JORDAN VALLEY WATER CONSERVANCY DISTRICT

Material Testing Services for the SWA-2 Project

February 2025

DESCRIPTION OF WORK: The project consists of providing material testing services and special inspections for the Southwest Aqueduct Reach 2 (SWA-2) Project. The project will include the construction of 10,550 feet of 66-inch diameter welded steel pipe and associated waterline appurtenances.

PROJECT SCHEDULE: The work will be ongoing from approximately May 2025 until May 2027. Material testing services will be required on an on-call basis during this period.

RECEIPT OF BIDS: Sealed bids will be received at the office of the Jordan Valley Water Conservancy District (JVWCD), Owner of the Work, located at 8215 South 1300 West, West Jordan, Utah 84088, until **2:00pm, on Tuesday, February 25, 2025.** Electronic bids may also be submitted in adobe .pdf format to ellisad@jvwcd.org. **JVWCD suggests that electronic bids be submitted 15 minutes prior to the bid opening deadline, to allow for verification of delivery.** A public bid opening will be held at the bid due time at the office of the Owner, attendance is not required. Bid results will be posted to the JVWCD's website within 24 hours of the bid opening.

OBTAINING CONTRACT DOCUMENTS: All Contract Documents may be obtained on the JVWCD's website (www.jvwcd.org), under the project "Material Testing Services for the SWA-2 Project". Prospective bidders must register at the District's web site under the project to receive project notifications and addenda, if any. Bidders are required to check the District's web site for any addenda prior to submitting a responsive bid. Bids determined to be non-responsive may be rejected. Design drawings for the construction of the SWA-2 Project are available to download from the project website.

SITES OF WORK: The work will be performed in Riverton City and South Jordan City, Utah. The beginning point of the pipeline will connect to an existing 66-inch steel pipeline at 13390 South 3200 West with the ending point connecting to an existing 60-inch steel pipeline at 11800 South 3200 West. Work will also be performed at 11400 South 3200 West to construct a main-line valve vault on an existing 78-inch diameter pipeline.

AWARD OF CONTRACT: Owner reserves the right to reject any or all Bids, including without limitation, nonconforming, nonresponsive, unqualified, unbalanced, or conditional Bids. Owner will reject the Bid of any Bidder that Owner finds, after reasonable inquiry and evaluation, to not be responsible. If Bidder purports to add terms or conditions to its Bid, takes exception to any provision of the Bidding Documents, or attempts to alter the contents of the Contract Documents for purposes of the Bid, then the Owner will reject the Bid as nonresponsive; provided that Owner also reserves the right to waive all minor informalities not involving price, time, or changes in the Work.

If Owner awards a contract for the Work, such award shall be to the qualified Bidder submitting the lowest responsive Bid. Any such award will be made by written notice and within 60 calendar days after opening of the bids, unless a different waiting period is expressly allowed in the Notice Inviting Bids.

MATERIAL TESTING SERVICE AGREEMENT: Comment on the acceptability of the enclosed Material Testing Services Agreement (Agreement), Attachment A. Any suggested changes to the Agreement must be identified with the bid (as an attachment), although JVWCD reserves the right to reject any suggestions. No changes will be considered after the bid due date.

EXECUTION OF CONTRACT: The Bidder to whom the award is made shall secure all insurance required by the specifications within ten calendar days after receipt of the Notice of Award from the Owner. The Bidder to whom the award is made shall execute a written contract with the Owner on the form of agreement provided within ten calendar days after receipt of the Agreement from the Owner. Failure or refusal to enter into a contract as herein provided or to conform to any of the stipulated requirements in connection therewith shall be just cause for annulment of the award. If the successful bidder refuses or fails to execute the contract, the Owner may award the contract to the second lowest responsible bidder, or reject all bids and re-advertise the project for rebidding. If the second lowest responsible bidder refuses or fails to execute the contract, the Owner may award the contract to the third lowest responsible bidder.

BONDS: Bonds are **not** required for this material testing project.

ADDRESS AND MARKING OF BID: The envelope enclosing the bid shall be sealed and addressed to the Jordan Valley Water Conservancy District and delivered or mailed to 8215 South 1300 West, West Jordan, Utah 84088. The envelope shall be plainly marked in the upper left-hand corner with the name and address of the bidder and shall bear the words "Bid for," followed by the title of the Contract Documents for the work and the date and hour of opening of bids. Electronic bids shall be submitted to the engineering administrative assistant, ellisad@jvwcd.org as an email attachment with the words “Bid for,” followed by the title of the Contract Documents for the work and the date and hour of opening of bids in the subject line of the email.

PROJECT ADMINISTRATION: All questions relative to this project shall be directed to the Project Manager: Kevin Rubow, by email at KevinR@jvwcd.org or by telephone at (801) 565-4300.

PROJECT SPECIFICATIONS: Project specifications for the material testing and inspection services are provided in Attachment B.

OWNER'S RIGHTS RESERVED: The Owner reserves the right to reject any or all bids, to waive any informality in a bid, and to make awards in the interest of the Owner.

Owner/ Engineer
Jordan Valley Water Conservancy District
Project Manager: Kevin Rubow, PE
8215 South 1300 West
West Jordan, Utah 84088
Telephone: (801) 565-4300
Email: KevinR@jvwcd.org

JORDAN VALLEY WATER CONSERVANCY DISTRICT

INSTRUCTIONS TO BIDDERS

INSURANCE REQUIREMENTS: Prior to executing the Agreement, the bidder must furnish certificates of insurance to include the following policies. Please note that these insurance certificates are **not** due at the time of bid. The limits of liability for the insurance required in this project shall provide for not less than the following amounts or greater where required by Laws and Regulations:

1. Workers' Compensation

   A. State: Utah — Statutory

2. Comprehensive General Liability

   A. Bodily Injury (including completed operations and products liability):

$500,000	Each Occurrence
$1,000,000	Annual Aggregate
or a combined single limit of	$1,000,000

   B. Property Damage liability insurance including Explosion, Collapse and Underground coverages where applicable.

   C. Personal Injury, with employment exclusion deleted.

$1,000,000	Annual Aggregate

3. Comprehensive Automobile Liability:

   A. Bodily Injury

$500,000	Each Person
$1,000,000	Each Occurrence

   B. Property Damage:

$500,000	Each Occurrence
or combined single limit of	$1,000,000

BID

Bid Schedule A					
	Description	**Quantity**	**Unit**	**Unit Price**	**Amount**
	Labor for Testing & Inspections				
A1	Soil Technician	300	Hours		
A2	Concrete Technician	150	Hours		
A3	Asphalt Technician	120	Hours		
A4	Rebar Inspections	40	Hours		
A5	Project Management	80	Hours		
	Material Samples				
A6	Soil Proctors, Gradations and Associated Lab Testing	15	Each		
A7	Concrete Samples (5 cylinders, 1 air, 1 slump per sample)	50	Each		
A8	Concrete Shrinkage Samples (3 prisms per sample)	8	Each		
A9	Pipeline Trench CLSM Backfill Samples (5 cylinders per sample)	75	Each		
A10	Asphalt Sampling for Binder Content and Gradation	3	Each		
	Additional Items				
A11	Travel	300	Visits		
A12	Contingency for Additional Testing Services	1	Allowance	$15,000	$15,000

Total Bid Schedule A: **$**_____

Bidder (Company name): _____

By: _____ Dated: _____
(Signature)

Name: _____ Title: _____
(Print)

ATTACHMENTS TO THIS BID

The following documents are attached to and made a condition of this Bid:

1. Information Required of Bidder.

INFORMATION REQUIRED OF BIDDER

The Bidder shall furnish the following information. Failure to comply with this requirement may render the Bid non-responsive and subject to rejection. Additional sheets shall be attached as required. No bid for the work will be considered from a bidder who does not hold an active license in good standing applicable to the type of work bid upon at the time of submission of the bid.

Company's name: _____

Company's address: _____

_____

_____

Company's Primary Contact: _____

Email address of primary contact: _____

Telephone number of primary contact: _____

BIDDER REQUIREMENTS:

1. The bidder shall have:

   a) A valid Utah Business license.

   b) Special inspections services to be certified by the International Code Council (ICC) per building code requirements.

   c) Personnel available for this project with the appropriate certifications for the material testing and inspection services listed in the project specifications.

   d) Laboratory accredited by AASHTO, ASTM C1077, ASTM D3740, and ASTM D3666.

2. Utah Department of Commerce Information (Business License)
   Business Entity Number: _____
   Delinquent Date: _____

3. As necessary, attach to your bid technical information showing compliance with the scope of work and/or technical specifications.

Bid Schedule Description

A1 through A4: Hourly billing rate to provide on-site soil density testing, concrete sampling, asphalt density testing, and rebar inspection prior to concrete placement as designated in the project specifications. Travel time to the site to perform these services are to be included in this hourly rate. Overtime is defined as all hours in excess of eight hours per day, outside of the normal hours of 7:00 am to 5:00 pm Monday through Friday and all hours worked on weekends and holidays. Overtime rates to be 1.5 times the hourly rate listed in the Bid Schedule. For these tasks, assume all hours worked as regular, non-overtime, hours.

A5: Hourly billing rate to provide the project management services to manage the material testing and inspections for this project and to review and distribute testing reports to the project team.

A6: Unit cost to provide laboratory soil analysis of backfill material including proctor, gradation, and Atterberg Tests to assist in determining compaction requirements are being met by the contractor. The time required to collect the field samples is to be included in the hourly rate for A1 – Soil Technician.

A7: Unit cost for concrete sampling. Each sample includes five cylinders, one slump test, one air and temperature test, unit weight test, and compressive strength testing of concrete cylinders (6” by 12” cylinders) as designated in the project specifications. The time required to collect the field samples is to be included in the hourly rate for A2 – Concrete Technician. Sample concrete once each day when being placed but not less than one sample for each 50 cubic yards placed.

A8: Unit cost for concrete shrinkage sampling. Each sample includes three prisms for shrinkage testing including the laboratory analysis as designated in the project specifications. The time required to collect the field samples is to be included in the hourly rate for A2 – Concrete Technician.

A9: Unit cost for CLSM sampling. Each sample includes five cylinders and compressive strength testing of CLSM cylinders as designated in the project specifications. The time required to collect the field samples is to be included in the hourly rate for A2 – Concrete Technician. Sample CLSM once each day when being placed but not less than one sample for each 300 cubic yards placed.

A10: Unit cost for the laboratory analysis on the asphalt material to verify asphalt binder content and gradation of aggregate. The time required to collect the field samples included in the hourly rate for A3 – Asphalt Technician. Sample asphalt as directed by the Engineer during the asphalt placement.

A11: Total mileage cost per site visit to perform material testing or inspection services.

A12: Contingency to provide testing or services requested that are not included in the above description. Additional services must be authorized, scheduled, and approved by the Owner prior to testing being performed.

NOTICE OF AWARD

To: [Insert Testing Agency's Name and Address]

Re: Material Testing Services for the SWA-2 Project

You are hereby notified that the Owner has accepted your bid for the above referenced project in the amount of $_____.

Furnish the required Certificates of Insurance within ten calendar days from the date of this notice to you. An acknowledged copy of this Notice of Award, together with all future correspondence regarding this project, shall be sent to JVWCD's Project Manager: Kevin Rubow

When the Agreement is provided, sign and return it within ten calendar days from receipt of the agreement.

Dated this ____ day of _____, 20___.

_____
Shane Swensen, PE
Chief Engineer

ACCEPTANCE OF NOTICE

Receipt of the above Notice of Award is hereby acknowledged by:

_____

This _____ day of _____, 20___.

Signature: _____

Printed Name: _____

Title: _____

Attachment A

Material Testing Services Agreement

MATERIAL TESTING SERVICES AGREEMENT

This Agreement is made as of_____("Effective Date"), by and between the Jordan Valley Water Conservancy District, a Utah special district ("District"), and _____ a _____corporation qualified to do business and doing business in the State of Utah ("Testing Agency").

RECITALS:

A. District desires to obtain material testing and inspection services relating to _____;

B. Testing Agency represents it has the necessary expertise and experience to perform the services requested by the District, and that it is properly registered to do business in the State of Utah; and,

C. Testing Agency has submitted a proposal outlining its proposed scope of activities for performance and completion of the services, and the Testing Agency is willing to perform the services requested by the District, consistent with the terms of this Agreement.

TERMS:

The parties agree as follows:

ARTICLE I
DEFINITIONS

1.1 Unless the context requires otherwise, the terms defined in this Article shall, for all purposes of this Agreement and for all schedules attached or referenced, have the meanings specified as follows:

1.1.1 Agreement: This Material Testing Services Agreement, including attachments.

1.1.2 Project: The Project is described in attached Schedule A.

1.1.3 Testing Agency's Fee: The Testing Agency's compensation for performing services.

1.1.4 Hourly Billing Rate: The hourly fee which the Testing Agency charges for time expended on the Project. The hourly billing rate shall be considered full compensation for time expended on the Project. Specific hourly billing rates for the Project are identified in attached Schedule B.

ARTICLE II
TESTING AGENCY'S SERVICES

2.1 Basic Services: The Testing Agency shall complete those tasks and services identified in Schedule A.

2.2 Additional Services: The District and the Testing Agency recognize and agree that services not expressly set forth in Schedule A are not covered by the Testing Agency's Fee and are considered to be additional services. No additional services may be provided by the Testing Agency, and no compensation shall be paid therefore by the District, except upon written confirmation by the District as an amendment to this Agreement.

ARTICLE III
TIME TO COMPLETE

The Testing Agency's services, as defined in Article II, shall be completed in accordance with the following schedule:

_____

_____

ARTICLE IV
KEY PERSONNEL

The following key personnel shall perform the Testing Agency's services in the capacities assigned as follows:

_____

_____

_____

Any substitution of key personnel and/or changes in assignments from those shown must first be approved by the District in writing before such substitution or change may be made by the Testing Agency.

ARTICLE V
COMPENSATION

5.1 Basic Services: The District shall pay to the Testing Agency as compensation for services attributable to the Project, the hourly billing rates as set forth in Schedule B multiplied by the number of hours expended in providing services. In no event, however, shall the total amount due to the Testing Agency as compensation for services exceed _____ and _____/100 Dollars ($_____).

5.2 Additional Services: In the event this Agreement is amended to provide for additional services by the Testing Agency, the Testing Agency's compensation for additional services shall be the hourly billing rate multiplied by the hours expended for additional services.

5.3 Progress Payments: The Testing Agency's invoices for services performed shall be delivered to the District after the end of the first calendar month following the Effective Date of this Agreement, and monthly thereafter so long as the Testing Agency's services shall continue. The compensation requested on any such invoice shall be itemized to show the hourly billing rate multiplied by time charged to the Project actually incurred in the month identified in the invoice.

5.4 Payment of Invoice: The amount shown on each invoice for the Testing Agency's Fee shall be due and payable by the District on receipt of each such invoice. The Testing Agency may levy a simple interest charge of twelve percent (12%) per annum on invoice amounts not paid within forty-five (45) days of the date of delivery of the invoice. Late payments made by the District shall be credited first to accrued interest charges and then to principal.

ARTICLE VI
SPECIAL TERMS AND CONDITIONS

6.1 Conflict of Interest: The Testing Agency shall not establish or otherwise continue any conflict of interest created by virtue of this Agreement, which is prohibited under any law.

6.2 Termination Prior to Completion: This Agreement may be terminated at any time by the District prior to completion of the Testing Agency's services upon written notice to the Testing Agency. Upon receipt of such notice, the Testing Agency shall immediately stop any further work in progress, and in such event, the Testing Agency shall be entitled to payment for all of its services performed to the date of cancellation and for all work required to organize and deliver to the District the materials developed in the course of the Testing Agency's services. Payment shall be due to the Testing Agency within forty- five (45) days after delivery of such materials and receipt of a verified and itemized invoice therefore.

6.3 Indemnity and Insurance: The Testing Agency shall indemnify, defend, and hold the District harmless from any claims under the Workers' Compensation Act, and from any claims, demands, suits, causes of action, or liability for bodily injury, death, or damages to property, real or personal, to the extent caused by or resulting from breach of contract, negligence, recklessness or intentional misconduct by the Testing Agency or by negligence of the Testing Agency's subconsultants, in the performance of the Testing Agency's services under this Agreement. During the course of this Agreement, and for a period of four (4) years following substantial completion of the Testing Agency's services under this Agreement, the Testing Agency shall maintain comprehensive general liability insurance providing coverage for all liability arising out of the performance of services in connection with the Project and this Agreement and comprehensive automobile liability insurance. The general liability insurance shall include coverage for all services rendered for the Project and shall be written with a limit of liability of $500,000.00 per claim and an aggregate of $1,000,000.00. Automobile insurance shall provide coverage in the minimum amount of $500,000 per person and $1,000,000 per occurrence for bodily liability and $500,000 per occurrence or combined single limit of $1,000,000 for property damage.

ARTICLE VII
GENERAL TERMS AND CONDITIONS

7.1 Standards of Performance: The Testing Agency shall perform its services in a manner consistent with the skill and care ordinarily provided by other providers of the same or similar services in the same or similar locality at the same or similar time under the same or similar circumstances.

7.2 Force Majeure: Neither party shall hold the other responsible for damages or delays in performance caused by acts of God, strikes, lockouts, accidents, acts of any governmental entity having jurisdiction over the parties and/or the subject matter of this Agreement (other than those governmental entities named as parties or beneficiaries to this Agreement), or other events beyond the reasonable control of the other or the other's employees and agents. In the event either party claims that performance of its obligation is prevented or delayed by such cause, that party shall promptly notify the other party of that fact and the circumstances preventing or delaying performance.

7.3 Assignment: Neither the District nor the Testing Agency shall delegate and/or assign their respective duties and/or rights under this Agreement without the prior written consent of the other. The Testing Agency may subcontract, however, portions of its services as it deems necessary to efficiently accomplish the Basic Services. Nothing in this paragraph shall release the Testing Agency from full compliance with the terms and conditions of Article IV.

7.4 Severability; Waiver: In the event a court, governmental agency or regulatory agency with proper jurisdiction determines that any provision of this Agreement is

unlawful, that provision shall terminate. If a provision is terminated, but the parties can legally, commercially and practicably continue to perform this Agreement without the terminated provision, the remainder of this Agreement shall continue in effect. One or more waivers by either party of any provision, term, condition or covenant shall not be construed by the other party as a waiver of any subsequent breach of the same by the other party.

7.5 Governing Law: This Agreement shall be governed by, construed and enforced according to the laws of the State of Utah.

7.6 Merger; Amendments: This Agreement represents the entire and integrated agreement between the District and the Testing Agency, and supersedes all prior negotiations, representations or agreements, whether written or oral, regarding the subject matter contained in this Agreement. The Agreement may be amended only by written instrument executed by all parties.

7.7 Attorney's Fees: In the event of a default or breach of this Agreement, the defaulting party agrees to pay all costs incurred by the non-defaulting party in enforcing this Agreement, or in obtaining damages, including reasonable attorney's fees, whether incurred through legal proceedings or otherwise.

7.8 Notice: Any notice or communication to be given under this Agreement shall be deemed given when sent by registered or certified mail, return receipt requested, to the parties at their respective addresses stated below or to any other address when notice of such change of address has been given to the parties.

7.9 Third Party Beneficiaries: Nothing contained in this Agreement shall create a contractual relationship with a cause of action in favor of a third party against either the District or the Testing Agency. The Testing Agency's services under this Agreement are being performed solely for the District's benefit, and no other entity shall have any claim against the Testing Agency because of this Agreement or the performance or non-performance of services hereunder. The District agrees to use reasonable efforts to include a provision in all contracts with other contractors and other entities involved in the Project to carry out the intent of this paragraph.

"District":	"Testing Agency":
Jordan Valley Water Conservancy District 8215 South 1300 West West Jordan, UT 84088	_____ _____ _____
By: _____ Alan E. Packard Its General Manager/CEO	By: _____ Its: _____

SCHEDULE A

TESTING AGENCY'S SERVICES

SCHEDULE B

TESTING AGENCY'S COMPENSATION

Attachment B

Project Specifications

Southwest Aqueduct, Reach 2:
Materials Testing Specification Reference

BOWEN COLLINS & ASSOCIATES

Project: 010-23-02			*Date:*	*1/21/2025*
Owner: JVWCD			*Prepared by:*	*JAH*
No.	Item			Spec/Std
1 Compaction Testing				
1a	Compaction tests (trench zone, pipeline structures)			SWA-2 31 23 00
1b	Base course compaction tests			APWA 31 23 26 32 11 23
2 Asphalt Testing				
2a	Quality control and density tests			APWA 32 12 05
2b	Core Samples (If req'd for permanent asphalt placed during cold weather)			Riverton & South Jo. Stds
3 CLSM Testing				
3	CLSM compressive strength tests			SWA-2 31 23 00
4 Concrete Testing				
4a	Concrete slump, temperature, air content, unit weight tests (per pour)			SWA-2 03 30 00
4b	Concrete compressive strength cylinders cast and tested (five 6" ⌀ by 12" cylinders per pour)			SWA-2 03 30 00
4c	Concrete shrinkage test prisms (one 4" by 4" by 11" prism per structure)			SWA-2 03 30 00

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APPENDIX A – GEOTECHNICAL INVESTIGATION – JVWCD SOUTHWEST AQUEDUCT REACH 2, RB&G ENGINEERING, INC., JUNE 2024

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SF299-11400 SWA-2
SF299 – SWA-2

VOLUME 2 OF 2 – DRAWINGS

Drawings for Southwest Aqueduct Reach 2 – 13400 S to 11800 S (Bound Separately

END OF SECTION

SECTION 01 45 00
QUALITY CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. The requirements of this Section apply to, and are a component part of, each Section of the Specifications.

1.2 REFERENCES

A. ASTM International (ASTM) standards, most recent editions:

ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM D3740	Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 20 – Submittal Procedures.

B. Submit Quality Control Plan.

C. Submit credentials for field Quality Control Representative showing experience acceptable to Engineer.

D. Submit credentials for testing laboratory showing compliance with Specifications and acceptable to Engineer.

E. Submit results of testing as specified below.

1.4 SITE INVESTIGATION AND CONTROL

A. Check and verify all dimensions and conditions in the field continuously during construction. Be solely responsible for any inaccuracies built into the Work due to Contractor's (including Subcontractor's) failure to comply with this requirement.

B. Inspect related and appurtenant Work and report in writing to Engineer, any conditions which will prevent proper completion of the Work. Failure to report any such conditions constitutes acceptance of all Site conditions. Required removal, repair, or replacement caused by unsuitable conditions shall be performed at no additional cost to Owner.

1.5 INSPECTION OF THE WORK

A. Inspect all Work performed by both Contractor and Subcontractors. Nonconforming Work and any safety hazards in the work area shall be noted and promptly corrected. Be responsible for the Work to be performed safely and in conformance with the Contract Documents.

B. The Work shall be conducted under the general observation of Engineer and is subject to inspection by representatives of Owner acting on behalf of Owner to ensure strict compliance with the requirements of the Contract Documents. Such inspection may include mill, plant, shop, or field inspection, as required. Owner, Engineer, or any inspector(s) shall be permitted access to all parts of the Work, including plants where materials or equipment are manufactured or fabricated.

C. The presence of Engineer, or any inspector(s), shall not relieve Contractor of responsibility for the proper execution of the Work in accordance with all requirements of the Contract Documents. Compliance is the responsibility of Contractor. No act or omission on the part of Engineer, or any inspector(s) shall be construed as relieving Contractor of this responsibility. Inspection of Work later determined to be nonconforming shall not be cause or excuse for acceptance of the nonconforming Work. Owner may accept nonconforming Work when adequate compensation is offered, and it is in Owner's best interest as determined solely by Owner.

D. All materials and articles furnished shall be subject to rigid documented inspection by qualified personnel. No materials or articles shall be used in the Work until they have been inspected and accepted by Contractor's Quality Control Representative and Engineer or other designated representative. No Work shall be backfilled, buried, cast in concrete, covered, or otherwise hidden until it has been inspected. Any Work covered in the absence of inspection shall be subject to uncovering. Where uninspected Work cannot be easily uncovered, such as in concrete cast over reinforcing steel, all such Work shall be subject to demolition, removal, and reconstruction under proper inspection.

E. All Owner furnished materials and articles shall be subject to rigid inspection by Contractor's Quality Control Representative before being used or placed in the Work. Inform Engineer, in writing, of the results of said inspections within one working day after completion of inspection. If any material or articles provided by Owner are considered to be of insufficient quality for use in the Work, immediately notify Engineer.

1.6 TIME OF INSPECTION AND TESTS

A. Furnish and prepare samples and test specimens required under these Specifications and for testing in ample time for the completion of the necessary tests and analyses before said articles or materials are to be used. Furnish and prepare all required test specimens without additional expense to Owner. As provided in the Contract Documents, performance of certain tests will be by Owner, and all costs therefore will be borne by Owner, except that the costs of any test, which shows unsatisfactory results shall be back charged to Contractor.

B. Notify Engineer at least three Workdays before being ready to backfill, bury, cast in concrete, hide, or otherwise cover any Work under this Contract and request inspection before beginning any such Work of covering. Failure to notify Engineer at least three Workdays in

advance of any such inspections shall be reasonable cause for Engineer to order a sufficient delay in scheduled operations to allow time for such inspection. Be responsible for costs of any remedial or corrective work required, and all costs of such delays, including its impact on other portions of the Work.

1.7 SAMPLING AND TESTING

A. Unless otherwise specified, all sampling and testing shall be in accordance with the methods prescribed in the current standards of the ASTM, as applicable to the class and nature of the article or materials considered. However, Engineer reserves the right to use any generally-accepted system of inspection which, in the opinion of Engineer, will ensure Engineer that the quality of the workmanship is in full accord with the Contract Documents.

B. Owner reserves the right to waive tests or quality control measures. However, waiver of any specific testing or other quality control measure, whether or not such waiver is accompanied by a guarantee of substantial performance as a relief from the specified testing or other quality control requirements as originally specified, and whether or not such guarantee is accompanied by a performance bond to assure execution of any necessary corrective or remedial work, shall not be construed as a waiver of any technical or qualitative requirements of the Contract Documents.

C. Notwithstanding the existence of such waiver, Owner reserves the right to make independent investigations and tests as specified in the following paragraph and failure of any portion of the Work to meet qualitative requirements of the Contract Documents shall be reasonable cause for Owner to require the removal or correction and reconstruction of any such Work.

D. In addition to any other inspection or quality control provisions that may be specified, Owner reserves the right to independently select, test, and analyze, at the expense of Owner, additional test specimens of any or all the materials to be used. Results of such additional tests and analyses shall be considered along with the tests or analyses made by the Contractor to determine compliance with the applicable specifications for the materials so tested or analyzed provided that wherever any portion of the Work is discovered, as a result of such independent testing or investigation by Engineer, which fails to meet the requirements of the Contract Documents, all costs of such independent inspection and investigation and all costs of removal, correction, reconstruction, or repair of any such Work shall be borne by Contractor.

1.8 RIGHT OF REJECTION

A. Engineer or designated representative, acting for Owner, always reserves the right to reject any articles or materials furnished hereunder which, in any respect, fail to meet the requirements of the Contract Documents, regardless of whether the defects in such articles or materials are detected at the point of manufacture or after completion of the Work at the Site. If Engineer or designated representative, through an oversight or otherwise, has accepted materials or Work which are defective or in any way contrary to the Contract Documents, such materials, no matter in what stage or condition of manufacture, delivery, or erection, may be rejected.

B. Promptly remove or replace rejected articles or materials from the Site of the Work after notification of rejection.

C. Bear all costs of removal and replacement of rejected articles or materials.

D. Failure to promptly remove and replace rejected Work shall be considered a breach of this Contract and Owner may, after 7 days' notice, terminate Contractor's right to proceed with the affected Work and remove and replace the Work and issue a back charge to cover the cost of the Work.

1.9 QUALITY CONTROL REQUIREMENTS

A. Establish and execute a Quality Control program for the services, which are being provided. The program shall provide adequate measures for verification and conformance to defined requirements of all personnel, including lower-tier subcontractors (including fabricators, suppliers, and sub-subcontractors). Prepare and submit a plan responsive to this Section for review by Engineer.

B. Furnish Engineer with a project specific Quality Control Plan. The plan shall contain a comprehensive account of quality control procedures applicable to this Project. The detailed requirements for this Plan are delineated in the following paragraphs. No progress payments will be made until the Quality Control Plan is fully accepted by Engineer.

C. Using the Quality Control Plan, describe and define the personnel requirements described herein. Provide personnel with assigned quality control functions reporting to a field Quality Control Representative. The field Quality Control Representative shall report to a senior manager of Contractor and shall not have supervisory or managerial responsibility over the work force. Persons performing quality control functions shall have sufficient qualifications, authority, and organizational freedom to identify quality problems and to initiate and recommend solutions. Contractor's Quality Control representative(s) shall be on-site as often as necessary (but not less than the daily hours specified in the Contract Documents) to remedy and demonstrate that Work is being performed properly and to make multiple observations of all Work in progress. The Quality Control Plan shall include a statement by the senior manager designating the Quality Control Representative and specifying authorities delegated to the Quality Control Representative to direct cessation or removal and replacement of defective Work.

D. The Quality Control Plan shall ensure the achievement of adequate quality throughout all applicable areas of the contract. In the Quality Control Plan, describe the program and include procedures, work instructions and records. In addition, describe methods relating to areas that require special testing and procedures as noted in the Specifications.

E. Identification and Control of Items and Materials: Describe procedures in the Quality Control Plan to ensure that items or materials that have been accepted at the site are properly used and installed. Provide procedures for proper identification and storage, and to prevent the use of incorrect or defective materials.

F. Inspection and Tests: Provide written procedures defining a program for control of inspections performed. These procedures shall be described in the Quality Control Plan.

1. Inspections and tests shall be performed and documented by qualified individuals. At a minimum, "qualified" shall mean having performed similar quality control functions on similar type projects. Records of personnel experience, training and qualifications shall be maintained and made available for review by Engineer upon request.

2. Maintain and provide to Engineer, within two working days of completion of each inspection and test, adequate records of all such inspections and tests. Inspection and test results shall be documented and evaluated to ensure that requirements have been satisfied.
3. Procedures shall include:
    a. Specific instructions defining procedures for observing all Work in process and comparing this Work with the Contract requirements (organized by specification section).
    b. Maintaining and providing Daily Inspection Reports. Such reports shall, at a minimum, include the following:
        1) Item(s) inspected
        2) Quality characteristics in compliance
        3) Quality characteristics not in compliance
        4) Corrective/remedial actions taken
        5) Statement of certification
        6) QC Manager's signature
    c. Specific instructions for recording all observations and requirements for demonstrating through the reports that the Work observed complied, or a deficiency was noted and action to be taken.
    d. Procedures to preclude the covering of deficient or rejected Work.
    e. Procedures for halting or rejecting Work.
    f. Procedures for resolution of differences between the Quality Control Representative(s) and the production representative(s).
4. The Quality Control Plan shall identify all contractual hold/inspection points as well as any Contractor imposed hold/inspections points.
5. The Quality Control Plan shall include procedures to provide verification and control of all testing provided, including:
    a. Maintaining and providing to Engineer Daily Testing Records. Such records shall, at a minimum, contain the following:
        1) Item(s) tested
        2) Quality characteristics in compliance
        3) Statement of correctness & certification
        4) Quality characteristics not in compliance
        5) Corrective/remedial actions taken
        6) QC Manager's signature
    b. Individual test records will contain the following information:
        1) Item tested –item number and description
        2) Test results
        3) Test designation
        4) Test work sheet including location sample was obtained
        5) Acceptance or rejection
        6) Date sample was obtained
        7) Retest information, if applicable
        8) Control requirements
        9) Tester signature
        10) Testing QC staff initials
    c. Providing for location maps for all tests performed or location of Work covered by the tests.
    d. Maintaining copies of all test results.
    e. Ensuring Engineer receives independent copy of all tests.

f. Ensuring testing lab(s) are functioning independently and in accordance with the specifications.
g. Ensuring re-tests are properly taken and documented.

G. Control of Measuring and Test Equipment: Measuring and/or testing instruments shall be adequately maintained, calibrated, and adjusted to maintain accuracy within prescribed limits. Perform calibration at specified periods against valid standards traceable to nationally recognized standards and documented.

H. Supplier Quality Assurance: The Quality Control Plan shall include procedures to ensure that procured products and services conform to the requirements of the Contract Documents. Requirements of these procedures shall be applied, as appropriate, to lower-tier suppliers and/or Subcontractors.

I. Deficient and Nonconforming Work and Corrective Action: The Quality Control Plan shall include procedures for handling of deficiencies and non-conformances. Deficiencies and non-conformances are defined as documentation, drawings, material, equipment, and Work not conforming to the specified requirements or procedures. The procedure shall prevent non-conformances by identification, documentation, evaluation, separation, disposition, and corrective action to prevent recurrence. Conditions having adverse effects on quality shall be promptly identified and reported to the senior level management. The cause of conditions adverse to quality shall be determined and documented and measures implemented to prevent recurrence. In addition, at a minimum, this procedure shall address:
1. Personnel responsible for identifying deficient and non-complying items within the work.
2. How and by whom deficient and non-compliant items are documented “in the field”.
3. The personnel and process utilized for logging deficient and non-compliant work at the end of each day onto a Deficiency Log.
4. Tracking processes and tracking documentation for deficient and non-compliant items.
5. Personnel responsible for achieving resolution of outstanding deficiencies.
6. Once resolved, how are the resolutions documented and by whom.

J. Special Processes and Personnel Qualifications
1. The Quality Control Plan shall include detailed procedures for the performance and control of special process (e.g., welding, soldering, heat treating, cleaning, plating, nondestructive examination, etc.).
2. Personnel performing special process tasks shall have the experience, training, and certifications commensurate with the scope, complexity, or nature of the activity. They shall be approved by Engineer before the start of Work on the Project.

K. Audits: The Quality Control Plan shall provide for documented audits to verify that quality control procedures are being fully implemented by Contractor as well as its subcontractors. Audit records shall be made available to Engineer upon request.

L. Documented Control/Quality Records
1. Establish methods for control of Contract Documents, which describe how Drawings and Specifications are received and distributed to assure the correct issue of the document being used. The methods shall also describe how as-built data are documented and furnished to Engineer.

2. Maintain evidence of activities affecting quality, including operating logs, records of inspections and tests, audit reports, material analyses, personnel qualification and certification records, procedures, and document review records.
3. Quality records shall be maintained in a manner that provides for timely retrieval, and traceability. Quality records shall be protected from deterioration, damage, and destruction.
4. Provide a list with specific records as specified in the Contract Documents, which will be furnished to Engineer at the completion of activities.

M. Acceptance of Quality Control Plan: Engineer's review and acceptance of the Quality Control Plan shall not relieve Contractor from any of its obligations for the performance of the Work. Contractor's quality control staffing is subject to Engineer's review and continued acceptance. Owner, at its sole option, without cause, may direct Contractor to remove and replace the Quality Control Representative. No Work covered by the Quality Control Plan shall start until Engineer's acceptance of the Quality Control Plan has been obtained.

N. Engineer may perform independent quality assurance audits to verify that actions specified in the Quality Control Plan have been implemented. No Engineer audit finding or report shall in any way remove any requirements of this Contract.

1.10 TESTING SERVICES

A. All tests which require the services of a laboratory to determine compliance with the Contract Documents shall be performed by an independent commercial testing firm acceptable to Engineer. The testing firm's laboratory shall be staffed with experienced technicians, properly equipped and fully qualified to perform the tests in accordance with the specified standards.

B. Independent testing laboratory shall be accredited by the American Association of State Highway and Transportation Officials (AASHTO) for the tests they will perform and as appropriate for the Work being performed. The laboratory shall also be accredited under ASTM C1077, ASTM D3740, and ASTM D3666.

C. Engineer shall have the right to inspect work performed by the independent testing laboratory both at the project and at the laboratory. This shall include inspection of the independent testing laboratory's internal quality assurance records (quality assurance manual, equipment calibrations, proficiency sample performance, etc.).

D. Obtain Engineer's acceptance of the testing firm before having services performed. Pay all costs for these testing services.

E. Testing services provided by Owner, if any, are for the sole benefit of Owner. However, test results shall be available to Contractor. Testing necessary to satisfy Contractor's internal quality control procedures shall be the sole responsibility of Contractor.

F. Testing Services furnished by Contractor: Unless otherwise specified, and in addition to all other specified testing requirements, provide all testing services in connection with the following materials as required for Engineer's review:
1. Concrete materials and mix designs.
2. Embankment, fill, and backfill materials.

3. Quality control testing of all precast concrete.
4. All other tests and engineering data required for Engineer's review of materials and equipment proposed to be used in the Work.
5. In addition, the following quality control tests shall be performed by Contractor:
    a. Holiday testing of pipeline coatings.
    b. Air testing of field-welded joints for steel pipe or pipe cylinders and fabricated specials.
    c. All testing and inspection of welding work including, but not limited to, welding procedure qualifications, welder operator qualifications, all work performed by the certified welding inspector, all appropriate nondestructive testing of welds and all repair and retest of weld defects.

G. Testing Services furnished by Owner: Unless otherwise specified, Owner will provide quality control testing services in connection with the following materials and equipment incorporated in the Work.
1. Concrete and CLSM strength tests.
2. Moisture-density and relative density tests on embankment, fill, and backfill materials.
3. In-place field density test on embankments, fills, and backfill.
4. Vibration testing and monitoring when working near Jordan Aqueduct
5. Other materials and equipment as specified herein.
6. Testing, including sampling, shall be performed by Engineer or testing firm's laboratory personnel, in general manner and frequency indicated in the Specifications.
7. Furnish all sample materials and cooperate in the testing activities, including sampling. Interrupt the Work when necessary to allow testing, including sampling to be performed. There shall be no claim for an increase in Contract Price or Contract Times due to such interruption. When testing activities, including sampling, are performed in the field by the testing firm's laboratory personnel, furnish personnel and facilities to assist in the activities.
8. The testing firm's laboratory shall perform all laboratory tests within a reasonable time consistent with the specified standards and will furnish a written report of each test. Distribution of the reports shall be as directed by Engineer.

H. Transmittal of Test Reports: Written reports of tests and engineering data furnished for Engineer's review of materials and equipment proposed to be used in the Work shall be submitted per Section 01 33 20 - Submittal Procedures.

I. The testing firm retained for material field testing shall furnish an electroniccopy of written report of each test. Copies of each test report will be transmitted to Engineer within three Workdays after each test is completed. Consecutively number each report for each type of test.

J. Testing firm shall furnish an electronic copy of each field and laboratory quality control test to Contractor, Owner and Engineer

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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DIVISION 03
CONCRETE

SECTION 03 11 00
CONCRETE FORMING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish, fabricate, and install concrete formwork, bracing, shoring, supports, and falsework in accordance with Contract Documents.

B. Work includes installation of form ties, clips, supports and other appurtenances necessary to meet Specifications and produce finished concrete structures.

1.2 RELATED SECTIONS

A. Section 03 30 00 – Cast-In-Place Concrete

1.3 REFERENCES

A. American Concrete Institute (ACI) standards, most recent editions:

ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 317	Standard Tolerances for Concrete Construction and Materials
ACI 318	Building Code Requirements for Reinforced Concrete
ACI 347	Formwork for Concrete

B. National Sanitation Foundation (NSF), most recent edition:

NSF 61	Drinking Water System Components, Health Effects

C. U.S. Department of Commerce, National Institute of Standards and Technology, (NIST) standards, latest editions:

PS 1	Structural Plywood
PS 20	American Softwood Lumber Standard (ASLS)

1.4 SYSTEM DESCRIPTION

A. Be responsible for the design, engineering, construction, maintenance, and safety of all falsework, including staging, walkways, forms, ladders, and similar appurtenances, which shall equal or exceed the applicable requirements of the provisions of the OSHA Safety and Health Standards for Construction, and the requirements specified herein.

B. Design and construct falsework to provide the necessary rigidity and to support the loads imposed. Design falsework for the support of a superstructure to support the loads that would be imposed if the entire superstructure were placed at one time.

C. Falsework Calculations and Drawings: All falsework or vertical shoring installations where the height of the falsework or vertical shoring, as measured from the top of the sills to the soffit of the superstructure, exceeds 14 feet, or where individual horizontal span lengths exceed 16 feet, or provision for vehicular or railroad traffic through falsework or vertical shoring is made, shall be approved and signed by a civil or structural engineer, registered in the State of Utah. Always maintain a current copy of the falsework plan or shoring layout on the job site.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 20 – Submittal Procedures.

B. Shop Drawings: Submit detailed drawings of the falsework proposed to be used. Include drawings with sufficient detail to indicate the general layout, sizes of members, anticipated stresses, grade of materials to be used in the falsework, means of protecting existing construction which supports falsework, and typical soil conditions. Submittals shall include the following:
   1. Form ties and all related accessories, including taper tie plugs, if taper ties are used.
   2. Form gaskets.
   3. Form releasing agent, including NSF certification when applicable.
   4. List of form materials and locations for use.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise expressly accepted by Engineer, utilize new material for all lumber brought on the job site for use as forms, shoring, or bracing. Unless otherwise indicated, form surfaces are to be smooth and fabricated from the following materials:
   1. Walls: Steel or plywood panel.
   2. Roof and Floor: Plywood.
   3. All Other Work: Steel panels, plywood or tongue and groove lumber

B. Form materials which may remain or leave residues on or in the concrete that is in contact with potable water must be classified as acceptable for potable water under NSF 61 within 30 days of application or use.

2.2 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Form ties (general):
      1) Burke Penta-Tie, Burke Company.
      2) Richmond Snap-Tys, Richmond Screw Anchor Company.
      3) Gates Ties, Gates and Sons, Inc.
      4) Engineer approved equal.

2.3 FORM AND FALSEWORK MATERIALS

A. Provide materials for concrete forms, formwork, and falsework that conform to the following requirements:
   1. Lumber: Douglas Fir or Southern Yellow Pine, construction grade or better, in conformance with U.S. Product Standard PS 20.
   2. Plywood: New, waterproof, synthetic resin-bonded, exterior type Douglas Fir or Southern Yellow Pine plywood manufactured especially for concrete formwork, conforming to the requirements of PS 1 for Concrete Forms, Class I, edge sealed.
   3. Form materials: Metal, wood, plywood, or other approved material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line, and grade shown. Metal forms shall be an approved type that will accomplish such results. Wood forms for surfaces to be painted shall be Medium Density Overlaid plywood, MDO Ext. Grade.

B. Unless otherwise indicated, provide exterior corners in concrete members with 3/4-inch chamfers. Re-entrant corners in concrete members do not require fillets unless otherwise indicated.

C. Design forms and falsework to support the roof and floor slabs for the total dead load, plus a live load of 50 psf (minimum). The minimum design load for combined dead and live loads is 100 psf.

2.4 FORM TIES

A. Provide form ties with integral waterstops with a plastic cone on both sides of walls, or other suitable means for forming a conical hole to ensure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties, or of other removable form-tie fasteners having a circular cross-section, may not exceed 1-1/2 inches; and all such fasteners must leave holes of regular shape for reaming.

2.5 FABRICATION

A. Form tolerances: Provide forms in accordance with ACI 347, ACI 318, or 350 and the following tolerances.
   1. Wall tolerances:
      a. Straight wall surface:
         1) Exposed wall surface: Flat planes within tolerance specified.
         2) Plumb within 1/4 inch in 10 feet or within 1 inch from top to bottom for walls over 40 feet tall.
         3) Depressions in wall surface: Maximum 5/16 inch when 10-foot straightedge is placed on high points in all directions.
         4) Thickness: Maximum +1/4 inch or -1/2 inch from dimensions shown.
   2. Slab tolerances:
      a. Exposed slab surfaces: Comprise of flat planes as required within tolerances specified.
      b. Slab finish tolerances and slope tolerances: Crowns on floor surface not too high as to prevent 10-foot straightedge from resting on end blocks, no low spots that allow a block of twice the tolerance in thickness to pass under the supported 10-ft straightedge:

1) Steel gage block: 1/4 inch thick.

c. Finish slab elevation: Slope slabs to floor sumps, drains, and gutter, to drain regardless of tolerances.

d. Thickness: -1/4 inch or +1/2 inch from thickness shown, except when thickness tolerance will affect slope, drainage, or slab elevation.

3. For all other tolerances, refer to ACI 117.

4. Make transitions from plus to minus tolerances gradual, even, and smooth.

PART 3 - EXECUTION

3.1 GENERAL

A. Use forms to confine the concrete and shape it to the required lines wherever necessary. Assume full responsibility for the adequate design of all forms. Promptly remove any forms which are unsafe or inadequate in any respect from the Work and replaced at no increased cost to Owner. Provide worker protection from protruding reinforcement bars in accordance with applicable safety codes. Provide a sufficient number of forms of each kind to permit the required rate of progress to be maintained. The design and inspection of concrete forms, falsework, and shoring shall comply with applicable local, state, and federal regulations.

B. Install plumb and string lines before concrete placement and maintain during placement. These lines will be used by both Contractor and Engineer for control and verification of the form lines. Provide sufficient number, properly installed for that purpose. During concrete placement, continually monitor plumb and string line form positions and immediately correct deficiencies.

C. Conform to the shape, lines, and dimensions of members as called for on the Drawings, substantial and free from surface defects, and sufficiently tight to prevent leakage. Brace forms or tie them together to maintain their position and shape under a load of freshly placed concrete. If adequate foundation for shores cannot be secured, provide trussed supports.

3.2 FORM CONSTRUCTION

A. Construct forms in conformance with ACI 347.

B. Set forms true to the required shape and size and conform to the established alignment and grade. Provide sufficient strength and rigidity to maintain form position and shape under the loads and operations incident to placing and vibrating the concrete. Provide suitable and effective means on all forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Plywood, 5/8-inch and greater in thickness, may be fastened directly to studding if the studs are spaced close enough to prevent visible deflection marks in the concrete. Assemble the forms tight to prevent the loss of water, cement, and fines during placing and vibrating of the concrete. Specifically, provide the bottom of wall forms that rest on concrete footings or slabs with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1 to 1-1/2-inch diameter polyethylene rod held in position to the underside of the wall form. Provide adequate clean-out holes at the bottom of each lift of forms. The size, number, and location of such clean-outs must be as acceptable to Engineer. Whenever concrete cannot be placed from the top of a wall form in a manner that meets the requirements of the Contract Documents, provide pour

windows of the size and spacing needed to allow placement of concrete to the requirements of Section 03 30 00 - Cast-in-Place Concrete. Provide size, number, and location of such form windows acceptable to Engineer.

C. Vertical surfaces: Form all vertical surfaces of concrete members except where placement of the concrete against the ground is shown. Add no less than 1 inch of concrete to the thickness of the concrete member as shown where concrete is permitted to be placed against trimmed ground in lieu of forms. Such permission will be granted only for members of comparatively limited height and where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed and has set.

D. Construction joints: Concrete construction joints will not be permitted at locations other than those shown or specified, except as may be acceptable to Engineer. When a second lift is placed on hardened concrete, take special precautions to include the number, location, and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory affect on the concrete. Set pipe stubs and anchor bolts in the forms where required.

E. Form ties

1. Embedded Ties: Ream holes left by the removal of form tie cones with suitable toothed reamers to leave the surface of the holes clean and rough before being filled with mortar as specified for finish of concrete surfaces in Section 03 30 00 - Cast-in-Place Concrete. Wire ties for holding forms will not be permitted. Leave no form-tying device or part thereof, other than metal, embedded in the concrete. Do not remove ties in such manner to leave a hole extending through the interior of the concrete members. The use of snap-ties which cause spalling of the concrete upon form stripping or tie removal will not be permitted. If steel panel forms are used, provide rubber grommets where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods must remain embedded and must terminate not less than 2 inches back from the formed face or faces of the concrete.

3.3 REMOVAL OF FORMS

A. Employ careful procedures for the removal of forms to avoid injury to the concrete. No heavy loading on green concrete will be permitted. In the case of roof slabs and above-ground floor slabs, maintain forms in place until test cylinders for the roof concrete attain a minimum compressive strength of 75 percent of the 28-day strength specified in Section 03 30 00 - Cast-in-Place Concrete; provided, that no forms shall be disturbed or removed under an individual panel or unit before the concrete in the adjacent panel or unit has attained 75 percent of the specified 28-day strength and has been in place for a minimum of 7 days. The time required to establish said strength will be determined by Engineer who will make several test cylinders for this purpose from concrete used in the first group of roof panels placed. If the time so determined is more than the 7-day minimum, then that time will be used as the minimum length of time. Forms for all vertical walls and columns must remain in place at least 2 days after the concrete has been placed. Forms for all parts of the Work not specifically mentioned herein must remain in place for periods of time as determined by Engineer and ACI 347.

3.4 REUSE OF FORMS

A. Forms may be reused only if in good condition and only if acceptable to Engineer. Light sanding between uses will be required wherever necessary to obtain uniform surface texture on all exposed concrete surfaces. Exposed concrete surfaces are defined as surfaces which are permanently exposed to view.

3.5 MAINTENANCE OF FORMS

A. Maintain forms at all times in good condition, particularly as to size, shape, strength, rigidity, tightness, and smoothness of surface. Forms, when in place, must conform to the established alignment and grades. Before concrete is placed, thoroughly clean the forms to remove dirt and debris. Treat form surfaces with a non-staining mineral oil or other lubricant acceptable to Engineer. Remove excess lubricant before placing the concrete. Where field oiling of forms is required, perform the oiling at least 2 weeks in advance of their use. Take care to keep oil off the surfaces of steel reinforcement and other metal items embedded in concrete.

3.6 FALSEWORK

A. Place falsework on a solid footing, safe against undermining, and protected from softening. When the falsework is supported on timber piles, limit the maximum calculated pile loading to 20 tons. When falsework is supported on any portion of the structure which is already constructed, the load imposed by the falsework shall be spread, distributed, and braced to avoid any possibility of damage to the structure.

END OF SECTION

SECTION 03 20 00
CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish, fabricate, and install reinforcing steel as shown on Contract Documents.

B. Work includes installation of tie wires, clips, supports, and other appurtenances necessary to meet Specifications and produce finished concrete structures.

1.2 RELATED SECTIONS

A. Section 03 30 00 – Cast-In-Place Concrete

B. Section 03 60 00 - Grout

1.3 REFERENCES

A. American Concrete Institute (ACI) standards, most recent editions:

ACI 315	Details of Concrete Reinforcement
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures

B. American Welding Society (AWS):

D1.4	Structural Welding Code – Reinforcing Steel

C. ASTM International (ASTM) standards, most recent editions:

ASTM A615	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A706	Standard Specification for Low Alloy Steel Deformed Bars for Concrete Reinforcement
ASTM A775	Standard Specification for Epoxy-Coated Reinforcing Steel Bars
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

D. Concrete Reinforcing Steel Institute (CRSI) standards, most recent editions:

Placing Reinforcing Bars

Manual of Standard Practice

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 20 – Submittal Procedures.

B. Submit details of the concrete reinforcement steel and concrete inserts at the earliest possible date after receipt of the Notice to Proceed.

C. Include, but not limit to, the following:
   1. Complete bar schedule, bar details and erection drawings to conform to ACI 315.
   2. Each type of bar marked with identification corresponding to identification tag on bar.
   3. Length, type, and location of all splices.
   4. Erection drawings shall be clear, easily legible and to a minimum scale of:
      a. 1/4 inch = 1 foot.
      b. 1/8 inch = 1 foot if bars in each face are shown in separate views.
   5. Size and location of openings.

D. Furnish a certified Affidavit of Compliance issued by steel manufacturer that reinforcing steel furnished for project meets requirements of ASTM standards referenced herein, as applicable.

E. Do not use Contract Documents as erection drawings.

1.5 QUALITY ASSURANCE

A. Qualifications
   1. Welding operators, processes, and procedures to be qualified in accordance with AWS D1.4.
   2. Welding operators to have been qualified during the previous 12 months prior to commencement of welding.

B. Certifications
   1. Submit manufacturer's certification that products submitted meet requirements of standards referenced.

1.6 DELIVERY, STORAGE AND HANDLING

A. Comply with Section 01 25 10 - Products, Materials, Equipment and Substitutions.

B. Store reinforcing steel on wood supports in a manner that prevents it from coming in contact with the ground.

C. Store only bars with same identifying label in same stack.

D. Cover epoxy coated reinforcement for protection against both moisture and ultraviolet light and so that condensation does not form on the bars.

E. When handling coated bars, use systems with padded contact areas.

F. Thoroughly inspect coated steel after delivery to the job site and again after installation to ensure that it is not damaged.
   1. Repair damage with patching material meeting manufacturer's requirements.
   2. Promptly patch sheared ends and other cuts or exposed areas before detrimental oxidation occurs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Mechanical Couplers:
      a. Lenton Form Saver by Erico Products.
      b. Dowel Bar Splicer System by Richmond Screw Anchor Company.
      c. Engineer-approved equal.

2.2 REINFORCEMENT STEEL

A. Materials:
   1. Reinforcing bars: ASTM A615, Grade 60.
   2. Reinforcing bars to be welded: ASTM A706.
   3. Smooth dowels: ASTM A615, Grade 60 plain billet steel bars epoxy coated in accordance with ASTM A775. Provide slip dowel sleeves to allow longitudinal movement equal to joint width plus 1/4 inch.
   4. Slip Dowel Sleeve: One or two component Speed Dowel System as manufactured by Greenstreak, Inc., to accept #5 rebar x 12-inch-long slip dowels, including epoxy coating when specified herein or shown on Drawings.
   5. Welded wire fabric: ASTM A1064 and the details indicated; provided, that welded wire fabric with longitudinal wire of W4 size wire and smaller shall be either provided in flat sheets or in rolls with a core diameter of not less than 10 inches; and provided further, that welded wire fabric with longitudinal wires larger than W4 size shall be provided in flat sheets only.
   6. Spiral reinforcement: Cold drawn steel wire conforming to the requirements of ASTM A1064.
   7. Welding Electrodes: E90 meeting requirements of AWS D1.4.

B. Fabrication of Bars:
   1. Fabricate with cold bends conforming to recommended dimensions shown in ACI 318.
   2. Field fabrication will be allowed only if Contractor has equipment to properly fabricate steel to same tolerances as for shop fabrications.
   3. Attach identification tags with identifying mark.
   4. Contractor may at his option continue steel reinforcement through openings in walls and slabs, then field cut opening.

2.3 BOLSTERS, CHAIRS AND ACCESSORIES

A. Conform to ACI 315 and CRSI Manual of Standard Practice.

B. Provide spacers, bolsters, chairs, ties and other devices necessary to properly space, place, support, and fasten steel reinforcement in place during concrete placement.

C. Metal accessories shall be stainless steel with plastic coated tips where legs will be exposed in finished concrete surfaces. Color of plastic shall be grey to match concrete color.

D. Do not use rocks, broken bricks, wood blocks, or concrete fragments for support of steel reinforcement.

E. Support between Reinforcing Steel and Formed Exposed Surfaces: Metal bar chairs.

2.4 PRECAST CONCRETE BLOCK BAR SUPPORTS (DOBIES)

A. Supports between Reinforcing Steel for Roof Slabs: Concrete block prohibited.

B. Minimum Compressive Strength of Blocks: 5,000 psi in seven days.

C. Minimum Bearing Area: 9 square inches. Place as required to maintain specified clearances.

D. Wire ties shall be embedded in concrete block bar supports.

2.5 MECHANICAL COUPLERS

A. Provide mechanical couplers where shown and where approved by Engineer and in accordance with ACI building code standards. The couplers shall develop the full tensile strength of the bars being spliced at each splice (Type 2).

B. Where the type of coupler used is composed of more than one component, supply all components required for a complete splice. This shall apply to all mechanical splices, including those splices intended for future connections.

2.6 EPOXY GROUT

A. Epoxy for grouting reinforcing bars shall be specifically formulated for such application, for the moisture condition, application temperature, and orientation of the hole to be filled. Epoxy grout shall meet the requirements found in Section 03 60 00 - Grout.

2.7 FABRICATION

A. Tolerances:
   1. Sheared lengths: plus or minus 1 inch.
   2. Overall dimensions of stirrups, ties, and spirals: plus or minus ½ inch.
   3. All other bends: +0 inch, -½ inch.

B. Minimum diameter of bends measured on the inside of the rebar to be as indicated in ACI 318.

C. Ship all reinforcement to job site with attached plastic or metal tags.
   1. Place on each tag the mark number of the reinforcement corresponding to the mark number indicated on the shop drawings.
   2. Mark numbers on tags to be so placed that the numbers cannot be removed.

2.8 TESTING

A. Perform at mill for each heat.

B. If requested by Engineer, furnish samples of each type of welded splice used in the Work in a quantity and of dimensions adequate for testing.

C. At the discretion of Engineer, radiographic testing of direct butt-welded splices will be performed. Provide assistance necessary to facilitate testing. Repair any weld which fails to meet the requirements of AWS D1.4. The costs of testing will be paid by Owner; except, the costs of all tests which fail to meet specified requirements shall be paid by Contractor at no increase in cost to Owner.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Tolerances:
   1. Rebar Placement:
      a. Clear distance to formed surfaces: plus or minus ¼ inch.
      b. Minimum spacing between bars: ¼ inch.
      c. Top bars in slabs:
         1) Members 8 inches deep or less: plus or minus ¼ inch.
         2) Members between 8 inches and 2 feet deep: plus or minus ¼ inch.
         3) Members more than 2 feet deep: plus or minus ¾ inch.
      d. Crosswise of members: Spaced evenly within plus or minus 1 inch.
      e. Lengthwise of members: plus or minus 2 inches.
   2. Minimum clear distance between rebars:
      a. Walls, and slabs: Distance equal to rebar diameter or 1 inch, whichever is greater.

B. Minimum concrete protective covering for reinforcement, unless indicated otherwise on Contract Documents:
   1. Concrete deposited against earth: 3 inches.
   2. Formed surfaces exposed to weather or in contact with earth:
      a. 2 inches for reinforcing bars #6 or larger.
      b. 1½ inch for reinforcing bars less than #6.
   3. Formed surfaces exposed to any liquid: 2 inches for all rebar sizes.
   4. Interior surfaces:
      a. 1½ inch for beams, girders, and columns.
      b. ¾ inch for slabs, walls, and joists.

C. Splice steel to conform to Chapter 12 of ACI 318 or ACI 350 as applicable. Unless indicated otherwise on Contract Documents, provide splices for reinforcing as follows:
   1. Rebar:
      a. Lapped splices shall be not less than a Class B splice for reinforcement unless otherwise indicated.
      b. Mechanical splices shall be used whenever shown on the Contract Documents and may be used at other locations at Contractor's option. Such locations shall be shown specifically on the rebar shop drawings.

c. Welding:
   1) Perform welding of rebars in accordance with requirements of AWS D1.4.
   2) Have each welder place an approved identifying mark near each completed weld.

2. Welded wire fabric: Splice lap length measured between outermost cross wires of each fabric sheet shall not be less than 1 spacing of cross wires plus 2 inches, or less than 1.5 times the development length, nor less than 6 inches. Development length shall be as required for the basic development length for the specified fabric yield strength in accordance with Section 12 of ACI 318 or ACI 350.
3. Provide splices of reinforcing not specifically indicated or specified subject to approval of Engineer.

D. Placing Rebars
1. Assure that reinforcement at time concrete is placed is free of mud, oil, or other materials that may affect or reduce bond.
2. Reinforcement with rust, mill scale, or a combination of both will be accepted as being satisfactory without cleaning or brushing provided dimensions and weights including heights of deformations on a cleaned sample are not less than required by applicable ASTM specifications that govern the rebar supplied.
3. Rebar support:
   a. Support rebars and fasten together to prevent displacement by construction loads or placing of concrete.
   b. On ground, provide supporting concrete blocks.
   c. Over formwork, provide plastic-coated metal chairs, runners, boosters, spacers, hangers, and other rebar support. Only tips in contact with the forms need to be plastic coated.
   d. Bars additional to those shown on the Contract Documents, which may be found necessary or desirable by Contractor for the purpose of securing reinforcement in position, shall be provided by Contractor at his own expense.
   e. Tie securely at minimum of 33% of intersections with 16-gage or larger annealed iron wire.
   f. Accommodate placement of formed openings.
   g. Where parallel horizontal reinforcement in beams in indicated to be placed in two or more layers, rebars in the upper layers shall be placed directly above rebars in the bottom layer with clear distance between layers to be 1 inch. Place spacer rebars at 3 feet maximum centers to maintain the required 1-inch clear distance between layers.
   h. Extend reinforcement to within 2 inches of concrete perimeter edges. If perimeter edge is earth formed, extend reinforcement to within 3 inches of the edge.
   i. To insure proper placement, furnish templates for all column vertical bars and dowels.
   j. Provide splices of reinforcement not specifically indicated or specified subject to Engineer's approval.
   k. Do not bend reinforcement after embedding in hardened concrete unless approved by Engineer. Do not bend reinforcing by means of heat.
   l. Tie wires shall be bent away from form surfaces.
   m. Do not tack-weld reinforcement.

E. Ensure that steel reinforcement and embedments do not exceed 160 Degrees F at time of concrete placement.

3.2 FIELD QUALITY CONTROL

A. Reinforcement Congestion and Interfaces:
   1. Notify Engineer whenever the specified clearances between rebars cannot be met.
   2. Do not place any concrete until Engineer submits a solution to rebar congestion problem.
   3. Rebars may be moved slightly to avoid interference with other reinforcement steel, conduits, or embedded items.
   4. If rebars are moved more than 1 bar diameter, or enough to exceed above tolerances, obtain Engineer's approval of resulting arrangement of rebars.
   5. No cutting of rebars shall be done without written approval of Engineer.

B. Employ a testing laboratory to perform and report following:
   1. Review and approve Contractor proposed welding procedures and processes for conformance with AWS D1.4.
   2. Qualify welders in accord with AWS D1.4.
   3. Test three samples of each bar size and each type of weld in accord with AWS D1.4. The tensile strength of each test shall be not less than 125 percent of the required yield strength of the rebar tested.
   4. Conduct nondestructive field tests (radiographic or magnetic particle) on not less than one random sample for each 10 welds. In addition, if any welds are found defective, test five previous welds performed by the same welder.
   5. Visually inspect each weld for presence of cracks, undercuts, inadequate size, and other visible defects.

3.3 COORDINATION

A. Coordination with placement of formwork, formed openings, embedded items, and other Work.

END OF SECTION

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SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Provide cast-in-place concrete work as shown on Contract Drawings and as specified herein.

B. Section includes:
1. Concrete Materials.
2. Proportioning and Mixing.
3. Ready Mixed Concrete.
4. Curing Materials.
5. Expansion Joint Filler.
6. Elastomeric Bearings.
7. Waterstops.
8. Liquid Floor Hardener.
9. Preparing for Concreting.
10. Placing of Concrete.
11. Finishing.
12. Curing.
13. Field Quality Control.

1.2 RELATED SECTIONS

A. Section 03 11 00 – Concrete Forming.

B. Section 03 20 00 – Concrete Reinforcing.

C. Section 03 60 00 – Grouting.

D. Section 07 14 00 – Fluid-Applied Waterproofing.

1.3 REFERENCES

A. American Concrete Institute (ACI) standards, most recent editions:

ACI 117	Standard Tolerances for Concrete Construction and Materials
ACI 211	Standard Practice for Selecting Proportions for Concrete
ACI 212	Chemical Admixtures
ACI 301	Specifications for Structural Concrete for Buildings
ACI 305R	Guide to Hot Weather Concreting
ACI 306R	Guide to Cold Weather Concreting

ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures

B. ASTM International (ASTM) standards, most recent editions:

ASTM C31	Standard Specification Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specifications for Concrete Aggregates
ASTM C39	Test for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C94	Standard Specifications for Ready-Mixed Concrete
ASTM C138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C143	Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C260	Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C586	Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method)
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C827	Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1293	Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM D412	Test Methods for Rubber Properties in Tension
ASTM D746	Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D747	Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam
ASTM D1751	Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2240	Test Method for Rubber Property - Durometer Hardness
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate

C. International Concrete Repair Institute (ICRI) standards, latest editions:

Guideline No 310.1R	Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion
Guideline No 320.2R	Guide for selecting and specifying Materials for repair of Concrete Surfaces

D. NSF International (NSF), most recent edition:

NSF 61	Drinking Water System Components, Health Effects

E. U. S. Army Corps of Engineers standards, most recent editions:

CRD-C 572	PVC Waterstops

1.4 DEFINITIONS

A. Construction Joints: Fresh concrete placed against a hardened concrete surface; joint between two pours is called a construction joint. Unless otherwise indicated, provide construction joints with a waterstop and sealant groove of the shape indicated.

B. Expansion Joints: To allow concrete to expand freely, space provided between two pours, formed as indicated. Space is made by placing filler joint material against the first pour; acts as a form for the second pour.

C. Control Joints: Provide weakened plane in concrete, where shrinkage cracks will likely occur. A groove, shape and dimensions indicated in Drawings, formed or saw-cut in concrete. Groove is filled with joint sealant material.

D. Laitance: In placement of concrete, accumulation of small inert particles of cement and aggregate on surface, caused by excess of water that, when it evaporates, leaves a thin layer, causing weakened plane for subsequent pour.

E. Alkalis: Term "alkalis" referred to herein is defined as sum of percentage of sodium oxide and 0.658 times percentage of potassium oxide ($Na_20+0.658K_20$). These oxides shall be oxide content determined in accordance with ASTM C114.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 20 – Submittal Procedures.

B. Product data:
   1. Concrete mix design(s) proposed for use. Proposed concrete mix design submittal to include the following information:
      a. Sieve analysis and source identification of fine and coarse aggregates. Include sand equivalency.
      b. Source test results for aggregate organic impurities.
      c. Source test results for deleterious aggregate per ASTM standards.
      d. Proportioning of all materials.
      e. Type of cement with mill certificate for cement.
      f. Slump.
      g. Air Content.
      h. Brand, type, ASTM designation, and quantity of each admixture proposed for use.
      i. 28-day cylinder compressive test results of trial mixes per ACI 350 and as indicated herein.
      j. Shrinkage test results.
      k. Standard deviation value for concrete production facility.
   2. Manufacturer and type of joint filler, joint sealant, curing agent, and finishing aid.
   3. Waterstops:
      a. Provide manufacturer's current test reports with written material certification.

b. Provide samples of extruded or molded sections of each size or shape to be used in the Work. Samples shall represent in all aspects, the material to be furnished under this Contract.
c. Provide sample of fabricated cross-construction of each size or shape of waterstop to be used. Fabricate samples so that material and workmanship represent the materials to be furnished in the Work.
d. Provide manufacturer's written certification as an integral part of the shipping form, to show that the material shipped to Work meets or exceeds the physical property requirements specified.

4. Manufacturer and type of bonding and patching mortar and bonding adhesive used at construction joints.
5. Pour plan for concrete pour sequence.

1.6 CONCRETE CONFERENCE

A. A meeting to review the detailed requirements of the Contractor's proposed concrete design mixes and to determine the procedures for producing proper concrete construction shall be held no later than 14 days after the notice to proceed.

B. All parties involved in the concrete work shall attend the conference, including the following:
1. Contractor's representative.
2. Testing laboratory representative.
3. Concrete subcontractor.
4. Reinforcing steel subcontractor and detailer.
5. Concrete supplier.
6. Admixture manufacturer's representative.

C. The conference will be held at a mutually agreed upon time and place. Notify Engineer no less than 5 days prior to the date of the conference.

1.7 QUALITY ASSURANCE

A. Preconstruction Testing: Perform all preliminary and trial batch laboratory tests on cement, aggregates, and concrete.

B. Testing Agencies: The testing laboratory shall meet or exceed the requirements of ASTM C1077.

1.8 DELIVERY, STORAGE AND HANDLING

A. Comply with Section 01 25 10 - Products, Materials, Equipment and Substitutions.

B. Mixing, transporting, handling, placing, curing, and testing concrete in accordance with applicable ACI and ASTM specifications and as specified.

C. Storage of material:
1. Cement:
a. Protect cement from exposure to moisture until used.
b. Do not use if caked or lumpy.

c. Store sacked cement to permit access for inspection and sampling.

2. Aggregate:
   a. Store to prevent segregation and contamination with other sizes or foreign materials.
   b. Obtain samples for testing from aggregates at point of batching.
   c. Do not use frozen or partially frozen aggregates.
   d. Do not use the bottom 6 inches of stockpiles in contact with ground.
   e. Allow sand to drain until moisture content is uniform prior to use.
3. Admixtures:
   a. Protect from contamination, evaporation, freezing, or damage.
   b. Maintain within temperature range recommended by manufacturer.
   c. Completely mix solutions and suspensions prior to use.

D. Delivery:
1. Prepare a delivery ticket for each load of ready-mix concrete delivered to the project. Truck operator shall hand ticket to Engineer at time of delivery, which shows the following information for each load:
   a. Mix identification mark.
   b. Quantity delivered (by volume).
   c. Amount of each material in batch.
   d. Outdoor temperature in the shade.
   e. Time at which cement was added.
   f. Amount of water added at jobsite by Contractor.
   g. Amount of superplastisizer added where applicable.

1.9 SITE ENVIRONMENTAL REQUIREMENTS

A. When temperature is below 40°F or is likely to fall below 40°F during 24-hour period after placing concrete, heat materials, (not in excess of 140°F) including both water and aggregates and protect concrete so that temperature of the concrete is between 50°F and 90°F for 24-hour period after placing concrete.

B. During hot weather, shade materials from sun and use cool water so temperature of concrete does not exceed 90°F at time of placing concrete.

C. Placing of concrete is not permitted where, in opinion of Engineer, wind, rain or inadequate facilities furnished by Contractor prevents proper finishing or curing of concrete.

1.10 COORDINATION

A. Coordination with placement of reinforcing steel, embedded items, and other Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Expansion joint fillers:
    a. WR Meadows, Inc.
    b. NMW, Incorporated
    c. Rubberite Cypress Sponge Corporation
    d. Engineer approved equal.
2. Membrane Curing Compound.
    a. 1100-Clear, WR Meadows, Inc.
    b. Clear Resin Cure (J11w), Dayton Superior.
    c. L&M Cure R, L&M Construction Chemicals, Inc
    d. Engineer approved equal.
3. Evaporation Retardant:
    a. AquaFilm (J74), Dayton Superior.
    b. Eucobar, Euclid Chemical Company.
    c. MasterKure ER 50, Master Builders.
    d. Engineer approved equal.
4. Waterstops, Plastic Serrated Type:
    a. BoMetals, Inc.
    b. Durajoint, DCA Construction Products
    c. Greenstreak, Sika, Inc.
    d. Vinylex, Sika, Inc
    e. Engineer approved equal.
5. Waterstops, Plastic Adhesive Type:
    a. Lockstop, Sika, Inc.
    b. Synko-Flex, Henry Company
    c. Engineer approved equal.
6. Waterstops, Hydrophilic Type
    a. Ultraseal, Adeka, Inc.
    b. Adcor ES, WR Grace,
    c. Hydro-Flex, Henry Company.
    d. Hydrotite, Sika, Inc.
    e. Engineer approved equal.
7. Bonding agent:
    a. Armatek 110 EpoCem, Sika, Inc.
    b. Engineer approved equal.
8. Set Controlling Admixtures
    a. For air temperature at the time of placement over 80°F; set-retarding and hydration control:
        1) MasterSet Delvo, Master Builders.
        2) Recover, GCP Applied Technologies.
        3) SikaTard 440, Sika Corporation.
        4) Engineer approved equal.
    b. For air temperature at the time of placement under 40°F: Non-corrosive set accelerating:
        1) Daraset 400, GCP Applied Technologies.
        2) MasterSet FP 20, Master Builders.
        3) Plastocrete 161FL by Sika Corporation.
        4) Engineer approved equal.
9. Air-entraining Agent:
    a. MasterAir AE 200, Master Builders.

b. Daravair 1000, GCP Applied Technologies.
c. Sika AEA-15, Sika Corporation.
d. Engineer approved equal.

10. Finishing Aids:
    a. Day1 Finishing Aid, Solomon Colors.
    b. Slab Assist, TK Products.
    c. Engineer approved equal.
11. Crystalline Waterproofing Repair Grout:
    a. Mortar IC, AquaFin, Inc.
    b. Penecrete Mortar, Penetron International, LTD.
    c. Concentrate Dry Pac, Xypex Chemical Corporation.
    d. Engineer approved equal.
12. Pigments for Underground Conduit Banks:
    a. Arizona Oxides, #1835.
    b. Bayer, Bayferrox #130.
    c. Davis, #117.
    d. As currently approved by Rocky Mountain Power Company.
13. Liquid Chemical Floor Hardener:
    a. Surfhard, Euclid Chemical Company, Cleveland, Ohio.
    b. Burke-O-Lith, EDOCO.
    c. Solidus Hardener, Lambert Corporation.
    d. Engineer-approved equal.

2.2 MATERIALS

A. Blended Hydraulic Cement: Comply with ASTM C595, Type IL (10) (MS), grey color.
1. Cement shall not contain more than 0.60 percent equivalent alkalis.
2. Limestone content is limited to 10 percent.
3. Single brand of cement used throughout Work; brand approved by Engineer.

B. Fly Ash: ASTM C618, Class F including supplementary optional requirements relating to reactive aggregates and alkalis, and loss on ignition (LOI) not to exceed 5 percent.
1. Maximum of 25 percent replacement at 1.0 pounds of fly ash per pound of cement replaced.

C. Coarse Aggregate: Conforming to ASTM C33 and as noted below.
1. Clean, hard, durable gravel, crushed gravel, crushed rock or combination thereof.
2. Reactivity: Non-reactive or below innocuous behavior level.
3. Prepare and handle coarse aggregates in two or more size groups for combined aggregates with maximum size greater than 3/4 inch.
4. When aggregates are proportioned for each batch of concrete, combine the size groups.
5. Obtain coarse aggregates from sources approved by Engineer.

D. Combined Aggregates: Well graded from course to fine sizes; uniformly graded between screen sizes to produce a concrete that has optimum workability and consolidation characteristics. Where a trial batch is required for a mix design, the final combined aggregate gradation will be established during the trial batch process.

E. Fine Aggregates: Natural or combination of natural and manufactured sand that is hard and durable.
   1. Lightweight Sand for Fine Aggregate: Not permitted.
   2. Sand Equivalency: Tested in accordance with ASTM D2419; not less than 80 percent for an average of 3 samples; not less than 80 percent for an individual test.
   3. Gradation: In accordance with ASTM C33; 15 to 30 percent passing number 50 screen; 5 to 10 percent passing number 100 screen.
   4. Fineness Modulus: Not over 3.00.
   5. Reactivity: Non-reactive or below innocuous behavior level.
   6. Obtain fine aggregates from sources approved by Engineer.

F. Water: Clean and free from objectionable quantities of organic matter, alkali, salts, and other impurities, as determined by Engineer.

G. Admixtures:
   1. Maximum total water-soluble chloride ion content contributed from all ingredients of concrete including water, aggregates, cementitious materials, and admixtures by weight percent of cement:
      a. 0.06 For prestressed concrete.
      b. 0.10 For all other concrete.
   2. Do not use calcium chloride.
   3. Provide admixtures of same type, manufacturer, and quantity as used in establishing required concrete proportions in the mix design.
   4. Air entraining admixtures: ASTM C260.
   5. Water reducing admixtures:
      a. Comply with ASTM C494, Type A.
      b. Conform to applicable provisions of ACI 212.3R.
      c. Follow manufacturer's instructions.
      d. Use chloride free admixtures only.
   6. Set controlling admixtures with or without water-reducing properties.
      a. ASTM C494, Types B through E.
      b. Conform to applicable provisions of ACI 212.3R.
      c. Do not use retarding or accelerating admixtures unless specifically approved in writing by Engineer and at no additional cost to Owner.
      d. Follow manufacturer's instructions.
      e. Use chloride free admixtures only.
   7. High Range Water Reducers:
      a. In accordance with ASTM C494, Type F.
      b. Conform to applicable provisions of ACI 212.3R.
      c. Locations for use of high range admixtures shall be as shown on the Contract Drawings. Do not use high range admixtures in other locations unless specifically approved by Engineer and at no additional cost to Owner.
      d. Added at the plant unless written permission is given by Engineer to add the product at the Site.
      e. Mixing: Minimum 70 revolutions or 5 minutes after addition of high-range water reducer.
      f. Slump before Addition: Maximum 2 inches.
      g. Slump after Addition: Minimum of 6 inches and maximum of 10 inches.

8. Pigments for Underground Conduit Banks: Add pigment to concrete encasing electrical duct banks as required by governing agency.

H. Curing Materials

1. Polyethylene sheet for use as concrete curing blanket shall be white and shall have a nominal thickness of 6 mils. The loss of moisture when determined in accordance with the requirements of ASTM C156 shall not exceed 0.055 grams per square centimeter of surface.
2. Polyethylene-coated waterproof paper sheeting for use as concrete curing blanket shall consist of white polyethylene sheeting free of visible defects, uniform in appearance, having a nominal thickness of 2 mils and permanently bonded to waterproof paper conforming to the requirements of Federal Specification UU B 790A (1) (2). The loss of moisture, when determined in accordance with the requirements of ASTM C156, shall not exceed 0.055 gram per square centimeter of surface.
3. Polyethylene-coated burlap for use as concrete curing blanket shall be 4 mils thick, white opaque polyethylene film impregnated or extruded into one side of the burlap. Burlap shall weigh not less than 9 ounces per square yard. The loss of moisture, when determined in accordance with the requirements of ASTM C156, shall not exceed 0.055 gram per square centimeter of surface.
4. Membrane Curing Compound: ASTM C309, Type 1, Class B. Sodium silicate compounds will not be allowed.

I. Expansion Joint Filler

1. Provide expansion joints in concrete construction where shown on Contract Drawings.
2. Expansion Joint Filler: Preformed, non-extruding, resilient type, constructed of cellular sponge rubber, extending full thickness of slab, in accordance with ASTM D1752, Type I.

J. Grout: As specified in Section 03 60 00 – Grouting.

K. Waterstop, Plastic Serrated Type:

1. Extruded elastomeric polyvinyl chloride compound: containing plasticizers, resins, stabilizers, and other materials necessary to meet requirements of Specifications.
   a. Store waterstops to permit free circulation of air around waterstop material.
   b. Provide manufacturer's factory fabrications for intersections, transitions, and changes of direction.
   c. In accordance with Specification CRD-C572.

	VALUE	ASTM STD.
PHYSICAL PROPERTY, SHEET MATERIAL		
Tensile Strength-minimum (psi)	1750	D412, Die C
Ultimate Elongation-minimum (%)	350	D412, Die C
Low Temp. Brittle-maximum (°F)	-35	D746
Stiffness in Flexure-minimum (psi)	400	D747
ACCELERATED EXTRACTION (CRD-C572)		
Tensile Strength-minimum (psi)	1500	D412, Die C
Ultimate Elongation-minimum (%)	300	D412, Die C
EFFECT OF ALKALIES (CRD-C572)		

	VALUE	ASTM STD.
Change in Weight (%)	+.25/-.10	-----
Change in Durometer, Shore A	+5	D2240
FINISHED WATERSTOP		
Tensile Strength minimum (psi)	1400	D412, Die C
Ultimate Elongation minimum (%)	280	D412, Die C

d. Style:
   1) Flat Strip, 6 inches long unless noted otherwise.

L. Waterstop, Plastic Adhesive Type: Non expansive plastic adhesive strip type conformable, manufactured solely for the purpose of preventing water from passing through construction joints.
   1. Primer as recommended by waterstop manufacturer.

M. Waterstop, Hydrophilic Type: Expansive, conformable blended rubber-based material.
   1. Primer as recommended by waterstop manufacturer.

N. Liquid Chemical Floor Hardener:
   1. Colorless, aqueous solution containing magnesium fluosilicate combined with a wetting agent.
      a. Premeasured, premixed, and packaged at the factory.
      b. Not less than 2 pounds fluosilicate per gallon.
      c. Provide material which does not react with, inhibit, or otherwise interfere with adhesives and bonding of future floor finishes.

O. Elastomeric Bearing Materials:
   1. Rubber bearing pads shall be furnished with the dimensions, material properties, and elastomer grade as required by the Drawings and in accordance with ASTM D2240, Type A, Shore 30 or 40 Durometer.
   2. Prepare concrete support surfaces and adhere pads to concrete per manufacturer's recommendations.

P. Finishing Aids:
   1. Topically applied colloidal silica compound.
   2. Do not use as a curing compound.
   3. Only to be used to assist in finishing by working into the surface immediately after application.

Q. Waterproofing: Refer to Section 07 14 00 – Fluid-Applied Waterproofing.

2.3 EQUIPMENT

A. On-Site Batch Plants:
   1. Direct weighing equipment approved by Engineer for measuring cement and aggregate. Scales certified by Bureau of Weights and Measures. Certification current within 6 months.
   2. Equip mixer with suitable water meter or another measuring device approved by Engineer.

a. Meter capable of measuring water in variable amounts within a tolerance of 1 percent.
b. Water feed control mechanism capable of being locked in position to deliver constant supply of specified amount of water to each batch of concrete.
c. Meter equipped with setback register with a readily visible vertical face and double hands indicating in cubic feet and decimals.
d. Provide positive, quick-acting cut-off valve in the water line to the mixer. Operating mechanism must not leak when valves are closed.

3. Batch mixer of an approved type and size, designed to ensure uniform distribution of all component materials throughout the mass during the mixing operation. Install and use a batch timer and counter, including lock release and audible indicator on each concrete mixer.

B. Concrete Pumps:

1. Provide pumping equipment with two cylinders, designed to operate with only one cylinder in case one is not functioning. In lieu of this requirement, provide a standby pump on the site during pumping.
a. Minimum Diameter of Hose (conduit): 4 inches.
b. Aluminum conduits for conveying the concrete will not be permitted.

C. Vibrators:

1. Internally vibrated, high speed power vibrators of an approved immersion type. In sufficient numbers with standby units as required.

D. Truck Mixers:

1. At the Contractor's option, ready-mixed concrete may be used meeting the requirements as to materials, batching, mixing, transporting, and placing as specified herein and in accordance with ASTM C94, including the following supplementary requirements.
2. Ready-mixed concrete shall be delivered to the site of the Work, and discharge shall be completed within 90 minutes after the addition of the cement to the aggregates or before the drum has been revolved 250 revolutions, whichever is first.
3. Truck mixers shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may be readily verified. The counter shall be of the resettable, recording type, and shall be mounted in the driver's cab. The counters shall be actuated at the time of starting mixers at mixing speeds.
4. Mix each batch of concrete in a truck mixer for not less than 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.
5. Truck mixers and their operation shall be such that the concrete throughout the mixed batch as discharged is within acceptable limits of uniformity with respect to consistency, mix, and grading. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than one inch when the specified slump is 3 inches or less, or if they differ by more than 2 inches when the specified slump is more than 3 inches, the mixer shall not be used on the Work unless the causing condition is corrected and satisfactory performance is

verified by additional slump tests. All mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit, and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.

6. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the Engineer.

2.4 REINFORCEMENT STEEL

A. Provide in accordance with Section 03 20 00 – Concrete Reinforcing.

2.5 CONCRETE MIXES

A. General: Concrete shall be composed of cement, admixtures, aggregates, and water. These materials shall be of the qualities specified and in accordance with ACI 301 specifications. The exact proportions in which these materials are to be used for different parts of the Work will be determined during the trial batch. In general, the mix shall be designed to produce a concrete capable of being deposited so as to obtain maximum density and minimum shrinkage and, where deposited in forms, to have good consolidation properties and maximum smoothness of surface. The aggregate gradations shall be formulated to provide fresh concrete that will not promote rock pockets around reinforcing steel or embedded items. The proportions shall be changed whenever necessary or desirable to meet the required results at no additional cost to the Owner. All changes shall be subject to review by the Engineer.

B. Fine Aggregate Composition:

1. In mix designs for structural concrete, the percentage of fine aggregate in total aggregate by weight shall be as indicated in the following table:

Fineness Modulus	Maximum Percent
2.7 or less	41
2.7 to 2.8	42
2.8 to 2.9	43
2.9 to 3.1	44

2. In all other concrete, the maximum percentage of fine aggregate of total aggregate, by weight, shall not exceed 50.

C. Concrete compressive strength, aggregate size, and slump in accordance with the following:

Type of Construction	Compressive Strength (psi)	Aggregate Gradation (ASTM C33)	Slump in Inches (Max.)	Max W/C Ratio (by Weight)
Structure walls and top slabs.	4,500	#57 (1")	4	0.45
Structure footings; foundations and bottom slabs.	4,500	#467 (1-1/2")	4	0.45
Reinforced concrete encasements; thrust blocks	4,000	#467 (1-1/2")	4	0.50
Site Slabs; Curb and gutter	4,000	#57 (1")	4	0.50
Lean Concrete	3,000	#467 (1-1/2")	5	0.60
Site underground conduit banks: Min. 3 lbs red pigment/sack cement	3,000	#8 (3/8")	5	0.60

1. Compressive Strength: minimum at 28 days of age.
2. Slump as shown above, plus or minus 1 inch.
   a. When plasticizing agents are added at the Site, measure slump before addition of any plasticizing agents.
   b. Measure at point of discharge of the concrete from delivery truck per ASTM C143.
   c. Concrete of lower than maximum slump may be used provided it can be properly placed and consolidated.
3. Minimum cement content:
   a. Reinforced Concrete: Six sacks (564 lbs) Portland Cement per cubic yard.
   b. Unreinforced Concrete: Five sacks (470 lbs) Portland Cement per cubic yard.
4. Air content: Provide air entrainment resulting in a total air content of 4 to 7 percent for all types of construction.
   a. Air content to be measured in accordance with ASTM C231, ASTM C173, or ASTM C138.
   b. Air may be omitted from interior slabs to be trowel finished.

D. Selection of Proportions:
1. General: Proportion ingredients to produce proper workability, durability, strength, and other required properties. Prevent segregation and collection of excessive free water on the surface.
2. Pan stair fill:
   a. Coarse aggregate: 100 percent passing a 1/2-inch sieve.
   b. Proportions:
      1) One sack (94 lbs) cement.
      2) 150 pounds coarse aggregate.
      3) 150 pounds fine aggregate (sand).
      4) Adjust mix to obtain satisfactory finishing.
3. Submit mix design data for approval as required by this specification Section.
4. Proportion mixture to provide desired characteristics using one of the methods described below:
   a. Method 1 (Trial Mix): Per ACI 350, Chapter 5, except as modified herein.

1) Air content within range specified above.
2) Record and report the temperature of trial mixes.
3) Proportion trial mixes per ACI 211.1.

b. Method 2 (Field Experience): Per ACI 350, Chapter 5, except as modified herein.
1) Field test records must be acceptable to Engineer to use this method.
2) Test records shall represent materials, proportions, and conditions similar to those specified herein.

c. Required average strength to exceed the specified 28-day compressive strength by the amount determined or calculated in accordance with the requirements of ACI 350, using the standard deviation of the proposed concrete production facility.

5. Shrinkage Limitation
a. Shrinkage limitations apply only to structural concrete.
b. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-day drying age or at 28-day drying age shall be 0.036 percent or 0.042 percent, respectively per ASTM C157, as modified herein.
c. Use a mix design for construction that has first met the trial batch shrinkage requirements.

2.6 SOURCE QUALITY CONTROL

A. Trial Batch: Based on submitted concrete mixes for each class of concrete.

B. Aggregates:
1. Fine and coarse aggregates shall be tested in accordance with ASTM C1260 or ASTM C1293 to show compliance with ASTM C33 for alkali-silica reactivity and shall be non-reactive unless employing the following additional measures:
a. When the above test results show the aggregates to be reactive, and fly ash or other supplementary cementing material (SCM) is approved for use in order to control alkali-aggregate reactivity, the proposed concrete mixture shall be tested in accordance with ASTM C1567 and produce expansion results of less than 0.10 percent at 14 days.
b. When a lithium admixture is approved for use to control alkali-aggregate reactivity, the proposed concrete mixture shall be tested in accordance with ASTM C1293 and produce expansion results of less than 0.04 percent in one year.
2. The fine and coarse aggregates shall be tested in accordance with ASTM C586 to show compliance with ASTM C33 for alkali-carbonate reactivity and shall be non-reactive.
3. The fine aggregate shall be tested in accordance with ASTM C40 to show compliance ASTM C33 for organic impurities.
4. The fine and coarse aggregate shall be tested in accordance with ASTM C88 to show compliance with ASTM C33.
5. The fine and coarse aggregate shall be tested in accordance with ASTM C142 to show compliance with ASTM C33.
6. The fine and coarse aggregate shall be tested in accordance with ASTM C123 to show compliance with ASTM C33.

7. The fine and coarse aggregate shall be tested in accordance with ASTM C117 to show compliance with ASTM C33.
8. The coarse aggregate shall be tested in accordance with ASTM C131 to show compliance with ASTM C33.
9. In addition to initial aggregate testing, each type of aggregate shall be tested at no increased cost to the Owner for conformance to ASTM C33 under any of the following conditions:
    a. Concrete placement extending longer than six months.
    b. There is a noticeable change in aggregate appearance, consistency, or ease of excavation.
    c. The aggregate supplier changes pits, or locations in the original pit.
10. If the test results fail to meet the requirements of ASTM C33 and this Section, the Engineer may stop the placement of concrete, and may require additional testing of aggregates or field and trial batch testing of concrete to verify conformance to ASTM C33 and the strength and shrinkage requirements of this Section.
11. The Engineer may conduct any additional testing of aggregates at any time during the concrete placement period. Depending on the test results, testing cost will be paid by Contractor or Owner, according to the General Conditions. If test data fails to conform to ASTM C33, the Engineer may stop the placement of concrete or take corrective actions as indicated above.

C. Concrete Testing:
1. Concrete testing to be performed by certified laboratory under direction of professional engineer licensed to practice in the State of Utah. Submit test results to Engineer and obtain approval prior to placement of concrete.
2. When concrete mix design is done per ACI 350, Method 1, (Trial Mix) incorporate shrinkage testing as specified herein into the mix design for all structural concrete mixes.
3. When concrete mix design is done per ACI 350, Method 2, (Field Experience), provide three drying shrinkage with seven compressive strength test specimens for approval of structural concrete mixes, using the actual materials and proportions proposed for the mixes. Provide additional trial batch testing when required by Engineer because of unsatisfactory test results.
4. Test four compression test cylinders at 7 days and three at 28 days:
    a. Determination of compressive strength in units of psi will be made in accordance with ASTM C31.
    b. Test in accordance with ASTM C469.
    c. Modulus of elasticity determined by following formula:
        1) $Ec = 33 * W * 1.5\sqrt{f'c}$
            a) Ec = Modulus of Elasticity
            b) W = Weight of Concrete, lb/ft3.
            c) f'c = Required 28 day strength, psi.
5. Drying Shrinkage Tests:
    a. Perform drying shrinkage tests for the trial batch.
    b. Provide one set of three specimens from each class of structural concrete.
    c. Specimen Prisms: 4 inches by 4 inches by 11 inches with effective 10-inch gauge length, fabricated, cured, dried, and measured in accordance with ASTM C157, modified as follows:

1) Remove specimens from molds at an age of 23 plus/minus 1/2 hour after trial batching; place immediately in water at 73 plus/minus 1 degree F for 30 minutes; and measure within 30 minutes thereafter to determine original length.
2) Submerge in saturated lime water at 73 plus/minus 3 degrees F for 7 days.
3) Remove specimens from lime water and measure length at 7 days of age. This is the base length for drying shrinkage calculations ("0" days drying age).
4) After determining base length for drying shrinkage, store specimens immediately in a humidity control room maintained at 73 plus/minus 3 degrees F and 50 plus/minus 4 percent relative humidity for remainder of test.
5) Make measurements to determine shrinkage expressed as percentage of base length: Report separately for 0, 7, 14, 21, and 28 days of drying age, after 7 days of moist curing.

d. Drying shrinkage deformation of each specimen shall be computed as the difference between the base length (at "0" days drying age) and the length after drying at each test age.
1) If the drying shrinkage of any specimen departs from the average of that test age by more than 0.0004 inch, the results obtained from that specimen shall be disregarded.
2) Compression test specimens shall be taken in each case from the same concrete used for preparing drying shrinkage specimens.

PART 3 - EXECUTION

3.1 PREPARING FOR CONCRETING

A. Earth surfaces shall be thoroughly wetted by sprinkling, prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon. Surface shall be free from standing water, mud, and debris at the time of placing concrete.

B. Construct forms to the shape, lines and dimensions of members shown on Drawings and sufficiently tight to prevent leakage of mortar. Take special care when forming concrete containing high range water reducing agents. Brace and tie forms to maintain position and shape.
1. Before placing concrete containing superplastisizing agents, Contractor shall submit a Pour Plan to Engineer for approval. Engineer may require additional manpower or equipment for these pours as required to limit defects in the concrete. The Pour Plan shall include the following:
a. Number of crew members and assignment of each.
b. Number of vibrators to be used.
c. Number of vibrators in reserve.
d. Time of day and anticipated duration of pour.
e. Type and capacity of pumping equipment if used.

C. Provide slabs and beams of minimum indicated depth when sloping foundation base slabs or elevated floor slabs to drains.
   1. For slabs on grade, slope top of subgrade to provide floor slabs of minimum uniform indicated depth.
   2. Do not place floor drains through beams.

D. Unless otherwise indicated, provide exterior corners in concrete members with 3/4-inch chamfers. Re-entrant corners in concrete members shall not have fillets unless otherwise indicated.

E. Complete all formwork, installation of parts to be embedded, reinforcement and surface preparation prior to placing concrete.
   1. Use setting diagrams, templates, and instructions for locating and setting embedments and attachments.
   2. Prior to placing concrete, position and support pipe, conduit, dowels, and other ferrous items required to be embedded, to ensure clearance between items and any part of concrete reinforcement as specified below.
   3. Securing such items in position by welding to reinforcement is prohibited.
   4. Embedded electrical conduits and piping:
      a. Install pipe, conduits and their sleeves passing through slabs or walls so as not to impair the strength of the concrete member.
      b. Pipes and conduits larger than 3 inches in diameter may be embedded in structural concrete only after submittal and review of location and reinforcement details.
      c. Pipes and conduits may be installed without the specific permission noted in paragraph b. above as follows:
         1) They are 3 inches or less in diameter, are spaced not less than 3 diameters on center (horizontally and vertically) and conform to paragraph 2) and 3) below.
         2) Pipes and conduits, including their fittings, which are embedded within a column, do not displace more than 4% of the cross-sectional area within the reinforcing steel cage.
         3) Pipes, conduits, and their sleeves embedded within a wall or slab are not larger (outside dimension) than 1/3 the overall thickness of the wall or slab in which they are embedded.
         4) There is a minimum of 2 inches between the pipe or conduit and surface of the slab or wall.
      d. In walls and slabs with 2 layers of reinforcement, install pipes and conduits between layers of reinforcement as close to the middle of the concrete as practical without disturbing the reinforcement. Outside diameter of the pipe or conduit shall not exceed 1/3 the slab or wall thickness. Do not space parallel and crossing runs of pipe or conduit closer than 3 diameters on center, except at cabinet and outlet box locations.
      e. In slabs with a single layer of reinforcement, install under reinforcement steel with a minimum of 2 inches clear to the concrete surface.

F. Provide openings in formwork to accommodate other trades. Accurately place and securely support all items built into forms.

G. Waterstops:
   1. Preparation
      a. Uncoil waterstop minimum of 24 hours prior to installation for ease of handling and fabrication.
      b. Position waterstop to ensure proper distance from steel reinforcing bars and to prevent rock pockets and honeycomb.
      c. Clean concrete joint and waterstop after first pour to remove debris and dirt.
   2. Installation
      a. Position waterstop across joints as specified herein and as indicated on Drawings.
      b. Center waterstops on joint unless shown otherwise.
      c. When centerbulb is present at moving joints, ensure that it is not embedded.
      d. All waterstops fully continuous for the extent of the joint.
      e. Secure plastic serrated waterstop in correct position before concrete placement with hog rings and wire to adjacent reinforcing steel at 12-inch maximum spacing. Center-to-center spacing may be increased upon written request and approval of Engineer.
      f. Take suitable precautions and means to support and protect waterstops during the progress of the work.
      g. Carefully place concrete without displacing waterstop from proper position.
      h. For waterstops in slabs, limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift waterstop to confirm full consolidation without voids, then place remaining concrete to full height of slab.
   3. Field Splices
      a. Only butt splices are permitted in the field. Butt splices shall be made by the method of continuous heat welding using a manufacturer-approved waterstop welding iron.
      b. Splice PVC waterstops neatly and in accordance with manufacturer's written instructions.
      c. Excessive PVC weld spatter is not acceptable.
      d. A maximum of one splice is permitted in any straight 20 feet of waterstop.

H. Construction, Expansion, and Contraction Joints:
   1. Provide at locations indicated or as approved by Engineer.
   2. Install construction joints in beams, slabs, and girders perpendicular to the planes of their surfaces.
   3. At least 48 hours shall elapse between placing of adjoining concrete construction.
   4. Before new concrete is placed against existing concrete, coat all construction joints with an approved bonding adhesive used and applied in accordance with manufacturer's instructions.

I. Thoroughly clean surfaces of metalwork to be in contact with concrete immediately before concrete is placed.

J. Remove ponded water from the excavation and moisten fill.

K. Remove laitance, tighten forms, roughen, clean, wet and slush hardened concrete with cement grout prior to placing fresh concrete at construction joints. Coat form surfaces with form release agents prior to placing reinforcing bars in forms.

L. Cylinder Storage Device
   1. Provide and maintain a cylinder storage device at a protected location on the Site, acceptable to Engineer and as follows:
      a. Maintain concrete test cylinders at a temperature range of 60 degrees F to 80 degrees F for the initial 24-hour curing period.
      b. Once placed in the storage device, do not move the cylinders during this period.
      c. Equip the storage device with an automatic 24-hour temperature recorder that continuously records on a time/temperature chart with an accuracy of ±1 degree F.
      d. Have the storage device available at the point of use at least 24 hours before concrete placement.
      e. A 24-hour test run may be required before placement of concrete.
   2. Engineer may stop placement of concrete if the storage device is not functional or cannot accommodate the required number of test cylinders.
   3. Use water containing hydrated lime if water is to be in contact with cylinders.

3.2 PLACING CONCRETE

A. Notify Engineer not less than 24 hours in advance of the times and places at which Contractor intends to place concrete.

B. Place concrete in compliance with ACI Specifications and requirements of this Section.

C. Place concrete only in presence of duly authorized representative of Engineer.

D. Remove and replace concrete not placed as specified or of inferior quality, as determined by Engineer, and assume associated expense.

E. Ready Mix Equipment:
   1. Do not exceed manufacturer's rated capacity of the mixer.
   2. Ensure sufficient mixing time for uniform distribution of materials.
   3. Discharge all concrete from mixer prior to mixing new batch.
   4. In accordance with ASTM C94.

F. Transporting:
   1. Transport concrete from mixer to place of deposit by methods, which prevent segregation or loss of material.
   2. Provide runways when wheelbarrows are used to transport concrete.
   3. Do not wheel conveying equipment over reinforcement or support runways on reinforcement.

G. Placing:
   1. Deposit concrete in a continuous manner and as rapidly as possible within planned joints or sections.

2. Do not use concrete that has attained initial set or contained mixing water for more than 90 minutes.
3. Uniformly distribute concrete during process of depositing and in no case move deposited concrete in forms more than 6 feet in horizontal direction.
4. Do not drop freely more than 5 feet in unexposed work or more than 3 feet in exposed work; where greater drops are required, use duct or other approved method.
5. Do not place concrete against icy or frost covered earth surfaces.

H. Compacting:
1. Compact by internal type vibrators supplemented by rodding and tamping as necessary, to maximum practicable density, free from pockets of coarse aggregate in such a manner that surfaces are smooth and free from voids.
2. Avoid excessive vibration of concrete; avoid segregation of aggregates.
3. Avoid disturbance of previous lifts where initial set has taken place.
4. Use of form vibrators or tapping of forms is prohibited.

I. Finishing/Trowel Aid:
1. Use finishing/trowel aid on horizontal surfaces where identified on Contract Drawings. The product may also be used on other horizontal surfaces at Contractor's option.
2. Apply finishing/trowel aid directly in front of float or trowel operations and immediately finish into the concrete surface.

J. Temperature of Delivered Concrete:
1. Maximum 90 degrees F.
2. Minimum concrete temperature in accordance with following table:

Outdoor Temperature at Placement (In shade)	Concrete Temperature (At delivery to Site)
Below 30 Degrees F	65 Degrees F
Between 30 and 45 Degrees F	60 Degrees F
Above 45 Degrees F	50 Degrees F

3. Heating concrete ingredients: Heat ingredients to temperature no higher than necessary to maintain specified placement temperature of concrete; maximum of 80 Degrees F.
4. Methods of heating concrete ingredients subject to approval of Engineer.
5. Pre-cooling of ingredients: Cool ingredients as required to maintain specified placement temperature of concrete.
6. No additional compensation due to the foregoing requirements.

K. Concrete Protection:
1. Protect all concrete against physical injury until final acceptance by Owner.
2. Protect concrete from reduced strength due to weather extremes.
3. Protect concrete that is still plastic and whenever precipitation is imminent or occurring, as determined by Engineer.
4. When the temperature is below 40 Degrees F or is likely to fall below 40 Degrees F during the 24-hour period after placing the concrete, follow the recommendations of ACI 306R, except as modified herein.

a. Do not place concrete on frozen ground or in contact with forms or reinforcing bars coated with frost, ice, or snow.
b. After the mean daily temperature in the vicinity of the Project site falls below 40 degrees F for more than 1 day, maintain concrete at a temperature above 50 degrees F for at least 72 hours after it is placed, with additional requirements listed under Article 3.3 - Curing below.
c. When removing protection, do not allow concrete to cool suddenly.
d. Calcium chloride will not be permitted as a concrete accelerator or to thaw frozen subgrade prior to concrete placement.

5. When the temperature is 90 Degrees F or above, or is likely to rise above 90 Degrees F within the 24-hour period after concrete placement; or when there is any combination of high air temperature, low relative humidity, and wind velocity which would impair concrete strength or quality, follow the recommendations of ACI 305R and the following:
   a. Keep concrete as cool as possible during placement and curing.
   b. Do not allow concrete temperature to exceed 90 Degrees F at placement.
   c. Prevent plastic shrinkage cracking due to rapid evaporation of moisture.
   d. Dampen subgrade and forms with cool water immediately prior to placement of concrete.
   e. Apply an evaporation retardant per manufacturer's instructions between placement and finishing operations.
   f. Protect the concrete with temporary wet covering during any appreciable delay between placement and finishing.
   g. Take appropriate precautions per ACI 305R when the actual or anticipated evaporation rate equals or exceeds 0.2 LBS/SF/HR as determined from ACI 305R.

3.3 CURING

A. Cure concrete for not less than 14 days after placing as follows:
   1. Leave forms in place at least 14 days.
   2. Strictly follow careful procedures for the removal of forms and perform with care so as to avoid injury to the concrete. No heavy loading on green concrete will be permitted.
   3. Keep encasement concrete, concrete cradles and anchor blocks moist until covered. The surface shall be covered with moist earth not less than 4 hours, or more than 24 hours, after the concrete is placed. Earthwork operations that may damage the concrete shall not begin until at least 7 days after placement of concrete.
   4. Concrete slabs may be cured by either of the following two methods:
      a. Method 1:
         1) After finishing slab, wet surface with a fine spray of water and cover with polyethylene-bonded waterproof paper sheeting.
         2) Lap sheets 4 inches at sides and ends and seal with adhesive tape to form a continuous watertight joint.
         3) Weigh sheeting down with wood planks to keep sheeting in contact with concrete.
         4) Repair or replace sheets immediately if damage occurs.
      b. Method 2:

1) Cover concrete with water-saturated polyethylene-coated burlap curing mats and keep continuously wet for curing period.
2) Lap sheets 4 inches at sides and ends and seal with adhesive tape to form a continuous watertight joint.
3) Weigh sheeting down with wood planks to keep sheeting in contact with concrete.
4) Repair or replace sheets immediately if damage occurs.

B. As an alternative to above referenced curing methods for formed and slab concrete, spray surface with liquid curing compound that does not affect bond of paint to concrete surface.
1. Apply curing compound in accordance with manufacturer's instructions as soon as the concrete has hardened enough to prevent marring on unformed surfaces, and within 2 hours after completion of finish or stripping of forms, if stripped in less than 14 days.
a. Maximum coverage rate of 200 square feet per gallon, applied in such a manner as to cover surface with a uniform film to seal thoroughly.
2. Curing vertical surfaces with a curing compound:
a. Cover vertical surfaces with a minimum of two coats of the curing compound.
b. Apply the first coat of curing compound immediately after form removal. Vertical surface at the time of receiving the first coat shall be damp with no free water on the surface.
c. Allow the preceding coat to completely dry prior to applying the next coat.
d. Vertical surface is defined as any surface steeper than 1 vertical to 4 horizontal.
3. Curing Compound: As specified herein.
4. Take care to avoid damage to seal during curing period.
5. Repair broken or damaged seals occurring before expiration of curing period by application of additional curing compound over damaged portion.
6. Do not use curing film method where construction joints are to be made

C. In hot weather, follow curing procedures outlined in ACI 305R and the following:
1. Begin curing unformed surfaces immediately after finishing and continue for 24 hours. Curing shall consist of application and maintenance of water saturated material to all exposed surfaces; horizontal, vertical, and otherwise. After 24-hour interval, continue curing, using one of the following methods:
a. Moist cure for six more days.
b. Application of curing compound as specified above.
2. Begin curing formed concrete immediately after placing. Curing shall consist of keeping forms continuously wet for 24 hours. Thereafter, continue curing, using one of the following methods:
a. Loosen forms and position soaker hose so that water runs down along concrete surfaces. Continue for six more days.
b. Strip forms and apply during compound as specified for vertical surfaces above. Do not allow concrete surfaces to dry prior to application of curing compound.

D. In Cold Weather, following curing procedures outlined in ACI 306R and the following:
1. Water curing of concrete may be reduced to 6 days during periods when the mean daily temperature in the vicinity of the worksite is less than 40 degrees F; provided

that, during the prescribed period of water curing, when temperatures are such that concrete surfaces may freeze, water curing shall be temporarily discontinued.

2. Concrete cured by an application of curing compound will require no additional protection from freezing if the protection at 50 Degrees F for 72 hours is obtained by means of approved insulation in contact with the forms or concrete surfaces; otherwise, the concrete shall be protected against freezing temperatures for 72 hours immediately following 72 hours protection at 50 Degrees F. Concrete cured by water curing shall be protected against freezing temperatures for 72 hours immediately following the 72 hours of protection at 50 Degrees F.
3. Discontinuance of protection against freezing temperatures shall be such that the drop in temperature of any portion of the concrete will be gradual and will not exceed 40 Degrees F in 24 hours. In the spring, when the mean daily temperature rises above 40 Degrees F for more than 3 successive days, the specified 72-hour protection at a temperature not lower than 50 degrees F may be discontinued for as long as the mean daily temperature remains above 40 Degrees F; provided, that the concrete shall be protected against freezing temperatures for not less than 48 hours after placement.
4. Where artificial heat is employed, special care shall be taken to prevent the concrete from drying. Use of unvented heaters will be permitted only when unformed surfaces of concrete adjacent to the heaters are protected for the first 24 hours from an excessive carbon dioxide atmosphere by application of curing compound; provided, that the use of curing compound for such surfaces is otherwise permitted by these Specifications

3.4 TREATMENT OF SURFACE DEFECTS

A. As soon as forms are removed, all exposed surfaces shall be carefully examined, and any irregularities shall be immediately rubbed or ground in a satisfactory manner in order to secure a smooth, uniform, and continuous surface. Plastering or coating of surfaces to be smoothed will not be permitted. No repairs shall be made until after inspection by the Engineer. In no case will extensively patching honeycombed concrete be permitted. Concrete containing minor voids, holes, honeycombing, or similar depression defects shall have them repaired as specified herein. Remove and replace concrete containing extensive voids, holes, honeycombing, or similar depression defects. Promptly execute all repairs and replacements herein specified at no additional expense to Owner.

B. Perform all repairs in accordance with the manufacturer's recommendations and with ICRI Guideline No 310.1R and Guideline No 320.2R. Follow these guidelines for removal geometry, exposing and undercutting reinforcing steel, cleaning and repair of reinforcing steel, and edge and surface condition of concrete, regardless of the amount of corrosion present or not present in the reinforcing steel.
   1. Remove unsound deteriorated concrete from Work by high pressure water blasting machines capable of scoring concrete surfaces to minimum amplitude roughness of 3/16-inch. Remove to provide for minimum thickness specified for mortar. If reinforcing is exposed in this process, remove additional concrete until the surface is a minimum of 1-inch or 1 bar diameter behind the exposed reinforcing.
   2. Clean exposed reinforcing bars of rust and other deleterious materials which may prevent bonding of the repair product.
   3. Keep surface at saturated surface dry (SSD) condition for a minimum of 24-hours prior to placement of repair material.

4. Place and cure repair grout as specified in Section 03 60 00 – Grouting and in accordance with manufacturer's written recommendations.
5. For exposed walls, include a portion of white Portland cement as required to make the color of the patch match the color of the surrounding concrete.

C. Ream holes left by tie-rod cones with suitable toothed reamers to leave the surfaces of the holes clean and rough. Repair these holes in an approved manner with dry-packed cement grout specified in Section 03 60 00 - Grouting. Do not ream holes left by form-tying devices having a rectangular cross-section, and other imperfections having a depth greater than their least surface dimension but repair them in an approved manner with dry-packed cement grout specified in Section 03 60 00 - Grouting.

D. Build up and shape repairs in such a manner that the completed Work will conform to the requirements of this Section, as applicable, using approved methods which will not disturb the bond, cause sagging, or cause horizontal fractures. Cure surfaces of said repairs as required for the concrete in the repaired section.

E. Prior to filling any structure with water, repair all cracks that may have developed by grooving and filling as shown on the Contract Drawings. Perform this repair method on the water bearing face of members. Prior to backfilling, repair cracks on faces of members in contact with fill, which are not covered with a waterproofing membrane, as specified herein.

3.5 PATCHING HOLES IN CONCRETE

A. Patching Small Holes
1. Fill holes which are less than 12 inches in their least dimension and extend completely through concrete members, as specified herein.
2. Fill small holes in members which are water-bearing or in contact with soil or other fill material, with nonshrink grout specified in Section 03 60 00 - Grouting. Where a face of the member is exposed to view, hold the nonshrink grout back 2 inches from the finished surface. Patch the remaining 2 inches according to the paragraph in Part 3 entitled "Treatment of Surface Defects."
3. Fill small holes through all other concrete members with nonshrink grout, with exposed faces treated as above.

B. Patching Large Holes
1. For holes which are larger than 12 inches in their least dimension, provide a keyway chipped into the edge of the opening all around, unless a formed keyway exists. Fill holes with concrete as specified herein.
2. For holes which are larger than 24 inches in their least dimension and which do not have reinforcing steel extending from the existing concrete, set reinforcing steel in drilled holes and epoxy grout as specified in Section 03 60 00 – Grouting. Match the reinforcing added to the reinforcing in the existing wall unless otherwise shown.
3. For large holes in members which are water bearing or in contact with soil or other fill, place either a hydrophilic type or a plastic adhesive type waterstop material around the perimeter of the hole as specified herein, unless there is an existing waterstop in place.

3.6 CONCRETE FINISH

A. General: Provide surfaces free from fins, bulges, ridges, offsets, honeycombing, or roughness of any kind, with finished, smooth, continuous hard surface. Allowable deviations from plumb or level and from the alignment, profiles, and dimensions shown are defined as tolerances and are specified herein. These tolerances are to be distinguished from irregularities in finish as described herein.

B. Do not use aluminum finishing tools.

C. Formed Surfaces:
   1. Exterior buried surfaces require no treatment after form removal except for curing, repair of defective concrete, and treatment of surface defects.
   2. Finish surfaces exposed to view as specified under "Architectural Concrete Finish" below.

D. Surface holes larger than 1/2 inch in diameter or deeper than 1/4-inch are defined as surface defects in basins and exposed walls.

E. Unformed Surfaces: After proper and adequate vibration and tamping, bring all unformed top surfaces of slabs, floors, walls, and curbs to a uniform surface with suitable tools. Immediately after the concrete has been screeded, treated with a liquid evaporation retardant. Use the retardant again after each operation as necessary to prevent drying shrinkage cracks. The classes of finish specified for unformed concrete surfaces are designated and defined as follows:
   1. Finish U1 – Sufficient leveling and screeding to produce an even, uniform surface with surface irregularities not to exceed 3/8 inch. No further special finish is required.
   2. Finish U2 After sufficient stiffening of the screeded concrete, float finish surfaces with wood or metal floats or with a finishing machine using float blades. Excessive floating of surfaces while the concrete is plastic and dusting of dry cement and sand on the concrete surface to absorb excess moisture will not be permitted. Minimize floating as necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities are limited to 1/4-inch. Tool joints and edges where shown or as determined by the Engineer.
   3. Finish U3 After the floated surface (as specified for Finish U2) has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel trowel with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface free from blemishes, ripples, and trowel marks. Provide finish that is smooth and free of all irregularities.
   4. Finish U4 Steel trowel finish (as specified for Finish U3) without local depressions or high points. In addition, lightly broom the surface with broom lines perpendicular to drainage unless otherwise shown. The resulting surface shall be rough enough to provide a nonskid finish.

F. Floor Hardener:
   1. Apply to all exposed concrete floor surfaces.
   2. Apply after concrete has cured minimum 7 days.
   3. Apply in accordance with manufacturer's recommendations.

4. Keep floors covered and free of traffic and loads for a minimum of 10 days after completion.

3.7 ARCHITECTURAL CONCRETE FINISH

A. General: Architectural finish is required for permanently exposed concrete surfaces and in other locations where specifically called out on the Contract Drawings.
   1. Immediately after the forms have been stripped, inspect the concrete surface, and repair any poor joints, voids, rock pockets, or other defective areas. Fill all form-tie holes as indicated herein.
   2. Do not apply architectural finishes until the concrete surface has been repaired as required and the concrete has cured at least 14 days.
   3. Conform all architecturally treated concrete surfaces to the accepted sample required herein in texture, color, and quality. Maintain and protect the concrete finish.

B. Smooth Concrete Finish
   1. Wet the concrete surface and apply grout with a brush. Use grout made by mixing one part Portland cement and one part fine sand that will pass a No. 16 sieve with sufficient water to give it the consistency of thick paint. Use 1/2 gray and 1/2 white Portland Cement as determined by Engineer. Vigorously rub the freshly applied grout into the concrete surface with a wood float filling all small air holes. After all the surface grout has been removed with a steel trowel, allow the surface to dry and, when dry, vigorously rub with burlap to remove completely all surface grout so that there is no visible paint-like film of grout on the concrete. Complete the entire cleaning operation for any area the day it is started and leave no grout on the surface overnight.
   2. Terminate cleaning operations for any given day at panel joints. It is essential that the various operations be carefully timed to secure the desired effect which is a light-colored concrete surface of uniform color and texture without any appearance of a paint or grout film.
   3. If improper manipulation results in an inferior finish, rub such inferior areas with carborundum bricks.
   4. Before beginning any of the final treatment on exposed surfaces, treat in a satisfactory manner, a trial area of at least 200 square feet in some inconspicuous place selected by the Engineer and preserve said trial area undisturbed until the completion of the job.

3.8 WATERPROOFING

A. Apply waterproofing to exterior surface of all buried roof slabs and walls of underground concrete structures.

B. Refer to Section 07 14 00 – Fluid-Applied Waterproofing.

3.9 TOLERANCES:

A. Construction Tolerances: Set and maintain concrete forms and perform finishing operations so as to ensure that the completed Work is within the tolerances specified herein. Surface defects and irregularities are defined as finishes and are to be distinguished from tolerances.

Tolerance is the specified permissible variation from lines, grades, or dimensions shown. Where tolerances are not stated in the Specifications, permissible deviations will be in accordance with ACI 117.

1. The following non-cumulative construction tolerances are hereby established and apply to finished walls and slab unless otherwise shown:

Item	Tolerance
Variation of the constructed linear outline from the established position in plan.	In 10 feet: 1/4 inch In 20 feet or more: 1/2 inch
Variation from the level or from the grades shown.	In 10 feet: 1/4 inch In 20 feet or more: 1/2 inch
Variation from plumb.	In 10 feet: 1/4 inch In 20 feet or more: 1/2 inch
Variation in the thickness of slabs and walls.	Minus 1/4 inch Plus 1/2 inch
Variation in the locations and sizes of slabs and wall openings.	Plus or minus 1/4 inch

3.10 FIELD QUALITY CONTROL

A. General

1. Tests on component materials and for slump, temperature, air content, unit weight, compressive strength and shrinkage of concrete will be performed as specified herein.
2. The cost of all laboratory tests for qualification of mix designs on cement, aggregates, and concrete, including strength and shrinkage testing will be borne by Contractor. The cost of all field-testing during construction, including slump, temperature, air, strength, and shrinkage will also be borne by Owner. However, Contractor will be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications.
3. Provide access for Engineer to aggregate stockpiles for concurrent sampling during construction.
4. Provide access for Engineer to batch plant for monitoring batching procedures during construction.
5. Supply concrete for testing at no additional cost to Owner. Assist Engineer in obtaining samples, and disposal and cleanup of excess material.
6. Take composite samples of concrete placed in the Work in accordance with ASTM C172 from the first placement of each class of concrete and at the following minimum frequency for each class:
    a. Not less than one sample per day on which concrete is placed.
    b. Not less than one sample for each 50 cubic yards of concrete placed.
    c. Not less than one sample for each 5,000 square feet of surface area for slabs or walls.
    d. Not less than 5 samples from randomly selected batches for the Work.

B. Slump Tests

1. Perform in accordance with requirements of ASTM C143 at frequency indicated for sampling above.

C. Temperature Tests
   1. Test concrete temperature per ASTM C1064 at frequency indicated for sampling above.

D. Air Content Tests
   1. Test air content per ASTM C231 at frequency indicated for sampling above.

E. Unit Weight
   1. Test unit weight per ASTM C138 at frequency indicated for sampling above.

F. Shrinkage Tests
   1. Drying shrinkage tests will be made for the first placement of each class of structural concrete, and during construction every 3 months to ensure continued compliance with these Specifications. Make A minimum of 1 test per structure shall be made regardless of the timing.
   2. Drying shrinkage specimens shall be 4-inch by 4-inch by 11-inch prisms with an effective gage length of 10 inches, fabricated, cured, dried, and measured in accordance with ASTM C157 as modified in this Section.
   3. The maximum concrete shrinkage for specimens cast in the field may not exceed the trial batch maximum shrinkage test value by more than 25 percent.
      a. If the required shrinkage limitation is not met during construction, take any or all the following actions, at no additional cost to the Owner, for securing the specified shrinkage requirements. These actions may include changing the source or aggregates, cement and/or admixtures; reducing water content; washing of aggregate to reduce fines; increasing the number of construction joints; modifying the curing requirements; or other actions designed to minimize shrinkage or the effects of shrinkage.

G. Field Compression Tests
   1. Field compression test specimens will be made at the frequency indicated for sampling above.
   2. Each set of test specimens will be a minimum of five cylinders.
   3. Make compression test specimens for concrete in accordance with ASTM C31. Specimen size: Cylinders, 6-inch diameter by 12-inch high.
   4. Perform compression tests in accordance with ASTM C 39. Test one cylinder at 7 days and two at 28 days. The remaining cylinders will be held to verify test results, if needed.

H. Evaluation and Acceptance of Concrete
   1. Evaluation and acceptance of the compressive strength of concrete will be according to the requirements of ACI 350 and as specified herein.
   2. A statistical analysis of compression test results will be performed according to the requirements of ACI 214. The standard deviation of the test results may not exceed 640 psi, when ordered at equivalent water content as estimated by slump.
   3. If any concrete fails to meet these requirements, take immediate corrective action to increase the compressive strength for all subsequent batches of the type of concrete affected.
   4. When the standard deviation of the test results exceeds 640 psi, the average strength for which the mix is designed shall be increased by an amount necessary to satisfy the

statistical requirement that the probability of any test being more than 500 psi below or the average of any three consecutive tests being below the specified compressive strength is 1 in 100. Calculate the required average strength using Criterion No. 3 of ACI 214 with the actual standard of deviation.

5. All concrete which fails to meet the ACI requirements and these Specifications, is subject to removal and replacement at no increase in cost to the Owner.

3.11 APPLICATION OF LOADS

A. Do not allow traffic, construction equipment, or materials of any kind to be placed on elevated concrete slabs until the concrete has attained a minimum age of 7 days and 80% of the minimum specified 28-day strength as proven by concrete strength tests.

B. Do not place backfill against cantilevered walls until the concrete has attained a minimum age of 7 days and 100% of the minimum specified 28-day concrete strength as proven by concrete strength tests.

C. Do not place backfill against walls that are tied to elevated slabs or decks until both the slabs and walls have attained a minimum age of 7 days and 80% of the minimum specified 28-day strength as proven by concrete strength tests.

3.12 SCHEDULES

A. Grout: As specified in Section 03 60 00 – Grouting.

B. Unformed Concrete Surfaces: Apply finish as follows.

Area	Finish
Grade slabs and foundations to be covered with concrete or fill material	U1
Floors to be covered with grouted tile or topping grout	U2
Slabs not water bearing	U4
Slabs to be covered with built-up roofing	U2
Interior and exterior slabs where Drawings require only light broom finish	U4
Interior slabs and finished floors with architectural finishes	U3
Top surface of walls	U3

END OF SECTION

SECTION 03 60 00
GROUTING

PART 1 - GENERAL

1.1 SUMMARY

A. Work includes various types of cementitious grout to be provided and installed per the Contract Documents

B. Section includes the following types of grout:
1. Cement grout.
2. Nonshrink grout.
3. Epoxy grout.
4. Grout for repair of concrete.
5. Pump and motor grout.
6. Concrete topping gout and concrete fill.

1.2 RELATED SECTIONS
1. Section 03 30 00 – Cast-in-Place Concrete

1.3 REFERENCES

A. American Concrete Institute (ACI) standards, most recent editions:

ACI 318	Building Code Requirements for Reinforced Concrete
ACI 308	Standard Practice for Curing Concrete

B. American Society for Testing and Materials (ASTM) standards, most recent editions:

ASTM C78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C94	Standard Specifications for Ready-Mixed Concrete
ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
ASTM C307	Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings
ASTM C348	Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars
ASTM C469	Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression

ASTM C531	Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
ASTM C579	Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
ASTM C827	Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
ASTM C882	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete By Slant Shear
ASTM C884	Standard Test Method for Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay
ASTM C939	Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C1090	Standard Test Method for Measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout
ASTM C1107	Packaged Dry, Hydraulic Cement Grout (Nonshrink)
ASTM C1181	Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts
ASTM C1202	Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
ASTM C1339	Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Grouts
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D696	Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C With a Vitreous Silica Dilatometer
ASTM E329	Standard Specification for Agencies Engaged in Construction Inspection and/or Testing

C. International Concrete Repair Institute (ICRI) standards, latest editions:

Guideline No 310.1R	Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion
Guideline No 320.2R	Guide for selecting and specifying Materials for repair of Concrete Surfaces

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 20 – Submittal Procedures.

B. Product Data:
   1. Submit certified test results verifying the compressive strength, shrinkage, and expansion requirements indicated herein.
   2. Submit manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of nonshrink and epoxy grout used in the Work.

C. Certification:
   1. Provide manufacturer's independent certification of compliance with ASTM C1107 without modification to the standard methods certifying that the Class B or C grout's post-hardening non-shrink properties are not based on gas expansion.
   2. Provide Manufacturer's certification that grouts have strengths of 3500 psi at 1 day, 6500 psi at 3 days and 7500 psi at 28 days when cured at 72 degrees F as well as meeting the 3, 7, and 28-day strengths when tested and cured at the 45 deg F and 95-degree F limits and all other requirements of ASTM C1107.
   3. The Contractor shall engage an independent testing laboratory to run a 24-hour grout evaluation in accordance with ASTM C1107 of each grout submitted for approval showing compliance with all aspects of the evaluation. Submit results to the Engineer for review.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 25 10 - Products, Materials, Equipment and Substitutions.

B. Maintain all materials clean, dry and protected against dampness, freezing and foreign matter.
   1. Store non-shrink grout materials in temperature controlled environments above 40 degrees F and below 90 degrees F.
   2. Store epoxy grout components in temperature controlled environments above 60 degrees F and below 90 degrees F.

C. Deliver epoxy resin, hardener, and aggregate in sealed pre-measured containers, palletized, and shrink-wrapped to prevent shipping damage.

D. Immediately remove from the Project site any cement-based grout material which becomes damp or otherwise defective.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Nonshrink, nonmetallic grout:
      a. 5 Star Grout, Five Star Products, Inc.

b. Masterflow 928, BASF Building Systems, Inc.
c. NS Grout, Euclid Chemical Company.
d. Sika Grout 212, Sika Corporation.
e. Engineer approved equal.

2. Epoxy grout:
a. HP Epoxy Grout, Five Star Products, Inc.
b. Masterflow 648 CP Plus, BASF Building Systems, Inc.
c. E3-Flowable, Euclid Chemical Company.
d. Sikadur 42 Grout-Pak, Sika Corporation.
e. Engineer approved equal.

3. Grout for pumps and motors:
a. Escoweld, ITW Polymer Technologies.
b. Chockfast Red, ITW Polymer Technologies.
c. DP Epoxy Grout, Five Star Products, Inc.
d. Engineer approved equal.

2.2 CEMENT GROUT

A. Cement grout shall be composed of one-part cement, three parts sand, and the minimum amount of water necessary to obtain the desired consistency. Where needed to match the color of adjacent concrete, white Portland cement shall be blended with regular cement as needed. The minimum compressive strength at 28 days shall be 4,500 psi.

B. Cement grout materials shall be as specified in Section 03 30 00 – Cast-in-Place Concrete.

2.3 NONSHRINK GROUT

A. Non-shrink grout shall be a prepackaged, inorganic, non-gas-liberating, non-metallic, cement-based grout requiring only the addition of water.

B. Cement from kilns burning metal-rich hazardous waste fuel shall not be used.

C. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each class of non-shrink grout herein shall be that recommended by the manufacturer for the particular application. All grouts (Grade B or C) shall be tested for height change of the hardened grout at 1, 3, 14, and 28 days in accordance with ASTM C1090 and shall be tested for compression at 1, 3, 7, and 28 days in accordance with the modified ASTM C109 testing procedure.

D. Class A non-shrink grouts: Not used.

E. Class B or C high precision, fluid, extended working time, non-shrink grouts:
1. Minimum 28-day compressive strength of 7500 PSI.
2. No shrinkage (0.0 percent) and a maximum of 4.0 percent expansion in the plastic state when tested in accordance with ASTM C827.
3. No shrinkage (0.0 percent) and a maximum of 0.2 percent expansion in the hardened state
4. When mixed to a fluid consistency of 20 to 30 seconds per ASTM C939 at temperature extremes of 45 to 90 degrees F shall have an extended working time of 30 minutes when tested in accordance with ASTM C1107.

F. Application:

1. Class B or C non-shrink grout shall be used for grouting under all base plates for structural steel members, grouting under all equipment base plates except for pumps and motors, and at all locations where grout is required by the Contract Documents except where epoxy grout or grout for pumps and motors is specifically required. Class B or C non-shrink grout shall be used in place of Class A non-shrink grout for all applications. Class B or C non-shrink grout shall not be used for dry packing applications or repair of concrete.

2.4 EPOXY GROUT

A. Epoxy grout shall be a pourable, nonshrink, 100 percent solids system. The epoxy grout system shall have three components: resin, hardener, and specially blended aggregate, all premeasured and prepackaged. The resin component shall not contain any nonreactive diluents. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable. Variation of component ratios is not permitted unless specifically recommended by the manufacturer. Manufacturer's instructions shall be printed on each container in which the materials are packaged. The chemical formulation of the epoxy grout shall be as recommended by the manufacturer for the particular application.

B. The mixed epoxy grout system shall have a minimum working life of 45 minutes at 75 degrees F.

C. The epoxy grout shall develop a compressive strength of 5,000 psi in 24 hours and 10,000 psi in 7 days when tested in accordance with ASTM C579, Method B. There shall be no shrinkage (0.0 percent) and a maximum 4.0 percent expansion when tested in accordance with ASTM C827.

D. The epoxy grout shall exhibit a minimum effective bearing area of 95 percent. This shall be determined by testing in accordance with ASTM C1339, for bearing area and flow.

E. The peak exotherm of a 2-inch diameter by 4-inch high cylinder shall not exceed 95 degrees F when tested with 75 degree F material at laboratory temperature. The epoxy grout shall exhibit a maximum thermal coefficient of 30 x 10-6 inches/inch/degree F when tested according to ASTM C531 or ASTM D696.

F. Application:

1. Epoxy grout shall be used to embed all anchor bolts and reinforcing steel required to be set in grout and for all other applications in the Contract Documents where grout type is not specifically indicated.

2.5 GROUT FOR REPAIR OF CONCRETE

A. Vertical, overhead, and shotcrete applications:

1. Shall not produce a vapor barrier.
2. One component, reoplastic, cement based, shrinkage compensated, non-expansive, gray concrete product.
3. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only the addition of water.

4. Free of chlorides and other chemicals causing corrosion with the following properties:
    a. Minimum Slant Shear Bond Strength: 2500 PSI at 28 days when tested in accordance with ASTM C882.
    b. Minimum Compressive strength: 6,500 PSI at 28 days when tested in accordance with ASTM C109.
    c. Minimum Tensile Bond Strength: 200 PSI at 28 days per ASTM C307.
    d. Minimum Flexural Strength: 1,200 PSI when tested in accordance with ASTM C348.
    e. Modulus of Elasticity: 3.6E6 PSI when tested in accordance with ASTM C469.
    f. Maximum Rapid Chloride Permeability: 772 coulombs when tested in accordance with ASTM C1202.

B. Horizontal and formed applications:
1. Shall not produce a vapor barrier.
2. One component, reoplastic, cement-based, shrinkage compensated, non-expansive, gray concrete product.
3. Flowable, extremely low permeability, sulfate resistant, easy to use and requiring only the addition of water.
4. Free of chlorides and other chemicals causing corrosion with the following properties:
    a. Minimum Shear Bond Strength: 2150 PSI at 7 days.
    b. Minimum Compressive Strength: 6000 PSI at 7 days when tested in accordance with ASTM C109.
    c. Minimum Flexural Strength: 770 PSI at 28 days when tested in accordance with ASTM C78.
    d. Maximum Chloride Permeability: 1,000 coulombs when tested in accordance with ASTM C1202.
    e. Modulus of Elasticity: 4.8E6 PSI when tested in accordance with ASTM C469.

2.6 GROUT FOR PUMPS AND MOTORS

A. Grout for pumps and motors shall be epoxy grouts meeting the following minimum requirements:
1. Creep shall be less than 0.005 in/in when tested by ASTM C1181 method. The test shall be at 70 degrees F and 140 degrees F with a load of 400 PSI.
2. Linear shrinkage shall be less than 0.080 percent and thermal expansion less than 17E-6 in/in/degree F when tested by ASTM C531.
3. The compressive strength shall be a minimum of 12,000 PSI in 7 days when tested by ASTM C579 Method B, modified.
4. Bond strength of grout to Portland cement concrete shall be greater than 2,000 PSI when using ASTM C882 test method.
5. Grout shall pass the thermal compatibility test when overlaid on Portland cement concrete using test method ASTM C884.
6. Tensile strength and modulus of elasticity shall be determined by ASTM D638. The tensile strength shall not be less than 1,700 PSI and the modulus of elasticity shall not be less than 1.8E6 PSI.
7. Peak exothermic temperature shall not exceed 110 degrees F when a specimen 6 inches in diameter by 12 inches high is used. Gel time shall be at least 150 minutes.

8. The grout shall be suitable for supporting precision machinery subject to high impact and shock loading in industrial environments while exposed to elevated temperatures as high as 150 degrees F, with a load of 2,000 PSI.

B. Primer, if required, shall conform to the written recommendations of the grout manufacturer.

C. Surface preparations shall conform to the written recommendations of the grout manufacturer.

D. Placement and Curing
1. Placement and curing procedures shall be in accordance with the written recommendations of the grout manufacturer.
2. A grouting performance demonstration/training session shall be conducted by the grout manufacturer's representative prior to foundation and baseplate preparation and the first grouting on site. This training session shall demonstrate proper preparation and installation methods and that the grouting material meets the strength requirements.

2.7 CONCRETE TOPPING GROUT AND CONCRETE FILL

A. Grout for topping of slabs and concrete fill for built up surfaces of tank, channel, and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures as necessary, with strength as specified above.

B. Where concrete topping is deeper than 6 inches, it will be considered "Concrete Fill" and may be placed using either grout as specified herein or "lean concrete", as specified in Section 03 30 00 – Cast-In-Place Concrete, when approved by Engineer.

2.8 CURING MATERIALS

A. Curing materials shall be as specified in Section 03 30 00 – Cast-In-Place Concrete for cement grout and as recommended by the grout manufacturer for prepackaged grouts.

2.9 CONSISTENCY

A. Use grouts with the consistency necessary to completely fill space to be grouted for the particular application. Where "dry pack" is called for in the Contract Documents, use grout with a consistency such that the grout is plastic and moldable but will not flow.

B. Regardless of consistency called for on the Contract Documents, the type of grout to be used shall be as indicated herein for the particular application.

2.10 MEASUREMENT OF INGREDIENTS

A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurement will not be allowed.

B. Prepackaged grouts shall have ingredients measured by means recommended by the grout manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. All surface preparation, curing, and protection of cement grout shall be as indicated in Section 03 30 00 – Cast-In-Place Concrete. The finish of the grout surface shall match that of the adjacent concrete.

B. Do not place grout on concrete or masonry substrates until those substrate materials have attained 28-day design strength unless authorized by Engineer.

3.2 MANUFACTURER'S SERVICES

A. The manufacturer of nonshrink grout and epoxy grout shall provide onsite technical assistance upon request.

B. Coordinate with the manufacturer all demonstrations, training sessions, and applicable site visits. The grout manufacturer shall conduct onsite, demonstration and training sessions for bleed tests, mixing, flow cone measurements, cube testing, application, and curing for each category and type of grout.

C. Training by the manufacturer is required for all types of grout installations. Grout manufacturer's representative shall train Contractor to perform the grout Work including mixing of grouts to required consistency, testing, placing, and curing on actual project base plates, tie holes, rock pockets, and other applications.

3.3 GROUTING PROCEDURES

A. Prepackage Grouts: All mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.

B. Base Plate Grouting:
   1. For base plates, the original concrete shall be blocked out or finished off a sufficient distance below the plate to provide for a 1 inch thickness of grout or a thickness as indicated on the Contract Drawings.
   2. After the base plate has been set in position at the proper elevation by steel wedges or double nuts on the anchor bolts, the space between the bottom of the plate and the original pour of concrete shall be filled with non-shrink-type grout. The mixture shall be of a trowelable consistency and tamped or rodded solidly into the space between the plate and the base concrete. A backing board or stop shall be provided at the back side of the space to be filled with grout. Where this method of placement is not practical or where required by Engineer, alternate grouting methods shall be submitted for acceptance by Engineer.

C. Concrete Topping Grout:
   1. All mechanical, electrical, and finish Work shall be completed prior to placement of concrete topping or concrete fill. The base slab shall be given a roughened textured surface by sandblasting or hydroblasting exposing the aggregates to ensure bonding to the base slab.

2. The minimum thickness of grout topping and concrete fill shall be one inch. Where the finished surface of concrete fill is to form an intersecting angle of less than 45 degrees with the concrete surface it is to be placed against, a key shall be formed in the concrete surface at the intersection point. The key shall be a minimum of 6-inches wide by 1-1/2 inches deep.
3. The base slab shall be thoroughly cleaned and wetted prior to placing topping and fill. No topping concrete shall be placed until the slab is complete free from standing pools or ponds of water. A thin coat of neat Type II cement grout shall be broomed into the surface of the slab just before topping of fill placement. The topping and fill shall be compacted by rolling or tamping, brought to established grade, and floated. Grouted fill for tank and basin bottoms where scraping mechanisms are to be installed shall be screeded by blades attached to the revolving mechanism of the equipment in accordance with the procedures outlined by the equipment manufacturer after the grout is brought to the established grade.
4. Concrete topping grout placed on sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement.
5. The surface shall be tested with a straight edge to detect high and low spots which shall be immediately eliminated. When the topping and fill has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. An approved type of mechanical trowel may be used as an assist in this operation, but the last pass over the surface shall be by hand-troweling. During finishing, no water, dry cement or mixture of dry cement and sand shall be applied to the surface.

D. Grout for Repair of Concrete
1. All repairs shall be performed in accordance with the manufacturer's recommendations and with ICRI Guideline No 310.1R and Guideline No 320.2R. These guidelines shall be followed for removal geometry, exposing and undercutting of reinforcing steel, cleaning and repair of reinforcing steel, and edge and surface condition of concrete and shall be followed regardless of the amount of corrosion present or not present in the reinforcing steel.
2. Remove unsound deteriorated concrete from Work by high pressure water blasting machines capable of scoring concrete surfaces to minimum amplitude roughness of 3/16-inch. Remove to provide for minimum thickness specified for mortar. If reinforcing is exposed in this process, then additional concrete shall be removed until the surface is a minimum of 1-inch or 1 bar diameter behind the exposed reinforcing.
3. Clean exposed reinforcing bars of rust and other deleterious materials which may prevent bonding of the repair product.
4. Keep surface at saturated surface dry (SSD) condition for a minimum of 24-hours prior to placement of repair material.
5. Place material in accordance with Manufacturer's written recommendations.
6. Cure material continuously for 7-days with water fog nozzles or other applications which provide a continuous wet curing of the repaired area in accordance with ACI 308.

E. CONSOLIDATION
1. Grout shall be placed in such a manner, for the consistency necessary for each application, so as to assure that the space to be grouted is completely filled.

END OF SECTION

SECTION 31 23 00
EARTHWORK

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall perform all earthwork indicated and required for construction of the Work, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

29 CFR 1926	OSHA Safety and Health Regulations for Construction
ASTM C 595	Standard Specification for Blended Hydraulic Cements
ASTM D 422	Method for Particle-Size Analysis of Soils
ASTM D 1556	Test Method for Density of Soil in Place by the Sand-Cone Method
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3) (2,700 kN-m/m^3)
ASTM D 1633	Test Method for Compressive Strength of Molded Soil-Cement Cylinders
ASTM D 2419	Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2487	Classification of Soils for Engineering Purposes
ASTM D 2901	Test Method for Cement Content of Freshly Mixed Soil Cement
ASTM D 2922	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods
ASTM D 4253	Test Methods for Maximum Index Density of Soils using a Vibratory Table
ASTM D4254	Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D 4318	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4832	Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders

ASTM D 5971	Practice for Sampling Freshly Mixed Controlled Low Strength Material (CLSM)
ASTM D 6023	Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)
ASTM D 6024	Test Method for Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application
ASTM D 6103	Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)

1.3 CONTRACTOR SUBMITTALS

A. The Contractor's attention is directed to the provisions of Subpart P, 29 CFR 1926 of the OSHA Safety and Health Standards for Construction, which relate to protection of employees in excavations. The Contractor shall submit, for information to the Engineer, the project excavation plan and the name of the Contractor's competent person, prior to commencing any excavation.

B. Submit samples of all materials proposed to be used in the work in accordance with the requirements in Section 01 33 20 – Submittal Procedures. Sample sizes shall be as determined by the testing laboratory.

C. Submit dewatering and water removal plan prior to performing any dewatering or water removal.

PART 2 - PRODUCTS

2.1 SUITABLE FILL AND BACKFILL MATERIAL REQUIREMENTS

A. General: Fill, backfill, and embankment materials shall be suitable material.

B. Suitable Materials: Suitable material is defined as selected or processed clean, well graded earth material, sands and gravels free of excessive fines. Suitable materials to have less than 20 percent rock and boulders larger than 4 inches, and be free of all grass, roots, brush, vegetation, or other deleterious materials.

C. Fill and backfill materials within 6 inches of any structure or pipe shall be smaller than 1 inch in any dimension.
   1. Suitable materials may be obtained from onsite excavations, may be processed onsite materials, or may be imported. If imported materials are required by this Section or to meet the quantity requirements of the Project, provide the imported materials at no additional expense to the Owner, unless a unit price item is included for imported materials in the bidding schedule. Onsite materials shall be stockpiled and segregated prior to use.
   2. The following types of suitable materials are defined:

Type A (Granular Backfill): Crushed rock or gravel, and sand well graded and readily compacted, non-plastic, meeting the following gradation requirements:

Sieve Size	Percentage Passing
1-inch	100
No. 40	15 - 60
No. 200	0 - 15

Type B (Crushed Rock): Manufactured angular, crushed rock, non-plastic, meeting the following gradation requirements:

Sieve Size	Percentage Passing
3/8-inch	100
No. 4	30 - 50
No. 200	0 - 5

Type C (Sand Backfill): Sand, non-plastic, meeting the following gradation requirements:

Sieve Size	Percentage Passing
3/4-inch	100
No. 4	80 - 100
No. 10	30-50
No. 40	10-30
No. 200	7 - 15

Pea Gravel or Squeegee is not acceptable as sand backfill.

Type D (Select Backfill): Suitable material that can be readily compacted and meets the requirements of AASHTO M 145 classification A-1-a, non-plastic, well graded with a maximum particle size of 2 inches.

Sieve Size	Percentage Passing
2-inch	100
No. 10	30-50
No. 40	15-30
No. 200	0 - 15

Type E (Pea Gravel Backfill): Crushed rock or gravel with 100 percent passing a 1/2-inch sieve and not more than 10 percent passing a No. 4 sieve.

Type F (Drainrock): Crushed rock or gravel conforming to one of the following gradation requirements, as shown on the Drawings or approved by the Engineer:

	Percentage Passing		
Sieve Size	3-inch Max.	2-inch Max.	3/4-inch Max.
3-inch	100	-	-
2-inch	90 – 100	100	-
1-1/2 inch	70 – 100	90 – 100	-
3/4 inch	0 - 50	0 – 15	100
1/2-inch	-	-	95 - 100
3/8-inch	0 - 10	0 - 5	70 - 100
No. 4	0 - 25	-	-
No. 8	0 - 5	-	-
No. 200	0 - 3	-	0 - 3

Type G (Type II Aggregate Base): Well-graded, clean, hard, tough, durable, and sound mineral aggregates consisting of crushed stone, or crushed gravel, free of organic matter and contamination from chemical or petroleum products meeting State specification requirements and conforming to the following Table and gradations:

Aggregate Properties			
	Aggregate Class		**Standard/Ref**
	A	**B**	
Dry Rodded Unit Weight	Not less than 75 lb/ft^3		AASHTO T 19
Liquid Limit/Plastic Index	Non-plastic	PI ≤ 6	AASHTO T 89 AASHTO 90
Aggregate Wear	Not to exceed 50 percent		AASHTO T 96
Gradation	Table 2		AASHTO T 11 AASHTO T 27
CBR with a 10 lb surcharge measured at 0.20 inch penetration	70% Minimum	N/A	AASHTO T 193
Two Fractured Faces	50% Min	N/A	AASHTO T 335

Sieve Size	Percentage Passing
1 ½ -inch	100
1-inch	90 - 100
3/4-inch	70 - 85
1/2-inch	65 - 80
3/8-inch	55 - 75
No. 4	40 - 60
No. 16	25 - 40
No. 200	7 - 11

Type H (Graded Drainrock): Graded drainrock shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting and drying. The material shall be uniformly graded and shall meet the following gradation requirements:

Sieve Size	Percentage Passing
1-inch	100
3/4 inch	90 - 100
3/8-inch	40 - 100
No. 4	25 - 40
No. 8	18 - 33
No. 30	5 - 15
No. 50	0 - 7
No. 200	0 - 3

Type J (Cement-Treated Backfill): Material which consists of Type F material, or any mixture of Types B, C, G, and H materials which has been cement-treated so that the cement content of the material is not less than 5 percent by weight when tested in accordance with ASTM D 2901. The ultimate compressive strength at 28 days shall be not less than 400 psi when tested in accordance with ASTM D 1633.

Type K (Topsoil): Stockpile topsoil material which has been obtained at the site by removing soil to a depth as defined in Section 31 10 00 – Site Preparation. Removal of the topsoil shall be done after the area has been stripped of vegetation and debris.

Type M (Aggregate Subbase): Crushed rock aggregate subbase material non-plastic that can be compacted readily by watering and rolling to form a stable base. The sand equivalent value shall not be less than 18 and shall meet one of the following gradation requirements, as shown on the Drawings or approved by the Engineer:

	Percentage Passing	
Sieve Size	3-inch Max.	2-inch Max.
3-inch	100 -	
2-inch	90 - 100	100
1-1/2 inch	-	95 - 100
1-inch	70 - 90	-
No. 4	30 - 65	30 - 65
No. 16	15 - 40	15 - 40
No. 200	2 - 12	2 - 12

Type N (trench plug): Low permeable fill material, a nondispersable clay material having a minimum plasticity index of 10.

Type O (Controlled Low Strength Material (CLSM), Flowable Fill): CLSM shall consist of a mixture of portland cement, pozzolan, coarse and fine aggregate, water, and approved admixtures, meeting the following requirements:

1. Blended Hydraulic Cement: Comply with ASTM C 595, Type IL (10) (MS), grey color.
2. Pozzolan: Provide fly ash conforming to ASTM C618, Type C or Type F.
3. Water: Potable, clean and free from objectionable quantities of silt, organic matter, alkali, salt and other impurities..
4. Aggregate:
   a. Free from organic matter, clean imported sand and gravel, or selected material from the excavation, imported material, or a combination thereof as approved by the Engineer. Containing no more alkali, sulfates, or salts than the native materials at the site. The soluble sulfate content of aggregate in the mixture shall not exceed 0.3 percent by dry weight.
   b. Well-graded mixture of crushed rock, soil or sand, with a nominal maximum size of 3/8 inch and conforming to the following sieve limits:

Sieve Size	Percentage Passing
1/2-inch	100
3/8-inch	> 70
No. 200	<12[1]

[1] If more than 5 percent of the aggregate passes the No. 200 sieve, the plasticity index must be less than 0.73 (liquid limit – 20) when tested in accordance with ASTM D-4318.

5. Proportion the CLSM to be a flowable, nonsegregating, self-consolidating low shrink slurry. The Contractor shall determine the materials and proportions used to meet the requirements of these Specifications.
6. Admixtures:
   a. Air entraining admixture per ASTM C260
   b. Water reducing admixture per ASTM C494

7. The unconfined compressive strength at 7 days shall be a minimum of 80 psi and a maximum of 200 psi. Contractor shall form a minimum of six test cylinders with proposed materials to confirm design strength and mix design. Four of the cylinders shall be broken at 7 days in conformance with applicable concrete cylinder specifications and results provided to Engineer. The remaining two cylinders shall be broken by Contractor at discretion of Engineer. Initial mix design and cylinder breaks shall be completed at least 28 days prior to use of the material on the jobsite. Final mix approval and use of the material shall not occur prior to confirmation of strength by the cylinder breaks.
8. The temperature of the CLSM discharged into the trench shall be below 90 degrees F but above 50 degrees F. Air temperature is to be 40 degrees F and rising. Do not place against frozen subgrade or other materials having temperature less than 32 degrees F. Protect flowable fill from temperatures below 40 degrees F for 72 hours.
9. Finish flowable fill smooth and to the grade indicated, finish free from fins, bulges, ridges, offsets and honeycombing. Wood float, steel trowel or similar is not required.
10. CLSM backfill under concrete structures shall be protected during curing as specified Section 03 30 00 - Cast-in-Place Concrete.
11. CLSM shall be tested in accordance with ASTM D 4832, ASTM D 5971, ASTM D 6023, and ASTM D6103

Type P: (Suitable Trench Backfill): Suitable material that can be readily compacted, with less than 35 percent passing the No. 200 sieve and a plasticity index of 10 or less.

2.2 UNSUITABLE MATERIAL

A. Unsuitable materials include but are not limited to the materials listed below.
   1. Soils which, when classified under ASTM D 2487 - Classification of Soils for Engineering Purposes, fall in the classifications of Pt, OH, CH, MH, or OL.
   2. Soils which cannot be compacted sufficiently to achieve the density indicated for the intended use.
   3. Materials that contain hazardous or designated waste materials including petroleum hydrocarbons, pesticides, heavy metals, slag, and any material which may be classified as hazardous or toxic according to applicable regulations.
   4. Soils that contain greater concentrations of chloride or sulfate ions or have a soil resistivity or pH less than the existing onsite soils.
   5. Topsoil, except as allowed below.

B. All unsuitable excavated material shall be disposed off site.

2.3 USE OF FILL, BACKFILL, AND EMBANKMENT MATERIAL TYPES

A. Use the types of materials as designated herein for all required fill, backfill, and embankment construction hereunder.

B. Where these Specifications conflict with the requirements of any local agency having jurisdiction or with the requirements of a pipe material manufacturer, notify the Engineer immediately. In case of conflict between types of pipe embedment backfills, use the agency-specified backfill material if that material provides a greater degree of support to the pipe, as determined by the Engineer. In case of conflict between types of trench or final backfill types,

use the agency-specified backfill material if that material provides the greater in-place density after compaction.

C. Fill and backfill types shall be used in accordance with the following provisions:

1. Embankment fills shall be constructed of Type P material, as defined herein, or any mixture of Type P and Type A through Type F materials.
2. Pipe zone backfill, as defined under "Pipe and Utility Trench Backfill" below, shall consist of the following materials for each pipe material listed below.
    a. Mortar coated pipe, concrete pipe, and uncoated ductile iron pipe shall be provided with Type A or C material in the pipe zone.
    b. Coal tar enamel coated pipe, polyethylene encased pipe, tape wrapped pipe, and other non-mortar coated pipe shall be backfilled with Type C material in the pipe zone.
    c. Plastic pipe and vitrified clay pipe shall be backfilled with Type C material in the pipe zone.
    d. Where pipelines are installed on grades exceeding 4 percent, and where backfill materials are graded such that there is less than 10 percent passing a No. 4 sieve, trench plugs of Type J or N material shall be provided at maximum intervals of 200 feet unless indicated otherwise.
    e. Type O material shall be used in the pipe zone where shown on plans, specified, or required by the Engineer for special crossings or other locations, or where otherwise approved.
    f. Type E material will not be allowed for backfill within the pipe zone.
3. Trench zone backfill for pipelines as defined under "Pipe and Utility Trench Backfill" shall be Type D backfill material.
4. Final backfill material for pipelines under paved areas, as defined under "Pipe and Utility Trench Backfill" shall be Type G backfill material. Final backfill under areas not paved shall be the same material as that used for trench backfill.
5. Trench backfill and final backfill for pipelines under structures shall be Type A or B, except where concrete encasement is required by the Contract Documents.
6. Aggregate base materials under pavements shall be Type G material constructed to the thicknesses indicated. Aggregate subbase shall be Type M material.
7. Backfill around structures shall be Type P material, or Types A through Type F materials, or any mixture thereof, except as shown.
8. Backfill materials beneath structures shall be as follows:
    a. Drainrock materials under hydraulic structures or other water retaining structures with underdrain systems shall be Type H material.
    b. Under concrete hydraulic structures or other water retaining structures without underdrain systems, Types F, G or H materials shall be used.
    c. Under structures where groundwater must be removed to allow placement of concrete, Type F material shall be used. Before the Type F material is placed, filter type geotextile fabric shall be placed over the exposed foundation.
    d. Under all other structures, Type F, G or H material shall be used.
9. Backfill used to replace pipeline trench overexcavation shall be a layer of Type F material encased in non-woven geotextile fabric to prevent migration of fines for wet trench conditions or the same material as used for the pipe zone backfill if the trench conditions are not wet.

2.4 PIPELINE MARKING TAPE

A. Metallic Tape: Tape shall be minimum 5.5 mils thick aluminum foil imprinted on one side, encased in high visibility inert polyethylene jacket. Tape shall be a minimum of 6 inches wide. Imprinted lettering shall be 1 inch tall, permanent black, as indicated. Joining clips shall be manufacturer's standard tin or nickel coated. Tape shall be as manufactured by Reef Industries (Terra "D"), Allen (Detectatape), or equal.

B. Plastic Tape: Tape shall be minimum 4-mil thick polyethylene which is impervious to alkalais acids, and chemicals and solvents which are likely in the soil. Tape shall be a minimum of 6 inches wide and lettering shall be 1-inch tall permanent black on a colored background. Tape shall be manufactured by Reef Industries (Terra Tape), Allen (Markline), or equal.

C. Warning Tape: Warning tape manufactured for marking and identifying underground utilities continuously inscribed with a description of utility, colored as follows:
   1. Red; Electric.
   2. Yellow; Gas, oil, steam, and dangerous materials.
   3. Orange: Telephone and other communications.
   4. Blue: Water Systems.
   5. Green: Sewer Systems.

2.5 MATERIALS TESTING

A. All soils testing of samples submitted by the Contractor will be done by a testing laboratory of the Owner's choice and at the Owner's expense. At its discretion, the Engineer may request that the Contractor supply samples for testing of any material used in the work.

B. Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Method for Particle-Size Analysis of Soils.

C. Determination of sand equivalent value will be performed using ASTM D 2419 - Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. Unified Soil Classification System: References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487. The Contractor shall be bound by all applicable provisions of said ASTM D 2487 in the interpretation of soil classifications.

E. The testing for chloride, sulfate, resistivity, and pH will be done by a testing laboratory of the Owner's choice and at the Owner's expense.

PART 3 - EXECUTION

3.1 EXCAVATION – GENERAL

A. General: Except when specifically provided to the contrary, excavation shall include the removal of all materials of whatever nature encountered, including rock and all obstructions of any nature that would interfere with the proper execution and completion of the Work. The removal of said materials shall conform to the lines and grades indicated or ordered.

Unless otherwise indicated, the entire construction site shall be stripped of all vegetation and debris, and such material shall be removed from the site prior to performing any excavation or placing any fill. Furnish, place, and maintain all supports and shoring that may be required for the sides of the excavations. Excavations shall be sloped or otherwise supported in a safe manner in accordance with safety requirements of the requirements of OSHA Safety and Health Standards for Construction (29CFR1926).

B. Maximum Length of Open Trench: The maximum length of open trench in urban and rural areas shall not exceed 500-feet at each pipe installation heading beyond the end of the installed pipeline, or the requirements of the agency with jurisdiction, whichever is lesser.

C. Construction Delays: In the case of any construction delay in excess of five calendar days, whether Contractor or Owner caused, the Contractor shall backfill the excavation, install temporary paving including temporary traffic markings, and restore traffic to pre-construction condition to minimize disruption to traffic and the community at no additional cost to the Owner.

D. Removal and Exclusion of Water: Remove and exclude water, including storm water, groundwater, irrigation water, and wastewater, from all excavations. Dewatering wells, well points, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level at least 2 feet below the bottom of excavations before the excavation work begins at each location. Water shall be removed and excluded until backfilling is complete and all field soils testing has been completed. Dewatering to include filtering to prevent migration of the soil materials and fines from the subgrade.

3.2 STRUCTURE, ROADWAY, AND EMBANKMENT EXCAVATION

A. Excavation Beneath Structures and Embankments: Except where otherwise indicated for a particular structure or ordered by the Engineer, excavation shall be carried to the grade of the bottom of the footing or slab. Where indicated or ordered, areas beneath structures or fills shall be overexcavated. The subgrade areas beneath embankments shall be excavated to remove not less than the top 6 inches of native material and where such subgrade is sloped, the native material shall be benched. When such overexcavation is indicated, both overexcavation and subsequent backfill to the required grade shall be performed. When such overexcavation is not indicated but is ordered by the Engineer, such overexcavation and any resulting backfill will be paid for under a separate unit price bid item if such bid item has been established; otherwise payment will be made in accordance with a negotiated price. After the required excavation or overexcavation has been completed, the exposed surface shall be excavated with a smooth-edged bucket to minimize disturbance, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

B. Excavation Beneath Paved Areas: Excavation under areas to be paved shall extend to the bottom of the aggregate base or subbase, if such base is called for; otherwise it shall extend to the bottom of the paving thickness. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished pavement. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

C. Notification of Engineer: Notify the Engineer at least 3 days in advance of completion of any structure excavation and allow the Engineer a review period of at least 1 day before the exposed foundation is compacted or is covered with backfill or with any construction materials.

3.3 PIPELINE AND UTILITY TRENCH EXCAVATION

A. General: Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with widths as indicated.

B. Trench Bottom: Except when pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe zone. Excavations for pipe bells and welding shall be made as required.

C. Open Trench: The maximum amount of open trench permitted in any one location shall be 500 feet, or the length necessary to accommodate the amount of pipe installed in a single day, whichever is greater. All trenches shall be fully backfilled at the end of each day or, in lieu thereof, shall be protected in accordance with Section 01 71 50 – Protection and Restoration of Existing Facilities. The Contractor shall provide temporary 6-foot chain link fencing panels for protection of all open excavations and trenches within public streets, residential areas, and all other locations with the exception of unimproved open areas where excavations and/or pipeline trenches that can be safely sloped in accordance with current OSHA standards to provide safe access without the use of shoring devices. Temporary fencing panels shall fully enclose open excavations and trenches and shall remain in place during all non-working hours.

D. Trench Overexcavation: Where trenches are indicated to be overexcavated, excavation shall be to the depth indicated and backfill shall be installed to the grade of the bottom of the pipe bedding.

E. Overexcavation: When ordered by the Engineer, whether indicated on the Drawings or not, trenches shall be overexcavated beyond the depth and/or width shown. Such overexcavation shall be to the dimensions ordered. The trench shall then be backfilled to the grade of the bottom of the pipe bedding. Overexcavation less than 6 inches below the limits on the Drawings shall be done at no increase in cost to the Owner. When the overexcavation ordered by the Engineer is 6 inches or greater below the limits shown, or wider, additional payment will be made. Said additional payment will be made under separate unit price bid items for overexcavation if such bid items have been established; otherwise payment will be made in accordance with a negotiated price.

F. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

G. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield so that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls. If the trench walls cave in or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3.4 OVEREXCAVATION NOT ORDERED OR INDICATED

A. Any overexcavation carried below the grade ordered or indicated, shall be backfilled to the required grade with the indicated material and compaction. Such work shall be performed at no additional cost to the Owner.

3.5 EXCAVATION IN LAWN AREAS

A. Where excavation occurs in lawn areas, the sod shall be carefully removed, dampened, and stockpiled to preserve it for replacement. Excavated material may be placed on the lawn; provided, that a drop cloth or other suitable method is employed to protect the lawn from damage. The lawn shall not remain covered for more than 72 hours. Immediately after completion of backfilling and testing of the pipeline, the sod shall be replaced and lightly rolled in a manner so as to restore the lawn as near as possible to its original condition. Provide new sod if stockpiled sod has not been replaced within 72 hours.

3.6 EXCAVATION IN VICINITY OF TREES

A. Except where trees are indicated to be removed, trees shall be protected from injury during construction operations. No tree roots over 2 inches in diameter shall be cut without express permission of the Engineer. Trees shall be supported during excavation by any means previously reviewed by the Engineer.

3.7 BACKFILL – GENERAL

A. Backfill shall not be dropped directly upon any structure or pipe. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed. Backfill around water retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed. Structures shall not be constructed on CLSM backfill until the CLSM has obtained a 7-day minimum cure.

B. Except for drainrock materials being placed in overexcavated areas or trenches, backfill shall be placed after all water is removed from the excavation, and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction.

C. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally. Do not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

D. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have all loose sloughing, or caving soil and rock materials removed. All materials disturbed from their intact condition that are 4 inches or larger in least dimension or aggregates of soil material thicker than 4 inches shall be removed from the excavation walls and base prior to placing pipe or any backfill material. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

3.8 PLACING AND SPREADING OF BACKFILL MATERIALS

A. Backfill materials shall be placed and spread evenly in layers. When compaction is achieved using mechanical equipment, the layers shall be evenly spread so that the depth of each uncompacted layer shall not exceed 8 inches of compacted thickness.

B. During spreading, each layer shall be thoroughly mixed as necessary to promote uniformity of material in each layer. Pipe zone backfill materials shall be manually spread around the pipe so that when compacted the pipe zone backfill will provide uniform bearing and side support.

C. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.

D. Where the backfill material moisture content is too high to permit the indicated degree of compaction the material shall be dried or mixed with drier material until the moisture content is satisfactory.

3.9 COMPACTION OF EARTH FILL, BACKFILL, AND EMBANKMENT MATERIALS

A. Each layer of Types A, B, C, G, H, and K backfill materials as defined herein, where the material is graded such that at least 10 percent passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density. Equipment that is consistently capable of achieving the required degree of compaction shall be used and each layer shall be compacted over its entire area while the material is at the required moisture content.

B. Each layer of Type E and J backfill materials shall be compacted by means of at least 2 passes from a flat plate vibratory compactor. When such materials are used for pipe zone backfill, vibratory compaction shall be used at the top of the pipe zone or at vertical intervals of 24 inches, whichever is the least distance from the subgrade.

C. Fill on reservoir and structure roofs shall be deposited at least 30 days after the concrete roof slab has been placed. Equipment weighing more than 10,000 pounds when loaded shall not be used on a roof. A roller weighing not more than 8,000 pounds shall be used to compact fill on a roof.

D. Pipe zone backfill materials that are granular shall be compacted by using vibratory compactors.

E. Equipment weighing more than 10,000 pounds shall not be used closer to structure walls than a horizontal distance equal to the depth of the fill at that time. Hand operated power compaction equipment shall be used where use of heavier equipment is impractical or restricted due to weight limitations. Reduce the lift thickness as necessary to achieve the required compaction.

F. Backfill around and over pipelines that is mechanically compacted shall be compacted using light, hand operated, vibratory compactors and rollers. Reduce the lift thickness as necessary to achieve the required compaction. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

G. Compaction Requirements: The following compaction test requirements shall be in accordance with ASTM D 1557, method C. Compaction shall be obtained with the moisture content within plus or minus 2 percent of the optimum moisture content. Where agency or utility company requirements govern, the highest compaction standards shall apply.

Location or Use of Fill	**Percentage of Maximum Density**
Pipe embedment backfill for flexible pipe	90
Pipe bedding and overexcavated zones under bedding for flexible pipe, including trench plugs	90
Pipe embedment backfill for steel yard piping	---
Pipe embedment backfill for rigid pipe	90
Pipe zone backfill portion above embedment for rigid pipe	90
Pipe bedding and overexcavated zones under bedding for rigid pipe	90
Final backfill, beneath paved areas or structures	95
Final backfill, not beneath paved areas or structures	90
Trench zone backfill, beneath paved areas and structures, including trench plugs	95
Trench zone backfill, not beneath paved areas or structures, including trench plugs	90
Embankments and fills	90
Embankments and fills beneath paved areas or structures	95
Backfill beneath structures and hydraulic structures	95
Backfill and fill around structures on reservoir or structure roof	90
Topsoil (Type K material)	80 (uncompacted placement) 90 for earthwork under topsoil – topsoil not to be compacted
Aggregate base or subbase (Type G or M material)	95

3.10 PLACEMENT OF CLSM

A. Following placement and anchoring of the pipe, remove all loose soil from trench walls and floor. Remove any unstable soil at the top of the trench, which might fall into the trench during placement of the CLSM.

B. Prior to placement of CLSM, the pipeline steel temperature shall be controlled as specified in Section 33 11 11 – Steel Pipe.

C. Deliver the CLSM to the trench in ready mix trucks and utilize pump or chutes to place the CLSM in the trench. Direct CLSM to one side of the pipe, taking care not to displace the pipe at any time. Continue placing CLSM on one side of the pipe until CLSM has gone under the pipe and up the other side to a depth of 1.5 feet above the pipe bottom. Use at least two hand-held vibrators to continuously liquefy and move CLSM into all voids. Adjust water in mixture to maintain fluid consistency but maintain strength requirements. Continue placing CLSM on both sides of the pipe continuously using two vibrators for every 30 feet of pipe run.

D. Maintain stability of pipe throughout CLSM placement. CLSM will likely require placement in lifts to prevent pipe flotation. No movement of the pipe caused by flotation will be allowed. If any movement occurs, the CLSM material shall be removed and the pipe placed back on line and grade. Any damage to the pipeline system caused by movement of the pipe shall be removed and/or repaired in full conformance with these Contract Documents at no additional cost to the Owner. Remove all sloughed material or other debris from top of previously placed CLSM.

3.11 PIPE AND UTILITY TRENCH BACKFILL

A. Pipe Zone
   1. The pipe zone is defined as that portion of the vertical trench cross-section lying between a plane 6 inches below the bottom surface of the pipe and a plane at a point 12 inches above the top surface of the pipe. The bedding is defined as that portion of pipe zone backfill material between the bottom of the trench and the bottom of the pipe. The embedment is defined as that portion of the pipe zone material between the bedding and a plane at a point 6 inches above the top surface of the pipe.
   2. After compacting the bedding, perform a final trim using a string line for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe. Excavation for pipe bells and welding shall be made as required.
   3. The pipe zone shall be backfilled with the indicated backfill material. Exercise care to prevent damage to the pipeline coating, cathodic bonds, and the pipe itself during the installation and backfill operations.
   4. If a moveable trench shield is used during backfill operations the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer. Do not displace the pipe or backfill while the shield is being moved.

B. Trench Zone: After the pipe zone backfills have been placed, backfilling of the trench zone may proceed. The trench zone is defined as that portion of the vertical trench cross-section lying between a plane 12 inches above the top surface of the pipe and a plane at a point

18 inches below the finished surface grade, or if the trench is under pavement, 18 inches below the roadway subgrade.

C. Marking Tape Installation:
   1. Continuously install metallic marking tape along the pipe at a depth of 3 feet below finish grade.
   2. Continuously install plastic marking tape along the pipe at the elevation indicated on the Drawings.

D. Final Backfill: Final backfill is all backfill in the trench cross-sectional area within 18 inches of finished grade, or if the trench is under pavement, all backfill within 18 inches of the roadway subgrade.

3.12 FIELD TESTING

A. General: All field soils testing will be done by a testing laboratory of the Owner's choice at the Owner's expense except as indicated below.

B. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D 1557. Field density in-place tests will be performed in accordance with ASTM D 1556 or by such other means acceptable to the Engineer.

C. In case the test of the fill or backfill show noncompliance with the required density, perform remedies as may be required to ensure compliance. Subsequent testing to show compliance shall be by a testing laboratory selected by the Owner, paid by the Contractor, at no additional cost to the Owner.

D. Provide test trenches and excavations including excavation, trench support, and groundwater removal for the Owner's field soils testing operations. The trenches and excavations shall be provided at the locations and to the depths required by the Owner. All Work for test trenches and excavations shall be provided at no additional cost to the Owner.

E. Frequency of Testing
   1. Backfill around structures and in embankments shall be tested every 300 square ft of each lift of placement.
   2. CLSM shall be tested each batch being placed or every 300 cubic yards that is placed.
   3. Pipe backfill shall have one test every 80 feet (2 joints) of backfill placed, per lift at Engineer’s discretion.

END OF SECTION

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