

Item No. 404S
Pneumatically Placed Concrete

404S.1 Description

This item shall govern furnishing and placing of "Pneumatically Placed Concrete" for riprap, concrete channel, canal lining, tunnel lining, encasement of designated structural steel members, covering of designated portions of concrete structures, repair of deteriorated or damaged concrete and other miscellaneous construction as indicated on the drawings.

This specification is applicable for projects or work involving either inch-pound or SI units. Within the text, the inch-pound units are given preference followed by SI units shown within parentheses.

404S.2 Submittals

The submittal requirements of this specification item may include:

- A. Mix design of the class (Type I or Type II) of concrete required on the project (encasement, repair, rip-rap, ditch lining),
- B. Application process (wet or dry),
- C. Work experience of the superintendent and workers performing specialized tasks to be employed on the project, and
- D. Type of Expansion joint material to be used on the project.

404S.3 Materials

Unless indicated otherwise on the drawings, Class II Portland cement concrete shall be used for encasement and Class I Portland cement concrete shall be used for repair.

Cement, water and sand shall conform to the requirements of Standard Specification Item No. 403S, "Concrete for Structures". Specifically the fine aggregate shall conform to the requirements of Table 2 and the coarse aggregate shall conform to the requirements of Table 1, Grade 7, unless otherwise indicated on the drawings.

Air entraining admixtures, retarders and water reducing admixtures, if used, shall comply with Standard Specification Item No. 405S, "Concrete Admixtures".

Bar reinforcement and wire fabric reinforcement shall conform to Standard Specification Item No. 406S, "Reinforcing Steel".

Expansion joint material shall conform to the requirements of Standard Specification Item No. 410S, "Concrete Structures".

Steel drive pins, studs or expansion bolts used for the attachment of reinforcing when covering designated portions of concrete structures with pneumatically placed concrete shall be capable of being driven to the specified depth without deforming or otherwise becoming unsuitable for the purpose intended. The pins shall have a minimum diameter of 1/8 inch (3 mm) and a minimum length of 2 inches (50 mm). Size and location of drive pins or studs and method of attachment of reinforcing shall be as indicated on the drawings.

The equipment used for driving the pins or studs shall be of the type, which uses an explosive for the driving force, and shall be capable of inserting the stud or pin to the required depth without

damage to the surrounding concrete. The Engineer or designated representative may require that a test be made of the equipment prior to approving it for use.

Expansion hook bolts, 1/4 inch (6 mm) diameter, shall be placed in a drilled hole of the size and depth recommended by the manufacturer. The Engineer or designated representative may require that a test be made of the driving equipment for steel drive pins and check the pull out quality of the expansion bolts, prior to approving their use.

404S.4 Proportioning and Mixing

The Contractor shall submit a mix design for approval by the Engineer or designated representative. The basic mix design shall conform to the following table:

Table 1 Minimum Requirements

	*Minimum of 1	Minimum 7 Day Compressive
Type	Part Cement to	Strength Cores
I	4 Parts Aggregate	2520 psi (17 MPa)
II	5 Parts Aggregate	2100 psi (14 MPa)
III	7 Parts Aggregate	1400 psi (10 MPa)

* The Contractor may use a design containing more cement than required by this specification when approved by the Engineer or designated representative.

The cement and aggregates shall be measured by volume with enough water added to bring the materials to the desired consistency. Test panels will be required prior to approval of the mix design. The concrete will be applied to a plywood panel and shall be a minimum size of 18 inches x 18 inches x 3 inches (450 x 450 x 75 mm) in depth. The panel will be shot with the same air pressure and nozzle tip to be used for the production work. The panel will be cured in the same manner required for the particular usage required by the contract.

Three 2-inch (50 mm) diameter cores will be taken from each panel and tested in compression at 7 days. The average strength of the cores shall be the strengths required in Table I. Testing of cores shall conform to TxDOT Test Method Tex-424-A.

The Engineer or designated representative may require additional test panels during the progress of the work if there is any change in materials, equipment or nozzle operator.

If, in the opinion of the Engineer, the cylinder strengths are indicating undesirable variation in the concrete, the Contractor may be required to change the mix design and/or method of placement so as to correct this condition.

Mixing and application may be done by either the dry mix or wet mix process. The materials shall be thoroughly and uniformly mixed using a mixer designed for pneumatic concrete application. It may be either a paddle type or drum type mixer. Transit mix concrete may be used for the wet process. No water shall be added to the mix after mixing and before application. Mixed material that has not been used within 45 minutes shall be rejected and no remixing or tempering will be permitted.

All mixing and placing equipment shall be cleaned at regular intervals and be kept in acceptable working condition. The nozzle liner water and air injection system should be inspected daily and replaced when the parts are worn.

404S.5 Construction Methods

A. Surface Preparation

All surfaces on which pneumatically placed concrete is to be placed shall be cleaned thoroughly of all paint, rust, loose mill, scales, grease and such other foreign materials which are likely to prevent adequate bond. Structural steel to be encased with pneumatically placed concrete shall not be painted. Concrete and reinforcing steel surfaces to be covered with pneumatically placed concrete shall be abrasion blasted clean and then the surface cleaned of loose material with filtered compressed air.

Concrete surfaces on which pneumatically placed Portland cement concrete is to be applied shall be thoroughly moistened by wetting prior to placement. Excess water shall be allowed to drain or shall be removed by filtered air blasting.

Where standing or running water is encountered it shall be removed before applying the Portland cement concrete.

The periphery of repair areas shall be saw cut 1 inch (25 mm) deep and existing concrete removed as necessary to prevent feathered edges.

Concrete adjacent to a crack shall be removed in such a manner as to leave the existing reinforcing steel throughout the repair area as intact as possible.

B. Reinforcement

All reinforcement to be embedded in pneumatically placed concrete shall be clean and free from loose mill scale, rust, oil or other coatings which might prevent adequate bond.

Reinforcement shall be secured rigidly in the position indicated. The clear distance between reinforcing bars shall be at least 2 1/2 inches (65 mm).

Minimum clear distance between forms and reinforcement and for cover shall be as indicated on the drawings. Space shall be provided for splicing bars in the approved manner.

For the covering of designated portions of concrete structures, welded wire fabric shall be held securely about 3/4 inch (20 mm) out from the surface to be covered. Adjacent sheets shall lap at least 6 inches (150 mm) and sheets shall be fastened together securely by tying at intervals not to exceed 18 inches (450 mm). In attaching the wire fabric, steel drive pins spaced at 2 feet (600 mm) on centers each way shall be driven to a penetration of not less than 1 inch (25 mm) or 1/4 inch (6 mm) hook bolts installed conforming to manufacturer's recommendation into the face of the designated portion to be covered or repaired. The wire fabric shall be fastened securely to each pin or bolt. Any pin that does not reach the desired depth or hook bolt that does not anchor properly in its hole may remain in place but must be supplemented by an additional pin or bolt installation meeting specification requirements. The welded wire fabric shall have a minimum of 1 inch (25 mm) cover to the finished concrete surface.

For the encasement of designated portions of steel structures, the welded wire fabric shall be bent to a template to conform as nearly as possible to the outlines of the steel members to be encased. Drilled holes not less than 1/2 inch (13 mm) nor more than 1 inch (25 mm) in diameter shall be provided in the webs of the members as near as practicable to the flanges for the purpose of attaching the reinforcing fabric. These holes shall be spaced approximately 3 feet (1 meter) on center. The welded wire fabric shall be held securely about 3/4 inch (20 mm) out from the surfaces of the members to be encased. Adjacent sheets shall lap at least 6 inches (150 mm) and sheets shall be fastened together securely by tying at intervals not to exceed 18 inches (450 mm). In placing the wire fabric, 3/8 inch (10 mm) round rods shall be

fastened to the structural steel through the holes provided in the webs of the members to be encased and the fabric shall be tied securely outside to rods. Ties shall be spaced approximately 12 inches (300 mm) on centers. The formed fabric shall conform, insofar as possible, to the shape of the structural member with a space of 3/4 inch (20 mm) between the fabric and the faces of the members to be encased.

C. Placing of Pneumatically Placed Concrete

Proper consistency shall be controlled at the nozzle valve by the operator for the dry mix process and a low water-cement ratio must be maintained. The consistency of the mix and the water shall be controlled by the mixer pump or by the transit mix truck when used for the wet mix process. The mix shall be sufficiently wet to adhere properly and sufficiently dry so that it will not sag or fall from vertical or inclined surfaces or separate in horizontal work.

No work shall be done without the permission of the Engineer or designated representative when the temperature is lower than 35°F (2°C). Concrete shall not be applied to a surface containing frost or ice. After placing, the concrete shall be protected from freezing and/or quick drying.

When encasing structural steel members or covering portions of structures the concrete may be applied in 1 coat; however, if the concrete, after being placed, shows any tendency to sag, it shall be applied in 2 or more coats. Pneumatically placed concrete for overhead work shall be placed in 2 or more coats as may be necessary to insure proper bond and to eliminate sag. In covering vertical surfaces, placing of the concrete shall begin at the bottom and be completed at the top.

Any sag or other defects shall be corrected to proper section by the Contractor at the Contractor's expense and as directed by the Engineer or designated representative.

The nozzle shall be held at an approximate distance of 2 to 4 feet (0.6 to 1.2 meters) and positioned so that the stream of flowing concrete shall impinge as nearly as possible at right angles to the surface being covered. Any deposit of loose sand shall be removed prior to placing any initial or succeeding layers of pneumatically placed concrete. When any deposit of loose sand is covered with pneumatically placed concrete, the concrete shall be removed and replaced with a new coat of pneumatically placed concrete after the receiving surface has been properly cleaned.

Before channel or canal lining or riprap is placed, the earth canal or channel slopes shall have been compacted uniformly and thoroughly and brought to a uniform moist condition. The subgrade for lining shall be excavated and fine graded to the required section. The use of forms for lining will not be required. The surfaces of pneumatically placed concrete for both channel lining and riprap shall be finished accurately by hand floating methods before the concrete has attained its initial set.

The original surface and the surface of each layer, which is permitted to harden before applying succeeding layers, shall be washed with water and filtered air blast or a stiff hose stream and loosened material removed. Any material which rebounds and does not fall clear of the work or which collects on horizontal surfaces shall be blown off from time to time to avoid leaving sand pockets.

D. Curing

Encasements shall be water cured for four (4) curing days.

For curing, the repair area shall have a piece of wet cotton mat taped into place over the repaired area followed with a covering of 4 mil (100 micrometers) minimum sheet plastic also

taped into place. The sheet plastic shall be larger than the mat and shall be continuously taped at the edges with 3 inch (75 mm). Reinforcement minimum width tape (air duct tape or better) to completely enclose the mat and hold in the moisture. After 4 days or longer the mat and cover may be removed.

After the curing period the patches will be tested by striking with a hammer to check for soundness and bond to existing concrete.

E. Riprap and Ditch Lining

Pneumatically placed concrete for riprap and for channel or canal linings shall be the type indicated on the drawings. The concrete shall be placed to the limits indicated on the drawings or as designated by the Engineer or designated representative. The surface shall be given a wood float finish or a gun finish as directed by the Engineer or designated representative. Curing of riprap and/or ditch lining shall be by either Type I or II membrane conforming to Standard Specification Item No. 409S, "Membrane Curing".

F. Operating Requirements for the Dry Mix Process

The compressor or blower used to supply air shall be capable of delivering a sufficient volume of oil free air at a pressure range of 40 to 85 psi (276 to 586 kPa) as required by the size of the nozzle employed. Required capacity of compressor and operating pressures are shown in Table 2 for the various nozzle sizes. Steady pressure must be maintained throughout the placing process. The water pump shall be of sufficient size and capacity to deliver the water to the nozzle at a pressure of not less than 15 psi (100 kPa) in excess of the required air pressure.

G. Operating Requirements for the Wet Mix Process

The pump shall operate so that the line pressure is between 100 psi and 300 psi (690 kPa to 2069 kPa) for delivery hoses with 1 1/2 inch to 3 inch (38 to 75 mm) diameters. The mixing equipment shall be capable of thoroughly mixing the materials in sufficient quantity to maintain continuous placement. When transit mix concrete is used, this equipment shall conform to Standard Specification Item No. 403S, "Concrete for Structures".

Table 2 COMPRESSOR CAPACITIES

Compressor Capacity Cubic Feet per Minute (Cubic Meters per Minute)	Hose Diameter Inches (millimeters)	Maximum Size of Nozzle Tip, Inches (millimeters)	Operating Air Pressure Available, Psi (kPa)
250 (7.1)	1 (25.4)	¾ (19.0)	40 (275.8)
315 (8.9)	1 ¼ (31.8)	1 ¼ (31.8)	45 (310.3)
365 (10.3)	1 ½ (38.1)	1 ¼ (31.8)	55 (379.2)
500 (14.2)	1 5/8 (41.3)	1 ½ (38.1)	65 (448.2)
600 (17.0)	1 ¾ (44.4)	1 5/8 (41.3)	75 (517.1)
750 (21.2)	2 (50.8)	1 ¾ (44.4)	85 (586.0)

The values shown in Table 2 are based on a hose length of 150 feet (46 meters) with the nozzle not more than 25 feet (8 meters) above the delivery equipment. Operating pressures shall be increased approximately 5 psi (34 kPa) for each additional 50 feet (15 meters) of hose and approximately 5 psi (34 kPa) for each 25 feet (8 meters) the nozzle is raised.

H. Rebound

Accumulation of loose particles of concrete, which do not adhere to the surface being covered, shall be removed and discarded. Concrete shall not be placed over such material.

I. Construction Joints

Particular care shall be given to the formation of construction joints. Unless otherwise indicated on the drawings, all joints subject to compressive stress or over existing construction joints shall be square butt joints. Tapered joints will be permitted at other locations except the outside 1 inch (25 mm) shall be perpendicular to the surface.

J. Workers

Only experienced superintendents and workers performing specialized tasks shall be employed. Satisfactory written evidence of such experience shall be furnished to the Engineer or designated representative upon demand.

404S.6 Measurement

Measurement of pneumatically placed concrete for encasement of structural steel members, will be by the square foot, in place, of the actual contact area

Measurement of pneumatically placed concrete for repair and restoration of concrete structures, tunnel linings and miscellaneous structures will be by the cubic yard in place using the surface area times the average depth of the patch.

Measurement of pneumatically placed concrete for riprap and ditch lining, shall conform to Standard Specification Item No. 591S, "Riprap for Slope Protection".

404S.7 Payment

Pneumatically placed concrete, measured as provided above, will be paid for at the unit price bid per square foot or cubic yard for "Pneumatically Placed Concrete" of the type specified.

The unit price bid per square foot shall be full compensation for all cement, aggregate, water, reinforcement, furnishing and driving all steel drive pins, for mixing, placing and curing pneumatically placed concrete and for all labor, tools, equipment and incidentals necessary to complete the work. Excavation for channel and canal lining will be paid for conforming to Standard Specification Item No. 120S, "Channel Excavation". Shaping and fine grading of channel or canal slopes and floors and excavation required for shaping slopes for headerbanks will not be paid for directly but shall be included in the unit price bid for "Pneumatically Placed Concrete". When headerbanks upon which "Pneumatically Placed Concrete" is to be placed have been built by prior contract, excavation for shaping or slopes will be paid for conforming to Item No. 401S, "Structural Excavation and Backfill".

Payment will be made under:

Pay Item No. 404S-A:	___Inch Pneumatically Placed Concrete -	Per Square Foot.
Pay Item No. 404S-B:	Pneumatically Placed concrete -	Per Cubic Yard.

End

<i>SPECIFIC</i> CROSS REFERENCE MATERIALS
Specification Item No. 404S, "Pneumatically Placed Concrete"

City of Austin Standard Specifications

<u>Designation</u>	<u>Description</u>
Item No. 120S,	Channel Excavation
Item No. 410S	Structural Excavation and Backfill
Item No. 403S	Concrete for Structures
Item No. 405S	Concrete Admixtures
Item No. 406S	Reinforcing Steel
Item No. 409S	Membrane Curing
Item No. 410S	Concrete Structures
Item No. 591S	Riprap for Slope Protection

Texas Department of Transportation: Manual of Testing Procedures

<u>Designation</u>	<u>Description</u>
Tex-424-A	Obtaining and Testing Drilled Cores of Concrete

<i>RELATED</i> CROSS REFERENCE MATERIALS

Specification Item No. 404S, "Pneumatically Placed Concrete"
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Texas Department of Transportation: Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges

<u>Designation</u>	<u>Description</u>
Item 360	Concrete Pavement
Item 420	Concrete Structures
Item 421	Portland Cement Concrete
Item 427	Surface Finishes for Concrete
Item 431	Pneumatically Placed Concrete
Item 437	Concrete Admixtures
Item 520	Weighing and Measuring Equipment
Item 522	Portland Cement Concrete Plants
Item 524	Hydraulic Cement