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## DIVISION 3 – CONCRETE

This work shall consist of furnishing and placing Portland cement concrete to construct cast-in-place concrete caps over vertical and near vertical mine openings and footings, in substantial compliance with the specifications and the lines, grades, and dimensions shown on the plans or established by the Project Manager. This work includes excavation of footings, furnishing and installation of forms, reinforcing steel, and concrete.

This work shall consist of grouting as indicated on the drawings. Unless otherwise specified all grouting shall be done with non-shrink grout.

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### 03001 – GENERAL REQUIREMENTS

All cast-in-place concrete shall be accurately formed, properly placed, and finished as indicated on the drawings and as specified in this section.

At least twenty-four (24) hours in advance, the Contractor shall inform the Project Engineer and Project Manager of the times and places at which he intends to place concrete. No concrete shall be placed without prior examination of the foundation conditions, formwork, and steel reinforcing by the Project Engineer or Project Manager.

All concrete work shall conform to all requirements of ACI 301, Specifications for Structural Concrete for Buildings, except as modified by the requirements below.

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### 03010 - CONCRETE MATERIALS

#### I. Materials

##### A. Cement

All cement used in concrete shall be Portland cement conforming to all requirements of ASTM C150, Type II, low alkali. High-early-strength Type III Portland cement may be used in concrete at the Contractor's option. When Portland cement is delivered in packages, the name and brand of the manufacturer and the type shall be plainly identified thereon. When cement is delivered in bulk, the same information shall be contained in the shipping invoices accompanying the shipment. A bag shall contain 94 pounds net weight and will be considered equal to one cubic foot. A barrel shall consist of 376 pounds net weight and will be considered equal to four cubic feet. The Contractor shall obtain from the manufacturer and furnish a certificate of compliance stating that the cement delivered to the work complies with the requirements herein provided. To prevent deterioration after delivery, cement and aggregates shall be stored as to prevent intrusion of foreign matter. Any material that has deteriorated or has been contaminated shall not be used for concrete.

**B. Admixtures**

Admixtures shall conform to ASTM C494. Sugar, calcium chloride or admixtures containing chloride from other than impurities from admixture ingredients will not be permitted. Air entraining admixtures shall be required and shall conform to ASTM C260. Water reducing admixtures may be used and shall conform to ASTM C494 or ASTM C1017.

**C. Curing Compounds**

Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C309.

**D. Water**

Water for concrete shall be clean and free from harmful amounts of acids, alkalis, oils, organic materials, salts, sand, sewage, or other deleterious substances and shall be furnished by the Contractor. Water shall be potable and shall have a pH value of not less than 4.5 nor more than 8.5 as determined by AASHTO T26 before its use. The sulfate content as SO<sub>4</sub> shall not exceed one thousand parts per million (1,000 ppm).

**E. Fine Aggregate**

1. General Characteristics. Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof, or other accepted inert materials composed of clean, durable, hard, uncoated, well-rounded grains.

2. Grading. Fine aggregate shall be well graded and, when tested by standard laboratory sieves, shall conform to the following:

Sieve (ASTM E11)	Percent Passing by Weight
3/8-in.	100
No. 4	95 to 100

The fine aggregate shall have not more than 45 percent passing any sieve and retained on the next consecutive sieve of those shown above, and its fineness modulus shall be not less than 2.3 nor more than 3.1.

3. Deleterious Substances. The maximum percentage of deleterious substances shall not exceed the following limits:

Clay lumps	3.0% by weight
Material finer than No. 200 sieve	3.0% by weight
Coal and lignite	1.0% by weight
Other deleterious substances	1.0% by weight

All fine aggregate shall be free from harmful amounts of alkali and organic impurities.

4. Soundness. Fine aggregate shall conform to the requirements of magnesium sulfate soundness of ASTM C33. The maximum loss in five (5) cycles shall not exceed 12 percent by weight.

F. Coarse Aggregate

1. General Characteristics. Coarse aggregate shall consist of natural gravel, crushed gravel, crushed stone, or crushed hydraulic-cement concrete, or a combination thereof, or other accepted inert materials having clean durable, hard, strong pieces; free from adherent coatings; and conforming to the requirements of these Specifications. Fifty percent by weight of the minus 3/4 inch sieve size particles shall have a minimum of two fractured faces.

2. Grading. Coarse aggregate shall be well graded between the limits specified and shall conform to the following requirements:

Sieve	Percent Passing by Weight
1-in.	100
3/4-in.	95 to 100

3. Deleterious Substances. The maximum allowable percentage of deleterious substances and physical properties shall not exceed the following limits:

Soft fragments	2.0% by weight
Clay lumps	0.25% by weight
Material finer than No. 200 sieve	1.0% by weight
Coal and lignite	0.25% by weight

4. Sampling and Testing. Methods of sampling and testing the coarse and fine aggregate shall be in accordance with ASTM C33.

5. Concrete Mix Design. Structural concrete for concrete footings and collars for steel bat cupolas and for other shaft bat compatible and airflow closures shall be made with aggregates and cement conforming to a minimum compressive strength of 3,500 pounds per square inch (psi) after twenty-eight (28) days. The concrete shall contain a minimum of 61 l

pounds of cement (6.5 bags) per cubic yard and a maximum water/cement ratio of 0.49. Fine aggregate shall be not less than 38 percent or more than 42 percent by weight of the mix.

All other concrete, including concrete for unreinforced cast-in-place plugs and hollow core plugs, shall conform to a minimum of 3,000 psi after twenty-eight days.

All concrete shall have an entrained air content between 4 percent and 8 percent by volume when determined with the requirements of ASTM C231.

6. Mixing Concrete. If the concrete is mixed on the site, equipment and mixing procedures shall conform to ACI 301. All concrete shall be thoroughly mixed in a batch mixer of an accepted type and capacity for not less than two minutes after all the materials including water have been placed in the drum. During mixing, the drum shall be operated at the speed specified by the manufacturer of the equipment. The entire contents of the mixer shall be discharged before being recharged, and the mixer shall be cleaned frequently. The concrete shall be mixed only in such quantities as are required for immediate use. No retempering of concrete will be permitted. Hand mixed concrete will not be permitted except by special acceptance of the Project Engineer.

7. Ready-Mixed Concrete. At the option of the Contractor, ready-mixed concrete may be used instead of concrete mixed at the job site. Ready-mixed concrete shall conform to all requirements of ASTM C94 and these Specifications as to grading of aggregates, strengths, consistency, and so on. The Project Manager shall have free access to the mixing plant at all times. Ready-mixed concrete shall be continuously mixed from the time the water is added until the time of use. Concrete shall be delivered to the site of the work, and discharged from the truck mixer or truck agitator shall be completed within one hour after the cement contacts the mixing water or with aggregates that are surface wet. The organization supplying ready-mixed concrete shall have sufficient plant and transportation facilities to assure continuous delivery of concrete at the required rate.

8. Proportioning. The proper proportioning of aggregates and cement will be determined by an acceptable independent testing laboratory at the expense of the Contractor. The proportioning of aggregates will be the most suitable combination of aggregates that will give the necessary workability and desired consistency when mixed with water and cement as specified. The ratio of cement to dry, fine aggregate shall be that necessary to provide the maximum amount of density of the mixture when used with the minimum amount of water required to produce the specified slump in the resulting concrete. This determination of the proper ratio shall be made by testing laboratory, at the expense of the Contractor, using representative samples of the aggregates which will be used, and before use shall be reviewed by the Project Engineer. The batch proportions used shall be such that full bags of cement are used in each batch.

9. Consistency. The consistency for concrete shall be kept uniform for each class of work and shall be checked by means of slump tests. The slump for concrete shall be not

less than two (2") and not more than four inches (4"). The consistency of the concrete shall be varied as directed by the Project Engineer or Project Manager. If through accident, intention, or error in mixing, any concrete is too wet, such concrete shall not be incorporated in the work, but shall be discarded as waste material at an accepted disposal area.

10. Placing Concrete. Where indicated, mine openings to be closed with a cast-in-place footings and steel structures and cast-in-place concrete caps shall be excavated to competent bedrock or founded on clean, durable existing concrete. The Contractor is responsible for site inspections, testing or exploration necessary to insure that the bid adequately reflects excavation conditions including hand trimming and leveling required.

The surface of hardened concrete upon which fresh concrete is to be placed shall be rough, clean, sound, and damp. The hardened surface shall be cleaned of all laitance, foreign substances (including curing compound), washed with clean water, and wetted thoroughly preceding placement of fresh concrete.

Concrete shall be handled from the mixer to the place of final deposit as rapidly as possible by methods that prevent separation or loss of ingredients. It shall be deposited as nearly as practicable in its final position to avoid rehandling. It shall be deposited in continuous layers, the thickness of which generally shall not exceed twelve (12") inches.

The rate of depositing concrete in forms shall be controlled to prevent deflection of the form panels. The concrete shall be thoroughly compacted by means of a suitable mechanical vibrator. Vibrating shall be supplemented with hand spading the concrete around the reinforcing steel.

The Contractor is cautioned that cold weather protection for concrete may be required should concrete be placed in the winter months. If cold weather concreting is done, it shall conform to the requirements of ACI 306R. No concrete shall be placed or be allowed to cure without protection in any weather where the temperature falls below forty degrees Fahrenheit (40° F) at any time during the daily 24-hour period. The period of time such protection shall be maintained shall be not less than seven (7) days. If hot weather concreting is done, it shall conform to the requirements of ACI 305R.

Concrete shall have a temperature of at least 50°F and not more than 80°F at the time of placing. At no time during placement or curing shall the concrete surface temperature be allowed to fall below 40°F. Concrete shall not be placed on frozen ground. Frozen aggregate shall not be used in concrete.

Finishes of concrete work shall be as specified in ACI 301.

11. Concrete Equipment. All concrete equipment used shall be of a type, capacity, and mechanical condition suitable for accomplishing all requirements of this work and all applicable local, state, and federal codes and regulations, both safety and otherwise.

Equipment shall be maintained in first class operating condition at all times. Concrete equipment may include a mixer equipped with a mechanically operated paddle type agitator or equivalent. This may be accomplished by using a single or multiple batch bin system. A water meter shall be installed by the Contractor on water lines to permit accurate measurement of the quantity of water used in making the various mixes. The Contractor shall supply certificates of calibration for all gauges and meters used on this work. Water supply lines for mixing shall be routed for maximum protection and minimum traffic interruption. Facilities shall be provided by the Contractor to measure the proportion of aggregate, cement, sand, water and admixtures required in the design mix. In addition, the Contractor shall devise a system to accurately measure the volume of concrete delivered from the mixing plant or transportation vehicle per unit of time.

12. Tests. At each cast-in-place concrete slab and cast-in-place concrete footing and for each 100 cubic yards of concrete or portion thereof placed, one sampling for compressive strength, consisting of a minimum of three cylinders shall be taken and paid for by the Contractor. All sample cylinders shall be taken at the same time: one cylinder to be used for a seven-day test and two for a 28-day test following standard lab curing. The Project Manager may require additional random samples, which will be done at EMNRD's expense.

An independent testing laboratory accepted by the Project Engineer shall make all tests of aggregates, cement, and concrete. Samples of concrete for specimens shall be taken at the mixer, or in the case of ready-mixed concrete, from the transportation vehicle during discharge in accordance with ASTM C172. Test cylinders shall be made and cured in accordance with ASTM C31. The test specimens shall be molded immediately after the sample is taken and then placed in a protected spot and kept under curing conditions similar to the conditions under which the concrete they represent is being cured. They shall be removed to the testing laboratory not sooner than six (6) days after casting.

The testing of cylinders shall be in accordance with ASTM C39. A slump test shall be made of each 25 cubic yards or fraction thereof, of concrete placed, or at the direction of the Project Manager. Slump tests shall be in accordance with ASTM C143 and shall be paid for by the Contractor.

### **03100 - CONCRETE FORMWORK**

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Concrete structures shall be cast in place with proper formwork. The Contractor shall be fully responsible for reinstallation of concrete structures should forming materials and methods fail to adequately support the concrete. All cast-in-place concrete structures shall meet the tolerances for formed surfaces specified in ACI 301.

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**03200 - CONCRETE REINFORCEMENT**

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**03210 - REINFORCING STEEL**I. Bars

Reinforcing steel bars shall be new billet steel conforming to ASTM A615, Grade 60.

II. Placing Reinforcing Steel

Reinforcing steel, before being placed, shall be thoroughly cleaned of heavy rust, scale or other coatings that will destroy or reduce the bond. A slight coating of rust will not be considered objectionable. Reinforcement shall be carefully formed to the dimensions indicated. It shall not be bent or straightened in a manner that will injure the material, including heating by a torch. Bars with kinks or bends not shown shall not be used. Reinforcing steel shall be accurately placed and secured against displacement by using annealed iron wire of not less than No. 18 gauge or suitable clips. The reinforcing steel shall be supported using bar supports to support the steel the proper distance above the bottom of the footings.

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**03250 - CONCRETE ACCESSORIES**

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Bar supports shall meet the requirements of CRSI Class C, plastic protected, or Class E, stainless steel protected.

A survey marker supplied by the Project Manager shall be set in each exposed cast-in-place footing, cap, or structure. At the location indicated by the Project Manager, the survey marker shall be cast in the structure or grouted by drilling a hole and grouting the cap in place using a non-shrink grout such as Moly Parabond, Quikrete, or Pour Rock. Alternately the survey marker may be fixed in the concrete structure using epoxy grout. For caps that are backfilled, a pipe monument as specified in Section 02890 and as shown on the drawings.

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**03300 - CAST-IN-PLACE CONCRETE**

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**03310 - INTEGRALLY COLORED CAST-IN-PLACE CONCRETE**

The Contractor shall submit product data and manufacturer's instructions for pigments and curing compounds to be used at integrally colored cast-in-place concrete. With the submittal shall be included the pigment manufacturer's color chart for color selection by the Project Engineer, indicating pigment number and required dosage rate. Submittals are for general color selection and may vary somewhat from concrete finished in the field according to Specifications.

Delivery, storage and handling of pigments shall comply with manufacturer's instructions. Pigments shall be delivered to the job site or batch plant in original, unopened packaging and shall be stored in dry conditions.

Pigments shall comply with ASTM C979 and shall be Davis Colors manufactured by Davis Colors (213.269.7311, [www.daviscolors.com](http://www.daviscolors.com)), or approved equivalent. Dosage rate shall be based on the weight of Portland cement, fly ash, lime and other cementitious materials but not aggregate or sand, and shall not exceed 10 percent of the weight of the cementitious materials content. The pigments shall be mixed in accordance with manufacturer's instructions, until pigments are uniformly dispersed throughout the mixture and disintegrating bags, if used, have disintegrated.

Curing compound for colored concrete shall comply with ASTM C309 and be approved by the pigment manufacturer for use with colored concrete. Curing compound shall be "Color Seal II" tinted to match colored concrete and manufactured by Davis Colors, or approved equivalent.

Formwork for integrally colored concrete shall be as specified above.

Minor variations in the final appearance of colored concrete, which are similar to natural variations in color and appearance of unpigmented concrete, are acceptable.

All efflorescence shall be removed with mild detergent or mild acid cleaners formulated to remove efflorescence, following initial testing on a small area to ensure that the surface will not be etched or discolored. Appropriate skin and eye protection shall be used.

### **03370 - CONCRETE CURING**

All concrete, regardless of temperature, weather, or season, shall be allowed to cure (kept moist) for a period of not less than seven (7) days after the concrete is poured. Curing will not be required longer than 72 hours only if high-early-strength concrete (Type III) is used.

The concrete in structures shall reach a minimum compressive strength of 3000 psi before attachment of the steel structures or backfilling can occur, except for backfilling shallow edges of concrete caps. Backfill material shall be placed in maximum two-foot (2') lifts and shall be placed in a manner which will prevent damage to the structures and which will allow these structures to assume the load from the fill gradually and uniformly. The material shall be compacted to a density of no less than what the backfill equipment is reasonably capable of obtaining to the satisfaction of the Project Manager.

Note that uneven curing of integrally colored concrete will lead to uneven color. Requirements for curing compounds used at colored concrete are specified above. Discolored concrete cured with plastic membrane sheets or non-approved compounds will be rejected.



Concrete temperatures for colored concrete shall be maintained between 65 and 85°F for the first three days after placing.

### **03600 - GROUTS**

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This section specifies grouting as indicated on the drawings.

#### **03610 - GROUT MATERIALS**

Nonshrinking grout	L&M Construction Chemicals “Crystex” or “Premier” or “Duragrout”, Master Builders “Masterflow 713 Plus” or “Masterflow 928” or “Set Grout”, Euclid “Hi-Flow Grout” or “N-S Grout”, “Five Star Grout”, or equal, meeting the requirements of ASTM C1107, Grade C
Water	Clean and free from deleterious substances

#### **03620 - NONSHRINKING GROUT**

Nonshrinking grout shall be furnished factory premixed so only water is added at the job site. Grout shall be mixed in a mechanical mixer. No more water shall be used than is necessary to produce a flowable grout. The grout shall meet strength requirements of  $f'_c = 5,000$  psi.

Concrete foundations to receive nonshrinking grout shall be saturated with water for 24 hours prior to grouting.

Grout shall be placed in strict accordance with the directions of the manufacturer so all spaces and cavities are filled without voids. Forms shall be provided where structural components will not confine the grout. The grout shall be finished smooth in all locations where the edge of the grout will be exposed to view after it has reached its initial set.

Nonshrinking grout shall be protected against rapid loss of moisture by covering with wet rags or polyethylene sheets. After edge finishing is completed, the grout shall be wet cured for at least seven days.

### **03990 - SUBMITTALS**

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Each proposed concrete mix shall be submitted in accordance with the procedure set forth in Section 01340, which submittal shall include the following information:

1. Slump on which design is based;

2. Total gallons of water per cubic yard;
3. Brand, type, composition and quantity of cement;
4. Specific gravity, source and gradation of each aggregate;
5. Ratio of fine to total aggregate;
6. Surface dry weight of each aggregate per cubic yard;
7. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture; and
8. Compressive strength base on seven-day and 28-day compression tests.

Other submittals shall be made as required by ACI 301.

The Contractor shall submit manufacturer's data or catalog information, including placing and finishing recommendations, for the grout materials, curing compounds and coloring pigment furnished. Submittals shall be made in accordance with the procedure set forth in Section 01340.

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**END OF DIVISION 3**