

ATTACHMENT 65001.02  
INSPECTION OF ITAAC-RELATED INSTALLATION OF  
STRUCTURAL CONCRETE

PROGRAM APPLICABILITY: 2503

65001.02-01 INSPECTION OBJECTIVES

01.01 To determine whether structural concrete work and related licensee quality control activities are being performed in accordance with design specifications and approved procedures

01.02 To evaluate the performance of ITAAC-related structural concrete placement, documentation, and verification activities.

01.03 To assess the adequacy of licensee controls for the installation of concrete expansion anchors.

01.04 To determine whether general concrete records reflect work accomplishment consistent with the design specifications and approved procedures.

01.05 To assess the adequacy of preparations to deal with contingencies in large concrete placements, e.g., cold joint formation.

01.06 To evaluate the adequacy of the implementation of the specific quality assurance program requirements related to structural concrete installation activities and records control and assure that problems are entered into the corrective action process.

65001.02-02 INSPECTION REQUIREMENTS AND GUIDANCE

The construction procedures should be reviewed, along with design control document (DCD), applicable specifications, drawings and other design documents, to ensure that the work activities are being properly performed in compliance with the procedural controls and design details. Also review the pertinent QC procedures applicable codes and standards, and regulatory Guides. Independently assess whether QA verification of concrete work is adequate to ensure compliance with construction specifications, requirements, and commitments. The American Concrete Institute (ACI) "Manual of Concrete Inspection" should be utilized during this inspection as a general reference. However, licensee-approved design details and procedural controls govern the conduct of structural concrete placement and related construction activities. **During inspection planning, the NRC Construction Experience (ConE) database should also be reviewed for any associated reports pertaining to the area of inspection.**

Due to the difficulties in performing remedial work on completed concrete and in conducting effective post-placement inspections, the first large, significant placements of structural concrete should receive special emphasis. This includes the need to

review the correlation from the design basis requirements to the specifications and drawings, for the concrete structure, and for the concrete composition and required properties. In most cases these first concrete activities will be associated with large basemat placements.

Selection of placements to be observed should provide for diversification of placement type and structures but be directly related to ITAAC verification. Placement types to be considered for sample inspection should therefore include:

- basemats (containment/reactor building and auxiliary building)
- containment/shield building wall (early and late placements, including large penetrations)
- containment dome (early placements)
- columns, shear walls, beams, and slabs in the reactor building, auxiliary building, and fuel handling building
- primary or secondary shield walls/biological shield wall or other internal structural concrete
- other areas such as the intake structure, emergency diesel building, or fuel handling building
- Ultimate heat sink water retaining structures, including weirs, submerged weirs, dikes, embankments, excavations, soil-retaining structures, or stabilized slopes

02.01 Inspection of Concrete Placement. Every three months during the first **two years** of placement of Category I concrete, **(or until approximately 30% to 50% of the safety related concrete has been placed)** select at least two placements. Thereafter, select at least two placements per year until all of the structural concrete for the facility has been placed. This general concrete inspection sample selection process may be refined to meet specific ITAAC verification needs.

Note: It should be recognized that some of the following inspection requirements and guidance in this procedure for structural concrete work, inspection, and record activities may not specifically apply to all facilities.

Ensure the following activities are being controlled, inspected, and accomplished in accordance with the requirements of licensee procedures and regulations:

- a. Reinforcing Steel and Embedment Placement. Verify the following items have been implemented:
  1. Reinforcing steel, embedments, and formwork are controlled and performed in accordance with the applicable specifications, codes, drawings, and procedures. Reinforcing steel and embedments are located properly in the structure and in the forms, are secured and free of

concrete or excessive rust, and have proper clearances.

Guidance. The areas where embedded plates with anchors are to be set in concrete should have the specified and designed amount of projection into concrete to provide bond. Excessively congested areas with reinforcing steel will make concrete pouring and vibration difficult to control. Reinforcing steel bending is properly performed and controlled. Piping or conduit embedments located in a concrete placement should be capped or plugged prior to concrete placement. Forms are secure, leak tight, and free from water or snow.

2. For containments using post-tensioned tendons, inspect the installation of trumpets, bearing plates, and tendon sheathing. Inspect the following before concrete is placed:
  - (a) Trumpets, bearing plates, and sheathing are installed within specified tolerances and are clean and free of damage.
  - (b) Tendon sheathing joints are mortar-tight.
  - (c) Sheathing vents and drains are installed as specified.

Guidance. Exceeding specified tolerances may affect the tensioning force required due to frictional losses. Surveying instruments may be used for location measurements.

- b. Reinforcing Steel Splices. (particularly for techniques other than the code endorsed "lapping" requirements) Verify the following:
  1. Process and crews are qualified.
  2. Each splice is defined by materials used, location, crew, type of splice, and heat number (if applicable).
  3. Sampling and testing are performed at proper frequency. Acceptance criteria are defined and confirmed as being satisfied.
  4. Inspections are performed during and after splicing by qualified inspection personnel.

Guidance. For splices, review the mechanical splicing instructions issued by the vendor. This document usually specifies the proper performance of all mechanical splicing operations. Verify whether vendor instructions were properly implemented.

When cadwelding operations are being performed, observe that specified materials (sleeves, powder, packing) are stored in accordance with specifications, codes, drawings, and procedures, and that cadwelding fixtures are in good condition. The reinforcing steel to be cadwelded

should be cleaned shortly before cadwelding to remove all non-adhering rust. The reinforcing steel ends should be aligned and butted within the tolerances specified.

Observe the placement of sleeves and the use of a marking system to ensure centering. When the firing is complete and packing removed, examine the sleeve and reinforcing steel to ensure that metal is showing at the vent, no slag at the tap hole, and each end of the sleeve shows proper fill (allowable void area not exceeded).

Ascertain whether each cadweld sleeve is identified. **Select a sample of the cadwelders to verify qualifications meet procedures and requirements.** Interview two cadwelding inspectors to determine whether they are familiar with the details of cadwelding requirements; also determine whether inspections of cadwelding conform to the specified frequency, whether QC inspection records are being maintained, and whether records are traceable to the location and identification of the sleeve.

- c. Concrete Liner Plate and Embed Erection and Fabrication. Verify the following:
  - 1. Plate and other materials are controlled in accordance with specifications, codes, drawings, and procedures.
  - 2. Forming, fitting, and aligning are controlled in accordance with specifications, codes, drawings, and procedures.
  - 3. Stud-welding is performed by qualified personnel in accordance with approved procedures.
  - 4. Examination and testing are in accordance with the specifications, codes, drawings, and procedures.
  - 5. Refer to 65001.B "Inspection of ITAAC Related Welding."
- d. Concrete Batching and Delivery. Verify that the following items have been implemented in the concrete production and delivery process:
  - 1. Batch plant is qualified in accordance with specifications, codes, drawings, and procedures, and producing concrete of the specified mix design. Scales and meters are calibrated. Equipment performs properly - rotation speed, timing, and blade wear are not excessive. Assure that the materials and concrete mix are free of deleterious material, and that there is no contamination between materials in storage, transportation, or process. Assure that batch records are generated, controlled, and that they indicate placement location, mix, volume, date, time, and special instructions.

Guidance. Concrete batch plants providing concrete for use at nuclear facilities may be certified to the National Ready Mixed Concrete

Association (NRMCA) program. This certification provides evidence that a registered professional engineer has reviewed the facility and has seen evidence that certain necessary capabilities exist to produce quality concrete. Any other batch plant certification should include the inspection attributes listed in the NRMCA checklist which is used to inspect the facility prior to any recommendation for certification. This portion of the inspection need only be done every 18 months.

2. Materials are properly qualified and traceable to approved sources. Storage and handling are not detrimental to the concrete materials; e.g., cement is protected from moisture and aggregate is not subject to excessive mixing of sizes or contamination.
3. Batch water quality requirements are met and water is adjusted to account for moisture content of aggregates. Aggregate moisture content tests are representative of actual stockpile conditions.

Guidance. The moisture content determination of aggregates becomes very important if the aggregate stockpiles are exposed to the elements.

4. Transporting equipment is suitable, reliable, and in an acceptable condition.
5. Time limit between mixing and placement has not been exceeded.
6. Temperature limits have not been exceeded.
7. Slump test results are being utilized at the batch plant to maximize placeability in more uniform batching, as detailed in the design specifications. If water additions are required, remixing in the truck conforms to the appropriate standards (e.g., ASTM C94) addressing the uniformity of mix. There should be precautions on the amount of re-tempering water additions allowed in consideration of the water-cement ratio as called out in the design specifications for the concrete.

Guidance. The practice of withholding water at the batch plant and then tempering at the point of placement should take into account the results of air content and slump measurements taken at the point of placement.

8. Scales should be calibrated and inspected for reliable working order. Verify that each truck is measured and each trip receives proper ticketing and documentation.
- e. Placement. Verify that the following items have been incorporated in the concrete placement process:
1. Pre-placement planning and training has been completed as required to assure good quality construction and to protect against unplanned construction joints.

2. The pre-placement inspection performed by QC has been completed before any concrete is placed.

Guidance. Quality control pre-placement inspections must not be unnecessarily rushed by advancing concrete work, especially during large slab or basemat placements. When possible, verify the actual as-built condition of reinforcing steel with respect to the engineering drawings. If deviations exist, verify that proper engineering evaluations have been performed.

3. The equipment to deliver concrete to the actual placement location is suitable and sized for the work - conveyors, lines, pumps, buckets, etc.

Guidance. Consider the potential for segregation of aggregates due to mishandling. Segregation can lead to fine particles to settle at the bottom, and large particles to surface at the top. In addition, excessive vibration of concrete will lead to unacceptable aggregate segregation after placement.

4. The placement has been cleaned and joint preparation is as defined in the construction specification.

5. Batch ticket is reviewed for verification of proper mix, transport time, placement location, and amount of temper water being added at the truck delivery point.

Guidance. Check time of concrete receipt for truck transported, centrally mixed concrete. Also verify the amount of water added, if permitted, and mixing time. Be sure that the placement is in accordance with specifications using required equipment to prevent the occurrence of excessive air voids.

6. Placement drop distances do not exceed specification requirements and do not result in segregation.

Guidance. Concrete should not strike forms or bounce against reinforcing bars causing segregation of aggregates.

7. Vibrators are approved, tested for frequency, and are used properly by trained individuals.

Guidance. There should be a sufficient number of vibrator operators and vibrators, which should be checked for proper operation before starting to place concrete. Vibrators less than 3" diameter are generally designed to operate at about 7000-8000 vibrations per minute when immersed in concrete. Large vibrators, used in heavy section concrete placement, operate at about 6000 vibrations per minute. Vibrators less than 3" in diameter can be operated by one man; 4" or larger vibrators are 2-man tools. Proper vibrator operation involves duration of vibration, distance

between vibrator insertions, and depth of insertions. The vibrators should be handled and operated vertically and never "cast" away from the operator horizontally and then retrieved. Concrete should be placed horizontally, in about 12-inch lifts, and never allowed to pile much higher in one area of the form than another. The vibrator should penetrate through the new concrete well into the previously placed layer to avoid any "layer cake" effect. Occasional contact of a vibrator with the forms is permissible, and with the reinforcement is desirable. Form vibration is generally not desirable, and care should be taken that reinforcement is not displaced by vibrators, or by people walking on the reinforcing steel. Vibrators should not be used to move concrete laterally.

Care should also be taken not to concentrate vibratory action in a specific area. Overly working and vibrating concrete into reinforcing-congested areas can cause segregation of aggregates in the mix. To assure that all aggregate remains suspended in the mix, the concrete should only be exposed to two or three vertical passes with the vibrating equipment for shallow pours. Deeper poured sections may require more vibration, but the vibratory equipment should not be allowed to rest or remain in one area for extended times and the exposure to vibration per vertical foot of wet concrete should be similar to the shallow pour.

8. Special attention is given to areas of high reinforcing or embedment steel congestion to preclude areas of voids or honeycombing.
  9. Records are produced and reviewed, and indicate mix, location, time placed, water additions, and temperature of the concrete mix and ambient conditions.
  10. Inspection during placement is performed as required.
  11. Verify that adequate planning and preparations have been made and that procedures are in place and available to address unexpected events, e.g., batch plant malfunction, equipment and personnel accident, and weather-related emergencies.
  12. Verify that accepted procedures and specifications are followed if work is **stopped** and resulting restart occurs.
- f. In-Process Testing. The following items should be verified in the review of the testing program conducted during the placements:
1. Concrete temperature, slump, air content, and unit weight are being determined at the proper location and frequency as required in the design specifications.
  2. Sample collection and testing techniques conform to the procedures specified in the ASTM standards, or equivalent.

3. Test specimen samples, for concrete strength determination, are sampled at the required location and frequency and are cured in accordance with specified requirements.
4. Personnel performing sampling and testing are trained and qualified.

Guidance. For large placements, e.g., basemats, containment domes, and/or other structures, generally continuous placement is a design requirement. However, due to unexpected events, a continuous placement may not be possible. In such a case, contingency preparations should include approved procedures for stopping a concrete placement; a time limit to restart the placement; profile and preparation of the joint interface; and, if reinforcement dowels are needed, approved size and bend profile, and ready availability of the dowels onsite. In addition, verify that the contingency planning, preparations, and engineering requirements have been reviewed by qualified personnel for technical adequacy.

- g. Curing. Verify that curing is in accordance with specifications and procedures with regard to the method, materials, duration, temperature (concrete and ambient), inspections (during curing and after form removal), and records.
- h. Acceptance. Verify that the final inspection results after form removal, test results and other information related to the placement (including deficiencies, defects, etc.) have been subjected to an integrated review before acceptance of the placement and that the as-built documentation is complete.

Guidance. This portion of the inspection may require subsequent follow-up to determine that final inspection, evaluation, and acceptance are being controlled and accomplished in accordance with QA/QC requirements. Final inspection procedures should include verifying embed locations, finishes, and defining any defects and required repairs.

02.02 Laboratory Testing. Semiannually during the placement of Category I concrete, the **concrete testing** laboratory should be inspected to verify that the materials and concrete testing activities are being controlled as required.

- a. Personnel Qualifications. The education, experience, and training of testing and inspection personnel have been verified by the employing organization. Verification must be supported by documentation. Certification of inspectors must show which ASTM tests the inspector is qualified to perform.

Guidance. Particular attention should be directed toward the qualification of personnel and their work performance. Commercial laboratories may hire untrained or inexperienced personnel near the site, then train and certify them for materials testing. A weak training program and low experience level could result in inconsistent or low quality inspection or test results. In addition to the reviews of training records, consider interviewing personnel who perform material inspection and testing, to independently assess depth of knowledge and experience. Also, be sensitive to a rapid turnover of personnel.

In some instances the design organization, the constructor, or licensee may require on-site testing laboratory inspection or review. This may be by reference to ASTM E 329 which could be satisfied by the efforts of Cement and Concrete Reference Laboratory/Materials Reference Laboratories (CCRL/MRL) of the National Bureau of Standards. If such a review has been performed, then these results should be obtained and reviewed prior to any NRC inspection efforts related to the materials and concrete test laboratory.

- b. Evaluation of Test Results. The evaluations are being performed, reviewed, and approved at an appropriate level and includes trending analysis. The records must be retrievable. There should be a mechanism for feedback to production control. Verify that the adverse trends or problems are identified at an appropriate threshold and entered into a corrective actions program. Where appropriate, results should be evaluated against approved acceptance criteria.
- c. Observed Testing. Testing conforms to the procedures specified in the ASTM standards. The procedures must be available at the work location.
- d. Calibration. Testing apparatus is being calibrated at the required frequency.

02.03 Special Considerations - The following items should be incorporated in the inspection of concrete placements when appropriate (refer to ACI standards for additional guidance):

- a. Hot and Cold Weather. Provisions for maintaining concrete temperature within specification must be provided. Hot and cold weather conditions must be defined (e.g., per ACI standards such as 318 and the Manual of Concrete Inspection) to avoid confusion.

Guidance. During periods when concrete is to be placed and cold weather is expected during the curing time, provisions must be made to keep the concrete above 40°F, preferably in the range of 50 to 60°F. If concrete is being mixed or transported in weather below 40°F, the ingredients may be pre-warmed so that the temperature of the concrete after placement is elevated to account for losses. Heating the water is the most effective and most easily controlled technique, but the aggregate must not be frozen. The water should not be so hot as to cause "flash set" of the cement during mixing; that is, the temperature of the mortar should not exceed 100°F. If hotter water is required to warm the aggregate, the water and aggregate may be mixed prior to addition of cement. If the aggregate is heated, close control must be exercised, and the aggregate must be frequently checked for variations in moisture content caused by local variations in heating. Direct fired heaters may produce carbon dioxide in the exhaust fumes forming calcium carbonate on the surface of fresh concrete.

Where the ambient temperature during concrete placement rises much above 70°F, consideration must be given to the effect of high temperatures on the concrete. Although concrete cured at temperatures up to 100°F gives higher early strength, with little degradation of long-term strength, high temperatures

during mixing, transportation, and placement can be seriously detrimental. The most obvious effect is that the concrete requires more water for workability or the use of additives. A less obvious effect is the need for special attention to curing, because the higher temperature increases water evaporation from the concrete.

Exposure to strong summer sun can raise the temperature of ingredients, equipment, forms, etc. far above the air temperature. If this occurs, provisions should be made for appropriate shades or screens and the equipment, forms, metallic embedments, etc. should be wetted just prior to concrete placement. If the ambient temperature is high enough so that the bulk temperature of freshly mixed concrete exceeds 80°F or 90°F, consideration should be given to some method of cooling the ingredients, such as chilling the water or using ice. If ice is used, it must be crushed or flaked so that all the ice is melted by the time mixing is completed.

- b. Pumping Concrete. Slump and air content losses must be monitored in order to assure placeability and adequate consolidation.
- c. Large Placements. Planning sessions must assure consideration of all contingencies. Verify that adequate planning and preparations have been made and that procedures are in place and available to address an unexpected event, e.g., batch plant malfunction, equipment and personnel accident, and weather-related emergencies.

Guidance. For large placements, e.g., basemats, containment domes, and/or other structures, generally continuous placement is a design requirement. However, due to unexpected events, a continuous placement may not be possible. In such a case, contingency preparations should include approved procedures for stopping a concrete placement; a time limit to restart the placement; profile and preparation of the joint interface; and, if reinforcement dowels are needed, approved size and bend profile, and ready availability of the dowels onsite. In addition, verify that the contingency planning, preparations, and engineering requirements have been reviewed by qualified personnel for technical adequacy.

02.04 Expansion Anchor Installation. Ascertain whether concrete expansion anchor installation activities are being adequately controlled by reviewing the applicable procedures, observing work, and checking (e.g., witness of torque wrench operation or QC inspection verification) that the proper tension has been developed in the bolt. Judgement should be used in selecting the specific sample size for inspection of the concrete expansion anchor installation process. The following items and inspection criteria should be used in determining whether the appropriate quality controls have been implemented:

- a. Concrete Drilling. Concrete drilling, including depth, perpendicularity, hole size and rebar damage prevention,
- b. Embedment. Embedded depth of the anchor bolt,

- c. Anchors. Bolt length projection beyond the concrete surface and thread engagement for the nut on the bolt,
- d. Torque. Installation torque to set the anchor bolts,
- e. Torque-Tension. Torque-tension relationship controlled by design,
- f. Design Dimensions. Minimum distance from concrete edges and openings, minimum bolt spacing, and minimum distance from embedded steel,
- g. Identification. Bolt diameter and applicable marking/stamps,
- h. Design Provisions. Design provisions for the subsequent installation of the supported components, including quality checks (e.g., use of torque seal).

Guidance. It is expected that new plants will significantly reduce or eliminate expansion anchors; therefore, this section may not apply. Before observing any concrete expansion anchor installation activities, the inspector should examine the bolts and related components in storage, evaluating any issues involving special preservation requirements, storage conditions, damage controls, material and component identification, and nonconforming material segregation. In selecting the concrete expansion anchor sample size and population for inspection, emphasis should be given to known ITAAC impact; early installations for process control checks; and the diversity of support installations using concrete expansion anchors; e.g., structural, piping, electrical, HVAC, etc.

QA/QC procedures provide a key element for the effective implementation of inspections and confirmation that concrete expansion anchor installation controls are adequate. QC inspections should require direct verification of important specification requirements and should not be accomplished merely by surveillance. Laboratory and field testing activities should provide for direct verification of correct material usage, the selection of proper reference standards, and should preclude the discretionary selection of inspection and testing parameters, without approved procedural direction and guidance. The installation and related QA procedures should reference hold point requirements for in-process inspection activities and address the QA stop work authority and controls if major program weaknesses or process control problems are identified.

If any rebar is damaged or cut during installation, ensure design controls are in place to evaluate the cumulative effect on the affected structures. Ensure the anchor bolt embedment depth accounts for any non-structural finish coats, coverings, or grout, on concrete slabs, especially floors.

02.05 Water Barriers for Foundations and Buildings. Exterior walls and the basemat of the nuclear island may require a water barrier up to site grade, **dependent on reactor design and approved COL.** An inspection of the exterior walls and the basemat of the nuclear island should be done to verify that the application of a water barrier was

performed during construction before the basemat and wall excavations were returned to grade level.

Guidance. The water barrier may consist of either a High Density Polyethylene (HDPE) double-sided textured waterproofing membrane, a HDPE single-sided self-adhering sheet waterproofing membrane, a sprayed-on waterproofing membrane, or a cementitious crystalline waterproofing additive included in a shotcrete layer. These applications may be present either in or on the walls and mudmat for the nuclear island. Depending on which waterproofing method is used, will determine when the ITAAC Inspections will commence.

For the HDPE double sided textured waterproof and sprayed-on waterproofing membranes, ITAAC Inspections shall commence prior to work starting on the mudmat located beneath the basemat foundation for the nuclear island.

The following Inspections should be completed:

- a. **Material Storage.** Inspection of the storage facilities for the waterproofing materials should be conducted to ensure that they meet the storage and handling requirements of the quality assurance program and manufacturer requirements.

Guidance. The materials used for the HDPE or sprayed-on waterproofing membranes may be sensitive to ultraviolet (UV) rays, extreme high or low temperatures, and in some cases, storage durations. It is important when reviewing the storage and material handling procedures to ensure that these requirements are identified and met.

- b. **Surface Preparation.** Inspection of the contractor's surface preparation prior to the application of either the primer or adhesive and subsequent protection preceding the membrane installation.

Guidance. Surface preparation procedures and activities should be consistent with manufacturer's recommendations, or, if applicable, qualification testing. In order for either the HDPE or spray-on membranes to adhere properly to the walls and mud mat, a primer or adhesive must be used. It is important that prior to the application of the primer or adhesive that the concrete surface has cured to the manufacturers recommendations and is properly cleaned to remove any excess moisture and surface laitance (dust). In addition, the surface must be free of holes, surface cracks, and abrupt transitions, excluding designed concrete expansion joints. Care must also be taken to protect the primer or adhesive from exposure to excess dust and moisture once it is applied. Improper surface preparation or protection of the primer or adhesive could have an adverse affect on the membranes ability to properly bond to the primary surface.

- c. **Membrane Installation.** Inspection should be conducted during the installation of the HDPE or sprayed-on waterproofing membrane.

Guidance. Installation procedures and activities (including, but not limited to, mixing and material preparation) should be consistent with manufacturer's

recommendations, or, if applicable, qualification testing. Joint details should also be reviewed. Special attention should be paid to weather conditions. Variances in temperature and humidity could possibly affect the installation of the membrane. For example, sprayed-on membranes may require a minimum curing time prior to being exposed to precipitation while HDPE membranes may experience temperature related thermal expansion or contraction that could ultimately cause a failure in the membrane.

- d. Final Inspection. Observation of either the membrane Inspection activities or a careful review of documented inspections should be conducted. It is also recommended that prior to the membrane being permanently covered, that a final visual inspection should be performed.

Guidance. It is important when observing the inspection activities or reviewing inspection documentation to ensure that the inspection personnel or laboratory are qualified to perform the necessary activities. Special attention should also be given to any equipment used for performing measurements to ensure recent calibration. Finally, either during the inspection or prior to the membrane being permanently covered, a visual inspection should be performed to look for any signs of potential membrane failure. Potential failure may include sagging, pinholes, blistering, lifting, and delamination/peeling.

- e. Review of the licensee's report of completion of the installation of the water barrier.

For the cementitious crystalline waterproofing shotcrete additive, ITAAC Inspections will commence with the start of excavation for the nuclear island. The placement of shotcrete on the vertical walls of the excavation is a part of the soil retention system and will establish a vertical face with lateral support of the adjoining undisturbed soil or rock. This shotcrete will contain the crystalline waterproofing materials. This installation closely follows the progress of the excavation and is from the top down.

The following Inspections should be completed:

- a. Shotcrete. Inspection of batch plant procedures and activities to evaluate preparation of the required shotcrete needed to produce the required waterproofing on the vertical walls of the excavation.

Guidance. The required mix for the vertical walls is typically 4,000 psi to 5,000 psi non-expansive pea gravel shotcrete mix, with a proper mix of portland cement, very fine silica sand, and proprietary chemicals needed to produce the required waterproofing. Refer to the design requirements and specifications.

Section 02.01.d provides guidance for inspection of batch plant procedures and activities, including proper storage and use of concrete materials and additives. It also provides guidance for inspections to ensure that the batch plant is providing the proper mix strength and using the proper additives.

- b. Mud Mat. Inspection of batch plant procedures and activities to evaluate the preparation of concrete for the mud mat to ensure proper strength mix and addition of the required cementitious crystalline waterproofing additives.

Guidance. The mix strength and the required waterproofing additives for the mud mat concrete should be as specified in construction and design specifications.

Section 02.01.d provides guidance for inspection of batch plant procedures and activities, including proper storage and use of concrete materials and additives. It also provides guidance for inspections to ensure that the batch plant is providing the proper mix strength and using the proper additives. Shotcrete Inspection. Visual inspection of vertical wall shotcrete placement activities to evaluate:

1. Proper placement of the welded wire mesh wall reinforcement system.
2. Proper placement of the shotcrete including measurements to ensure that thickness of installed shotcrete **meets the design requirements.**
3. Adequate preparation of construction joints between vertical wall applications to ensure that the construction joints do not provide a leak path.

Guidance. Installation activities will be dependent on whether the excavation is in soil or rock. In soil, activities will include installation of “soil nails,” or some other approved method of soil retention, prior to installation of the welded wire mesh and vertical shotcrete placement. In rock, activities will include provisions for proper support of the welded wire mesh and vertical shotcrete placement. In either case, inspections should include verification that the welded wire mesh is properly supported and that it is properly embedded and covered by the shotcrete so as to preclude potential leak paths through the waterproof barrier.

- c. Mud Mat Inspection. Visual inspection of mud mat installation to evaluate: 1) Proper placement of the welded wire mesh reinforcement system; 2) Proper preparation and protection of the construction joint between the vertical wall shotcrete and the mudmat to ensure that the construction joint does not provide a leak path; 3) Final mud mat thickness is at least nine inches thick, or as specified on the design drawings.
- d. Review of the licensee’s report of completion of the installation of the water barrier.

02.06 Record Review. Conduct a general review of the documentation generated for each concrete placement inspected, along with at least two structural concrete placements that were not the subject of direct observation and inspection activities. As a minimum, the concrete records establishing that any applicable ITAAC have been met should be reviewed and the complete records for at least two of the early concrete placements should be assessed for completeness, accuracy, and documented evidence

that the quality and code requirements have been satisfied. In confirming the adequacy of the structural concrete records, the following areas should be sample-inspected to verify that the requisite objective evidence of quality and code compliance has been met:

- a. Receipt Inspection and Material Certification. Records should confirm the requisite material characteristics, performance tests, nondestructive tests, and other specification requirements.
- b. Installation Inspections. Records should confirm that adequate concrete production, placement, inspection, protection and curing activities were performed; that the installation of embedded components was properly controlled; and that objective test results are available to demonstrate compliance with quantitative acceptance criteria.
- c. Training/Qualification of Craft, QA, and Inspection Personnel. Records should establish that craft personnel have been adequately trained in their assigned tasks (e.g., “cadwelding”) and that QA/QC personnel and other certified inspectors have been qualified to the requisite standards and trained with respect to their responsibilities.

Guidance. Where required in the records documenting material certification, chemical and physical tests for components, parts, and materials should meet the specification requirements for not only the acceptance criteria, but the required test frequencies, as well. Concrete placement testing includes certain in-process tests (e.g., slump tests), as well as completed concrete strength tests (e.g., cylinder compressive testing) and other material testing activities (e.g., mechanical rebar splice tensile testing).

Inspection records should provide evidence that the timing of events (e.g., a concrete pre-placement inspection) and time-dependent work activities (e.g., concrete truck mixing) are consistent with their specification requirements, thereby validating information or conditions applicable to the quality activity being inspected. Training records should provide evidence of not only general procedural training for both craft and QC personnel, but also specific qualification requirements (e.g., cadweld crews or concrete test laboratory personnel) where required for special processes.

02.07 Problem Identification and Resolution. The inspector should confirm that problems identified during the inspection are entered into the licensee/constructor corrective action program in accordance with program requirements. The inspector may review licensee actions to address similar or related problems that were previously identified, in order to check the extent of condition and confirm the effectiveness of the licensee’s corrective measures.

Guidance. This inspection is to assure that problems are entered into the applicable process to assure corrective actions appropriate to the circumstances are developed and prioritized. Inspections of Quality Assurance Program implementation, effectiveness of Problem Identification and Resolution, and Self-Assessment will be performed under the **IMC 2504** process.

02.08 Construction Interface Concerns. This section is included to provide inspectors a background on past structural concrete control problems and management issues that should be more closely scrutinized to give the NRC early information on potential problems. To the extent that engineering and design change activities will continue during the construction of the facility, the design and engineering controls that were reviewed in accordance with IMC 2502 [i.e., First-of-a-Kind (FOAK) Engineering Inspections] will continue to be sample-inspected under IMC 2504. The following inspection guidance provides some insight into the project management and engineering interfaces likely to be encountered during the NRC inspection of structural concrete activities.

These inspection activities are not intended to be prescriptive, but rather are aimed at ensuring that the NRC is aware of how the project is progressing and being managed with respect to design-construction interfaces, construction discipline interfaces, and the controls exercised by the licensee. The following list is not intended to be all-inclusive, but does provide highlights on this subject.

- a. Poor coordination of structural concrete activities with other disciplines. Input from various designers, suppliers, and contractors should be properly integrated into instructions addressing interdisciplinary work (e.g., building steel or piping, electrical, mechanical equipment supports embedded in concrete placements).
- b. Frequency of civil/structural design engineers visits to the construction site to conduct follow-up checks of concrete placement activities. Assess the interchange of design information between designer, constructors, inspectors, and managers regarding structural work, constructability issues, and field changes.
- c. **Timeliness in design changes and drawing revisions.** Check that coordination is in place to preclude the need for “last-minute” changes and delays after the concrete placement has been scheduled. **This coordination should include consideration for testing requirements of embedded piping.**
- d. Changes in the sources of concrete materials and admixtures from those originally being used. If major changes occur, reinspection of mix designs may be in order.
- e. Licensee controls used to ensure the construction quality for areas inaccessible after the concrete placement. Assess that the issues (e.g., embedded items) have been adequately addressed by both documented contractor checks and independent QA verification activities.
- f. QA/QC inspection controls for signing off on the readiness for a concrete placement. Examine the inspections for timeliness and problems identified just prior to concrete placements, resulting in inordinate delays.

- g. Management oversight. Determine whether there is an appropriate level to include a sufficient number of experienced, trained craft supervisors and QA/QC inspectors present during concrete placement activities.

02.09 Concrete Quality Process Problems. The following concrete-related problems (compiled from the NRC inspection records for the prior generation of plants constructed in accordance with 10 CFR 50) represent findings that NRC inspectors might encounter during the inspection of structural concrete activities.

- a. Inadequate QA/QC records.
- b. Improper use of vibrators.
- c. Exceeding allowable time to place concrete.
- d. Improper sampling of aggregates.
- e. Improper curing of concrete test cylinders.
- f. Exceeding allowable concrete temperatures.
- g. Materials improperly certified.
- h. Cylinder break test records exceed allowable coefficient of variation.
- i. Improper splicing practices (reinforcement cleaning, alignment, gage marks, thread damage, inadequate swagging force, etc.).
- j. Inadequate concrete curing.
- k. Samples of concrete not taken where and when required.
- l. Excessive amounts of concrete admixtures.
- m. Inadequate cleanliness of placement.
- n. Spacing of reinforcing steel in error.
- o. QC inspections not done conscientiously.
- p. Excessive drop of concrete.
- q. Batch plants improperly qualified.
- r. Incorrect location or placement of embedded items such as anchor bolts, plates, and dowels.

While the above concerns primarily reflect process problems in the placement and inspection of structural concrete, these problems, if not corrected and adequately

addressed, also adversely affect certain SSC for which concrete quality is a contributing factor. Therefore, this listing of findings provides not only examples of construction, but also a compilation of problems that could have an indirect effect on the acceptance of related concrete ITAACs. When evaluating an ITAAC item, **the inspector should** exercise judgement in determining what impact any construction quality issue may have not only upon the conduct of proper “inspections, tests and analyses,” but also upon the resultant product and its demonstrated ability to satisfy the documented “acceptance criteria.” ACI 318 can be referenced for further information.

#### 65001.02-03 RESOURCE ESTIMATE

Resource estimates are currently under development for this inspection procedure. This document will be revised to add this information as it becomes available.

#### 65001.02-04 REFERENCES

American Society for Testing and Materials (ASTM) C94, Standard Specification for Ready-Mixed Concrete.

ASTM E-329, “Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.”

American Concrete Institute (ACI), “Manual of Concrete Inspection.”

ACI 318 – “Building Code Requirements for Reinforced Concrete.”

National Ready Mixed Concrete Association (NRMCA) Checklist.

Regulatory Guide 1.69, Concrete Radiation Shields for Nuclear Power Plants, Revision 0, 12/73

Regulatory Guide 1.94, Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants, Revision 1, 4/76

Regulatory Guide 1.107, Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures, Revision 1, 2/77

Regulatory Guide 1.136, Materials, Construction, and Testing of Concrete Containments, Revision 2, 6/81

Regulatory Guide 1.142, Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments), Revision 2, 11/01

END

Attachment 1

Revision History For 65001.02

Commitment Tracking Number	Document Accession Number and Issue Date	Description of Change	Training Needed	Training Completion Date	Comment Resolution Accession Number
N/A	10/03/07 CN 07-030	Researched commitments for 4 years and found none.  Initial issuance	N/A	N/A	N/A
N/A	11/22/2011 CN 11-037 ML112700826	This document is being revised to update and clarify the the waterproofing membrane and buried piping issue	N/A	N/A	ML113040367