SPECIAL TYPES OF CONCRETE
5-694.800

5-694.810 GENERAL

In the general use of the word concrete, the idea implied is the conventional placement of the material within formed areas where the material will remain. There are, however, many variations of this procedure and a few are listed below.

5-694.811 SHOTCRETE

This term is given to a special method of mortar placement. It is usually used to repair surface areas where concrete has deteriorated, but is also used to build up thin layers of concrete to protect steel from corrosion. The mortar is ejected from a nozzle under pressures of 175 to 345 kPa (25 to 50 psi). Dry sand and cement are premixed in relatively large quantities. The sand-cement mixture and the water are introduced into the nozzle through separate hoses and are blended in the nozzle to produce a fairly dry mortar. Both the dry mix and the wet mix are acceptable to Mn/DOT. The provisions for uniformly graded aggregate as in ACI 506R-90 or in Mn/DOT's Special Provisions for the specific project should be met. Pozzolan substitution is not allowed except with the permission of the Mn/DOT Concrete Engineer. ACI 506R-90 provides detailed guidelines for shotcreting.

Prior to application of shotcrete, the Contractor shall clean the surface to remove loose concrete, dust and metallic rust or scalings. See Figure A 5-694.811. Contractor shall apply shotcrete perpendicular to the surface as shown in Figure B 5-694.811. Placement should start in the corners and work toward the center. Place it in thin layers with about one to two hour time lapse between layers. See Figure C 5-694.811 for a completed section of shotcreted median barrier.

Figure A 5-694.811

Figure B 5-694.811

Figure C 5-694.811

5-694.812 LIGHTWEIGHT CONCRETE

Lightweight concrete is a material that is produced by using lightweight aggregate.

Lightweight aggregate may consist of processed shale, clay, clinker, or other material. The production includes a burning process where the material expands and as a result has less density (weight per unit volume). Due to this expansion, some lightweight aggregate may be very absorptive. Such aggregate may require pre-wetting prior to concrete batching.

Lightweight concrete has a range in unit weight from about 1280 to 1920 kg/m^3 (80 to 120 lb/ft^3**)** depending on the lightweight material used. Some lightweight aggregate will produce concrete of 1760 kg/m^3 (110 lb/ft^3**)** and have compressive strengths comparable to conventional concrete.

Because of the high water absorption of lightweight aggregate, the air content of the mixture is measured using ASTM C 173 "Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method." This method is necessary since the standard pressure method will give false readings.

5-694.813 TILT-UP CONSTRUCTION

In tilt-up construction, either conventional or lightweight concrete can be used. Concrete slabs or panels are cast on smooth surfaces on the ground or on the previously placed concrete floor. After the concrete has cured and attained sufficient strength, the concrete panels are raised into place.

Advantages of this method of construction are that concrete walls are fabricated without erecting side forms and elimination of the more difficult vertical placement method.

5-694.814 UNDERWATER CONSTRUCTION

The decision to perform an underwater concrete placement is made when the alternatives namely the use of cofferdams, caissons or pumping-dry are neither practical nor cost-beneficial and the hydrodynamic conditions will neither erode nor affect the concrete when placed underwater.

When concrete is placed under water, use extreme care to prevent the loss of cement from the concrete. Since some cement is lost in the best operation, the cement content of the concrete is higher than for the standard method of placement. Keep the water as still as possible. Move equipment slowly in the water so that cement erosion from the surface of the concrete will not occur. Check that the water temperature is at least 10°C (50°F) where practical, but not less than 2°C (35°F). When the water temperature is low, maintain the concrete temperature at 20 to 25°C (70 to 80°F).

The best method for placing concrete under water is with a tremie. A tremie is a large tube or pipe, 250 mm (10 in.) or more in diameter, which has a funnel shaped hopper at the top for charging the tube with concrete, and a shut-off valve at the other end. The tremie is filled with concrete with the valve closed when the unit is out of the water. The unit is then lowered into the water until the valve end rests on the bottom. The valve is opened and the concrete permitted to slowly flow from the tremie. Keep the tremie filled with the concrete to the water level so that additional concrete is added as concrete is discharged. If water gets into the tube, remove the unit and recharge with concrete. Maintain a continuous operation until the full height of the planned section is in place.

5-694.815 PRE-STRESSED CONCRETE

Pre-stressed concrete is placed and finished similar to conventional concrete placement. The cement content is about 60 to 89 kg/m^3 (100 to 150 lb/yd^3) higher than most concrete.

Pre-stressed concrete is so named because it is intentionally placed under stress before any dead or live loads are applied to it. Steel strands that extend through a form are placed under high tensile stress. After the strands are securely anchored and the concrete is placed, finished and reaches required strength, the tensioning force is removed and the stress in the strands is transferred to the concrete as pre-compression.

There are two methods of tensioning concrete: pre-tensioning and post-tensioning. In the pre-tensioning process, strands are stressed prior to concrete placement. In the post-tensioning process, flexible tubes are cast in the concrete after which steel tendons are later pulled through the tubes, stressed and anchored into place. A grout is used to encase the tendons and bond them to the tube.

Below are several pictures that illustrate some of the pre-stressing concrete process.

Figures A and B 5-694.815 show placement of reinforcement and strands.

The arrangement of rebars and pre-stressing strands in a girder are shown in Figures C and D 5-694.815.

Concrete is placed and carefully vibrated in a pre-stressed girder in Figures E and F 5-694.815.

Figure G 5-694.815 shows torching of the strands in the finished girder.

Figure H 5-694.815 shows handling of the pre-stressed girders prior to transportation.

The pre-stressed concrete girder is ready for transportation in Figure I 5-694.815.

Figure A 5-694.815

Figure B 5-694.815

Figure C 5-694.815

Figure D 5-694.815

Figure E 5-694.815

Figure F 5-694.815

Figure G 5-694.815

Figure H 5-694.815

Figure I 5-694.815

5-694.816 CELLULAR CONCRETE

Cellular Concrete is defined as lightweight portland cement concrete containing a high percentage of gas cells (distinguishable from air voids in terms of cell sizes and lognormal distribution) created mechanically by means of the addition of foaming agents. A density range of 320 to 1900 kg/m^3 (20 to 120 lb/ft^3) characterizes cellular concrete products that include CLSM (Controlled Low Strength Material). This low density is due to the uniformly distributed non-contiguous air cells that also account for high workability and desirable thermal conductivity.

Usage of the material includes, filling of pipe annuli, load reduction in bridge approach, geofill, submerged load reduction and control of active pressures on retaining walls. The Mn/DOT Concrete Engineering Unit shall evaluate each proposed usage in any Agency project.

Materials Required:
- Foaming agent or gas forming admixture conforming to ASTM C 869
- Portland cement ASTM C 150
- Mn/DOT approved admixtures/pozzolans or as specifically approved for the project by the Mn/DOT Concrete Engineer
- Potable water free of deleterious material

When used as annular fill for pipe-liners, Contractors shall secure the pipeliner to the invert of the existing culvert with fasteners, blocks, or other means to prevent the pipe liner from floating during grouting operations. Another possible means of accomplishing this is by constructing multiple grout lifts.

Contractor Mix Design

A minimum of 15 days prior to the commencement of grout placement, the Contractor shall submit a mix design to the Mn/DOT Concrete Engineer for review and approval. To produce a cubic yard of grout, and a flow diameter of 200 to 250 mm (8 to 10 in.), the Contractor shall design the grout material as follows:

- A minimum of 45 kg (100 lb.) of portland cement
- Sufficient quantities of Class C fly ash
- Fine aggregate
- Foaming agent and water

The foaming agent shall comply with ASTM C 869 when tested in accordance with ASTM C 796. For the use of other admixtures, specific approval by the mix designer and the Mn/DOT Concrete Engineer are required. Only Mn/DOT certified cementitious sources are allowed. Final approval of the mix design is based on satisfactory field placement.

The mix design shall include the following test information:

- 7 and 28 day compressive strength
- Initial and final set times – ASTM C 403
- Flow diameter

The Contractor Shall:

- Design a grouting procedure that will fill all voids between the existing culvert and the liner pipe so that the liner pipe will not collapse.
- Provide a pressure gauge that will measure the grouting pressure and a means to accurately measure the volume of grout injected.
- Submit a grouting plan to the Engineer for approval.
- Fill with grout all voids between the existing culvert and pipe liner, including all breaks or holes in the existing culvert.
- After grouting the liner, which is connected to the in-place culvert, encapsulate the remaining length of liner with a 150 mm (6 in.) minimum thickness of 3Y43 concrete and seal the extreme ends of the annular space with an approved seal.
- Finish the inlet end with a 45 degree mitered fillet-transition between the in-place culvert and the inside of the liner.
- If grout holes are utilized, use cylindrical wooden plugs or other approved plugs to effectively plug holes until the grout has set and then remove and fill them with cement.
- Test the plastic material according to ASTM C 495 at a rate of 1 specimen per 15 m^3 (20 yd^3) after testing the first cubic meter (cubic yard). The minimum sampling rate is 2 samples per unit. A unit is defined as one annular length through which pumping is done from one injection point.
- Test the hardened cellular concrete according to ASTM C 513-86 or as required by the Engineer.

5-694.817 SELF-CONSOLIDATING CONCRETE

This includes such concretes other than cellular concrete that are placed without any mechanical consolidation or are, highly superplasticized for enhanced flowability to facilitate non-conventional placement methods. The use of self-consolidating concrete is restricted to the discretion of the Mn/DOT Concrete Engineer who will provide the guidelines on situation-specific cases.