



ADDENDUM

Public Building Commission of Chicago | Richard J. Daley Center | 50 West Washington Street, Room 200 | Chicago, Illinois 60602 | (312) 744-3090 | pbccchicago.com

ADDENDUM NO.: 01
PROJECT NAME: Ernst Prussing Elementary School Annex
PROJECT NO.: 05175
CONTRACT NO.: C1587
DATE OF ISSUE: November 9, 2017

NOTICE OF CHANGES, MODIFICATIONS, OR CLARIFICATIONS TO CONTRACT DOCUMENTS

The following changes, modifications, or clarifications are hereby incorporated and made an integral part of the Contract Documents. Unless clearly expressed otherwise by this Addendum, all terms and conditions defined in the original Contract Documents shall continue in full force and effect and shall have the same meaning in this Addendum. Issued Addenda represent responses/clarifications to various inquiries. Contractors shall be responsible for including all associated labor/material costs in its bid. Drawings/specifications corresponding to inquiry responses will be issued with the Issue for Construction Documents, upon issuance of building permit.

ITEM NO. 1: **CHANGE TO KEY DATES**
None.

ITEM NO. 2: **REVISIONS TO BOOK 1 – PBC INSTRUCTIONS TO BIDDERS**
Change 1 REMOVE Section IV. Proposal and Execution Documents, Section B. BID FORM and **REPLACE WITH** Exhibit A. REVISED BID FORM (Note: Revised Dever Beam Repair Allowance Amount)
Change 2 REMOVE Section IV. Proposal and Execution Documents, G. DEVER BEAM ALLOWANCE SCHEDULE and **REPLACE WITH** Exhibit B. DEVER BEAM ALLOWANCE SCHEDULE

ITEM NO. 3: **REVISIONS TO BOOK 2 – PBC STANDARD TERMS AND CONDITIONS**
None.

ITEM NO. 4: **REVISIONS TO BOOK 3 – TECHNICAL SPECIFICATIONS**
Change 1 Book 3 – Volume 1 – REVISED – Section 00 01 10 – Table of Contents
Change 2 Book 3 – Volume 1 – REMOVE – Section 01 35 59 – Indoor Air Quality Requirements
Change 3 Book 3 – Volume 1 – INSERT – Section 03 20 00 – Concrete Reinforcement.
Change 4 Book 3 – Volume 1 – INSERT – Section 03 30 01 – Cast in Place Concrete for Structural Remediation.
Change 5 Book 3 – Volume 1 – INSERT – Section 03 37 13 – Shotcrete.
Change 6 Book 3 – Volume 1 – INSERT – Section 03 60 30 – Epoxied-In Anchors.
Change 7 Book 3 – Volume 1 – INSERT – Section 03 64 23 – Epoxy Injection.
Change 8 Book 3 – Volume 1 – INSERT – Section 03 72 50 – Externally Bonded FRP Reinforcement - Laminates.
Change 9 Book 3 – Volume 1 – INSERT – Section 03 95 00 – Concrete Repairs.
Change 10 Book 3 – Volume 1 – REPLACE – Section 01 35 60c – LEED Checklist for Schools v.2009.

ITEM NO. 5: **REVISIONS TO DRAWINGS**
Change 1 Drawing AF1.1, within the Finish Legend: under Tag: RBCK Rubber Cork Tackable Wall Surface **REPLACE** "Roll Thickness 12MM" **WITH** "Roll Thickness 9MM".
Change 2 Drawing E2.1; Above the west entrance door by Vestibule 047, **ADD (1)** wall mounted type S3 exterior wall mounted light fixture.

ITEM NO. 6: REQUEST FOR INFORMATION
None.

List of Attachments and Drawings:

This Addendum includes the following attached Specifications and/or Documents:

1. Section 00 01 10 – Table of Contents
2. Section 03 20 00 – Concrete Reinforcement
3. Section 03 30 01 – Cast in Place Concrete for Structural Remediation
4. Section 03 37 13 – Shotcrete
5. Section 03 60 30 – Epoxied-in Anchors
6. Section 03 64 23 – Epoxy Injection
7. Section 03 72 50 – Externally Bonded FRP Reinforcement - Laminates
8. Section 03 95 00 – Concrete Repairs
9. Section 01 35 60c – LEED Checklist for Schools v.2009

This Addendum includes the following attached Drawings:

1. AF1.1 – Finish Legend and Notes
2. E2.1 – Electrical First Floor Plan Lighting

END OF ADDENDUM NO. 01

EXHIBIT A – REVISED BID FORM

A. REVISED - BID FORM

FIRM NAME:

LINE	ITEM	AMOUNT
1.	BASE WORK ONLY	\$
2.	COMMISSION'S CONTRACT CONTINGENCY	\$ 540,000.00
3.	SITE WORK ALLOWANCE	\$ 150,000.00
4.	ENVIRONMENTAL ALLOWANCE	\$ 75,000.00
5.	CAMERA ALLOWANCE	\$ 100,000.00
6.	MOISTURE MITIGATION ALLOWANCE	\$ 175,000.00
7.	DEVER BEAM REPAIRS ALLOWANCE	\$ 200,000.00
8.	TOTAL BASE BID (1+2+3+4+5+6+7)	\$
AWARD CRITERIA FIGURE (See Section V. Proposal Support Document, line 15 of Award Criteria Figure)		\$

SURETY: Please specify full legal name and address of Surety:

EXHIBIT B – DEVER BEAM ALLOWANCE SCHEDULE

G. DEVER BEAM REPAIRS ALLOWANCE SCHEDULE – PRUSSING ELEMENTARY SCHOOL ANNEX

Bid Item	Description	Detail	Unit	Unit Prices
1	Perform epoxy injection of cracks on underside, top, and/or sides of concrete slabs, joists, and beams.	N/A	Lin. Ft.	\$150
2	Repair spalled or delaminated concrete on underside surface or vertical surface of concrete beam, column, or joist on the interior of the building.	2/SR6.0	Sq. Ft.	\$450
3	Repair spalled or delaminated concrete at bottom of a joist stem.	1/SR6.0	Lin. Ft.	\$250
4	Remove and replace a concrete joist and adjacent slab	4-6/SR6.0	Lin. Ft.	\$1,425
5	Perform full depth concrete repair at joist slab between joist stems.	3/SR6.0	Sq. Ft.	\$300
6	Repair spalled or delaminated concrete on underside surface of concrete slab.	3/SR7.0	Sq. Ft.	\$200
7	Repair spalled or delaminated concrete on vertical surface of tunnel walls.	2/SR7.0	Sq. Ft.	\$150
8	Install a supplemental epoxied-dowel shear reinforcement into concrete beam.	7/SR6.0	Ea.	\$250
9	Perform polyurethane grout injection of cracks in tunnel walls.	N/A	Lin. Ft.	\$125
10	Repair spalled or delaminated concrete on top surface of concrete spandrel beam on exterior of building.	4/SR7.0	Lin. Ft.	\$200
11	Repair spalled or delaminated concrete on vertical surface of concrete spandrel beam on exterior of building.	5/SR7.0	Sq. Ft.	\$150

NOTES:

1. All Work associated with the above allowance schedule shall be approved in writing by the Commission Representative prior to proceeding.
2. Authorized additional repair work will be paid for in accordance with the above allowance schedule.
3. The unit prices in this allowance schedule include all overhead, profit, and schedule impact costs. Unit prices noted above shall govern for any deviations (additions or deductions) from the scope of work outlined on the drawings.
4. The concrete repair unit prices noted above exclude any shoring that may be required at the repair locations.
5. All unused portions of the allowance funds must be returned to the Commission.

SECTION 00 01 10

TABLE OF CONTENTS

PRUSSING ELEMENTARY SCHOOL ANNEX & RENOVATIONS

The following listed documents comprise the Project Manual for the project listed above. Where numerical sequence of sections is interrupted, such interruptions are intentional.

The complete Project Manual for this project consists of Book 1, Book 2 and Book 3, which must not be separated for any reason. The Architect and Owner disclaim any responsibility for any assumptions made by a Contractor or Subcontractor who does not receive a complete Project Manual, including all sections listed in the Table of Contents.

BOOK 3 – VOLUME I

INTRODUCTORY INFORMATION

Section Number	Section Title	CPS Control Rev.
00 00 00	PBC Project Manual Cover Page	PBC 01_02/23/17
00 01 10	Table of Contents	PBC 00_07/07/17
00 01 11	Information Available to Bidders – see also Vol III for reports	PBC 01_04/01/15



PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

Section Number	Section Title	CPS Control Rev.
	Book 1 (provided by the Public Building Commission)	

SPECIFICATIONS GROUP

GENERAL REQUIREMENTS SUBGROUP

DIVISION 01 – GENERAL REQUIREMENTS

Section Number	Section Title	CPS Control Rev.
	Book 2 (provided by the Public Building Commission)	

01 14 10	Pre-Construction Mockup	PBC 01_07/31/10
01 14 11	Construction Operations and Site Utilization Plan	PBC 01_08/15/14
01 35 59	Indoor Air Quality Requirements	PBC 04_02/08/13
01 35 60.1	LEED® Requirements	PBC 05_09/22/14
01 35 60a	Attachment A – Materials Credit Documentation Sheet	PBC 04_08/17/14
01 35 60b	Attachment B – Low Emitting Mtls. Credits Documentation Sht.	PBC 01_05/15/13
01 35 60c	Attachment C – LEED® Checklist for Schools v.2009	PBC 01_01/01/09
01 35 61	LEED® Coordinator	PBC 02_09/22/14
01 35 62	Erosion and Sedimentation Control	PBC 01_09/14/12
01 35 64	Coordination, Commissioning Authority, and General Requirements	02_05/01/12
01 35 65	Commissioning (Cx) Requirements	01_02/28/06
01 35 66	Commissioning (Cx) Submittal Procedures	01_08/17/08



01 35 67	Commissioning (Cx) Project Record Documents	01_08/17/08
01 35 68	Commissioning (Cx) Operation and Maintenance Data	01_02/28/06
01 35 69	Commissioning (Cx) Process	01_08/17/08
01 35 70	Commissioning (Cx) Pre-Functional Checklists	01_08/17/08
01 35 71	Commissioning (Cx) Functional Performance Testing	01_08/17/08
01 35 72	Commissioning (Cx) Demonstration & Training	01_08/17/08
01 50 10	Commission Representative Field Office	PBC 04_04/03/17
01 52 40	Construction Waste Management and Disposal	PBC 03_09/22/14
01 56 11	General Dust, Fume, and Odor Control	1_01/21/10
01 56 11.10	Temporary Dust, Fume, and Odor Control	01_01/21/10
01 57 15	Integrated Pest Management	PBC 01_09/11/11
01 70 71	Final Cleaning - Schools	PBC 01_10/20/10
01 73 10	Cutting and Patching	PBC 03_07/20/09
01 79 00	Demonstration and Training	03_07/20/09

FACILITY CONSTRUCTION SUBGROUP

DIVISION 02 – EXISTING CONDITIONS

Section Number	Section Title	CPS Control Rev.
02 24 00	Environmental Assessment	PBC 01_09/18/12
02 24 01	Environmental Scope Sheets	01_04/01/15
02 26 00	Hazardous Materials Assessment	PBC 01_09/18/12
02 41 16	Building Demolition	PBC 01_07/31/15
02 41 19	Selective Demolition - Environmental	PBC 01_07/31/15
02 65 00	Underground Storage Tank Removal	PBC 01_07/31/15
02 82 14	Asbestos Abatement – Interiors	PBC 01_07/31/15
02 82 15	Asbestos Abatement – Exteriors	PBC 01_07/31/15
02 83 19.13	Lead-Based Paint Abatement	PBC 01_07/31/15
02 83 20	Disturbance of Painted Surfaces Assumed to Contain Lead	PBC 01_05/19/15
02 86 13	Hazardous and Universal Waste Management	PBC 01_07/31/15
02 87 13	Animal Excrement and Carcass Abatement	PBC 01_07/31/15

DIVISION 03 – CONCRETE

Section Number	Section Title	CPS Control Rev.
03 30 00	Cast-In-Place Concrete	02_04/10/08
03 20 00	Concrete Reinforcement	
03 30 01	Cast-In-Place Concrete for Structural Remediation	
03 37 13	Shotcrete	
03 60 30	Epoxyed-In Anchors	
03 64 23	Epoxy Injection	
03 72 50	Externally Bonded FRP Reinforcement – Laminates	
03 95 00	Concrete Repairs	
03 54 16	Hydraulic Cement Underlayment	02_08/20/07



DIVISION 04 – MASONRY

Section Number	Section Title	CPS Control Rev.
04 01 20	Maintenance of Unit Masonry	01_02/28/06
04 20 00	Unit Masonry	04_04/02/10

DIVISION 05 – METALS

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
05 12 00	Structural Steel Framing	02_04/10/08
05 21 00	Steel Joist Framing	02_04/10/08
05 31 13	Steel Floor Decking	02_04/10/08
05 31 23	Steel Roof Decking	02_04/10/08
05 40 00	Cold-Formed Metal Framing	02_04/10/08
05 50 00	Metal Fabrications	04_03/22/13

DIVISION 06 – WOOD, PLASTICS, AND COMPOSITES

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
06 10 53	Miscellaneous Rough Carpentry	03_04/10/08
06 16 43	Gypsum Sheathing	02_04/10/09
06 40 23	Interior Architectural Woodwork	03_04/10/08

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
07 01 50.23	Roof Removal	02_10/30/07
07 01 50.61	Roof Deck Repair	01_02/28/06
07 11 13	Bituminous Dampproofing	02_08/20/07
07 21 00	Thermal Insulation	03_04/10/08
07 21 29	Sprayed Insulation	04_04/10/08
07 27 00.20	Fluid Applied Air and Vapor Barriers	PBC 01_02/28/10
07 31 13	Asphalt Shingles	02_10/30/07
07 52 00	Modified Bituminous Membrane Roofing	04_11/08/10
07 62 00	Sheet Metal Flashing and Trim	04_01/21/10
07 72 00	Roof Accessories	02_08/20/07
07 81 16	Cementitious Fireproofing	02_08/20/07
07 84 13	Penetration Firestopping	03_04/10/08
07 92 00	Joint Sealants	03_04/10/08
07 95 13	Expansion Joint Assemblies	02_08/20/07

DIVISION 08 – OPENINGS

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
08 11 13	Hollow Metal Doors and Frames	03_04/10/08
08 14 16	Flush Wood Doors	03_04/10/08
08 15 00	Fiberglass Reinforced Polyester (FRP) Flush Door Assemblies	01_02/28/06
08 31 13	Access Doors and Frames	02_08/20/07
08 41 13	Aluminum-Framed Entrances and Storefronts	03_04/10/08
08 51 13	Aluminum Windows	04_01/16/14
08 56 57	Window Guards – Exterior	02_01/05/07
08 71 00	Door Hardware	04_02/28/06
08 71 13	Automatic Door Operators	01_07/27/07
08 80 00	Glazing	02_04/10/08
08 91 00	Louvers	02_02/20/07

DIVISION 09 – FINISHES

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
09 01 22	Plaster Patching	02_08/20/07
09 21 16	Gypsum Board Assemblies	03_04/10/08

09 21 19	Gypsum Board Shaft Wall Assemblies	03_04/10/08
09 30 00	Tiling	03_04/10/08
09 51 13	Acoustical Panel Ceilings	03_01/13/14
09 65 13	Resilient Base and Accessories	03_04/10/08
09 65 19	Resilient Tile Flooring	
09 77 23	Fabric-Wrapped Panels	02_08/20/07
09 91 00	Painting	02_01/16/14
09 91 03	Renovation Painting – Surface Preparation	01_02/28/06
09 91 05	Renovation Painting	01_02/28/06
09 97 23	Concrete Floor Coatings	03_04/10/08

DIVISION 10 – SPECIALTIES

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
10 11 00	Visual Display Units	02_04/10/08
10 14 03	Interior Signage	02_08/20/07
10 14 05	Exterior Signage	02_08/20/07
10 14 07	Exterior Signage – Emergency	02_08/20/07
10 21 13	Toilet Compartments	02_04/10/08
10 28 13	Toilet Accessories	03_01/27/11
10 44 00	Fire Protection Specialties	02_08/20/07
10 44 03	Installation of Fire Extinguishers and Cabinets	01_02/28/06
10 51 13	Metal Lockers – Elementary Schools	04_04/10/08

DIVISION 11 – EQUIPMENT

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
11 40 00	Food Service Equipment	02_08/20/07
11 52 13	Projection Screens	02_08/20/07

DIVISION 12 – FURNISHINGS

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
12 24 13	Roller Window Shades – Manual	03_08/22/07
12 24 14	Roller Window Shades – Motorized	02_08/20/07
12 48 13	Entrance Floor Mats	02_08/20/07
12 93 00	Site Furnishings	01_03/18/14

DIVISION 14 – CONVEYING EQUIPMENT

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
14 24 23	Hydraulic Passenger Elevators	01_06/09/17

BOOK 3 – VOLUME II - FACILITY SERVICES SUBGROUP

DIVISION 21 – FIRE SUPPRESSION

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
21 05 53	Identification for Fire-Suppression Piping and Equipment	01_05/10/13
21 11 00	Facility Fire-Suppression Piping	01_02/28/06
21 31 13	Electric-Drive, Centrifugal Fire Pumps	01_02/28/06

DIVISION 22 – PLUMBING

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
22 05 13	Common Motor Requirements for Plumbing Equipment	01_01/16/14
22 05 16	Expansion Fittings and Loops for Plumbing Piping	15_01/16/14
22 05 17	Sleeves and Sleeve Seals for Plumbing Piping	15_01/16/14
22 05 18	Escutcheons for Plumbing Piping	15_01/16/14
22 05 23	General-Duty Valves for Plumbing	15_01/16/14
22 05 29	Hangers and Supports for Plumbing Piping	15_01/16/14
22 05 48	Vibration Controls for Plumbing Piping and Equipment	01_02/28/06
22 05 53	Identification for Plumbing Piping and Equipment	02_05/10/13
22 07 00	Plumbing Insulation	04_05/22/08
22 11 16	Domestic Water Piping	01_02/28/06
22 11 19	Domestic Water Piping Specialties	01_02/28/06
22 11 23	Domestic Water Pumps	01_02/28/06
22 11 23.13	Domestic Water Packaged Booster Pumps	02_11/06/09
22 13 16	Sanitary Waste and Vent Piping	01_02/28/06
22 14 13	Facility Storm Drainage Piping	01_02/28/06
22 14 23	Drainage Piping Specialties	01_02/28/06
22 14 26	Facility Storm Sewer Drainage	03_01/21/10
22 14 29	Sump Pumps	01_02/28/06
22 36 00	Commercial Fuel-Fired Water Heaters	01_02/28/06
22 40 00	Plumbing Fixtures	02_02/06/09

DIVISION 23 – HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
23 01 30.51	HVAC Air-Distribution System Cleaning	02_11/08/10
23 05 03	General Provisions for HVAC Work	01_02/28/06
23 05 05	Basic HVAC Materials and Methods	03_08/20/10
23 05 13	Common Motor Requirements for HVAC Equipment	01_02/28/06
23 05 15	Motors – Variable Frequency Controllers	02_03/18/11
23 05 16	Expansion Fittings and Loops for HVAC Piping	01_02/28/06
23 05 19	Meters and Gauges for HVAC Piping	03_08/20/10
23 05 23	General-Duty Valves for HVAC Piping	01_02/28/06
23 05 29	Hangers and Supports for Piping and Equipment	01_02/28/06
23 05 48	Vibration Controls for HVAC Piping and Equipment	01_02/28/06
23 05 53	Identification for HVAC Piping and Equipment	02_05/10/13
23 05 93	Testing, Adjusting, and Balancing for HVAC	03_03/18/11
23 07 00	HVAC Insulation	07_05/31/13
23 09 20	Building Automation System (BAS)	06_03/18/11
23 09 20.01	Building Automation System (BAS) – Exhibits	02_04/03/07
23 09 21	Building Automation System (BAS) – Basic Materials, Interface Devices, and Sensors	06_04/27/10
23 09 22	Building Automation System (BAS) – Operator Interfaces	05_11/08/08
23 09 23	Building Automation System (BAS) – Field Panels	04_11/08/08
23 09 24	Building Automation System (BAS) – Communication Devices	03_04/03/07
23 09 25	Building Automation System (BAS) – Software and Programming	04_11/08/08
23 09 25.01	Building Automation System (BAS) – Software and Programming – Exhibits	03_11/08/08
23 09 26	Building Automation System (BAS) – Sequence of Operation	04_02/28/08
23 09 27	Building Automation System (BAS) – Commissioning	04_03/18/11

23 21 13	Hydronic Piping	05_08/20/10
23 21 23	Hydronic Pumps	01_02/28/06
23 23 00	Refrigerant Piping	02_08/20/10
23 25 00	HVAC Water Treatment	02_03/18/11
23 31 13	Metal Ducts	03_08/20/10
23 33 00	Air Duct Accessories	02_12/06/09
23 34 23	HVAC Power Ventilators	01_02/28/06
23 36 00	Air Terminal Units	02_12/03/09
23 37 13	Diffusers, Registers, and Grilles	01_02/28/06
23 37 23	HVAC Gravity Ventilators	01_02/28/06
23 41 13	Panel Air Filters	02_05/22/08
23 51 00	Breechings, Chimneys, and Stacks	03_11/06/09
23 51 13	Draft Control Devices	01_02/28/06
23 52 16	Condensing Boilers	06_04/13/10
23 74 13	Packaged, Outdoor, Central-Station Air-Handling Units	01_02/28/06
23 81 26	Split-System Air-Conditioners	01_08/20/10
23 82 36	Finned-Tube Radiation Heaters	01_02/28/06
23 82 39.13	Cabinet Unit Heaters	01_02/28/06
23 82 39.16	Propeller Unit Heaters	01_02/28/06

DIVISION 26 – ELECTRICAL

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
26 05 03	General Requirements for Electrical Systems	01_02/28/06
26 05 05	Basic Electrical Materials and Methods	03_07/23/14
26 05 11	Conductors and Cables for Electrical Systems	02_07/23/14
26 05 26	Grounding and Bonding for Electrical Systems	02_03/30/06
26 05 29	Hangers and Supports for Electrical Systems	01_02/28/06
26 05 33	Raceways and Boxes for Electrical Systems	03_04/13/09
26 05 53	Identification for Electrical Systems	02_03/30/06
26 08 13	Testing of Electrical Systems	01_02/28/06
26 09 23	Lighting Control Devices	01_02/28/06
26 09 36	Modular Dimming Controls	01_02/28/06
26 24 16	Panelboards	02_02/28/06
26 27 26	Wiring Devices	02_12/04/08
26 28 13	Fuses	01_02/28/06
26 28 16	Enclosed Switches and Circuit Breakers	01_02/28/06
26 29 13	Enclosed Controllers	01_02/28/06
26 43 00	Surge Protection Devices	02_08/20/10
26 51 00	Interior Lighting	02_02/26/14
26 56 00	Exterior Lighting	02_02/26/14

DIVISION 27 – COMMUNICATIONS

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
27 05 03	Communications General Requirements	02_07/23/14
27 05 53	Identification for Communications Systems	02_07/23/14
27 08 00	Commissioning of Communications	02_07/23/14
27 11 16	Communications Cabinets, Racks, and Enclosures	06_07/23/14
27 13 13	Communications Copper Backbone Cabling	02_03/30/10
27 13 23	Communications Optical Fiber Backbone Cabling	04_07/23/14
27 15 00.19	Communications Horizontal Cabling	03_07/23/14

27 51 00	Distributed Audio-Video Communications Systems	01_02/28/06
27 51 16	Public Address Systems	01_02/28/06
27 53 14	Wireless Master Clock Systems	01_07/23/14
27 60 13	Wireless Access Points for Data Communications	02_07/23/14

DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
28 13 15	Access Control System – Door Entry (Large Installation)	02_07/23/14
28 16 00	Intrusion Detection	03_07/23/14
28 23 09	DVS - Digital Video Surveillance System and Components (For New Elementary and High Schools)	PBC 01_04/16/15; 06_11/04/14
28 31 00	Fire Detection and Alarm	03_11/08/10

SITE AND INFRASTRUCTURE SUBGROUP

DIVISION 31 – EARTHWORK

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
31 13 00	Tree and Landscape Protection	
31 22 14	Earthwork	05_01/21/10
31 22 21	Finish Grading for Synthetic Grass Surfacing System	01_04/15/11
31 23 17	Excavating, Backfilling, and Compacting for Utilities	03_06/30/08
31 23 18.13	Soil, Fill, Backfill, CU Structural Soil, and Construction and Demo Debris Removal	PBC 01_07/31/15
31 23 18.14	CCDD - Clean Construction or Demolition Debris and Uncontaminated Soil Disposal	PBC 01_07/31/15
31 23 18.15	Special, Non-Hazardous Special and Hazardous Waste Soil Removal and Disposal	05_01/21/10
31 23 23	Acceptance of Backfill, Topsoil, and CU Structural Soil	PBC 01_07/31/15

DIVISION 32 – EXTERIOR IMPROVEMENTS

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
32 12 16	Hot Mix Asphalt Paving	01_11/08/10
32 13 13	Portland Cement Concrete Paving	02_08/17/07
32 18 14	Synthetic Grass Surfacing System – Playfields	PBC 03_06/23/17
32 31 19	Decorative Metal Fences and Gates	04_04/05/10
32 31 29	Wood Fence	05_03/25/10
32 92 23	Sodding	02_08/17/07
32 93 11	Plantings	04_06/30/08

DIVISION 33 – UTILITIES

<i>Section Number</i>	<i>Section Title</i>	<i>CPS Control Rev.</i>
33 10 13	Water Service	03_01/21/08
33 41 00	Sewerage and Drainage	
33 46 17	Subdrainage for Synthetic Grass Surfacing System	01_04/15/11

VOLUME III – REPORTS (APPENDIX)

<i>Section Number</i>	<i>Section Title</i>	<i>Control Rev.</i>
A	Geotechnical Report with Appendices 1-14	

CPS Control Rev.: 18_07/23/14
PBC Control_07/07/17
Project Rev.: A_11/06/17

B	Hazardous Materials Report with Appendices A-L
C	Phase I Site Assessment with Appendices A-E

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SECTION 03 20 00

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 DESCRIPTION

- A. The Work of this Section includes furnishing, fabricating, and placing reinforcing steel.
- B. Related sections:
 - 1. Section 03 30 01 - Cast-in-Place Concrete for Structural Remediation
 - 2. Section 03 37 13 - Shotcrete
 - 3. Section 03 95 00 - Concrete Repair

1.2 STANDARDS

- A. ASTM A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement, latest edition.
- B. ASTM A615/A615M, Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcement, latest edition.
- C. ACI SP-66, Detailing Manual, latest edition.
- D. ACI 318, Building Code Requirements for Structural Concrete, latest edition.
- E. CRSI Manual of Standard Practice, latest edition

1.3 PAYMENT

- A. The work of this section shall be on a lump sum basis in accordance with the Contractor's bid.

PART 2 PRODUCTS

2.1 REINFORCEMENT AND ACCESSORIES

- A. LEED Certification: Provide reinforcing having minimum 40% recycled steel content manufactured within 500 miles of the site.
- B. New steel reinforcing bars shall conform with requirements of ASTM A615, Grade 60.
- C. New stainless steel anchors: Type 304 stainless steel threaded rod cut and bent to shapes indicated on drawings. 1/4 or 3/8 in. diameter as indicated on drawings.
- D. Welded wire fabric shall conform with requirements of ASTM A185.
- E. Reinforcing Bar Supports
 - 1. Bar supports shall conform to Bar Support Specifications and Standard Nomenclature of the CRSI Manual of Standard Practice.
 - 2. Alternative bar support devices may be used with the prior approval of the Engineer.

2.2 FABRICATION

- A. All bends and hooks shall conform to bend dimensions defined as "ACI Standard Hooks" in the CRSI Manual of Standard Practice unless otherwise shown on the plans.
- B. Reinforcing bars shall conform to the dimensions shown on the Drawings, within the fabricating tolerances as shown in the CRSI Manual of Standard Practice.

PART 3 EXECUTION

3.1 PLACING

- A. Prior to placing concrete, all reinforcing bars located partially or completely within the pour area shall be supported and securely tied.
- B. Runways or another approved protection scheme shall be provided for reinforcing located in a pour or which extends into the pour, in order to prevent damage from moving equipment or pumping equipment.
- C. Unless permitted by the Engineer, reinforcing shall not be bent after being embedded in hardened concrete.

END OF SECTION

SECTION 03 30 01

CAST-IN-PLACE CONCRETE FOR STRUCTURAL REMEDIATION

PART 1 GENERAL

1.1 DESCRIPTION

- A. The Work of this Section includes furnishing, placing, finishing and curing of Portland Cement concrete at the structural remediation locations.
- B. Related sections:
 - 1. Section 03 20 00 - Concrete Reinforcement

1.2 REFERENCE STANDARDS

- A. The most recent edition of standard shall apply.
- B. American Concrete Institute (ACI)
 - 1. Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete (ACI 211.1)
 - 2. Specification for Structural Concrete (ACI 301)
 - 3. Guide for Concrete Floor and Slab Construction (ACI 302.1R)
 - 4. Guide for Measuring, Mixing, Transporting, and Placing Concrete (ACI 304R)
 - 5. Recommended Practice for Hot Weather Concreting (ACI 305R)
 - 6. Recommended Practice for Cold Weather Concreting (ACI 306R)
 - 7. Building Code Requirements for Structural Concrete (ACI 318)
- C. American Society for Testing and Materials
 - 1. Standard Practice for Making and Curing Concrete Test Specimens in the Field (ASTM C31/C31M)
 - 2. Specification for Concrete Aggregates (ASTM C33)
 - 3. Test Method for Compressive Strength of Cylindrical Concrete Specimens (ASTM C39)
 - 4. Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete (ASTM C42)
 - 5. Specification for Ready-Mixed Concrete (ASTM C94)
 - 6. Test Method for Slump of Hydraulic Cement Concrete (ASTM C143)
 - 7. Specification for Portland Cement (ASTM C150)
 - 8. Specification for Sheet Materials for Curing Concrete (ASTM C171)
 - 9. Standard Practice for Sampling Freshly Mixed Concrete (ASTM C172)
 - 10. Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method (ASTM C231)
 - 11. Specification for Air-Entraining Admixtures for Concrete (ASTM C260)
 - 12. Specification for Liquid Membrane-Forming Compounds for Curing Concrete (ASTM C309)
 - 13. Specification for Chemical Admixtures for Concrete (ASTM C494)
 - 14. Specification for Concrete Made by Volumetric Batching and Continuous Mixing (ASTM C685)
 - 15. Classification for Concrete Made by Volumetric Batching and Continuous Mixing (ASTM C685)

16. Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction (ASTM E329)

1.3 QUALIFICATIONS

- A. Contractor performing the Work of this Section shall be capable of demonstrating experience in at least five projects, satisfactorily completed within the past five years, of similar scope and complexity to this Project.

1.4 SUBMITTALS

- A. Delivery Tickets: Furnish copies of delivery tickets for each load of concrete delivered to the site.
- B. Field Test Reports: Submit reports of concrete tests at the end of each day's testing, as described later in this section.
- C. Laboratory Test Reports: Submit copies of laboratory test reports for concrete materials and mix design tests.
- D. Product Data: Submit copies of manufacturer's specifications with application and installation instructions for propriety materials and items upon request.
- E. Mill Certificates: Submit copies of steel producer's certificates of mill analysis, tensile and bend tests for reinforcing steel, upon request.
- F. Shop Drawings: Submit shop drawings sealed by a registered engineer for fabrication, bending, and placement of concrete reinforcement. Comply with the ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures." Show bar schedules, stirrup spacing, diagrams of bent bars, arrangements and assemblies, as required for the fabrication and placement of concrete reinforcement.
- G. LEED Submittals: Submit the following and such other data requested or required for LEED accounting purposes.
 - 1. Certification stating recycled steel content, including percentage of post-industrial and post-consumer content, demonstrating compliance with specification.
 - 2. Certification stating steel was manufactured within 500 miles of the Project.
 - 3. Certification stating the percentage and amount of recycled lightweight aggregate in the design mix and stating that such aggregate was manufactured within 500 miles of the Project.
 - 4. Certification stating the percentage and amount of replacement of Portland cement with Fly Ash and Pozzolan in each design mix.
 - 5. Certification stating ready-mix concrete was produced within 500 miles of the project.

1.5 PAYMENT

- A. The work of this section shall be on a lump sum basis in accordance with the Contractor's bid.

PART 2 PRODUCTS

2.1 CONCRETE MIX REQUIREMENTS

- A. Minimum 28-day design compressive strength shall be 4,000 psi.
- B. Mix designs for normal weight concrete shall be proportioned in accordance with ACI 211 and this Specification. Mix designs proposed for use, when tested in a laboratory, shall have an average 28-day compressive strength in excess of design strength as required in Chapter 4 of ACI 318.
- C. Maximum water-cement ratio shall not exceed 0.40 by weight of cement for structural repair concrete.
- D. Slump
 - 1. Concrete to be mixed with a high range water-reducing admixture (superplasticizer) shall be delivered to the Project Site with a slump of not less than 2 in. and not more than 4 in. before addition of the superplasticizer. Slump after Project Site addition of superplasticizer shall not be less than 5 in. or more than 7 in. Alternately, a high range water reducer with added retarder for reducing rate of slump loss may be used.
 - 2. Slump of non-superplasticized concrete shall not exceed 4 in. at the time of discharge from the truck.
- E. The entrained air content shall be 6.0 percent by volume, plus or minus 1.5 percent, and shall be measured according to ASTM C231.

2.2 CONCRETE MATERIALS

- A. Portland Cement shall conform to ASTM C150, Type I or Type II. Type III cement is not permitted.
- B. The following types of admixtures may be used when approved by the Architect/Engineer.
 - 1. Air-entraining Admixtures ASTM C260
 - 2. Chemical Admixtures ASTM C494
- C. Calcium Chloride shall not be permitted in the concrete as an intentional additive or as an unintended contaminant on aggregates or any other concrete materials.
- D. Coarse aggregate shall be normal-weight crushed stone or gravel, unless otherwise noted. Fine aggregate shall be natural or manufactured sand. Aggregate particles shall be clean, hard, and angular, of uniform quality, and free from soft, thin elongated pieces, disintegrated stone, dirt, organic, or other injurious materials occurring either free or as a coating. Aggregates shall be supplied from a source approved by the Architect/Engineer. Aggregate gradation shall conform to ASTM C33 with the following limitations:
 - 1. Minimum percentage of coarse aggregate by weight of total aggregate shall be 55 percent.
 - 2. Maximum aggregate size shall be $\frac{3}{4}$ in. for structural repair concrete.
- E. Mixing water shall be potable, clean and free of injurious quantities of substances known to be harmful to Portland Cement.

2.3 TESTING OF CONCRETE MIX DESIGNS

- A. Mix designs of each separate mix shall be prepared and the following data shall be submitted to the Architect/Engineer for each mix design.
 - 1. Sieve analysis for fine and coarse aggregate
 - 2. Test for aggregate organic impurities
 - 3. Proportions of all materials
 - 4. Mill certificates for cement
 - 5. Slump , during laboratory tests
 - 6. Air content, during laboratory tests
 - 7. Three, 7 and 28-day laboratory compression test results (Minimum three cylinders for each test age for a total of nine cylinders)
- B. A mix design previously used and which complies with specifications may be submitted for approval. Include all information listed above. During construction, tests will be made by an approved Testing Agency to determine if the concrete complies with the specified requirements. The Contractor shall cooperate in the making of such tests to the extent of allowing free access to the Work for the selection of samples and the storage of specimens, and in affording protection to specimens against injury or loss through his operations. The Contractor shall furnish all concrete for testing.

2.4 FORM MATERIALS

- A. Forms: Construct formwork with plywood, metal, or metal-framed plywood-faced to provide continuous, straight, smooth as-cast surfaces. Minimum plywood grade shall be APA Plyform Class 1, B-B Exterior type. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Drawings. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.
- B. Form Ties:
 - 1. Provide factory-fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection, and to prevent spalling concrete surfaces upon removal.
 - 2. Provide ties so that portion remaining within concrete after removal of exterior parts is at least 1/2 in. from the outer concrete surface where occupied space is below grade.
 - 3. Unless otherwise specifically shown, provide stainless steel ties having cones 1 in. diameter at surface and minimum 1 in. deep where tie holes shown ungrouted.
- C. Form Coatings: Provide commercial formulating form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds.

PART 3 EXECUTION

3.1 FORMWORK

- A. The Contractor shall be responsible for the design and construction of all formwork. Forms shall conform to shape, lines, grade, and dimensions of existing members and shall be braced and tied together to maintain position and shape during placement of concrete. Seal between

existing construction and forms to minimize bleeding at form edges and provide clean straight lines after form stripping.

- B. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Brace temporary closures and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings in forms in as inconspicuous location as possible, consistent with Project requirements.
- C. Form exposed corners with chamfers. Form chamfers with 3/4 in. x 3/4 in. strips, unless otherwise shown, accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Miter chamfer strips at changes in direction.
- D. Provide openings in concrete formwork to accommodate work of other trades, including those under separate prime contracts (if any). Size and location of openings, recesses and chases are the responsibility of the trade requiring such items. Accurately place and securely support items to be built into forms.
- E. Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is to be placed. Retighten forms immediately after concrete placement as required to eliminate leaks.
- F. Coat form contact surfaces with form-coating compound before reinforcement is placed. Do not allow excess form-coating material to accumulate in the forms or come into contact with surfaces which will be bonded to fresh concrete. Apply in compliance with Manufacturer's instructions.

3.2 FALSEWORK (SHORING)

- A. Provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof.
- B. Provide camber in formwork as required for anticipated deflections due to weight and pressures of fresh concrete and construction loads for long span members without intermediate supports.
- C. Carefully inspect falsework and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure; make necessary adjustments to produce work of required dimensions.
- D. Remove shores and reshore in a planned sequence to avoid damage to partially cured concrete. Locate and provide adequate reshoring to safely support the work without excessive stress of deflection.
- E. Shoring shall remain in place a minimum of 14 days after placing slab, and longer if required, until the concrete has attained its required minimum 28 day design compressive strength and heavy loads due to construction operations have been removed.

3.3 BATCHING AND MIXING

- A. All concrete shall be delivered to the Project Site ready-mixed. Ready-mix concrete shall be batched, mixed, and transported in accordance with applicable provisions of ASTM C94.

Batch plants used in production of ready-mixed concrete shall comply with standards set forth by Plant Manufacturers Bureau of National Ready-Mix Concrete Association. Truck mixers, agitators, and nonagitating units used to mix and transport ready-mix concrete production facilities shall comply with Standards of Truck Mixers Manufacturers Bureau of National Ready-Mixed Concrete Association. Ready-mix concrete production facilities shall be currently certified by National Ready-Mix Concrete Association and the Contractor shall submit a copy of that certification to the Owner's Representative.

- B. Concrete shall be delivered to Project Site and discharged within 90 minutes or before 300 revolutions of mixer drum, after introduction of mixing water. Indiscriminate addition of water to increase slump is prohibited.
 - 1. When concrete arrives at Project Site with slump below that suitable for placing, water may be added providing the maximum permissible slump is not exceeded. In the event water is added at Project Site, it shall be incorporated by additional mixing equal to at least 30 revolutions of the drum at mixing speed recommended by manufacturer. If additional water is added, the amount added shall be noted on delivery ticket and ticket signed by person authorizing addition of water.
 - 2. Concrete to which water has been added in such amounts as to cause the water/cement ratio to exceed the specified maximum allowable value will be rejected. When concrete arrives at job Project Site with a slump exceeding maximum specified slump, concrete shall be rejected.
 - 3. All superplasticizing admixtures shall be added at the jobsite. The quantity of superplasticizer added shall be in accordance with the approved mix design and the recommendations of the manufacturer, and may be adjusted for variations in initial slump.
 - a. Initial, or "water" slump shall be tested for each truckload prior to addition of superplasticizer.
 - b. Where superplasticizer is added manually at the back of the drum, mixing vanes and sides of drum shall be washed by hose spray with a nominal amount of water prior to mixing.
 - c. Following addition of superplasticizer, concrete shall be re-mixed for not less than 100 revolutions of the drum.
 - d. Retempering of the mix with additional superplasticizer may be done only with the approval of the Architect/Engineer.
- C. Plant-batched air-entraining and chemical admixtures, when used, shall be incorporated into the mix in amounts and manner recommended by the manufacturer and approved by the Architect/Engineer. Accuracy of measurement of any admixture shall be within plus or minus three percent. Two or more admixtures may be used in the same concrete provided such admixtures are added separately and that the combination is compatible and has no deleterious effect on the concrete.
- D. The temperature of the concrete, when discharged, shall be not less than 65 deg F when the air temperature is below 40 deg F. If heated water or aggregates are used, the water shall be combined with the aggregates in the mixer before cement is added. Cement shall not be added to mixtures of water and aggregate when the temperature of the mixture exceeds 70 deg F.
- E. The temperature of the concrete, when discharged, shall not exceed 85 deg F.

3.4 PLACING CONCRETE

- A. Before placing concrete, all equipment for mixing and transporting concrete shall be cleaned, vibrators shall be checked for workability, all frost, ice, mud, debris, and water shall be removed from concrete surfaces and forms, forms shall be thoroughly wetted or oiled, and reinforcement shall be securely tied in place and thoroughly cleaned of ice and other coatings which may destroy or reduce bonding with concrete. No concrete shall be placed until the Architect/Engineer has approved the forms and the condition and placement of reinforcement.
- B. Where new concrete is cast against existing concrete surfaces, thoroughly wet the existing surface between 4 to 12 hours prior to placement but do not allow puddles to form. Blow dry any visible moisture 2 hours prior to placement with clean, dry air. At time of placement of concrete, existing concrete surfaces shall be in a saturated, surface dry condition, showing no visible moisture.
- C. Conveying the concrete from the mixer to the place of deposit shall not cause separation or loss of materials.
- D. Placing of concrete shall be such that it shall be deposited as nearly as possible to its final position to avoid segregation due to rehandling or flowing. Placing shall be at such a rate that at all times concrete shall be plastic and flow readily into corners of forms and into spaces between rebars. No concrete that has partially hardened or has been contaminated by foreign materials shall be deposited.
- E. When concreting is commenced, it shall be carried on as a continuous operation until the section is completed. When being deposited, concrete shall not be allowed to fall a vertical distance greater than four feet from point of discharge to point of deposit.
- F. Concrete placement shall not disturb or displace reinforcing bars, floor drains, or other embedments.
- G. All newly placed concrete shall be consolidated by means of vibration. Generally, vibration shall be accomplished by means of an internal vibrator running at a minimum speed of 7000 rpm or higher, depending on the nature of the concrete being consolidated. Extra vibrators shall be kept at the Project Site to be used in case a vibrator does not work. When immersion-type vibrators are used to consolidate concrete around epoxy-coated reinforcing, the vibrators shall be equipped with rubber or non-metallic vibrator heads.

3.5 FINISHING

- A. After screeding, fresh concrete surfaces shall be bullfloated. The concrete surface shall have a smooth trowel finish, followed by a medium broom drag.
- B. Slope finished surfaces of topping as indicated on the Drawings.
- C. The maximum variation in slab surface from planar shall be 3/16 inch in 10 ft using an approved ten foot straight edge as described in ACI 302.R-89. If variations greater than this exist, the Engineer may direct the Contractor to grind to bring the surface within requirements; patching of low spots shall not be permitted. Grinding shall be done as soon as possible, preferably within 3 days, but not until concrete is sufficiently strong to prevent dislodging coarse aggregate particles.

- D. Control joints 1/4 the slab thickness shall be cut into the overlay as shown on the Drawings. Joints shall be made with a power blade within 4 to 12 hours after the slab has been placed and finished. Joints shall be cut as soon as the concrete surface is firm enough not to be torn or damaged by the blade, and before random shrinkage cracks can form in the concrete slab.

3.6 CONSTRUCTION JOINTS

- A. Locate and install construction joints, which are not shown on the Drawings, so as not to impair strength and appearance of the structure. Construction joint placement is subject to submittal by Contractor and approved by Architect/Engineer.
- B. Provide keyways at least 1-1/2 in. deep in all construction joists in walls, slabs and between walls and footings.
- C. Place construction joints perpendicular to the main reinforcement.

3.7 CURING

- A. Structural repair concrete shall be maintained above 55 deg F and in a moist condition for at least the first 7 days after placing. Curing shall be accomplished by burlap covers kept continuously wet and covered with 4 mil polyethylene sheets conforming to ASTM C171 with edges lapped and tightly sealed by sand, wood planks, pressure-sensitive tape, mastic, or glue.
- B. Adequate protection shall be provided for concrete during freezing or near freezing weather. All concrete materials, reinforcement, forms, filler, and ground with which concrete is to come in contact shall be free of frost, ice, and snow. Whenever air temperature is below 40 deg F, the minimum temperature of concrete when discharged shall be 65 deg F, and concrete during the required curing period shall be maintained at a temperature not less than 50 deg F. Throughout heating period, concrete shall be kept moist as specified. The concrete temperature shall be monitored automatically or manually each half-hour during cold weather.
- C. Placement and curing of concrete during hot weather shall be in conformance to the requirements of ACI 305R.

3.8 FIELD QUALITY CONTROL

- A. Testing of concrete
 - 1. A set of six 6-in. diameter by 12-in. long test cylinders shall be made at a frequency of once per day, or once for each 20 cubic yards of ready-mixed concrete placed, whichever results in a larger number of tests. Four in. diameter by 8 in. long test cylinders may be substituted when the maximum aggregate size does not exceed 3/4 in. or as allowed by ASTM specification.
 - 2. All cylinders shall be made and tested by a qualified approved Testing Agency which meets the requirements of ASTM E329, and their reports will be sent to the Architect/Engineer and Contractor. Costs for these tests shall be paid by the Owner, except where specifically indicated otherwise in this Section.
 - 3. Two cylinders from each set shall be tested at seven days, and an additional two cylinders at 28 days, in accordance with ASTM C31. The remaining cylinders shall be laboratory-cured and held in reserve for strength testing beyond 28 days, if necessary and if directed by Architect/Engineer. Additional cylinders may be made and tested at the Contractor's expense where it is desired to demonstrate 75 percent of specified 28-day strength earlier than seven days after placement, and where high early strength is expected. All cylinders

- to be tested earlier than 7 days shall be field-cured in the part of the structure in which the concrete is placed, and shall be removed from the structure not more than 24 hours before the time of the test.
4. At the time each set of cylinders is made, the fresh concrete shall be tested for slump and air content in accordance with ASTM C143 and C231, respectively, and the concrete mix temperature and air temperature shall be measured and recorded.
 5. Concrete which fails to meet the slump or air content requirements shall be tested again using a different concrete test sample from the same source. If the second series of tests reveals the concrete does not meet the slump or air content requirements, the nonconforming concrete shall be rejected and properly disposed. A new batch of concrete shall be mixed or obtained at the Contractor's expense.
 6. Unless directed otherwise by the Architect/Engineer, samples of concrete for test specimens shall be taken from the transport vehicle during discharge.
 7. Test specimens shall be molded promptly after the sample is taken and then placed in Project Site storage provided by the Contractor. Storage shall be in a shed, box or other enclosure maintained at a temperature between 60 and 80 deg F. Specimens shall be stored for a minimum of 16 hours prior to removal from the sampling location.
 8. Strength of concrete shall be considered satisfactory if:
 - a. The average compressive strength results of two 28-day tests in each set of cylinders equals or exceeds the specified 28-day strength, and neither of the 28-day tests results is 500 psi or more below specified 28-day strength; or
 - b. Compressive strength equals or exceeds the specified 28-day strength for each of two successive cylinder tests made before 28 days. In this case, additional scheduled tests may be waived.
 9. Testing: The following information shall be recorded and reported in a test summary report.
 - a. Individual test specimen strength, type of failure
 - b. Slump
 - c. Air content
 - d. Concrete and air temperature
 - e. Specimen number
 - f. Concrete pour location
 - g. Date cast
 - h. Date tested
 - i. Concrete properties specified
 - j. Notice if tests indicate concrete is or is not in conformance with specifications.
- B. Should results of cylinder tests, including testing of reserved cylinders after 28 days if directed by Architect/Engineer, not meet preceding strength requirements, the Contractor shall submit a revised mix design data for concrete which will conform to the specifications. In the event of failure of test cylinder specimens for any portion of work, the Contractor, at the Contractor's expense, shall have sample cores cut from that portion of structure represented by unsatisfactory test specimens. Three cores shall be taken from each area in question according to ASTM C42. Concrete in the area represented by core tests will be considered structurally adequate if the average of the three cores is equal to at least 85 percent of specified 28-day cylinder strength, and if no single core has a strength less than 75 percent of the 28-day strength. If these strength acceptance criteria are not met by core tests, the Contractor shall remove and replace all questionable areas of concrete at the Contractor's expense.

3.9 LIMITATIONS OF OPERATIONS

- A. No vehicular or construction traffic shall be permitted in adjacent bays for at least 72 hours after a concrete pour.
- B. No vehicular or construction traffic shall be permitted on a concrete deck pour for at least 3 days and until the concrete has achieved its specified 28-day compressive strength.

END OF SECTION

SECTION 03 37 13

SHOTCRETE

PART 1 GENERAL

1.1 SUMMARY

- A. This Section includes installation of shotcrete applied by wet- or dry-mix process on vertical and overhead surfaces, including shotcrete materials, batching procedures, placement procedures, finishing, and curing.
- B. Related sections:
 - 1. Section 03 95 00 - Concrete Repair

1.2 REFERENCES

- A. Reference Standards: All standards latest edition as of the date of this Specification
 - 1. American Concrete Institute (ACI)
 - a. ACI 117R - Standard Specification for Tolerances for Concrete Construction and Materials
 - b. ACI 211.1 - Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
 - c. ACI 301 - Standard Specification for Structural Concrete
 - d. ACI 305 - Standard Specification for Hot Weather Concreting
 - e. ACI 306.1 - Standard Specification for Cold Weather Concreting
 - f. ACI 506R - Guide to Shotcrete
 - g. ACI 506.2 - Specification for Shotcrete
 - 2. ASTM International
 - a. ASTM C33: Standard Specification for Concrete Aggregates
 - b. ASTM C94: Standard Specification for Ready-Mixed Concrete
 - c. ASTM C150: Standard Specification for Portland Cement
 - d. ASTM C171: Standard Specification for Sheet Materials for Curing Concrete
 - e. ASTM C173: Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
 - f. ASTM C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
 - g. ASTM C260: Standard Specification for Air-Entraining Admixtures for Concrete
 - h. ASTM C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 - i. ASTM C494: Standard Specification for Chemical Admixtures for Concrete
 - j. ASTM C595: Standard Specification for Blended Hydraulic Cements
 - k. ASTM C618: Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
 - l. ASTM C685: Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
 - m. ASTM C989: Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
 - n. ASTM C1064: Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete

- o. ASTM C1077: Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
- p. ASTM C1116: Standard Specification for Fiber-Reinforced Concrete and Shotcrete
- q. ASTM C1140: Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels
- r. ASTM C1141: Specification for Admixtures for Shotcrete
- s. ASTM C1240: Standard Specification for Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout
- t. ASTM C1260: Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)
- u. ASTM C1480: Standard Specification for Packaged, Pre-Blended, Dry, Combined Materials for Use in Wet or Dry Shotcrete Application
- v. ASTM C1604: Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete
- w. ASTM E329: Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

1.3 DEFINITIONS

- A. Shotcrete: Mortar or concrete pneumatically projected onto a surface at high velocity.
- B. Wet-Mix Shotcrete: Shotcrete with ingredients, including mixing water, mixed before introduction into delivery hose. Accelerator, if used, is usually added at the nozzle.
- C. Dry-Mix Shotcrete: Shotcrete with most of the water added at nozzle.
- D. Rebound: Shotcrete material which ricochets off the receiving surface.

1.4 SUBMITTALS

- A. Product Data: For manufactured materials and products including forming accessories, shotcrete materials, admixtures, and curing compounds.
- B. Design Mixes: For each shotcrete mix, including the following:
 - 1. Statement of intended use for mix and mix identification designation.
 - 2. Proportion of all materials, including admixtures added at the nozzle. For wet-mix shotcrete, include air content before shooting and expected air content after shooting.
 - 3. Sieve analysis for fine and coarse aggregate.
 - 4. Sources of all materials.
 - 5. Mixing method.
- C. Qualification Data: For Installer, including nozzleman
- D. Material and Mix Test Reports: For shotcrete materials and mix, including the following:
 - 1. Aggregate organic impurities.
 - 2. Aggregate alkali reactivity.
 - 3. 7- and 28- day compressive strengths.
- E. Material Certificates: For each material item, signed by manufacturers.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified installer employing experienced supervisors and operators.
 - 1. Nozzleman:
 - a. ACI- or American Shotcrete Association (ASA)-certified for the method to be used and vertical and overhead shooting.
 - b. No less than one year experience on similar applications or successful completion of three projects of similar size and character.
 - 2. Field Supervision: No less than three years of experience as a certified shotcrete nozzleman. Maintain experienced full-time supervisor(s) on Project site when shotcreting preparation or operations are in progress.
 - 3. Equipment Operators and Blow Man: No less than six months apprenticeship on similar applications.
- B. Testing Agency Qualifications: An independent agency qualified according to ASTM C1077 and ASTM E329 for testing indicated, and acceptable to Owner's Representative and Engineer.
- C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.
- D. Comply with provisions of the following, unless more stringent requirements are indicated:
 - 1. ACI 506.2, "Specification for Shotcrete."
 - 2. ACI 301, "Specification for Structural Concrete."
- E. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle materials according to the manufacturer's recommendations and in such a manner as to prevent damage to materials and structure.
 - 1. Store packaged materials on elevated platforms and protect from weather, moisture including condensation, and neglect.
 - 2. Store packaged materials unopened until ready to use.
- B. Deliver materials to the site in the manufacturer's original and unopened containers, clearly labeled with the manufacturer's name and type of products.
- C. Arrange aggregate stockpiles and use in a manner to avoid segregation or contamination with foreign matter or other aggregates. Cover aggregate stockpiles during periods of wet weather.
- D. Store materials in areas designated for storage by Owner.

1.7 PROJECT CONDITIONS

- A. Existing Conditions
 - 1. Examination: Examine the conditions where work will be performed and notify Engineer of existing conditions encountered that are at variance with Drawings or Specifications, or may interfere with proper execution of the work.

- a. Correct conditions detrimental to timely and proper completion of work.
- b. Verify all dimensions and details on the Drawings prior to acquisition or installation of materials.

PART 2 PRODUCTS

2.1 REINFORCING MATERIALS

- A. Reinforcing bars, wires, accessories, and anchors as specified in Sections 03 95 00.

2.2 FORM MATERIALS

- A. Forms: Form-facing panels that will provide continuous, straight, smooth, concrete surfaces. Furnish panels in largest practical sizes to minimize number of joints.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

2.3 SHOTCRETE MATERIALS

- A. Portland Cement: ASTM C150, Type I. Use only one brand and type of cement for Project.
- B. Silica Fume: ASTM C1240, amorphous silica.
- C. Normal-Weight Aggregates: ASTM C33, from a single source, free of salt and organic impurities and as follows:
 1. Aggregate Gradation: ACI 506R, Gradation No. 1 with 100 percent passing 3/8-inch, or Gradation No. 2 with 100 percent passing 1/2-inch sieve.
- D. Gradation No. 1 is the preferred gradation. Gradation No. 2 may be used if the Contractor can show during preconstruction testing that reinforcement sizes and spacings to be encountered on the job can be properly encased using larger aggregate sizes.
- E. Water: Potable, complying with ASTM C94/C94M, free from deleterious materials that may affect setting or strength of shotcrete.
- F. Calcium chloride shall not be permitted in the concrete as an additive.

2.4 ADMIXTURES

- A. General: ASTM C1141, Class A or B, but limited to the following admixture materials when accepted by Engineer. Calcium chloride or admixtures that contain more than 0.1 percent water-soluble chloride ions by mass of cementitious material will not be accepted. Certify chloride content and compatibility of admixtures with each other and with other cementitious materials.
 1. Air-Entraining Admixture: ASTM C260.
 2. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 3. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
 4. Water-Reducing and Accelerating Admixture: ASTM C494/C494M, Type E.
 5. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.

6. Accelerating Admixture: ASTM C494/C494M, Type C.

- B. Shotcrete mix shall be modified to include a required amount of GUN-RITE HP-W additive or approved equal. The recommended proportion of this additive in the mix is one unit of GUN-RITE HP-W (40 lbs) per every two bags of cement (188 lbs).

2.5 CURING MATERIALS

- A. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.
- B. Water: Potable.
- C. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, subject to compliance with local regulations. See Section 03 31 00, Par. 2.6.C for additional information.

2.6 SHOTCRETE MIXTURES

- A. Prepare design mixes for each type and strength of shotcrete.
- B. Limit water-soluble chloride ions to 0.15 percent by weight of cement or cementitious materials per ACI 301.
- C. Admixtures: When approved by Engineer for use in shotcrete design mixes, use admixtures according to manufacturer's written instructions.
1. Do not add dry powdered water-reducing admixtures to dry-mix shotcrete.
 2. Limit the use of accelerating admixture in wet-mix shotcrete to what is strictly required to achieve early strength requirements. Add air entraining admixture to improve pumpability, but such that the air content of the in-place shotcrete does not exceed 6 percent.
- D. Design-Mix Adjustments: Subject to compliance with requirements, shotcrete design-mix adjustments may be proposed when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant.
- E. Proportion dry mixtures by field test data methods and wet mixtures according to ACI 211.1 and ACI 301, using materials approved for Project, to provide shotcrete with the following properties:
1. Drilled core specimens (1-1/2 inch diameter, 3 inch long):
 - a. 28-Day Compressive Strength: 4000 psi
 - b. 7-Day Compressive Strength: 3300 psi
 2. Sawn cube specimens (3 inch cube):
 - a. For cube specimens, the minimum compressive strength shall be at least equal to the above specified strengths (Par. 2.6.E.1) divided by 0.85 for 7 and 28 days.

2.7 SHOTCRETE EQUIPMENT

- A. Mixing Equipment: Capable of thoroughly mixing shotcrete materials in sufficient quantities to maintain continuous placement.
- B. Dry-Mix Delivery Equipment: Capable of discharging aggregate-cement mixture into delivery hose under close control and maintaining continuous stream of uniformly mixed materials at

required velocity to discharge nozzle. Equip discharge nozzle with manually operated water-injection system for directing even distribution of water to aggregate-cement mixture.

1. Provide uniform, steady supply of clean, compressed air to maintain constant nozzle velocity while simultaneously operating blow pipe for cleaning away rebound.
 2. Provide water supply with uniform pressure at discharge nozzle to ensure uniform mixing with aggregate-cement mix. Provide water pump to system if line water pressure is inadequate.
- C. Wet-Mix Delivery Equipment: Capable of discharging aggregate-cement-water mixture accurately, uniformly, and continuously at velocities that apply materials to the prepared surface with minimum rebound and maximum adherence and density.
1. Provide uniform, steady supply of clean, compressed air to maintain constant nozzle velocity while simultaneously operating blow pipe for cleaning away rebound.
 2. Provide access equipment to allow application of shotcrete to all surfaces at a minimum range of one foot from the nozzle.
 3. Use a pump with metering equipment to monitor and control rate of admixtures added at the nozzle.

2.8 BATCHING AND MIXING

- A. Measure mix proportions by weight batching according to ASTM C94/C94M or by volume batching complying with ASTM C685/C685M requirements.
1. Batch by weight to control proportions. With Engineer's permission, volume batching may be used provided that a minimum of one weight batching check is made every 8 hours. Batch cement in one-bag units. In volume batching, adjust fine-aggregate volume for bulking. Test fine aggregate moisture content at least once daily to determine extent of bulking.
 2. Approved prepackaged shotcrete materials may be used at Contractor's option. Predampen prepackaged shotcrete materials and mix before use.

PART 3 EXECUTION

3.1 SITE INSPECTION

- A. Prior to commencing Work, examine surfaces to receive Work and verify dimensions and existing conditions. Commencing Work constitutes acceptance of Work surfaces and conditions.

3.2 PREPARATION

- A. Prepare unsound concrete removal areas, surfaces to receive shotcrete, and embedded reinforcement as specified in Section 03 95 00.
- B. Alignment control: Install ground wires to establish thickness and planes of shotcrete surfaces. Install ground wires at corners and offsets not established by forms. Pull ground wires taut and position adjustment devices to permit additional tightening.
- C. Embedded items: Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by shotcrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

3.3 FORMWORK

- A. General: Design, erect, support, brace, and maintain forms, according to ACI 301, to support shotcrete and construction loads and to facilitate shotcreting. Construct forms so shotcrete members and structures are secured to prevent excessive vibration or deflection during shotcreting.
 - 1. Fabricate forms to be readily removable without impact, shock, or damage to shotcrete surfaces and adjacent materials.
 - 2. Construct forms to required sizes, shapes, lines, and dimensions using ground wires and depth gages to obtain accurate alignment, location, and grades in finished structures. Construct forms to prevent mortar leakage but permit escape of air and rebound during shotcreting. Provide for openings, offsets, blocking, screeds, anchorages, inserts, and other features required in the Work.
 - 3. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.4 STEEL REINFORCEMENT

- A. Fabricate, place, and support reinforcement as specified in Section 03 95 00.

3.5 APPLICATION

- A. All areas prepared for shotcrete repair will be reviewed and approved by the Engineer prior to application of any shotcrete.
- B. Apply temporary protective coverings and protect adjacent surfaces against deposit of rebound and overspray or impact from nozzle stream. Do not apply shotcrete during periods of high wind which could interfere with the shotcrete stream, unless suitable enclosures or wind breaks are installed.
- C. Wet and damp dry existing surfaces to obtain a saturated-surface-dry condition immediately before placing shotcrete to facilitate bond and prevent excessive absorption from shotcrete.
- D. Apply shotcrete according to ACI 506.2.
- E. Apply dry-mix shotcrete materials within 45 minutes after predampening and wet-mix shotcrete materials within 90 minutes after batching. Do not place shotcrete if drying or stiffening of the mix takes place at any time prior to delivery to the nozzle.
- F. Deposit shotcrete in the minimum number of layers required to build up the full thickness of shotcrete without sagging, sloughing, or dislodging. Cut out and replace concrete that sags or sloughs at no additional cost to Owner.
- G. Remove and dispose of rebound and overspray materials during shotcreting to maintain clean surfaces and to prevent rebound entrapment. Do not re-use rebound or previously expended material.
- H. Maintain reinforcement in position during shotcreting. Place shotcrete to completely encase reinforcement and other embedded items. Maintain steel reinforcement free of overspray and prevent buildup against front face during shotcreting.

- I. Do not place subsequent lifts until previous lift of shotcrete is capable of supporting new shotcrete.
 - 1. Broom or scrape shotcrete with a trowel once lift has reached initial set to provide roughened surface and to remove rebound and overspray.
 - 2. Do not apply curing compounds or other bond breaking agents to surfaces that will receive an additional layer of shotcrete.
 - 3. Do not allow shotcrete that is to receive an additional layer to reach final set.
- J. Remove hardened overspray, rebound, and laitance from shotcrete surfaces to receive additional layers of shotcrete; dampen surfaces before shotcreting.
- K. Do not disturb shotcrete surfaces before beginning finishing operations.
- L. Remove ground wires or other alignment control devices after shotcrete placement.
- M. Installation Tolerances: Place shotcrete without exceeding installation tolerances permitted by ACI 117R, increased by a factor of 2.
- N. Sound all new shotcrete surfaces after shotcrete has set and repair delaminated areas in accordance with Article 3.10.

3.6 SURFACE FINISHES

- A. General: Finish shotcrete according to descriptions in ACI 506R for the following finishes:
- B. Natural Finish:
 - 1. Gun Finish: Natural undisturbed finish.

3.7 CURING

- A. Protect freshly placed shotcrete from premature drying and excessive cold or hot temperatures.
- B. Start initial curing as soon as free water has disappeared from shotcrete surface after placing and finishing.
 - 1. If there is a delay between the shotcrete layers or finishing operations, temporarily cover work with a clear or white polyethylene film or similar plastic sheeting, minimum thickness 4 mils, to retard early drying.
- C. Curing Exposed Surfaces:
 - 1. Moisture Curing: Keep surfaces continuously moist for at least seven days with water, continuous water-fog spray, water-saturated absorptive covers, or moisture-retaining covers. Lap and seal sides and ends of covers.
 - a. Moist-cure shotcrete that contains fly ash, slag, or silica fume. Use of curing compounds will not be approved for shotcrete mixes that contain supplementary cementing materials.
 - 2. Curing Compound: Apply two coats of curing compound uniformly in continuous operation by power spray according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
 - 3. Apply curing compound to natural- or gun-finished shotcrete at rate of 100 sq. ft./1gal.
 - a. Do not apply curing compound on any surfaces that will receive additional shotcrete or cementitious materials.

- b. Do not apply curing compound in severe drying conditions.
- D. Curing Formed Surfaces: Cure formed shotcrete surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.

3.8 FORM REMOVAL

- 1. Forms not supporting weight of shotcrete may be removed after curing at not less than 50 deg F for 24 consecutive hours after gunning, provided shotcrete is hard enough not to be damaged by form-removal operations and provided curing and protecting operations are maintained.
- 2. Leave forms supporting weight of shotcrete in place until shotcrete has attained design compressive strength. Determine compressive strength of in-place shotcrete by testing representative field-cured specimens of shotcrete.
- 3. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing materials are unacceptable for exposed surfaces. Apply new form-coating compound as specified for new formwork.

3.9 FIELD QUALITY CONTROL

- A. Notify the Engineer at least 48 hours in advance of shotcreting work. Engineer will provide periodic observation of the shotcreting work to help monitor proper techniques and the soundness of the in-place product. Engineer will also examine the completed shotcrete work.
- B. Owner will engage a qualified independent testing agency to sample materials, visually grade cores, perform tests, and submit reports during shotcreting.
- C. Air Content: ASTM C173/C173M, volumetric method or ASTM C231, pressure method; one test for each compressive-strength test for each mix of air-entrained, wet-mix shotcrete measured before pumping.
 - 1. Shotcrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each set of compressive-strength specimens.
 - 2. Test Panels: Make a test panel, reinforced as in structure, for each shotcrete mix and for each workday or for every 50 cubic yards of shotcrete placed, whichever is less. Produce test panels with dimensions of 24 by 24 inches minimum and of average thickness of shotcrete, but not less than 3-1/2 inches. Make test panels in same orientation and with same nozzleman as work represented. Clearly label each test panel with the date placed, nozzleman, and portion of structure represented.
 - 3. From each test panel, testing agency will obtain six 1-1/2 inch diameter by 3 inch long cores or 3 inch cube test specimens immediately prior to testing: one set of three specimens unreinforced and one set of three specimens reinforced.
 - a. Test each set of unreinforced specimens for compressive strength at seven days according to ASTM C1140 and construction testing requirements in ACI 506.2.
 - b. Visually inspect each set of reinforced shotcrete cores taken from test panels and determine mean core grades according to ACI 506.2. Core grades will be considered satisfactory when testing satisfies both of the following:
 - 1) Mean core grades do not exceed 2.5.
 - 2) No single core grade exceeds 3.0.

- c. Include the following in each test report:
 - 1) Specimen number.
 - 2) Date placed.
 - 3) Nozzleman.
 - 4) Portion of structure represented by specimen.
 - 5) Date tested.
 - 6) Shotcrete properties specified.
 - 7) Individual test specimen strength and type of failure.
 - 8) Indicate whether the shotcrete test results are in accordance with specifications.
- D. Strength of shotcrete will be considered satisfactory when testing satisfies the following:
 - 1. Seven-day compressive strength:
 - a. Drilled core specimens: Mean compressive strength of each set of three unreinforced cores equals or exceeds 100 percent of specified core compressive strength, with no individual core less than 88 percent of specified seven-day core compressive strength.
 - b. Sawn cube specimens: Mean compressive strength of each set of three sawn cubes equals or exceeds 100 percent of specified sawn cube compressive strength, with no individual cube less than 88 percent of specified compressive strength.
 - 2. Should test results not meet the preceding requirements, associated shotcrete work will be rejected unless additional testing is performed at 28 days and above requirements are satisfied for specified 28-day compressive strengths.
- E. Engineer or Owner's Representative may perform destructive and non-destructive testing to detect voids in shotcrete. Owner will pay for initial testing. If substantial voids are found, Contractor will pay for subsequent tests.

3.10 REPAIRS

- A. Remove and replace shotcrete that does not pass specified tests, is delaminated, or exhibits laminations, voids, or sand/rock pockets exceeding limits for specified core grade of shotcrete at no cost to Owner.
 - 1. Remove unsound or loose materials and contaminants that may inhibit bond of shotcrete repairs. Chip or scarify areas to be repaired to extent necessary to provide sound substrate. Cut edges square and 1/2 inch deep at perimeter of work, tapering remaining shoulder at 1:1 slope into cavity to eliminate square shoulders. Dampen surfaces and apply new shotcrete.
 - 2. Engage the Owner's testing agency to perform additional tests on shotcrete repairs in accordance with Paragraph 3.9 above. Pay all costs associated with testing shotcrete repairs.
 - 3. All prepared areas will be examined by Engineer prior to the placement of repair shotcrete. Do not proceed with shotcreting until preparation has been approved by Engineer.
 - 4. Place, finish, and cure repair shotcrete in the same manner specified for the shotcrete work.
- B. Repair core holes from in-place testing according to repair provisions in ACI 301 and match adjacent finish, texture, and color. Repair core holes at no additional cost to Owner.

3.11 CLEANING

- A. Remove and dispose of rebound and overspray materials from final shotcrete surfaces and areas not intended for shotcrete placement.

END OF SECTION 03 37 13

SECTION 03 60 30

EPOXIED-IN ANCHORS

PART 1 GENERAL

1.1 WORK INCLUDED

- A. This work shall consist of providing the necessary labor, materials, equipment and supervision to install epoxied-in anchors.
- B. Definition
 - 1. Epoxied-in anchor: The completed composite of reinforcing bar or threaded rod dowel surrounded by epoxy within the drilled hole.

1.2 RELATED WORK

- A. Section 03 37 13 - Shotcrete
- B. Section 03 95 00 - Concrete Repair

1.3 STANDARDS AND QUALITY ASSURANCE

- A. Applicator Qualifications
 - 1. The Contractor shall have three years of experience in performing work similar to that shown on the drawings and described in these specifications.
 - 2. An on-site supervisor shall be provided by the Contractor for the duration of the epoxied-in anchor work. This supervisor shall have had 2 years documented supervisory experience with the products to be used.
- B. Source quality control
 - 1. The material supplier shall provide (via the Contractor) the following test data for each production run or batch of epoxy formulation to be used:
 - a. Tensile strength by ASTM D638
 - b. Elongation at break by ASTM D638
 - c. Flexural strength by ASTM D790
 - d. Flexural modulus by ASTM D790
 - e. Compressive yield strength by ASTM D695
 - f. Compressive modulus by ASTM D695
 - g. Heat deflection temperature by ASTM D648
 - h. Slant shear by AASHTO
- C. Reference standards
 - 1. American Society for Testing Materials Standards
 - a. Test for Sag Flow of Highly Viscous Resins (ASTM D2730)
 - b. Test for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins (ASTM D2471)
 - c. Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) (ASTM C78)
 - d. Test for Compressive Properties of Rigid Plastics (ASTM D695)
 - e. Test for Deflection Temperature of Plastics Under Flexural Load (ASTM D648)
 - f. Test for Tensile Properties of Plastics (ASTM 638)

- g. Tests for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials (ASTM D790)
 - h. Specifications for Stainless and Heat-Resisting Steel Bars and Shapes (ASTM A276)
 - 2. American Association of State Highway and Transportation Officials Test for Slant Shear Strength of Epoxy Bonding Agent (AASHTO 237)
 - 3. American Concrete Institute "Manual of Standard Practice for Detailing Concrete Structures" (ACI 315)
 - 4. Concrete Reinforcing Steel Institute "Manual of Standard Practice"
- D. Allowable tolerances:
- 1. The epoxied-in dowels shall be installed such that the ends of dowels and the clear cover fall within +0 and -1/4 in. of that specified.

1.4 SUBMITTALS

- A. The Contractor shall submit the following to the Architect/Engineer:
- 1. Technical data sheets for each epoxy product or formulation to be used showing that his products meet the requirements of the specifications. Technical data shall include:
 - a. Intended use
 - b. Pot life (neat)
 - c. Initial cure time (1000 psi)
 - d. Tack free (thin film)
 - e. Final cure (75% ultimate strength)
 - f. Tensile strengths by ASTM D638 (14 days)
 - g. Tensile elongation by ASTM D638 modified (14 days)
 - h. Flexural strength and modulus per ASTM D790 at 24 hrs, 3 days, and 7 days at 77°F.
 - i. 24-hr compressive strength by ASTM C109 modified (1 part epoxy to 3-1/4 parts aggregate)
 - j. VOC content

1.5 PRODUCT DELIVERY

- A. The product shall be delivered and handled according to the manufacturer's recommendations.
- B. Damaged, open containers shall not be used.

1.6 JOB CONDITIONS

- A. Existing and environmental conditions: The Contractor shall examine the condition of surfaces where epoxied-in anchors are required. He shall follow the recommendations of the manufacturer with regard to limitations of the materials in various moisture and temperature conditions.

1.7 PAYMENT

- A. The Work of this Section shall be on a lump sum basis in accordance with the Contractor's bid.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Epoxy for Anchors: The Epoxy shall be Hilti HIT-RE 500-SD or Hilti HIT-HY 200 (as specifically noted on drawings) by Hilti, Inc. or an approved equal.

- B. Reinforcing Steel:
 - 1. New steel reinforcing bars shall conform with requirements of ASTM A615, Grade 60. Provide diameter and shape specified on drawings.
- C. Stainless Steel Anchors: Type 304 1/4 in. diameter stainless steel threaded rods cut and bent to shapes indicated on drawings.

Maximum yield strength - 30 ksi
Minimum tensile strength - 75 ksi

PART 3 EXECUTION

3.1 MOCK-UPS

- A. Install mock-ups of each anchor type for review by Engineer.

3.2 INSPECTION

- A. Examine surfaces where epoxied-in anchors are to be installed for unsound concrete that would adversely affect the execution and quality of work.
- B. Where such conditions are found, notify the Architect/Engineer and proceed with work at other locations.

3.3 PREPARATION

- A. Lay out the locations of epoxied-in anchors according to the drawings and specifications.
- B. The Contractor is advised to use a magnetic detector, (i.e., James instruments "R-Meter", or equal) to avoid drilling into existing embedded reinforcing. He should also refer to the original drawings for information on the approximate size, number and location of existing reinforcing bars. These drawings are available from the Owner.

3.4 INSTALLATION OF ANCHORS

- A. Drilling holes:
 - 1. Holes may be wet-or dry-drilled using either percussive or rotary machines.
 - 2. Wet-drilled holes shall be flushed with clean water to remove residue, then blown out using oil-free compressed air, or allowed to air dry.
 - 3. Dry-drilled holes shall be blown out using oil-free compressed air to remove all loose concrete debris.
 - 4. Holes shall be the diameter required by the adhesive manufacturer for the specified anchor/threaded rod diameter to be used.
- B. Anchors shall be dry and free from contaminants, such as dirt, oil, and grease.
- C. Proportioning and mixing:
 - 1. Mix the components of the epoxy in proper proportions according to the manufacturer's directions.

D. Installation:

1. The epoxied-in anchors shall be installed by mixing and injecting a pre-measured quantity of epoxy to the back of the hole and insertion of the anchor.
2. The method of installation is intended to achieve 100 percent filling of the annular space between the anchor and the drilled hole.
3. The Contractor shall follow the manufacturer's instructions for use and the installation shall be in general accordance with one of the following methods. The initial installation is subject to a review of mock-ups of all anchor types.
 - a. Suction tube: This is a simple tube of a size that will fit inside the anchor hole. The tube is fitted with an inner tube, or plunger, that has a screw, approximately 3 in. long, attached to one end. Approximately 3 rubber washers, alternated with smaller metal washers are attached to the end of the machine screw. The rubber washers must be in contact with the inner surface of the outer tube to provide an air-tight seal.
 - 1) Place the open end of the outer tube into the mixed grout and suck the material into the tube by slowly pulling out the plunger tube. When filled, remove the tube, leaving the plunger in place and wipe off excess epoxy.
 - 2) Insert the filled tube to the back of the anchor hole. Slowly withdraw the outer tube with one hand while keeping firm pressure on the plunger with the other hand. Note: Only partially fill the hole. Calibrate the tube for the estimated volume of grout for the hole with a piece of tape around the outside of the plunger tube.
 - 3) Insert the anchor into the filled hole while slowly working it back and forth to assist removal of air. Insert small wooden edges into the hole opening to position the anchor temporarily until the grout has set or gelled.
 - b. Hand Operated Caulk Gun. The caulk gun should be fitted with a wide tip opening and a length of polyethylene or copper tubing matching the depth of the anchor hole.
 - 1) Fill the gun with epoxy in the same manner as for sealant.
 - 2) Place the extension tube to the back of the anchor hole. Begin injection evenly, while slowly with-drawing the tube.
 - 3) Insert the anchor as above.

3.5 CLEAN-UP

- A. The epoxied-in anchors shall be cleanly installed and squared up as shown on the drawings. Excess epoxy shall be cleaned up. Wood shims shall be removed.
- B. Safety of Personnel:
 1. Avoid skin contact with epoxy materials, solvents and epoxy strippers. Epoxy resins and particularly epoxy hardeners may cause skin sensitization.
 2. Wear rubber gloves (preferably with a cloth liner) and protective clothing. Where splashing may occur, wear goggles or face shields. Barrier creams are recommended but do not substitute for protective clothing.
 3. If skin contact occurs, wash immediately with a waterless cleaner, followed by soap and water. Should eye contact occur, flush immediately with plenty of water for 15 minutes and call a physician.

END OF SECTION

SECTION 03 64 23

EPOXY AND GROUT INJECTION

PART 1 GENERAL

1.1 DESCRIPTION

- A. This work shall consist of providing the necessary labor, materials, equipment and supervision to inject epoxy into cracks as required by Section 03 72 50 – Externally Bonded FRP Reinforcement, and at other locations specified by Engineer. In addition, work shall include the injection of chemical grout into cracks and joints at locations specified by Engineer.

1.2 STANDARDS

- A. American Society for Testing and Materials Standards (ASTM)
 - 1. Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) (ASTM C78)
 - 2. Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (ASTM C109)
 - 3. Standard Test Method for Tensile Properties of Plastics (ASTM D638)
 - 4. Standard Test Method for Deflection Temperature of Plastics Under Flexural Load (ASTM D648)
 - 5. Standard Test Method for Compressive Properties of Rigid Plastics (ASTM D695)
 - 6. Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials (ASTM D790)
 - 7. Standard Test Method for Viscosity of Epoxy Resins and Related Components (ASTM D2393)
 - 8. Standard Test Method for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins (ASTM D2471)
- B. American Association of State Highway and Transportation Officials (AASHTO)
 - 1. Test for Slant Shear Strength of Epoxy Bonding Agent (AASHTO 237)

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate Work to ensure that adjacent areas are not adversely affected and that fumes due to injection Work are not objectionable. Coordinate:
 - 1. With Owner's Representative.
 - 2. With other trades:
 - a. To ensure that work done by other trades is complete and ready for injection Work.
 - b. To avoid or minimize Work on, or in immediate vicinity of, injection Work in progress.
- B. Pre-installation Meeting:
 - 1. Conduct meeting at Site.
 - 2. Review requirements for injection Work, including:
 - a. Construction schedule.
 - b. Availability of materials, Injection Subcontractor's personnel, equipment, and facilities needed to make progress and avoid delays.

- c. Site use, access, staging, and set-up location limitations.
 - d. Cracks and joints to be injected, and condition of other construction that will affect injection Work.
 - e. Surface preparation and substrate condition and pretreatment.
 - f. Injection procedures.
 - g. Testing and inspection requirements.
 - h. Site protection measures.
 - i. Governing regulations.
3. Contractor's Site superintendent, injection-material manufacturer's technical representative, Injection Subcontractor's foreman, Owner's Representative, and Architect/Engineer shall attend.
- C. Sequencing: For cracks and joints in areas of unsound concrete:
1. Remove unsound concrete per Section 03 95 00.
 2. Prepare and inject cracks and joints.
 3. Prepare and clean concrete removal areas per Section 03 95 00; install replacement material per Section 03 95 00.

1.4 QUALITY ASSURANCE

- A. Application Qualifications
1. The Contractor shall have a minimum of three years of experience in performing epoxy injection work.
 2. The Contractor shall submit a list of at least five projects in which epoxy injection was performed successfully. This list shall contain the following for each of the five projects:
 - a. Project name
 - b. Owner of project
 - c. Owner's Representative, address, and telephone number
 - d. Description of work
 - e. Cost of portion of work similar to that specified in this section
 - f. Total cost of project
 - g. Date of completion
 3. The sum of the costs of the three or more projects provided in 2.e above shall be a minimum of \$30,000.
 4. A full-time on-site supervisor shall be provided by the Contractor for the duration of the epoxy injection work. This supervisor shall have had 2 years documented supervisory experience with the products to be used. The Contractor shall submit a list of projects the supervisor has worked on with the same information as required in Paragraph 2 above.
 5. In addition, the Contractor shall meet all of the following requirements:
 - a. The manufacturer of the epoxy shall have a minimum of three years experience providing epoxies similar to those specified in this section.
 - b. Upon request, the manufacturer of the epoxy shall supply a representative who shall be present at the site for the duration of the epoxy injection work and who will supervise the Contractor's crew doing the epoxy injection. This representative shall have 3 years of field experience supervising the injection of epoxy. The Contractor shall submit a list of projects the representative has worked on with the same information as required in Paragraph 2 above.
- B. Source Quality Control
1. The material supplier shall provide the following test data for each epoxy formulation to be used:

- a. Tensile strength by ASTM D638
- b. Elongation at break by ASTM D638
- c. Flexural strength by ASTM D790
- d. Flexural modulus by ASTM D790
- e. Compressive yield strength by ASTM D695
- f. Compressive modulus by ASTM D695
- g. Heat deflection temperature by ASTM D648
- h. Slant shear by AASHTO 237

1.5 SUBMITTALS

- A. Product Data: Injection-material manufacturer's literature including written instructions for evaluating, preparing, and treating substrate; technical data including tested physical and performance properties; and mixing and injection instructions.
 1. Include temperature ranges for storage and application of materials, and special cold-weather application requirements or limitations.
 2. Include recommended Site protection measures.
 3. Include Globally Harmonized System (GHS) Safety Data Sheets or, if not yet available, Material Safety Data sheets for information only.
- B. Certificates:
 1. Signed by injection-material manufacturer, certifying that products furnished comply with requirements and are recommended by manufacturer for uses indicated.
 2. Signed by injection-material manufacturer, certifying that Subcontractor is approved to install its products.

1.6 MOCK-UPS

- A. Mockups: Install one crack for each injection product to demonstrate injection procedures and quality.
 1. Architect/Engineer will observe injection procedure and completed installation. Notify Architect/Engineer and Owner's Representative seven days in advance of mockup construction.
 2. If Architect/Engineer determines mockup does not comply with requirements, modify mockup or construct new mockup until mockup is approved.
 3. Approved mockup will be standard for judging completed Work.
 4. Approved mockups may become part of completed Work if undisturbed at time of Substantial Completion.

1.7 PRODUCT DELIVERY

- A. The product shall be delivered and handled according to the Manufacturer's recommendations.
- B. Damaged, open containers shall not be used.
- C. All labels shall clearly indicate:
 1. Name of manufacturer
 2. Manufacturer's product name or product number
 3. Manufacturer's lot number
 4. Mix ratio
 5. Conformance with the injection adhesive specification
 6. SPI hazardous material rating and appropriate warnings for handling

- D. Deliver materials to Site in original containers with seals unbroken, labeled with manufacturer's name; product brand name and type; date of manufacture; lot number; SPI hazardous rating and appropriate warnings for handling; and directions for storing and mixing.
- E. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling, or installation. Reject and remove from Site new materials which exhibit evidence of moisture during application, or have been exposed to moisture.
- F. Store materials in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by injection-material manufacturer.
- G. Limit stored materials on structures to safe loading capacity of structure at time materials are stored, and to avoid permanent deck deflection.
- H. Conspicuously mark damaged or opened containers or containers with contaminated materials, and remove from Site as soon as possible.
- I. Remove materials that cannot be applied within stated shelf life from Site and replace with new materials.

1.8 JOB CONDITIONS

- A. Existing and environmental conditions: The Contractor shall examine the condition of surfaces into which the epoxy is to be injected. Contractor shall follow the recommendations of the Manufacturer with regard to surface preparation and to limitations of the materials in various moisture and temperature levels.
- B. Verify existing dimensions and details prior to start of injection Work. Notify Architect/Engineer of conditions found to be different than those indicated in the Contract Documents. Architect/Engineer will review situation and inform Contractor and Injection Subcontractor of changes.
- C. Maintain adequate ventilation during preparation and injection Work.

1.9 UNIT PRICES

- A. The Contractor shall submit unit prices as required on the Bid Proposal Form. Payment based on linear feet of cracks and joints injected.

1.10 WARRANTY

- A. Joint and Several Warranty by Manufacturer, Contractor, and Injection Subcontractor:
 - 1. Written warranty, signed by injection-material manufacturer, Contractor, and Injection Subcontractor, including:
 - a. Additional injection of injected cracks and joints that do not comply with requirements; that do not remain watertight; that fail in adhesion, cohesion, or general durability; or that deteriorate in manner not clearly specified by submitted injection-material manufacturer's data as inherent quality of material for application indicated. Warranty does not include deterioration or failure of injection material due to failure of substrate prepared according to requirements.

- b. Provide access to warranty work, including removal and replacement of overlying materials. Warranty includes replacement of overlying materials as necessary.
 - c. Labor and materials to perform warranty work.
- 2. Warranty Period: 5 years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Epoxy Injection Resin: Injection resin shall be Kemko 038 Injection Resin as manufactured by Chemco Systems, Tyfo 103 as manufactured by Fyfo Co., LLC, or approved equal.
- B. Epoxy Injection Surface seal: Surface seal shall be Kemko 046 Quickseal for dry or damp surface seal, or approved equal.
- C. Chemical Grout: Grout shall be Deneef Flex LV Pure / SLV Pure Polyurethane, or approved equal.

2.2 PRESSURE INJECTION EQUIPMENT

- A. Injection equipment shall be capable of continuously metering, mixing, and pumping injection material under pressure through crack injection ports; equipment shall be approved by injection-material manufacturer.
 - 1. Volumetric metering shall continuously dispense components in proportions specified by injection-material manufacturer, within tolerance of plus or minus 5 percent.
 - 2. Delivery shall be at constant, preset pressure recommended by injection-material manufacturer. Pressure loss in either line in 3 minutes, when stalled at 80 percent or higher of maximum possible discharge pressure, shall be less than 5 pounds per square inch.
 - 3. Pump shall be equipped with automatic shut-off device to prevent injection of unmixed components.
- B. The pressure injection system shall be capable of filling cracks as small as .005 in. wide.

PART 3 EXECUTION

3.1 SURFACE PREPARATION, PLACEMENT OF INJECTION PORTS

- A. In the event that unsound concrete is located in a zone along the crack, and this prevents the complete injection of the crack, that unsound concrete shall be removed prior to injection.
- B. Surfaces adjacent to cracks or other areas of application shall be cleaned of dirt, dust, oil, efflorescence, paint or other foreign materials which may be detrimental to establishing a bond of the sealing material prior to epoxy injection.
- C. Where cracks to be injected have sealant, waterproofing material, or other debris in the cracks, these cracks shall be cleaned using abrasive blasting and high-pressure air jet as appropriate. Grind the crack if mineral deposits are present that may inhibit proper injection.

- D. The entry ports shall be located either on the crack surface or in a drilled hole intersecting the crack. Port setting shall be done in such a manner as not to plug the crack at that location and prevent subsequent adhesive injection.
- E. Install injection ports to achieve complete filling of crack or joint.
 - 1. Number and spacing of injection ports shall be approved by representative of injection-material manufacturer.
 - a. Spacing shall not exceed lesser of 2 feet; thickness of member for full-depth cracks and joints; or depth of crack for partial-depth cracks.
 - 2. As required drill holes along crack or joint.
 - 3. Install injection ports on crack surface or in drilled holes in such manner that crack or joint is not plugged and injection Work is not adversely affected.
- F. The surface seal material shall be applied to the face of the crack between and around the entry ports. For through cracks the surface seal shall be applied on both faces, where possible.
- G. Adhesive injection shall not be started before the seal material has had adequate time to acquire sufficient strength to withstand injection pressures.

3.2 INJECTION

- A. The Contractor shall notify the Engineer of the start of injection work.
- B. Injection of the epoxy adhesive shall begin at the lowest entry port and continue until the adhesive emerges from the next adjacent (higher) port.
- C. As soon as the adhesive emerges from the adjacent port, injection shall be stopped, the port sealed and the injection transferred to the adjacent port.
- D. The process of injection, waiting for emergence of adhesive from the next adjacent port, sealing of the injection port and continuation of injection in the adjacent port shall continue until the crack is filled.
- E. The process of injection described in 3.2B to 3.2D may be modified to the extent that injection at the original port may be continued after emergence of adhesive from the adjacent port by sealing that port and waiting for emergence at the next higher port or ports. This modification of the regular injection procedure may be used if the injection pressure does not substantially increase, the port seals remain in place and no leaks become apparent.
- F. If port to port travel of the injection adhesive is not indicated, the work shall be stopped and remedial action shall be taken which may require resetting of surface ports or drilling holes which intersect with the cracks from a different angle. Such work shall only be done after authorization from the Engineer.

3.3 FINISHING

- A. After the crack has been completely filled, the injection adhesive shall be given sufficient time to cure to a state which allows removal of the seal without any adhesive run-out or smearing of the adjacent surface.
- B. All surface seal material and injection adhesive which runs or spills shall be carefully removed from the surface.

- C. The face of the repaired crack shall be finished flush with the adjacent surface and indentations or protrusions caused by the placement of entry ports shall be removed.
- D. After the work has been accepted by the Engineer, test core holes shall be filled using a two component epoxy grout mix, applied by hand trowel and thoroughly rodded and tamped in place. The surface finish shall match the color and texture of the adjacent surface to the satisfaction of the Engineer. Materials and procedures for filling test core holes shall be submitted to and approved by the Engineer before proceeding with this work.

3.4 GROUTING

- A. Perform initial injection Work in the presence of a representative of injection-material manufacturer. At conclusion of Site visit, representative shall prepare and furnish letter to Architect/Engineer, stating whether installation was completed in accordance with requirements. These services shall be provided at no additional cost to Owner.
- B. Commence injection only after hydraulic cement or epoxy gel has developed sufficient strength to withstand injection pressure without debonding or rupture.
- C. Maintain the concrete substrate and injection material at a suitable temperature for a suitable time period so that injection material will completely fill crack or joint and will achieve full cure.
- D. Continuously inject material into crack or joint, as recommended by injection-material manufacturer.
 - 1. Use injection pressure of 200 to 3,000 pounds per square inch, depending on the crack or joint width, the thickness of the member, and the condition of the substrate.
 - 2. Start injection at lowest injection port and continue until injection material emerges from adjacent port.
 - 3. Remove injection nozzle and cap injection port immediately after injection material emerges from adjacent port.
 - a. Alternately, cap adjacent port and continue injection until injection material emerges from next higher port; alternate procedure may be used if injection pressure does not substantially increase, port caps remain in place, and no leaks occur.
 - 4. Continue injection process upward from port to port, waiting for emergence of injection material from adjacent port and capping injection port, until crack or joint is filled.
 - 5. After injecting three or four ports, re-inject last three or four ports.
 - 6. If port-to-port travel does not occur, stop Work and modify injection setup to achieve port-to-port travel. Modifications may include resetting injection ports, installing injection ports at closer spacing, or drilling holes which intersect crack or joint at different angle. Modifications shall be approved in advance by representative of injection-material manufacturer and Architect/Engineer.

3.5 FIELD QUALITY ASSURANCE

- A. Core testing to verify adhesive penetration and bond strength
 - 1. The Contractor shall obtain 1-2 in. diameter test core samples from the injected cracks at locations specified by the Engineer.
 - 2. Two test core samples shall be taken in the first one hundred lineal feet of repaired crack and one test core for each one hundred lineal feet thereafter. The test cores shall be taken from locations as selected by the Engineer.

3. At the direction of and at locations identified by the Engineer, Contractor shall take two core samples of sound concrete, if its strength is not known or is subject of disagreement. The cores shall be tested in accordance with the method specified in 3.5 A.4 and their average compressive strength shall establish the minimum bond strength required for test cores to be acceptable.
4. Methods of core testing and test requirements:
 - a. Adhesive Penetration (Visual Inspection):
 - 1) Observe penetration of injection material into crack or joint on side of core sample.
 - 2) Injection Work is acceptable if 90 percent of crack or joint is filled with injection material.
 - b. Bond Strength/Compression Test (ASTM C42): Failure primarily in concrete before adhesive failure becomes apparent at 90% of the concrete or the sound concrete sample compressive strength. For concrete with a compressive strength of 6,500 psi or greater, the test cores shall not fail below 90% of the actual compressive strength or at 6,500 psi, whichever is lower.
 - 1) Contractor shall patch core holes.
5. Test evaluation and acceptance:
 - a. Failed tests due to lack of adhesive penetration: The work in this area shall be stopped until the crack area represented by the failing test core has been re-injected, re-cored (verification cores), as directed by the Engineer and satisfactorily re-tested.
 - b. Failed tests due to lack of bond strength: The work shall be stopped in that area. Two additional tests cores (verification cores) shall be taken at the direction of the Engineer and tested. Compliance of the verification cores with the test requirements of 3.5 A.4 shall constitute permission to resume work. Upon failure of the verification cores to meet the test requirements of 3.5 A.4, the Engineer may authorize continuation of the work in the area, if in his judgment the actual bond strength of the verification cores is adequate, or he may order additional verification cores, both in the sound concrete and the work area or he may reject the work.

B. Injection Equipment Tests

1. To verify the performance of the injection equipment, pressure and ratio test shall be conducted by the method, in a frequency and with the results as set forth below.
2. Pressure/Ratio Test Equipment: The test equipment shall be a device with two independent sections, identical in design and function, one for each adhesive component, complete with proper fittings, pressure gauges (250 psi max. rating), in-line filters and needle valves with appropriate discharge nozzles. The device shall be capable of controlling flow rate and pressure of each adhesive component independently by opening or closing the needle valves.
3. Pressure Test
 - a. Test Method: The mix-head of the injection equipment, in the off-position for this purpose, shall be disconnected from the two adhesive component delivery hoses which are then re-connected to the appropriate section of the pressure/ratio test device. The valves of the test device shall be closed. The injection equipment shall then be started and allowed to operate until the pressure in the test device reaches and exceeds 160, but not more than 200 psi in both sections. The injection equipment shall then be turned off and the pressure shall be let down to 160 psi, the valves shall be closed and the pressure in the system observed for five minutes.
 - b. Test Result: During the five minute waiting period the pressure in each section of the pressure/ratio test device shall not fall to below 150 psi.

- c. Frequency of Test: The pressure test shall be performed on the injection equipment at the beginning and the middle of each work shift it is used.
- 4. Ratio Test
 - a. Test Method: Employing the test device described in 3.5 B.2 and connecting it in the same manner as described in 3.5 B.3 to the injection equipment, the injection equipment is in operation and the adhesive components are being simultaneously discharged and collected in separate preweighed or volumetric calibrated containers. At least 100 g or 3 fluid ounces of the lesser volume component of the two component adhesive shall be collected. For greater accuracy of the test, samples shall be obtained by simultaneously collecting the adhesive components while the equipment is running. To accomplish this, the sample containers shall be quickly and simultaneously moved into the stream of the adhesive components and removed when sufficient sample was collected.
 - b. Test Requirements: The test shall be conducted at atmospheric pressure and at 160 psi at the prevailing job site temperature and employing the adhesive to be used in the repair.
 - c. Test Results: The average error of at least three individual tests in the ratio of the two adhesive components collected shall not exceed $\pm 5\%$.
 - d. Test Frequency: The ratio test shall be conducted at the beginning and the middle of each shift the injection equipment is in use. The Engineer may direct the contractor/subcontractor to conduct additional ratio tests, if there is reason to believe that the equipment does not deliver the adhesive in the proper proportions.

END OF SECTION

SECTION 03 72 50

EXTERNALLY BONDED FRP REINFORCEMENT - LAMINATES

PART 1 GENERAL

1.1 DESCRIPTION

- A. Furnish all labor, materials, tools, equipment, and supervision necessary for repairing and reinforcing selected concrete joists and girders with externally bonded fiber reinforced polymer (FRP) reinforcement, as shown on the Drawings and as specified herein.
- B. Related sections:
 - 1. Section 03 64 23 - Epoxy Injection
 - 2. Section 03 95 00 - Concrete Repair

1.2 REFERENCE STANDARDS (MOST RECENT EDITION SHALL APPLY)

- A. American Concrete Institute (ACI):
 - 1. ACI 503R, Use of Epoxy Compounds with Concrete
 - 2. ACI 546R, Concrete Repair Guide
 - 3. ACI 440.2R, Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures
- B. International Code Committee Evaluation Service (ICC-ES)
 - 1. ICC-ES AC125, Acceptance Criteria for Externally Bonded FRP Composite Systems
 - 2. ICC-ES AC178, Acceptance Criteria for Inspection of Externally Bonded FRP Composite Systems
 - 3. ICC-ES AC10, Acceptance Criteria for Quality Control Manual
- C. American Society for Testing and Materials (ASTM):
 - 1. C 1583, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)
 - 2. D 3039, Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
 - 3. D 4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
 - 4. E 84, Standard Test Method for Surface Burning Characteristics of Building Materials
- D. American National Standards Institute (ANSI)/Underwriters Laboratories (UL)
 - 1. ANSI/UL 263, Fire Resistance Ratings
- E. International Concrete Repair Institute (ICRI)
 - 1. #03730 Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion
 - 2. #03732 Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays
 - 3. #03733 Guide for Selecting and Specifying Materials for Repairs of Concrete Surfaces

1.3 SUBMITTALS

- A. Submit product information and other data specified herein in accordance with submittal provisions.
 - 1. Manufacturer's product data sheets indicating product standards; technical specifications; material and section properties, and physical and chemical characteristics of all materials used in the FRP system; and limitations of all materials used in the FRP system.
 - 2. Certified independent test reports of ultimate tensile strength, rupture strain, modulus, and other evidence that the materials and system provided for this Project are in compliance with the physical properties published in the Manufacturer's currently available technical data sheets. Test reports shall include data from a minimum of 20 replicate test specimens, and shall describe the test method used, number of tests, mean values, and standard deviations.
 - 3. Installation of large scale structural testing of the composite system on representative test specimens, conducted and reported by an independent testing agency.
- B. Complete shop drawings shall be submitted for each configuration of FRP system. The shop drawings shall contain details of the type, locations, dimensions, number and thickness of layers, orientations of all FRP materials, joint and end details, locations to be applied, finish coatings, and all other information required for the proper installation of the system. Shop drawings shall indicate specific reference to joist and girder repair identification marks, as shown on the Drawings.
- C. Submit design calculations prepared by an engineer experienced in the design of FRP composite strengthening systems on behalf of the Contractor to determine the layout of the FRP materials to be installed. Submitted calculations shall be stamped by a structural engineer licensed in the State of Illinois. Design calculations shall conform to requirements set forth in ACI 440 and be based on the design modulus and area of the composite to be installed. The composite system shall be designed to achieve the structural performance shown on the Drawings.
- D. System manufacturer's quality control manual in compliance with ICBO AC10, "Acceptance Criteria for Quality Control Manuals."
- E. Submit representative samples of the following items in accordance with submittal requirements.
 - 1. FRP fabric
 - 2. Cured FRP system laminate
- F. Submit the following information within three days of submitting proposal.
 - 1. List of five (5) composite strengthening projects successfully completed by the composite system installer similar in size and scope of this project. The list should include at a minimum the dates of the work, type, description and amount of work performed, along with the name, current address, and phone number of project owner and engineer.
 - 2. Resume with relevant experience for the applicator's key personnel (project superintendent and assistant) proposed for this project. The superintendent shall have a minimum experience of 1 year in directing projects of this nature.
 - 3. Written verification from the system Manufacturer that the applicators have received the required certifications and training.

- G. Submit a list of a minimum fifteen (15) similar composite strengthening projects using the Manufacturer's composite system. The list should include at a minimum the dates of the work, type, description and amount of work performed.
- H. The Contractor shall organize and conduct a preconstruction meeting that shall be attended by the Contractor, the FRP installers, the technical representative of the FRP Manufacturer, and the Engineer. At this meeting, the Contractor and FRP installer shall present detailed descriptions of their proposed installation procedures. The Engineer may require installation procedures and details to be provided in writing for review.

1.4 QUALITY ASSURANCE

- A. Manufacturer/Supplier Qualifications:
 - 1. The Manufacturer shall have a minimum of fifteen (15) documented successful field installations of product specified in this Section in similar applications over a minimum period of three (3) years.
 - 2. The Manufacturer shall support a training program to instruct applicators in the installation of the products specified in this Section.
 - 3. The Manufacturer shall provide a technical representative to be on site full time immediately prior to and during installation in the first five repairs. Designated technical representative shall have field experience with at least 10 similar installations of FRP systems, and shall observe work and provide necessary direction to installer to ensure that proper installation procedures are employed. Additional site visits shall be performed at the direction of the Engineer, or as required by field conditions.
- B. Contractor Qualifications:
 - 1. Contractor shall be approved in writing by the Manufacturer.
 - 2. Contractor shall have a minimum of fifteen (15) successful installations of the specified materials during the previous three (3) years.
 - 3. A field representative who has completed the course of instruction (supported by the Manufacturer) in the installation of the products specified in this Section shall be present on site during installation of the FRP system.
 - 4. Contractor shall employ only experienced craftsmen trained in the installation of specified products. Contractor shall provide names of the foreman and those individuals properly trained for installation of the specified FRP systems. Only these individuals shall be permitted to install the FRP repairs.
 - 5. Foreman must have worked on five (5) successful installations of the specified materials during the previous three (3) years.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Delivery: The products shall be delivered and stored in original, unopened containers. Containers shall be clearly marked with legible and intact labels listing the Manufacturer's name, brand name, product identification, manufacturing date, expiration date, and batch number.
- B. Storage
 - 1. Store, condition, and handle all products and materials as recommended by the Manufacturer to prevent damage or deterioration.
 - 2. Stored fiber reinforcement and epoxy resins shall be protected from dust, moisture, and chemical exposure.
 - 3. Do not expose epoxy or other liquid components to temperatures below 40 degrees F.

4. Store all products and materials under temperature and climatic conditions as recommended by product Manufacturer. Do not expose to direct sunlight, flame sources, extreme heat, or other hazards. Epoxy resins shall be stored separately from hardeners.
5. Fiber reinforcement shall not be folded. If remaining fiber reinforcement from an opened roll exists at the end of the work day, the fiber reinforcement must be either stored lying flat or re-rolled onto the existing fabric roll.

C. Handling

1. Exercise care during handling of fiber reinforcement.
2. Fiber reinforcement shall not be separated, unraveled, twisted, torn, or otherwise damaged during handling.
3. It is the responsibility of the certified personnel to identify substandard materials and eliminate them from the materials to be used.

1.6 PROJECT CONDITIONS

- A. Precautions shall be taken to avoid damage to any surface near the work zone due to mixing, handling, and application of specified material. Any surfaces marred by preparations for or during installation of the repair shall be restored to the condition that existed prior to the Work at no cost to the Owner.
- B. Contractor shall not damage any adjacent finishes. Contractor shall repair all damages.
- C. Maintain control of concrete chips, dust, and debris in each area of work. Clean up and remove such material at the completion of each day.
- D. Contractor shall not block means of egress required by local authorities or applicable building codes.

1.7 WARRANTY

- A. The completed installation of FRP system shall be warrantied jointly and severally by the product Manufacturer and Contractor against defects in material and application, for a period of five (5) years from the completion of the application.
- B. Any work proving defective within five (5) years from the date of acceptance shall be corrected at no cost to the Owner.

1.8 MOCK-UP

- A. Provide an on-site mockup of a typical FRP repair on a joist and beam for purposes of evaluating repair procedures and finished appearance. Joist and beam used for mockup shall not be one of joists or beams designated on Drawings to receive repairs. Coordinate selection of appropriate joist or beam for mockup with Engineer. For bidding purposes only, assume that the size of the mockup repair shall be not greater than 50 sq ft.
- B. Prepare a representative sample area within the mock-up in accordance with the requirements of Section 3.3 to be used as a reference standard depicting a satisfactorily prepared substrate.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND MATERIALS

- A. The following FRP systems are considered to meet or exceed the requirements of this specification and are acceptable for use:
 - 1. Tyfo Fibrwrap Systems, as supplied by Fyfe Company LLC, San Diego, CA, Telephone: (858) 642-0694.
 - 2. V-Wrap FRP Composite Strengthening System, as supplied by Structural Technologies, 10150 Old Columbia Road, Columbia, MD, Telephone: 410-850-7000
 - 3. SikaWrap Composite Strengthening System, as supplied by Sika Corporation, 201 Polito Ave., Lyndhurst, NJ, Phone: 800-933-7452.
- B. Composite fabrics:
 - 1. For shear repairs:
 - a. Typical
 - 1) Tyfo SCH-41 carbon fiber
 - 2) V-Wrap C200H carbon fiber
 - 3) SikaWrap Hex 103C
 - b. Bi-Directional (where indicated)
 - 1) Tyfo BCC carbon fiber
 - 2) V-Wrap C220B carbon fiber
 - 3) SikaWrap Hex 115C
 - 2. For flexure repairs:
 - a. Tyfo SCH-41 carbon fiber
 - b. V-Wrap C200H carbon fiber
 - c. SikaWrap Hex 103C
- C. Epoxy primer/saturant:
 - 1. Tyfo S epoxy
 - 2. V-Wrap 770
 - 3. Sikadur 300/330
- D. Primer/filler: Thickened epoxy for protective final coating and filling voids or detailing.
 - 1. Tyfo WS
 - 2. V-Wrap PF
 - 3. Sikadur 30/330
- E. Class 1(A) Smoke and Flame Spread Coating per ASTM E84
 - 1. Tyfo RR coating
 - 2. Equivalent product from V-Wrap
 - 3. Equivalent product from Sika

2.2 GENERAL SYSTEM REQUIREMENTS

- A. FRP Composite System
 - 1. All FRP composite systems shall be proprietary systems consisting of all associated carbon or glass fiber reinforcement and polymer adhesives/epoxy resins. Combinations of FRP composites consisting of fiber reinforcement and polymers provided by more than one manufacturer are not allowed.
 - 2. Materials shall be suitable for overhead applications as shown on Drawings.

3. Materials used in the FRP system shall have had a history of satisfactory service in an environment similar to Chicago, Illinois.
4. Filler compound for epoxy leveling course (for filling localized concave conditions between 1/16 in. and 1/4 in. in depth) shall be clean, dry fine silica sand (such as fine masonry sand), or approved equal.
5. Putty and primer for use in preparing surfaces for composite application shall be proprietary systems and produced by the same manufacturer of the composite system.
6. Smoke and flame spread coating must have been tested as an assembly (composite and fire coating material) by UL, ASTM, or ANSI standards.

2.3 FABRICATION

- A. FRP fabrics shall be fabricated in manufacturing plant to exact length and size indicated on Drawings and/or required by existing field conditions.
- B. On-site fabrication of FRP fabric shall be permitted only under the following conditions:
 1. Contractor submits detailed description of techniques and equipment proposed for use in field fabrication.
 2. FRP Manufacturer reviews proposed field fabrication and certifies in writing that field fabrication will not negatively affect the performance of the FRP system.
- C. Splices in the FRP fabric shall be avoided, unless approved by the Engineer. Where approved by the Engineer, splices in the strong fiber direction shall consist of a minimum 12 in. fabric overlap, and shall be staggered by a minimum of 24 in. with respect to splices in adjacent plies.
- D. Laps in FRP fabric shall be permitted under the following conditions.
 1. Gap between adjacent sheets of fabric at side laps shall not exceed 1/2 in.
 2. No more than two side laps per ply shall occur over the repair width.

PART 3 EXECUTION

3.1 GENERAL

- A. Screen off work zone as required to protect pedestrians, vehicles, and adjacent property.
- B. Proper substrate surface preparation, epoxy adhesive application, and FRP laminate installation are critical elements of the Work. No deviations from the Specification requirements shall be permitted without review and approval by the Engineer.
- C. Notify Engineer a minimum of 48 hours prior to commencing substrate preparation work on initial FRP repair.
- D. Notify Engineer a minimum of 48 hours prior to installing repairs at each repair location.

3.2 EXAMINATION

- A. Prior to submitting proposal and initiating work, contractor shall examine existing conditions to assess quality of concrete substrate, identify potential obstructions, and verify dimensions/geometry shown on Drawings. Particular attention shall be directed at the conditions of the surface profile and soundness as related to the degree of preparation that may

be required to bring the substrate into compliance with the requirements set forth in these specifications.

- B. Identify all cracks in substrate wider than 0.01 in. Notify Engineer of crack locations.
- C. Identify evidence of corrosion in existing steel reinforcement. Notify Engineer of any such evidence observed.
- D. Identify all spalls and potentially debonded concrete locations. Notify engineer of any such evidence observed.
- E. Conflicts with Existing Utilities
 - 1. Contractor shall determine the need for, and perform, all disconnection and/or temporary or permanent rerouting of existing utilities, in consultation with the Owner, to facilitate the FRP repair installation.
 - 2. Do not allow contact between installed FRP system and metallic objects.

3.3 PREPARATION

- A. Environmental Conditions
 - 1. Do not install FRP if the concrete surface temperatures are below 45° F or the minimum temperature specified by the product manufacturer. The most stringent requirement shall apply.
 - 2. Do not install FRP if ambient temperatures are below 45° F or above 95° F or the minimum and maximum temperatures specified by the product manufacturer. The most stringent requirements shall apply.
 - 3. Do not install FRP when surface moisture is present on the substrate or when precipitation or condensation is anticipated in the work areas.
 - 4. Utilize fans, dehumidifiers, or other equipment as required to allow proper curing of epoxy in high humidity environments.
- B. Concrete Repair
 - 1. Unsound areas of the concrete substrate (such as broken pieces, delaminated areas, etc.) shall be removed and repaired in accordance with Section 03 95 00.
 - 2. Repair mortar shall be allowed to cure for a minimum of 24 hours or as recommended by the manufacturer of the repair mortar for the specific environmental conditions that exist at the time of application and curing. The most stringent of these time criteria shall apply. After proper curing, the entire patch area shall be lightly abraded with 60-grit sandpaper or open weave 3M abrasive pads. The surface of applied repair mortars shall be prepared in accordance with item 3.03(C) of this Section.
 - 3. Cracks in the concrete substrate greater than 0.010 in. wide shall be pressure injected with epoxy in accordance with Section 03 60 23.
- C. Surface Preparation
 - 1. Prior to proceeding with surface preparation for scheduled repairs, prepare a representative sample area within the mock-up repair. The sample area shall be prepared in accordance with the requirements of this Specification, and shall be used as a reference standard depicting a satisfactorily prepared substrate.
 - 2. Verify that concrete (new repair material) has cured and aged for minimum time period recommended by the FRP manufacturer.

3. Verify that concrete substrate (existing and new repair areas) is sound and is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263 or Delmhorst moisture meter or manufacturer recommended procedure.
4. For shear repairs, external corners of the beam shall be rounded off to a radius of 3/4 in. by grinding and internal corners shall be formed with thickened epoxy to a radius of 3/4 in.
5. Protrusions: Substrate shall be free of fine, sharp edges and other protrusions that will impair or prevent application of a uniform glue line between the substrate and FRP material. Concrete surface protrusions shall be ground and smoothed to less than 1/16 in.
6. Concave Conditions: Substrate shall be free of depressions, pits, and other concave conditions that will cause the FRP to deviate unacceptably from a linear profile after installation. Localized concave conditions exceeding 1/4 in. over a distance of 4 ft shall be filled with approved repair mortar, or approved equal, in accordance with the Manufacturer's recommendations for surface preparation, mixing, application, and finish.
7. The surface of the concrete shall be profiled using abrasive blasting and/or disc grinding to a minimum Concrete Surface Profile designation in CSP-3 as defined by the International Concrete Repair Institute (ICRI Guideline #03732).
8. All substrates shall be clean, sound, and free of surface moisture and frost. Surface contaminants (laitance, surface lubricants, broken mortar pieces, paint coatings, staining, etc.) shall be removed by abrasive blasting, disc grinding, and/or other equivalent mechanical means.
9. Dust generated from surface grinding shall be removed using a clean air blower or other suitable means. If the dust has been removed by means of water washing, the surface shall be thoroughly dried.

D. Surface Soundness

1. The surface soundness of the concrete, and if present, the adhesion of repair patches, shall be verified after preparation by pull-off testing in accordance with ASTM C1583. Testing shall consist of direct tension adhesion testing using an approved testing device.
2. Surface soundness testing shall be performed on 100 percent of the first five (5) beams to be repaired. Each beam shall be tested at four (4) locations along the substrate. Minimum average pull-off strength required is 250 psi, and with no single test result less than 200 psi. All tests shall create failure completely within the concrete substrate. Beams that exhibit unsatisfactory soundness shall be re-blasted or ground by the Contractor and retested until satisfactory substrate is attained.
3. The frequency of additional surface soundness testing will be determined by the Engineer based on the results of the initial testing. If satisfactory results are attained in 100 percent of the first five (5) beams tested for surface soundness, then no testing shall be required unless conditions in Paragraph 3.3 D.4 apply.
4. Additional surface soundness testing shall be required if a variation in concrete substrate or surface preparation technique exists.
5. Repair area of substrate affected by above testing as follows.
 - a. Create shoulders around perimeter of affected area to a depth of 1/2 in. (\pm 1/8 in.) using a core barrel.
 - b. Chip out neatly to attain a uniform nominal depth of 1/2 in.
 - c. Repair area in accordance with Paragraph 3.3 B. of this Section.

3.4 INSTALLATION

A. Application of Primer and Putty

1. Primer: The FRP system primer shall be applied to all areas on the concrete surface where the FRP system is to be placed. The primer shall be placed uniformly on the prepared surface at the Manufacturer's specified rate of coverage. The primer shall be allowed to cure per the FRP Manufacturer's installation instruction before applying subsequent materials.
2. Putty or Filler: Where applicable, the FRP system putty or filler shall be used only to fill voids in the substrate (less than two (2) sq. in. in area and less than 1/4 in. in depth) and smooth surface discontinuities prior to application of other materials. Rough edges or trowel lines of cured putty shall be ground smooth prior to continuing the installation. The putty shall be allowed to cure per the FRP Manufacturer's installation instructions before applying subsequent materials. Application of subsequent materials shall be in accordance with Manufacturer's recommendations for proper adhesion.

B. Mixing of Polymer Resins and Adhesives

1. Resins (including primers and putties) shall be mixed according to the FRP system Manufacturer's installation instructions and under conditions that satisfy the ambient temperature requirements and the temperature requirements of epoxy components as written in this Section and in the approved product submittal.
2. The components of epoxy resin shall be mixed with a mechanical mixer.
3. Components that have exceeded their shelf life shall not be used.
4. Mix only that quantity of epoxy resin that can be used within 3/4 of pot life stated in Manufacturer's published literature.
5. Additives which are intended to extend the materials are not permitted.
6. Do not use epoxy resin that has been retempered or been previously applied to either substrate or FRP material and removed, regardless of epoxy workability or time elapsed since mixing.
7. Fiber Reinforcement and Saturating Resin: Both epoxy resin and fabric shall be measured accurately, combined, and deposited uniformly at the rates shown on the approved shop drawings and per Manufacturer's recommendations.

C. Application and Curing

1. The concrete substrate shall be cleaned using clean, oil free compressed air a maximum of four hours prior to application of the FRP fabric.
2. One sheet of FRP fabric may be applied at a time
3. Apply the mixed epoxy resin onto the concrete with a trowel or spatula to a nominal thickness of 1/16 in. If applied with a notched trowel, the applied resin should be "knocked down" so as to provide a more uniform thickness of resin and to minimize the possibility of entrapped air.
4. Clean the FRP laminate on side designated to receive epoxy resin using acetone or other solvent approved by the manufacturer with white rags until FRP residue cannot be seen on the rag. Dry the FRP laminate with a clean white rag and allow solvent to flash off.
5. Apply the mixed epoxy resin onto the FRP laminate with a device specially profiled to deposit a nominal thickness of 1/16 in.
6. Within the working time of the epoxy, place the FRP laminate onto the concrete surface. Press the laminate into the epoxy resin using a hard rubber roller until the adhesive is forced out a slight amount along all edges of the laminate. A uniform pressure should be applied so that a minimum contact area of 95 percent is achieved.
7. Thickness of the glue line shall be greater than 1/16 in. and less than 1/8 in.
8. The extruded epoxy adhesive shall be neatly tooled or removed so as to form a flush beveled surface around the perimeter of the FRP laminate.
9. The reinforcing fibers shall be placed with sufficient saturating resin to achieve full saturation of the fibers. Sufficient saturating resin shall be prescribed by the FRP system

Manufacturer. The fiber reinforcement shall be pressed onto the concrete surface using methods that produce a uniform, constant force that is distributed across the entire width of fabric. Splices and laps shall be installed in accordance with the approved shop drawings, the Manufacturer's recommendations, and Section 2.03(C) of this specification. The most stringent of these lap splice requirements shall apply.

10. Apply subsequent layers of fabric until specified number of layers is achieved, per Drawings.
11. Entrapped air between layers shall be released or rolled out before the epoxy sets.
12. Epoxy curing temperatures shall be maintained in the temperature range designated for the formulation used. Temperature cure ranges and times shall be in accordance with the approved product submittals and Manufacturer's recommendations. The cured composite shall have uniform thickness and density, bond between layers, and lack porosity.
13. Loading exceeding 500 lbs. shall not be permitted on the repaired member for a period of 48 hours following application of the FRP repair. If ambient temperatures are below 60° F for more than 12 hours during this 48-hour period, additional restrictions on loading may be required.

3.5 PROTECTIVE TOPCOATS

- A. Subsequent to repair installation approval by Engineer, A Class 1(A) Smoke and Flame Spread Coating shall be applied to all FRP repairs in accordance with the manufacturer's recommendations.

3.6 FIELD QUALITY CONTROL

- A. Contractor shall perform field quality control as required by this section.
- B. A trained field supervisor shall observe all aspects of onsite preparation and material application including surface preparation, epoxy resin component mixing, application of primer, application of resin and fiber sheet, curing of composite materials, and the application of protective coatings.
- C. Inspection for Voids/Delaminations
 1. After allowing at least 24 hours for initial resin cure to occur, perform a visual and acoustic tap test inspection of the layered surface.
 2. Voids requiring corrective action shall be marked and repaired in accordance with Paragraph 3.7 of this Section.
- D. Bond Testing
 1. Direct tension pull-off testing shall be conducted per ASTM C1583.
 2. Direct tension pull-off tests shall be conducted under the following test conditions:
 - a. The FRP system shall be allowed to cure a minimum of 24 hours before execution of the direct tension pull-off test.
 - b. The locations of the pull-off test shall be representative and on flat surfaces. Pull-off tests shall be conducted on areas of the FRP system at a location of maximum ply thickness and within the end 2 ft of the outermost ply.
 3. Test Frequency
 - a. For the initial 5 percent of beams repaired, perform a minimum of one direct tension pull-off test per 200 sq ft of installed FRP (surface area). For the remainder of repaired beams, perform a minimum of one direct tension pull-off test per 500 sq ft of installed FRP.
 - b. At least one pull-off test shall be performed for each day's work.

- c. Pull-off tests shall be performed on each type of concrete substrate or for each surface preparation technique if variations in such conditions exist.
 - 4. Conditions of Acceptance
 - a. The failure mode must be cohesive failure within the concrete.
 - b. Average tensile bond strength shall be in excess of 250 psi, with no single test result less than 200 psi.
 - 5. Repair the tested areas in accordance with Paragraph 3.7 of this Section.
- E. Report: The trained field supervisor shall submit a weekly quality control report to the Engineer describing the inspection of the completed installation. Daily reports shall contain locations of installation, temperature records, batch number of each product used, measured square footage of fiber reinforcement installed, amount of resin used, and results of bond testing. The bond test sample must be submitted to the engineer for review. Ambient temperatures shall be recorded a minimum of three times during each day that epoxy adhesives are mixed.

3.7 REPAIR OF DAMAGED OR DEFECTIVE AREAS

- A. Repair of delaminated areas of installed FRP reinforcement.
 - 1. Small delaminations less than 2 sq in. each do not require corrective action, as long as the total delaminated area is less than 5 percent of the total laminate area and there are no more than five such delaminations per 10 sq ft.
 - 2. Moderate delaminations less than 25 sq in., but greater than 2 sq in. may be repaired by filling the delamination by low-pressure injection of the saturant or by the following procedure specified for large delaminations. Two small (maximum 1/8 in. diameter) holes shall be drilled in the delaminated FRP to allow injection of the saturant and escape of entrapped air.
 - 3. Large delaminations, greater than 25 sq in. shall be repaired by selectively cutting away the affected sheet, reapply primer and putty layers, and applying an overlapping FRP patch of equivalent plies and fiber orientations.
- B. Repair procedures for conditions that are not specifically addressed shall be approved by the Engineer on a case-by-case basis.

3.8 TESTING FOR FRP SYSTEM MATERIAL PROPERTIES

- A. Contractor shall prepare sample panels of 12 in. by 12 in. cured FRP laminate at intervals directed by Engineer, but not less than two sample panels per day. Record the lot number of fabric and resin used to fabricate the sample panels.
- B. Mix samples of resin in accordance with Manufacturer's recommendations. On a smooth, flat, level surface covered with polyethylene sheeting, prepare sample by priming with epoxy resin and placing two layers of composite oriented in the same direction. Apply additional topping of epoxy and cover with sheeting. Remove all air bubbles from sample. Store samples in a sample box. Do not move samples for a minimum of 48 hours after casting.
- C. A testing laboratory retained by the contractor shall perform tests in accordance with ASTM D3039. Prior to testing, sample panels shall be conditioned for 48 hours at 140 degrees F. Five coupons shall be removed from each 12 in by 12 in. sample panel and tested for their material properties in the longitudinal fiber direction. Each coupon shall be nominally 3/4 in. wide by 9 in. long in the fiber direction.

- D. Testing results shall be made available to Engineer within three weeks of sample panel submission to the testing agency. The testing report shall include the following:
 - 1. Ultimate tensile strength.
 - 2. Tensile modulus
 - 3. Percent elongation
 - 4. Orientation of the FRP fabric fibers
- E. Acceptable minimum values for ultimate tensile strength and percent elongation are defined as the average values characteristic of the installed system reduced by three standard deviations. Characteristic average values and the associated standard deviations are determined from Manufacturer's published test data or other data furnished to Engineer and used by Engineer in the design of the FRP repair.
- F. Any test value below acceptable minimum values shall be considered non-compliant. Installed work represented by sample panel shall be reviewed by Engineer and may be subject to remedial measures.

END OF SECTION

SECTION 03 95 00

CONCRETE REPAIR

PART 1 GENERAL

1.1 DESCRIPTION

- A. This work shall consist of performing concrete repairs including repair of spalled or missing concrete and voids using concrete repair material.
- B. Spalls, Missing Concrete: Concrete repair work of spalled or missing concrete and voids includes:
 - 1. Exposing and undercutting reinforcing steel
 - 2. Repairing, cleaning, and treating reinforcing steel
 - 3. Edge and surface conditioning of concrete area to be patched
 - 4. Application of concrete repair mortar
 - 5. Finishing of concrete patch to match adjoining surfaces
 - 6. Curing the concrete repair areas
- C. Related sections:
 - 1. Section 03 20 00 - Concrete Reinforcement
 - 2. Section 03 60 30 - Epoxied-In Anchors
 - 3. Section 03 37 13 - Shotcrete

1.2 REFERENCES

- A. Definitions:
 - 1. Cementitious Materials: Portland cement alone or in combination with one or more of fly ash, silica fume, and other pozzolans, or slag cement.
- B. Reference Standards: Latest edition as of Specification date.
 - 1. American Concrete Institute (ACI):
 - a. 117: Specification for Tolerances for Concrete Construction and Materials and Commentary.
 - b. 301: Specifications for Structural Concrete.
 - c. 305R: Guide to Hot Weather Concreting.
 - d. 306R: Guide to Cold Weather Concreting.
 - e. 347: Guide to Formwork for Concrete.
 - 2. ASTM International:
 - a. A615/A615M: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - b. A775/A775M: Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
 - c. A1064/A1064M: Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
 - d. C31/C31M: Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - e. C33/C33M: Standard Specification for Concrete Aggregates.

- f. C39/C39M: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- g. C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
- h. C94/C94M: Standard Specification for Ready-Mixed Concrete.
- i. C143/C143M: Standard Test Method for Slump of Hydraulic-Cement Concrete.
- j. C150/C150M: Standard Specification for Portland Cement.
- k. C171: Standard Specification for Sheet Materials for Curing Concrete.
- l. C172: Standard Practice for Sampling Freshly Mixed Concrete.
- m. C231/C231M: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
- n. C260/C260M: Standard Specification for Air-Entraining Admixtures for Concrete.
- o. C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
- p. C494/C494M: Standard Specification for Chemical Admixtures for Concrete.
- q. C1064/C1064M: Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
- r. C1077: Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
- s. C1152/C1152M: Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete.
- t. C1218/C1218M: Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
- u. C1260: Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
- v. C1524: Standard Test Method for Water-Extractable Chloride in Aggregate (Soxhlet Method).
- w. C1583/C1583M: Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
- x. D3963/D3963M: Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Reinforcing Steel Bars.
- 3. Concrete Reinforcing Steel Institute (CRSI):
 - a. Manual of Standard Practice.
- 4. International Concrete Repair Institute (ICRI):
 - a. Guide for Using In-Situ Tensile Pull-off Tests to Evaluate Bond of Concrete Surface Materials.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate Work to ensure that adjacent areas are not adversely affected. Coordinate:
 - 1. With Owner's Representative.
 - 2. With other trades:
 - a. To ensure that work done by other trades is complete and ready for concrete replacement Work.
 - b. To avoid or minimize work on, or in immediate vicinity of, concrete replacement Work in progress.
 - c. To ensure that subsequent work will not adversely affect completed concrete replacements.

- B. Pre-placement Meeting:
 - 1. Conduct meeting at Site.
 - 2. Review requirements for concrete replacement Work, including:
 - a. Construction schedule.
 - b. Availability of materials, personnel, equipment, and facilities needed to make progress and avoid delays.
 - c. Site use, access, staging, and set-up location limitations.
 - d. Concrete removal, surface preparation, and substrate condition.
 - e. Placement procedures.
 - f. Special details.
 - g. Minimum cure period.
 - h. Testing and inspection requirements.
 - i. Temporary protection and repair of damaged concrete replacements.
 - j. Structural loading limitations of deck.
 - k. Government regulations.
 - 3. Contractor's Site superintendent, Owner's Representative, and Architect/Engineer shall attend.

1.4 SUBMITTALS

- A. Product Data: Submit product data for proprietary materials and items, including patching materials and forming accessories, curing and coating compounds
- B. Repair Procedures: Submit repair mortar manufacturer's narrative description of procedures and methods for removal of concrete, repairing and cleaning of reinforcing steel, and applying new repair mortar and coatings.
- C. Steel Reinforcement Shop Drawings: Details of fabrication, bending, and placement, prepared according to ACI 315. Include material, grade, bar schedules, stirrup spacing, bent bar diagrams, arrangement, and supports of concrete reinforcement. Include special reinforcement required for openings through concrete structures.
- D. Statement of Application: Provide statement, signed by authorized representative of patching materials manufacturer, that manufacturer has reviewed contract documents and project conditions relating to concrete repair and that manufacturer's materials proposed for use are suitable for the applications indicated.
- E. Certification: Submit manufacturer's certification that products provided comply with specified requirements.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Installer shall have not less than 5 years successful experience providing concrete repairs similar in size and complexity to that required for this project, and shall be approved by the repair material manufacturer.
- B. Standards: Comply with provisions of the following Codes and Standards, except where more stringent requirements are shown or specified:
 - 1. ACI 318, "Building Code Requirements for Reinforced Concrete," latest edition.
 - 2. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice", latest edition.

- C. Testing: The Owner may engage a testing laboratory to perform material evaluation tests.
 - 1. Materials and installed work may require testing and re-testing at any time during progress of the work. Re-testing of rejected materials for installed work, shall be done at the Contractor's expense.
- D. Preparation: Field Sample: Provide a field sample of concrete prepared for application of repair mortar, including undercutting and preparation of reinforcing steel, for Engineer's review prior to proceeding with placement. Sample shall be an area approximately 1'-0" x 1'-0". Locate as determined by the Engineer.
- E. Mockups: Construct mockups to demonstrate construction procedures, quality of Work, and aesthetic effects.
 - 1. Construct at least 10 square feet and 10 linear feet of replacements for each type of repair specified. Use equipment, materials, and procedures proposed for use on Project.
 - 2. Construct mockups on existing members, at locations designated by Architect/Engineer, under same weather conditions expected during Work. Provide access to mockup locations.
 - 3. Architect/Engineer will observe concrete removal and surface preparation work, prepared concrete removal areas, and installation of repair material. Notify Architect/Engineer and Owner's Representative at least seven days in advance of when mockups will be constructed.
 - 4. Photograph concealed portions of approved mockup before concealing, and retain photographs at Site.
 - 5. Perform three pull-off tests in conformance with ASTM C1583/1583M and ICRI Guide for Using In-Situ Tensile Pull-off Tests to Evaluate Bond of Concrete Surface Materials and use average of test values to determine conformance with requirements. Repair test core holes with concrete.
 - 6. If Architect/Engineer or Owner's Representative determines mockup does not comply with requirements, modify mockup or construct new mockup until mockup is approved. Remove and replace mockups that are not approved.
 - 7. Approved mockups shall be maintained in undisturbed condition throughout Project as basis for acceptance of completed work and may become part of completed Work if undisturbed at time of Substantial Completion.
 - 8. Do not order materials or proceed with repair Work until mockups have been approved by Architect/Engineer and Owner's Representative.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle materials according to manufacturer's recommendations and in such manner as to prevent damage to materials or structure.
- B. Deliver, store, and handle reinforcing steel to prevent bending and damage.
 - 1. Avoid damaging reinforcement coating.
 - 2. Repair damaged reinforcement coating according to ASTM D3963/D3963M.
- C. If concrete is to be site-batched:
 - 1. Store materials in dry condition and protect from dirt, dust, and other contaminants.
 - 2. Store cement bags on pallets.

3. Store aggregate stockpiles in manner to avoid segregation or contamination with foreign matter or other aggregates. Store away from normal drainage paths and cover with canvas or plastic if necessary to keep dry.
- D. For proprietary materials:
 1. Deliver materials to Site in original bags and containers with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, lot number, and directions for storing and mixing with other components.
 2. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling, or installation. Reject and remove from Site new materials which exhibit evidence of moisture during application, or have been exposed to moisture.
 3. Store materials in original, undamaged bags or containers in a clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by manufacturer. Manufacturer's standard packaging and covering is not considered adequate weather protection.
- E. Limit stored materials on structures to safe loading capacity of structure at time materials are stored, and to avoid permanent deck deflection.
- F. Conspicuously mark damaged or opened bags or containers or bags or containers with contaminated materials, and remove from Site as soon as possible.
- G. Remove materials that cannot be applied within stated shelf life from Site and replace with new materials.

1.7 PROJECT CONDITIONS

- A. Environmental Conditions: Perform concrete repairs only when weather and forecasted weather conditions comply with requirements of repair material manufacturer.
- B. Verify existing dimensions and details prior to the start of concrete replacement Work. Notify Architect/Engineer of conditions found to be different than those indicated in the Contract Documents. Architect/Engineer will review situation and inform Contractor of changes.
- C. Comply with Owner's limitations and restrictions for Site use and accessibility.
- D. Handle and place materials in strict accordance with safety requirements required by material manufacturers; GHS or Material Safety Data Sheets; and local, state, and federal rules and regulations. Maintain GHS or Material Safety Data Sheets with materials in storage area and available for ready reference on Site.

PART 2 PRODUCTS

2.1 FORM MATERIALS

- A. Forms for Exposed Concrete: Plywood panel materials, to provide continuous, straight, smooth, exposed surfaces.
 1. Use overlaid plywood complying with U.S. Product Standard PS-1 "A-C or B-B High Density Overlaid Concrete Form", Class I.

2. Use plywood complying with U.S. Product Standard PS-1 "B-B (Concrete Form) Plywood", Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.

2.2 REINFORCING MATERIALS

- A. Replacement Reinforcing Bars: ASTM A 615, Grade 60 deformed.
- B. Supports for Reinforcement: Provide supports for replacement reinforcement as necessary including wire ties and spacers, and other devices for spacing, supporting, and fastening reinforcing bars in place.

2.3 REPAIR MATERIALS

- A. Anti-Corrosion Coating: Multi-component, solvent-free, moisture-tolerant epoxy-modified cementitious product formulated as an anti-corrosion coating.
 1. Corrosion Inhibition: Material shall have been proven by independent laboratory testing to prevent corrosion of reinforcing steel when tested under procedures of the Federal Highway Administration Program Report FHWA/RD88/193.
 2. Product:
 - a. Provide Sika Armatec 110 EpoCem; Sika Corp.
 - b. Provide MasterProtect P 8100 AP; BASF Construction Chemicals, LLC.
- B. Repair Mortar: Silica fume polymer-modified portland cement mortar intended for use as a patching mortar at thicknesses of 1/2" and greater, freeze-thaw resistant, compatible with coefficient of thermal expansion of concrete.
 1. Flowable Mortar:
 - a. Bond Strength: 2200 psi at 28 days, per ASTM C-882 modified
 - b. Flexural Strength: 720 psi min at 28 days, per ASTM C-293.
 - c. Splitting Tensile Strength: 500 psi min. at 28 days, per ASTM C-496.
 - d. Compressive Strength: 3000 psi at 1 day, 6500 psi at 28 days, per ASTM C-109.
 - e. Product:
 - 1) Provide SikaTop 111 Plus; Sika Corp.
 - 2) Provide MasterEmaco S440 CI; BASF Construction Chemicals, LLC.
 2. Non-Sag Mortar:
 - a. Bond Strength: 1000 psi at 28 days, per ASTM C-882 modified.
 - b. Flexural Strength: 1000 psi min at 28 days, per ASTM C-293.
 - c. Splitting Tensile Strength: 400 psi min. at 28 days, per ASTM C-496.
 - d. Compressive Strength: 1500 psi at 1 day, 4300 psi at 28 days, per ASTM C-109.
 - e. Product:
 - 1) Provide SikaTop 123 Plus; Sika Corp.
 - 2) Provide MasterEmaco N400; BASF Construction Chemicals, LLC.
- C. Mixing water shall be potable, clean and free of injurious quantities of substances.

2.4 MIXING

- A. Mix repair materials in accordance with Manufacturer's instructions. Mix multi-component products using equipment recommended by Manufacturer. Only mix quantities which can be used within its pot life.

PART 3 EXECUTION

3.1 GENERAL

- A. Coordinate the work required for the removal of the loose and delaminated concrete, the repair and cleaning of the exposed reinforcing steel, the placement of forms, and the placement of repair mortar to minimize the time that reinforcing steel is exposed.

3.2 CONCRETE SURFACE PREPARATION

- A. Remove delaminated concrete and remove additional concrete as required to provide minimum required thickness of repair material.
- B. Edge Preparation: Make a minimum 1/2" deep sawcut along perimeter of repair areas. Make cut at right angle to surface. Avoid feather edges. Geometric configurations or repair patches shall be kept as simple as possible.
- C. After removal and edge conditioning are complete, remove bond inhibiting materials (dirt, concrete slurry, loosely bonded aggregates) by abrasive blasting or high pressure waterblasting with or without abrasive. Check the surfaces after cleaning to insure that surface is free from additional loose aggregate, or that additional delaminations are not present.
- D. If hydro demolition is used, cement and particulate slurry must be removed from the prepared surfaces before slurry hardens.

3.3 EXPOSING AND UNDERCUTTING REINFORCING STEEL

- A. Remove damaged or unsound concrete. Use concrete removal procedures which will not structurally weaken the surrounding precast concrete.
- B. Once initial concrete removal is made, undercut exposed oxidized (corroded) reinforcing. Undercutting shall provide clearance for cleaning, full bar circumference bonding to surrounding concrete, and securing the patch structurally.
- C. Provide minimum 3/4" clearance between exposed reinforcement and surrounding concrete or 1/4" larger than largest aggregate in repair mortar, whichever is greater.
- D. Concrete removal shall extend along the bars to locations along the bar free of bond inhibiting corrosion, and where the bar is well bonded to surrounding concrete.
- E. If unoxidized reinforcing steel is exposed during the undercutting process, care shall be taken not to damage the bar's bond to surrounding concrete. If bond between bar and concrete is broken, undercutting of the bar shall be required.
- F. Any reinforcement which is loose shall be secured in place by tying to other secured bars or by other approved methods.

3.4 REPAIRING AND CLEANING OF REINFORCING STEEL

- A. After removal of concrete, notify Engineer for inspection of steel reinforcing.

- B. If a reinforcing bar has lost more than 20% of its cross section, provide one of the following repair methods:
 - 1. Completely replace reinforcing, or
 - 2. Add supplemental reinforcing over the affected section. The new reinforcing bar may be mechanically spliced to the existing bar, or placed parallel to and approximately 3/4" from the existing bar. Lap length shall be in accordance with ACI 318.
- C. Remove heavy oxides and scale from the exposed reinforcing bars, as necessary to insure maximum bond of the replacement material.

3.5 APPLYING REPAIR MORTAR

- A. General: Perform repairs using flowable mortar or non-sag mortar as appropriate to conditions at each location.
- B. Forms:
 - 1. Support, brace, and maintain forms as required to support loads that might be applied. Construct formwork so concrete repair patch is of correct size, shape, and alignment.
 - 2. Construct forms of one piece and to obtain accurate alignment, location, grades, and plumb work in finished repair.
 - 3. Fabricate forms for easy removal without hammering or prying against concrete surfaces.
 - 4. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive repair mortar. Remove chips, wood, sawdust, dirt or other debris just before concrete is placed. Tighten forms and bracing before repair mortar placement to prevent mortar leaks and maintain alignment.
- C. Preparation of Form Surfaces:
 - 1. Coat contact surfaces of forms with a nonresidual, form-coating compound.
 - 2. Do not allow excess form-coating material to accumulate on forms or to come into contact with existing concrete surfaces against which repair mortar will be placed. Apply in compliance with manufacturer's instructions.
- D. Repair Mortar Placement:
 - 1. Apply a cementitious slurry coat to prepared concrete and reinforcing steel surfaces in compliance with manufacturer's instructions.
 - 2. Deposit repair mortar continuously in a manner to avoid segregation at its final location and in accordance with manufacturer's instructions.

3.6 FINISHING

- A. Finish of Formed Surfaces: Provide an as-cast concrete surface to match the existing cast in place concrete surface, with a minimum of seams. Repair and patch defective areas including fins and other projections completely removed and smoothed. Match approved field sample.

3.7 CURING

- A. Concrete shall be maintained above 55° F and in a moist condition for at least the first 7 days after placing.
- B. Moist curing shall be accomplished by burlap covers kept continuously wet, or continuous waterproof paper, of four mil polyethylene sheeting conforming to ASTM C171-69 with

edges lapped and tightly sealed by sand bags, wood planks, pressure-sensitive tape, mastic, or glue.

3.8 CONCRETE SURFACE REPAIRS

- A. Defective Concrete: Repair defective areas designated by Architect/Engineer. Remove and replace concrete that cannot be repaired to Architect/Engineer's satisfaction.

Modify dimensions below as necessary.

- B. Surface defects on exposed surfaces include
1. Voids, such as spalls, air bubbles, honeycomb, rock pockets, and form-tie voids, more than 1/2 inch in any dimension in solid concrete but not less than 1 inch deep.
 2. Cracks at least 1/8 inch wide. Notify Architect/Engineer of cracks that penetrate through section.

For finish Classes from ACI 347R, see note for Paragraph 3.01C.

3. Fins and other projections exceeding 1/2 inch.
 4. High or low spots in repaired areas that create areas of standing water that are at least 1/2 inch deep and at least 9 square feet in area.
- C. Repair defects on concealed surfaces that affect concrete's durability and structural performance as determined by Architect/Engineer.
- D. As soon as possible, cut out spalls, air bubbles, honeycombs, rock pockets, and voids. Make edges of cuts perpendicular to concrete surface. Clean voids and fill with repair mortar according to the manufacturer's recommendations. Use polymer- or silica fume-modified, cementitious, non-sag mortar that is specifically intended for this application. Use one of the following or approved equal:
1. MasterEmaco N 400 manufactured by BASF Construction Chemicals, LLC.
 2. SikaTop 123 Plus manufactured by Sika Corporation.
- E. After concrete has gained sufficient strength to be unaffected by grinding, grind off fins, other projections, and high areas.
- F. Repair materials and installation not specified above may be used if approved by Architect/Engineer.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to sample materials and perform tests during concrete placement.
- B. Provide:
1. Access to Work.
 2. Materials for sampling.
 3. Site facilities for sampling, testing, and storage of materials.
 4. Incidental labor.
- C. Testing Services: Sampling and testing of composite samples of fresh concrete shall be performed according to the following requirements:

1. Testing Frequency: Obtain one composite sample of each concrete mix for each day's pour.
2. Take samples from transport vehicle or mixer during discharge according to ASTM C172. Take samples at other locations if directed by Architect/Engineer.
3. Slump: ASTM C143/C143M; one test for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change. If high-range, water-reducing admixture is used, perform one test prior to adding admixture.
4. Air Content: ASTM C231/C231M; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
5. Concrete Temperature: ASTM C1064/C1064M; one test for each composite sample; and one test hourly when air temperature is 40 degrees F and below or 80 degrees F and above.
6. Compression Test Specimens: ASTM C31/C31M.
 - a. Cast four standard cylinder specimens for each composite sample, immediately after sample is taken. Store specimens at the Site for at least 16 hours at a temperature of 60 to 80 degrees F. Provide a temperature-controlled box or other enclosure if necessary. After at least 16 hours, but not more than 30 hours, transport the specimens to the laboratory and air cure at 73 degrees F and 50 percent relative humidity.
 - b. If requested by Architect/Engineer, take three additional cylinder specimens and field cure in the vicinity of the area that they represent and in the same manner as that portion of the structure.
7. Compressive-Strength Tests: ASTM C39/C39M.
 - a. Test one laboratory-cured specimen at seven days and two at 28 days. Hold the fourth specimen in reserve in case additional testing is required.
 - b. Test one field-cured specimen at seven days and two at 28 days.
8. Test results shall be reported in writing to Owner's Representative, Architect/Engineer, concrete supplier, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain:
 - a. Name of concrete testing and inspecting agency.
 - b. Project identification name.
 - c. Date of concrete placement.
 - d. Specific location of concrete batch in Work.
 - e. Concrete mix number, design compressive strength at 28 days, design slump range, and design air content range.
 - f. Specimen number, cylinder size, dates of compression tests, compressive breaking strengths and types of break for seven- and 28-day tests, and measured slump, air content, and air and concrete temperatures.
 - g. Statement that indicates whether test results are in conformance with Specifications.
9. Concrete strength is satisfactory if the average of two 28-day compressive-strength tests in each set of specimens equals or exceeds the specified 28-day compressive strength and neither test value is more than 500 pounds per square inch less than the specified 28-day strength.
10. If any seven-day compressive-strength test result is less than 75 percent of the specified 28-day compressive strength, submit revised mix design data for concrete that will conform to Specifications.
11. When the compressive strength of field-cured specimens is less than 85 percent of the companion laboratory-cured cylinders, evaluate operations and provide corrective procedures for protecting and curing the in-place concrete. Pay the cost of sampling and

testing non-conforming field-cured specimens. Owner will pay the cost of sampling and testing conforming field-cured specimens.

12. Non-Conforming Concrete:

- a. If tests indicate that concrete is not in conformance with the Specification, remove and replace non-conforming concrete or perform additional testing, acceptable to Architect/Engineer, to verify conformance with the Specification, at no cost to Owner.
- b. Procure core samples in accordance with ASTM C42/C42M.
- c. If tests indicate that the slump, air entrainment, or other requirements have not been met, examine core samples petrographically, according to ASTM C856, to evaluate hardened concrete characteristics.
- d. If compressive-strength tests do not meet the acceptance requirements, procure three core samples from each portion of the structure represented by the unsatisfactory tests, and test in compression. The strength of concrete in the area represented by core tests is satisfactory if the average of three compressive strength tests equals or exceeds 85 percent of the specified 28-day compressive strength and no compressive-strength test value is less than 75 percent of the specified 28-day compressive strength. If strength acceptance criteria are not met, remove and replace non-conforming concrete areas at no cost to Owner.
- e. Perform additional inspection and testing, at no cost to the Owner, to determine the compliance of replaced or additional work with the specified requirements.

3.10 CLEANING

- A. At the end of each workday, clean the Site and Work areas and place rubbish, empty cans, rags, and other discarded materials in appropriate containers.
- B. After completing the concrete replacement Work:
 1. Clean soiling from adjacent surfaces. Exercise care to avoid scratching or damage to surfaces.
 2. Repair surfaces stained, marred, or otherwise damaged during concrete replacement Work.
 3. Clean up debris and surplus materials and remove from Site.

END OF SECTION



LEED 2009 for Schools New Construction and Major Renovations

PBC CPS Prussing Elementary

Project Checklist

16 8 Sustainable Sites Possible Points: 24

Y	?	N			
Y			Prereq 1	Construction Activity Pollution Prevention	
Y			Prereq 2	Environmental Site Assessment	
1			Credit 1	Site Selection	1
4			Credit 2	Development Density and Community Connectivity	4
		1	Credit 3	Brownfield Redevelopment	1
4			Credit 4.1	Alternative Transportation—Public Transportation Access	4
		1	Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
2			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	2
		2	Credit 4.4	Alternative Transportation—Parking Capacity	2
		1	Credit 5.1	Site Development—Protect or Restore Habitat	1
1			Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
		1	Credit 6.2	Stormwater Design—Quality Control	1
1			Credit 7.1	Heat Island Effect—Non-roof	1
1			Credit 7.2	Heat Island Effect—Roof	1
1			Credit 8	Light Pollution Reduction	1
		1	Credit 9	Site Master Plan	1
		1	Credit 10	Joint Use of Facilities	1

6 5 Water Efficiency Possible Points: 11

Y			Prereq 1	Water Use Reduction—20% Reduction	
4			Credit 1	Water Efficient Landscaping	2 to 4
		2	Credit 2	Innovative Wastewater Technologies	2
2		2	Credit 3	Water Use Reduction	2 to 4
		1	Credit 3	Process Water Use Reduction	1

13 20 Energy and Atmosphere Possible Points: 33

Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
9		10	Credit 1	Optimize Energy Performance	1 to 19
		7	Credit 2	On-Site Renewable Energy	1 to 7
2			Credit 3	Enhanced Commissioning	2
1			Credit 4	Enhanced Refrigerant Management	1
1		1	Credit 5	Measurement and Verification	2
		2	Credit 6	Green Power	2

7 6 Materials and Resources Possible Points: 13

Y			Prereq 1	Storage and Collection of Recyclables	
		2	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 2
		1	Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2

Materials and Resources, Continued

Y	?	N			
		2	Credit 3	Materials Reuse	1 to 2
2			Credit 4	Recycled Content	1 to 2
2			Credit 5	Regional Materials	1 to 2
		1	Credit 6	Rapidly Renewable Materials	1
1			Credit 7	Certified Wood	1

9 10 Indoor Environmental Quality Possible Points: 19

Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
Y			Prereq 3	Minimum Acoustical Performance	
		1	Credit 1	Outdoor Air Delivery Monitoring	1
		1	Credit 2	Increased Ventilation	1
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
4			Credit 4	Low-Emitting Materials	1 to 4
		1	Credit 5	Indoor Chemical and Pollutant Source Control	1
1			Credit 6.1	Controllability of Systems—Lighting	1
1			Credit 6.2	Controllability of Systems—Thermal Comfort	1
1			Credit 7.1	Thermal Comfort—Design	1
		1	Credit 7.2	Thermal Comfort—Verification	1
		3	Credit 8.1	Daylight and Views—Daylight	1 to 3
		1	Credit 8.2	Daylight and Views—Views	1
		1	Credit 9	Enhanced Acoustical Performance	1
		1	Credit 10	Mold Prevention	1

5 1 Innovation and Design Process Possible Points: 6

1			Credit 1.1	Innovation in Design: Exemplary Connectivity/Transit Access	1
1			Credit 1.2	Innovation in Design: Exemplary Regional Materials	1
1			Credit 1.3	Innovation in Design: Recycled Content	1
1			Credit 1.4	Innovation in Design: Low/No Mercury Lamping	1
1			Credit 2	LEED Accredited Professional	1
		1	Credit 3	The School as a Teaching Tool	1

4 Regional Priority Credits Possible Points: 4


1			Credit 1.1	Regional Priority: SSc4.1	1
1			Credit 1.2	Regional Priority: SSc6.1	1
1			Credit 1.3	Regional Priority: SSc7.2	1
1			Credit 1.4	Regional Priority: SSc4.3	1


60 50 Total Possible Points: 110


Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110



←→ MATERIAL DIRECTION

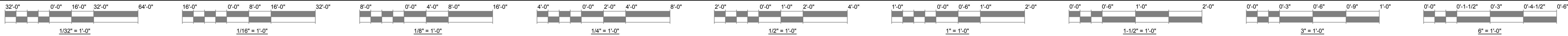
 VINYL FLOOR TILE
NEUTRAL COLOR
VT-GY

 VINYL FLOOR TILE
ACCENT COLOR
VT-BL

 VINYL FLOOR TILE
ACCENT COLOR
VT-GN

Sheet

AF1.1



ELECTRICAL FIRST FLOOR PLAN LIGHTING
1/8" = 1'-0"

- [X] LIGHTING CONTROL SCHEME - CLASSROOMS:**
1. ZONE 1 - DIM1 (AV)
 2. ZONE 2 - DIM 2
 3. ZONE 3 - DIM 1, DAYLIGHT 1
 4. ZONE 4 - DIM2, DAYLIGHT 2

EMERGENCY LIGHTING NOTES:

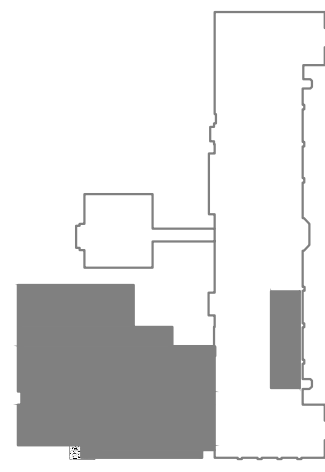
1. ALL CIRCUITS FOR EXIT AND EMERGENCY FIXTURES SHALL BE ROUTED WITH SEPARATE RACEWAYS, NO GENERAL LIGHTING CIRCUITS ARE ALLOWED TO SHARE THE EMERGENCY RACEWAYS.
2. REFER TO E1.0 DRAWING FOR CHICAGO APPROVED EXIT-DIRECTIONAL SIGN SCHEDULE.
3. PROVIDE LOCKABLE DEVICE ON ALL CIRCUIT BREAKERS SERVING EXIT SIGNS, NIGHT LIGHTS AND EMERGENCY LIGHTS, REFER TO PANELBOARD SCHEDULES.
4. EMERGENCY FIXTURES IN INDIVIDUAL ROOMS (SUCH AS: TOILETS, MECHANICAL, ELECTRICAL ROOMS ETC.) SERVED BY SINGLE LIGHTING CIRCUIT TO BE CONNECTED TO LOCAL LIGHTING CIRCUIT AHEAD OF ANY SWITCHING DEVICES (EBU TYPE OF FIXTURE).

NOTES:

1. ALL NEW RACEWAYS AND BACK BOXES SHALL BE CONCEALED IN CEILING AND WALLS FOR ALL NEW CONSTRUCTED WALLS. SURFACE MOUNTED TWO CHANNEL RACEWAYS ALLOWED IN EXISTING BUILDING ONLY WHERE CONCEALED INSTALLATION IS NOT FEASIBLE. REFER TO DETAILS AND SPECIFICATIONS.
2. SPACE ABOVE CEILING IS A PLENUM RATED CEILING (EXCEPT DINING ROOM AND LINK CLEAR STORY AREAS), ALL DEVICES, FIXTURES, J-BOXES AND PULL BOXES TO BE PLENUM RATED.
3. EXTERIOR LIGHTING FIXTURES SHALL BE CONTROLLED VIA RELAY PANEL ON TIMER SCHEDULE AND PHOTOCELL.
4. ALL LIGHTING FIXTURES SHALL BE FED FROM LP-1A VIA RELAY LIGHTING PANEL, EXCEPT EMERGENCY LIGHT FIXTURES AND EXIT SIGNS THAT TO BE FED FROM EXISTING EM-B IN BOILER HOUSE (EMERGENCY SYSTEM BACKED BY EXISTING DIESEL GENERATOR), ROUTE CIRCUITS VIA EMERGENCY RELAY LIGHTING PANEL.

KEYED NOTES:

E.1 EMERGENCY FIXTURES (EBU) TO BE CONNECTED TO LOCAL LIGHTING CIRCUIT AHEAD OF ANY SWITCHING DEVICES



ERNST PRUSSING ELEMENTARY SCHOOL ANNEX & RENOVATIONS

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Landscape/Civil Engineers of Record

CCJM Engineers, Ltd.
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MEPP Engineers of Record

Wiss, Janney, Elstner Associates
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Acoustics Consultant

Mackesy and Associates
321 N Clark St, #500
Chicago, IL
Food Service Consultant

WARNING:
ASBESTOS-CONTAINING BUILDING MATERIALS ARE OR MAY BE PRESENT IN THIS BUILDING. AN ASBESTOS MANAGEMENT PLAN IS AVAILABLE IN THE SCHOOL. FOR REVIEW UPON REQUEST. NO PERSON MAY DISTURB ASBESTOS-CONTAINING MATERIALS UNLESS THAT PERSON IS A LICENSED ASBESTOS WORKER OR CONDUCTS SUCH WORK IN ACCORDANCE WITH SPECIFICATIONS CONTAINED IN THE PROJECT DOCUMENTS AND IN COMPLIANCE WITH ILLINOIS DEPARTMENT OF HEALTH RULES AND REGULATIONS.

Issuance		
MARK	DESCRIPTION	DATE
A	ADDENDUM 01	11/09/2017

PBC Project Name: ERNST PRUSSING ELEMENTARY SCHOOL ANNEX & RENOVATIONS

PBC Contract No: 05175
Project No: 217102.00

Title
ELECTRICAL FIRST FLOOR PLAN LIGHTING

Sheet

E2.1