DEVELOPMENTAL SPECIFICATIONS
FOR
DEEP SOIL INJECTION FOR PAVEMENT LEVELING

Effective Date
October 17, 2023

THE STANDARD SPECIFICATIONS, SERIES 2023, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

23042.01 DESCRIPTION.

This work consists of raising, filling voids, or densification of base soils under Portland cement concrete or bituminous pavements by furnishing and injecting high density polyurethane material into the base soils at locations shown on the plans.

23042.02 MATERIALS.

A. High Density Polyurethane.

1. Material for raising and undersealing pavements shall be a closed cell, high density polyurethane (HDP) system with the following physical characteristics:

Table DS-23042.02-1: HDP Characteristics

Technical Property	Requirement
Density, min., per ASTM D 1622	3.5 – 4.5 lbs/ft^3
Compressive strength, min., per ASTM D 1621	55 psi
Flexural Strength, min., per ASTM D 790	90 psi
Shear Strength, min., per ASTM C 273	45 psi
Tensile Strength, min., per ASTM D-1623	90 psi
Closed Cell Content, per ASTM D 6226	>85%
Curing Rate	90% of compressive strength within 30 minutes after injection

2. Material shall be hydro-insensitive in the material's component reaction such that the injected product is not significantly compromised by soil moisture or free water under the pavement. Hydro-insensitivity shall be verified by submittal of a certificate from an independent testing lab showing that the materials meets or exceeds the limits of the Test Procedure for Hydro-Insensitivity of High Density Polyurethane Grout – Panel Test (NYSDOT GTP-9) - Appendix A.

3. The material shall be a two-part 1:1 by volume high density polyurethane. The material shall be water blown, not chemical blown. The material shall be a polyurethane-foaming mixture, having a water insoluble diluent, which permits the formation of polyurethanes in excess water. The presence of a water insoluble diluent and the characteristics listed above must be certified by the manufacturer.

4. Acceptance of the polyurethane material will be based on certification and test results.
   a. A certification from the polyurethane manufacture must be submitted prior to the preconstruction conference that the HDP meets the specification requirements. The certification must have independent test results that show the materials properties meeting the specification requirements. These tests must be from the same material components proposed to be used in the project.
   b. Testing for compliance with ASTM 1621 and ASTM D1622 must be completed.
      1) Prior to beginning work and with the inspector observing, the Contractor must prepare five machine mixed field samples for density and compressive strength determination. The samples shall then be transported to an independent third-party testing laboratory at the contractor's expense. At the laboratory, a nominal 2 inch by 2 inch by 2 inch sample shall be taken from the center of each of the field samples and the density of the material shall be determined in accordance with ASTM D1622. The compressive strength shall then be determined by testing in accordance with ASTM D1621.
      2) The Contractor shall submit electronic copies of the stress strain curves (ASTM D1621 showing force, lbs. vs. deflection, %) as well as density calculations, including measured specimen dimensions (ASTM D1622) for each specimen tested.
      3) Field samples shall be prepared and sent for testing for each individual batch/lot number of resin component used on the project.
   c. The compressive strength and density determined from ASTM D1621 and ASTM D1622 shall be used to determine the percent of pay for this item as outlined in Measurement and Payment.

5. Provide the Engineer certification from the manufacturer stating that the material provided is in accordance with this special provision. The MSDS for all pertinent production material shall be included with the certification.

6. All stored polyurethane material shall be sealed and protected from contamination by dust or any foreign material.

B. Nonshrink Grout.
Per Materials I.M. 491.13.

23042.03 CONSTRUCTION.

A. General.

1. The Contractor, as well as the project supervisor, shall have at least 3 years of experience in stabilization of pavement foundation soils by injecting high density polyurethane. Prior to the preconstruction conference, provide a list of at least five projects of similar size and scope completed by the Contractor in the last 3 years.

2. Submit written documentation to the Engineer at least 5 working days before preconstruction conference the following:
   - Details of proposed means of establishing and controlling line and grade of stabilized pavement.
   - Details of methods for control and disposal of waste materials.
   - Details of chemical spill control and cleanup.
   - Details of methods to prevent scorching or self-igniting when injecting into large voids.

- Details of the curing period and open to traffic times.

3. Submit an injection plan at least 10 working days before the start of any injection work. The plan shall include the details of the proposed hole spacing, propose injection depth(s), diameter, drilling methods and hole injection sequence for the stabilization process. Injection plans shall be prepared and certified by a Professional Engineer licensed in the State of Iowa.

4. Do not perform deep soil injection for pavement leveling when the subgrade is frozen or if daytime temperatures are below 35°F unless material is kept above 40°F until it gets to the injection location.

B. Equipment.

1. Portable Dynamic Cone Penetrometer.

a. Provide a portable dynamic cone penetrometer (DCP) for on-site soils investigation to assist in location and depth of weak foundation soils and determination of correct injection pattern and injection elevations through tubes to densify weak soils. The DCP is to be capable of taking readings up to 30 feet below grade. DCP testing may be required as directed by the Engineer to confirm existing sub-grade soil conditions. The name, model and description of the DCP unit intended for use must be submitted prior to the preconstruction meeting.

b. The DCP testing equipment shall conform to the following properties

- Diameter of Cone Tip = 35.6 mm (1.40 inches)
- Angle of Cone Tip = 60 degrees
- Area of Cone Tip = 10 square cm (1.55 square inches)
- Diameter of Rods = 20 mm (0.7874 inches)
- Length of Rods = 1 m (39.37 inches)
- Weight of Rods = 2.4 kg (5.29 pounds)
- Weight of Drop Hammer = 30 kg (66 pounds)
- Free Fall Drop Height = 20 cm (7.874 inches)
- Capable of Reaching = 30 Feet below grade

c. A manufacturers data sheet or certification of the DCP equipment showing the properties shall be provided prior to the preconstruction conference.

2. Pumping Units.

As a minimum, a truck with two mounted pumping units capable of injecting the polyurethane material at a controlled rate into the aggregate base, subbase, or foundation soils to the required depth(s). Ensure the pumping units are equipped with certified flow meters to precisely measure the amount of each component injected, so that the ratio by volume is maintained for quality control and a certified volume of injected polymer material obtained for proper payment. Ensure that the units are equipped with pressure and temperature control devices capable of maintaining proper temperature and proportionate mixing of the two chemical components. Certification from the manufacturer (or independent third party) demonstrating that each flow meter intended for use has been tested within the past 12 months and must be submitted prior to the preconstruction meeting.

3. Drills.

Pneumatic or electric drills are required, capable of efficiently drilling injection holes through the pavement and granular base or subbase without damaging the structural integrity of the existing pavement. Drill host holes for the placement of injection tubing cut to proper length(s) as per the plans, or as indicated on the field QC plan and DCP testing, as approved by the Engineer. (Depth of granular material should be available from As-Built information included in the project plans.)

4. Equipment for Monitoring Movement.
Supply satisfactory equipment such as rotating laser levels and receivers to monitor movement of pavement to within 0.01 foot, to verify that the injected foundation soils have been properly densified and to ensure proper lift of pavement to grade if required. Supply satisfactory equipment to monitor differential movement of bridge approach at abutment walls and for correction of faulted jointed pavement. Supply satisfactory horizontal movement monitoring equipment when injecting in the vicinity of MSE walls.

C. Preparation.

1. Establish a target profile in the presence of the Engineer using an elevation measuring device or string line.

2. Locate reinforcing steel by ferro scan survey, ground penetrating radar or other non-destructive method approved by the Engineer. Do not damage existing reinforcing steel during preparation and installation. (Existing reinforcing steel placement on bridge approaches should be available from As-Built information included in the project plans.)

3. Deep Soil Injection.
- **a.** Have a Professional Engineer licensed in the State of Iowa prepare and certify injection plans.
- **b.** Perform a DCP test(s) to determine the strength of the existing soils.
- **c.** A testing report of the DCP tests summarizing the stability of the soil layers shall be created. The reports shall be submitted as part of the injection plan. The plan shall contain:
  - **1)** Test Location – Highway, Milepost and Station and location in pavement
  - **2)** Test date
  - **3)** DCP blow counts by depth
  - **4)** Equipment operator
  - **5)** Evaluation of blow count and a determination of stability needs
  - **6)** Certification of the test report
- **d.** Finalize injection plan using the DCP test results.
  - **1)** Verify injection locations and pattern.
  - **2)** Develop the injection depth(s).
  - **3)** If the depth of injection(s) to stabilize soils exceeds 8 feet, the injection plan shall include multiple injection depths separated by approximately 4 foot increments working from the top (4 feet under the pavement slab) down to the depth of soils to be stabilized or to stabilize the lowest poor soils then work up. All injection holes at one depth (horizontal 4 foot grid) shall be filled before beginning the injections at the next depth. The initial and subsequent injection depth(s) may raise the pavement or approach slab, but the final injection depth shall be used to raise the pavement or approach slab to the target profile. Note: this may require multiple injection ports at each location in the horizontal 4 foot grid.
  - **4)** Plan should prevent filling of granular base or subbase with high density polyurethane foam.

4. Unless otherwise approved by the engineer, saw cut longitudinal joints between panels to be stabilized and lifted as necessary to prevent damage while lifting. A plan of sawing should be submitted for approval to the engineer before any sawing operations start.

5. Joints shall be clear of debris before starting the slab lifting process.

6. Protect the integrity of roadway and approach slab drains.

7. Drill Injection Holes.
- **a.** Drill round vertical holes with a diameter no greater than 1 inch.

b. Evenly space holes according to the finalized injection plan, but not greater than 4 feet by 4 feet on center, or as directed by the Engineer.

8. Insert injection tubes according to the authorized injection plan. Injection tubes must be countersunk a minimum of 4 inches into the pavement.

D. Injection.

1. Inject the amount of high density polyurethane foam required to stabilize soils and lift the pavement or approach.
- **a.** Lift the pavement or approach slab to within ± 0.01 feet from the target profile.
- **b.** Injection below a bridge approach slab.
  - **1)** Continually monitor movement of the approach slab at the bridge deck end utilizing a differential fault meter.
  - **2)** Cease injection and move injection to holes further way from the backwall if the approach slab begins to lift off the backwall.
- **c.** Monitor retaining walls and wingwalls for movement. Cease injections to the hole if movement of the wall is detected.
- **d.** Perform operations such that, if necessary, alternating adjacent areas are filled and lifted to minimize cracking or other damage to the pavement. Any damage to the pavement as a result of poor installation practices shall be repaired as directed by the Engineer.

2. Prevent material and debris from falling into streams, pedestrian areas, live traffic, or railroad tracks.

3. Clean injection holes and work area.
- **a.** Remove high density polyurethane foam material from the injection holes down to the top of the recessed tubes.
- **b.** Clean the pavement surface adjacent to the injection holes with a wire brush if necessary to remove excess polymer.
- **c.** The pavement work area must be cleaned of all loose material.

4. Fill all injection holes with non-shrink grout. Return to the site after 24 hours to verify that the hole grouting is adequate and to perform additional grouting if necessary. Strike patches flush with the surface of the surrounding pavement.

E. All drill tailings, excess polyurethane material and other debris shall be cleaned up at the end of each working day or before the lane is opened to traffic. When adjacent lanes are open to traffic, provisions shall be made to prevent material from encroaching onto the open lane or squirting onto passing vehicles. Polyurethane material shall not enter into gutters or closed drainage systems. Suitable means to restrict the infiltration of the residue into a closed drainage system shall be provided by the Contractor. Polyurethane material shall be removed from the pavement surface before any residue is blown by traffic action or wind. All removed material shall be disposed of according to federal, state, and local regulations.

F. Repair or replace pavement and approach slabs damaged as a result of the work, including cracks that develop, to the satisfaction of the Engineer. Cost of repairs or replacement are incidental to the work.

G. Opening to Traffic.
Injected pavement may be opened to traffic after 30 minutes of final injection of polyurethane material as material is at a minimum 90% strength within 30 minutes. Pavement shall be free of debris and swept clean prior to opening to traffic.

H. Safety.
The Contractor shall have a comprehensive Safety Manual pertaining to the equipment, material,

and process, demonstrating capability of safely conducting the work specific to stabilizing foundation soils with high density polyurethane.

I. Warranty.
Material shall have a warranty against shrinkage and deterioration for a period of 2 years. If settlement of more than 1/4 inch in the injected areas occurs, Contractor shall return to inject the affected area to lift to proper grade at no additional charge to the Contracting Authority.

23042.04 METHOD OF MEASUREMENT.

A. Deep Soil Injection.
The amount of high density polyurethane material necessary to accomplish the deep soil stabilization, void filling, and pavement lifting will be measured by certified flow meters, in pounds, and reported in writing to the Engineer daily.

B. DCP Testing.
The DCP testing will be paid for each location that testing is completed and an acceptable testing report is submitted.

23042.05 BASIS OF PAYMENT.

A. Deep Soil Injection.

1. The Contractor will be paid the contract unit price for the pounds of raw polyurethane material used and accepted by the Engineer. This payment shall be full compensation for furnishing all labor, equipment, and materials to level the pavement. Drilling and grouting of injection holes shall be incidental to this item.

2. Payment per pound shall be determined and/or adjusted per the following:
a. Failure to provide a passing Hydro-Insensitivity Panel Test (Article 23042.02, A, 2) prior to the work will result in the rejection of the material and no payment shall be made for any work completed.
b. Payment Adjustment for Density.

Table DS-23042.05-1: Payment Adjustment for Density

Density, lb./cu. ft.	< 3.5	3.5 to 4.5	>4.5
% Pay[1]	0%	100%	See formula below [2]

[1] The adjustment in pay for density shall be applied to the pounds of material used as based on the unit price of the polyurethane material indicated by batch/lot number.
[2] Percent Pay = (4.5 / Density) * 100
Density = average density (lb./cu. ft.) per individual batch/lot number per ASTM D1622 (round to 1 decimal place)

c. Payment Adjustment for Unconfined Compressive Strength.

Table DS-23042.05-2: Payment Adjustment for Unconfined Compressive Strength

Unconfined Compressive Strength, psi	< 55	≥ 55
% Pay[1]	0%	100%

[1] The adjustment in pay for unconfined compressive strength shall be applied to the pounds of material used as based on the unit price of the polyurethane material indicated by batch/lot number.

B. DCP Testing.

The Contractor will be paid the contract unit price for each DCP test location. This payment shall be full compensation for furnishing all labor, equipment, testing, evaluation and reporting for each location.

GTP-9

TEST PROCEDURE FOR HYDRO-INSENSITIVITY OF HIGH DENSITY POLYURETHANE GROUT – PANEL TEST

GEOTECHNICAL TEST PROCEDURE
GTP-9
Revision #1

AUGUST 2015

NEW YORK STATE OF OPPORTUNITY. | Department of Transportation | Office of Technical Services | Geotechnical Engineering Bureau

GEOTECHNICAL TEST PROCEDURE:
HYDRO-INSENSITIVITY OF HIGH DENSITY POLYURETHANE GROUT – PANEL TEST

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STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL ENGINEERING BUREAU

AUGUST 2015

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1. SCOPE

1.1 This procedure is used to demonstrate that the high density polyurethane material meets the 90% density and compressive strength requirements in dry and wet conditions.

2 APPLICABLE DOCUMENTS

2.1 ASTM D 1622 Standard Test Method for Apparent Density of Rigid Cellular Plastics.
2.2 ASTM D 1621 Standard Test Method for Compressive Properties of Rigid Cellular Plastics.
2.3 ASTM D 1623 Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics.
2.4 NYSDOT Geotechnical Test Procedure (GTP-8) Test Procedure for Hydro-Insensitivity of High Density Polyurethane Grout – Barrel Test.

3 TERMINOLOGY

3.1 **Slabjacking** is used to correct settlement and stability problems associated with concrete slabs positioned over unstable ground materials. As defined in *Ground Improvement Technology Manual*, FHWA DP-3 (1996), slabjacking procedures include:

- ✓ Raising or leveling;
- ✓ Under-slab void filling (no raising);
- ✓ Grouting slab joints; and
- ✓ Asphalt subsealing.

Proprietary methods for slabjacking utilize chemical grouts to create a reaction to fill the void, seal the crack, or create uplift pressure to realign the slab.

3.2 **Hydrophilic** chemical grouts can produce either closed cell foam or a non-cellular gel when mixed with water. Hydrophilic chemical grout attracts water and is able to bond to wet surfaces. This product seeks out water as it reacts and allows the resin to work its way into water filled pores. Hydrophilic chemical grouts are flexible and resilient after full cure and will allow movement to occur in the structure without damaging the seal or bond.

3.3 **Hydrophobic** chemical grouts require a catalyst that is blended into the resin prior to installation. The dosage of catalyst added to the resin controls the reaction time and the volume of foam produced. Hydrophobic chemical grouts repel water after activation. Hydrophobic resins cure rigid and do not recover from compression. Hydrophobic chemical grout is low viscosity and permeates loose and non-consolidated soils readily.

4 SUMMARY OF METHOD

4.1 This laboratory test procedure is used to ensure that the High Density Polymer Material maintains 90% of the density of the dry polyurethane grout when injected directly into water.

4.2 Hydro-insensitivity is the inherent chemical property of a material to be unaffected by water (i.e. to behave in such a manner as if there was no water present). For hydro-insensitive polyurethanes (hydrophobic), the reacting components will polymerize even in the presence of water. This procedure tests and compares dry injection shots and wet injection shots.

5 SIGNIFICANCE AND USE

5.1 Polyurethane grouting is a grouting technique that employs a high density expanding polymer used as fill to densify and stabilize low-density compressible soils. The process may be used to fill voids beneath concrete slabs, or behind walls, or may be used to cutoff water flow through concrete joints. The grout, injected through predrilled injection ports, or "packers", expands under reaction to fill the crack or void. Polyurethane grouts can be single or multi-component grouts and can react when coming in contact with water or require a reactant.

6 APPARATUS

6.1 Provide a wood box constructed of 2" x 4" framing and ¾" thick plywood on the top and bottom as indicated in the detail. The box dimensions will be 48" in length and 48" in width by 3" in depth. Ensure that the bottom seams of the box are sealed with latex caulk so that the box is capable of holding water. Provide an injection tube with ½" diameter steel or copper tubing on the top in the center of the box for injecting HDP material. The plywood on the top of the box will be fixed with 1½" long wood screws. The inside of the box will also contain four 2" x 4" blocks (3½" by 9" by 1½" in dimension) spaced equidistant at 9½" from the injection tube and parallel to the sides of the box.

6.2 Provide a stop watch to keep time.

6.3 Provide axle grease to coat the inside of the box so that the HDP material can be easily removed.

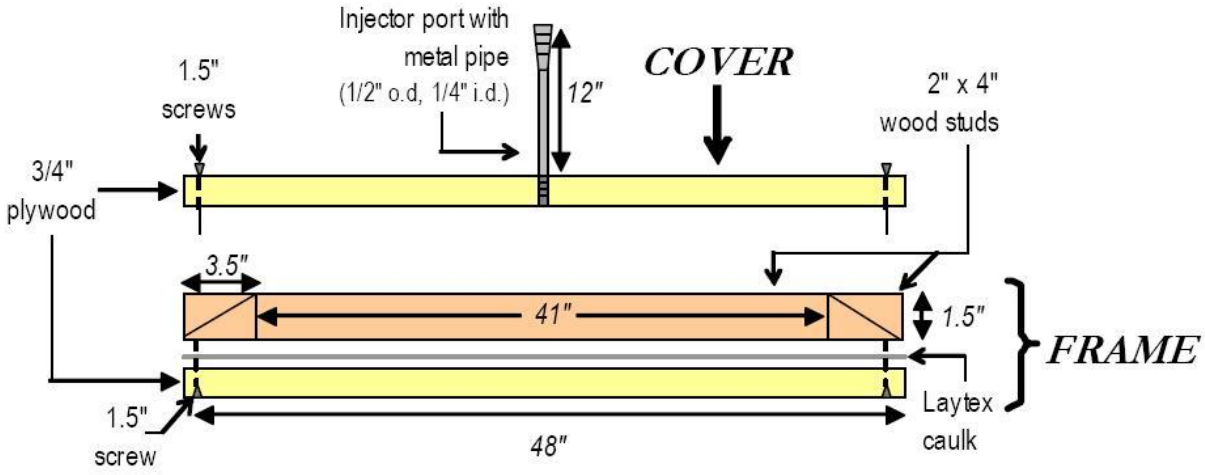

Figure 1 Apparatus - Side View

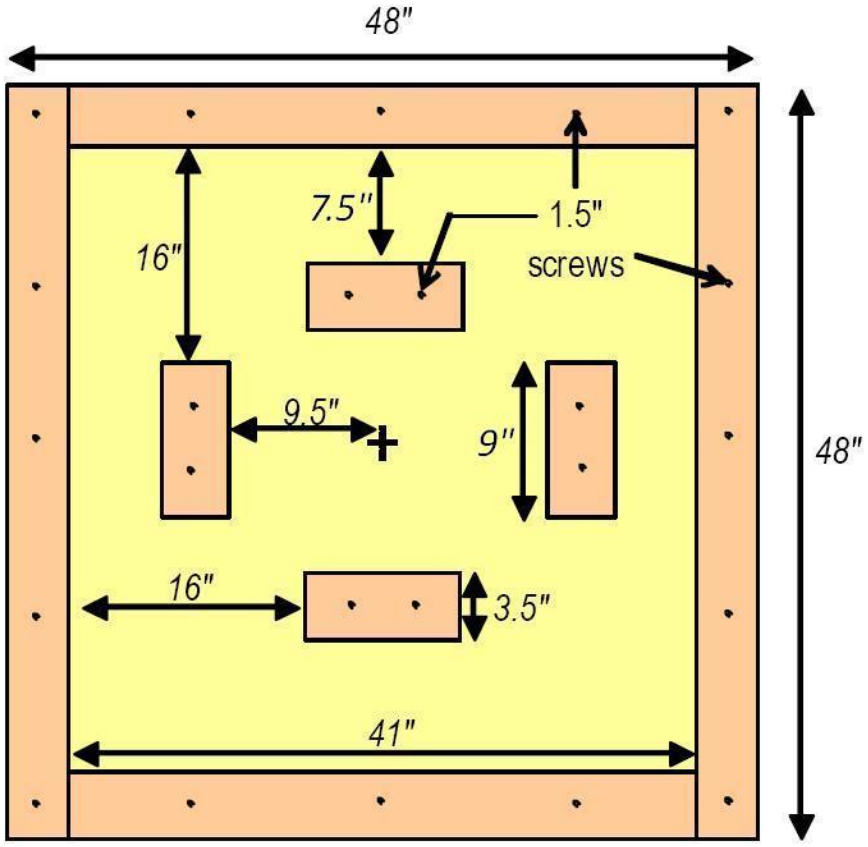

Figure 2 Apparatus – Top View (Frame)

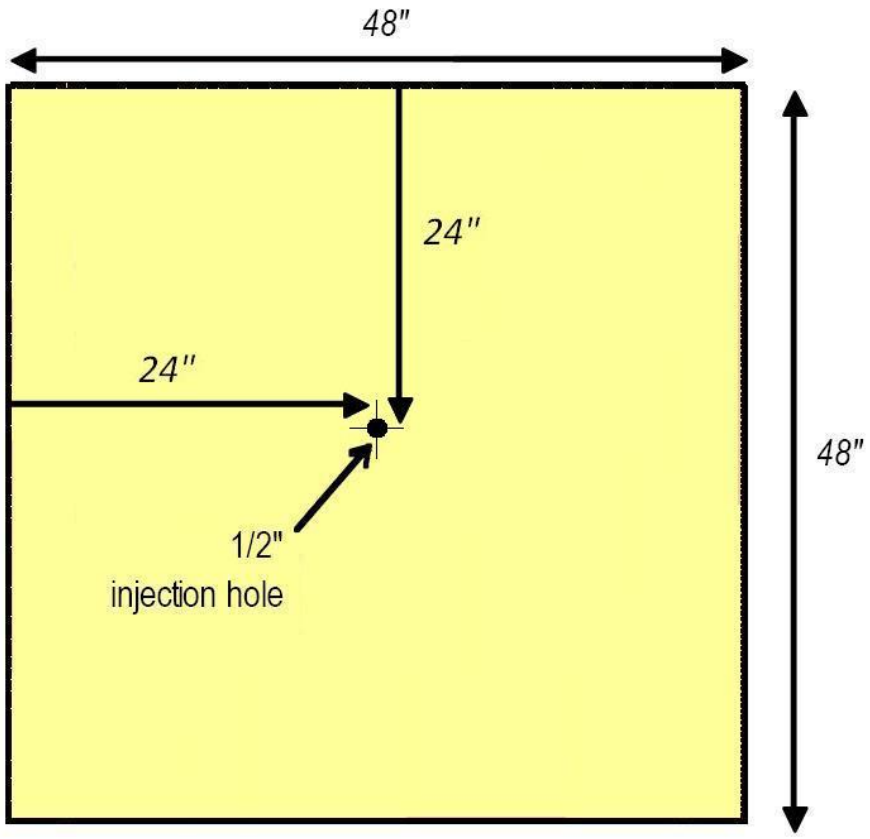

Figure 3 Apparatus – Top View (Cover)

7 PROPORTIONING EQUIPMENT

7.1 Record the type and setting of the metering and proportioning equipment for the HDP material.
7.2 Record the temperature of components A and B, air temperature and water temperature.
7.3 Record the pressure settings for components A and B.

8 PROCEDURE

8.1 Place the box on a flat and level surface.
8.2 Coat the inside surface with a light coating of axle grease so that the HDP material can be easily removed.
8.3 Fix the top cover of the box with 1½" wood screws to provide the necessary confinement for the HDP material.

8.4 Perform a calibration injection of the HDP material and record the time required to inject 5 lbs. of material. Record the time. Weigh the sample to check against the certified flow meter weights to ensure correct calibration.

8.5 Inject the HDP material into the box using 5 lbs. of material. After 10 minutes of completing the injection, remove the top cover off the box. After 30 minutes, sample the HDP material for density (ASTM D1622) and compressive strength (ASTM D1621) testing. Density and compressive strength samples shall be taken from the center portion of the box in the interior of the 2" x 4" blocks.

8.6 Repeat steps 8.2 and 8.3. Add 15 lbs. of water to the box and repeat step 8.5.

Figure 4 Frame Assembly

Figure 5 Sampling Area

Figure 6 Injector

Figure 7 Cover

9 DOCUMENTATION

Report the following:

9.1 Type and settings of the metering and proportioning equipment.
9.2 Temperatures and pressures of components A, B, air and water during test.
9.3 Density and compressive strength results of the HDP in the dry and wet conditions.
9.4 Percent of density: **PASS** or **FAIL**.

APPENDIX

Hydro-Insensitivity of High Density Polyurethane Grout - Panel Test Data Sheet

Polymer Type & Manufacturer _____

Lot # & Date on Component Containers_____

PROPORTIONING EQUIPMENT

Proportioner _____ Hose Length (ft.) _____

Gun _____ Gun Set-up _____

A/B/H Temperature (°F) _____ A/B Pressure (psi) _____

CALIBRATION TEST

_____ Time at Beginning of Injection (HH:MM:SS)

_____ Time at End of Injection (HH:MM:SS)

_____ Sample Weight (lbs.) vs. _____ Certified Flow Meter Weight (lbs.)

INJECTION PROCEDURE – DRY

_____ (✓) 5 lbs. of Material Injected into Box

_____ (✓) After 10 minutes, Remove Top Cover

_____ (✓) After 30 minutes, Sample the HDP Material

INJECTION PROCEDURE - WET

_____ (✓) Add 15 lbs. of Water into Box

_____ (✓) 5 lbs. of Material Injected into Box

_____ (✓) After 10 minutes, Remove Top Cover

_____ (✓) After 30 minutes, Sample the HDP Material

MATERIAL ANALYSIS

	Dry Injection Shots		**Wet Injection Shots**	
	Density (pcf)	Compressive Strength (psi)	Density (pcf)	Compressive Strength (psi)
Sample 1	_____	_____	_____	_____
Sample 2	_____	_____	_____	_____

	% Retention of Density
Sample 1	_____
Sample 2	_____

Technician_____

Date_____