
INSPECTION PROCEDURE 69020 APPENDIX B

INSPECTION OF STRUCTURAL CONCRETE AT NON-POWER PRODUCTION AND UTILIZATION FACILITIES

Effective Date: March 25, 2025

PROGRAM APPLICABILITY: IMC 2550

69020.B-01 INSPECTION OBJECTIVES

- 01.01 To determine if safety-related structural concrete work is being performed in accordance with regulatory requirements, the licensing basis, specifications, drawings, and work procedures.
- 01.02 To determine if the applicant/licensee's system for preparing, reviewing, and maintaining records relative to safety-related structural concrete activities reflect work accomplishment consistent with specifications and procedures.
- 01.03 To determine if the as-built condition of safety-related concrete structures meets the specified design requirements, specifications, and drawings.
- 01.04 To determine if the implementation of the quality assurance program (QAP) related to work activities for safety-related structural concrete is effective and to verify that deviations from requirements are appropriately resolved.

69020.B-02 INSPECTION REQUIREMENTS

- 02.01 For the structural concrete activities selected for inspection, determine if appropriate and adequate procedures in the following areas are compatible with the QAP and prescribe adequate methods to meet the specifications:
 - a. qualification of materials (cement, water, aggregate, and admixtures)
 - b. concrete mix design
 - c. concrete batch plant
 - d. placement activities (concrete forms, rebar and splices, embedded items, cleanliness, and inspection)
 - e. in-process testing of plastic concrete (slump, entrained air, temperature, unit weight, and cast cylinders)
 - f. concrete placement activities and inspection of concrete placement activities
 - g. post-placement activities (adequate curing and identification and repair of defects)
 - h. evaluation and review of concrete test results
 - i. engineering direction
 - j. qualifications of construction quality control personnel

- 02.02 Determine if the applicant/licensee has an established audit program (including plans, procedures, and audit schedule) for assessing the adequacy of work control functions and requirements in their licensing basis for structural concrete. Determine if examination, inspection, and test personnel associated with performing tests and inspections of structural concrete are qualified and/or certified to perform their assigned work.
- 02.03 Determine if the following structural concrete activities are being controlled and accomplished in accordance with the requirements of the documents reviewed in Section 02.01, above:
- a. qualification of materials (cement, water, aggregate, and admixtures)
 - b. concrete mix design
 - c. concrete batch plant
 - d. preplacement activities (concrete forms, rebar and splices, embedded items, cleanliness, and inspection)
 - e. in-process testing of plastic concrete. (slump, entrained air, temperature, unit weight, and cast cylinders)
 - f. concrete placement activities and inspection of concrete placement activities
 - g. post-placement activities (adequate curing and identification and repair of defects)
 - h. evaluation and review of concrete test results
 - i. engineering direction
 - j. qualifications of construction quality inspection personnel
 - k. configuration management
- 02.04 Review the documentation generated for the structural concrete activities. Determine if the applicant/licensee/contractor system for documenting safety-related work is functioning properly. Records should be complete, reviewed by quality control, engineering personnel, or designee, and readily retrievable. Review safety-related records in the following areas:
- a. receipt inspection and material certification (if applicable)
 - b. installation inspection
 - c. nonconformance/deviation record(s)
 - d. training/qualification records of craft, and quality inspection personnel (as required)
 - e. configuration management records

69020.B-03 INSPECTION GUIDANCE

General Guidance

Inspectors should review the facility description in the safety analysis report (SAR) or equivalent and be familiar with the safety-related structures, and associated structural concrete, being constructed at the site. The purpose of these as-built inspections is to verify that the assumptions and critical attributes reviewed during the licensing review process remain valid; the design was appropriately translated to construction specifications; the licensee/applicant constructed the facility in accordance with these specifications; and any changes made to the design described in the SAR comply with the licensee's configuration management program. For applicants/licensees that do not classify structures as safety-related, but special nuclear materials would be stored or processed in the structure, the inspection, if needed, should be risk-informed and consider attributes that focus on verifying that a failure of the structure, and

associated structural concrete, would not create an additional unmitigated accident sequence, such as criticality, radiological, fire, etc.

Inspectors should also be familiar with the licensee's QAP and use IP 69021, "Inspections of Quality Assurance Program Implementation During Construction of Non-Power Production and Utilization Facilities" to perform "vertical slice" inspections as described in the body of this IP. Inspectors should complete this appendix by inspecting the attributes listed in this appendix for structural concrete work on-site at the time of the inspection with a focus on safety-related structures. Inspectors should also coordinate this appendix with inspection of foundations and buildings (Appendix A of this IP), and structural steel and steel supports (Appendix C of this IP) for efficiency, if possible.

Inspectors should contact the applicant/licensee prior to the on-site inspection to help determine which structures and associated structural concrete are to be inspected. Observation during in-progress construction of the buildings is desirable but not required. If necessary, inspectors may select completed structural concrete for inspection. Inspectors should not attempt to inspect all buildings on the site but may expand if significant concerns with the applicant/licensee's control of structural concrete construction arise.

Inspectors should collect applicant/licensee procedures, building specifications, and work completion records in advance, if possible. If unable to review these documents in advance of the on-site inspection, then the licensee should be notified that these documents, and any other relevant documents, should be available when the inspector(s) arrives at the site.

Inspectors should choose one or more safety-related structural concrete activities and review the areas listed in Sections 02.01 through 02.04 of this document to the extent practical and may use their judgment in determining which areas to concentrate on if time is limited. However, inspectors should gain an understanding of the applicant/licensee's program to the extent necessary to determine if the licensee conforms to regulatory requirements. Not all the items in the inspection requirements section will be applicable or required in all situations for all safety-related structures and associated programs.

03.01 Inspection Requirement 02.01

Review construction specifications related to structural concrete to determine if the specified technical requirements conform to the commitments contained in the licensing basis. Review concrete construction procedures and verify that they specify provisions for on-site engineering direction and are adequate for procurement and use of materials, control of hold points, and control of design changes. Determine if adequate procedures in the following areas are compatible with the quality assurance program, and prescribe adequate methods to meet the construction specifications:

- a. qualification of materials (cement, water, aggregate, and admixtures)
- b. concrete mix design
- c. concrete batch plant
- d. preplacement activities (concrete forms, rebar and splices, embedded items, cleanliness, and inspection)
- e. in-process testing of plastic concrete (slump, entrained air, temperature, unit weight, and cast cylinders)
- f. concrete placement activities and inspection of concrete placement activities
- g. post-placement activities (adequate curing and identification and repair of defects)
- h. evaluation and review of concrete test results

- i. engineering direction
- j. qualifications of construction quality inspection personnel

03.02 Inspection Requirement 02.02

- a. Review applicant/licensee's audit program (including plans, procedures, and audit schedule) for assessing the adequacy of work control functions and requirements in structural concrete construction activities.
- b. Review the audit program to verify if examination, inspection, and test personnel associated with performing tests and inspections of structural concrete construction activities are qualified and/or certified to perform their assigned work.
- c. Verify records establish that required audits were performed, that deficiencies identified during audits were corrected, and that adequate corrective actions were completed.

03.03 Inspection Requirement 02.03

Determine if the following applicable structural concrete construction activities are being controlled and accomplished in accordance with the requirements of the documents reviewed in Section 02.01, above:

- a. Qualification of Materials. Review the qualification testing for the materials (cement, water, aggregate, and admixtures) selected for use in the concrete. Review the qualification tests for other hardware associated with structural concrete, such as reinforcing steel, rebar splices, curing compounds, embedded items, etc.

Chemical and physical tests for materials used should indicate that specifications have been met. Testing should be performed at the required frequencies. Tests results may be provided by the manufacturers via certified materials test reports or may be performed at an independent or in the onsite testing laboratory. Test results should be reviewed for the following materials:

- 1. concrete-mix materials (cement, fly ash, sand, aggregate, water, admixtures, etc.) and all constituents used in other cement-like materials, such as gunite, grout, dry pack or manufactured materials such as epoxy;
 - 2. reinforcing steel;
 - 3. reinforcing splicing materials;
 - 4. waterproof membranes, water stops, joint materials and sealants;
 - 5. embedded mechanical items such as piping, conduit, mechanical and electrical penetrations (sleeves), sumps, drains, and grating material, etc.;
 - 6. off-the-shelf anchorage components and embedment's (bolts, hangers, inserts, etc.), and embedded structural steel items (shear connectors, embedded plates, etc.);
 - 7. materials used during construction such as for construction joint preparation, form-release agents, and curing compounds; and
 - 8. other structural concrete materials that may be used.
- b. Concrete Mix Design. Review the concrete mix designs, supporting material qualifications, and testing to be used in safety-related structures. If more than three concrete mix designs are used, review a sample of the highest strength or most-used mixes, and the associated material qualifications.

A concrete-mix design should be completed for each type/strength of concrete mix to be used in safety-related structures. The mix design should be completed using the qualified materials, sufficiently in advance of the planned concrete-placement start dates, to demonstrate that the concrete mix will satisfy the job requirements for slump, air entrainment, strength and any other specified parameters. Test cylinders need to be molded, cured and tested to demonstrate that the required design requirements will be achieved within the specified time period (e.g., 7, 28, or 90 days). It is not an acceptable practice to attempt to base the final concrete design strength on incomplete test results (e.g., estimating the 28-day strength, based on results of test cylinders tested at ages of 7 and 14 days). If the sources of materials used in the concrete are changed, new mix designs may need to be qualified, before placement.

c. Concrete Batch Plant. Verify the following:

1. Batch plant has been inspected and certified to the appropriate standards. Scales and meters are calibrated at necessary frequency and to specified tolerances. Mixer-efficiency tests are being performed in accordance with American Society for Testing and Materials (ASTM) C-94 (or the committed standard in the licensing basis), at proper intervals. Batch plant is inspected to verify equipment performs properly and that rotation speed, timing, and blade wear are not excessive. There should be no contamination of materials or concrete mix. Batch records are generated, controlled, and indicate placement location, mix, volume, date, time, and special instructions.
2. Verify concrete uniformity testing is performed in accordance with ASTM C-94, or as equivalent, at periodic intervals. Verify that the batch plant scales have been calibrated through their full range of use on the project. Water meters and admixture dispensers also require calibration. During observation of concrete batching operations, verify that the scales re-zero after each batch.
3. Materials are properly qualified and traceable to approved sources. Materials need to be properly stored at the batch plant. Nonconforming or unqualified materials should be segregated from qualified materials. Storage of cement and admixtures require control so that shelf life is controlled, and older materials are used before recently received materials. Cement and fly ash are required to be protected from moisture. Generally, cement should be used within 180 days of manufacture. Admixtures should be used within the shelf life specified by the vendor.

Verify storage and handling of materials are controlled:

- a) cement (and fly ash, if used) are protected from moisture,
 - b) aggregate is not subject to excessive segregation of sizes or contamination from debris, dirt, other materials, or mixing with other sizes of aggregates,
 - c) admixtures are prevented from freezing, and
 - d) there are provisions for production of concrete in hot weather (replacing water with ice in concrete mix) and cold weather (heating mix water).
4. 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 and are taken periodically, during daily concrete production.

- a) Admixtures need to be protected from freezing. An adequate supply of all materials needs to be available at the batch plant, to complete the placement, with sufficient reserves of materials to make up for concrete batches that may be rejected because of noncompliance with specification requirements.
 - b) Potable water is generally suitable for making concrete. However, testing (chemical analysis) of the water should be performed to verify that it does not contain impurities that may be detrimental to the concrete or reinforcing steel. Also, concrete should be batched using site water and compared to concrete batched using distilled water. In this test, the normally accepted standard is that the site water is deemed acceptable if samples batched from site water do not result in a reduction in strength of more than 10 percent less than samples batched using distilled water. The moisture content determination of aggregates is an important test to accurately calculate the total water in each batch of concrete. Fine and coarse-aggregate-moisture-content testing needs to be performed periodically, throughout daily concrete production. Frequency of testing will be determined based on weather conditions and variations in the moisture content.
5. Concrete transporting equipment is suitable and in an acceptable condition. Trucks used to transport concrete from the batch plant to the job site need to be inspected to ensure that they are clean and free from dirt/debris and/or water which could become mixed with, and contaminate, the concrete. Truck mixers should be certified in accordance with National Ready Mixed Concrete Association (NRMCA) standards. The certification process also includes concrete uniformity testing in accordance with ASTM C-94 (or equivalent), at periodic intervals, if mixing of the concrete is performed in the trucks, or water or other ingredients are added to the concrete batch after the concrete is discharged from the batch plant. Verify that the drum revolution counters are operable and reset after each batch is discharged.
- d. Preplacement Activities, including concrete forms, rebar and splices, embedded items, cleanliness, and inspection. Verify the following items have been implemented:
- 1. Reinforcing steel and embedment's, such as anchor bolts, water stops, or embedded plates, are installed in accordance with applicable specifications, codes, drawings, and procedures. Reinforcing steel size, spacing, lap and mechanical splices, and embedment's, are located properly within the forms, are secured and clean (i.e., free from oil, paint, weak dried mortar, dried mud, loose rust, etc.), have proper clearances from face of forms or excavated surfaces (i.e., verify rebar will have minimum required cover, in addition to the correct "d" distance), and anchorage. The areas where embedded plates with anchors such as Nelson studs are to be set in concrete should have sufficient concrete to provide bond and should not be excessively congested with reinforcing steel. Reinforcing steel bending is properly performed and controlled.
 - 2. The structural steel needs to be firmly held within the forms (usually tie wire is used), to prevent the rebar from being displaced by movement of the plastic concrete, or by other construction activities, such as concrete vibration, or by movement of construction personnel in the form areas. Forms are secure, leak-proof, and free from water, ice, or snow. Particular attention needs to be directed to installation of column ties, stirrups, and dowels. The placement has been cleaned, and joint

preparation is as specified in the construction specification. Locations of construction joints are as shown on the drawings. The construction quality control pre-placement inspection should be completed before any concrete is placed. Records should document that all preplacement inspections have been completed.

3. Verify that other hardware items to be embedded in the concrete placement are clean, properly located, and firmly anchored. Verify that pre-placements of electrical and instrument grounding grids and embedded connection plates are correct. Piping or conduit embedment's in or through concrete should be capped or plugged before to concrete placement. Also, verify proper testing of the building ground mat.
4. Storage of reinforcing steel should be examined to verify that storage conditions are adequate to ensure that rebar will not become contaminated with materials such as mud, excessive rust, grease, oil, etc., which could affect the bonding of the rebar and concrete.
5. Mechanical Rebar Splices. Review the mechanical splicing instructions issued by the vendor. This document usually specifies the proper performance of all mechanical splicing operations. Determine if the mechanical splicing instructions are being used. Verify the following:
 - a) Process (e.g., cad weld or bar-lock couplers) and crews are qualified.
 - b) Each splice is defined by materials used, location, crew, type of splice, and heat number (if applicable).
 - c) Sampling and testing are performed at proper frequency and acceptance criteria are defined.
 - d) Inspections are performed during and after splicing by qualified inspection personnel.
6. Preplacement planning and training have been completed to ensure good-quality construction, and to protect against unplanned construction joints.
7. The equipment to deliver concrete to the actual placement location, such as conveyors, lines, pumps, buckets, etc., is suitable and in an acceptable condition. Ensure that there are enough concrete vibrators on hand, with extras on standby, for consolidating concrete. Sufficient access available to placement location for vibrator operators, concrete placement equipment, inspection personnel, and other craftsman. Adequate preparations for curing, protection from rain, and hot or cold weather protection are completed before the start of concrete placement activities.
- e. In-Process Testing of Plastic Concrete. The following items should be verified in the review of the testing program conducted during concrete placement:
 1. Concrete is sampled at the proper frequency for determination of temperature, slump, air content, and unit weight.
 2. Taking of a sample and testing techniques conform to the procedures specified in applicable ASTM standards. Samples for pumped concrete are required to be obtained from the end of pump line, at point of placement.
 3. Test specimens (cylinders), for concrete strength testing are sampled at the required location and frequency. Cylinders are molded, handled, and cured in accordance

with specified requirements. Curing boxes are available to properly store and cure cylinders for the first 24 hours, per the requirements of ASTM C-31 (if applicable).

4. Testing apparatuses in the onsite laboratory used to perform testing on materials and plastic concrete are being calibrated at the required frequency. Observed testing conforms to the procedures specified in the applicable ASTM standards.
 5. Personnel performing sampling and testing are trained and qualified.
 6. Concrete-testing personnel have authority to reject concrete batches not meeting specification requirements.
- f. Concrete Placement Activities. Verify the following:
1. Records are produced, reviewed, and indicate mix, location, time placed, water additions, and temperature of the concrete mix and ambient conditions. Records reflect the results of inspections, the actual field conditions, testing frequency requirements, and that data calculations are checked.
 2. The area where concrete is to be placed needs to be clean and free of debris. Materials such as sawdust, wood, dried mortar, tie wire, and other debris need to be removed from the forms before placement of concrete. Access ports are usually provided in the forms to permit cleaning and inspection. Water jets and/or compressed air should be used for cleaning.
 3. Inspections during placement are performed by qualified personnel. Inspection personnel should inspect pre-placements within a timeframe that represents the actual conditions before the placement. Quality control pre-placement inspections should 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.
 4. Concrete batch tickets are reviewed for verification of proper mix, placement location, and amount of water, if any, withheld from the batch.
 - a) The quantity of withheld water, also referred to as retempering water, is determined based on the maximum water to cement ratio. Time limit (normal maximum of 1.5 hours) between mixing and delivery has not been exceeded, and the total number of revolutions of the truck mixer does not exceed 300, or as required. (See ASTM C-94 or equivalent.)
 - b) The practice of withholding water at the batch plant and then tempering at the point of placement should consider the results of air content and slump measurements taken at the point of placement. Efficient radio communications between the batch plant and field construction quality control testing personnel will minimize the need for water tempering at the point of placement and thus result in more uniform batching. Check time (90 minutes max) of concrete receipt for truck transported, centrally mixed concrete, and number of truck-mixer revolutions (300 max). Also, verify the amount (quantity should be documented) of water added, if permitted, and re mixing (minimum 30 revolutions).

- c) Addition of super water-reducing (super plasticizers) admixtures to concrete batches are controlled. When admixtures or withheld water are added after concrete is discharged from batch plant, remixing in the truck for a minimum of an additional 30 revolutions of the truck mixer is required to conform to ASTM C-94 on uniformity of mix. After addition of super plasticizers or withheld water and remixing, slump tests should be performed to confirm the slump is within specification limits.
- 5. Specification temperature limits have been met.
- 6. Placement drop distances do not exceed specification requirements and do not result in segregation. Concrete should not strike forms or bounce against reinforcing bars causing segregation of aggregates from the mix.
- 7. Special attention is given to areas of high reinforcing or embedment steel congestion, to preclude areas of voids or honeycombing.
- 8. Forms should be well secured and braced so they will not be displaced by the fresh concrete or concrete-placement activities. The permitted rate of rise of the fresh concrete needs to be specified to avoid excessive loads on the forms caused by hydraulic forces from the fresh concrete. Otherwise, there could be form failures (blow-outs) resulting in injuries to construction personal and/or damage to safety-related structures or components.
- 9. The joints should be kept damp for a specified period, usually 12 to 24 hours, before concrete placement. There should be no standing water in the forms.
- 10. Vibrators are approved, tested for frequency, and are used properly by trained individuals. 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) layers, 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 steel. Vibrators should not be used to move concrete laterally. Any excess water in the forms should be removed and not permitted to mix with the concrete.
- 11. Additionally, consideration should be given for having enough vibrator operators and, preferably, some spare vibrators, which should be checked for proper operation before starting to place concrete. Vibrators less than (3 inches) 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 inches) in diameter can be operated by one man; (4 inches) or larger vibrators are two-man tools.

- g. Post-Placement Activities. Including adequate curing, as well as identification and repair of defects. Verify the following:

1. Verify that curing is performed in accordance with specifications and procedures regarding the method, materials, duration, and temperature (concrete and ambient). Verify that inspections (during curing and after form removal) are performed and documented in records.

The concrete needs to be protected from damage and properly cured. Proper curing requires keeping the surface of the concrete moist, and, in cold weather, warm, so that hydration of the cement continues until the concrete achieves design strength. Curing can be accomplished using moisture (water sprays, etc.) or by use of a curing compound. However, curing compounds should not be used on construction joints unless they are removed prior to the next placement. Curing compounds used on construction joints may act as a bond breaker and result in successive placements not achieving good bond. Minimum curing times should be specified in the construction records. Formation of ice (freezing of the curing water) on surfaces of the concrete during the curing period should not be permitted. Forms need to remain in place for the period specified in the procedures. The time to remove the concrete forms is often based on achieving a minimum concrete strength.

2. Verify that concrete placements are inspected after form removal to identify any defects in concrete. Examples of defects are voids (honeycomb), cold joints, excessive cracking, delamination's, excessive entrapped air voids (bug holes), or evidence of form-related defects such as sand streaking or inadequate bracing. Identified defects require documentation, evaluation, and repair, in accordance with the applicant/licensee's quality assurance program.

Defective areas in concrete should be repaired as soon as possible after the forms are removed. Design engineering approval should be obtained for all concrete repair methods. It is not acceptable to repair concrete defects by merely plastering over them with mortar. Concrete defects need to be cut to a depth to expose sound concrete and filled with concrete of the same strength as that in the structure. Repair of defects are usually classified as cosmetic if they are shallow surface defects, and structural if they extend to a depth below the outer layer of rebar. Locations of concrete defects and repair methods need to be documented in licensee inspection records. Note that areas repaired are required to be protected from the elements and cured to achieve adequate design strength.

- h. Evaluation and Review of Concrete Test Results. Verify that the final inspection results after form removal, test results, and other information related to the placement (including deficiencies, defects, etc.) have been reviewed before acceptance of the placement, and that the as-built documentation is complete. Verify test results are evaluated at an appropriate level and evaluation includes trending analysis. Verify non-conforming conditions identified during concrete construction activities are documented, evaluated, and repaired in accordance with the applicant/licensee's QAP.

1. 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 quality assurance program. Final inspection procedures should include verifying embed locations and identification of any defects and required repairs. Review the results of compressive strength determinations. Verify that

- results are being evaluated in accordance with ACI 214, "Recommended Practice for Evaluation of Compression Test Results of Field Concrete." During this portion of the inspection, also review the results of strength tests on mechanical reinforcing steel splices.
2. Records should be verified to show that mix specified was delivered and placed. Structural drawings or specifications will indicate the design concrete strength. Evaluate the licensee's trending analysis of nonconforming items and determine if generic items are being identified and corrected.
- i. Engineering Direction. Verify that engineering direction is available, onsite, to monitor structural concrete construction activities. The onsite engineering staff should be supplemented by an experienced structural engineer to approve design changes, monitor and review quality control test results, and identify changed conditions. The onsite engineering staff should be involved in disposition of nonconformance reports, and preparation of field change requests, for approval by the design-engineering organization.
 - j. Qualifications of Construction Quality Inspection Personnel. Verify that personnel qualifications (education and experience) of testing and inspection personnel have been verified by the employing organization.
 1. Personnel qualifications should be supported by documentation. Informal interviews may be conducted with quality control inspection personnel to determine how well the inspectors know the requirements of their work activity. Determine if sufficient qualified construction quality control personnel are at the construction site, commensurate with the work in progress, and adequately performing their assigned duties through the established organizational structure.
 2. Particular attention should be directed toward the qualification of personnel and their work performance. Construction experience shows that in the past, there was a tendency for some organizations to hire untrained personnel residing near the site who had no prior work experience in concrete materials testing or inspection, train them, and certify them. Although the individuals were trained and certified, in some instances, inexperience of personnel and the lack of depth of knowledge has been found to be detrimental to an effective construction quality control/ quality assurance program. Changing of personnel between different jobs and turnover of personnel can also result in problems.
 3. In determining the adequacy of construction quality control staffing; the effectiveness of their activities should be considered. Insufficient or unqualified personnel, or inadequate management, may result in inadequate inspections of concrete-construction activities. Capabilities and effectiveness, rather than only the number of personnel, are the principal criteria to be used.
 - k. Configuration management. For the activities observed during Inspection Requirement 02.03., verify if changes occurred during these construction activities, the applicant/licensee properly controlled and documented these changes for engineering review, approval, and subsequent incorporation into the final as-built drawings. Verify these actions were completed in accordance with their procedures and quality assurance program.

03.04 Inspection Requirement 02.04

Review the documentation generated for structural concrete construction activities. Determine if the licensee/contractor system for documenting safety-related work is functioning properly. The record-keeping activities should reflect the actual conditions encountered in the field and provide adequate documentation of work and inspections. Determine if records are being maintained, reviewed, and approved, as specified. This is important in activities such as review of concrete strength. A comparison of the actual concrete strength can help in determining the reason for low strengths relatively early in the construction phase before the completion of extensive concrete work. Records should include sufficient detail to document that: (1) rebar installation met requirements; (2) the concrete strength meets design requirements; (3) curing was adequate; and (4) repairs, if necessary, completed in accordance with design requirements. Records should be complete, reviewed by QC and/or engineering personnel and readily retrievable. Review a sample of the following records:

- a. Receipt Inspection and Material Certification (if applicable). Verify applicable for materials purchased from offsite suppliers, such as cement, concrete aggregate (sand and gravel), concrete admixtures, and reinforcing steel, splices, and other components. Verify records confirm that required material characteristics, performance tests, nondestructive test, and other specification requirements were met.
- b. Installation Inspection. Verify the following:
 1. Records confirm that concrete production, concrete placement, and installation of components were performed as specified.
 2. Records confirm that the required inspections (including concrete form removal) were performed, and acceptance criteria defined.
 3. Records indicate specified concrete strength was obtained.
- c. Nonconformance/Deviation Record(s). Verify records include current status of these items. Verify nonconformance reports include the status of corrective action or resolution (e.g., if adequate corrective action were taken when concrete vibration was determined to be inadequate, or concrete strength-test results were not within acceptance criteria).
- d. Training/Qualification Records of Craft, and Construction Quality Inspection Personnel (as required). Verify if records establish that construction quality inspection personnel are adequately qualified to perform their assigned duties and responsibilities and that craft personnel have been trained in their assigned tasks. Verify records are complete and current and show which activities inspectors are qualified to perform.
- e. Configuration Management Records. Review and evaluate a selected sample of configuration management records, and determine if:
 1. Records associated with design and field changes, as well as related work and IP changes, reflect that timely review and evaluation of design and field change documents have been performed by personnel who are qualified.
 2. Records of periodic inspections ensure that only the most recent approved documents, including design changes, were used in the field.

3. Design changes are subject to adequate design control, including consideration of the impact of the change on the overall design and on as built records.
4. Records of nonconformance's to design requirements include preparation of a nonconformance report even if the nonconformance is resolved through the design-change process.

03.05 Additional Guidance

Note: Informal interviews with field-craft and inspection personnel may be randomly conducted to determine how well employees know the requirements of their work activity. Determine if sufficient adequately qualified quality control inspection personnel are at the construction site, commensurate with the work in progress, and adequately performing their assigned duties through the established organizational structure.

- a. Useful References. American Concrete Institute (ACI) – 311.1 "Manual of Concrete Inspection," is a good reference, which may be used during the conduct of this inspection. However, the applicant/licensee's specific documents, which include specifications, drawings, and procedures, specify and control the construction and inspection processes.
- b. Prevalent Errors and Concerns. Prevalent errors and recent concerns are areas in which the inspector should be alert to potential generic issues. This section is included to provide background, for inspectors, on past structural concrete problems that have been identified and on certain areas that should be more closely scrutinized to give NRC early information on potential problems. The following are potential problems identified as concrete related violations at previous projects. (Note: These are not listed in order of their importance to safety.)
 1. inadequate quality assurance/quality control records documenting concrete work activities
 2. improper use of vibrators
 3. exceeding allowable time to place concrete
 4. improper sampling of aggregates
 5. improper curing of concrete test cylinders
 6. exceeding allowable concrete temperatures
 7. materials improperly certified
 8. concrete cylinder compression test records exceed allowable coefficient of variation
 9. improper splicing practices (reinforcement cleaning, alignment, gage marks, thread damage, and inadequate swaging force, etc.)
 10. inadequate concrete curing. samples of concrete not taken where and when required
 11. excessive doses of concrete admixtures

12. inadequate cleanliness of placement
 13. omission of reinforcing steel, incorrect spacing of reinforcing steel, and/or improper anchorage (failure to firmly tie the rebar) of the steel
 14. QC inspections not done conscientiously
 15. excessive drop of concrete
 16. batch plants improperly qualified
 17. improper repair of concrete defects
 18. intentional violation of work procedures by craft personnel to avoid rejection of their work, or to simplify their work. Examples included melting of tie wire into ends of completed cadwelds, unauthorized addition of water to concrete, and covering concrete defects (honeycomb) with mortar to prevent detection by quality control inspectors.
 19. construction personnel and supervision intimidation of construction quality control inspectors
- c. Special Considerations. The following items should be incorporated into inspection of concrete placements when appropriate (refer to American Concrete Institute standards for additional guidance):
1. Hot and Cold Weather: Provisions for maintaining concrete temperature within specification should be provided. Hot and cold weather conditions should be defined, to avoid confusion.
 2. Pumping Concrete: Slump and air-content losses should be monitored to ensure placement and adequate consolidation. Samples for pumped concrete are required to be obtained from end of pump line, at point of placement.
 3. Large Placements: Planning sessions should assure consideration of all contingencies, [e.g., adverse weather, loss of power, concrete production delays (batch plant breakdowns)].
- d. Construction Quality Control. The construction specifications should translate design requirements into details sufficient to define the technical requirements for concrete construction activities. The specifications should provide for control of design changes and the issuance of design change notices. The review of procedures, specifications, and drawings should ensure that concrete construction and inspection activities are controlled and performed in accordance with applicable requirements. Construction quality control procedures should specify acceptance-testing requirements and should specify the personnel and interface responsibilities required to define, control, and resolve field problems or design problems that are evidenced during construction. Construction quality control procedures should provide for effective inspections that will assure that work is performed in accordance with specification requirements. The procedures should require verification of specified controls and should not be accomplished merely by surveillance. Laboratory and field-testing procedures should provide for verification of correct material usage, correct selection of reference

standards, and should prohibit discretionary selection of inspection and testing parameters. Construction procedures should reference the required inspection hold points and address the construction quality department authority to stop work.

- e. Cadwelding. When cadwelding operations are being performed, verify that specified materials (sleeves, powder, and packing) are properly stored, and that cadwelding fixtures are in good condition. The reinforcing steel to be cadwelded should be cleaned shortly before cadwelding, to remove all non-adherent rust. The reinforcing steel ends should be aligned and butted within the tolerances specified, using the spacers provided with the cadweld kits.

Observe the placement of sleeves and the use of a marking system to ensure centering. When the firing is completed 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).

Determine if each cadweld sleeve is identified. By interviews with two cadwelding inspectors, determine if they are familiar with the details of cadwelding requirements; also determine if inspection of cadwelding conforms to the specified frequency, if inspection records are being maintained, and if records are traceable to installation location, and identification of the cadwelder (craftsman).

- f. Other Types of Mechanical Splices. (e.g. Bar-Lock splices) If a type of mechanical splice is used, review design and construction documentation, and manufacturer's instructions to determine specific installation and testing requirements. Review the laboratory test data used to qualify the splices and verify that the licensee's installation procedures will result in an installed configuration that will reflect the laboratory testing conditions. Typical inspection parameters for all types of mechanical splices require cleanliness of the ends of the rebar to be spliced, verification of adequate embedment of the rebar ends, within the splicing sleeve, and verification that the sleeve is centered over the ends of both bars to be spliced. Identification of each splice and the craftsman/crew who completed the splice is also generally required. All craftsmen are required to be trained. All splices require inspection and acceptance by construction quality control inspectors. A testing program will normally be specified to ensure the splices fabricated at the job site meet design requirements.
- g. Temperature Effects. During periods when concrete is to be placed or cold weather is expected during the curing time, provisions should be made to keep the concrete above [40 degrees Fahrenheit (F)], preferably in the range of [(50 to 60 degrees F)]. If concrete is being mixed or transported in weather below (40 degrees 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 should 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 degrees F). If hotter water is required to warm the aggregate, the water and aggregate may be mixed before addition of cement. If the aggregate is heated, close control should be exercised, and the aggregate should 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. Also, use of chemicals should not be permitted to accelerate the concrete set times in cold weather.

Where the ambient temperature during concreting rises much above (70 degrees F), consideration should be given to the effect of high temperatures on the concrete. Although concrete cured at temperatures up to (100 degrees 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 work ability 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, and metallic embedment's, etc., should be wetted just before concrete placement. If the ambient temperature is high enough so that the bulk temperature of freshly mixed concrete exceeds (80 degrees F or 90 degrees 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 should be crushed or flaked so that all the ice is melted by the time mixing is completed.

69020.B-04 RESOURCE ESTIMATE

Completion of this appendix requires 40–80 hours of direct inspection. Inspection preparation, including review of applicable licensing basis, safety analysis report (SAR), and codes and standards is not included in this estimate.

69020.B-05 PROCEDURE COMPLETION

This inspection procedure appendix is complete when one inspection sample is complete. Refer to Section 69020-05, "Procedure Completion," of IP 69020, "Inspection of Safety-Related Items (and Services) During Construction of Non-Power Production and Utilization Facilities," for details on what constitutes a completed inspection sample. Inspectors are not expected to complete every activity in the appendices of this IP. Instead, inspectors should prioritize inspection activities based on 1) importance of the activity to safety, 2) availability of the onsite activity at the time of the inspection, and 3) available inspection resources. This appendix need not be completed if there are no safety-related items (or services) covered by this appendix at an NPUF.

69020.B-06 REFERENCES

Refer to licensing basis requirements for applicable codes and standards for each fuel facility.

American Concrete Institute (ACI)

ACI 214, "Evaluation of Strength Test Results of Concrete"

ACI 311, "Recommended Practice for Concrete Inspection"

ACI 311.1, "ACI Manual of Concrete Inspection"

ACI 311.4, "Guide for Concrete Inspection"

ACI 311.5, "Guide for Concrete Plant Inspection and Testing of Ready Mixed Concrete"

American Society for Testing and Materials (ASTM)

ASTM C-31, "Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field"

ASTM C-94, "Standard Specification for Ready Mixed Concrete"

National Ready Mixed Concrete Association (NRMCA)

NRMCA, "Concrete Plant Standards of the Concrete Plant Manufacturers Bureau"

NRMCA, "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau"

Others

U. S. Army Corps of Engineers, Handbook for Concrete and Cement, Published by US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss.

For information and standards for studs (proprietary name: Nelson Studs), which are used to secure embedded item such as pipe sleeves and plates, to concrete structures, refer to Chapter 8, "Stud Welding," Volume 2 of the Welding Handbook, Seventh Edition, published by the American Welding Society.

END

List of Attachments:

Revision History for IP 69020 Appendix B

Attachment 1 – Revision History for IP 69020 Appendix B

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment and Feedback Resolution Accession Number (Pre-Decisional, Non-Public)
N/A	ML24264A194 03/25/25 CN 25-005	Procedure was rewritten for conformance with changes to IMC 2550 and is now a standalone appendix to IP 69020.	N/A	N/A