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1. GENERAL REQUIREMENTS

Concrete shall consist of a mixture of air-entraining Portland cement, fine aggregate, coarse aggregate, and water, combined in the proportions specified for the various grades.

2. DESIGN AND CLASSIFICATIONS

Concrete will be classified and shall be proportioned on the basis of strength requirements and will be designated as Grade AA, A, B and C.

Grade AA concrete will be designed on the basis of four thousand pounds (4,000#) per square inch compressive strength when cured in moist air at 65°F. to 75°F. for 28 days.

Grade A concrete will be designed on the basis of three thousand five hundred pounds (3,500#) per square inch compressive strength when cured in moist air at 65°F. to 75°F. for 28 days.

Grade B concrete will be designed on the basis of three thousand pounds (3,000#) per square inch compressive strength when cured in moist air at 65°F. to 75°F. for 28 days.

Grade C concrete will be designed on the basis of two thousand five hundred pounds (2,500#) per square inch compressive strength when cured in moist air at 65°F. to 75°F. for 28 days.

The following table shows for each grade of concrete the compressive strength at 28 days in pounds per square inch, the minimum number of barrels of cement required per cubic yard of concrete, and the approximate proportions of fine and coarse aggregate:

Grade	Min. Compressive Strength @ 28 days lbs. per sq. in.	Minimum Cement lbs./cu. yd. of Concrete	Approximate Proportions by Volume (dry, loose)
AA	4,000	611 (6 ½ sacks)	1: 1-3/4 : 3
A	3,500	564 (6 sacks)	1: 2 : 3-1/4
B	3,000	517 (5 ½ sacks)	1: 2-1/4 : 3-1/2
C	2,500	494 (5 ¼ sacks)	1: 2-1/2 : 4

NOTE: The above figures are approximate only and must be revised for the particular aggregate used. Proportions shown are based on air-entrained concrete. (A sack of cement weighs 94 pounds.)

Unless otherwise called for on the plans or specified in other sections of these Contract Documents, the grade of concrete to be used shall be AA.

The concrete mixture shall be designed by an independent testing laboratory for the materials to be used and shall be subject to the approval of the Owner. The cost of the design of the concrete mixture shall be borne by the Contractor.

The materials used shall conform to the specifications therefor as found under "Material Requirements" of these specifications.

The type of cement used shall be standard Portland cement or air-entraining cement, unless otherwise specified.

The class of coarse aggregate used shall be as required by these specifications for each type of work. No admixtures shall be used unless approved by the Engineer.

3. TESTS

The Contractor, at his own expense, shall furnish tests of cement, fine aggregate, coarse aggregate, and reinforcing steel, and of test cylinders. Testing is to be done by an approved independent testing laboratory. All sampling and testing is to be done in accordance with the latest revision of the ASTM applicable specification.

Six (6) copies of tests shall be furnished the Engineer or distributed to parties designated by the Engineer.

Cement tests shall be made for each 3,000 barrels.
Fine aggregate tests shall be made for each 2,000 tons.
Coarse aggregate tests shall be made for each 2,000 tons.
Reinforcing steel tests shall be made for each 100 tons.

Three (3) test compression cylinders shall be made for each pour. One shall be tested for 7-day strength, and the other two for 28-day strength. An inspector representing the Owner will make the cylinders. The laboratory shall furnish necessary forms. The Contractor shall properly store cylinders on the job in damp sand at proper temperatures and shall deliver cylinders to the laboratory within 48 hours after they are made. Where required by the Engineer, cylinders shall be cured under the same conditions as the unit poured.

4. SLUMP

The Contractor shall use the least slump possible consistent with workability for proper placing of concrete. For the purpose of this section, the Engineer shall determine the required slump and his decision shall be final.

Slump will be determined by an inspector representing the Owner, by means of the slump cone test as outlined in ASTM Designation C143-52 as amended to date. Contractor shall furnish cone and rod.

5. MIXING TIME

Each complete batch of concrete shall be mixed for one and one-half (1-1/2) minutes after the mixer is fully charged.

6. HANDLING CEMENT

The cement shall be stored in such manner as to permit easy access for inspection and identification of each shipment and in a suitable weather tight building that will protect the cement from damage. Sacks shall be piled in layers on a suitable floor so that the side of the piles shall be at least 12 inches from the sidewalls. When permission is given to store cement in the open, a floor at least 6 inches above the ground and a waterproof covering shall be provided and so placed as to insure easy runoff in case of rain.

All cement for any given structure shall be of the same brand produced by a single mill unless otherwise provided by authorization of the Owner. At the time of its use in the work, the cement shall be free from lumps. Cement sacks shall be thoroughly shaken when emptying sacks into the batch. Cement salvaged by the Contractor by cleaning sacks mechanically or otherwise, or from discarded sacks of cement, shall not be used in the work.

7. HANDLING AGGREGATES

The fine and coarse aggregates are to be furnished, stocked, and handled on the project so that uniformity of grading will be obtained at the time of batching. The area on which stockpiles are to be built shall be thoroughly cleaned of all foreign materials and shall be firm, reasonably level, and well drained. Piles shall be built in layers not to exceed four feet in height, and each layer shall be complete before beginning the next layer. No aggregates, which have become intermixed prior to proportioning, shall be used. Sufficient aggregate shall be available at the site to preclude the possibility of damaging delays while placing the concrete.

8. PROPORTIONING MATERIALS

Aggregates shall be proportioned by weight, except for smaller structures and for incidental construction, where they may be proportioned by volume, when approved by the Owner.

When proportioned by weight, the amount of each aggregate required for a single batch shall be weighed in a separate container. The equipment for weighing shall be of an approved type, and of such accuracy that there will not be an error of more than one percent (1%) in any one batch.

When proportioned by volume, the amount of each aggregate required for a single batch shall be measured separately and accurately. Shovel methods of measuring will not be permitted. The unit of volumetric measurement will be one (1) cubic foot.

Cement in bulk, when permitted, shall be proportioned by weight.

9. MIXERS AND MIXING OF CONCRETE

It is the intent of these specifications that the concrete for structures shall be mixed in the plant located at the site of the work. Concrete from a central plant located elsewhere and mixed in transit and the transportation of the dry mix in a truck transit mixer will be acceptable. (See paragraph headed "Transit-Mix Concrete", elsewhere in these specifications).

The mixer or mixers shall be of an approved batch type. They shall be provided with readily adjustable devices that will measure the water to within one percent (1%). Mixers shall be capable of quickly and completely discharging without segregation or loss. The efficiency of the mixers shall be maintained at all times through repair or replacement of worn parts when necessary.

The capacity of the mixer or mixers shall be such that the last unit shown on the plans can be easily poured in one 8-hour shift. In no case shall the capacity be less than that necessary to handle a full one-bag batch of the required proportions. During the mixing period the mixer drum shall revolve at a rate not less than fourteen (14) or more than twenty (2) revolutions per minute. The volume of mixed material in each batch shall not exceed the manufacturer's rated capacity of the mixer. The drum of the mixer shall be kept free from hardened concrete and shall be completely emptied before recharging. Retempering or remixing concrete that has partially set will not be permitted. The mixer shall be cleaned thoroughly each time when out of operation for more than one-half hour.

The use of a fractional sack of cement will not be permitted unless the fractional part is measured by weight.

10. CONCRETE HANDLING EQUIPMENT

The concrete handling equipment shall be of such a nature and shall be so located that the concrete after leaving the mixer will reach its destination within a minimum lapse of time with no segregation and without loss. The use of chutes, except at or in the forms, is prohibited.

11. PLACING CONCRETE

Before concrete is placed in any unit, the forms and the placing and fixing of all steel and incidental items shall be complete, and the forms, steel, adjacent concrete, etc., shall be thoroughly cleaned and wetted down.

No concrete shall be deposited in any unit until the area has been completely dewatered and not until after the Contractor has made satisfactory provisions to eliminate all possibility of water entering or flowing through the concrete while it is being poured or is taking its set.

All concrete shall be so deposited as to maintain the top surface level, unless otherwise shown on the plans, and also as to avoid any appreciable flow in the mass. It shall be compacted by continuous vibrating, tamping, spading, or slicing. Care shall be taken to eliminate all voids and to provide full bond on reinforcing steel, waterproofing, and embedded fixtures.

When depositing concrete in deep forms, proper precautions shall be taken to eliminate the possibility of segregation through free dropping of the concrete.

No concrete shall be placed on frozen ground.

12. VIBRATING CONCRETE

Mechanical vibration shall be employed. Concrete shall be compacted and thoroughly worked around all reinforcement and embedded fixtures and into the corners of the forms by working with suitable tools combined with the use of vibrators applied internally and provided a frequency not less than 3,000 impulses per minute. All such vibrating, including the methods and equipment shall be subject to the approval of the Owner. The time of vibrating in any area shall only be sufficient to get efficient compaction, but shall in no case be carried to the point where there is segregation of the fine and coarse materials of the mix. There shall be an absolute minimum of direct vibration of the steel or forms during the process of vibrating.

13. PLACING REINFORCING STEEL

Reinforcing steel shall be laid carefully and shall be so supported and tied with wire as to hold the bars rigidly in the locations shown on the plans.

At the bottom of beams, for separating and supporting beam reinforcement, the Contractor will be required to use steel saddles and separators. In other locations, he shall use such steel bar chairs as may be necessary. Chairs for reinforcement in slabs shall be of the continuous type in lengths of not less than four feet (4'). Where top and bottom reinforcement occurs in slabs, such continuous type chairs shall be so constructed and placed that they will both properly support each layer of steel and keep the two layers separated at the proper distance.

When it is necessary to splice rods, it shall be done by overlapping them a distance equal to at least forty (40) times their thickness or diameter. At such splices, the overlapping shall be securely wired. Splices shall be avoided at points of maximum stress. Where splices are otherwise detailed on the drawings, such details shall take preference over these specifications.

Unless otherwise indicated on the plans, concrete protection for reinforcing steel shall be in conformance with the following American Concrete Institute (ACI) Standards for cast in place concrete:

Minimum Cover Inches

(a) Concrete cast against and permanently exposed to earth	3 inches
(b) Concrete exposed to earth or weather:	
No. 6 through No. 18 bars	2 inches
No. 5 bar, W31 or D31 wire, and smaller	1 ½ inches
© Concrete not exposed to weather or in contact with ground:	
Slabs, walls, joists	
No. 14 and No. 18 bars	1 ½ inches
No. 11 bar and smaller	¾ inches
Beams, columns:	
Primary reinforcement, ties, stirrups, spirals	1 ½ inches

Dowels shall be placed before the pour and shall not be inserted during or after the concrete is poured.

14. FORMS

Forms for monolithic concrete tunnel sewers shall be made of steel. Metal forms or wood lagging with steel ribs may be used for other structures. Forms shall be reasonably watertight and shall be made and erected in a workmanlike manner, true to lines and grades called for on the plans and so braced and tied that they will remain true to those lines and grades. They shall be so constructed that they will produce concrete with true surfaces, sharp corners, and clean offsets.

Form lumber shall be of a type which will show a minimum of swelling, shrinkage, or warping, and no lumber shall be used which is mismatched, or which contains loose knots, torn or loosened grain, warp, skips, or wane. Re-use of lumber or other form material will be permitted only when, in the judgment of the Engineer, results can be obtained equal to those from the use of new material. Some tolerance, however, will be allowed in the case of form material for unexposed concrete surfaces.

Unit stresses in any component part of the forms shall not exceed the unit working stresses for temporary structures as recommended by the National Design Specification for Wood Construction and American Plywood Association for the type of lumber being used, and the deflection between supports of any part, stressed as a beam, shall not be greater than 1/360 of the span.

Sheeting lumber may be either dressed four sides, shiplap, or tongue and groove.

Sheet lumber for horizontal or included units shall be tongue and groove or shiplap material of not less than 1-inch nominal thickness. No exposed corners shall be beveled except where shown on the plans, or at the direction of the Engineer.

Plywood and similar sheet products, clear at least one face, may be used as sheeting if the limits of deflection specified above for sheeting lumber are attained. This may require backing in the case of thin sheets of long spans.

All forms, after they are built or erected, but before the reinforcing steel is placed, shall be oiled with light oil that will not adhere to nor stain the concrete.

Special and/or a particular type of form shall be used where, as, and if elsewhere called for in these specifications or on the plans.

15. REMOVAL OF FORMS

In tunnel construction, forms for more than one day's pour will not be required but premature removal of forms will not be permitted, and the schedule of removal of such forms shall be subject to the approval of the Owner.

Forms for units not subject to flexure may be removed as soon as the concrete has set sufficiently to preclude all possibility of damage to the section involved, but in no case in less than 24 hours.

All other forms shall be removed only with the permission of the Owner.

16. CURING

The Contractor shall provide means such that all concrete will be cured in a manner which will minimize the possibility of moisture evaporating from the unit for a period of five (5) days after pouring. Should the breaking strengths of test cylinders made from concrete of the unit involved and cured under the same conditions as that unit, show a strength of at least 50 percent of its designed strength in less than the above five (5) days, the Contractor may be permitted, at his request, to shorten this curing period accordingly. Forms shall be considered as adequate protection of the adjacent face until such forms are removed.

17. FINISHING CONCRETE

The finish of concrete surfaces on inside walls and floors shall be made as smooth as possible, special consideration being given to those surfaces which will be exposed to the flow of sewage.

As soon as the forms are removed, the surface of the concrete shall be carefully examined and any irregularities of surface shall be treated as directed by the Engineer. Fins and irregular projections shall be removed in a workmanlike manner, care being exercised to prevent undue spalling of adjacent surfaces.

If, in the opinion of the Engineer, the defects in the concrete are of such a nature as to warrant condemnation, that portion of the pour may be ordered replaced in its entirety and the Contractor shall promptly replace same without additional compensation. The Contractor alone shall be responsible for the trueness of the surface of the concrete and shall correct any deviation in the manner ordered by the Engineer.

Tolerances from lines, grades and dimensions specified in the Contract Documents shall follow the variances established in the current edition of the American Concrete Institute FormWork Standard.

Rubbing with Carborundum stone and/or the use of grinding wheels to obtain smooth finish will be required for exposed to view exterior concrete surface.

Floors, walkways and stairs of structures and buildings shall be given a steel trowel finish unless otherwise specified. Pavement and sidewalk shall be given a standard wood float finish.

In tunnel construction, in addition to the removal of fins and irregular projects, the entire interior surface shall be given a cement mortar brush coat.

18. WINTER PRECAUTIONS

When placing concrete in cold weather, the Contractor shall plan and prosecute his work in a manner which will assure results free from damage through freezing, contraction, and loss of ultimate strength.

No concrete shall be poured when the air temperature is below 40°F. unless the aggregates and water are properly heated. Concrete which has been poured at higher temperatures but has not attained a strength equal to 75 percent of the required strength of the class of concrete involved, shall be housed and protected in accordance with the provisions of this section should the temperature fall below 40°F.

The temperature limits of aggregates and water entering the mixer shall be as follows:

Limits of Temperatures

Water	-	75°F. Min.	140°F. Max.
Fine Aggregate	-	65°F. Min.	140°F. Max.
Coarse Aggregate	-	65°F. Min.	110°F. Max.
Concrete (resulting)	-	60°F. Min.	90°F. Max.

Concrete when deposited shall be not less than 50°F. or more than 90°F.

Application of heat to the materials shall be made in a manner that will keep these materials clean and free from injurious substances.

Aggregates may be heated only steam coils or stream jets, except the case of small quantities of concrete when the Engineer may approve other methods. A sufficient quantity of properly heated aggregates shall be on hand prior to starting the pouring of any unit.

Concrete shall be properly housed with canvas, burlap, or other windproof material in such a manner that any necessary stripping of the forms or finishing of the concrete can proceed without undue damage to the concrete from the elements. Heating of the housing shall be done in a manner which will maintain a temperature between 50°F. and 70°F. at all times for at least five (5) days, and shall provide proper curing conditions for the concrete. In the case of concrete sewer inverts which are a separate pour in the bottom of deep trenches, the Engineer will permit, except in very severe weather conditions, the use of a straw covering in lieu of other housing.

No extra or special or unit payment will be made for concrete heating or housing or other winter precautions and the cost for such shall be included in the work items provided for in the proposal.

19. MATERIALS

a. Cement

(1) General Requirements

Every facility shall be provided for sampling and inspecting cement at the mill or at the site of the work.

The temperature of the cement, at the time of delivery to the mixer, shall not exceed 165°F., and it may be required that it be stored at the Contractor's expense until cooled to that temperature.

(2) Specific Requirements

Standard Portland cement shall conform to the requirements of the current Standard Specifications for Portland cement, ASTM C-150 Type I.

Air-entraining Portland cement shall conform to the requirements of the current Standard Specifications for air-entraining cement ASTM Designation: C-175 Type IA.

(3) Sampling and Testing

Sampling and testing shall be done in accordance with the current Standard Methods of Sampling and Testing Portland cement of the ASTM.

b. Coarse Aggregates for Concrete

(1) General Requirements

Washing will be required to eliminate dust, clay, or silt coating. Aggregates that have been washed shall not be used sooner than 24 hours after washing unless approved by the Engineer.

Cars used for shipping aggregates shall be clean and in a condition of good repair. The use of straw, marsh hay, or other similar materials for closing cracks or holes in cars will not be tolerated.

(2) Specific Requirements

Coarse aggregates shall be gravel, crushed rock or slag which shall conform to the requirements of these specifications and shall meet the physical requirements stated below.

Gravel shall consist of hard, clean, durable particles of rock or pebbles and shall be free from lumps of clay.

Crushed rock shall consist of angular fragments of crushed hard heads or boulders or crushed igneous rock from weathered rock and of uniform quality.

Slag shall consist of clean, tough, durable pieces of air-cooled blast-furnace slag, reasonably uniform in density and quality and reasonably free from glassy pieces. It shall contain no free (unhydrated) lime and only negligible quantities of clay lumps will be permitted.

(3) Sampling and Testing

Sampling and testing will be done in accordance with the Current Standards or Tentative Standards of the ASTM for coarse aggregate.

All sieve and screen analysis, determination of clay, silt, and dust content and percentages of objectionable particles will be based on dry weights.

(4) Physical and Grading Requirements

Coarse aggregates shall meet the physical requirements of the current MDOT Specifications for MDOT Designation #17-A.

c. Fine Aggregates

This specification covers material for use in concrete and mortar.

(1) General Requirements

The general requirements shall be the same as specified for coarse aggregates.

(2) Specific Requirements

Fine aggregates shall consist of sharp sand that shall be composed of clean, hard, durable grains and shall be free from lumps of clay and organic or other deleterious substances.

Fine aggregates shall meet the requirements of the current MDOT Specifications for: MDOT Designation #2 NS, Natural sand for cement concrete and MDOT Designation #2 MS, Masonry sand for mortar.

(3) Sampling and Testing

Sampling and testing shall be done in accordance with the methods outlined in the Current Standard or Tentative Standard Specifications of the ASTM as they apply.

d. Water for Concrete

Water shall be free from oil, acid, alkali, organic matter, and any other deleterious substances. Water approved by the State Board of Health may be used without testing. The Engineer must approve water from other sources before using.

e. Steel Reinforcement

Bar Reinforcement

Unless otherwise provided on the plans or in these specifications, all bars shall be deformed bars of Intermediate Grade as specified in the current ASTM Standard Specifications for Billet Steel Reinforcing Bars, Serial Designation: A 15.

Where mill shipments are made, the Contractor will be required to furnish to the Engineer certified copies of the chemical analysis of each melt from which the bars were drawn. Bond, pull, elongation, and weight tests will be made in conformity with the above ASTM Specifications, using samples selected at the fabricating plant from the material to be used.

After fabricating, the bars shall be bundled and each bundle identified with a metal tag showing the bar mark.

20. TRANSIT-MIX CONCRETE

Transit-mix concrete will be allowed. If the Contractor uses it, the transit-mix concrete shall meet all the foregoing requirements specified for job-mixed concrete and in addition, the following:

The Contractor shall, at his own expense, employ an independent testing laboratory to provide a qualified inspector who shall be present at the plant when deliveries of concrete are made. The inspector shall determine as to the compliance of the mix with the specifications, and shall sign a form certifying to compliance and to amount of load. On each form, the mix shall be stated.

For transit-mix concrete, the batched materials shall be properly proportioned and in a dry state. The Contractor under the direction of the Batching Plant Superintendent shall add the proper amount of water to the mixer on the trucks, and no additional water shall be added. No admixtures or accelerators shall be added except as herein noted, without the approval of the Engineer's representative. The source of supply of transit-mix concrete shall be subject to the approval of the Owner.

Trucks shall not be loaded beyond their rated capacity and shall have mixing drums cleaned of all set-up materials at frequent intervals while in use. Trucks with leaking water valves shall not be used.

Each batch of concrete shall be mixed for not less than 70, nor more than 100 revolutions of the mixer at the rate of rotation specified by the manufacturer of the mixer as the mixing speed. Additional mixing shall be done at a slower speed specified by the manufacturer for agitation. The concrete shall show an even color and consistency from beginning to end of batch when discharged from the mixer. Mixing shall continue at the place of deposit of concrete prior to dumping, if necessary, to fulfill the requirements herein specified.

Mixing shall be continuous after water is added to the mix in the drum, but no concrete shall be placed in the forms more than 45 minutes after water is added to the mix.

21. SHOP DRAWINGS FOR STEEL

The spacing and size of reinforcing steel are shown on the plans for concrete structures. The Contractor shall submit to the Engineer, before delivery of steel, two (2) copies of detail steel plans. These plans will be approved or corrected and one (1) copy returned to the Contractor. Five (5) sets of approved or corrected plans shall then be furnished to the Engineer.