ITEM 431

PNEUMATICALLY PLACED CONCRETE

431.1. Description. Furnish and place pneumatically applied concrete for the construction of portions of structures, repairing concrete structures, encasement of structural steel members, lining ditches and tunnels, soil-nail walls, and other work as shown on the plans or as directed. Pneumatically applied concrete can be either dry-mix or wet-mix. The dry-mix process consists of dry-mixed fine aggregate and hydraulic cement to which water is added immediately before its pneumatic expulsion from a nozzle. The wet-mix process consists of mechanically premixed concrete pneumatically applied through a nozzle.

431.2. Materials. Provide Class I concrete for repairs and Class II concrete for encasement unless otherwise noted. Provide the class of concrete shown on the plans for other work.

With the exceptions noted in Sections 431.2.A, “Exceptions to Item 421, ‘Hydraulic Cement Concrete,’” 431.2.B, “Exceptions to Item 440, ‘Reinforcing Steel,’” and 431.2.C, “Exception to DMS-6310, ‘Joint Sealants and Fillers,’” provide materials in accordance with the pertinent requirements of the following Items:

- Item 420, “Concrete Structures”
- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcing Steel”
- DMS-6310, “Joint Sealants and Fillers”
- DMS-4640, “Chemical Admixtures for Concrete.”

A. Exceptions to Item 421, “Hydraulic Cement Concrete.” Provide a fine aggregate that meets the requirements of Item 421, Table 4, Grade 1, and a coarse aggregate that meets the requirements of Item 421, Table 3, Grade 7, unless otherwise noted on the plans.

B. Exceptions to Item 440, “Reinforcing Steel.” Provide steel pins, studs, or expansion bolts with a minimum diameter of 1/8 in. and a minimum length of 2 in. to attach reinforcement for the repair of concrete structures as shown on the plans or as directed. Reinforcing steel may be either welded wire fabric or reinforcing bars unless otherwise shown on the plans.

C. Exception to DMS-6310, “Joint Sealants and Fillers.” Provide a preformed bituminous fiber material unless otherwise noted on the plans.

D. Proportioning and Mixing. Submit for approval a proposed mix design conforming to the basic mix design requirements provided in Table 1.

<table>
<thead>
<tr>
<th>Class</th>
<th>Ratio of Cement to Total Aggregate</th>
<th>Minimum 7-Day Compressive Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1:4</td>
<td>3,000</td>
</tr>
<tr>
<td>II</td>
<td>1:5</td>
<td>2,500</td>
</tr>
<tr>
<td>III</td>
<td>1:7</td>
<td>1,700</td>
</tr>
</tbody>
</table>

1. More cement may be used when approved.

Measure the cement and aggregates by volume, and mix with enough water to achieve the desired consistency. Use as little water as possible to achieve sufficient adhesion. Mix concrete sufficiently dry so that it will not sag or fall from vertical or inclined surfaces, or separate in horizontal work.

To verify the mix design before approval, prepare test panels using the same air pressure, nozzle tip, and position to be used for the production work. For each test panel, apply a 3-in. layer of concrete to a plywood sheet with minimum dimensions of 18 in. × 18 in. Cure the test panels in the same manner as the proposed work.

Take three cores, each 2 in. in diameter, out of each test panel and test in compression at seven days in accordance with Tex-424-A. The mix design will be approved when the average strength of the three
cores conforms to the strengths shown in Table 1. Provide additional test panels as directed if there are any changes in materials, equipment, or nozzle operator during the work.

431.3. Construction.

A. Surface Preparation. When concrete is to be placed against soil, grade the area of proposed work accurately to the elevation and dimensions shown on the plans. Compact with sufficient moisture to provide a firm foundation and to prevent absorption of water from the concrete, but without free surface moisture.

When concrete is used to encase structural steel members, remove paint, rust, loose mill scale, grease or oil, and all other foreign materials that may reduce the bond of the concrete to the steel.

When concrete is placed against concrete or rock, remove all deteriorated or loose material by chipping with pneumatic, electric, or hand tools. Cut square or slightly undercut shoulders approximately 1 in. deep along the perimeter of repair areas. Sandblast the surface to clean all rust from exposed reinforcing steel and to produce a clean rough-textured surface on the concrete or rock. Wet the surface against which the concrete will be placed for at least 1 hour with potable water. Place the concrete when the surface has dried to a saturated surface-dry (SSD) condition. Achieve SSD conditions by high-pressure water blasting 15 to 30 minutes before placing the repair material. A saturated surface-dry condition is achieved when the surface remains damp when exposed to sunlight for 15 minutes.

Provide joints, side forms, headers, and shooting strips for backing or paneling. Use ground or gauging wires where necessary to establish thickness, surface planes, and finish lines.

B. Reinforcement. Place and secure reinforcement to ensure that there is no displacement from impact of applying pneumatically placed concrete. Place reinforcing bars at a spacing not less than 2-1/2 in. Support reinforcing wire fabric or bars using anchor studs, expansion hook bolts, grouted rebar, or steel pins capable of resisting a pullout force of 2,500 lb. Space anchors no more than 12 in. center-to-center on overhead surfaces, 18 in. center-to-center on vertical surfaces, and 36 in. center-to-center on top horizontal surfaces. Use at least 3 anchors in each individual patch area. Secure steel pins or studs into the concrete with epoxy or other approved methods. Do not use explosive force to shoot pins, studs, or other anchors into concrete. Check the resistance to pullout of the reinforcing anchors as directed. Notify the Engineer prior to installation of the anchors. Locate anchors so that there is no damage to prestressing tendons or conduits embedded in the concrete.

Use reinforcement when performing repair work in all areas where the thickness of the concrete will exceed 1-1/2 in. Use a single layer of either 2 × 2 – W1.2 × W1.2 or 3 × 3 – W1.5 × W1.5 of welded wire fabric unless noted otherwise on the plans. Use a single layer of wire fabric to reinforce each 4-in. thickness of patch or fractional part in areas where the concrete thickness exceeds 4 in. Encase completely each layer of wire fabric in concrete that has taken its initial set before installing the succeeding layer of wire fabric. Place the reinforcing fabric parallel to the finished surface, and support it so that it will be a minimum of 3/4 in. out from the surface to be covered. Provide a minimum of 1 in. clearance between the finished concrete surface and all steel items including anchors, reinforcing bars, and wire fabric. Lap adjacent sheets at least 6 in. and tie together securely at a spacing of no more than 18 in. Pre-bend fabric before installing to fit around corners and into re-entrant angles.

For encasement of steel members, pre-bend the welded wire fabric using a template to conform as nearly as possible to the outlines of the members to be encased. Drill holes between 1/2 and 1 in. in diameter in the webs of the members as close as possible to the flanges to allow for attachment of the reinforcing fabric. Space these holes at approximately 3 ft. on center. Use 3/8-in. diameter rods placed through these holes to secure the reinforcing fabric. Hold the reinforcing fabric at least 3/4 in. out from the surface of the steel member. Lap adjacent fabric sheets at least 6 in. and tie together at a spacing not to exceed 12 in.

C. Pneumatic Placement of Concrete.

1. General. Place the concrete when the ambient temperature is above 35°F. Do not place concrete against a surface containing frost or ice. Protect concrete from freezing or quick drying after placement. For construction of portions of structures, repairing concrete structures, or encasement of structural steel members, apply the concrete using pneumatic equipment that sprays the mix.
onto the prepared surface at a velocity less than 100 ft. per second. Minimize rebound and produce a compacted dense homogenous mass. Do not apply concrete if high winds will prevent proper application or if rain could wash out the concrete.

For construction of portions of structures, repairing concrete structures, or encasement of structural steel members, provide documentation that the nozzle operator is certified by the American Concrete Institute for the process (wet-mix or dry-mix) and application (vertical or overhead) to be used. Hold the nozzle approximately 2 to 4 ft. from the surface and position it so that the concrete impinges nearly at right angles to the surface being covered. Use shooting strips to ensure straight lines, square corners, and a plane surface of concrete. Place to keep the trapping of rebound to a minimum. Slope the concrete off to a thin edge at the ends of each day’s work or at similar stopping periods requiring construction joint. Thoroughly clean and wet previously placed concrete before placing an adjacent or additional section. Apply a sufficient number of coats to obtain the required thickness. Place coats on vertical and overhead surfaces in layers not greater than 1 in. thick. Place so that the coat does not sag or decrease the bond of the preceding coat. Provide a sufficient interval between successive layers in sloping, vertical, or overhead work to allow initial but not final set. Clean the surface to remove the thin film of laitance to provide for a bond with succeeding applications. Remove rebound and accumulated loose sand from the surface to be covered prior to placing of the original or succeeding layers of concrete. Correct any sags or other defects to the proper section as directed.

Apply the concrete using either the wet-mix or dry-mix process unless otherwise noted on the plans. Mix the materials thoroughly and uniformly using a paddle or drum type mixer designed for pneumatic application. Wet-mix process applications can use transit-mix concrete. Do not use the wet-mix process for repair of damaged concrete.

Clean mixing and placing equipment at regular intervals. Inspect the nozzle liner and water and air injection system daily and replace worn parts as necessary.

2. **Dry-Mix Process.** Use a compressor or blower capable of delivering a sufficient volume of oil-free air at the pressure shown in Table 2. Maintain steady pressure throughout the placing process. Use a water pump with the size and capacity to deliver water to the nozzle with a pressure at least 15 psi more than the required air pressure.

<table>
<thead>
<tr>
<th>Compressor Capacity, CFM</th>
<th>Hose Diameter, in.</th>
<th>Maximum Size of Nozzle Tip, in.</th>
<th>Operating Air Pressure Available, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>1</td>
<td>3/4</td>
<td>40</td>
</tr>
<tr>
<td>315</td>
<td>1-1/4</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>365</td>
<td>1-1/2</td>
<td>1-1/4</td>
<td>55</td>
</tr>
<tr>
<td>500</td>
<td>1-5/8</td>
<td>1-1/2</td>
<td>65</td>
</tr>
<tr>
<td>600</td>
<td>1-3/4</td>
<td>1-5/8</td>
<td>75</td>
</tr>
<tr>
<td>750</td>
<td>2</td>
<td>1-3/4</td>
<td>85</td>
</tr>
</tbody>
</table>

The values shown in Table 2 are based on a hose length of 150 ft. with the nozzle less than 25 ft. above the delivery equipment. Increase operating pressure approximately 5 psi for each additional 50 ft. of hose and approximately 5 psi for each 25 ft. the nozzle is raised.

3. **Wet-Mix Process.** Operate the pump at a line pressure between 100 psi and 300 psi. Use delivery hoses between 1-1/2 in. and 3 in. in diameter. Use mixing equipment capable of thoroughly mixing the materials in sufficient quantity to maintain continuous placement.

D. **Construction Joints.** Use a square butt joint where the joint is subject to compressive stress or is over existing construction joints unless noted otherwise on the plans. Use tapered or square butt joints at other locations. Square the outside 1 in. of tapered joints perpendicular to the surface.

E. **Finish.** Use a sharp trowel to cut off all high spots after the concrete has been placed to the desired thickness or screed to a true plane as determined by shooting strips or by the original concrete surface.
Lightly apply cutting screeds, where used, to all surfaces so as not to disturb the concrete for an appreciable depth. Work in an upward direction when concrete is applied on vertical surfaces. Give the finished concrete a final flash coat of about 1/8 in. unless directed otherwise. Obtain a uniform appearance on all exposed surfaces.

F. **Curing.** Cure encasements with water for 4 days. Cure repairs and structural construction using either a piece of wet burlap taped over the repaired area with a covering of 4-mil minimum plastic sheet also taped in place or membrane curing as approved. Overlap the burlap with the plastic sheet, and continuously tape the edges with a tape at least 3 in. wide (air duct tape or better) to completely enclose the mat and hold in moisture. Cure in this manner for 4 days. Curing is not required for soil-nail walls. Apply membrane curing in accordance with Item 420, “Concrete Structures,” for tunnel and ditch linings and vertical or overhead patches as approved.

G. **Repair of Defects.** Repair or replace debonded areas as directed.

431.4. **Measurement.** Measurement of pneumatically placed concrete for encasement of structural members will be by the square foot of the actual contact area.

Measurement of pneumatically placed concrete for repair of concrete structures will be by the cubic foot in place using the surface area times the average depth of the patch.

431.5. **Payment.** When pneumatically placed concrete is specified as a bid item, the work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Pneumatically Placed Concrete (Encasement)” or for “Pneumatically Placed Concrete (Repair).” This price is full compensation for cement, aggregate, water, and reinforcement; furnishing and driving steel drive pins; furnishing and placing expansion bolts; removal of deteriorated or unsound concrete; mixing, placing, and curing pneumatically placed concrete; and equipment, labor, tools, and incidentals. Pneumatically placed concrete used for work other than encasement or repair will not be paid for directly but will be considered subsidiary to pertinent Items.