SECTION 03 3021

REINFORCED CONCRETE–HIGH CONFIDENCE

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LANL MASTER SPECIFICATION

Word file at <http://engstandards.lanl.gov>

In general, this Section applies to nuclear facilities and their safety-class structures, systems and components (SSCs). It specifically applies to structural concrete for buildings/structures that are designed in accordance with ACI 349, facilities classified as NPH Design Category (NDC) -3, and ML-1/Safety Class SSCs.

* This Section does not apply to work involving prestressed or precast concrete.

Use of this Section requires an Independent Review.

Safety-significant (SS) SSCs that are NDC-3 must also use this section as a result of DOE O 420.1C Chg 1. See “NOTE” associated with the “Materials Paragraph” under NDC-3 Acceptance Criteria, General in ESM Chapter 5 Section III for more detail.

For SS SSCs that are “less than” NDC-3, this Section can be used by modifying the basis from ACI 349 to ACI 318.

For lesser NPH facilities Projects, use Section 03 3001, Reinforced Concrete.

Procurement of ML-1/2 requires use of either an IESL (LANL-qualified) supplier meeting ASME NQA-1 or (more likely) use of a commercial grade dedication approach; for CGD see the **High Confidence Reinforced Concrete Technical Evaluation and Acceptance (TEA) Plan - Template** posted under this Section in the [Div 03](http://engstandards.lanl.gov/specs.shtml#03) Master Spec index and upgrade as appropriate.

Examples of a **High Confidence Concrete Placement Readiness Review Checklist** are also posted with this Section on the website above.

When editing to suit Project, author shall add job-specific requirements and delete only those portions that in no way apply to the activity (e.g., an aspect that does not apply).

Note: Items in brackets are to be added or omitted according to job specific requirements. To seek a variance from applicable requirements, contact the Engineering Standards Manual (ESM) Structural Specs [POC](http://engstandards.lanl.gov/POCs.shtml#struc). Please contact POC with suggestions for improvement as well.

When assembling a specification package, include applicable sections from all Divisions, especially Division 1, General Requirements.

Delete information within and including “stars” during editing.

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1. GENERAL
	1. SCOPE
2. This Section provides the requirements for furnishing and delivering high confidence portland-cement concrete including:
	* + 1. Portland cement,
			2. supplementary cementitious materials,
			3. water,
			4. admixtures,
			5. aggregates,
			6. mixture designs,
			7. batching and mixing facilities,
			8. transport units,
			9. concrete work-preplacement and placement,
			10. erecting and designing forms,
			11. concrete reinforcing and accessories,
			12. construction, isolation, expansion, and contraction joint devices,
			13. bracing,
			14. shoring,
			15. anchorage,
			16. curing and protection, and
			17. non-structural/cosmetic repair of concrete.
		1. The nuclear safety elements of this Project that require high-confidence, reinforced concrete include the [concrete mat foundation and turndowns, walls, roof slab, and parapets. These elements are credited for strength and durability during normal operation as well as during and after a design basis earthquake event.]
		2. Related Sections
			1. Division 1 - General Requirements

[2. 03 3001 Reinforced Concrete (for normal confidence)]

[3. 03 3053 Miscellaneous Cast-in-Place Concrete (for non-safety concrete work associated with civil site work)]

[4. 03 6000 Grouting]

[5. 05 0521 Post-Installed Concrete Anchors – High Confidence]

[6. 05 0520 Post-Installed Concrete and Grouted-Masonry Anchors – Normal Confidence]

* 1. Definitions
		1. Hold Point: A mandatory verification point in the progression of a process activity that cannot be passed without being released by the responsible party that established the Hold Point. It is mandatory that the Subcontractor formally notify the LANL Subcontractor Technical Representative (STR) five (5) business days prior to a scheduled Hold Point, or within a time period agreed to by LANL. A Hold Point cannot be bypassed without the specific release by the approved official of the designating organization.
		2. Witness Point: A verification point in the sequence of Work which is designated for LANL to do monitoring and which Work may PROCEED ONLY after notifying the STR. It’s mandatory that the Subcontractor formally notifies the STR two (2) business days in advance of all Witness points, or within a time period agreed to by LANL.
		3. Alkali-Silica Reactivity (ASR): The alkali–silica reaction is a reaction which occurs over time in [concrete](http://en.wikipedia.org/wiki/Concrete) between the highly alkaline [cement](http://en.wikipedia.org/wiki/Portland_cement) paste and reactive non-crystalline ([amorphous](http://en.wikipedia.org/wiki/Amorphous)) [silica](http://en.wikipedia.org/wiki/Silica), which is found in many common [aggregates](http://en.wikipedia.org/wiki/Construction_aggregate).
		4. Certificate of Conformance (CoC): A document signed or otherwise authenticated by an authorized individual certifying the degree to which items or services meet specified requirements.
		5. Certified Material Test Report (CMTR): A written and signed document that is approved by a qualified party and contains data and information that attests to the actual properties of an item and the actual results of all required tests. Certified mill test report is a form of a CMTR.
		6. National Institute of Standards and Testing (NIST).
		7. Admixture: Material other than water, aggregate, or hydraulic cement, used as an ingredient of concrete and added to concrete before or during its mixing to modify its properties.
		8. Aggregate: Granular material, such as sand, gravel, crushed stone, and iron blast-furnace slag, used with a cementing medium to form a hydraulic-cement concrete or mortar.
		9. Cementitious Materials: Materials as specified in ACI 349 Chapter 3, which have cementing value when used in concrete either by themselves, such as Portland cement, blended hydraulic cements, and expansive cement, or such materials in combination with fly ash, other raw or calcined natural pozzolans, silica fume, and/or ground-granulated blast-furnace slag.
		10. Concrete: Mixture of Portland cement or any other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without admixtures.
		11. Concrete, Specified Compressive Strength of, (f’c): Compressive strength of concrete used in design and evaluated in accordance with provisions of Chapter 5 of ACI 349, expressed in pounds per square inch (psi). Whenever the quantity f’c is under a radical sign, square root of numerical value only is intended, and result has units of pounds per square inch (psi).
		12. Construction Joint: The surface where two successive placements of concrete meet, across which it may be desirable to achieve bond and through which reinforcement may be continuous.
		13. Contraction Joint: Formed, sawed, or tooled groove in a concrete structure to create a weakened plane and regulate the location of cracking resulting from the dimensional change of different parts of the structure.
		14. Creep: Time-dependent deformation due to sustained load.
		15. Deformed Reinforcement: Deformed reinforcing bars, bar mats, deformed wire, and welded wire reinforcement conforming to ACI 349, paragraph 3.5.3.
		16. Development Length: Length of embedded reinforcement required to develop the design strength of reinforcement at a critical section. See ACI 349, paragraph 9.3.3.
		17. Effective Depth of Section (d): Distance measured from extreme compression fiber to centroid of longitudinal tension reinforcement.
		18. Embedment: A steel component embedded in the concrete to transmit applied loads to the concrete structure. The embedment can be fabricated of plates, shapes, fasteners, reinforcing bars, shear connectors, inserts, or any combination thereof.
		19. Embedment Length: Length of embedded reinforcement provided beyond a critical section.
		20. Engineer/Engineer of Record (EOR): The licensed professional engineer, employed by the owner-contracted design authority or other agency, responsible for the overall design of the facility or Project (e.g., issues construction Drawings, Specifications, or other documents, etc.). EOR and Architect/Engineer are synonymous. [For this Project the EOR and LANL are the same entity.]
		21. Evaluation: An engineering review of an existing safety related concrete structure with the purpose of determining physical condition and functionality. This review may include analysis, condition surveys, maintenance, testing, and repair.
		22. Expansion Joint: A separation provided between adjoining parts of a structure to allow movement where expansion is likely to exceed contraction; or an isolation joint intended to allow independent movement between adjoining parts.
		23. Isolation Joint: A separation between adjoining parts of a concrete structure, usually a vertical plane, at a designed location such as to interfere least with performance of the structure, yet such as to allow relative movement in three directions and avoid formation of cracks elsewhere in the concrete and through which all or part of the bonded reinforcement is interrupted.
		24. LANL: The managing contractor of the Los Alamos National Lab (LANL, which is [Los Alamos National Security, LLC]; however, “LANL” is used herein), which acts as Owner. LANL also means Subcontract Administrator, the individual authorized to act on the behalf of LANL.
		25. Mass Concrete: Any volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat from hydration.
		26. Reinforced Concrete: Structural concrete reinforced with no less than the minimum amounts of prestressing steel or nonprestressed reinforcement specified in ACI 349 Chapters 1 through 21 and Appendixes A through C.
		27. Reinforcement: Material that conforms to ACI 349, section 3.5, excluding prestressing steel unless specifically included. Included in this definition are the terms “reinforcing bars,” “reinforcing steel,” as well as terms commonly used for products derived from steel reinforcement (e.g., “stirrups,” “ties,” etc.).
		28. Reshores: Shores placed snugly under a concrete slab or other structural member after the original forms and shores have been removed from a larger area, thus requiring the new slab or structural member to deflect and support its own weight and existing construction loads applied before the installation of the reshores.
		29. Shores: Vertical or inclined support members designed to carry the weight of the formwork, concrete, and construction loads above.
		30. Shrinkage: Time-temperature-humidity-dependent volume reduction of concrete as a result of hydration, moisture migration, and drying process.
		31. Stirrup: Reinforcement used to resist shear and torsion stresses in a structural member; typically bars, wires, or welded wire reinforcement either single leg or bent into L, U, or rectangular shapes and located perpendicular to or at an angle to longitudinal reinforcement. The term “stirrups” is usually applied to lateral reinforcement in flexural members and the term “ties” to those in compression members. See also tie.
		32. Structural Walls: Walls proportioned to resist combinations of shears, moments, and axial forces induced by earthquake motions. A shearwall is a structural wall. Structural walls shall be categorized as ordinary or special reinforced concrete structural walls.
		33. Ordinary Reinforced Concrete Structural Wall: A wall complying with the requirements of ACI 349 Chapters 1 through 18.
		34. Special Reinforced Concrete Structural Wall: A cast-in-place wall complying with the requirements of ACI 349, sections 21.2 and 21.7 in addition to the requirements for ordinary reinforced concrete structural walls.
		35. Technical Safety Requirements: The limits, controls, and related actions that establish the specific parameters and requisite actions for the safe operation of a nuclear facility.
		36. Tie: Loop of reinforcing bar or wire enclosing longitudinal reinforcement. A continuously wound bar or wire in the form of a circle, rectangle, or other polygon shape without re-entrant corners is acceptable. See also stirrup.
		37. Wall: Member, usually vertical, used to enclose or separate spaces.
		38. Welded Wire Reinforcement: Reinforcing elements consisting of plain or deformed wires, conforming to ASTM A 82 or A 496, respectively, fabricated into sheets in accordance with ASTM A 185 or A 497, respectively.
		39. Yield Strength: Specified minimum yield strength or yield point of reinforcement. Yield strength or yield point shall be determined in tension according to applicable ASTM standards as modified by ACI 349, section 3.5.
		40. f’c: Specified compressive strength of concrete, psi.
		41. f’cr: Required average compressive strength of concrete used as the basis for selection of concrete proportions, psi.
		42. db: Nominal diameter of bar, wire, or prestressing strand, inches (in.).

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Revise the paragraph below in accordance with Project specifics. The bracketed text in the subparagraphs merely serves as examples of the level of specificity required. Subparas. A and B are written in a manner that indicates that they apply to the same Project.

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* 1. SAFETY FUNCTION PERFORMANCE REQUIREMENTS

[A. The reinforced concrete structure/building will support equipment and distribution systems during normal operation, as well as during and after the design basis earthquake (DBE).]

[B. The building’s interior reinforced concrete wall protects [ ] systems from fire under any design event including the DBE.]

[C. The reinforced concrete SSC contains radioactive material and provides containment of such during normal operation, as well as during and after the DBE.

* 1. References
		1. References noted herein form a part of this Section to the extent applicable. The publications are referred to in the text by the basic designation only. The related publishing organizations are stipulated in Section 01 4200, References and in “Codes-and-Standards Paragraph (below).”
		2. Work, products, and materials shall conform to ACI 301, ACI 349, and other specific referenced publications and standards except where otherwise specified herein.
		3. Codes and Standards: The following tables provide the codes standards that shall be used and referenced for this Project.

Notes:

(1) The applicable edition/version of a given code or standard shall be either the latest one or the one referenced by the version of ACI 349 that applies to the Project.

(2) Codes and Standards that are referenced within the tabulated codes and standards shall be considered applicable to this Project.

* + - 1. American Concrete Institute (ACI)

|  |  |
| --- | --- |
| 117 | Standard Specifications for Tolerances of Concrete Construction and Materials |
| 201.2R | Guide to Durable Concrete |
| 301 | Specifications for Structural Concrete |
| 304R | Guide for Measuring, Mixing, Transporting, and Placing Concrete  |
| 304.2R | Placing Concrete by Pumping Methods  |
| 304.4R | Placing Concrete with Belt Conveyors  |
| 305R | Hot Weather Concreting |
| 306R | Cold Weather Concreting |
| 309R | Guide for Consolidation of Concrete |
| 318 | Building Code Requirements for Reinforced Concrete |
| 347 | Guide to Formwork for Concrete |
| 349 | Code Requirements for Nuclear Safety Related Concrete Structures |

* + - 1. American Society of Mechanical Engineers: Quality Assurance Requirements for Nuclear Facility Applications, ASME NQA-1 2008 with the NQA-1 2009 addenda (hereafter “NQA-1”).
			2. ASTM International

|  |  |
| --- | --- |
| A 82 | Standard Specification for Steel Wire, Plain, for Concrete Reinforcement |
| A 184 | Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement |
| A 185 | Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete |
| A 370 | Standard Test Methods and Definitions for Mechanical Testing of Steel Products |
| A 496 | Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement |
| A 497 | Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete |
| A 706 | Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement |
| C 31 | Standard Practice for Making and Curing Concrete Test in the Field |
| C 33 | Standard Specification for Concrete Aggregates |
| C 39 | Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| C 88 | Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate |
| C 94 | Standard Specification for Ready-Mixed Concrete |
| C 131 | Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine |
| C 138 | Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete |
| C 143 | Standard Test Method for Slump of Hydraulic-Cement Concrete |
| C 144 | Standard Specification for Aggregate for Masonry Mortar |
| C 150 | Standard Specification for Portland Cement |
| C 171 | Standard Specification for Sheet Materials for Curing Concrete |
| C 172 | Standard Practice for Sampling Freshly Mixed Concrete |
| C 192 | Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory |
| C 231 | Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method |
| C 260 | Standard Specification for Air-Entraining Admixtures for Concrete |
| C 295 | Standard Guide for Petrographic Examination of Aggregates for Concrete |
| C 309 | Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete |
| C 404 | Standard Specification for Aggregates for Masonry Grout |
| C 494 | Standard Specification for Chemical Admixtures for Concrete |
| C 566 | Standard Test Method Total Evaporable Moisture Content of Aggregate by Drying |
| C 595 | Standard Specification for Blended Hydraulic Cements |
| C 618 | Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete |
| C 685 | Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing |
| C 845 | Standard Specification for Expansive Hydraulic Cement |
| C 989 | Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars |
| C 1017 | Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete |
| C 1064 | Standard Test Methods for Temperature of Freshly Mixed Hydraulic-Cement Concrete |
| C 1077 | Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation |
| C 1157 | Standard Performance Specification for Hydraulic Cement |
| C 1218 | Standard Test Method for Water-Soluble Chloride in Mortar and Concrete |
| C 1240 | Standard Specification for Silica Fume Used in Cementitious Mixtures |
| C 1293 | Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction |
| C 1567 | Standard Test Method for Determining toe Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method) |
| C 1602 | Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete |
| D 1751 | Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types) |
| E 329 | Standard Specification for Agencies Engaged in Construction Inspection and/or Testing |
| E 1155 | Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers |
| E 1252 | Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis |

* + - 1. American Welding Society (AWS): D1.4 Structural Welding Code—Reinforcing Steel
			2. Concrete Reinforcing Steel Institute: CRSI MSP-2 Manual of Standard Practice
			3. International Code Council: International Building Code (IBC)
	1. ACTION SUBMITTALS AND RECORD MANAGEMENT
		1. Submit the following in accordance with Project submittal procedures for specified items.

Note: All submittals require LANL approval.

* + - 1. General requirements:
				1. Subcontractor Quality Assurance (QA) Plan (QAP) including all subtier subcontractors.
				2. Commercial Grade Dedication (CGD) Plans compliant with NQA‑1, Part II, Subpart 2.14 for concrete, concrete constituents, and reinforcing steel, as required, and as included within this Section in accordance with Subcontractor’s QA Plan as approved by LANL.
				3. An inspection or Verification of Inspection and Test (VIT) Plan that complies with Subcontractor’s QAP for approval by LANL. A VIT template for use by Subcontractor based on mix design 5000-8E is included as Attachment A to this section (requires revision if another mix design is used). Subcontractor shall prepare comprehensive VIT Plan that includes all inspections and tests required by codes, standards, and CGD Plans applicable to the work.[[1]](#footnote-1)
				4. Documentation required by VIT Plan such as logs and results of tests and inspections performed.
				5. Documentation that testing agencies have been approved by the LANL Building Official (LBO) and EOR before performing any testing work.
				6. Documentation that testing agencies have an NQA-1-compliant quality program prior to performing any work.

Note: There is a requirement for LBO approval and NQA-1 flow down to any subtier testing agencies and/or locations. This places a premium on planning to ensure the specific testing agencies and locations are properly approved before all of the required concrete constituent/material testing to support any alternate mix design(s) that have to be submitted for approval to LANL begins.

* + - * 1. Submit the QAP/Quality Control Program and applicable Implementing Procedures of the concrete supplier to be implemented during material receiving, storage, and handling; concrete batching and production; and delivery
				2. The Subcontractor's testing agency shall submit test and inspection results that pertain to the Work to LANL and concrete supplier in a timely manner (i.e., within a few/several days of performing such inspections and tests). Any deficiencies discovered shall be reported to LANL in writing during the shift of discovery and managed in accordance with Subcontractor QAP and Subcontract requirements.
			1. Formwork and formwork accessories:
				1. Drawings and procedures for installation and removal of reshoring and backshoring. Refer to ACI 347 and ACI 347.2R for guidance on items to consider.
				2. Data on formwork release agent or formwork liners.
				3. Design calculations and drawings for formwork, shoring and reshoring.

Calculations for removal of shores and reshoring for slabs and beams that aren’t cast on the ground shall be in accordance with NQA-1.

* + - * 1. Data sheet on form ties.
				2. Data and sample of expansion joint materials (sealer and filler).
				3. Form-facing materials.
			1. Steel reinforcement, reinforcement supports, embeds and accessories:
				1. Reinforcing-bar manufacturer’s Certified Material Test Report (CMTRs) traceable to the heat # or test identification # on the shipping tags.
				2. Shop drawings indicating bar sizes, spacing, locations, piece numbers, and quantities of reinforcing steel, bending and cutting schedules, supporting and spacing devices. Identify all lap splice lengths.
				3. CMTRs for other construction materials such as, pre-stress strands, Form Savers, cadwelds, etc. Mechanical splice submittals shall also be provided with International Code Council (ICC) Evaluation Service (ES) Reports (ESRs), or equivalent independent third-party-evaluation document, showing full compliance to the IBC.
				4. CMTRs for steel embedments in concrete.
			2. Non-preapproved concrete-mixture design(s):

Note: These submittals are not required when one or more of the pre-approved mixture design(s) included herein (in PART 2) will be used.

* + - * 1. Concrete mixture design. This shall include the following:

CMTRs and/or CoCs and/or test reports and/or test results and/or manufacturer data showing conformance with Section requirements for aggregates, cement, other cementitious materials, water source, and all admixtures.

Methodology and test data used to establish mixture proportions,

Mix proportions and characteristics.

Information on types, classes, producers’ names, and plant locations for cementitious materials; types, pit or quarry locations, producers’ names, gradings, and properties required by ASTM C 33 for aggregates; types, brand names, and producers’ names for admixtures; and source of supply for water and ice. Except for admixtures and water, test results confirming conformance to applicable ASTM specifications shall not be older than 90 days. Test results for aggregate soundness, abrasion, and reactivity may be older than 90 days, but not older than one (1) year, provided test results for the other properties specified in ASTM C 33 indicate that aggregate quality has not changed.

Documentation indicating compliance of the mix design with the specified requirements for sulfate resistance.

Documentation verifying compliance of the mix design with the specified requirements for ASR.

Documentation verifying compliance with specified requirements for freezing and thawing exposure.

Test reports for mix design, all materials, and testing as required by this Section and/or referenced codes and standards.

* + - 1. Handling, Placing, and Constructing:
				1. Concrete placement records including location map.
				2. Concrete cylinder test reports and charts
				3. Location map showing location of reinforcing bars by lot/heat number.
				4. Reports for construction and removal of forms and reshoring

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Include the subparagraph below if Project includes floors, members or walls and concerns regarding “strength-gain-with-age” of such, and/or such components being subjected to relatively large construction loads. If retaining this subpara., indicate the amount of load (s) above which the submittal is required. Typically such loads a) Are some fraction of the minimum-required design live load, and b) Include consideration of the compressive strength that the concrete has achieved prior to being loaded.

If this subpara. retained then delete the one below it.

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* + - * 1. Submit a plan, for LANL approval, identifying location, duration and magnitude of construction loads on completed floors, members, or walls in excess of [\_\_\_\_\_\_ lbs per square foot area load] [,\_\_\_\_\_\_lbs per linear foot uniformly distributed load] [, and \_\_\_\_\_ lbs concentrated load].

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If previous subpara. deleted then the following subpara. must be retained.in order to ensure compliance with ACI 349 para. 1.3.2.

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* + - * 1. Submit a plan, for LANL approval, identifying location, duration and magnitude of construction load, prior to placement of load, that:

Exceeds the design loads (identified on the construction Drawings) for concrete that has achieved its design strength and the structure is complete and self-supporting, and/or

Any construction loading on the structure prior to concrete achieving 100% of it compressive design strength, or if the structure is incomplete and not completely self-supporting.

* + - * 1. Subcontractor Cold-Weather Plan.
				2. Subcontractor Hot-Weather Plan.
				3. Description of conveying equipment.
				4. Subcontractor hazardous/inclement/wet weather placement protection plan.
				5. Method of measuring concrete surface temperature changes.
				6. Method for removal of stains, rust, efflorescence, and surface deposits.
				7. Qualifications of finishing Subcontractor and flatwork finishers (ACI flatwork certification). The supervisor for the Subcontractor responsible for the concrete finishing (or at least one finisher) must have a current ACI-flatwork certification.
				8. One legible copy of the batch ticket for each load of concrete. Information on the batch ticket shall include (but not necessarily limited to) the following:

Name of ready-mix batch plant

Serial number of ticket

Date

Truck number

Name of purchaser

Specific designation of job (name and location)

Specific class or designation (design mix number) of the concrete in conformance with that employed herein

Amount of concrete in cubic yards

Time loaded or of first mixing of cement and aggregates

Reading of revolution counter at the first addition of water

Type and brand, and amount of cement

Type and brand, and amount of admixtures

Class, brand, and amount of coal fly ash, raw or calcined natural pozzolans, grade, brand and amount of ground granulated blast-furnace slag

Maximum size of aggregate

Weights of fine and coarse aggregate

Ingredients certified as being previously approved

Water/cementitious material ratio

Daily fine and coarse aggregate moisture content

Amount of water that can be added at the jobsite without exceeding the water/cementitious material ratio

Water added by receiver of concrete and his initials.

Note: any water added to the truck must also be witnessed by the LANL Field Engineer or Inspector.

* + - * 1. Documentation proving compliance with the LANL-approved mix design, this shall include:
			1. CMTRs and/or CoCs for aggregates
			2. CMTRs for cement
			3. CMTRs and/or CoCs for fly ash
			4. CMTRs and/or CoCs for all admixtures
			5. A CoC prior to the initial delivery that confirms the source of the constituents and stating that tests confirm compliance and that these sources are the same for the mix design testing and the delivered mix.

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Delete the following “Mass-concrete submittals” if Pre-Approved Concrete Mixture Design 5000-8E is to be used. Also delete if Pre-Approved Concrete Mixture Design 5000-4N is to be used provided that mass concrete isn’t applicable (per the author note associated with the last para. under CONCRETE QUALITY, MIXING, AND PLACING in Part 2).

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* + - * 1. Mass concrete: If concrete is identified as mass concrete the Subcontractor shall submit a thermal control plan for each mass concrete placement. Unless otherwise specified or permitted, the thermal control plan shall include following items:

Calculated or measured adiabatic temperature rise of concrete;

Upper limit for concrete temperature at time of placement;

Description of specific measures and equipment that will be used to ensure maximum temperature in placement will not exceed specified maximum temperature limit;

Calculated maximum temperature in placement based on expected conditions at time of placement and use of proposed measures to control temperatures;

Description of specific measures and equipment that will be used to ensure temperature difference will not exceed specified temperature difference limit;

Calculated maximum temperature difference in placement based on expected conditions at time of placement and use of proposed measures to control temperature differences;

Description of equipment and procedures that will be used to monitor and log temperatures and temperature differences;

Drawing showing locations for temperature sensors in placement;

Description of format and frequency of providing temperature data to LANL;

Description of measures to address and reduce excessive temperatures and temperature differences, if they occur;

Description of curing procedures, including materials and methods, and curing duration; and

Description of formwork removal procedures to ensure temperature difference at temporarily-exposed surface will not exceed temperature difference limit, and how curing will be maintained.

* + - * 1. Scrub coat (for repair of surface defects other than tie holes)
1. CMTR and/or CoC for sand.
	* 1. Records: The Subcontractor QAP shall address record documentation and shall include the following minimum requirements:
			1. Unless otherwise specified (elsewhere in the Project Specification), within 30 working days after completion of the work, or as requested by LANL for any portion or portions of the work, all quality related records generated throughout the order completion process shall be submitted to LANL for inclusion into the permanent Project record. A copy of the records shall be kept by the Subcontractor in accordance with Subcontract requirements.
		2. For LANL's records, when not otherwise required herein, submit copies, licenses, certifications, records, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, and similar documents, used to establish compliance with standards and regulations that pertain to performance of the Work.
	1. QUALITY ASSURANCE
		1. Refer to Section 01 4000 for quality requirements.
		2. Subcontractors shall identify, collect, compile, maintain, and protect complete files and all quality related records for supplied equipment in accordance with their approved QAP.
		3. Records shall be protected by the Subcontractor in a manner compliant with NQA-1 requirements, and shall be made accessible to LANL, throughout the design, procurement, manufacture, test, and shipping processes.
		4. All safety related material shall be procured as “High Confidence” from a LANL-qualified (IESL) supplier (meeting NQA-1) or procured as Commercial Grade Items (CGI) in accordance with NQA-1 Part II Subpart 2.14 and Subcontractor’s QAP with a nuclear safety designation.
		5. The placement of all concrete (including implementation of hot or cold weather concrete plans) and reinforcing shall be performed in accordance with NQA-1 and Subcontractor’s LANL-approved QAP.

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Edit the following para to indicate the required concrete critical characteristics (CCs) based on the Project’s credited safety function.

While the 3 listed CCs will apply to/for most Projects, the EOR is responsible for ensuring these are all that’s necessary and sufficient.

An example of a CC that’s not listed that might be necessary is density (i.e., if a Project requires concrete that has a shielding function).

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* + 1. Critical characteristics required for the concrete to perform its credited safety function are:
			1. Reinforcing material properties must conform to ASTM A 706 (Grade 60) specifications for tensile strength, elongation, bar diameter, and deformation size and spacing.
			2. The indicated f’c value(s) must be achieved.
			3. The provisions, properties, characteristics, etc. applicable to the indicated durability requirements shall be complied with/achieved.

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In order to ensure that all witness or hold points applicable to the Work are included in the following paragraph, refer to IBC Ch. 17.

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* + 1. Witness or hold points for the work shall be as follows:
			1. Hold and witness points per the LANL-approved CGD plan.
			2. Hold point before placing concrete for approval of mix designs unless pre-approved mix designs are used.
			3. Hold point before formwork and reinforcing steel is placed to verify subgrade is prepared in accordance with the Project Specification.
			4. Hold point after formwork is placed to verify critical dimensions and tolerances.
			5. Hold point to verify reinforcing material properties (e.g., CMTRs, etc.) at receipt on site.
			6. Hold point to verify reinforcement, mechanical splices, and embeds placed in accordance with Subcontract requirements prior to placement.
			7. Witness point to verify concrete constituents (e.g., cement; aggregate gradation, moisture content, correction factor; etc.)
			8. Witness point to verify fabrication of specimens for strength tests, and concrete properties (i.e., slump and air content, and the temperature of the concrete) prior to placement.
			9. Hold point before welding to verify welding procedure.
			10. Witness point to verify welding.
			11. Witness point to verify anchor(s) post-installed into hardened concrete.
			12. Witness point to verify that concrete is placed in accordance with the techniques contained in the pre-approved submittal on such.
			13. Witness point to verify that concrete is cured in accordance with the techniques contained in the pre-approved submittal on such.
			14. Hold Point for LANL to perform inspections, tests, and observations per Project’s SSI. As was indicated previously (herein, in the footnote associated with the “VIT-Plan subpara.” under SUBMITTALS AND RECORD MANAGEMENT, General Requirements), these hold points must be included in Subcontractor’s VIT Plan.
		2. Unless stated otherwise herein, the work shall comply with the most stringent of the following documents: ACI 301 and ACI 349; CRSI Manual of Standard Practice and Placing Reinforcing Bars; and ACI Manual of Concrete Practice and ASTM A 184. The required versions of these documents are provided in (previous) “Codes-and-standards Paragraph” under REFERENCES.
		3. The work shall be available for inspection at all times by LANL and LANL’s Independent Testing Agency for the purpose of determining that the work is properly executed in accordance with this Section. Failure to detect defective workmanship or material during any interim inspection shall not constitute acceptance of workmanship and materials.
		4. Acquire cement, aggregate, and fly ash from same source as used to produce the specific mix design for all work. Formally notify LANL of any material source changes at least one (1) month prior to concrete delivery including the test agency test documentation.
		5. The Subcontractor shall use ACI 305R when concreting during hot weather, or 306R during cold weather, to develop the required cold/hot weather plan. See COLD WEATHER REQUIREMENTS and HOT WEATHER REQUIREMENTS (below, in PART 3) for details of plan and plan development.
		6. Testing Agency Qualifications: Testing agencies that perform High Confidence concrete related inspection and testing shall be nationally accredited in accordance with ASTM C 1077 and ASTM E 329. Testing agency shall perform work under an NQA-1 compliant program. Field and laboratory testing agencies including laboratory locations shall be approved by LANL, or designee, in accordance with the contract documents, and provisions of the IBC.
		7. Reinforcing bars (rebar) shall comply with the provisions of ASTM A 706. In addition, the rebar fabricator shall maintain Heat Number Traceability for all rebar to ensure heat numbers for the rebar are traceable to the rebar delivered. These heat numbers (or lot numbers if they correlate to the heat numbers on the CMTR documentation) must be identified on the tags attached to the rebar bundles and traceable to the associated CMTR(s). Once the tags on the rebar bundles are confirmed to match the associated CMTRs by the appropriate receiving inspection; the bundles may be broken and the rebar located as required. Traceability shall be maintained in accordance with the associated requirements herein.

Note: Unless specifically authorized by LANL, foreign reinforcing steel is not allowed.

* + 1. The batch plant and delivery vehicles providing concrete to the Subcontractor must be certified (and maintain current certification) under the National Ready Mix Concrete Association (NRMCA) process and work under the LANL-approved QAP.
		2. Devices used for acceptance or testing, including all levels of sub-tiers, must be calibrated within recognized tolerances specified by this Section and reference codes and standards (see “Codes and standards” for versions) and calibrated to NIST or other recognized national standards. The devices must be suitably marked for traceability to the calibration documentation with recalibration due dates marked on each device. The users must maintain a usage log and identify any “as-found/as-received” out of tolerance devices to LANL in accordance with the LANL-approved Subcontractor QAP within 3 working days along with where the device(s) were used.

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Retain “Mockups” if closely-spaced form work, coupled with rebar congestion, raise doubt about the quality of the completed work.

If retaining, de-conflict content with related portions of Section 01 4000, *Quality Assurance*.

Revise wording if only 1 mockup is required.

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* + 1. Mockups: Cast concrete formed-surface panels to demonstrate typical depositing, placement, surface finish, tolerances, and standard of workmanship.

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Revise size of mockup panel in 1st subpara. below if required.

The default value is from commercial template used for Sect. 03 3000, and it appears in ACI 301.

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* + - 1. Build panel approximately 100 sq. ft. [Insert area] in the location indicated or, if not indicated, as directed by LANL.
	1. DELIVERY, STORAGE AND HANDLING
		1. Handling, storage, shipping and receiving of “High Confidence” items shall be in accordance with Section 01 4000 *Quality Requirements*, ASME NQA-1, and Subcontractor’s QAP.
		2. Do not deliver concrete until forms (including confirmation of approved calculations for formwork when required), reinforcement, embedded items, chamfer strips, and any other prerequisites specified in the job specific “Test and Inspection Plan” are in place and ready for concrete placement. Job site storage of materials shall be in accordance with ACI 301 and NQA-1. Protect materials from contaminants such as grease, oil, and dirt. Ensure materials can be accurately identified after bundles are broken and tags removed.
		3. Inspection/Documentation Verification Witness Point: Product and raw material inspection shall be performed at time of delivery to site receiving area and prior to off-loading and incorporation into the work. Verify conformance with specified requirements and Project environmental, safety and health (ES&H) and radiological requirements through inspection of material, shipping documentation, material safety data sheets (MSDS) documentation, data sheets, test documentation and other shipping manifest information. Material not passing inspection shall be dispositioned per the LANL-approved Subcontractor QAP.
		4. Measures shall be established to provide for storage materials so as to prevent damage or deterioration. All stored materials shall be properly tagged or labeled to permit identification.
		5. Cementitious materials and aggregates shall be stored in such a manner as to prevent deterioration or intrusion of foreign matter. Any material that has deteriorated or has been contaminated shall not be used for concrete.
		6. Reinforcing material shall be stored in such a manner as to permit inventory control and to preclude damage or degradation of properties to less than ASTM- specification requirements. Protect from contaminants such as grease, oil, and dirt. Reinforcing steel, by groups of bars or shipments, shall be identifiable by documentation, tags, or other means of control, to a specific heat number or heat code until review of the certified material test report has been performed. Ensure bar sizes can be accurately identified after bundles are broken and tags removed. Painting on reinforcement, other than for traceability requirements identified herein, must be approved in writing by LANL.
1. Products and Materials
	1. General
		1. All concrete work, Projects and materials shall conform to applicable provisions indicated herein (in PART 1, under REFERENCES, Codes and Standards) except as otherwise specified in what follows.
		2. LANL shall have the right to order testing of any materials used in concrete construction to determine if materials are of quality specified.
		3. A complete record of tests of materials and of concrete shall be available for inspection, by LANL.
		4. ACI 201.2R shall be considered when selecting materials for concrete mix design. The more stringent requirements between this Section and ACI 201.2R shall be used.
	2. FORM MATERIALS AND ACCESSORIES
		1. Design of Formwork:
			1. Shop drawings and calculations shall be prepared and submitted to LANL for approval prior to construction. All documents shall be sealed by a professional engineer licensed in the state of New Mexico. ACI 347 shall be used as the guide for design, inspection, and construction of formwork.
			2. Forms shall result in a final structure that conforms to shapes, lines, and dimensions of the members as required by the construction Drawings and this Section.
			3. Forms shall be substantial and sufficiently tight to prevent leakage of mortar.
			4. Forms shall be properly braced or tied together to maintain position and shape.
			5. Forms and their supports shall be designed so as not to damage previously placed structure.
			6. Design of formwork shall include consideration of the following factors:
				1. Rate and method of placing concrete;
				2. Construction loads, including vertical, horizontal, and impact loads;
				3. Special form requirements for construction of shells, folded plates, domes, architectural concrete, or similar types of elements.
				4. When using steel liners as formwork, special attention shall be given to both of the following:

Liner supports to provide the required tolerances for penetrations.

The depth of placement to limit the deformation of the liner.

* + - * 1. Where coating systems are to be applied to the concrete, formwork shall be compatible with the coating system
		1. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints
			1. Plywood, metal, or other approved panel materials.
				1. Metal form surfaces shall not contain irregularities, dents, or sags.
				2. Exterior-grade plywood panels, suitable for concrete forms, complying with APA PS 1, and as follows:

High-density overlay, Class 1 or better.

Medium density overlay, Class 1 or better; mill-release agent treated and edge sealed.

Structural 1, B-B or better; mill oiled and edge sealed.

B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.

* + - * 1. AHA A135.4, hardboard for smooth form lining.
			1. Prefabricated forms.
				1. Preformed Steel Forms: Minimum 16 gage matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.
				2. Glass Fiber Fabric Reinforced Plastic Forms: Matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished concrete surfaces.
				3. Pan Type: Glass fiber of size and profile required.
				4. Tubular Column Type: Round, spirally wound laminated fiber material, surface treated with release agent, non-reusable, of sizes required.
				5. Void Forms: Moisture resistant treated paper faces, biodegradable, structurally sufficient to support weight of wet concrete mix until initial set; 2-in. thick.
		1. Rough-Formed Finished Concrete: Plywood, lumber, metal or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
		2. Form Ties: Snap-off type, plastic cone type free of defects that could leave holes larger than 1 in. in concrete surface.
		3. Form-Release Agent: Colorless mineral oil which will not stain concrete, absorb moisture, or impair natural bonding or color characteristics of coating intended for use on concrete.
		4. Corners: Chamfered, wood strip type; ¾ in. x ¾ in. size.
		5. Dovetail Anchor Slot: Galvanized steel, 22-gage thick, foam-filled, release-tape- sealed slots, anchors for securing to concrete formwork.
		6. Flashing Reglets: Galvanized steel, 22-gage thick, longest possible lengths, with alignment splines for joints, foam- filled, release-tape-sealed slots, anchors for securing to concrete formwork.
		7. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Size as required, of sufficient strength and character to maintain formwork in place while placing concrete.

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Include the following item if waterstops are necessary (e.g., a below-grade joint in-between exterior wall and the foundation, etc.). If item is deleted then delete associated installation provision (i.e., 3.10.A.15).

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[J. Waterstops: Polyvinyl chloride, minimum 1750-psi tensile strength, minimum 50 °F to plus 175 °F working temperature range, maximum possible lengths, ribbed profile, preformed corner sections. A CoC from the manufacturer is required as confirmation that the waterstop(s) used meets the requirements in this paragraph.]

* 1. REINFORCING AND ACCESSORIES
		1. Reinforcing Steel
			1. All deformed bars and stirrups, and ties, shall conform to ASTM A 706 Grade 60 unless noted otherwise on the construction Drawings.
			2. A minimum of one tensile test shall be required for each 50 tons of each bar size produced from each heat of steel (ASTM A 370) or as specified in the LANL-approved GGD Plan, whichever is more stringent.
			3. Manufacturer’s CMTRs are required for each delivery and they must be traceable to the reinforcing steel tag bundles via the lot or heat number. Once the documentation is confirmed to be adequate and traceable by the responsible receiving inspection personnel, the bundles may be broken. All reinforcement within a specific lot/heat number shall be painted with a non-permanent marking paint. Each lot shall be assigned a specific color, and each bar in a lot shall be painted with the respective assigned color at each end. The paint strip shall be 2- to 6-in. wide maximum. If the painted ends are cut off or the paint otherwise removed during fabrication or installation, the paint shall be reapplied. If bars are to be cut, the paint markings shall be transferred on bars prior cutting. Bars shall be traced by lot/heat numbers by location in the structure. A location map shall be provided to LANL by the Subcontractor for review prior to concrete placement.
			4. Other construction materials such as Form Savers, cadwelds, mechanical splices, etc. must be supported by ICC ESRs (or equivalent) showing full compliance to the applicable IBC code of record for the Project.
		2. Fabricate concrete reinforcing in accordance with CRSI Manual of Standard Practice.
		3. Locate and install reinforcing splices as indicated on construction Drawings.
		4. Welding of reinforcing bars will be permitted only with approval of LANL. Welding, if approved, shall conform to ACI 301 Sect. 3 and AWS D1.4 and shall meet the requirements of Section 01 4455, Onsite Welding and Joining Requirements including approval of the welding procedures. Filler material CMTRs are required. Reinforcing steel cannot be used for filler metal, gap filler, lightning grounding, or other uses that involve welding.
		5. Chairs, Bolsters, Bar Supports, Spacers
			1. Size and shape for strength and support of reinforcement during concrete placement conditions including load bearing pad on bottom to prevent vapor barrier puncture.
			2. Special chairs, bolsters, bar supports, spacers adjacent to weather exposed concrete surfaces to be plastic coated steel type; size and shape as required.
		6. Tie Wire: Minimum 16 gage annealed type.
		7. Couplers: Couplers shall be Type 2 couplers or LANL- approved alternates and shall meet the following requirements:
			1. Mechanical splices shall develop 125% of the yield strength of the bar in compression.
			2. Mechanical splices shall develop the specified tensile strength of the bar.
			3. Mechanical splices shall have an ICC ESR (or equivalent) that is compliant with the code of record for the Project.
	2. CONCRETE MATERIALS
		1. Cements
			1. Cement shall conform to ASTM C 150.
			2. Cement used in the work shall correspond to that on which selection of concrete proportions was based.
			3. Every shipment of cement shall be accompanied by a certified mill test report stating the results of tests representing the cement in shipment and the ASTM specification limits for each item of required chemical, physical, and optional characteristics. No cement shall be used in any structural concrete prior to receipt of 7-day mill test strengths.
		2. Aggregates
			1. Concrete aggregates shall conform to ASTM C 33.
			2. Testing requirements.
				1. All tests required by the Subcontractor’s LANL-approved CGD plan.
				2. Tests for full conformance with each of the requirements of ASTM C 33, including tests for potential reactivity (ASTM C 1293[[2]](#footnote-2)), and any additional requirements identified in this Section and/or in the LANL-approved CGD plan, shall be performed before usage in construction.
				3. A daily inspection control program shall be carried out during concrete production to determine and control consistency in potentially variable characteristics such as aggregate water content, gradation, fineness modulus, and material finer than No. 200 sieve.

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The ASTM standards in the following subparagraph are required by ACI 349 with the exception of ASTM C 1293. The “aggregate-reactivity test” in ACI 349 is ASTM C289; however, that standard was withdrawn in 2007. Per ASTM C 33, “Test Method C 1293 “…is considered to be the most reliable procedure among ASTM Test Methods for the evaluation of aggregates for alkali-silica reaction.”

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* + - * 1. Tests for conformance with ASTM C 131, ASTM C 1293, and ASTM C 88 shall be repeated as directed by LANL and whenever there is reason to suspect a change in the basic geology or mineralogy of the aggregates. In the event of “reason to suspect,” LANL approval and authorization is required prior to proceeding with this testing.
				2. Obtain a petrographic examination of coarse aggregate in accordance with ASTM C 295. Specifically include an assessment by the petrographer of the proposed aggregate for use in Portland-cement concrete. Perform all tests recommended by the petrographer required for confirming suitability of the proposed aggregate. Submit the petrographic examination report and associated test reports for LANL approval prior to production.\*

\* Note: Unless there is reason to suspect a change in the basic geology or mineralogy of the aggregate, this testing need not be performed if a pre-approved mix design(s) is used. If the event of “reason to suspect,” LANL approval and authorization is required prior to proceeding with this testing.

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In the following subpara., the use of ASTM C 566 for testing for aggregate moisture content comes from ACI 311.5, *Guide for Concrete Plant Inspection and Testing of Ready-Mixed Concrete*.

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* + - * 1. Test for aggregate moisture content shall be performed daily, or more often if there is a reason to suspect a change in moisture content, in accordance with ASTM C 566.
		1. Water
			1. Water used in mixing concrete shall be potable or, if not potable, shown to be in compliance with ASTM C 1602.
	1. ADMIXTURES
		1. Admixtures to be used in concrete shall be submitted with the mixture design and approved by LANL prior to use.
		2. An admixture shall be shown capable of maintaining essentially the same composition and performance throughout the work as the product used in establishing concrete proportions in accordance with the “Selection-of-Concrete-Proportions Paragraph (below, under CONCRETE QUALITY, MIXING, AND PLACING).”
		3. Air-entraining admixtures shall conform to “*Standard Specification for Air-Entraining Admixtures for Concrete*” (ASTM C 260).
			1. The “Optional Uniformity Requirements” of ASTM C 260 section 5 are required to be performed, and the manufacturer shall provide documentation showing conformance with section 5. Infrared Analysis (IA) shall be provided and is permitted to be completed using ASTM E 1252. The manufacturer shall state in writing that the air-entraining admixture supplied for use in the work is essentially identical in concentration, composition, and performance to the air-entraining mixture tested in accordance with ASTM C 260. The manufacturer shall also state in writing the chloride content of the admixture and whether or not chloride was added during its manufacture. The manufacturer shall ensure that the manufacturer date is provided on the submittal. LANL reserves the right to request retesting of materials exceeding 6 months from the point of manufacture. All documentation shall be submitted to LANL for review and approval prior to use
		4. Water-Reducing Admixtures, Retarding Admixtures, Accelerating Admixtures, Water-Reducing and Retarding Admixtures, and Water-Reducing and Accelerating Admixtures: Conform to ASTM C 494.
			1. The optional “Uniformity and Equivalence” requirements in section 6 of ASTM C 494 are required to be performed and the manufacturer shall provide in writing, documentation showing conformance with section 6. The manufacturer shall state in writing that the admixture supplied for use in the work is essentially identical in concentration, composition, and performance to the admixture tested in accordance with ASTM C 494. The manufacturer shall also state in writing the chloride content of the admixture and whether or not chloride was added during its manufacture. The manufacturer shall ensure that the manufacturer date is provided on the submittal. LANL reserves the right to request retesting of materials exceeding 6 months from the point of manufacture. LANL also reserves the right to request retesting within the limits as specified in the General Requirements section of ASTM C 494.
		5. Fly ash or other pozzolans used as admixtures shall conform to ASTM C 618.
		6. Ground-granulated blast-furnace slag used as an admixture shall conform to ASTM C 989.
		7. Admixtures used in concrete containing ASTM C 845 expansive cements shall be compatible with the cement and produce no deleterious effects.
		8. Silica fume used as an admixture shall conform to ASTM C 1240.
		9. Testing
			1. Shall be performed as required by the Subcontractor’s LANL-approved CGD plan and VIT plan.
			2. Tests for compliance with the specification for each admixture shall be required prior to initial shipment and acceptance on site for usage in construction and as directed by LANL and at a minimum of every three (3) months.
				1. The tests in question are the infrared analyses referred to in the preceding subparagraphs on air-entraining and water-reducing admixtures.
			3. An infrared spectrum trace of the conformance test sample of air-entraining and water-reducing admixture shall be furnished with the conformance test results.
				1. The tests in question are the infrared analyses referred to in the preceding subparagraphs on air-entraining and water-reducing admixtures.
	2. ACCESSORIES
		1. Bonding Agent: Polymer resin emulsion.
		2. Non-Shrink Grout: Refer to Section 03 6000, Grout.
		3. Joint Filler: ASTM D 1751; asphalt impregnated fiberboard or felt.
		4. Curing Compound: ASTM C309 or C1315.
		5. Curing Sheet Materials: ASTM C171.
	3. CONCRETE QUALITY, MIXING, AND PLACING
		1. General Requirements
			1. Concrete shall be proportioned to provide an average compressive strength f’cr, as prescribed in the “Required-average-strength subparagraph” under “Proportioning on the Basis of Field Experience or Trial Mixtures, or Both (below),” and shall satisfy the durability criteria of “Durability Requirements (below).” Concrete shall be produced to minimize the frequency of strength tests below f’c, as prescribed in PART 3 (i.e., under EVALUATION AND EXCEPTANCE OF CONCRETE, Laboratory-Cured Specimens).
			2. The concrete strength, f’c, shall be based on 28-day tests in accordance with ASTM C 39.
			3. Splitting tensile strength tests shall not be used as a basis for field acceptance of concrete.
		2. Selection of Concrete Proportions
			1. Proportions of materials for concrete shall be established to provide:
				1. Workability and consistency to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding;
				2. Resistance to special exposures as required by the “Durability-Requirements Paragraph (below);”
				3. Conformance with strength requirements as shown on the construction Drawings and indicated in PART 3 (i.e., under EVALUATION AND EXCEPTANCE OF CONCRETE).
			2. Where different materials are to be used for different portions of the proposed work, each combination shall be evaluated.
			3. Concrete proportions shall be established in accordance with one of the two following methods and shall meet the applicable requirements in the “Durability-Requirements Paragraph (below):”
				1. Proportioning on the Basis of Field Experience or Trial Mixtures, or Both, or
				2. Proportioning Without Field Experience or Trial Mixtures
		3. Proportioning on the Basis of Field Experience or Trial Mixtures, or Both
			1. Meet applicable provisions in ACI 349 Section 5.3, *Proportioning on the Basis of Field Experience or Trial Mixtures, or Both*.
		4. Proportioning Without Field Experience or Trial Mixtures
			1. Meet applicable provisions in ACI 349 Section 5.4, Proportioning without Field Experience or Trial Mixtures.
		5. Average Compressive Strength Reduction
			1. Meet applicable provisions in ACI 349 Section 5.5, Average Compressive Strength Reduction.

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To ensure that the following “Durability-Requirements Para.” is complied with, the EOR shall assign the exposure categories and classes (ref. ACI 349 Ch. 4, para. 4.2) on the construction Drawings and/or where indicated in Part 3 herein (i.e., in para. 1.3, GENERAL).

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* + 1. Durability Requirements
			1. Per the indication [on the construction Drawings] [and] [in Part 3 herein, in Paragraph 3.1, GENERAL], comply with the applicable provisions shall be complied with.
		2. Pre-Approved Concrete Mixture Designs
			1. The following two mixture designs, 5000-4N and 5000-8E, have been pre-approved and comply with this Section and the applicable codes and standards referenced herein.
1. Mix 5000-4N—Exterior, 5000 psi concrete at 28 days, 4-in. slump, 6% air, 25% fly ash (proportions per CY), 0.34 water-cementitious ratio, 3/4-in. large aggregate, target 1-1/2-hour placement time (AMEC Project 14-519-00761). Placement time can vary widely depending on material temperatures and environmental conditions at the time of concrete production.

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This mixture design has a cementitious content > 660 lbs/ft3; which, per ACI 301-10, indicates that “mass-concrete considerations” should apply to its use. However, this “line in the sand” doesn’t appear in ACI 301-16, which merely refers to “…high cementitious materials contents.” Also, based on testing of concrete placed using mixture design 5000-8E (below), the concrete resulting from 5000-4N won’t necessarily behave as “mass concrete.”

Given all of the above, and other related content in ACI 301, Projects using 5000-4N must consider the resulting concrete as potentially being mass concrete (only) when both of the following conditions apply:

A) Thickness > 2 feet and

B) The concrete placement won’t occur in “cold weather (i.e., concrete will be uninsulated),” or be subjected to cold rain or windy conditions; thermal protection for the placement isn’t planned (i.e., the concrete isn’t otherwise considered to be mass concrete); and the average air temperature\* will be 10F below the temperature of the delivered concrete.

\*Average Air Temperature = the average of the daily high and the daily low air temperatures on the day of placement, the preceding several days, and the following several days.

For more on this subject, refer to the article, *When Should Mass Concrete Requirements Apply?*, in the Summer-15 edition of ASPIRE, written by Gajda and Feld of the CTLGroup.

Projects in which mass concrete is applicable shall comply with the related requirements herein:

* + The last subpara. of Handing, Placing and Constructing (in PART 1, under SUBMITTALS AND RECORD MANAGEMENT, General Requirements); and
	+ The last para. of DEPOSITING (in PART 3).

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|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **Source** | **Description** | **Quantity** |
| Cement | GCC – Tijeras, NM | Type I/II | 578 lbs |
| Fly Ash | Salt River Materials Group, 4 Corners | Class F | 192 lbs |
| Coarse Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | #67 | 1600 lbs |
| Fine Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | Washed Sand | 1147 lbs |
| Water | Los Alamos Transit Mix, Public Water Supply | Site Water | 262 lbs |
| Air |  |  | 6.00% |
| Air Entraining Admixture (Note 1) | BASF | MasterAir AE 200 | 7.3 oz (1.0 oz/cwt) |
| Full Range Water Reducer (Note 1) | BASF | MasterGlenium 3030 | 70.7 oz (9.2 oz/cwt) |
| Note 1: Admixture dosages may vary based on temperature. |

* + - * 1. Mix 5000-8E—Exterior, 5000 psi concrete @ 28day, 8-in. slump at arrival and no less than 4 in. after 2-1/2 hours after initial mixing, 6% air, 25% fly ash (proportions per CY), 0.343 water-cementitious ratio, ¾-in. large aggregate (AMEC Project 14-519-00761).

Note: Mix 5000-8E has been developed with a target extended placement time of 2-1/2 hours from initial mixing. Placement time can vary widely depending on material temperatures and environmental conditions at the time of concrete production.

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Despite the fact that this mixture design has a cementitious-materials content on par with that of 5000-4N, as is stated in the author note associated with 5000-4N, testing done on concrete placed with 5000-8E indicated that the temperature limits beyond which concrete must be considered mass-concrete aren’t exceeded; thus, Projects using this mixture design need not comply with the related requirements herein.

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| **Material** | **Source** | **Description** | **Quantity** |
| --- | --- | --- | --- |
| Cement | GCC – Tijeras, NM | Type I/II | 580 lbs |
| Fly Ash | Salt River Materials Group, 4 Corners | Class F | 193 lbs |
| Coarse Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | #67 | 1600 lbs |
| Fine Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | Washed Sand | 1162 lbs |
| Water | Los Alamos Transit Mix, Public Water Supply | Site Water | 255 lbs |
| Air |  |  | 6.00% |
| Air Entraining Admixture (Note 1) | BASF | MasterAir AE 200 | 0.91 oz min – 11.6 oz max (oz per cu yd) |
| Full Range Water Reducer (Note 1) | BASF | MasterGlenium 3030 | 23.2 oz min – 139.1 oz max (oz per cu yd) |
| Hydration Stabilizer (Note 1) | BASF | Delvo | 15.5 oz min – 69.6 oz max (7.0 oz/cwt) |
| Note 1: Admixture dosages may vary based on temperature. |

1. EXECUTION
	1. GENERAL
		1. The Subcontractor must schedule and manage any sub-tiers to ensure that the proper approach and scheduling is used to obtain all necessary approvals and tests and inspections.
		2. A (concrete) pre-pour meeting shall be held a minimum of 24 hours prior to planned placement and attended by all interfacing subcontractors (e.g., Subcontractor, testing agencies and associated personnel, concrete supplier, inspectors, etc.) and LANL representatives (e.g., Project personnel, facility personnel, security, etc.) to ensure technical and quality requirements are planned and fully understood by “all affected.”
			1. All concrete shop drawings shall be reviewed and coordinated by all interfacing subtier subcontractors having work that impacts the design and/or installation of the concrete.
			2. A pre-pour inspection checklist will be signed off by all interfacing subtier subcontractors, and the LANL Inspector, before placing concrete.
		3. Work shall conform to applicable provision of ACI 301 and ACI 349 unless otherwise specified herein.
		4. Construction tolerances shall be as shown on the construction Drawings and ACI 117, or this Section whichever is more stringent.
		5. Prior to placement of concrete, ensure that all inspections of formwork and reinforcing have been completed in accordance with approved VIT Plan.
		6. Place concrete in accordance with ACI 301. Consolidate concrete by internal vibration per the more stringent of ACI 301 and ACI 309R, unless otherwise directed by LANL.
		7. Notify LANL a minimum of 48 hours prior to commencement of concrete operations.
		8. Install joint filler, primer and sealant in accordance with manufacturer’s instructions.
		9. Install joint devices in accordance with manufacturer’s instructions.
		10. Place concrete continuously between predetermined expansion, isolation, and construction joints.

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Edit the following para to indicate the required concrete mixture and concrete properties.

The default value in subparas. a (f’c), c.i (“air”), and c.ii (max. aggregate size) are based on the pre-approved mixture designs (in Part 2 herein), the constituents and properties of which satisfy the durability requirements for exposure categories and classes F1 – F3, S1, P1, and C0 – C1.

Regarding exposure to sulfate (“S”) in subparas. c, if the Project consists of building, or a similar type of structure in which the only such exposure would result from the soil, then “S0 (i.e., not applicable)” shall be assumed unless the geotechnical report indicates sulfates are present in the soil. If the geotechnical report indicates sulfates are present in the soil, the exposure class shall be determined, assigned and complied with.

Subparas. d, pertaining to type of cement and concern for potential alkali-silica reactivity (ASR), need not be retained if a pre-approved mixture design(s) is used.

To increase the likelihood of good quality control, limit the number of mix designs used on a Project to as few as necessary.

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* + 1. Project Requirements: Concrete mixtures and the resulting concrete supplied for this Project shall conform to this Section including the following:

[Exterior walls, and foundation] [, and] [Exterior tanks/vaults]

f’c = [5000psi @ 28 days].

Slump shall meet the requirements of the “Slump Paragraph” under MIXING (below).

The applicable exposure [category] [categories] and [class] [classes] are [[Freezing and Thawing, F and] [F2] [F1] [F3]] [[, Sulfate, S and] [S1] [S2] [S3]] [[, Permeability, P and P1]] [[, Corrosion protection of reinforcement, C and] [C0] [C1] [C2]].

Target air content, percent: [6].

Nominal maximum aggregate size, in.: [3/4].

[d. Cement shall be Type [I, II, I/II Low-Alkali] cement in accordance

 with ASTM C 150. CMTRs for cement shall include equivalent alkalies (%). Equivalent alkalies shall be less than [0.6%].]

[Interior walls, foundation, floor slab and roof slab] [, and] [Interior tanks/vaults]

* + - * 1. f’c = [5000psi @ 28 days].
				2. Slump shall meet the requirements of the “Slump Paragraph” under MIXING (below).
				3. The applicable exposure category [category] [categories] and [class] [classes] are [[Sulfate, S and] [S1] [S2] [S3]] [[, Permeability, P and P1]] [[, Corrosion protection of reinforcement, C and] [C0] [C1] C2]].

Target air content, percent: [6].

Nominal maximum aggregate size, in.: [3/4].

 [d. Cement shall be Type [I, II, I/II Low-Alkali] cement in accordance

 with ASTM C 150. CMTRs for cement shall include equivalent alkalies (%). Equivalent alkalies shall be less than [0.6%].]

1. Maximum nominal large aggregate size shall be [3/4] in. unless approved by LANL.
	1. PREPARATION OF EQUIPMENT and PLACE OF DEPOSIT
		1. Preparation before concrete placement shall include the following:
			1. All equipment for mixing and transporting concrete shall be clean;
			2. All debris and ice shall be removed from spaces to be occupied by concrete;
			3. Forms shall be properly coated;
			4. Masonry filler units that will be in contact with concrete shall be well drenched;
			5. Reinforcement shall be thoroughly clean of ice, concrete or other deleterious coatings;
			6. Water shall be removed from place of deposit before concrete is placed unless a tremie is to be used or it shall be displaced by methods that shall exclude incorporation of additional water in the concrete during placement and consolidation; and
			7. All laitance and other unsound material shall be removed before additional concrete is placed against hardened concrete.
	2. MIXING
		1. All concrete shall be batched using automated equipment with digital recordation and shall be mixed until there is a uniform distribution of materials and shall be discharged completely before mixer is recharged.
		2. Ready mixed concrete shall be mixed and delivered in accordance with requirements of ASTM C 94 or ASTM C 685.
		3. Slump
			1. Unless otherwise specified or permitted by LANL, concrete shall have, at the point of placement, a slump of 4 in. Determine the slump by ASTM C 143. Slump tolerances shall meet the requirements of ACI 117. When a Type I or II plasticizing admixture conforming to ASTM C 1017 or a Type F or G high-range water-reducing admixture conforming to ASTM C 494 is permitted per the LANL-approved mixture design to increase the slump of concrete, concrete shall have been proportioned to a slump of 2 to 4 in. before the admixture is added and a maximum slump of 8 in. at the point of delivery after the admixture is added, unless otherwise specified.
		4. Adding mixing water in the field is only permitted if the ready-mix producer held back water at the batch plant and the slump after transport is less than that specified in the design documents. Care must be taken not to exceed the water-cement ratio. To adjust for measuring technique accuracy, the amount of water that can be added shall be reduced by 10% from the maximum calculated water holdback volume. In addition, mixing water added in the field to adjust slump is permitted only when the water measuring device used is as follows:
			1. A LANL-approved mechanical calibrated device; or
			2. The ready mix truck sight glass may be used if the following condition is met:
2. The water-measuring device shall be manually verified prior to the addition of water. This requirement need not exceed one verification per set of water additions by a given truck in a given Project-site visit. The intent of the verification to ensure that the measuring device is accurate within a tolerance of + 5%. This can be accomplished by dispensing water in a graduated cylinder/container and the measuring device reading compared to the graduation marks in the cylinder/container. The amount of water added to the concrete mix is adjusted in accordance with the results of the verification.
	1. CONVEYING
		1. Concrete shall be conveyed from mixer to place of final deposit by methods that will prevent separation or loss of materials.
		2. Conveying equipment shall be capable of providing a supply of concrete at site of placement without separation of ingredients and without interruptions sufficient to permit loss of plasticity between successive increments.
		3. Aluminum pipe shall not be used to convey concrete.
	2. DEPOSITING
		1. Concrete shall be deposited as nearly as practical in its final position to avoid segregation due to re-handling or flowing.
		2. Concreting shall be carried on at such a rate that concrete is at all times plastic and flows readily into spaces between reinforcement.
		3. Placement Time and Drum Revolution Counter:
			1. Mixture designs with a target 1-1/2-hour maximum placement time:
				1. Concrete shall be placed within 300 maximum revolutions and 1-1/2 hours after initial mixing for Central-Mixed concrete, or 100 to 300 revolutions within 1-1/2 hours after initial mixing for shrink-mixed and truck-mixed concrete.
				2. The preceding revolutions/time limits can be exceeded when both of the following conditions are met:
3. The concrete shall be of such slump or slump flow that it can be placed without the addition of water to the batch.
4. The air content, slump, and temperature of concrete shall be as specified and verified through additional testing in accordance with FIELD QUALITY CONTROL (below) except that testing shall be performed at the point of delivery. Testing as required in FIELD QUALITY CONTROL, and at frequencies indicated in the “Frequency-of-testing Paragraph” under Evaluation and Acceptance of Concrete (below), shall be taken at the point of placement for concrete acceptance.
	* + 1. Mixture designs with an extended placement time: Mixture designs that have been specifically designed for a placement time that exceeds 1-1/2 hours from initial mixing shall not be placed outside of the maximum design placement time. Concrete that exceeds the maximum placement time shall be rejected. If concrete is placed within this design placement time, the revolution counter shall be noted on the batch ticket; however, no limit applies.
		1. Re-tempered concrete shall not be used.
		2. After concreting is started, it shall be carried on as a continuous operation until placing of a panel or section, as defined by its boundaries or predetermined joints, is completed except as permitted or prohibited by the “Construction-Joints Paragraph (below, under FORMWORK, EMBEDDED PIPES AND CONSTRUCTION JOINTS ).”
		3. Top surfaces of vertically formed lifts shall be generally level.
		4. When construction joints are required, joints shall be made in accordance with “Construction-Joints Paragraph.”
		5. All concrete shall be thoroughly consolidated by suitable means during placement and shall be thoroughly worked around reinforcement and embedded fixtures and into corners of forms.
		6. When the ambient temperature falls below 40 °F or rises above 80 °F the cold or hot weather plan, respectively, shall be implemented and a record shall be kept of concrete temperatures and of protection given to concrete during placement and curing.
		7. Mass Concrete: Projects in which the concrete meets the definition of Mass Concrete (see PART 1, DEFINITIONS); or has a minimum dimension exceeding 4 feet; or comes from a mixture that contains Type III cement, accelerating admixtures, or has a cementitious-materials content in excess of 660lbs/yd3; shall comply with the following requirements.
			1. General requirements: Mass concrete shall comply with requirements of this Section unless otherwise specified in Contract Documents.
				1. The maximum temperature in concrete after placement shall not exceed 158 °F; and
				2. The maximum temperature difference between center and surface of placement shall not exceed 35 °F.
			2. Curing and protection:
				1. Unless otherwise specified or permitted, both of the following subparagraphs – “Preservation of moisture” and “control of concrete temperature” – shall be complied with verbatim.
				2. Preservation of moisture

Cure and protect concrete in accordance with CURING (below) for a minimum of 7 days. If strength criterion in the third subparagraph (i.e., “c”) in “Curing (in the “Curing-and-Protection Paragraph” under CURING)” is used, strength measurement shall be representative of in-place strength within 2 in. of concrete surface.

Preserve moisture by maintaining forms in place. For surfaces not in contact with forms, apply one of the procedures specified in the “Curing-methods subparagraph” in the “Curing-and-Protection Paragraph”. Unless otherwise specified, do not use water curing.

* + - * 1. Control of concrete temperature: Control concrete temperature and temperature difference within concrete from time the concrete is placed until time internal temperature has cooled from its maximum so the difference between average daily ambient and internal temperatures at time of protection removal is less than specified temperature difference limit.

Monitoring concrete temperatures—Place one temperature sensor at the center of mass of placement and one temperature sensor at a depth 2 in. from center of nearest exterior surface. Place an additional sensor at each location to serve as a backup in the event that other temperature sensor fails. In addition, provide a temperature sensor in a shaded location for monitoring ambient on-site temperature.

Monitor temperatures hourly using electronic sensors capable of measuring temperature from 32 °F to 212 °F to an accuracy of 2 °F. Ensure temperature sensors are operational before placing concrete. Provide data from sensors to LANL on a daily basis, until requirements of “Control of concrete temperature (immediately above)” are met.

Excessive temperatures or temperature differences — Compare temperatures and temperature differences with maximum limits specified in “General requirements (above)” every 12 hours. If either exceeds specified limits, take immediate action as described in accepted thermal control plan to remedy situation. Do not place additional mass concrete until cause of excessive temperature or temperature difference has been identified and corrections are accepted.

* 1. CURING
		1. Curing and Protection
			1. Unless otherwise specified or permitted, the following subparagraph – “Curing (to include its three subparagraphs)” – shall be complied with verbatim.
			2. Curing—Cure concrete in accordance with the applicable “Unformed- or Formed-concrete- surfaces subparagraphs (immediately below)” for at least 7 days after placement. Cure high early-strength concrete for at least 3 days after placement. When permitted, and when the duration of curing is to achieve a specified level of in-place strength, moisture retention measures may be terminated when any one of the following conditions has been met:
				1. Tests of at least two 6 in. x 12 in. or at least three 4 in. x 8 in. cylinders, that have been field-cured in accordance with ASTM C 31, indicate compressive strength of at least 70% of f’c when tested in accordance with ASTM C 39;
				2. The compressive strength of laboratory-cured cylinders, representative of the in-place concrete, exceeds 85% of f’c, provided the temperature of the in-place concrete has been maintained at 50 °F or higher during curing; and
				3. Concrete strength reaches f’c as determined by accepted in-place test methods meeting the requirements of ACI 301 2.3.4.2.

When one of the curing methods (in “Curing-methods subparagraph,” below) is used initially, the method may be replaced by one of the other methods after concrete is one- (1-) day old, provided the concrete is not permitted to become surface-dry at any time. Of the listed methods (in “Curing methods”), select one for use that supplies additional water during the entire curing period for concrete containing silica fume and when specified in Contract Documents.

* + - 1. Unformed concrete surfaces—Apply one of the procedures in “Curing methods” after placement and finishing of concrete surfaces that are not in contact with forms.
			2. Formed concrete surfaces—Keep absorbent wood forms wet until they are removed. After formwork removal, cure concrete by one of the methods in “Curing methods.”

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The following paragraph does not indicate “accelerated curing” as being a permissible curing method despite the fact that it is included in ACI 349 (ref. para. 5.11.3, which refers to ACI 318, 5.11.3). The reason being the Commentary (found in ACI 318, R5.11.3) indicates “…Accelerated curing procedures require careful attention to obtain uniform and satisfactory results…”

If, for some reason (i.e., special/extenuating/unique circumstances), accelerating curing is desired then LANL permission must be formally requested and received prior to including it in the following para. (e.g., “Application of other LANL-accepted curing methods,” etc.). The formal request for permission shall include measures that will be taken to ensure that “uniform and satisfactory results” will be obtained (e.g., inclusion in Subcontractor’s QA Plan, pre-pour inspection checklist and meeting, etc.). If such permission is granted then the number of days indicated in paras. 6 and 7 can be reduced in accordance with ACI 349.

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* + - 1. Curing methods—After placing and finishing, provide or preserve moisture in concrete. Unless otherwise specified, use one or more of the following methods:
				1. Ponding, continuous fogging, or continuous sprinkling;
				2. Application of mats or fabric kept continuously wet;
				3. Continuous application of steam (under 150 °F);
				4. Application of sheet materials;
				5. Application of a curing compound. Apply the compound in accordance with manufacturer’s recommendation as soon as water sheen has disappeared from the concrete surface and after finishing operations. The application rate shall not be less than 1 gal/200 ft2 for each coat. For rough surfaces, such as those specified in ACI 301, paragraphs 5.3.4.2.a and 5.3.4.2.d, apply curing compound in two applications at right angles to each other. Do not use curing compound on surface where concrete or other material will be bonded, unless the curing compound will not prevent bond or unless measures are to be taken to completely remove the curing compound from areas to receive bonded applications; and
				6. Application of other LANL-accepted curing methods.
			2. Protection—Within 30 minutes after finishing operations are complete, protect concrete from premature drying or excessively hot or cold temperatures, and mechanical injury. Maintain concrete protection to prevent freezing of the concrete and to ensure necessary strength development for structural safety. Remove protection so that the maximum decrease in temperature measured at the concrete surface in a 24-hour period shall not exceed the following:
				1. 50 °F for sections less than 12 in. in the least dimension;
				2. 40 °F for sections from 12 to 36 in. in the least dimension;
				3. 30 °F for sections 36 to 72 in. in the least dimension; and
				4. 20 °F for sections greater than 72 in. in the least dimension.

Measure concrete temperature using a method acceptable to LANL, and record the concrete temperature. When the concrete surface temperature is within 20 °F of the ambient or surrounding temperature, protection measures may be removed.

* + - 1. Concrete [other than high-early-strength] shall be maintained above 50 °F and, in a moist condition, for at least the first 7 days after placement.

[8. High-early-strength concrete shall be maintained above 50 °F and, in a moist condition, for at least the first 3 days after placement.]

* + 1. When required by LANL, supplementary strength tests in accordance with the “Field-Cured-Specimens Paragraph (below, under EVALUATION AND ACCEPTANCE OF CONCRETE)” shall be performed to assure that curing is satisfactory.
		2. Where a liquid membrane curing compound is used, particular attention shall be given to its compatibility with any protective coatings that are to be applied following curing.
	1. COLD WEATHER REQUIREMENTS
		1. When concrete must be placed in cold weather as defined by ACI 306R, the Subcontractor must develop a detailed “Cold-Weather Implementation Plan” and submit it for approval by LANL. This approval shall account for those recommendations addressed in ACI 306R and ACI 349 (curing) as appropriate and any elements required for worker safety. This cold-weather plan shall cover:
			1. the production,
			2. transportation,
			3. placement,
			4. protection,
			5. curing (ACI 349) and
			6. temperature-monitoring of concrete during cold weather; in the submittal, include procedures to be implemented upon abrupt changes in weather conditions or equipment failures.

Do not begin cold-weather concreting until these procedures have been submitted to and approved by LANL.

Note: ACI 301 applies for any conditions not specifically addressed by one of the standards/guides noted.

* + 1. Protection may be removed when the concrete surface temperature is within 20 ºF of the ambient temperature measured with a calibrated measuring device.
		2. Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near-freezing weather.
		3. All concrete materials and all reinforcement, forms, fillers, and ground with which concrete is to come in contact shall be free from frost.
		4. Frozen materials or materials containing ice shall not be used.
		5. Concrete shall comply with the requirements of ACI 306R and this Section. Where a contradiction exists, this Section shall govern.
	1. HOT WEATHER REQUIREMENTS
		1. When concrete must be placed in hot weather as defined below, Subcontractor must develop a detailed “Hot-Weather Implementation Plan” and submit it for approval by LANL. This approval shall account for those recommendations addressed in ACI 305R and ACI 349 (curing) as appropriate and any elements required for worker safety. This hot-weather plan shall cover:
			1. the production,
			2. transportation,
			3. placement,
			4. protection,
			5. curing (ACI 349) and
			6. temperature-monitoring of concrete during hot weather; in the submittal, include procedures to be implemented upon abrupt changes in weather conditions or equipment failures.

Do not begin hot-weather concreting until these procedures have been submitted to and approved by LANL.

Note: ACI 301 applies for any conditions not specifically addressed by one of the standards/guides noted.

* + 1. Protection may be removed when the concrete surface temperature is within 20 ºF of the ambient temperature measured with a calibrated measuring device.
		2. These practices (ACI 305R) shall be used when the ambient daytime temperature at any time at the job-site is 80 ºF or more.
		3. During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure.
		4. Concrete shall comply with the requirements of ACI 305R and this Section. Where a contradiction exists, this Section shall govern.
	1. EVALUATION AND ACCEPTANCE OF CONCRETE
		1. Concrete shall be evaluated and accepted in accordance with the requirements of the remaining Paragraphs in this portion of the Section (i.e., “Frequency of Testing” through “Appearance”).

Qualified field testing technicians shall perform tests on fresh concrete at the job site, prepare specimens required for curing under field conditions, prepare specimens required for testing in the laboratory, and record the temperature of the fresh concrete when preparing specimens for strength tests. Qualified laboratory technicians shall perform all required laboratory tests at the point of placement.

* + 1. Frequency of Testing
			1. Samples for strength tests of concrete should be taken at least once per day for each class of concrete placed, or at least once for each 50 yd3 of concrete placed, or as specified in the approved CGD plan, whichever is more stringent.
			2. If Project total volume of concrete is such that frequency of testing required by 3.9.B.1 would provide less than five strength tests for a given class of concrete, tests shall be made from at least five randomly selected batches or from each batch if fewer than five batches are used.
			3. A strength test shall be the average of the strengths of a minimum of two 6-in. diameter x 12-in. tall cylinders, or three 4-in. diameter x 8-in. tall cylinders, made from the same sample of concrete and tested at 28 days or at test age designated for determination of f’c.
		2. Laboratory-Cured Specimens
			1. Samples for strength tests shall be taken in accordance with ASTM C 172.
			2. Cylinders for strength tests shall be molded and laboratory-cured in accordance with ASTM C 31 and tested in accordance with ASTM C 39.
			3. Strength level of an individual class of concrete shall be considered satisfactory if both of the following requirements are met:
				1. Every arithmetic average of any three consecutive strength tests equals or exceeds f’c ;
				2. No individual strength test (average of two “6x12” cylinders, or three “4x8” cylinders) falls below f’c by more than 500 psi when f’c is 5000 psi or less; or by more than 0.10 f’c when f’c is more than 5000 psi.
		3. Field-Cured Specimens
			1. LANL may require strength tests of cylinders cured under field conditions to check the adequacy of curing and protection of concrete in the structure.
			2. Field-cured cylinders shall be cured under field conditions in accordance with ASTM C 31.
			3. Field-cured test cylinders shall be molded at the same time and from the same samples as laboratory-cured test cylinders.
			4. Procedures for protecting and curing concrete shall be improved when strength of field-cured cylinders at test age designated for determination of f’c is less than 85% of that of companion laboratory-cured cylinders. The 85% limitation shall not apply if field-cured strength exceeds f’c by more than 500 psi.
		4. Appearance
			1. The concrete surface shall be free from honeycombs, embedded debris, and dimensional variance as defined herein and in ACI 301 (and in the associated documents and standards referenced therein).
	1. FORMWORK, EMBEDDED PIPES AND CONSTRUCTION JOINTS
		1. General
			1. Prior to placement of formwork, ensure that all inspections are complete and documentation has been accepted by LANL in accordance with approved VIT Plan.
			2. Hand trim sides and bottom of earth forms. Remove loose soil prior to placing concrete.
			3. Erect formwork, shoring and bracing to achieve design requirements and maintain tolerances in accordance with requirements of ACI 301 and ACI 347 (or more stringent design requirements as specified in this Section or construction Drawings). Contact surfaces of the formwork should be carefully installed to produce neat and symmetrical joint patterns, unless otherwise specified. Joints should be vertical or horizontal and, where possible, should be staggered to maintain structural continuity.
			4. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.
			5. Arrange and assemble formwork to permit dismantling, stripping and removal of remaining principal shores. Do not damage concrete during stripping.
			6. Align joints and make watertight. Keep form joints to a minimum.
			7. Provide chamfer strips on external corners of beams, joists, columns, and walls.
			8. Apply form release agent prior to placement of reinforcing steel, anchoring devices, and embedded items.
			9. Do not apply form release agent where concrete surfaces receive special finishes or applied coverings which are affected by agent. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.
			10. Install void forms in accordance with manufacturer’s recommendations. Protect forms from moisture or crushing.
			11. Provide formed openings where required for items to be embedded in or passing through concrete work.
			12. Locate and set in place items which cast directly into concrete.
			13. Clean formed cavities of debris prior to placing concrete. Clean and remove foreign matter as erection proceeds.
			14. Install accessories in accordance with manufacturer’s instructions, straight, level, and plumb. Ensure items are not disturbed during concrete placement.
			15. Install waterstops in construction joints and at other joints indicated to form a continuous diaphragm. Install in the longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field-fabricate joints in waterstops according to manufacturer’s written instructions.
			16. Provide temporary ports or openings in formwork where required to facilitate placement, cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.
			17. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.
			18. During cold weather, remove ice and snow from within forms. Do not use deicing salts or water to clean out forms. Use compressed air or other means to remove foreign matter. Ensure that water and debris drain to exterior through clean-out ports.
			19. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and other imposed loads without excessive deflection or creep or until the concrete strength indicated in the “Removal-of-Forms-Shores-and-Reshoring Paragraph (below)” has been achieved. Perform form removal in accordance with the recommendations of ACI 347.
			20. Store removed forms in manner to avoid any damage to form surfaces that will later be in contact with fresh concrete. Discard damaged forms.
			21. After formwork removal, place construction or equipment loads on reinforced concrete only after cylinder break results indicate strengths meet specified requirements. Exceptions to this requirement must be approved in writing by LANL.
			22. Verify lines, levels, and centers before proceeding with formwork. Ensure that dimensions agree with the construction Drawings. Verify “square” for slabs, floors, and walls. “Square” specifically means a 90-degree corner or connection, whether horizontal or vertical, such as a floor, wall or ceiling.

Note: all required preliminary activities, such as inspections, geotechnical and soil compaction/moisture testing, must be approved by LANL to proceed with the placement.

* + - 1. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.
			2. Verify that concrete cover for reinforcement conforms to the construction Drawings and to the “Concrete-protection-for-reinforcement Paragraph (below, under DETAILS OF REINFORCEMENT).
		1. Removal of Forms, Shores, and Reshoring
			1. Removal of forms—Forms shall be removed in such a manner as not to impair safety and serviceability of the structure. Concrete exposed by form removal shall have sufficient strength not to be damaged by removal operation.

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The EOR must decide whether to declare when the removal of shores and reshoring for “elevated concrete” is allowed to occur, or to delegate this to the Subcontractor.

- If the former (i.e., EOR declares “when”), the following subparagraph shall be edited by deleting the options pertaining to calcs/analyses, and the last column of Table 3-1 (on the next page) shall be edited to include the construction load that can safely be supported (at the time the concrete achieves the indicated required-strength value) for each applicable element.

- If the latter (i.e., Subcontractor decides “when”), the following subparagraph shall be edited by selecting the options pertaining to calcs/analyses, and Table 3-1 shall be edited by deleting the column, “Construction Load.”

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* + - 1. Removal of shores and reshoring—The three (3) provisions that are included in the following subparagraph (i.e., a.1 – a.3) shall apply to slabs and beams except where cast on the ground.
				1. Before starting construction, the Subcontractor shall develop a procedure and schedule for removal of shores and installation of reshores [and for calculating the loads transferred to the structure during the process.]

The [structural analysis and] concrete strength data used in planning and implementing form removal and shoring shall be furnished by the Subcontractor to LANL when so requested;

No construction loads shall be supported on, nor any shoring removed from, any part of the structure under construction except when that portion of the structure in combination with remaining forming and shoring system has sufficient strength to support safely its weight and loads placed thereon;

Sufficient strength shall be demonstrated by [structural analysis considering proposed loads,] strength of forming and shoring system, and concrete strength data. Concrete strength data shall be based on tests of field-cured cylinders or, when approved by LANL, on other procedures to evaluate concrete strength.

* + - * 1. No construction loads exceeding the combination of superimposed dead load plus specified live load shall be supported on any unshored portion of the structure under construction, unless analysis indicates adequate strength to support such additional loads.
			1. Where coating systems are to be applied to the concrete, only those hardeners, additives, and form release agents that are compatible with the coating system shall be used.
			2. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.
			3. Concrete forms shall not be permitted to be removed until the following strengths have been achieved:

| **Table 3-1 – Required Concrete Strength for Formwork Removal\*** |
| --- |
| Structural Element | Required Strength | [Construction Load, psf\*\* |
| Foundation and ground-supported flatwork | 50% f’c | \_\_\_\_\_\_\_\_\_ |
| Walls and parapets | 70% f’c  | \_\_\_\_\_\_\_\_\_ |
| Roof slab | 75% f’c | \_\_\_\_\_\_\_\_\_] |

**\*** If this Section, or referenced codes/standards herein, require higher strength prior to stripping the forms, then the most stringent of the requirements shall be used.

**\*\***Maximum load, not including element self-weight, that can safely be supported when the concrete achieves the indicated required strength.

* + - 1. Concrete curing shall be maintained in accordance with CURING (above) and the applicable ACI codes after forms have been removed.
			2. The Subcontractor shall be permitted to remove the concrete formwork prior to obtaining the results from the 7-day lab-cured cylinder break provided the following requirements are met:
				1. Concrete strength shall meet the requirements of Table 3-1 (above),
				2. The concrete strength shall be determined by the average of the strengths of a minimum of two 6-in. diameter x 12-in. tall, or three 4-in. diameter x 8-in. tall, field-cured cylinders made from the same sample of concrete and tested in accordance with ASTM C 39,
				3. Field cured cylinders shall be prepared in accordance with the “Field-cured-specimens Paragraph (above, under EVALUATION AND ACCEPTANCE OF CONCRETE).”
				4. The number of field-cured cylinder sets shall be the same as required for the 7- and 28-day laboratory-cured cylinder sets,
				5. Curing shall continue to meet the requirements of this Section after formwork is removed, and
				6. All other requirements for formwork removal from this Paragraph (i.e., Removal of Forms, Shores, and Reshoring) are met.
		1. Conduits and Pipes Embedded in Concrete
			1. Conduits, pipes, and sleeves of any material not harmful to concrete and within limitations of this Paragraph shall be permitted to be embedded in concrete with approval of LANL, provided they are not considered as structurally replacing the displaced concrete, except as provided in the related subparagraph (below, “Conduits…considered as structurally…).”
			2. Conduits and pipes of aluminum shall not be embedded in structural concrete unless effectively coated or covered to prevent aluminum-concrete reaction or electrolytic action between aluminum and steel.
			3. Conduits, pipes, and sleeves passing through a slab, wall, or beam shall not significantly impair the strength of the construction.
			4. Except when conduits and pipes are shown on the respective, associated Project construction Drawings, conduits and pipes embedded within a slab, wall, or beam (other than those merely passing through) shall satisfy the following three (3) provisions:
				1. They shall not be larger in outside dimension than 1/3 the overall thickness of slab, wall, or beam in which they are embedded.
				2. They shall not be spaced closer than three (3) diameters or widths on center.
				3. They shall not significantly impair the strength of the construction.
			5. Conduits, pipes, and sleeves shall be permitted to be considered as structurally replacing the displaced concrete in compression provided the following three (3) provisions are met:
				1. They are not exposed to rusting or other deterioration.
				2. They are of uncoated or galvanized iron or steel not thinner than standard Schedule 40 steel pipe.
				3. They have a nominal inside diameter not over 2 in. and are spaced not less than three (3) diameters on centers.
			6. All piping and fittings, where required by the respective, associated Project-Specification sections, shall be tested as a unit for leaks before concrete placement. Pressure tests shall be in accordance with the applicable piping specification, code or standard.
			7. No liquid, gas, or vapor, except water not exceeding 90 °F nor 50 psi pressure, shall be placed in the pipes until the concrete has attained its design strength, unless otherwise approved by LANL.
			8. In solid slabs, piping, unless it is for radiant heating or snow melting, shall be placed between top and bottom reinforcement.
			9. Concrete cover for pipes, conduits, and fittings shall not be less than 1-1/2 in. for concrete exposed to earth or weather, nor less than 3/4 in. for concrete not exposed to weather or in contact with ground.
			10. Reinforcement with an area not less than 0.002 times area of concrete section shall be provided normal to piping.
			11. Piping and fittings shall be assembled according to the applicable Project-Specification section(s). Screw connections shall be prohibited.
			12. Piping and conduit shall be so fabricated and installed that cutting, bending, or displacement of reinforcement from its proper location will not be required.
			13. All piping containing liquid, gas, or vapor pressure in excess of 200 psi above atmospheric pressure or temperature in excess of 150 °F shall be sleeved, insulated, or otherwise separated from the concrete and/or cooled to limit concrete stresses to an acceptable fraction of the affected design strength/property (e.g., compressive strength, tensile strength, modulus of elasticity, etc.) and to limit concrete temperatures to the following:
				1. For normal operation or any other long-term period, the temperatures shall not exceed 150 °F, except for local areas that are allowed to have increased temperatures not to exceed 200 °F;
				2. During an accident or for any other short-term interruption, the temperatures shall not exceed 350 °F for the interior surface. However, local areas are allowed to reach 650 °F from fluid jets in the event of a pipe failure;
				3. Higher temperatures than given in the previous two subparagraphs (i.e., “a” and “b”) may be allowed in the concrete if tests are provided to evaluate the reduction in strength and this reduction is applied to the affected design strength/property. Evidence shall also be provided that verifies that the increased temperatures do not cause deterioration of the concrete with or in the absence of applied loads.

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Regarding the next 2 paras. (i.e., “Joints”), ACI 349 para. 1.2.1.j requires details and location of all joints to be shown on the Drawings.

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* + 1. Construction Joints
			1. Surface of concrete construction joints shall be clean of all materials that inhibit bond. Materials such as curing compounds, laitance, saw dust, wood, dirt, polyethylene, pipe tape coating, and paper shall be removed. If a bonding agent is used, preparation/cleaning (above and beyond that described) shall be in accordance with manufacturer’s written instructions. Where key joints are not provided, the finished surface amplitude shall be 1/4 in.
			2. A maximum of 10 minutes before new concrete is placed, all construction joints shall be wetted and standing water removed.
			3. Construction joints shall be located as shown on the construction Drawings or shall be approved by LANL.
			4. Construction joints in floors shall be located within the middle third of spans of slabs, beams, and girders.
			5. Construction joints in girders shall be offset a minimum distance of two times the width of intersecting beams.
			6. Beams, girders, or slabs supported by columns or walls shall not be cast or erected until concrete in the vertical support members is no longer plastic.
			7. Beams, girders, haunches, drop panels, and capitals shall be placed monolithically as part of a slab system, unless otherwise shown on the construction Drawings or specified herein.
		2. Contraction Joints
			1. While the concrete is still plastic (i.e., within several hours after placement), provide joints in slabs as shown on the construction Drawings. The depth of each joint will be at least one-quarter of the slab thickness, but not less than one (1) in.
	1. DETAILS OF REINFORCEMENT
		1. Standard Hooks
			1. The term “standard hook,” as used in this document, shall mean one of the following:
				1. A 180-degree bend plus 4db extension, but not less than 2-1/2 in. at free end of bar.
				2. A 90-degree bend plus 12db extension at free end of bar.
				3. For stirrup and tie hooks

No. 5 bar and smaller, 90-degree bend plus 6db extension at free end of bar; or

No. 6, No. 7, and No. 8 bar, 90-degree bend plus 12db extension at free end of bar; or

No. 8 bar and smaller, 135-degree bend plus 6db extension at free end of bar.

* + - * 1. Seismic hooks defined as follows: a hook on a stirrup, hoop, or crosstie having a bend not less than 135 degrees, except that circular hoops shall have a bend not less than 90 degrees. Hooks shall have a six-diameter (but not less than 3 in.) extension that engages the longitudinal reinforcement and Projects into the interior of the stirrup or hoop.
		1. Minimum Bend Diameters
			1. Diameter of bend measured on the inside of the bar, other than for stirrups and ties in sizes No. 3 through No. 5, shall not be less than the values in Table 3-2 (below).

|  |
| --- |
| **Table 3-2 Minimum Diameters of Bend** |
| Bar Size | Minimum Diameter |
| No. 3 through No. 8 | 6db |
| No. 9, No. 10, and No. 11 | 8db |
| No. 14 and No. 18 | 10db |

* + - 1. Inside diameter of bend for stirrups and ties shall not be less than 4db for No. 5 bar and smaller. For bars larger than No. 5, diameter of bend shall be in accordance with Table 3-2 (above).
		1. Bending
			1. All reinforcement shall be bent cold prior to placement, using industry-standard practices/equipment, unless otherwise permitted by LANL.

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If field-bending of partially-embedded rebar is “shown,” compliance with the associated provisions of ACI 301 (i.e., *Field bending or straightening*, found in the Section, Reinforcement and Reinforcement Supports) must be required.

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* + - 1. Reinforcement partially embedded in concrete shall not be field bent, except as shown on the construction Drawings or permitted by LANL.
		1. Surface Conditions of Reinforcement
			1. At the time concrete is placed, reinforcement shall be free from mud, oil, or other nonmetallic coatings that decrease bond.
			2. Steel reinforcement with rust, mill scale, or a combination of both shall be considered satisfactory, provided the minimum dimensions (including height of deformations) and weight of a hand-wire-brushed test specimen comply with applicable ASTM specifications herein (in PART 1, under REFERENCES; and in PART 2, under REINFORCING AND ACCESSORIES).
		2. Placing Reinforcement
			1. Reinforcement shall be accurately placed and adequately supported before concrete is placed, and shall be secured against displacement within tolerances permitted by ACI 349 Chapter 7 (i.e., Details of Reinforcement), paragraph 7.5.2.
			2. Welding of crossing bars shall not be permitted for assembly of reinforcement unless authorized by LANL.
			3. Bars shall be permitted to be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items subject to the approval of LANL. If bars are moved more than one (1) bar diameter, or enough to exceed the above tolerances, the resulting arrangement of bars shall be subject to approval by LANL.

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The following minimum cover requirements come from ACI 318 Ch. 7 (since that’s what ACI 349 defers to for “cover”), and apply ONLY when BOTH of the following conditions are met:

1. Larger cover is not required by corrosion and/or fire-protection requirements of Ch. 7.

2. The concrete is cast-in-place (CIP), nonprestressed.

If both of these conditions are not met then the following paragraph must be edited in accordance with Chapter. 7.

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* + 1. Concrete Protection for Reinforcement

Cast-in-place concrete (nonprestressed)—The following minimum concrete cover shall be provided for reinforcement:

| **Table 3-4 Minimum Concrete Cover** |
| --- |
| **Condition**  | **cover, in.** |
| Concrete cast against and permanently exposed to earth | 3 |
| Concrete exposed to earth or weather: |  |
| No. 6 through No. 18 bars | 2 |
| No. 5 bar, and smaller | 1-1/2 |
| Concrete not exposed to weather or in contact with ground: |  |
| Slabs, walls, joists |  |
| No. 14 and No. 18 bars | 1-1/2 |
| No. 11 bar and smaller | 3/4 |
| Beams, columns |  |
| Primary reinforcement, ties, stirrups, spirals | 1-1/2 |

Where the above table and the construction Drawings are in conflict the following shall be used:

* + - * 1. Requirements of Table 3-4 (above) are less than the cover requirements on the Drawings: The construction Drawings shall be used for cover requirements.
				2. Requirements of Table 3-4 are greater than the cover requirements on the construction Drawings: LANL shall be notified to provide direction. The concrete shall not be permitted to be cast until cover is resolved.
	1. Defective Concrete
		1. Defective concrete is concrete not conforming to acceptance criteria in this Section and the codes and standards referenced herein.

Note: In accordance with the contract, concrete that has not been placed in accordance with the applicable portions of this Section can be considered defective due to the potential for such concrete to not be durable (e.g., concrete that is not placed properly in “cold/hot weather” is subject to poor long-term performance, etc.).

* + 1. Do not accept or place defective concrete that is not in conformance with acceptance criteria. Return the fresh concrete to the supplier.
		2. Defective concrete shall be address through the Non-Conformance Report (NCR) process and the LANL-approved Subcontractor QAP. The Subcontractor repair method shall not be permitted to be implemented until approved by LANL.

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* 1. CONCRETE FINISHING
		1. Finish Requirements—Unless noted otherwise on the construction Drawings, the concrete finish shall meet the following requirements:
			1. Wall finishes:
				1. Exterior Permanently Exposed Areas—Smooth-formed finish in accordance with ACI 301, paragraph 5.3.3.4.a.
				2. Interior Permanently Exposed Areas—Smooth-formed finish in accordance with ACI 301, paragraph 5.3.3.4.a.
				3. Exterior Covered Areas—Smooth-formed finish. In accordance with ACI 301, paragraph 5.3.3.3.b.
			2. Floor finish and flatness/levelness requirements:
				1. Finish—Trowel finish in accordance with ACI 301, paragraph 5.3.4.2.c.
				2. Tolerances for floors, and floor finishes shall be confirmed by measuring in conformance with ACI 301 section 5.3.4.3.
			3. Roof slab finish and flatness/levelness requirements:
				1. Finish—Float finish in accordance with ACI 301, paragraph 5.3.4.2.b.
				2. Tolerance shall meet the requirements of conventional bullfloated slab in accordance with ACI 117, paragraph 4.5.7
	2. Nonstructural/Cosmetic Concrete Repair

Note: These provisions are only applicable to nonstructural defects/deficiencies.

Defects that affect the critical characteristics identified in PART 1 (in the “Critical-Characteristics Paragraph” under QUALITY ASSURANCE) as determined by LANL, and other structural defects, shall be addressed through the Non-Conformance Report (NCR) process and the LANL-approved Subcontractor QAP.

* + 1. Nonstructural/cosmetic defects that are required to be repaired shall include the following:
			1. Voids larger 3/4-in. wide or 1/2-in. deep.

Note: This does not apply if the void results in exposed reinforcing steel; repairs of this type shall be submitted for approval by LANL through the NCR process and in accordance with the LANL-approved Subcontractor QAP.

* + - 1. Projections larger than 1/8 in.
			2. Unless otherwise required by this Section or other contract documents, minor surface imperfections left by air bubbles or sand streaks need not be repaired.
		1. Repair materials used shall be submitted to LANL for approval prior to use.
		2. Repair tie-holes and other surface defects immediately after formwork removal, unless otherwise permitted.
		3. Repair of Tie-Holes: Plug tie-holes. When Portland-cement patching mortar conforming to the “Site-Mixed-Portland-Cement-Repair-Mortar” paragraph (below) is used for plugging, clean and dampen tie-holes before applying the mortar. When other materials are used, apply them in accordance with manufacturer’s recommendations. If other materials are used, material manufacturer data shall be submitted to LANL for approval prior to use.
		4. Repair of Surface Defects Other Than Tie-Holes: Outline honeycombed or otherwise defective concrete with a ½- to ¾-in. deep saw cut and remove such concrete down to sound concrete. When chipping is necessary, leave chipped edges perpendicular to the surface or slightly undercut. Do not feather edges. Dampen the area to be patched plus another 6 in. around the patch area perimeter. Prepare scrub coat according to the following Paragraph (i.e., “Scrub Coat”). Thoroughly scrub coat into the surface. When the scrub coat begins to lose water sheen, apply patching mortar prepared in accordance with the “Site-Mixed-Portland-Cement-Repair-Mortar Paragraph (below)” and thoroughly consolidate mortar into place. Strike-off mortar, leaving the patch slightly higher than the surrounding surface to compensate for shrinkage. Leave the patch undisturbed for one (1) hour before finishing. Keep the patch damp for seven (7) days.
		5. Scrub Coat: For scrub coat material, mix approximately one part Portland cement and one part sand by damp loose volume with water to produce the consistency of thick cream. Use sand meeting the requirements of ASTM C 144 or ASTM C 404.
		6. Site-Mixed Portland-Cement Repair Mortar: For repairs in concrete exposed to view, repair mortar shall match adjacent concrete color, and a trial batch shall made in order to verify color compatibility of repair material with surrounding concrete. When the repair is too dark, substitute white Portland cement for a part of the gray cement to produce a color closely matching surrounding concrete. Use a repair mortar at a stiff consistency with no more mixing water than is necessary for handling and placing. Mix the repair mortar and manipulate the mortar frequently with a trowel without adding water.
		7. Repair Materials Other than Site-Mixed Portland-Cement Mortar: Use repair materials in accordance with manufacturer’s recommendations or as acceptable to EOR. Manufacturer data sheets shall be submitted to LANL for approval prior to use of materials.
	1. FIELD QUALITY CONTROL
		1. Provide a certified testing agency to perform field testing in accordance with ACI 301 and NQA-1. Testing laboratory certification may be obtained through AASHTO or another nationally recognized accreditation service as allowed by ASTM C 1077. National accreditations must be specific to the specific facility and/or mobile unit. LANL, or designee, must approve the test agency prior to performance of any work.
			1. Testing agencies for performing testing services on concrete materials shall meet the requirements of ASTM C 1077.
			2. Field testing of concrete shall be performed by an ACI-Certified Concrete Field-Testing Technician – Grade I.
			3. Laboratory testing of concrete shall be performed by an ACI-Certified Concrete Laboratory Technician – Grade I or equivalent per ASTM C 1077.
			4. Verification of batching operations shall be performed by an NRMCA-Certified Concrete Technologist – Level 3.
		2. Inform LANL 48 hours in advance of field testing to allow for witnessing of testing.
		3. The Testing Agency shall perform the following tests in accordance with this Section. Samples for Acceptance Testing are to be taken at the discharge from the transit mixer (and into a wheel barrow per ASTM C 172), except when using concrete pumps or conveyors to transport concrete to its final placement location. When pumps or conveyors are used, the samples for acceptance tests shall be taken at the end of the pipe at the point of placement or last conveyor belt. Pumping of concrete should follow ACI 304.2R and belt conveying ACI-304.4R.

Note: The tests below shall always be performed whenever concrete test specimens are taken.

* + 1. Sample concrete in accordance with ASTM C 172.
		2. Record temperature of concrete in accordance with ASTM C 1064.
		3. Perform slump test in accordance with ASTM C 143.
		4. Perform air content test in accordance with ASTM C 231, pressure method.
		5. Perform density testing in accordance with ASTM C 138 when required by ASTM C 94.
		6. Prepare concrete strength-test cylinders in accordance with ASTM C 31.

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In the following paragraph, the 24-hr. default value for the “low end” of the period during which strength-test cylinders must be picked up shouldn’t be used without scrutiny. The reason being “low breaks” could result from moving cylinders in which the concrete hasn’t “set up.” The 24-hr. figure was selected based on field experience with the “extended-set” pre-approved mixture design (i.e., “5000-8E” herein).

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* + 1. The Testing Agency shall test the strength test cylinders in accordance with ASTM C 39 at 7 days and 28 days. Strength test cylinders must be picked-up at the job site between [24] and 48 hours after molding. See ASTM C 94 and ASTM C 31 for specific curing times.
		2. Coordinate the sequencing of concrete construction to schedule LANL Special Inspection per the requirements of IBC Chapter 17. Provide 48-hour notification to schedule special inspectors.
		3. Perform test and inspections as required by LANL-approved VIT Plan.

END OF [MAIN] SECTION

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Do not delete the following reference information:
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THE FOLLOWING REFERENCE IS FOR LANL USE ONLY

This Project-Specification Section is based on LANL Master Specification Section 03 3021 Rev. 1, dated November 28, 2017

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Authors note for VIT that follows: Depending on the safety function and type of installation, the Functional Classification column SC entry could change to SS and thus entry should be validated by the engineer.
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**Coversheet and Revision History**

|  |
| --- |
| **SPECIFICATION PACKAGE NUMBER: [Project ID]-03 3021** |
| **SPECIFICATION PACKAGE TITLE: Reinforced Concrete–High Confidence** |
| Material to be Purchased: [x]  Safety Class [ ]  Safety Significant [ ]  ML-3 [ ]  Non-Safety |
| **Revision Number** | **Revision Date** | **Description/Justification for Revision** | **Signature** | **Date** |
|  |  |  | **Preparer:\*** |  |
|  |  |  | **Checker/Independent Reviewer:\*** |  |
|  |  |  | **LANL SME (Security):\*** |  |
|  |  |  | **Design Team Leader:\*** |  |
|  |  |  | **Quality Assurance:\*** |  |
|  |  |  | **LANL Design Authorization Approval:** |  |
|  |  |  | **Classification:****DC/RO:** |  |
| **Rev. No.** | **Date** | **Revision Description** | **Preparer** | **Checker/IR** | **Design Team Lead** | **Design Authority** | **LANL Design Authority** |
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\* Subcontractors may use equivalent titles for their organizations.

| **Insp No.** | **Component or Item Description** | **Reference** | **Funct. Class** | **Inspection Requirements** | **Acceptance Criteria** | **Implementing Organization** | **Witness or Hold Point** | **Implementing Activity, Schedule** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| I-1 | Visual Inspection that Cement conforms to Specification 03 3021 | TEA-TA-ZZZZ-NNNNSection 03 3021 Parts:1.6.G.71.7.C.2.4.A.2.7.G.1 | SC | Verify cement conforms to Section 03 3021* Every shipment of cement shall be accompanied by a CMTR stating the results of tests representing the cement in shipment and the ASTM specification limits for each item of required chemical, physical, and optional characteristics.
* No cement shall be used in any structural concrete prior to receipt of 7-day mill test strengths.
 | Provide CMTR for cement to document conformance to:* ASTM C150
* Provided by GCC-Tijeras NM, Type 1/II
* 7 day mill test strengths
 | LOI (LANL)PI (Subcontractor) | Witness Point | Prerequisite to placement of concrete. |
| I-2 | Visual Inspection that Fly Ash conforms to Section 03 3021 | TEA-TA-ZZZZ-NNNNSection 03 3021 Parts:1.6.G.71.7.C.2.5.E.2.7.G.1 | SC | Verify Fly Ash conforms to Section 03 3021 | Provide CMTR and/or CoC’s to:* Document conformance to ASTM C618
* Provided by Salt River Materials Group, Four Corners
 | LOI (LANL)PI (Subcontractor) | Witness Point | Prerequisite to placement of concrete. |
| I-3 | Visual Inspection that Air Entraining Admixtures conform to Section 03 3021 | TEA-TA-ZZZZ-NNNNSection 03 3021 Parts:1.6.G.71.7.C.2.5.C.2.7.G.1 | SC | Verify Air-Entraining Admixture conforms to Section 03 3021 | Provide CMTR and/or CoC for MasterAir AE 200 to document conformance to ASTM C260. | LOI (LANL)PI (Subcontractor) | Witness Point | Prerequisite to placement of concrete. |
| I-4 | Visual Inspection that Admixtures conform to Section 03 3021 | TEA-TA-ZZZZ-NNNNSection 03 3021 Parts:1.6.G.71.7.C.2.5.D.2.7.G.1 | SC | Verify Admixtures conform to Section 03 3021* Water-reducing admixture,
* Hydration Stabilizer admixture
 | Provide CoC for MasterGlenium 3030 and Delvo admixtures to document conformance to ASTM C494. | LOI (LANL)PI (Subcontractor) | Witness Point  | Prerequisite to placement of concrete. |
| I-5 | Subgrade prepared in accordance with Section 03 3021. | Section 03 3021 Parts:1.6.G.3 | SC | Verify that Subgrade is prepared in accordance with the approved Specification and required inspection and tests are complete. | Document required subgrade inspection and tests have been completed and are acceptable and the subgrade is free from debris and loose material. | PI (Subcontractor)LOI (LANL)OITA (Testing Agency) | Hold Point  | Prerequisite to placement of formwork and reinforcing steel. |
| I-6 | Formwork complies with critical dimensions and tolerances | Section 03 3021 Parts:1.6.G.43.10 | NS/SC\* | Verify that the formwork has been installed in accordance with the applicable Drawings and Specifications. | Document inspection of formwork and compliance with ACI 301, ACI 347, Drawings and Specifications. | PI (Subcontractor)LOI (LANL) | Hold Point | Prerequisite to placement of concrete. |
| I-7 | Reinforcing Material Properties | Section 03 3021 Part:1.6.G.5. | SC | Verify Reinforcing material properties meet specification. | Confirm deformed bars, stirrups and ties conform to ASTM A 706 Grade 60. A minimum of one tensile test required for each 50 tons of each bar size produced from each heat of steel (ASTM A370).Manufacturer’s CMTRs for each delivery and traceable to the reinforcing steel tag bundles via the lot or heat number. Reinforcing within a specific lot/heat number painted a specific color at each end. Bars shall be traced by lot/heat numbers by location in the building. A location map shall be provided to LANL by the Subcontractor for review and approval prior to placement of concrete. | PI (Subcontractor)LOI (LANL) | Hold Point  | At receipt inspection. |
| I-8 | Reinforcing Steel, Mechanical Splices, and Embeds are placed in accordance with Subcontract Requirements | Section 03 3021 Parts:1.6.G.6.2.33.11.E.1 | SC | Verify Reinforcing Steel, Mechanical Splices, and Embeds are placed in accordance with Subcontract Requirements including Drawings and Specifications. | Reinforcing Steel, Mechanical Splices, and Embeds are placed in accordance with ACI 349 Chapter 7, Drawings, and Specifications. | PI (Subcontractor)LOI (LANL) | Hold Point | Prerequisite to placement of concrete. |
| I-9 | Owner’s Special Inspections | Section 03 3021 Parts:1.6.G.14Project Statement of Special Inspections (SSI) | SC | LANL Inspections required by IBC.LANL Special Inspection required by LANL Statement of Special Inspections. | Documented LANL Special Inspection. | LOI (LANL) | Hold Point  | Prerequisite applicable to work stages of concrete construction as per SSI. |
| I-10 | Visual Inspection during initial Batch Plant startup and once daily if batching is extended.  | TEA-TA-ZZZZ-NNNN Section 03 3021 Parts:1.6.G.7.2.4.B.2.c.3.3.A.3.3.B.  | SC | Perform source verification during initial Batch Plant startup and daily if extended beyond one dayshift. Verify:* The moisture contents of the aggregates have been measured daily at the beginning of production per ASTM C566 and the amount of mix water has been adjusted accordingly.
* Verify the gradation, fineness modulus and material finer than number 200 sieve for the fine aggregate and coarse #67 aggregate per ASTM C136.
* The proportions for all concrete mix constituents entered into the plant batching computer match the Pre-Approved Mix Design 5000-8E.
* Verify that concrete is mixed a minimum amount of time at the specified mixing speed prior to leaving the batch plant.
 | * Aggregate moisture content has been taken into account for the water balance and recorded on the batch ticket.
* Aggregate, both fine and #67 coarse, shall conform to ASTM C33 and be monitored for significant changes to gradation, fineness modulus and material finer than number 200 sieve.
* Batch plant computer entries compliance to match the Pre-Approved Mix Design 5000-8E
* Satisfactorily completion of batch plant startup steps
* Minimum mixing time: 90 seconds
 | PI (Subcontractor)OITA (Testing Agency) | Witness | During concrete production and as a Prerequisite to placement of concrete.  |
| I-11 | Visual Inspection of batch tickets for each load delivered to verify that mixed concrete conforms to pre-approved mix design 5000-8E for concrete materials. | TEA-TA-ZZZZ-NNNN Section 03 3021 Part:1.6.G.7. | SC | Inspection of Batch Tickets for each load delivered:* Compare brand, type/description, amounts, and sources for each constituent listed against Pre-Approved Mix Design, 5000-8E
* Verify that the batched amount of each constituent is within the tolerance specified.
 | See Section 03 3021, Part 2.7.G for list and quantity of concrete materials and associated tolerances per Pre-Approved Mix Design 5000-8E. | PI (Subcontractor)OITA (Testing Agency)LOI (LANL) | Witness Point  | Prerequisite to placement of concrete. |
| I-12 | Visual Inspection to verify any field adjustments of mixed concrete conforms to Section 03 3021 | Section 03 3021 Parts:3.3.D. | SC | Verify the presence of field adjustments to the mix design 5000-8E, including additions of mixing water if applicable. Adding mixing water in the field is only permitted if the ready-mix producer held back water at the batch plant and the slump after transport is less than that specified in the design documents. Care must be taken not to exceed the water-cement ratio. To adjust for measuring technique accuracy, the amount of water that can be added shall be reduced by 10% from the maximum calculated water holdback volume. In addition, mixing water added in the field to adjust slump is permitted only when the water measuring device complies with Section 03 3021 Part 3.3.D. | Adjustments, if performed, comply with Section 03 3021 water addition limits. Document and control any additions of water in the field. | PI (Subcontractor)OITA (Testing Agency)LOI (LANL) | Witness Point  | Prerequisite to making field adjustments and prior to initial discharge for placement. |
| I-13 | Visual Inspection to verify mixed concrete is placed within 2-1/2 hours. | TEA-TA-ZZZZ-NNNN Section 03 3021 Parts:1.6.G.122.7.G.1.b.3.5.C.2 | SC | Verify that discharge of concrete is completed within 2-1/2 hours after water has been introduced to the cement and mix constituents. Document the number of drum revolutions prior to discharge for placement.Verify Concrete is placed in accordance with the techniques contained in the pre-approved submittal on such. | Concrete shall not be placed outside of the maximum design placement time of 2-1/2 hours. Concrete that exceeds the 2-1/2 hours shall be rejected. If concrete is placed within the 2-1/2 hours, the revolution counter shall be noted on the batch ticket; however, no limit applies.Concrete that has partially hardened or is contaminated by foreign material shall not be deposited in the structure.Concrete shall be placed using techniques per approved submittal. | PI (Subcontractor)LOI (LANL) | Witness Point | Prerequisite to placement of concrete.During concrete placement |
| I-14 | Implement Cold-Weather or Hot- Weather Plan if needed. | Section 03 3021 Parts:3.7.3.8. | SC | Cold-Weather Implementation or Hot Weather Implementation Plan. | Cold Weather: As defined by ACI 306R and ACI 349 (curing) as appropriate.Hot Weather: As defined by ACI 305R and ACI 349 (curing) as appropriate. | PI (Subcontractor) | None. | Prerequisite to placement of concrete. |
| I-15 | Visual Inspection to verify concrete curing methods and duration | Section 03 3021 Parts:1.6.G.133.6 | SC | Verify that concrete curing is performed in accordance with the methods and durations required by Section 03 3021 and per pre-approved submittal on such. | Cure concrete in accordance with the applicable “Unformed- or Formed-concrete- surfaces” subparagraphs per Section 03 3021 for at least 7 days after placement. Cure high early-strength concrete for at least 3 days after placement. When permitted, and when the duration of curing is to achieve a specified level of in-place strength, moisture retention measures may be terminated when any one of the following conditions has been met: * Tests of at least two 6 in. x 12 in. or at least three 4 in. x 8 in. cylinders, that have been field-cured in accordance with ASTM C 31, indicate compressive strength of at least 70% of f’c when tested in accordance with ASTM C 39;
* The compressive strength of laboratory-cured cylinders, representative of the in-place concrete, exceeds 85% of f’c, provided the temperature of the in-place concrete has been maintained at 50 °F or higher during curing; and Concrete strength reaches f’c as determined by accepted in-place test methods meeting the requirements of ACI 301 2.3.4.2.
 | PI (Subcontractor)LOI (LANL) | Witness | Following concrete placement |
| T-1 | Test aggregates for conformance to ASTM C33 | Section 03 3021 Part:2.4.B.2.b. | SC | Tests for full conformance with each of the requirements of ASTM C 33, including tests for potential reactivity.  | Conform to ASTM C33 requirements. | OITA (Test Agency) | NA | As directed by LANL or if there is reason to suspect a change in the basic geology or mineralogy. |
| T-2 | Test moisture content of aggregate prior to Batch Plant startup and daily if extended beyond one dayshift. | TEA-TA-ZZZZ-NNNN Section 03 3021 Part:2.4.B.2.f. | SC | Test in accordance with ASTM C566 (Total Evaporable Moisture Content). | Aggregate Moisture:* Moisture content has been taken into account for the water balance and recorded on the batch ticket.
 | OITA (Test Agency) | NA | Prerequisite to placement of concrete and prior to first batch daily. |
| T-3 | Tests Gradation of Aggregate stockpile | TEA-TA-ZZZZ-NNNN Section 03 3021 Part:2.4.B.2.c. | SC | Verify the gradation, fineness modulus and material finer than number 200 sieve for both the fine aggregate and coarse #67 aggregate per ASTM C131. | Aggregate, both fine and #67 coarse, shall conform to ASTM C33. | OITA (Test Agency) | NA | Prerequisite to placement of concrete and prior to first batch daily. |
| T-4 | Test to verify that mixed concrete conforms to Section 03 3021 for air content, slump, temperature, and density | TEA-TA-ZZZZ-NNNN Section 03 3021 Parts:3.15.C.3.15.D.3.15.E.3.15.F.3.15.G.3.15.H. | SC | Obtain samples in accordance with ASTM C172, starting with the first truckload and thereafter in accordance with the sampling plan. | 1. Temperature less than or equal to 95F during normal weather.
2. Air Content 6% +/- 1.5%.
3. Density between 137 and 143 pcf.
4. Slump: 4” minimum to 9.5” maximum.
 | OITA (Test Agency)PI (Subcontractor)LOI (LANL) | Witness Point. | Prerequisite to placement of concrete.Field Testing of Concrete. |
| T-5 | Test to verify that concrete strength meets minimum strengths per specifications | TEA-TA-ZZZZ-NNNN Section 03 3021 Parts:1.6.G.83.93.15.I3.15.J  | SC | The certified testing agency shall perform the laboratory testing in accordance with ASME NQA-1-2008 with 2009 Addenda. Obtain, prepare cylinders and test concrete in accordance with ACI 301, ASTM C31, and ASTM C39. Frequency of testing shall be at least once per day or at least once for each 50 cubic yards placed:* ASTM C172 “Standard Practice for Sampling Freshly Mixed Concrete”.
* Perform compressive strength testing of cylinders per Section 03 3021, ACI 301, ASTM C31 and ASTM C39. Samples for pumped or conveyer concrete must be taken at the end of the pump hose or end of the conveyer belt.
* Take concrete strength test cylinders, 4 inch diameter x 8 inches tall or 6 inch diameter x 12 inches tall, in accordance with ASTM C31.
* Testing agency must test the strength test cylinders in accordance with ASTM C39.
 | * Minimum 5,000 psi at 28 days.
* Strength level is satisfactory if both of the following requirements are met:
1. Every arithmetic average of any three consecutive strength tests equals or exceeds f’c;
2. No individual strength test falls below f’c by more than 500 psi when f’c is 5000 psi or less.
 | OITA (Test Agency)PI (Subcontractor)LOI (LANL) | Witness Point | Prerequisite to acceptance of concrete.Acceptance Testing of Concrete. |
| T-6 | Floor Flatness/ Levelness Requirements | Section 03 3021 Part:3.13.A.2.b. | NS | The floor flatness/levelness shall be measured in accordance with ACI 301 Section 5.3.4.3. | Per ACI 301 Section 5.3.4.3 and ACI 117. | OITA (Testing Agency) | NA | Prerequisite to acceptance of finished concrete work on this structure. |

\*Note: Formwork itself is Non-Safety (NS) however the formwork dimensions are critical and considered Safety Class (SC).

| **Content Requirements for VIT Plans****Specification Package Number: [Project ID]-03 3021** |
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| **Column Title** | **Required Information** |
| Inspection/Test Number | Enter a sequential number for each inspection or test to be performed (e.g., I-1, I-2, through I-n for inspections; T-1, T-2, and T-n for tests). |
| Component or Item Description | Describe the item or component that is to be inspected or tested (e.g., Damper Assembly; instrumentation and controls electrical components; hydraulic actuator assembly; component handling equipment). Multiple inspections or tests may be performed on any specific item or component. Each inspection or test will require a separate line on the inspection or test plan.  |
| Specification Number & Paragraph | Cite the specific paragraph in the related Specification that states the requirements for the inspection of test that is to be performed. |
| Functional Class | State the Functional Class that applies to the item or component that is to be inspected or tested (i.e., SC=Safety Class; SS=Safety Significant; OHC=Other Hazard Class; ML-3; NS=Non-Safety). |
| Inspection Requirements | Describe each individual inspection or test that is to be performed. The description must be specific enough to plan and schedule the related inspection or test. The description should include the characteristic to be inspected or tested and method to be performed in accordance with what performance criteria (e.g., for inspection: structural weld visual inspection per Std. XYZ Section 123; critical piping weld joint PT per Std. ABC Section 789. For Testing: Damper leak test per Std. EFG Section 456 [or Spec. section paragraph number]; post-seismic testing operational test). |
| Acceptance Criteria | Cite the specific acceptance criteria (Section/Paragraph/Table) in the Specification or refer to the criteria in the related National/Industry Standard down to the definitive section/paragraph. |
| Implementing Organization | Identify the organization or entity that will perform the inspection or test (e.g., CSUM=CMRR start up management; OII=outside independent inspector; OITA=outside independent test agency; LRI=LANL Receipt Inspection; LOI=LANL Owner's Inspector; LSQR=LANL Supplier Quality Representative; S=supplier; PI=peer inspection group; Other, specify). |
| Witness or Hold Point | State whether a Witness or Hold Point is associated with the inspection or test to be performed. If not, enter NA. |
| Implementing Activity, Schedule | Identify the activity or event related to when in the fabrication process the inspection or test will be performed (e.g., in process first item; in process every item; pre-shipment; pre or post functional test; post seismic evaluation; in process % sample of lot or run). If sampling has been used, ensure that the sampling procedures are based on standard statistical methods that have been approved by engineering. |

END OF SECTION

1. This includes hold points associated with the inspections and tests required by IBC Ch. 17. Refer to the Project’s Statement of Special Inspections (SSI) for details. [↑](#footnote-ref-1)
2. In lieu of C 1293 aggregate testing, which takes one year, it’s permissible to 1) assume that the aggregate is indeed potentially reactive, 2) mitigate the potential through the use of an appropriate admixture (e.g., fly ash, etc.), and 3) prove the mitigation is adequate via testing per ASTM C 1567. [↑](#footnote-ref-2)