laudenat at (860) 444-5248.

Very truly yours

NORTHEAST NUCLEAR ENERGY COMPANY

T. C. Feigenbaum
Executive Vice President and
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A001/.

cc: T. T. Martin, Region I Administrator
V. L. Rooney, NRC Project Manager, Millstone Unit No. 3
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Attachment 1

Millstone Nuclear Power Station, Unit No. 3

Test Results

August 1996

ATTACHMENT 1
MP3 CONTAINMENT MAT POROUS CONCRETE
PHASE III MOCK-UP TEST

SUMMARY

Millstone 3 has performed a mockup test at Alden Research Laboratory which was intended to duplicate the response of the containment basemat when exposed to flowing water. Figure 1c illustrates a cross section of the 11 foot by 11 foot slab which includes the same combination of Portland and Calcium Aluminate porous concrete, as well as the mortar and structural concrete. Although the primary purpose of this test was to assess the response of the porous concrete when subject to water flow, it also included the interface between the structural concrete and the porous concrete. The results of the compression tests and the visual examinations performed to date did not reveal any degradation of the structural basemat as a result of the water flow through the test slab. However, during removal of the strength test specimens, loss of bond was detected between the structural Portland Cement section, and the Calcium Aluminate porous concrete. A detailed description of the testing completed to date is provided below.

PURPOSE OF THIS SEGMENT OF THE MOCKUP TESTING

The purpose of testing the Portland Cement based concrete on top of the porous concrete test mold, was to determine the impact of the flowing water on the containment porous concrete system. The concrete representing the containment basemat was placed on top of the porous concrete mold similar to the actual construction of the containment, as shown in Figure 1c. This testing is completed by subjecting the test mold to water flow and periodically removing core samples for compressive strength testing. Simultaneously, core samples were removed from a sister mold, which was not exposed to the porous concrete or water flow, and were also tested for compressive strength. Concrete cylinder samples cast during the concrete placement are also tested for compressive strength at specified time intervals.

MATERIALS USED IN CONSTRUCTION OF THE TEST MOLD

CEMENT

PORTLAND CEMENT

Portland Cement is Type II (low Alkali) conforming to ASTM C150.

CALCIUM ALUMINATE CEMENT

Chemical Properties, (ASTM C114)

AL_2O_3 + TiO_2 , percent minimum	42.0
CaO, percent maximum	38.0
SiO_2 , percent maximum	10.0
Fe_2O_3 , percent maximum	18.0

ATTACHMENT 1
MP3 CONTAINMENT MAT POROUS CONCRETE PHASE III MOCK-UP TEST

Physical Properties

Time of setting by Vicat Needle, ASTM C191, hours, minimum	2
Fineness (use either method)	
Air permeability, ASTM C204 sq. cm per gm, minimum	2600
Turbidimeter, ASTM C115, sq. cm per gm, minimum	1500
Strength, at 24 hours, ASTM C109, psi, minimum	3500

AGGREGATE

COURSE

Course aggregates were obtained from the Wauregan Quarry, owned and operated by Tilcon Connecticut Incorporated. The # 4, # 57, & # 67 gradations are in accordance with ASTM C33 and C136. Table 1 shows the gradation analysis of these aggregates.

FINE

Fine aggregates were Millbury Sand from Concrete Service Company, no gradation analysis was performed.

CONCRETE MIXES

Mix A - Porous Concrete with Portland Cement Type II, quantities per cubic yard

Cement, pounds/sacks	560/5.96
Coarse Aggregate #57, pounds	2670
Water to Cement Ratio (maximum)	0.384

Mix B - Porous Concrete with Calcium Aluminate Cement, quantities per cubic yard

Cement, pounds/sacks	560/5.96
Coarse Aggregate #57, pounds	2670
Water to Cement Ratio (maximum)	0.320

Mix C - Mortar Seal with Calcium Aluminate Cement, quantities per cubic yard

Cement, pounds/sacks	900/9.57
Coarse Aggregate #57, pounds	2757
Water to Cement Ratio (maximum)	0.439

Mix D - Mortar with Portland Cement Type II, quantities per cubic yard

Cement, pounds/sacks	900/9.57
Coarse Aggregate #57, pounds	2757
Water to Cement Ratio (maximum)	0.439

Mix E - Containment Foundation with Portland Cement Type II, quantities per cubic yard (10' thick mat)

Cement, pounds/sacks	500/5.32
Fine Aggregate, pounds	1315
Coarse Aggregate #4, pounds	752
Coarse Aggregate #67, pounds	1127
Percent Air Admixture	3 to 6
Water to Cement Ratio (maximum)	0.532

MEMBRANE

The membrane consists of two layers of waterproof membrane installed as recommended by the membrane manufacturer.

FORMS

The concrete forms and boundaries for the water separation consist of poly coated plywood for waterproofing.

WATER

The water used for the concrete batching and curing were tested and found to be free of unacceptable quantities of oils, acids, alkalides, salts and organic materials in accordance with ASTM C94. The results of the chemical analysis is presented in Table 2.

DESCRIPTION OF THE TEST MOLD

The test mold represents, a typical cross section of the containment porous concrete and basemat. The test mold has nominal dimensions of 11 feet by 11 feet with an inlet water

reservoir constructed at one end, and outlet pipe at the other end of the mold. One half of the mold contains a rubber membrane similar to the actual containment layers and in the other half of the mold the rubber membrane has been conservatively eliminated.

The cross section of the mold in the area of the membrane consists of: the bottom form; a 10 inch layer of Mix A Portland Cement porous concrete; the waterproof membrane; a two inch layer of Mix D mortar; the 9 inch layer of Mix B Calcium Aluminate porous concrete; a two inch layer of mortar; a one foot layer of Mix E Portland Cement concrete. The cross section in the portion without the rubber membrane is similar except the rubber membrane, the mortar on top of the membrane and the Mix E concrete have been omitted. The center wall of the mold as well as the inlet end wall have been provided with perforations to allow water entrance. One inch diameter orifices are provided for draining of the mold. Details of the test mold are shown in Figures 1(a-c).

MOLD CONSTRUCTION

Table 3 includes the placement schedule of each layer of porous concrete and seal mortar. The number of days indicated in the Table between pours are the conservatively selected number of days curing before the placement of the next pour.

POROUS CONCRETE MIX A (Portland Cement)

Mix A is placed in a 10 inch thick layer of porous concrete on top of the bottom of the mold form. The concrete is consolidated to represent a density of approximately 118 to 131 pcf. This concrete layer is wet cured prior to further construction activities.

MEMBRANE

Two layers of waterproof membrane were placed on top of the Mix A. The membrane extends to the top of the mold, such that it encases subsequent layers of the concrete.

MORTAR MIX D (Portland Cement)

Mix D was placed in a 2 inch layer of seal mortar on top of the waterproof membrane as protection for the subsequent concrete placement. This mortar was cured for a minimum of 48 hours prior to further construction activities.

FLOW PATH

As a flow path for subsequent flow testing, the rubber membrane and Mix D are intentionally ruptured at the predetermined locations of proposed core-bore samples.

POROUS CONCRETE MIX B (Calcium Aluminate Cement)

Mix B was placed in a 9 inch thick layer of porous concrete on top of the waterproof membrane. The concrete is consolidated to represent a density of approximately 118 to 131 pcf. This concrete was cured by applying a thin spray of water at the top surface to remove the heat. This process is continued for 24 hours after initial set of the porous concrete.

MORTAR MIX C (Calcium Aluminate Cement)

Mix C was placed in a two inch layer on top of the 9 inch layer of porous concrete. This mortar was cured for a minimum of 48 hours prior to further construction activities.

STRUCTURAL CONCRETE MIX E (Portland Cement)

Mix E was placed in a 12 inch layer on top of the 2 inch layer of calcium aluminate cement mortar. An additional sister mold, measuring 3 feet x 3 feet x 12 inches high, of Mix E was also constructed from the same batch of concrete, and maintained separate from the mockup (Figure 2). The sister mold was constructed in a wooden form carefully constructed to be free from any Calcium Aluminate cement products. Both sections of Mix E concrete are wet cured for 7 days prior to any flow testing. Five concrete test cylinders were made at the time of the placement in accordance with ASTM C31.

HYDRAULIC TESTING OF THE MOLD

The Sequence of the Flow Testing is as follows:

CYCLE 1

1. The 6 inch diameter inlet # 2, the 6 inch diameter outlet #1, and the two 1 inch diameter drain orifices are closed, refer Figure 1.

2. The 6 inch diameter outlet # 2 is maintained open.

3. The inflow of water is regulated through the 6 inch diameter inlet # 1 for 21 days.

4. The water is stopped for 7 days and the mold is drained through the two 1 inch diameter orifices located at far end of the mold.

5. Core samples are removed from the mold in the sequence identified in section "Concrete Testing of Compressive Strength Samples"..

6. Cored holes are filled with crushed stone.

7. The water flow is restarted in the reverse direction in the sequence outlined below:

Close inlet # 1
Close outlet # 2 and the two drain orifices
Open outlet # 1
Regulate the water flow for 21 days
Stop the water for 7 days and drain the mold for the coring operation.

8. Continue the same cycle for the duration of the testing. The rate of flow of water through the test mold for the first twelve months is presented in Table 4.

CONCRETE TESTING OF COMPRESSIVE STRENGTH SAMPLES

TEST CYLINDERS

Five 6 inch diameter by 12 inch high cylinders were prepared for compression testing from Mix E, in accordance with ASTM C31 and C39, at the time of concrete placement in the mold. After laboratory curing, two cylinders were tested for compressive strength at 28 days and three cylinders were tested at 56 days. At 150 pcf density of the cylinders, the average compressive strength was determined to be 4935 psi and 5257 psi corresponding to the age of 28 and 56 days. The results are included in Table 5.

CORE BORE SAMPLES FROM THE MOCK-UP MOLD

After being exposed to a continuous flow of water for 24 hours a day and 21 days, the following core samples have been extracted at the specified time intervals. The cores from the test slabs (both the test mold and sister mold), were tested for compressive strength at 40 days, 60 days and 90 days after construction. The location of these core samples are shown in plan view, Figure 1a.

At 40 days; Two cores located at C-6 and E-6,
At 60 days; Two cores located at D-7 and E-7,
At 90 days; Two cores located at C-8 and E-8

The average compressive strength values of the cored samples have been summarized in Table 5. The 60 day average strength of 4925 psi corresponds to a core density of 145 pcf.

CORE BORE SAMPLES FROM THE SISTER MOLD

Concrete Mix E in the sister mold was constructed and cured similar to the mock-up but it was not subjected to either water flow or contact with calcium aluminate cement. Two sets of two 6

inch diameter core samples were removed from the 3 foot x 3 foot x 12 inch high sister mold. A set of two cores were removed from locations SM-1 and SM-2 at 40 days, and a second set of two cores were removed from locations SM-3 and SM-4 at 60 days (Figure 2). The samples were then tested for compressive strength. A 60 day average compressive strength of 4695 psi was achieved, at a core density of 149.5 pcf. Table 5 summarizes the test data for the sister mold samples.

OBSERVATIONS

During the 21 day flow test into the mold, close observations were made regarding any cement reaction, and there was no evidence of deterioration of the concrete at the interface of the structural concrete with the Calcium Aluminate Cement. Additionally, no white residue indicative of potential degradation at the interface of the two cements was evident.

Upon core sample removal all cores were inspected for their structural integrity and sound appearance. No visual differences were noted between the cores from the slab on top of the Calcium Aluminate cement mortar mock-up, and the cores removed from the sister mold.

The 3 foot x 3 foot x 12 inch thick concrete slab on top of the mock-up with water flow remained in position until the end of the sixth month. The slab was removed with little effort. When removed, the concrete slab showed lack of bonding to the seal mortar at the interface. The impression at the interface was smooth with any adverse affect between the cements limited to the face of the surfaces.

CONCLUSIONS

The containment structure is designed for the loads and load combinations presented in the Millstone 3 FSAR Section 3.8.1.3.1. The allowable stresses are in accordance with ACI 318-71. The design basis of the containment mat, and proportioning of ingredients in the concrete mix are for a concrete mix design of 3000 psi at 60 days. Proportioning of ingredients used in Mix E is similar to the design basis mix. Mix E was used to construct the mock-up of the containment mat slab interface with the Calcium Aluminate Cement layer below the containment mat.

The 60 day compressive strength of concrete samples from the mock-up test slab subjected to water flow, and the 60 day wet cured compressive strength of concrete samples from the sister mold have exhibited a minimum strength of 4925 psi. This is well above the design basis strength of 3000 psi at 60 days. In addition when all cores were removed from the mock-up slab and inspected, as well as from the sister mold, the concrete integrity was intact with no visual difference. Therefore it can be concluded from the mock-up test that the the containment mat concrete containing Portland Cement has not experienced any significant

decrease in strength as a result of interacting with the porous concrete layer containing Calcium Aluminate Cement.

Even though lack of bond at the mating suriaces of containment mat slab with the porous concrete layer was observed in the mockup testing, this is not expected to have any adverse impact on the structural integrity of the Millstone 3 containment basemat.