SECTION 03 3001

REINFORCED CONCRETE

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LANL MASTER SPECIFICATION

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

This Section applies to non-prestressed\* structural concrete for buildings that are designed in accordance with (IAW) ACI 318, facilities classified as Natural Phenomena Hazards (NPH) Risk Category (RC) I - IV facilities, and ML-3 and ML-4 projects[[1]](#footnote-1). In general, this section does not apply to nuclear facilities. This section can be used for Safety Significant (SS) nuclear SSCs that are classified as NDC-1 or NDC-2 (i.e., hence, designed and constructed as though they are RC II or RC IV, respectively, per ESM Ch. 5 Sect. III).\*\* If this section is used for ML-1 or ML-2 concrete, all applicable quality-related requirements from Section 03 3021, *Reinforced Concrete – High Confidence* shall be incorporated.

\* While this Section does not apply to work involving pretensioned concrete, it can be altered for such by adding the applicable provisions, requirements, submittals, etc. in ACI 318 and 301. The same goes for the following types of work:

- Steel-fiber-reinforced concrete; however, in this instance, the LANL pre-approved mix designs can’t be used since they do not include steel fiber(s).

- Lightweight Structural Concrete; however, in this instance, the LANL pre-approved mix designs can’t be used since they are ‘normal weight.’ And ACI 318 Ch. 26 includes requirements for ‘lightweight mixes (that aren’t included in ACI 301).’

- Mass Concrete (ref. LANL ESM Ch. 5 Sect. II, *para. 4.2*).

- Shrinkage-Compensating Concrete; however, in this instance, the LANL pre-approved mix designs can’t be used since they don’t meet the “Materials” and “Performance and design requirements” stipulated in ACI 301.

- Industrial Floor Slabs; however, in this instance, the LANL pre-approved mix designs can’t be used since they don’t have the nominal maximum aggregate size required by ACI 301.

Precast structural concrete: This Section does not apply to such work, and can’t be altered for such. LANL Section 03 4100, *Precast Structural Concrete*, must be used.

Similarly, this Section does not apply to work involving post-tensioned concrete, precast and cast-in-place architectural concrete, and tilt-up construction; and can’t be altered for such. And, since there are no LANL section templates for these types of work, specification sections for them must be created “from scratch.”

\*\* For nuclear facilities and their safety class (SC) structures, systems, and components (SSCs), use Section 03 3021, Reinforced Concrete – High Confidence. 03 3021 applies to design IAW ACI 349, facilities classified as NPH Design Category (NDC)-3, and ML-1/SC SSCs. Per DOE O 420.1C Chg 1, SS SSCs must comply with ACI 349; hence, they are required to be constructed IAW 03 3021. ESM Ch. 5 Sect. III, para. 1.1.1.D provides some flexibility on this.

The ESM Ch. 5 Sect. I ‘crosswalk tables’ between the old NPH Performance Category designations (i.e., PC-1 - PC-3) and the current designations (i.e., RCs and NDCs) should be reviewed by those using this section for work in existing facilities (that are still ‘PC-based’).

When editing to suit project, author shall add job-specific requirements and delete only those portions that in no way apply to the construction subcontractor (to include text within and including “stars,” or Author Notes, like this one) and/or the work (e.g., items in brackets are to be added or omitted according to job-specific requirements, etc.). 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.

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1. GENERAL
	1. SECTION INCLUDES
		1. Formwork, shoring, bracing, and anchorage.
		2. Reinforcement and accessories.
		3. Cast-in-place, normal weight, non-prestressed concrete.
		4. Construction, isolation, and contraction joint devices associated with concrete work.
	2. DEFINITIONS and ACRONYMS (as used herein)
		1. Cementitious Material: Portland cement by itself, or Portland cement in combination with fly ash (or other raw or calcined natural pozzolans, silica fume, and slag cement).
		2. Reinforced Concrete: Structural concrete reinforced with no less than the minimum amounts of reinforcement specified in ACI 318 (with the exception of Chapter 14).
		3. Plain Concrete: Structural concrete with no reinforcement, or with no more than the minimum amount specified in ACI 318 for plain concrete.
		4. Engineer-of-record (EOR)/Architect-Engineer: The responsible engineer for the overall design of the work.
		5. LANL Subcontract Technical Representative: STR.
		6. In accordance with: IAW
		7. Certificate of conformance (C of C): A document signed or otherwise authenticated by an authorized individual certifying the degree to which items or services meet the specified requirements.
		8. Certified material test report (CMTR): A document issued by the original manufacturer of the material that identifies the actual chemical and/or physical properties and any test(s) performed to the applicable nationally recognized standards or as specified by Subcontract. The CMTR shall be traceable to the material supplied through heat number, batch number, manufacturer's lot numbers, or other method as allowable by manufacturer’s quality assurance program or national recognized standard. The CMTR shall be signed by the manufacturer's authorized representative as defined by the manufacturer’s quality assurance program or as otherwise authorized.
		9. National Institute of Standards and Testing: NIST.
		10. Reinforcement: Non-prestressed bars and wires; structural steel, pipe and tubing for composite columns; and headed shear studs and stud assemblies.
		11. 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 is 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. REFERENCES
		1. References noted in this Section form a part of the Section to the extent applicable. The publications are referred to in the text by the basic designation only.
		2. Work, products, and materials shall conform to ACI 301 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 318 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 Association of State and Highway Transportation Officials (AASHTO)
			2. American Concrete Institute (ACI)[[2]](#footnote-2)

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| --- | --- |
| 117 | Standard Specifications for Tolerances of Concrete Construction and Materials |
| 211.1 | Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete (Reapproved 2009) |
| 301 | Specifications for Structural Concrete |
| 304.2R | Placing Concrete by Pumping Methods  |
| 304.4R | Placing Concrete with Belt Conveyors  |
| 305R | Guide to Hot Weather Concreting |
| 306R | Guide to Cold Weather Concreting |
| 309R | Guide for Consolidation of Concrete |
| 318 | Building Code Requirements for Reinforced Concrete |
| 347 | Guide to Formwork for Concrete |

* + - 1. American Hardboard Association (AHA): A135.4 Basic Hardboard
			2. American Plywood Association (APA): Voluntary Product Standard, PS 1, Structural Plywood
			3. ASTM International

|  |  |
| --- | --- |
| A 615 | Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement |
| A 706 | Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement |
| A 1064 | Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete |
| 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 42 | Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete |
| C 94 | Standard Specification for Ready-Mixed Concrete |
| 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 150 | Standard Specification for Portland Cement |
| 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 457 | Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete |
| C 494 | Standard Specification for Chemical Admixtures for Concrete |
| C 618 | Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use in 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 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 |

* + - 1. American Welding Society (AWS): D1.4 Structural Welding Code—Reinforcing Steel
			2. Concrete Reinforcing Steel Institute (CRSI): Placing Reinforcing Bars
			3. International Code Council: International Building Code (IBC)
			4. National Ready Mix Concrete Association (NRMCA).
	1. SUBMITTALS
1. Documents required to be submitted to LANL are included in the appendedSubmittal Table as they apply (including timeframes for submission, unless the STR authorizes changes to a timeframe(s)). NOTE: All submittals require EOR review and approval. Where indicated in the log with Section 01 3300 *Submittal Procedures*, this approval must occur prior to submission to LANL.
	1. DESIGN CHANGE(S)
		1. If an item listed in the appended Design Change(s) Table B1 applies, it shall be resolved using a Field Change Request (FCR) or other LANL-Engineering-approved method.
	2. QUALITY ASSURANCE
2. Unless stated otherwise herein, comply with the following documents: the version of ACI 301 referenced by the applicable edition of ACI 318 that the project/job is required to comply with; and the latest versions of LANL Master Specification Section 01 4000 *Quality Requirements* (non-nuclear) and CRSI *Placing Reinforcing Bars*. If a conflict occurs between this Section and any of these documents, notify the LANL STR.
3. The Work is subject to inspection at all times by the Owner and Owner’s Independent Testing Agency for the purpose of determining that the Work is properly executed IAW this Section. Failure to detect defective workmanship or material during any interim inspection does not constitute acceptance of workmanship and materials.
4. Acquire cement, aggregate, and fly ash to be used in the proposed Work from same source as used to develop the final mixture proportions. Subcontractor must provide LANL a C of C confirming the source of all concrete materials (except for admixtures), that test results confirm conformance to applicable specifications, and confirming that all concrete materials (including admixtures) used to develop mixture proportions correspond to those to be used in the proposed Work.
5. If different concrete mixtures are to be used for different portions of the Work, each mixture shall comply with the mixture requirements indicated for it. Subcontractor must provide LANL a C of C confirming this.

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ACI 318 (26.5.4.1 and 26.5.5.1) require the EOR to indicate in the construction documents the temperature limits for concrete as delivered in cold and hot weather, respectively. Ensure these limits (i.e., max. and min. temperatures) are indicated herein and/or on the Drawings.

- For guidance on establishing the cold-weather limits, see ACI 301, 4.2.2.6; ACI 306R,

 Table 5.1; and ASTM C94, 12.10.

- For guidance on establishing the hot-weather limits, see ACI 301, 4.2.2.6 and 5.3.2.1.c;

 ACI 305R, 4.4; ASTM C94, 12.11; and ACI 305.1, 3.2.1.

Finally, the PART 3 article referred to below stipulates that these limits shall be met.

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1. Curing Concrete, and Hot and Cold Weather Concreting. Work shall conform to all related requirements of ACI 301 and to the approved versions of the Hot and Cold Weather Implementation Plans.
	1. Subcontractor shall use the approved version of the Hot Weather Implementation Plan when concreting during hot weather, and the approved version of the Cold Weather Implementation Plan when concreting during cold weather. See PART 3 article CURING AND Protection for details of these plans and their development.
2. Testing Agency Qualifications: Testing agencies that perform concrete-related testing shall be nationally accredited per ASTM C1077, and testing agencies that perform reinforcing steel testing shall meet ASTM E329. For field and laboratory testing agencies and testing personnel request approval by the LANL Building Official, or designee, IAW the provisions of the IBC and the LANL Engineering Standards Manual Chapter 16.
3. The reinforcement fabricator shall maintain Heat Number Traceability for all reinforcement to assure heat numbers for the reinforcement are traceable to the reinforcement 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 reinforcement bundles and traceable to the associated CMTR(s). Once the tags on the reinforcement bundles are confirmed to match the associated CMTRs by the appropriate receiving inspection; the bundles may be broken and the reinforcement located as required.

Note: Unless authorized by LANL, use of foreign reinforcement is prohibited.

NOTE: If/when a request to weld reinforcing bars has been approved by the EOR and LANL, a welding procedure must be used that has been similarly approved. Welding shall conform to ACI 301 para. 3.2.2.2, AWS D.1.4, and Section 01 4455, *Onsite Welding and Joining Requirements*. Reinforcing bars cannot be used for filler metal, gap filler, lightning grounding, or other uses that involve welding. For other than ASTM A 706 reinforcing bar, a CMTR of the reinforcing bar material properties that demonstrate compliance with AWS D1.4 is required.

1. The batch plant must be certified (and maintain current certification) under the NRMCA process.
2. Devices used for acceptance or testing, including all levels of sub-tiers, must be calibrated within recognized tolerances specified herein (to include the referenced Codes and Standards) 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 the appropriate LANL STR within 3 working days along with where and how the device(s) was used.
	1. DELIVERY, STORAGE AND HANDLING
		1. Store cementitious materials and aggregates to prevent deterioration or contamination.
		2. Material that has deteriorated or has been contaminated shall not be used in concrete.
		3. Do not deliver concrete until vapor barrier, 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. Jobsite storage of materials shall be per ACI 301 (e.g., paragraphs 3.1.2, 5.1.3, 6.1.4, etc.). Ensure materials can be accurately identified after bundles are broken and tags removed.
		4. Inspection/Documentation Verification Witness Point: Perform product and raw material inspection 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 marked and prevented from entering the site or placed in an off-site quarantine area until the inspection and verification process is satisfactorily completed.
			1. Reinforcement: Store reinforcement of different sizes and shapes in separate piles on racks raised above the ground (to avoid excessive rusting). Protect from contaminants such as grease, oil, and dirt. Ensure bar sizes can be accurately identified after bundles are broken and tags removed. Painting on reinforcement must be approved in writing by the engineer-of-record.
3. PRODUCTS and materials
	1. general
		1. All concrete Work, products, and materials shall conform to applicable provisions of ACI 301 except as otherwise specified herein.
	2. FORM MATERIALS AND ACCESSORIES
		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-inch 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: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

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Furnish units that will leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.

Furnish ties that, when removed, will leave holes no larger than 1 inch in diameter in concrete surface.

Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

* + 1. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

2. Form release agent for form liners shall be acceptable to form liner manufacturer.

* + 1. Corners: Chamfered, wood strip type; ¾ x ¾ in. size.
		2. Dovetail Anchor Slot: Galvanized steel, 22 gage thick, foam filled, release tape sealed slots, anchors for securing to concrete formwork.
		3. 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.
		4. 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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Revise the Waterstop paragraph below to suit Project; delete if not required.

The waterstop currently indicated is flexible PVC, which is designed for use in construction and expansion joints with limited movement to resist the passage of fluids.

For more info on types of waterstops, the associated material types that are available, what type of waterstop & material should be used for a given application, etc. refer to the AIA MasterSpec Evaluations document, 033000\_sd; or the article “[Understanding Waterstops](https://www.constructionspecifier.com/understanding-waterstops-to-ensure-success-one-must-specify-for-performance-install-with-care/)” in the Jul-’15 edition of The Construction Specifier.

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* + 1. Waterstops: Polyvinyl chloride, minimum 1750 psi tensile strength, minimum 50 degrees F to plus 175 degrees F working temperature range, maximum possible lengths, ribbed profile, preformed corner sections. Waterstop shall be installed IAW the manufacturer’s recommendations. A C of C from the manufacturer is required as confirmation that the waterstops meets the requirements in this paragraph.
	1. REINFORCEMENT AND ACCESSORIES

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Indicate reinforcing steel ASTM designation and grade in subparagraph A IAW design requirements. ASTM A706 reinforcing steel is intended for applications where controlled tensile properties, or chemical composition restrictions to enhance weldability, or both, are required.

This distinction is highlighted by the fact that IBC and ACI 318 have restrictions pertaining to ASTM A 615 reinforcing steel used to resist seismic forces and/or is to be welded. These restrictions do not apply to ASTM A 706.

* For the seismic requirements, ref. ACI 318, 20.2.2.5(b).
* For the welding requirements, ref. IBC 1705.3 and ACI 318, 26.6.4.

In addition to indicating ASTM designation and grade for reinforcing steel, ACI 318 para. 26.1.1.1 requires these be indicated for ALL reinforcement, as well as the following (as applicable). In instances in which these apply to project, it is **unacceptable** to merely refer to ACI 318 (e.g., *Splices shall be IAW ACI 318*, etc.):

- Type, size, location requirements, detailing, and embedment length of reinforcement.

- Concrete cover to reinforcement.

- Location and length of lap splices.

- Type and location of mechanical splices.

- Type and location of end-bearing splices.

- Type and location of welded splices and other required welding of reinforcing bars.

- ASTM designation for protective coatings of reinforcement.

- Corrosion protection for exposed reinforcement to be bonded with extensions on future Work.

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* + 1. Reinforcing Steel: [ASTM A 615, grade [40] [60]] [ASTM A 706] deformed bars and stirrups; and ties.
		2. Accessory materials, such as proprietary mechanical splices (e.g., rebar couplers, Form Savers, Cadwelds, etc.) must be supported by ICC-Evaluation Service reports indicating full compliance with the applicable code of record for the project.
		3. Welded Steel Wire Fabric: ASTM A1064 Plain type in flat sheets
		4. Chairs, Bolsters, Bar Supports, Spacers: Size and shape for strength and support of reinforcement during concrete placement conditions including load-bearing pad on bottom to prevent vapor barrier puncture. Special chairs, bolsters, bar supports, spacers adjacent to weather exposed concrete surfaces to be plastic coated steel type; size and shape as required.

 NOTE: Concrete “dobie” blocks used to hold up and position reinforcement must have documentation to show that their strength in compression is at least the compressive strength (in pounds per square inch, or psi) of the concrete used in the placement.

* + 1. Tie Wire: Minimum 16 gage annealed type.
	1. CONCRETE MATERIALS
		1. Cement: ASTM C 150, Type I or Type II.
		2. Fine and Coarse Aggregates: Conform to ASTM C 33.

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ACI 318, 26.4.1.3.1(b) includes requirements for water above and beyond that indicated below in some applications. Edit the following if necessary/applicable.

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* + 1. Water: ASTM C 1602.
		2. Fly Ash: Conform to ASTM C 618, type F. Fly ash, 20–30% of combined weight of fly ash and cement shall be used for the LANL standard concrete mix. For alternate acceptable means of reducing Alkali-Silica Reaction (ASR), see Para. 2.7.B.
	1. ADMIXTURES
		1. Air Entrainment: Conform to ASTM C260.
		2. Water reduction and Setting Time Modification: Conform to ASTM C494.
	2. ACCESSORIES
		1. Bonding Agent: Polymer resin emulsion.

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The requirement to use a vapor barrier comes from IBC 1907.1, which includes exceptions. If an exception(s) applies, don’t require use of a vapor barrier.

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* + 1. Vapor Barrier: 6 mil clear polyethylene film of type recommended for below grade application.
		2. Grout: Refer to Section 03 6000, *Grouting*.
		3. Isolation/Expansion Joint Filler: ASTM D 1751; asphalt impregnated fiberboard or felt.
	1. CONCRETE MIX
		1. Standard Mix Design
			1. The standard mix design for LANL shall contain from 20–30% (by weight of total cementitious material) Type F fly ash conforming to ASTM C 618 for mitigating the deleterious effects of ASR in concrete that is common with the siliceous nature of aggregates found in Northern New Mexico.

NOTE: Pre-approved LATM mixes in Para. 2.7.H comply with this ‘standard.’

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Note: ASR is the reaction between the alkali hydroxide in Portland cement and certain siliceous rocks and minerals present in the aggregates, such as opal, chert, chalcedony, trydymite, cristobalite, strained quartz, etc. The products of this reaction often result in significant expansion and cracking of the concrete, and ultimately failure of the concrete structure, including significant potential for foreign object damage.

EPA recommends that procuring agencies use concrete and other cementitious materials containing coal fly ash (pozzolan). Include the limits on soluble alkalies for Portland cement and for pozzolan whenever there is a possibility of alkali-aggregate reactive aggregates being furnished.

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* + 1. Alternative Mix Designs

Alternate means for mitigating ASR, including use of ground slag, silica fume, or lithium compound admixtures will be acceptable if appropriate tests and documentation are submitted in advance to LANL and approved (per Appendix A, Submittal Table).

Note: Mix designs intended to provide more flexibility than the ranges (e.g., slump, air-content, water cement ratio, etc.) must obtain a formal variance to the Section.

* + - 1. Where aggregates are provided which are demonstrated through appropriate tests to have acceptable reactivity levels (i.e., less than 0.1%), mix designs may be provided without the fly ash required by Para. 2.7.A.1. Test required is ASTM C1260 (or other pre-approved alternate).
			2. Demonstrate acceptable ASR resistance for concrete with fly ash using ASTM C 1567 (i.e., less than 0.1%).
			3. Proportion concrete IAW ACI 301 paragraph 4.2.3.
			4. Mix designs shall be original designs performed by the supplier’s testing agency. Mix designs extrapolated from pre-selected data are not permitted. Configuration mix designs—i.e., those already in use by the supplier—are also not permitted. All mix designs shall be established through the process of trial batch determination of the compressive strengths at the various water-cement ratio trial points for each concrete class, and adhere to the requirements of this Section.
			5. Trial design batches, mixture proportioning studies, and testing requirements for various classes and types of concrete specified shall be the responsibility of the Subcontractor. Base mixture proportions on compressive strength (as noted above) as determined by test specimens fabricated IAW ASTM C 192 and tested IAW ASTM C 39. Samples of all materials used in mixture proportioning studies shall be representative of those proposed for use in the project and shall be accompanied by the manufacturer’s or producer’s test report indicating compliance with this Section. Make trial mixtures having proportions, consistencies, and air content suitable for the Work based on methodology described in ACI 211.1. Note that the use of fly ash may require an increase of air entraining admixture to attain specified air content of concrete. The trial mixture shall use at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project. The maximum water-cement ratio required shall be based on equivalent water-cement ratio calculations as determined by the conversion from the weight ratio of water to cement plus pozzolan, [silica fume,] and ground granulated blast-furnace slag by weight equivalency method. Design laboratory trial mixture for maximum permitted slump and air content. Each combination of materials proposed for use shall have a separate trial mixture, except accelerators or retarders can be used without separate trial mixtures. Report the temperature of concrete in each trial batch. For each water-cement ratio, make at least three test cylinders for each test age, cured per ASTM C 192 and tested per ASTM C 39 for 7 and 28 days. From these results, plot a curve showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition, plot a curve showing the relationship between 7- and 28­‑day strengths.
		1. Provide concrete meeting the following criteria:

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For each concrete mixture, the EOR is required (by ACI 318) to specify the following items based on (EOR-) assigned exposure classes**\*** or (EOR’s) design of members:

* + - 1. Minimum specified compressive strength of concrete, f ’ c.
			2. Test age for demonstrating compliance with f ’ c if different from 28 days.
			3. Maximum w/cm applicable to most restrictive assigned durability exposure class.
			4. Nominal maximum size of coarse aggregate not to exceed the least of (i), (ii), and (iii):
		1. one-fifth the narrowest dimension between sides of forms
		2. one-third the depth of slabs
		3. three-fourths the minimum specified clear spacing between individual reinforcing bars or wires, or bundles of bars

For the default value for aggregate size (i.e., 0.75”), the above ‘translates’ to the following limiting (and ‘code-compliant’) scenario (based on i–iii): members and slabs as thin as 4” and 2.5”, respectively; and rebar/rebar bundles spaced as close as 1”.

* + - 1. For members assigned to Exposure Classes F1–F3, air content from ‘318’ 19.3.3.1.
			2. For members assigned to Exposure Category C, applicable chloride ion (CL**-**) limits for assigned Exposure Class (i.e., C0–C2) from ‘318’ 19.3.2.1.
			3. For members assigned to Exposure Classes S1–S3, type of cementitious materials from ‘318’ 19.3.2.1.

**\***ACI 318 Ch. 19 requires the EOR to “…assign exposure classes [IAW] the severity of the anticipated exposure of members for each exposure category in Table 19.3.1.1.” However, 26.4.2.1(b) says this “assignment” must be indicated by EOR only when the Subcontractor is required to determine concrete properties “from scratch (using ACI 301).” The typical exposure category (in Table 19.3.1.1) of concern at LANL is F, Freezing and Thawing, and the typical upper-bound severity of exposure is Severe (i.e., F2).

Given the above, the default values for min. f’c, nominal maximum aggregate size, maximum water/cementitious materials ratio, and air content that appear in the first two “Exterior subparagraphs’ below are based on achieving ‘F2 concrete.’ Added benefits of this are that such concrete also meets the ‘low-permeability requirements (i.e., W1),’ and the ‘no-concern-for-sulfate requirements (i.e., S0),’ of Ch. 19.

For projects that involve F3 exposure class; or Sulfate (S1–S3) and/or Corrosion (C0–C2**\*\***) exposure categories, use of solely the criteria for ‘exterior’ concrete (i.e., listed in subparas. 1-3 below), whether or not the default values (described above) are used, will NOT ensure that the resulting concrete meets the durability requirements of Ch. 19.

**\*\***It should be noted that C0 doesn’t mean that, if the concrete won’t be exposed to conditions that require protection against corrosion of reinforcement, “corrosion can be ignored.” As is indicated in ‘318’ Table 19.3.2.1, the ingredients of “C0 (and C1) concrete” must be tested for the quantity of CL**-**.

If the design or construction requirements dictate that in-place strength of concrete be achieved at specific ages or stages of construction, the EOR must indicate such.

If/when f’c > 5,000 psi, per ‘318’ 26.4.4.1(b), test data documenting the characteristics of the proposed mix are required; AND the “strength acceptance criteria (i.e., para. 3.12.B.1 herein)” must be edited IAW ‘318’ 26.12.3.1(b)(2).

To increase the likelihood of good quality control, limit the number of mixtures used on a project to as few as necessary.

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* + - 1. Exterior concrete exposed to freezing and thawing:
				1. Minimum compressive strength, f ’ c : [4,500 psi @ 28 days].
				2. Maximum nominal aggregate size: [0.75 in.]
				3. Maximum water/cement ratio: [0.45]
				4. Slump: [4 inch]
				5. Air content: [6] percent.
			2. Exterior concrete to be pumped, exposed to freezing and thawing(1):
				1. Minimum compressive strength, f ’ c : [4,500 psi @ 28 days].
				2. Maximum nominal aggregate size: [0.75 in.]
				3. Maximum water/cement ratio: [0.38].
				4. Slump: [6 inch] at discharge of truck.
				5. Slump: [3 to 7 ½ inch] at pump discharge.
				6. Air content: [6] percent.

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**Caution** - 5000 psi concrete is prone to hairline cracking.

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* + - 1. Exterior concrete exposed to freezing and thawing:
				1. Compressive strength, f ’ c : [5000 psi, at 28 days].
				2. Maximum nominal aggregate size: [0.75 inch].
				3. Maximum water/cement ratio: [0.34].
				4. Slump: [4 inch].
				5. Air Content: [6] percent.

Note (1): In addition to meeting slump criteria at pump discharge, paragraph 3.11.C herein requires strength, temperature , and air-content criteria to be met at pump discharge (i.e., samples for testing are taken at the placement-end of the pipe/hose). This requirement does not change/alter the ACI tolerances for the criteria (i.e., the tolerances apply to test results on samples taken at the placement-end of pipe/hose). For example, test results from 4.5% to 7.5% for air content will be deemed acceptable since the criteria is 6% and the ACI tolerance is +1.5%.

* + - 1. Interior concrete not exposed to freezing and thawing:
				1. Compressive strength, f ’ c : [3,000 psi at 28 days].
				2. Maximum nominal aggregate size: [0.75 inch].
				3. Maximum water/cement ratio: [0.44].
				4. Slump: [4 inch.]
				5. Air content: [3] percent.
			2. Interior concrete not requiring air-entraining agent:
				1. Compressive strength, f ’ c : [3,000 psi, @ 28 days.]
				2. Maximum nominal aggregate size: [0.75 in.]
				3. Maximum water/cement ratio: [0.51].
				4. Slump: [4 inch].
				5. Air Content: None specified
			3. Interior concrete not exposed to freezing and thawing
				1. Compressive strength, f ’ c : [4,000 psi @ 28 days].
				2. Maximum nominal aggregate size: [0.75 in.]
				3. Maximum water/cement ratio: [0.44].
				4. Slump: [4 inch]
				5. Air content: [3] percent.
		1. In designing concrete mixes with fly ash and ASR aggregates, consider effects on workability, set times, times for strength development and curing, and other characteristics. Make appropriate adjustments in construction activities, for example, times for removing forms or shoring.
		2. Use accelerating admixtures in cold weather only when submitted and approved as a constituent of the design mix prior to use. Use of admixtures will not relax cold-weather-placement requirements.
		3. Do not use calcium chloride as an admixture.
		4. Use set-retarding admixtures during hot weather only when submitted and approved as a constituent of the design mix prior to use.

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The pre-approved mix designs listed below are permitted for use for concrete of the following exposure classes:

* Exterior Mixes 5000-4N and -8E: F0 – F3, S0, W0 – W1, and C0 – C1
* Interior Mix 21: F0, S0, W0 – W1, and C0 – C1
* Interior Mix 20: F0, S0, W0, and C0 – C1

Interior Mix 20 shall not be used for finished floors/floors that have finishing requirements; it doesn’t comply with ACI 301 para. 4.2.2.1 (i.e., Table 4.2.2.1).

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1. Pre-approved LATM Design Mixes (Ref: AMEC Project 14-519-00761 for Mix Nos. 5000-4N and -8E and AMEC Project No. 4-519-003279 for LATM Mix Nos. 20 and 21).

Several Los Alamos Transit Mix (LATM) design mixes are pre-approved by LANL.

LANL will provide quality control of the concrete as follows: LATM will provide Construction Management (CM) Materials Test Lab with test results from a LANL Building Official-approved test agency four times per year for aggregate (fine and coarse) specific gravity, absorption, and gradations to comply with the current ASTM C 33. In addition, LATM will provide aggregate soundness, abrasion, and deleterious substances test results annually (alkali-silica reactivity and freeze-thaw durability only required with change in aggregate properties and/or cementitious materials). CM will also perform gradation, specific gravity, and absorption tests bi-annually. CM will share all results with Engineering Project Delivery (EPD) bi-annually, who may then re-evaluate each LATM pre-approved concrete mix. These test results and other evaluations will be documented and any required actions will be identified and implemented as necessary. \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*
Note: Regarding the two (2) Exterior Mixes: Although they have a cementitious content that exceeds 660lbs/ft3, based on field experience with one of these mixture designs, the concrete resulting from either mix won’t necessarily behave as “mass concrete.”
   -    A Project using these mixes is required to 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 & the daily low air temperatures on the day of placement, the preceding several days, & the following several days.

If both (A) and (B) do apply, the Project’s EOR is responsible for ensuring compliance with ESM Ch. 5 Sect. II para. 4.2, 1904.3 Mass Concrete.

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The pre-approved mixes are:

a. LATM Mix 5000-4N(1) - Exterior, 5000 psi concrete @ 28day, 4" slump, 6% air, 25% fly ash (proportions per CY), 0.34 water-cementitious ratio, 3/4 large aggregate, 1-1/2 hour placement time.

| **Material** | **Source** | **Description** | **Quantity** |
| --- | --- | --- | --- |
| Cement | GCC – Tijeras, NM | Type I/II | 578lbs |
| Fly Ash | Salt River Materials Group, 4 Corners | Class F | 192lbs |
| Coarse Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | #67 | 1600lbs |
| Fine Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | Washed Sand | 1147lbs |
| Water | Los Alamos Transit Mix, Public Water Supply | Site Water | 262lbs |
| 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 | 23.1 oz min – 138.6 oz max (oz per cu yd) |

b. LATM Mix 5000-8E(1) - Exterior, 5000 psi concrete @ 28day, 8" slump at arrival and no less than 4 inches after 2-1/2 hours after initial mixing, 6% air, 25% fly ash (proportions per CY), 0.343 water-cementitious ratio, 3/4 large aggregate. Note Mix 5000-8E has been developed with an extended placement time of 2-1/2 hours from initial mixing.

|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **Source** | **Description** | **Quantity** |
| Cement | GCC – Tijeras, NM | Type I/II | 572lbs |
| Fly Ash | Salt River Materials Group, 4 Corners | Class F | 191lbs |
| Coarse Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | #67 | 1600lbs |
| Fine Aggregate | Los Alamos Transit Mix, El Guique Pit, Espanola, NM | Washed Sand | 1153lbs |
| Water | Los Alamos Transit Mix, Public Water Supply | Site Water | 262lbs |
| 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 (oz per cu yd) |
| Note 1: Delvo quantity range results in about 1-hour of retardation at lower temperatures at 2-oz. dosage, and up to about 3 hours at higher temperatures at 9-oz. dosage. |

* 1. LATM Mix No. 21(6) -- Interior, 4000 psi concrete, 4" slump, 3% air (use aggregate correction factor of 0.3 for ML-3 and ML-4 concrete), 20% fly ash (proportions per CY):

Type I-II Cement: Gcc Rio Grande, Tijeras 520 lbs

Class F Fly Ash: Salt River Materials, 4-Corners 130 lbs

Water 280 lbs

Washed Concrete Sand: El Guique Quarry 1243 lbs

Sz#67 Coarse Aggregate: El Guique Quarry 1750 lbs

Water-Reducing Agent: MB poly heed 997 25.7 oz(2)

Air-Entraining Agent: MB Micro Air, 4.6 oz(3)

* 1. LATM Mix No. 20(6) -- Interior, 3000 psi concrete, 4" slump, 3% air (use aggregate correction factor of 0.3 for ML-3 and ML-4 concrete), 20% fly ash (proportions per CY):

Type I-II Cement: Gcc Rio Grande, Tijeras 417 lbs

Class F Fly Ash: Salt River Materials, 4-Corners 104 lbs

Water 268 lbs

Washed Concrete Sand: El Guique Quarry 1378 lbs

Sz#67 Coarse Aggregate: El Guique Quarry 1765 lbs

Water-Reducing Agent, MB poly heed 997 20.8 oz(4)

Air-Entraining Agent: MB Micro Air, 2.6 oz(5)

Note (1): If construction circumstances require such, this mix can be pumped. If the mix is pumped, then the requirements of Field QC (i.e., para. 3.11.C herein) apply: strength, slump and air-content criteria must be met at pump discharge (i.e., samples for testing are taken at the placement- end of the pipe/hose). This requirement does not change/alter the ACI tolerances for the criteria (i.e., the tolerances apply to test results on samples taken at the placement-end of pipe/hose). For example, test results from 4.5% to 7.5% for air content will be deemed acceptable since the criteria is 6% and the ACI tolerance is +1.5%.

Note (2): Temperature and slump variation may require adjustment in dosage within the range of 19.5 fl oz/cy to 45.5 fl oz/cy

Note (3): Temperature and slump variation may require adjustment in dosage within the range of 0.8 fl oz/cy to 9.75 fl oz/cy

Note (4): Temperature and slump variation may require adjustment in dosage within the range of 15.6 fl oz/cy to 36.5 fl oz/cy

Note (5): Temperature and slump variation may require adjustment in dosage within the range of 0.65 fl oz/cy to 7.8 fl oz/cy

Note (6): When this mix is used in an ML-1 or ML-2 application, the aggregate correction factor (ACF) must be determined by testing IAW ASTM C 231, and the ACF must be reported via submittal.

1. EXECUTION
	1. general
		1. Work shall conform to applicable provisions of ACI 301 unless otherwise specified herein.

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Edit the following if more restrictive tolerances are required by project, or if ACI 117 doesn’t address tolerances applicable to project.

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* + 1. Construction tolerances for member size and location shall be per ACI 117.
		2. Batch, mix, test, transport and deliver concrete, along with test records IAW ASTM C 94. Base acceptance for slump on testing per ASTM C 94 and comparison to the requirements established in the design documents.

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While the following Para. pertains to the use of too much water in the concrete (i.e., it tries to ensure that the specified w/cm ratio isn’t exceeded), the only thing that prevents not enough water for a slab-on-grade (SOG) w/o a vapor barrier (VB) is the underlying soil being at its optimum moisture content (+ 2%). Refer to the Article, SOIL COMPACTION AND TESTING in LANL Master Spec Sect. 31 2000 for details. Thus, for SOG w/o VB, ensure Project Spec includes Sect. 31 2000 (edited for compliance with Geotech Report).

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* + 1. Adding 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. Take care to avoid exceeding 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 measuring device; or
2. The ready-mix truck sight glass may be used if the following conditions are met**:**
3. The trucks must have a current NRMCA certification
4. There must be a pass (i.e. “P”) entry on the NRMCA Fleet Inspection Reporting Spreadsheet – Truck Mixers under Section/Column 5.1.6, Water Gage or Meter. The aforementioned spreadsheet shall be part of a current NRMCA certification of the ready-mix producer and its facilities and its trucks.
	* 1. provide secured space, electrical power, and access for initial curing of concrete-strength-test cylinders (in subsequent Article, Field Quality Control, herein).
	1. EXAMINATION
		1. Verify lines, levels, and centers before proceeding with formwork. Ensure that dimensions agree with the 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 geotechnical and soil compaction/moisture testing, must be confirmed in order to be considered completed.

* + 1. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.
		2. Inspect erected formwork, shoring, and bracing to ensure it is IAW formwork design, and that supports, fastenings, wedges, ties, and items are secure.
		3. Do not use wood formwork more than three times for concrete surfaces to be exposed to view. Do not patch formwork.
		4. Verify that concrete cover for reinforcement conforms to the drawings and to the cover-related provisions in the subsequent Article, REINFORCEMENT PLACEMENT.
	1. FORMWORK
		1. Hand trim sides and bottom of earth forms. Remove ice, debris, loose soil, etc. prior to placing concrete.
		2. Erect formwork, shoring and bracing to achieve design requirements and maintain tolerances IAW requirements of ACI 301 and ACI 347 (or more stringent design requirements). Camber structural slabs and beams IAW ACI 301. 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.
		3. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.
		4. Arrange and assemble formwork to permit dismantling, stripping and removal of remaining principal shores. Do not damage concrete during stripping.
		5. Align joints and make watertight. Keep form joints to a minimum.
		6. Obtain approval from the EOR for all construction joint locations not shown on the drawings and before framing openings (in structural members) which are not detailed/shown.
		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. Install void forms IAW manufacturer’s recommendations. Protect forms from moisture or crushing.
		10. Do not apply form release agent where concrete surfaces receive special finishes or applied coverings that are affected by agent. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.
		11. Provide formed openings where required for items to be embedded in or passing through concrete.
		12. Locate and set in place items that 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 IAW manufacturer’s instructions, straight, level, and plumb. Ensure items are not disturbed during concrete placement.
		15. Install waterstops continuous without displacing reinforcement.
		16. Provide temporary ports or openings in formwork where required to facilitate 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. Formwork for parts of the Work that does not support weight of concrete (e.g., sides of beams, etc.) may be removed after cumulatively curing at not less than 50ºF (measured with a calibrated device) for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved at least 75 percent of its 28-day design compressive strength.

1. Alternatively, the Subcontractor can develop and submit to LANL a procedure and schedule for formwork removal. The basis for such shall be a structural analysis and concrete-strength data (per ACI 301 paragraph 2.3.4.1), both of which must included in the submittal. The Subcontractor’s procedure and schedule can be implemented only if and when LANL approves the submittal.

2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

* + 1. Perform form removal IAW the recommendations of ACI 347.
		2. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.
		3. Store removed forms in manner to avoid any damage to form surfaces that will later be in contact with fresh concrete. Discard damaged forms.
		4. 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 the engineer of record.
	1. REINFORCEMENT PLACEMENT

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Unless otherwise indicated by the EOR, the tolerances associated with placement of reinforcement ‘default’ to those stipulated in ACI 117. Per ACI 318 para. R26.6.2.1, “…The [EOR] should specify more restrictive tolerances…when necessary to minimize the accumulation of tolerances resulting in excessive reduction in effective depth [d] or cover [cc]…” If/when “necessary,” Para. 26.6.2.1 provides (more restrictive) tolerances that can be specified. The undersides of elevated slabs, beams, arches, etc. (i.e., “formed soffits”) are cited as an example of when more restrictive tolerances have been required.

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* + 1. Edit ACI 301 paragraph 3.3.2.1 to read as follows:

 “*Tolerances*…before concrete is placed”, or during concrete placement.

* + 1. Spiral units shall be continuous bar or wire placed with even spacing and without distortion beyond the tolerances for the specified dimensions.
		2. For longitudinal column bars forming an end-bearing splice, the bearing of square cut ends shall be held in concentric contact.
		3. Offset bars shall be bent before placement in the forms.
		4. Do not displace or damage vapor barrier. If vapor barrier is damaged, repair it prior to concrete placement.

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The following minimum reinforcement-cover requirements come from ACI 318 para. 20.6.1 and are applicable ONLY to cast-in-place, non-prestressed concrete members, and in instances in which greater cover is not required by fire-protection requirements.

The following doesn’t include the ‘318’ cover requirements for headed shear stud reinforcement, coated reinforcement, or embedments.

Finally, diaphragm collector cover might be governed by ‘318’ para. 18.12.7.6.

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* + 1. Maintain the following minimum concrete cover for reinforcement:

| **Concrete exposure** | **Member** | **Reinforcement** | **Specified****cover, in.** |
| --- | --- | --- | --- |
| Cast against and permanently in contact with ground | All | All | 3 |
| Exposed to weather or in contact with ground | All | No. 6 through No. 18 bars  | 2 |
| No. 5 bar, W31 or D31 wire, and smaller | 1-½ |
| Not exposed to weather or in contact with ground | Slabs, joists and walls | No. 14 and 18 bars  | 1-½ |
| No. 11 bars and smaller | ¾ |
| Beams, columns, pedestals, and tension ties | Primary reinforcement, stirrups, ties, spirals and hoops | 1-½ |

* 1. PREPARATION

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Per ACI 318, 26.5.6.1, the EOR must provide locations and details of construction, isolation, and contraction joints (if such joints are required by the design).

The same paragraph includes “Design information” requirements pertaining to transfer of forces through construction joints, and ‘surface preparation.’ If any of these requirements apply to project then the respective portions of 26.5.6.1 must be followed-through on/indicated.

On a related note, B.1 (below) is a result of 26.5.6.1(c), which applies to design for shear friction IAW ‘318’ 22.9, and to contact surfaces at construction joints for structural walls.

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* + 1. Modify ACI 301 paragraph 2.2.2.5.a to read as follows:

 “Unless otherwise specified…Locate construction joints…equal to or greater than twice the width of the beam”, measured from the face of the intersecting beam “; Locate joints in walls…”

* + 1. Prepare previously placed concrete by cleaning with steel brush, pressure washing, or other acceptable means to fully remove any laitance\*.

[1. When new concrete is to be placed against previously hardened concrete, intentionally roughen the latter to a full amplitude of approximately ¼ inch.]

[2. Where indicated/authorized by the EOR, apply bonding agent IAW the manufacturer's recommendations.]

\*Laitance is a weak layer of [cement](http://en.wiktionary.org/wiki/cement) and [aggregate](http://en.wiktionary.org/wiki/aggregate) [fins](http://en.wiktionary.org/wiki/fins) on a [concrete](http://en.wiktionary.org/wiki/concrete) surface that is usually caused by an [over-wet](http://en.wiktionary.org/wiki/overwet) [mixture](http://en.wiktionary.org/wiki/mixture), [overworking](http://en.wiktionary.org/wiki/overworking) the mixture, improper or excessive finishing or combination thereof.

* + 1. In locations shown on the design drawings where new concrete is to be dowelled to existing concrete, unless noted otherwise on the design drawings, drill holes in existing concrete; insert steel dowels to the specified depth and pack solid with non-shrink grout that meets or exceeds the concrete minimum strength.

Note: All aspects of this grouting/grout must comply with Section 03 6000, Grouting.

* + 1. Prior to placement of concrete, ensure that the Project Geotechnical Investigation report has been read and understood, soils inspections have been performed with satisfactory results, and soils testing documentation has been completed and the results are satisfactory.\*

\* For a variety of reasons, some/all of these items might not be applicable to a given project. Refer to Sheet S-0001 of the Project structural drawings, the Statement of Special Inspections (SSI), and the Test & Inspection Plan (TIP) in order to determine which items are applicable to a given project.

* 1. PLACING CONCRETE
		1. Place concrete IAW ACI 301.
		2. Notify the LANL STR a minimum of 24 hours prior to commencement of concrete operations.
		3. Unless permission to do otherwise is granted by LANL, standing water shall be removed from place of deposit before concrete is placed.
		4. Masonry filler units that will be in contact with concrete shall be prewetted prior to placing concrete.
		5. Concrete shall not be pumped through pipe made of aluminum or aluminum alloys.
		6. Ensure that reinforcement, inserts, embedded parts, formed joint fillers, joint devices, and formwork are not disturbed during concrete placement.
		7. Install vapor barrier under interior slabs-on-ground. Lap joints minimum 6 in. and seal watertight by sealant applied between overlapping edges and ends or taping edges and ends.
		8. Install joint filler, primer and sealant IAW manufacturer’s instructions.

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Remove the brackets in what follows if the slab-on-ground is part of the seismic force-resisting system. Also see related author note associated with subsequent Article, Construction of Concrete Members. Finally, if retaining the bracketed text, if what precedes the comma isn’t applicable, it can be deleted.

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* + 1. Separate slabs-on-ground from vertical surfaces with ¼ in. thick joint filler. [Unless it is explicitly shown/detailed/called out, the preceding isn’t applicable to slabs that are indicated as being part of the seismic force-resisting system.]
		2. Extend joint filler from bottom of slab to within ¼ in. of finished slab surface.
		3. Install joint devices IAW manufacturer’s instructions.
		4. Place concrete at a rate that ensures the following:
			1. An adequate supply of concrete is provided at the location of placement.
			2. Concrete at all times has sufficient workability such that it can be consolidated by the intended method(s).
		5. Concrete shall be placed continuously between predetermined isolation, contraction, and construction joints.
		6. Edit ACI 301 5.3.2.4 to read as follows:

 “*Depositing*…Place concrete for beams…haunches,” drop panels and shear caps “at the same time…slabs”, unless otherwise shown.

* + 1. Concrete that has been contaminated or has lost its initial workability to the extent that it can no longer be consolidated by the intended method(s) shall not be used.
		2. Consolidate concrete by internal vibration per ACI 301 or ACI 309R; whichever is more stringent, unless otherwise directed by the EOR.
		3. Top surfaces of vertically formed lifts shall be generally level.
	1. CONCRETE FINISHING
		1. Unless indicated/noted otherwise, screed floors and slabs on grade to a surface flatness of maximum 1/4 inches in 10 ft.
		2. Provide formed concrete surfaces to be left exposed with smooth rubbed finish.
		3. Finish concrete floor surfaces IAW ACI 301.
			1. Edit ACI 301 5.3.4.1 to read as follows:

“*Placement*—”Unless EOR specifies more, “a minimum of one…or equivalent.”

* + - 1. Finishes shall meet the requirements of ACI 301 section 5.3.4.2.
			2. Tolerances for floors, slabs, and floor finishes shall be confirmed by measuring in conformance with ACI 301 section 5.3.4.3.
		1. Wood-float surfaces which will receive tile with full bed setting system.
		2. Steel trowel surfaces which will receive carpeting, resilient flooring, seamless flooring, or thin-set tile.
		3. Steel trowel surfaces which are scheduled to be exposed.
		4. In areas with floor drains, maintain floor elevation at walls; pitch surfaces uniformly to drains at 1/8 in. per foot, minimum.
	1. CURING AND PROTECTION

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Per ACI 318 para. 26.5.3.2(a)–(c), sub-para. A.2 (below) does not apply to high-early strength concrete, or to concrete that’s cured using “accelerated curing.” Thus, if either of these apply to the project then A.2 must be edited accordingly.

And 26.5.3.2(d) and (e) permit field-cured cylinders to be used to determine whether or not concrete in a structure has received adequate curing and protection. If such is desired/required for the project (i.e., in lieu of/in addition to ‘full compliance’ with the ‘normal/typical’ curing and protection provisions) then these ‘318’ provisions must edited into what follows (per 26.5.3.1).

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* + 1. General
			1. Cure and protect concrete IAW ACI 301 unless noted otherwise.
			2. Concrete shall be maintained at a temperature of at least 50°F (measured with a calibrated measuring device) and in a moist condition for at least the first 7 days after placement.

a. As indicated in ACI 301-16 paragraph 5.3.6.2, if bleed water sheen is not visible on an unformed surface after strikeoff and initial bull floating, provide initial curing by means of fogging (except in “cold weather”) or application of evaporation retarder (e.g., BASF MasterKure ER 50, etc.) until final curing method is applied.

* + - 1. To ensure that placement of concrete in both cold weather (as defined by ACI 306R) and hot weather, as defined herein (below), are done properly, Subcontractor shall develop a “Cold-Weather Implementation Plan (CWIP)” and a “Hot-Weather Implementation Plan (HWIP).”
			2. Hot weather exists when the air temperature has risen to, or is expected to rise to/above, 80 ºF at the time of concrete placement.
			3. ACI 306R, ACI 305R, and LANL guidance on the CWIP and HWIP shall be used to develop the Project-specific CWIP and HWIP.
				1. For the CWIP, see Appendix C herein for LANL guidance.
				2. For the HWIP, see Appendix D herein for LANL guidance.
				3. These Appendices are not intended to replace the authoritative ACI Guides; rather, they’re intended to serve as outlines or starting points for effectively and efficiently creating submittals that that are likely to be accepted.
			4. The CWIP and HWIP shall be approved for use by the Project’s EOR, and submitted to and approved by the LANL STR, prior to the start of cold or hot weather concreting.
		1. Concreting in Cold Weather
			1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather.
			2. Frozen materials or materials containing ice shall not be used.
			3. Forms, fillers, and ground which concrete will contact shall be free from frost and ice.
			4. Select concrete materials and production methods so that the concrete temperature at delivery complies with the specified and/or indicated temperature limits.
		2. Concreting in Hot Weather
			1. Select concrete materials and production methods so that the concrete temperature at delivery complies with the specified and/or indicated temperature limits.
			2. Handling, placing, protection, and curing procedures shall limit concrete temperatures or water evaporation that could reduce strength, serviceability, and durability of the member or structure.
	1. construction of concrete members

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Referring to para. B below, ACI 318 para. 26.5.7.1(d) requires EOR to indicate locations where slab and column placements must be integrated during placement (IAW ‘318’ 15.3). Delete B if this does not apply to project.

Referring to para. C below, ACI 318 para. 26.5.7.1(b) requires EOR to identify if a slab-on-ground is designed as a structural diaphragm or part of the seismic-force-resisting system. Delete C if this does not apply to project.

Para. A should be deleted if the project does not involve placement of members supported by columns or walls.

Finally, ’318’ 26.5.7.1(c) requires EOR to provide details for construction of sloped or stepped footings designed to act as a unit.

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[A. Beams, girders, or slabs supported by columns or walls shall not be cast until concrete in the vertical support members is no longer plastic.]

[B. At locations where slab and column concrete placements are required to be integrated during placement, column concrete shall extend outward at least 2 ft. into floor slab from face of column for full slab depth and be integrated with floor concrete.]

[C. Saw cutting in slabs-on-ground identified in the construction documents as structural diaphragms or part of the seismic-force-resisting system shall not be permitted unless specifically indicated or approved by the EOR.]

* 1. contraction joints
		1. While the concrete is still plastic (i.e., within several hours after placement), provide joints in slabs at no more than 10 feet on center in each direction. The depth of each joint will be at least one-quarter of the slab thickness, but not less than one inch.
	2. FIELD QUALITY CONTROL
		1. Provide a certified testing agency to perform field testing IAW ACI 301. 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. The engineer-of-record and the LANL Building Official must approve the test agency prior to performance of any Work. See LANL Engineering Standards Manual (ESM) Chapter 16 for additional details/requirements.
			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 done by ACI-Certified concrete laboratory technician-grade 1 or equivalent per ASTM C 1077
		2. Inform the LANL STR 48 hours in advance of field testing to allow for witnessing of testing.

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The EOR shall determine the frequency and type of field and laboratory testing. The batch plant that supplies concrete to LANL currently produces concrete with a standard deviation of f ‘c + 1200 psi for 3000–5000-psi, air-entrained concrete, and 1.1f ‘ c + 700 psi for > 5000-psi, air-entrained concrete.

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* + 1. The Testing Agency shall perform the following tests and collect strength cylinders on one batch in every 50 cu. yds. of concrete placed or once a day when less than 50 cu. yds. is placed. 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 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. All concrete is to be tested.

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

a. Provide the on-site curing container and verify that cylinders are maintained in accordance with ASTM C31.

b. Number of cylinders: Four (4) 6-inch diameter x 12-inch tall, or six (6) 4-inch diameter x 8-inch tall.

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In the following para., the “low end” of the period during which strength-test cylinders had to be picked up was “a hard” 8 hours, & predates the recent pre-approved mix designs (i.e., 15, 15X, 5000-4N & 5000-8E). The figure is now a soft/flexible 24 hours due to many instances of “low breaks” resulting from the use of these mix designs. Although such “cause-effect” hasn’t been established with certainty, there is definitely a possibility that the cylinders that broke at < f’c did so as a result of being moved prior to the concrete in them achieving “final set.” The 24-hr. figure has proven to be adequate for the “extended-set,” high-confidence, pre-approved mixture design, “5000-8E,” and shouldn’t be used for other mix designs without scrutiny. ASTM C 31 says, “Specimens shall not be transported until at least 8 h after final set.” *Design and Control of Concrete Mixtures*, 15th Ed., PCA, says, “Typically, initial setting occurs between 2 and 6 hours after batching and final setting occurs between 4 and 12 hours.”

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* + 1. The Testing Agency shall test the strength test cylinders IAW 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.

**\*** It might be permissible to pick up a cylinder(s) sooner than this. Permission must be sought and received from the LANL Chief Inspector.

* + 1. 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.

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Mixes incorporating fly ash cement replacement typically show higher long-term strength (90 days) and an initial slower strength gain than for regular mixes without fly ash. Fly ash mixes typically show that the compressive s strength at 28 days with Class F fly ash cement replacement is between 80% and 95% of the strength without replacement.

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* 1. CONCRETE ACCEPTANCE CRITERIA
		1. Fresh Concrete
			1. Temperature - Less than 95 degrees F.
			2. Slump - per Article 2.7.

Note: Slump that is lower than the minimum slump may be placed when the LANL inspector determines that the concrete is workable and can be vibrated. (This does not authorize low slump for other reasons such as concrete being placed beyond the time limit.) The LANL inspector will note the low slump in the inspection report but will not generate an NCR unless the concrete strength report indicates that it is unacceptable.

* + - 1. Air content - per Article 2.7.

Note: High air-content beyond the specified range becomes a factor that can impact strength but not durability. The LANL inspector will note the high air-content the inspection report but will not generate an NCR unless the concrete strength report indicates that it is unacceptable.

* + - 1. Drum revolution counter: 300 maximum revolutions within 1-1/2 hours after initial mixing for LATM-mixed concrete, or 100 to 300 revolutions within 1-1/2 hours after initial mixing for shrink-mixed and truck-mixed concrete.

NOTE 1: The preceding revolutions/time limits can be exceeded when BOTH a. AND b. (below) are met:

The concrete shall be of such slump or slump flow that it can be placed without the addition of water to the batch.

The air content of air-entrained concrete, slump, and temperature of concrete shall be as specified.

NOTE 2: If pre-approved mix design “5000-8E” is placed within 2-1/2 hours from initial mixing then, as long as the maximum number of revolutions is noted on the batch ticket, there is no limit of revolutions.

* + 1. Strength
			1. Concrete strength is satisfactory if the average of all sets of 3 consecutive strength test results equal or exceed the specified 28 day strength f ’ c and no individual strength test result falls below the specified 28 day strength f ’ c by more than 500 psi.
		2. Appearance
			1. Free from honeycombs, embedded debris, and dimensional variance beyond ACI 301 and its references.
		3. Construction requirements
			1. Conforming to required lines, details, dimensions and tolerances specified for construction.
	1. DEFECTIVE CONCRETE
		1. Defective concrete is concrete not conforming to the prior Article, CONCRETE ACCEPTANCE CRITERIA.
			1. At the discretion of LANL Building Official, concrete that has not been placed IAW the applicable portions of the prior Article, CURING AND PROTECTION 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.).
			2. Pre-approved mix design “5000-8E” will be considered defective if it is not placed within 2-1/2 hours of initial mixing.
		2. Do not accept or place defective concrete that is not in conformance with acceptance criteria. Return the fresh concrete to the supplier.
		3. Replace defective concrete not meeting strength criteria, at Subcontractor’s expense. The Subcontractor may, at its expense, evaluate the concrete’s in-place strength by testing 3 core samples for each strength test where LANL cured cylinders were more than 500 psi below f ’ c IAW ACI 301 and ASTM C 42. Fill core holes IAW ACI 301.
		4. Replace defective concrete not meeting appearance criteria, at Subcontractor’s expense. The STR may allow repair of defective concrete at Subcontractor’s expense.
		5. Repair or rework concrete not in conformance with details, tolerances, and other construction requirements at Subcontractor’s expense.
		6. Concrete that has been determined to be potentially defective regarding durability (refer to the initial Paragraph of this Article) will either be replaced at Subcontractor’s expense, or tested (to try to prove concrete will be durable) at Subcontractor’s expense.
			1. If Subcontractor chooses to test the concrete in question, the test method will be ASTM C 457. If the test results indicate a maximum air-void spacing factor (Ḹ) of 0.008, on average, and with no single value exceeding 0.010, the concrete will be considered to have been proven to be durable. Otherwise, the concrete shall be replaced at Subcontractor’s expense.

**APPENDIX A
SUBMITTAL TABLE**

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NOTE A: The portion of the author note on page 1 that pertains to ‘editing to suit project’ applies here (to the A1 Submittal Table) as well. Some assistance is provided in this regard through the use of author notes embedded in the table. However, in order to comply with this requirement, the “Forward to checklists” in ACI 301 must be understood and followed-through on (since the vast majority of the submittal items have ACI 301 as the source).

NOTE B: Submittal items under ACI 301 paragraphs 2.1.2.1 and 2.1.2.2 pertaining to formwork drawings, design calculations, etc. have been unnecessarily included on many LANL projects. When considering these items for inclusion on a project, in addition to guidance in the author note (e.g., ACI 347, etc.), the following should be thought through: If the formwork were to fail, could safety be jeopardized, an injury result, costly damage occur, etc.?

NOTE C: For “Work not specified” in/by ACI 301 (e.g., heavyweight shielding concrete, shotcrete, self-consolidating concrete, etc.), the main body of this Section requires editing, and related submittal items must be added to the following table.

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Subcontractor is responsible for full compliance with this Section and all applicable portions of ACI 301. The submittals listed in the A1 Submittal Table below are those specific submittals that LANL must receive from the Subcontractor.

Other potential submittals associated with the various codes and standards, and indicated as being required by the engineer of record (EOR), remain the responsibility of the Subcontractor.

The submittals must be submitted by the Subcontractor to the LANL STR within the time frame noted in the “timeframe” column to the right of the submittal item. The submittal time frames may be adjusted for individual projects by Subcontract or the LANL STR. The LANL STR will obtain the review and approval of the EOR and any other authority and notify the Subcontractor after approval is granted for each submittal.

In addition, 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 of concrete constituents that make up new mix designs.

The submittal reviews should be generally consistent with the following schedule (Section 01 3300 takes precedence on this):

1. 2 days for the STR to give the submittal to the A/E
2. 10 days for the A/E to approve the submittal.
3. 2 days for the STR to return the approved submittal
4. 5–10 days for the Subcontractor to act on the approval
5. 5 days for the Subcontractor to correct any submittals for re-review followed by a 5-day review period

(A mature process will take approximately 5 weeks if the submittal is not returned unapproved).

Note 1: Design-build Subcontractors shall obtain their EOR approvals before submitting the submittals to the LANL STR (differs from 3rd bullet in schedule above) where indicated in the log with Section 01 3300 Submittal Procedure.

Note 2: The term “engineer-of-record (and EOR)” is synonymous with the term “architect/engineer (i.e., as applicable to project in question).”

Note 3: The term “Contract Documents” includes the set of documents prepared by the EORas the basis for construction; these documents contain contract forms, contract conditions,

Specifications, Drawings, addenda, and contract changes.

Note 4: Source: Requirement source is ACI 301-10 unless noted otherwise.

**TABLE A1 REQUIRED SUBMITTALS**

All submittals and review comments (from LANL and/or EOR) should be retained in files for future reference during the Work.

In addition to the submittal requirements listed below, any/all submittal requirements indicated on the Construction Drawings are also applicable to the Project. In the event of a conflict between the submittal requirements listed below and any that appear on the Construction Drawings, contact the LANL STR. As necessary, review the Source of an indicated submittal item(s) for additional detail.

| **LANL Submittal ID** | **Submittal Items** \*\*\*\*and *Author Notes*\*\*\*\* | **Timing** | **Source** |
| --- | --- | --- | --- |
| **General requirements** |
|  | [Quality Control Plan.]\*\*\*\**Only required when specified in Exhibit H of the Subcontract*\*\*\*\* | 1 month before initial placement | [1.5.2] |
|  | Request to use a testing agency that is not currently approved by LANL. NOTE 1: Submittal also applies to sub-tier concrete fabricators and batch plants.NOTE 2: Request must be approved before such agency can be used.\*\*\*\**The submittal required by* *ACI 301 para. 1.6.2.1 is “informally embedded” in this submittal. However, in the event that the constructor chooses to use a “currently-approved agency,” neither this submittal nor the ‘301’ one is necessary*\*\*\*\* | 3 months before initial placement. | 1.6.F herein |
|  | [Test data on materials and concrete mixtures.]\*\*\*\**Not required for concrete materials and mixtures when pre-approved mix designs are used for construction.* *Also required when specified in Exhibit H of the Subcontract*\*\*\*\* | 1 month before initial placement | [1.6.2.2.e] |
|  | [Quality control program of the concrete supplier.] \*\*\*\**Except* *in the case of subcontracted design-build contracts, not required for concrete materials and mixtures when pre-approved mix designs are used for construction.* *Also required when specified in Exhibit H of the Subcontract.**When required,* r*efer to the NRMCA publication Guideline Manual for Quality Assurance and Quality Control for a description of suitable quality control program*\*\*\*\* | 1 month before initial placement | [1.6.2.2.f] |
| **Formwork and formwork accessories**\*\*\*\**Review the submittals listed pertaining 2.1.2.1 and 2.1.2.2 and delete those items that are not required to be submitted. Rationale/reason for any/all deletions shall be documented.* \*\*\*\* |
|  |  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.*\*\*\*\* | 1.5 months before formwork installation. | 2.1.2.1.d |
|  | Data on formwork release agent or formwork liners. | 15 work days before formwork installation. | 2.1.2.1.e,& 2.2.D herein |
|  | Shop drawings for formwork. | 15 work days before formwork installation. | 2.1.2.2.a |
|  | Design calculations for formwork shoring, reshoring, and backshoring. | 15 work days before formwork installation. | 2.1.2.2.b |
|  | Data sheet on form ties. | 15 work days before formwork installation. | 2.1.2.2.c |
|  | Data sheet on isolation/expansion joint materials. | 15 work days before formwork installation. | 2.1.2.2.d |
|  | Data sheet on waterstop materials and splices.C of C from manufacturer that waterstops meet specified requirements. | 15 work days before formwork installation. | 2.1.2.2.e,and 2.2.I herein |
| **Reinforcement and reinforcement supports** |
|  | CMTRs for each delivery traceable to the bundle tags by heat (or lot) number. | Upon receipt of delivery. | 3.1.1.1.a, &1.6..G herein |
|  | Placing drawings showing fabrication dimensions and locations for placement of reinforcement and supports. | 1 month before reinforce- ment placement. | 3.1.1.1.b |
|  | List of splices indicated in Subcontract Documents. | 1 month before reinforcement placement. | 3.1.1.1.c |
|  | Copy of CRSI Plant Certification. | 15 work days before planned shipment date. | 3.1.1.1.g |
| **Concrete mixtures** |
| **Standard Mix Designs (i.e., Pre-Approved Mix Designs)**\*\*\*\**The 1st submittal listed (pertaining para. 2.7.H herein) is applicable only for ML-1 or ML-2 concrete*\*\*\*\* |
|  | Test report(s) indicating aggregate correction factor (determined IAW ASTM C 231). | Prior to first concrete placement | 2.7.H herein |
|  | Delivery ticket (for each batch of concrete).NOTES: 1. Content of ticket shall be legible, and shall comply with ASTM C94 14.1 with the following changes/exceptions:

14.1.7: LATM Mix No. of the concrete in conformance with that employed in job specifications.14.2.2: Amount of cement.14.2.3 – 14.2.5: Delete/Not necessary.14.2.6: Amount of admixtures14.2.12: Delete/Not necessary.Additional content: Water/cementitious material ratio (w/cm), and the amount of water that can be added at the jobsite with exceeding w/cm1. Any/all water added at the jobsite shall be witnessed by a LANL technical representative (e.g., field engineer, inspector, etc.).
 | At the completion of each day’s placement(s) | 4.3.2, andASTM C94 14.1 |
| **Alternative Mix Designs**\*\*\*\**If only a Standard Mix(es) will be used on/by the Project, this portion of the Table (i.e., Alternate Mix Designs) should be deleted.* \*\*\*\* |
|  | Mixture proportions and characteristics.If different mixtures are to be used for different portions of proposed Work, C of C confirming that each mixture complies with the indicated mixture requirements. \*\*\*\**Check that mixture proportions conform to the requirements of 4.2.2 and 2.7.C for cementitious material content, w/cm, slump, nominal maximum size of coarse aggregate, air content, admixtures, and chloride-ion concentration, as well as compressive strength and yield*. In case of conflict between 4.2.2 and 2.7.C, contact LANL STR \*\*\*\* | 15 work days before placement | 4.1.2.1; 2.7.C herein; and ACI 318, 26.4.3.1(d) |
|  | Mixture proportion data (i.e., calculation of f ‘ cr, and, if applicable, the field-test records used for this; and field-test data, or trial mixtures, used to establish average compressive strength).Strength test records shall be < 2-years old.\*\*\*\**Several different methods can be used to select mixture proportions that will produce the necessary placeability, density, strength, and durability of the concrete.**Field experience of concrete mixtures previously used under similar conditions provides the best assurance that the proposed concrete mixture can be used satisfactorily and will have the specified properties.**If no field test records are available, refer to ACI 211.1 for selecting the initial quantities of materials based on material properties and specified concrete properties. ACI 211.1 recommends mixture characteristics be checked by trial batches in the laboratory or in the field.**Blending aggregates to meet criteria for a combined grading is another proportioning method that can be used. Listed below are some of the different procedures that have been used to determine proportions of blended aggregates:** *Combined fineness modulus;*
* *8 to 18% retained on each of the standard sieves;*
* *Coarseness factor chart; and*
* *0.45 power chart.*

*When one of the above or similar proportioning methods is used, the specific combined grading to which aggregate is to be blended, along with the tolerances for control, must be submitted. This proportioning method also requires concrete characteristics to be checked by trial batches*.\*\*\*\* | 15 work days before placement | 4.1.2.2, and 4.2.3.4.a or 4.2.3.4.b; 2.7.B herein; and ACI318, 26.4.3.1(b) |
|  | 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 C33 for aggregates; types, brand names, and producers’ names for admixtures; and source of supply for water and ice, and properties required by ASTM C1602 for water..Except for admixtures, test results confirming conformance to applicable 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 1 year, provided test results for the other properties specified in ASTM C33 indicate that aggregate quality has not changed.C of C confirming the source of the concrete materials (except for admixtures), that test results confirm conformance to applicable specifications, and confirming that ALL concrete materials used to develop mixture proportions correspond to those to be used in the proposed Work. | 1 month before placement | 4.1.2.3; 1.5.C and 2.7.B herein; and ACI 318, 26.4.1.3.1(a) |
|  | Field-test, or Trial-mixture, records; and data on material and mixture proportions.Strength test records shall be < 2-years old. | 15 work days before placement | 4.1.2.4, 4.1.2.5, and ACI 26.4.3.1(b) |
|  | Documentation indicating compliance with the specified requirements for sulfate resistance. | 15 work days before the initial placement | 4.2.2.7.a |
|  | Documentation verifying compliance with specified requirements for freezing and thawing exposure. | 15 work days before the initial placement | 4.2.2.7.b |
|  | Documentation verifying compliance with specified requirements for low permeability. | 15 work days before the initial placement | 4.2.2.7.c |
|  | Documentation verifying compliance with specified requirements for corrosion resistance. | 15 work days before the initial placement | 4.2.2.7.d |
|  | Delivery ticket (for each batch of concrete).NOTES: 1. Content of ticket shall comply with ASTM C94 14.1 and be legible.
2. In addition to content required by ’14.1,’ the ticket shall also indicate w/cm, and the amount of water that can be added at the jobsite with exceeding w/cm.
3. Any/all water added at the jobsite shall be witnessed by a LANL technical representative (e.g., field engineer, inspector, etc.).
 | At the completion of each day’s placement(s) | 4.3.2, andASTM C94 14.1 |
| **Handling, placing, and constructing**\*\*\*\**Review the submittals listed pertaining 5.1.2.1 and delete those items that are not required to be submitted.* \*\*\*\* |
|  | Quality-control Test and inspection reports. | Within 1 month after placement | 5.1.2.1.a |
|  | Proposed method of measuring concrete temperature*.* | 15 work days before the initial placement | 5.1.2.1.b,5.3.6.5 |
|  | Qualifications of finishing Sub-tier/Subcontractor and flatwork finishers for finishing unformed surfaces.\*\*\*\*O*nly a min. one (1) finisher, or finishing supervisor, is required to be certified; thus, if project requires more, that number must be specified (i.e., edit 3.7.C.1 accordingly)* \*\*\*\* | 15 work days before the initial placement | 5.1.2.1.c,5.3.4.1; &3.7.C.1 herein |
|  | Shop drawings of placing, handling, and constructing methods. | 15 work days before the initial placement | 5.1.2.1.d |
|  | Notification of concrete placement.NOTE: As soon as, if not prior to, “notification” is given/submitted, ensure the associated tests and inspections are coordinated properly/adequately. | 48 hours before initial placement, and at least 24 hours before subsequent ones | 5.1.2.1.e |
|  | Request for acceptance of preplacement activities to ensure the preplacement activities are properly inspected. | 48 hours before placement | 5.1.2.1.f |
|  | Description of conveying equipment. | 15 work days before the initial placement | 5.1.2.2.a |
|  | Proposed method for removal of stains, rust, efflorescence, and surface deposits. | 15 work days before performing the work | 5.1.2.2.b,5.3.7.6 |
| \*\*\*\**Submittals 5.1.2.2 .c -- 5.1.2.2.e can be deleted if concreting won’t occur “exposed to the elements.” Otherwise these submittals are “conservatively included” in this table (vs. being in Table B1) given their respective timing and since predicting the weather is difficult. If concreting will occur exposed to the elements, but it’s somehow known with a great deal of certainty that one or more of these submittals won’t be necessary, the submittal(s) can be deleted.* \*\*\*\* |
|  | Proposed wet-weather protection activities.Project EOR and/or LANL STR can waive this submittal if concreting will not be (or was not) performed during “wet weather.” | 48 hours before placement | 5.1.2.2.c,5.3.2.1.a |
|  | Hot-weather Implementation Plan.Project EOR and/ or LANL STR can waive this submittal if concreting will not be (or was not) performed during “hot weather.” | 5 work days before placement | 5.1.2.2.d &3.8.A herein |
|  | Cold-Weather Implementation Plan.Project EOR and/ or LANL STR can waive this submittal if concreting will not be (or was not) performed during “cold weather.” | 5 work days before placement | 5.1.2.2.e &3.8.A herein |
| \*\*\*\**Retain 5.1.2.2.f only* *if samples finished in accordance with 5.3.3.2 must be submitted.*\*\*\*\* |
|  | Sample finish (for finishing formed surfaces when/if matching sample finish is required). | 5 work days before beginning finishing | 5.1.2.2.f |
| \*\*\*\**Retain 5.1.2.2.g only* *if samples of exposed-aggregate finish is specified and/or indicated (elsewhere).* \*\*\*\* |
|  | Specification and manufacturer’s data on surface retarder used in producing exposed-aggregate finish and method of use. | 5 work days before beginning finishing | 5.1.2.2.g,5.3.4.2.i |
| \*\*\*\**Retain 5.1.2.3.b only* *if a bonded two-course slab(s) is specified and/or indicated (elsewhere). Such a slab consists of a base slab plus a bonded topping, and is typically used only in applications involving heavy-duty industrial vehicular traffic. Refer to ACI 302.1R for more detail.* \*\*\*\* |
|  | Request to use, and specification and data on, bonding agents other than cement grout for two-course slabs. | 5 work days before beginning finishing | 5.1.2.3.b,5.3.4.2.f |
| \*\*\*\**Retain 5.1.2.3.c only* *if underwater placement will be necessary/potentially necessary.\*\*\*\** |
|  | Proposed method for underwater placement. | 5 work days before placement | 5.1.2.3.c,5.3.2.4 |

**APPENDIX B
DESIGN CHANGES**

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

NOTE: The portion of the author note on page 1 that pertains to ‘editing to suit project’ applies here (to the Design Change(s) Table) as well. Some assistance is provided in this regard through the use of author notes embedded in the table. However, in order to comply with this requirement, the “Forward to” checklists in ACI 301 must be understood and followed-through on (since the vast majority of the tabulated items have ACI 301 as the source).

For “Work not specified” in/by ACI 301 (e.g., heavyweight shielding concrete, shotcrete, self-consolidating concrete, etc.), the main body of this Section requires editing, and related items must be added to the following table.

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Subcontractor shall prepare a Field Change Request (FCR) for each and every item listed in the Design Change(s) Table ***as necessary/if applicable***.

Subcontractor shall provide each FCR to the LANL STR within the timeframe noted in the “timeframe” column to the right of the tabulate item. The timeframes may be adjusted for individual projects by Subcontract or the LANL STR. The LANL STR will obtain the review and approval of the EOR and any other authority and notify the Subcontractor after approval is granted for each FCR.

In addition, 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 of concrete constituents that make up new mix designs.

The FCR reviews should be generally consistent with the following schedule:

1. 2 days for the STR to give the FCR to the A/E
2. 10 days for the A/E to approve the FCR.
3. 2 days for the STR to return the approved FCR.
4. 5–10 days for the Subcontractor to act on the approval.
5. 5 days for the Subcontractor to correct any FCR for re-review followed by a 5-day review period

(A mature process will take approximately 5 weeks if the FCR is not returned unapproved).

Note 1: Design-build Subcontractors shall obtain their EOR approval before providing an FCR to the LANL STR (differs from 3rd bullet in schedule above).

Note 2: The term “engineer-of-record (and EOR)” is synonymous with the term “architect/engineer (i.e., as applicable to project in question).”

Note 3: The term “Contract Documents” includes the set of documents prepared by the EOR as the basis for construction; these documents contain contract forms, contract conditions,

Specifications, Drawings, addenda, and contract changes.

Note 4: Source: Requirement source is ACI 301-10 unless noted otherwise.

**TABLE B1 Design Change(s)**

All FCRs and review comments (from LANL and/or EOR) should be retained in files for future reference during the Work.

In the event of a conflict between the items listed below and related ones that appear on the Construction Drawings, contact the LANL STR. As necessary, review the Source of an indicated item(s) for additional detail.

| **Item No.** | **Items** \*\*\*\*and *Author Notes*\*\*\*\* | **Timing** | **Source** |
| --- | --- | --- | --- |
| **General requirements** |
|  | Request to use accelerated testing. Correlation data and statistical procedure that will be used to estimate the standard-cured, 28-day strength from the measured accelerated strength. | 1 month before initial placement | 1.6.2.2.g |
|  | Documentation of actions to increase strength test results (if/when ACI 301 1.6.6.1 isn’t met). | Within 3 work days of “finding” | 1.6.5.1 |
|  |  Correlation data relating compressive strength to the results of the in-place test (if/when in-place testing, as permitted by ACI 301, is used).  Refer to ACI 228.1R for acceptable correlation testing programs. Using cast-in-place cylinders in accordance with ASTM C873 does not require correlation; however, measured strengths need to be corrected using the factors in ASTM C42 if the length-diameter ratio is less than 1.75. | Within 3 work days of testing. | 1.6.5.3 |
|  | Proposed repair methods, materials, and modifications to the Work (if/when completed concrete work is found to be noncompliant with Subcontract Documents). | Within 3 work days of “finding” | 1.7.1.4 |
|  |  Description of repair to be performed to bring potentially under-strength concrete into compliance with Subcontract Documents. | Within 3 work days of “finding” | 1.7.4.2.e |
|  | Description of repair work performed to bring nondurable concrete into compliance with Subcontract Documents. | Within 3 work days of “finding” | 1.7.5.2.e |
|  | Identification of any “as-found/as-received” out-of-tolerance devices, and description of where and how the device(s) was used. | Within 3 work days of “finding” | 1.6.I herein |
| **Formwork and formwork accessories**\*\*\*\**Review the items listed pertaining 2.1.2.1 and 2.1.2.2 and delete those that are not applicable to project.* \*\*\*\* |
|  | Data on form-facing materials (if different from that specified in 2.2.1.1). | 1 month before formwork installation. | 2.1.2.1.a |
|  | Alternative locations and details for construction and contraction joints (if different than those indicated). | 1.5 months before formwork installation. | 2.1.2.1.b |
|  |  Correlation data on alternative methods of determining concrete strength for formwork removal. \*\*\*\**Refer to ACI 228.1R for recommendations on developing suitable correlation data*\*\*\*\* | 1.5 months before formwork installation. | 2.1.2.1.c |
|  | Request to use ferrous ties with breakback less than 3/4 in. with Surface Finish-2.0 or Surface Finish-3.0. | 1 month before formwork installation. | 2.2.1.2 |
|  | Alternative material or size (to those specified or permitted), or both, for chamfer strips. | 1 month before formwork installation. | 2.2.1.6 |
|  | Request to use earth cuts as form surfaces. | 1 month before formwork installation. | 2.2.2.3 |
|  | Location and details of construction, isolation/expansion, and contractions joints (not shown/indicated), or alternative locations and details (to those shown/indicted) of these joints. | 1.5 months before formwork installation. | 2.2.2.5.a |
|  | Alternative locations and details (to those indicated) for construction, expansion, and contraction joints. | 1.5 months before formwork installation. | 2.2.2.5.c |
|  | Request to remove formwork at a lower compressive strength than specified compressive strength for removal of forms. | 1.5 months before formwork installation. | 2.3.2.5 |
|  |  Data correlating alternative concrete strength-measuring methods for formwork removal. \*\*\*\**Refer to ACI 228.1R for recommendations on developing suitable correlation data.*\*\*\*\* | 1.5 months before formwork installation. | 2.3.4.2 |
| **Reinforcement and reinforcement supports** |
|  | Request to use splices not indicated in Subcontract Documents. | 1 month before reinforcement placement. | 3.1.1.1.c |
|  | Request to use mechanical splices**\*** not indicated in Subcontract Documents.An ICC Evaluation Service Report (ESR) – or something comparable – for the splice product shall accompany the request, and must indicate that the product complies with the Project Code of Record. **\***Includestypicalproprietary splicing/coupling systems, as well as Form Saver, and Cadweld.  | 1 month before reinforcement placement. | 3.1.1.1.d |
|  | Request for placement of column dowels without using templates. | 15 work days before reinforcement placement. | 3.1.1.1.e |
|  | Request and procedure to field bend or straighten partially embedded reinforcing bars. | 15 work days before reinforcement placement. | 3.1.1.1.f |
|  | Request to weld reinforcing bar; and description of reinforcing bar weld locations, welding procedure specifications, and welder qualifications.For other than ASTM A 706 reinforcing bar, CMTR of the reinforcing bar material properties that demonstrate conformance to the requirements of AWS D1.4. | 15 work days before welding. | 3.1.1.2.a, & 1.6.G herein |
|  | Proposed supports for coated reinforcement and materials for fastening coated reinforcement not covered in 3.3.2.4. | 15 work days before reinforcement placement. | 3.1.1.2.b |
|  | Request to relocate reinforcement beyond the specified placing tolerances (to avoid interference with other reinforcement, conduits, or embedded items), in which the ‘relocated’ reinforcement arrangement shall be indicated. | 1 month before reinforcement placement. | 3.1.1.3.a,& 3.3.2.2 |
|  | Inspection and quality-control program of plant applying epoxy coating that is not certified by Concrete Reinforcing Steel Institute (CRSI). | 1 month before planned shipment date. | 3.1.1.3.b |
|  | Provide certification program, equivalent to that of CRSI-certified plant, for non-CRSI-certified plant applying epoxy coating for evaluation by EOR. | 1 month before planned shipment date. | 3.2.1.2.b |
|  | Request use of alternative reinforcement support type. | 15 work days before reinforcement placement. | 3.2.1.10 |
|  | Request to heat reinforcement before bending. | 15 work days before reinforcement placement. | 3.2.2.1 |
|  | Request to extend reinforcement through control joints, including saw-cut joints. | 15 work days before reinforcement placement. | 3.3.2.5 |
|  | Request to use alternative method for setting column dowels. | 15 work days before reinforcement placement. | 3.3.2.6 |
|  | Request and procedure to field bend or straighten partially embedded reinforcing bars. | 15 work days before reinforcement placement. | 3.3.2.8 |
|  | Request to use other method to measure preheat temperature. | 15 work days before reinforcement placement. | 3.3.2.8.a |
|  | Request to field-cut reinforcement. | 15 work days before cutting. | 3.3.2.9 |
| **Concrete mixtures** |
| **Standard Mix Designs (i.e., Pre-Approved Mix Designs)** |
|  | Request to deliver concrete at a temperature exceeding 95°F. | 10 work days before placement | 4.2.2.6 |
| **Alternative Mix Designs**\*\*\*\**If only a Standard Mix(es) will be used on/by the Project, this portion of the Table (i.e., Alternate Mix Designs) should be deleted.* \*\*\*\* |
|  | Requests for adjustments to mixture proportions.Requests to adjust mixture proportions necessary for workability or consistency.\*\*\*\**If Subcontractor desires to decrease the cementitious materials content of the concrete mixture after having satisfied the requirements of 4.2.3.6, review a request for acceptance of the proposed revised mixture with a lower cementitious-materials content on a trial basis.**If Subcontractor finds it necessary to increase the cementitious-materials content, review a request for acceptance of the proposed revised mixture with a higher cementitious-materials content on a trial basis.**Confirm adequacy of modified proportions has been verified from a set of new field test data*.\*\*\*\* | 15 work days before use in a placement | 4.1.2.6, 4.2.3.5,and 4.2.3.6 |
|  | Evaluation and test results required in 4.2.2.1 verifying the adequacy of concrete to be placed in floors if the cementitious materials content is less than the minimum specified in Table 4.2.2.1. | 15 work days before the initial placement | 4.1.2.7 |
|  | Request to use the volumetric batching and proposed method. | 15 work days before the initial placement | 4.1.2.9, 4.3.1.2 |
|  | Requests to use cementitious materials other than ASTM C150 Type I or Type II. When ASTM C595 or C1157 cements are used in structures that will be subjected to deicing chemicals, verify compliance of the concrete with Table 4.2.2.7.b.2. | 15 work days before the initial placement | 4.2.1.1 |
|  | Request to use admixtures. | 15 work days before the initial placement | 4.2.1.4; 2.7.Eand 2.7.G herein |
|  | Request to change materials and data verifying that properties of the concrete mixture conform to the requirements of 4.2.2. | 15 work days before the initial placement | 4.2.1.5 |
|  | Request to use a lower cementitious-materials content. | 15 work days before the initial placement | 4.2.2.1 |
|  | Request to use a slump other than that specified. | 10 work days before placement | 4.2.2.2 |
|  | Request to deliver concrete at a temperature exceeding 95°F. | 10 work days before placement | 4.2.2.6 |
| **Handling, placing, and constructing***.* |
|  | Request for placement of concrete in hot weather with a temperature exceeding that specified and/or indicated. | 2 work days before placement | 5.1.2.2.d |
|  | Proposed location and treatment of construction joints not indicated in Subcontract Documents, including method for surface preparation and achieving bond. | 5 work days before beginning ‘jointing’ | 5.1.2.3.a |
|  | Proposed location of contraction or expansion joints not indicated in Subcontract Documents. | 5 work days before beginning ‘jointing’ | 5.1.2.3.d |
|  | Request to use, and proposed methods of, curing other than those of 5.3.6.4. | 5 work days before placement | 5.1.2.3.e,5.3.6.4 |
|  | Description of proposed coated form ties. | 15 work days before formwork installation. | 5.1.2.3.f |
|  | Specification data, methods of use, and application procedure for proposed repair material other than site-mixed Portland-cement mortar described in 5.3.7.4. | 5 work days before placement | 5.1.2.3.g |
|  | Request to use alternative repair materials and supporting data. Request to not match color. | 5 work days before placement | 5.2.1.4,5.3.7.5 |
| \*\*\*\*Do not r*etain 5.3.2.3.c if LATM Mix Nos.* 5000-4N and/or -8E *will be used on/in the Project (since these are ‘pumpable’ mixes; hence, “alternative mixture” not necessary/applicable). If other mixes will be used, do not retain if modification of them is not/will not be permitted.\*\*\*\** |
|  | When permitted, alternative mixture for pumped concrete. | 5 work days before placement | 5.3.2.3.c |
|  | Detailed plan for alternative saw cutting method, such as shallow-cut and dry-cut method. Refer to ACI 302.1R for further guidance. | 5 work days before beginning ‘jointing’ | 5.3.5 |
|  | Request to use shorter duration for moisture retention, or if a curing method other than that specified is desired. | 5 work days before placement | 5.3.6.1 |
|  | Request to delay repair of tie holes and surface defects*.* | 5 work days before placement | 5.3.7.1 |
|  | Alternative repair method. | 5 work days before placement | 5.3.7.3 |

**APPENDIX C**

**COLD-WEATHER IMPLEMENTATION PLAN (CWIP)**

**SUBMITTAL DEVELOPMENT GUIDANCE**

Section 03 3001 (e.g., 3.8.A and App A) requires the Subcontractor to submit a CWIP, based on this document and ACI 306R-16, at least 5 work days[[3]](#footnote-3) before placement in cold weather**\***. The purpose of the CWIP submittal is to ensure cold-weather concreting is performed properly and safely.

**\*** “Cold weather” is defined by ACI 306R (in its Section 2.2).

The level of detail provided in the CWIP is key. Including inadequate detail will result in rejection of the submittal, but including too much detail can unduly limit options. The CWIP should simply describe the means and methods (based on the recommendations in ACI 306R) intended to be used in order to ensure cold-weather concreting is performed properly and safely. The CWIP shouldn’t include anything that the Subcontractor isn't prepared to do since, once it is approved by the engineer of record and LANL, provides a written record of intentions.

**Introduction**

Introduce the CWIP with a statement like the following:

This Cold Weather Implementation Plan (CWIP) is submitted as required by Project Specification Section 03 3001 and conforms to the requirements therein, to include the following definition of cold weather:

"Cold weather exists when the air temperature has fallen to, or is expected to fall below, 40°F (4°C) during the protection period; protection period is defined as the time recommended to prevent concrete from being affected by exposure to cold weather during construction."

By following this CWIP, concrete placed during cold weather will develop the indicated and/or specified strength and durability.

Additional detail on “protection period” is provided below under “Protection against less-than-permissible temperatures.”

**Production**
Discuss the details of cold weather concrete production with LA/Espanola Transit Mix. If they have a written plan they’re willing to share, include the applicable portions of it in the CWIP. Describe how the minimum and maximum concrete temperatures in ACI 306R Table 5.1[[4]](#footnote-4) will be met. Heated mixing water, aggregates, or both are typically used.

Note: The use of means other than, or in addition to, heated mixing water and aggregate (e.g., use of increased cement content, accelerating admixtures, cold-weather admixture systems, rapid-setting cements, etc.) could constitute a “change of materials (per ACI 301 paragraph 4.2.1.5[[5]](#footnote-5)).” Also, 03 3001 prohibits the use of calcium chloride (as an admixture).

**Preparation and Transportation**
Describe how the subgrade will be protected from frost and, if frozen, how it will be thawed**\***; and how reinforcement and forms will be protected from accumulation of ice or snow (prior to concrete placement). In some cases, covering the subgrade with insulating material for a few days will protect it from frost/freezing. In other cases it may be necessary to apply heat to the subgrade followed by insulation. Provide specifics on the use of insulation and/or heat and its duration.

**\*** Thawed subgrade shall be re-compacted.

Generally, concrete can be produced at a high enough temperature at the plant so no special methods are needed to insulate the concrete truck drum. If the concrete will be placed by crane and bucket, pumping, or conveyor, very low air temperatures may necessitate steps to ensure that the placement temperature doesn't drop below the allowable minimum. Scheduling deliveries that reduce truck waiting time (i.e., as much as possible given that the LANL Vehicle Access Portals can be potential choke points) is the least expensive way of achieving this goal. Discuss the aforementioned topics, as applicable, in the CWIP, and relate temperature measurements (i.e., of the air and/or the concrete prior to placement) to the action to be taken if the placement temperature falls below the allowable minimum.

Finally, indicate in the CWIP the temperature range (in degrees Fahrenheit) stipulated by the EOR that the as-delivered concrete must be within, and that provisions will be made in advance of concrete placement to protect it against less-than-permissible temperatures without drying of concrete.

**Protection against less-than-permissible temperatures**
The “protection period,” or the time in terms of days, begins as soon as possible after placement, consolidation and finishing**\***. The duration of the “protection period” (recommended to prevent concrete from being adversely affected by exposure to “cold weather” during construction) is indicated in ACI 306R Table 7.2. Equipment, materials and methods used to maintain concrete placed during “cold weather” at the recommended temperature given in Line 1 of ACI 306R Table 5.1 and for the length of time in Table 7.2 include insulating materials, heaters, enclosures, and internal heating (or a combination of these).

* If insulating materials are to be used, ensure the required type(s) and amount(s) needed to provide the R-value(s) indicated in ACI 306R Tables 9.3 will be on hand. On a related note, if quick cycling of forms is a possibility, the R-value of insulating material by itself (vs. that with formwork in place) may have to be relied on for some/much of the protection period (i.e., for the concrete affected by quick form cycling).
* If heaters are to be used**\*\***, ensure direct-fired ones are properly vented and not used to directly heat the surface of concrete.
* If an enclosure(s) is to be used, ensure the materials needed to build it will be on hand: plastic sheeting, lumber, vents, hardware, and (perhaps) heaters.
* If internal heating is to be used, ensure moisture retention and temperature control are addressed in the CWIP.

**\*** When finishing flatwork, if bleed water is present, wait until it evaporates, or skim it off using a rope, hose, or squeegee before troweling.

**\*\*** Prior to the use of flame-producing items in technical areas with Weapons Facility Operations (WFO), acquire a spark/flame permit, and/or written approval from the Facility Operations Director (FOD).

Describe in CWIP the means and methods of “protection” that will be used. And, if the project includes multiple types of concrete elements that would be affected by “cold weather” differently (e.g., slabs on grade vs. elevated slabs, interior walls vs. exterior walls, etc.), this description must have a commensurate level of detail. Describe how concrete temperature during placement being no higher than 20°F more than the minimum temperature values in Table 5.1 will be ensured. Finally, as applicable, describe worker- and fire-safety measures that will implemented.

**Temperature monitoring**
Describe in the CWIP where and how concrete temperatures (at least on the surface if not internally, too**\***) will be monitored and recorded at the point of placement. ACI 306R recommends measuring concrete temperature at regular intervals to ensure the effectiveness of the provided protection. Indicate the general locations of temperature-measuring devices having an accuracy of ± 2°F**\*\*** and the frequency with which the temperature measurements will be taken.

**\*** Since internal temperature monitoring is recommended by ACI 306R, if such monitoring isn’t going to be performed, the CWIP must indicate why not.

**\*\*** All temperature-measuring devices shall be calibrated.

At the end of the “protection period,” ACI 306R recommends a gradual decrease in surface temperature to minimize thermal stresses that might cause cracking. Thus, indicate in the CWIP how the concrete will be allowed to cool such that the maximum allowable temperature drop in the first 24 hours after the end of “protection period’ (in Line 5 of Table 5.1) isn't exceeded.

**Curing**
Describe in the CWIP how prevention of concrete-surface desiccation (e.g., evaporation of moisture, extreme drying, etc.) will be accomplished. This description will account for curing after the “protection period” and, if an enclosure is used, curing during the “protection period.” Also, describe how curing conditions will be such that the recommended minimum concrete temperatures in Table 5.1 aren’t exceeded by more than 20°F.

Water curing is discouraged if concrete will be exposed to freezing temperatures (unless additional protection measures are used) because a high moisture content renders the concrete vulnerable to freezing. Insulating materials serve the dual purpose of keeping the concrete warm and preventing moisture loss. Leaving wood forms in place is effective for walls and columns. Indicate if curing compounds will be used.

**Abrupt changes in weather and backup equipment and materials**
In the CWIP, indicate the weather service(s) that will be monitored in order to stay abreast of potential local weather changes. Describe how concrete will be protected from unexpected freezing (i.e., periods that don’t qualify as “cold weather”). Indicate the backup materials and equipment that will be on hand in the case of breakdowns. Finally, having a procedure for installing “emergency construction joints” in the CWIP could prove to be beneficial.

Additional detail on most of the topics discussed herein (e.g., production, preparation, protection, temperature monitoring, and curing) can be found in ACI 306R.

**APPENDIX D**

**HOT-WEATHER IMPLEMENTATION PLAN (HWIP)**

**SUBMITTAL DEVELOPMENT GUIDANCE**

Section 03 3001 (e.g., 3.8.A and App A) requires the Subcontractor to submit a HWIP, based on this document and ACI 305R, at least 5 work days[[6]](#footnote-6) before placement in hot weather.**\*** The purpose of the HWIP submittal is to ensure hot-weather concreting is performed properly and safely.

**\*** “Hot weather” is defined in Section 03 3001 Para. 3.8.A.

The level of detail provided in the HWIP is key. Including inadequate detail will result in rejection of the submittal, but including too much detail can unduly limit options. The HWIP should simply describe the means and methods (based on the recommendations in ACI 305R) intended to be used in order to ensure hot-weather concreting is performed properly and safely. The HWIP shouldn’t include anything that the Subcontractor isn't prepared to do since, once it is approved by the engineer-of-record (EOR) and LANL, it provides a written record of intentions.

**Introduction**

Introduce the HWIP with a statement like the following:

This Hot Weather Implementation Plan (HWIP) is submitted as required by Project Specification Section 03 3001 and conforms to the requirements therein, to include the following definition of hot weather:

"Hot weather exists when the air temperature has risen to, or is expected to rise above, 80°F at the time of concrete placement."

By following this HWIP, hot-weather concrete will develop the indicated and/or specified strength and durability.

**Production and Delivery**
Discuss the details of hot-weather concrete production with LA/Espanola Transit Mix. If they have a written plan they’ll share, include the applicable portions of it in the HWIP. Describe how the concrete temperature will be reduced and controlled. Refrigerated mixing water, replacement of some mixing water with ice, shading and/or wetting the aggregate stockpile, are typically used.

Note: The use of means other than, or in addition to, cooled mixing water and aggregate (e.g., use of decreased cement content, increased supplementary cementitious materials, set-retarding admixtures, water-reducing admixtures, extended set-control admixtures, etc.) could constitute a “change of materials (per ACI 301 paragraph 4.2.1.5[[7]](#footnote-7)).”

Since delays and prolonged agitation/mixer revolutions lead to higher concrete temperatures and slump loss, schedule deliveries that reduce truck waiting time (i.e., as much as possible given that the LANL Vehicle Access Portals can be potential choke points). And ensure that the rate of delivery is manageable given the available crew to place, finish and cure; and the available placement and finishing equipment, and protection. If/when possible, schedule around the most favorable weather conditions (i.e., day and time of day). Discuss these topics in the HWIP.

Finally, indicate in the HWIP the temperature range (in degrees Fahrenheit) stipulated by the EOR that the as-delivered concrete must be within.

**Preparation for placing and curing**
Discuss specific measures that will be taken in preparation for concrete placement. Examples of such measures are as follows:

* Moistening the subgrade[[8]](#footnote-8), and fogging forms and reinforcement prior to placing concrete.
* Ensuring mixers, chutes, pump lines and other equipment in contact with the concrete are shaded, covered with wet burlap or painted white.
* Erecting/installing temporary sunscreens and windbreaks.
* Having all forms, equipment and workers ready to handle concrete.

Indicate in the HWIP how site conditions (i.e., air temperature, sun exposure, humidity and wind speed) and concrete temperature (i.e., at time of delivery and after it’s placed) will be monitored**\*** in order to determine and prepare the necessary protective measures, or to revise them. And, if the air temperature could drop 40 °F or more within the same day, indicate how the concrete will be protected from thermal shock.[[9]](#footnote-9)

**\*** All monitoring/ measuring devices shall be calibrated.

**Also, i**ndicate the backup materials and equipment that will be on hand in the case of breakdowns. An example of backup equipment is at least one (1) standby vibrator for every three (3) in use.

**Protection against moisture loss**
The goal is to protect the concrete from moisture loss during the placing and curing periods. Examples of such protection include covering with moisture-retaining material such as wet burlap, plastic sheeting or liquid-membrane curing compound;[[10]](#footnote-10) and evaporation retardants.

Describe in HWIP the means and methods of protection that will be used to protect against moisture loss. And, if the project includes multiple types of concrete elements that would be affected by this differently (e.g., flatwork vs. formed concrete), this description must have a commensurate level of detail.

**Placement and finishing**

**Place and consolidate the concrete as quickly as possible. The same goes for finishing; however, don’t begin a finishing operation if the concrete isn’t ready. For example, for flatwork, don’t begin finishing if there’s still bleedwater on the surface, and don’t begin final finishing until water sheen has disappeared (from the surface). Also, with regard to flatwork,** take special precautions when finishing slabs on grade placed directly on vapor retarders.[[11]](#footnote-11)

**In discussing placement and finishing in the HWIP, if applicable, differentiate between formed concrete and flatwork.**

**Curing and protection**

Immediately following final finishing, protect the concrete (from low humidity, drying winds, and large ambient temperature differential) and start the curing process. Cure continuously for at least seven (7) days with water or with another method from ACI 308.1[[12]](#footnote-12).

**Guard against rapid cooling of concrete (i.e., more than 5 °F per hour, or more than 50 °F per day, during the first day) with a least dimension of less than 12 inches and/or** that obtains high strength at an early age. If applicable, indicate in the HWIP how such concrete will be gradually cooled.

**In addition to discussing the aforementioned topics in the HWIP, if applicable, indicate the differences in means and methods associated with curing and protecting formed concrete versus flatwork.**

**Testing and inspection**
Make slump and air-content tests, and strength-test cylinders immediately after obtaining the concrete sample.

Protect test cylinders at the jobsite to maintain temperature (i.e., 60–80 °F for f’c < 6,000 psi) and moisture for initial curing. For example, cast cylinders in plastic molds with a plastic lid (or cover them with plastic sheeting), don’t leave them unprotected in direct sunlight, provide field-curing boxes with ice or refrigeration[[13]](#footnote-13), submerge them in water inside an insulated cooler(s)/ bucket(s) with a lid(s), etc.

Inspection (i.e., quality control vs. quality assurance/special inspection) is necessary to ensure the HWIP is executed and adhered to thoroughly.

Discuss testing and inspection in the HWIP.

Additional detail on all of the topics discussed herein can be found in ACI 305R.

END OF SECTION

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Do not delete the following reference information:

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

THE FOLLOWING STATEMENT IS FOR LANL USE ONLY

This project specification is based on LANL Master Specification 03 3001 Rev.13, dated January 23, 2020.

1. While the vast majority of “structural-concrete projects” are “building-related” & thus have designs based on ACI 318, there are instances in which this paradigm doesn’t hold. For example, a slab-on-grade that isn’t part of a structural system is still “structural concrete” if it’s designed to resist gravity loads (e.g., industrial floors designed in accordance with ACI 360R, etc.). [↑](#footnote-ref-1)
2. Per ACI, certain of their standards, such as Specifications 305.1, 306.1 and 308.1, shouldn’t be referenced unless indicated as applicable in their entirety; thus, not listed here although mentioned later in section. [↑](#footnote-ref-2)
3. One (1) day/work day is one 24-hour period. [↑](#footnote-ref-3)
4. With regard to Line 1 of Table 5.1, the word “maintained” applies to the “protection period.” [↑](#footnote-ref-4)
5. On a related note, paragraph 4.2.1.4 stipulates that admixtures used shall be the same as those used in trial mixtures or in the concrete represented by submitted field test records. [↑](#footnote-ref-5)
6. One (1) day/work day is one (1) 24-hour period. [↑](#footnote-ref-6)
7. On a related note, paragraph 4.2.1.4 stipulates that admixtures used shall be the same as those used in trial mixtures or in the concrete represented by submitted field test records. [↑](#footnote-ref-7)
8. Ensure there’s no free water (i.e., don’t allow excessive water to pond). [↑](#footnote-ref-8)
9. Refer to 03 3001 Appendix C for thermal protection guidance. [↑](#footnote-ref-9)
10. Using white-pigmented membrane curing compounds will help with proper coverage and reflect heat from the surface. [↑](#footnote-ref-10)
11. Refer to NRMCA’s Concrete in Practice (CIP) 29 for details. [↑](#footnote-ref-11)
12. Refer to Section 3.6 of ACI 308.1 for acceptable hot-weather curing methods. [↑](#footnote-ref-12)
13. Refer to NRMCA’s CIP 9 and 34 for more detail. [↑](#footnote-ref-13)