

CITY OF ABILENE**ITEM 268****CHEMICAL TREATED SUBGRADE****268.1 DESCRIPTION.**

This item shall consist of constructing a chemical treated subgrade by pulverization or pressure injection in accordance with the requirements as herein specified and as shown on the plans. This item will be applicable for clay subgrades where the plasticity index is greater than 20 and the soils have a potential for shrinking and swelling with changes in soil moisture content. This item is applicable for new or existing subgrade stabilization and where the existing pavement section is either removed or left in place.

268.2 METHODS OF WORK.

Ion exchange chemical treated subgrade shall consist of one (1) of the following methods of work:

- (1) **Method A – Mixing and Pulverizing.** For new pavement construction or existing pavement reworking where the existing surfacing and base are removed. This work is a mix-in-place treatment using the ion exchange chemical solution.
- (2) **Method B - Chemical Pressure Injection with Hand Injection Equipment.** For new pavement construction where surface area to be treated is small or existing pavement where pavement section is either removed or left in place. This work treats the in place soils by injecting the ion exchange chemical solution into the subgrade soils under pressure on a grid pattern.
- (3) **Method C – Chemical Pressure Injection with Self-Propelled Equipment.** For new pavement construction only, this method treats the in place soils by injecting the ion exchange chemical solution into the subgrade soils under pressure on a grid pattern.

268.3. MATERIALS.

(1) **Ion Exchange Chemical.** The project site shall be stabilized by mixing and pulverizing (mixing in place) or pressure injection using ion exchange chemical EcSS 3000, as produced by American Clay Stabilization, L.L.C., or approved equivalent. To be considered equivalent to EcSS 3000, an ion exchange chemical shall (a) be shown to be able to reduce the swell characteristics of potentially expansive clays by submission of historic documentation of swell tests performed by qualified, independent geotechnical engineering laboratories and (b) be shown to not only reduce the negative charge of the clay particles (by measurement of the Zeta Potential) but to also change the clay structure from an expanding crystalline lattice to a noncrystalline, amorphous structure by removing aluminum and other ions from the clay lattice, breaking up the silica sheets and disconnecting the silica sheets from the alumina sheets, as documented by studies at a major U.S. university or by the research arm of a U.S./State governmental agency.

The undiluted chemical, a mild sulphonic acid, shall have a pH of approximately one (1) and a specific gravity of 1.15 minimum. **The Contractor shall submit manufacturer certificates for each shipment of chemical.**

(2) **Water.** Water used for mixing shall be clean, fresh, potable and free of materials or other substances injurious to the chemical reaction. The water used may be chlorinated, as typically treated for drinking water.

Unless otherwise shown on the Plans, the joint sealant materials to be used shall be self-leveling silicone pavement sealant as manufactured by Dow Corning or approved equal.

(3) Composition. The chemical/water solution shall be proportioned in the ratio of 300 gallons of water to one gallon of ion exchange chemical or as recommended by the manufacturer and shown on the plans. For **Method A** (mixing and pulverizing) or **Method B** (hand equipment injection) work, first fill the water truck or mixing tank half full with water and add the appropriate amount of ion exchange chemical. Then fill the remainder of the water truck or mixing tank with water. For **Method C** (self-propelled equipment injection) work, the ion exchange chemical is pumped directly from the storage tank on the rig into the water downstream of the water pump at the required dilution rate. The Engineer, or his representative, shall be present at the time of mixing the ion exchange chemical with water. The ion exchange chemical/water solution shall be applied in a manner to ensure uniformity of mixture. Composition shall be consistent at the mixing location and application location.

Only the amount of ion exchange chemical solution that can be applied, and mixed in place as appropriate, that working day should be mixed in the water truck or mixing tank. The diluted ion exchange chemical solution shall not be stored in the water truck or mixing tank overnight.

(4) Product Delivery. The undiluted ion exchange chemical shall be delivered to the job site in sealed containers. The Contractor shall provide a certificate from the manufacturer on each shipment of ion exchange chemical certifying that the chemical is indeed as specified.

(5) Material Handling and Storage. The ion exchange chemical may be stored on site in sealed containers placed in a bermed area or other location with secondary containment, as approved by the Engineer. The containers shall be covered for protection. When needed, the sealed containers may be moved to the construction area for use. A metered pump shall be used when transferring the ion exchange chemical from the sealed containers to a water truck, mixing tank or storage tank of the injection rig.

268.4. EQUIPMENT.

(1) General. Equipment shall be suitable for the intended work. The following equipment is necessary for this item for new construction (**Method A, B or C**) or where an existing pavement section is removed (**Method B**):

- (a) Motor Grader with Scarifier.
- (b) 5,000-Gallon Water Truck.
- (c) Mixer/Pulverizer (Optional for Method A).
- (d) Sheepsfoot or Other Kneading Compactor with at Least 12 Tons Compactive Effort.
- (e) Disc (Optional for Method A).
- (f) Pneumatic Roller.

(2) Injection Equipment. The following equipment is necessary for this item for new construction (**Method C**) or if the new construction area is small where the existing pavement section is either removed or left in place (**Method B**):

- (a) **Hand Held Injection Equipment (Method B).**

- (i) **General.** Injection equipment shall be hand-held injection rods constructed to provide straight pipe injection under pressure to the stated treatment depth. Injection equipment shall be equipped with the means for monitoring and controlling the amount of chemical injected.
 - (ii) **Injection Rod System.** The injection rod system shall consist of hand-held injection rods, each capable of being forced into the soil with minimum lateral movement to prevent excessive blowbacks and loss of chemical around the injection rods. The injection rods inject chemical/water solution at the bottom of the rod.
 - (iii) **Pump Unit.** The injection rig pump unit shall have pumps installed, one for each injection rod, and shall be capable of injecting at least 5½ gallons/minute of the chemical/water solution at 500 to 1500 pounds per square inch constant pressure. Water is pumped into two holding tanks on the injection pump unit where the undiluted chemical is then mixed into the two holding tanks. The chemical/water solution is then pumped to each hand-held injection rod.
- (b) **Self-Propelled Injection Equipment (Method C).**

- (i) **General.** Injection equipment shall be self-propelled and constructed to provide straight pipe injection under pressure to the stated treatment depth. Injection equipment shall be equipped with a flow meter, pressure meter and control valve for monitoring and controlling the amount of chemical injected.
- (ii) **Injection Vehicle.** The injection shall be self-propelled with up to six (6) injection rods and be capable of penetrating into hard clays with minimum lateral movement to prevent excessive blowbacks and loss of chemical around the injection rods. The injection vehicle shall have a minimum weight of 10 tons to allow for penetration and treatment of hard clays.

The lower portion of the injection rods shall be of a hardened material that will allow maximum depth of penetration. The hole pattern shall allow for a 360-degree dispersion near the end of the rod, but not on the end of the rod, which would tend to jet a deeper path for the injection rod.

- (iii) **Pump Unit.** The injection rig pump unit shall be equipped with turbo-pumps (centrifugal pumps) capable of injecting at least 7,500 gallons/hour of the chemical/water solution at a constant pressure of 200 to 250 pounds per square inch. Water may be pumped directly from a nearby fire hydrant, frac tank or water truck. The undiluted chemical is stored in a tank, with secondary containment, on the pump unit. The chemical is injected into the water downstream of the water pump to the injection vehicle.

268.5. CONSTRUCTION METHODS.

- (1) **General.** The work shall be performed to the width and depth shown on the typical sections. The treatment shall be performed to a minimum of one-foot outside the road lines, or as shown on the plans. If the soil moisture content of the soil to be treated changes dramatically from the specified range (Subarticle 268.5(4)(a)(iii)), adjustments to the composition of the chemical/water solution may be adjusted by the Contractor based on the field conditions as approved by the Engineer.
- (2) **Workmanship.** The Contractor shall submit to the Engineer evidence that workmen are competent in the specified construction methods. The Contractor shall ensure the competent, experienced personnel will carry out all operations specified. A chemical application specialist shall control the composition, mixing and application of the chemical as approved by the Engineer.

- (3) **Subgrade Preparation.** Prior to ion exchange chemical treatment of the existing soils and/or new soils, the subgrade shall be constructed and shaped to conform to the typical sections, as shown on the plans or as established by the Engineer. This work shall be done in accordance with the provisions of applicable bid items. When shown on the plans, existing Asphaltic concrete, base material or Portland cement concrete that is removed will be paid for in accordance with the applicable bid Item.

When shown on the plans and when directed by the Engineer, the Contractor shall then proof roll the roadbed in accordance with Item 216, "Rolling (Proof)". Soft spots identified shall be corrected as directed by the Engineer.

- (4) **Subgrade Treatment with the Ion Exchange Chemical.** After subgrade preparation has been completed, treatment with the ion exchange chemical shall be as follows:

(a) **Method A – Treatment by Mixing and Pulverizing.**

- (i) **Scarification.** After subgrade preparation, the existing subgrade shall be pulverized its full width not to exceed twelve (12) inches, unless otherwise shown on the plans. For treatment depths of greater than twelve (12) inches, the treatment may be performed in multiple lifts, where each lift is no greater than twelve (12) inches.

When the Contractor uses a disc and/or pulverizing machine that will process the material to a plan depth, the Contractor will not be required to excavate to the secondary grade or windrow the material. This method will only be permitted if a machine is provided that will ensure that the material is cut uniformly to the proper depth and that will plane the secondary grade to a uniform surface over the entire width of the cut. The machine shall provide a visible indication of the depth of cut at all times.

If the Contractor's equipment will not meet the plan depth, then he shall be allowed to windrow in order to expose the secondary base or subgrade for proper disking and/or pulverization.

- (ii) **Pulverization.** After application of the ion exchange chemical solution, the subgrade shall be pulverized so that in a thirty-seven (37) pound sample a minimum of ninety (90) percent shall pass the one and one-half (1½) inch sieve.

- (iii) **Moisture Tolerances.** Unless otherwise approved by the Engineer, prior to scarifying and/or pulverization, soil moisture content may not be less than minus (-) four (4) percent below optimum moisture as determined by Test Method TEX-113-E and not greater than plus (+) six (6) percent above optimum moisture, as measured by Test Method TEX-103-E. For soil moisture contents outside of this range, the composition of the ion exchange chemical solution may be adjusted as described in Subarticle 268(1). After application of the ion exchange chemical solution, the Contractor shall be required to keep the treated material at or above optimum moisture until covered by the next course or pavement layer.

- (iv) **Ion Exchange Chemical Application.** The ion exchange chemical/water solution shall be pumped from the water truck at a rate of one gallon of undiluted ion exchange chemical (301 gallons of diluted solution) for each 600 cubic feet of subgrade, i.e., 1200 square feet of surface area for each 600 cubic feet of subgrade, i.e., 1200 square feet of surface area for each 6-inch thick lift, unless otherwise directed by the chemical application specialist. Based on moisture conditions, the chemical application specialist may adjust the 300:1 dilution rate by varying the amount of water, but the quantity of undiluted ion exchange chemical used to treat a specific volume of soil shall not vary from a minimum of one gallon for every 600 cubic feet of soil. Should the plans require

the subgrade to be worked at a depth greater than twelve (12) inches, the Contractor shall be required to work the subgrade material in multiple lifts, not to exceed twelve (12) inches per lift unless otherwise approved by the Engineer.

The Contractor shall take precautions as necessary when application occurs on unlevel or sloping terrain so as to avoid excessive runoff of the ion exchange chemical solution down slopes or through the channelization of the soil from the equipment of the soil from the equipment.

- (v) **Application.** The ion exchange chemical solution shall be spread only on that area where mixing operation can be completed during the same working day. The ion exchange chemical/water solution is applied as follows:
 - (*) **Mixer/Pulverizer.** The water truck with the chemical/water solution shall proceed alongside or ahead of the mixer/pulverizer to pump the solution to the mixer/pulverizer's additive system. As an alternate, a rear-mounted sprayer can be used to apply the chemical/water solution ahead of the mixer, provided the mixer is close enough to mitigate the potential for ion exchange chemical solution runoff. The ion exchange chemical solution shall be applied to and mixed into the soil uniformly.
 - (**) **Motor Grader.** Spray the ion exchange chemical solution from the water truck onto the mixed soils, with multiple applications. The rate of spraying shall be adjusted so as not to form puddles of ion exchange chemical/water solution. Between spraying, multiple passes with the motor grader, using the windrow method, shall be performed to thoroughly mix the soils. The chemical/water solution shall be applied evenly to the soil. The mixing shall be performed in such a time and manner to mitigate the potential for runoff. No more than one half of the width of the road should be sprayed at one time.
- (vi) **Mixing.** The subgrade material and ion exchange chemical solution shall be thoroughly mixed by equipment approved by the Engineer. The mixing shall continue until the treated material reaches a homogeneous mixture. The soil surface shall be sealed by the end of the workday.

Natural weather conditions that increase the moisture content of the treated material beyond the acceptable allowances as described in Subarticle 268.5(4)(a)(iii), and prior to full and complete compaction will require watering as described in Item 204 "Sprinkling". Prior to compacting the treated material, the moisture content of the material shall meet acceptable limits as described in Subarticle 268.5(4)(a)(iii).

- (vii) **Compaction Methods.** The treated soil shall be compacted by "Density Control" and may begin when the mixing is complete and accepted by the Engineer, as described in Subarticle 268.5(4)(a)(vi). Throughout this entire operation, the shape of the course shall be maintained by blading and the surface upon completion shall be smooth and in conformity with the typical sections, lines and grades as shown on the plans or as established by the Engineer. Unless otherwise shown on the plans, the material shall be compacted uniformly to the extent necessary to provide not less than 95 percent compaction. Roadway density testing will be as outlined in Test Method Tex-115-E. During this operation, the Contractor is required to follow the moisture tolerances in Subarticle 268.5(4)(a)(iii).

(b) Method B – Treatment by Pressure Injection Using Hand Equipment.

- (i) General.** For the case where existing pavement will remain in place, small holes, three-fourths (3/4) inch in diameter, are drilled through the existing pavement system. The injection rods are placed into the drilled hole or directly onto the prepared subgrade and the underlying clay soils are injected to the specified depth. The chemical application specialist employed by or subcontracted with the Contractor based on the field conditions and approved by the Engineer shall determine injection pressure, spacing, and adjustments to the composition of the solution based on soil moisture conditions.

For the case of injection through an existing in place pavement, the holes drilled through the existing pavement section shall be filled with a non-shrink grout after injection has been completed.

For the case of new construction or where the existing pavement section has been removed to expose the subgrade for treatment, the ion exchange chemical solution shall be injected and allowed to cure a minimum of 72-hours before the subgrade is compacted, finished graded and tested as described in Subarticle 268.5(4)(a)(vii).

- (ii) Injection Pressure.** The injection pressure shall be adjusted to inject the ion exchange chemical solution from the pump unit to the injection rods, within the constant pressure range of 500 to 1500 pounds per square inch. Pressures and solution flow shall be adjusted, based on field conditions, to provide for proper penetration into the soil.

- (iii) Injection Spacing.** A maximum spacing of three (3) feet between each rod shall generally be used for the injection operation. Injections shall be made in a grid pattern, where the grid spacing is equal in all directions. The injection point of each row shall be offset half the spacing distance between adjacent rows.

- (iv) Injection Depth.** The injection depth shall be as specified on the plans, but in no case less than two (2) feet below the finished subgrade elevation. The rods shall be forced downward and the chemical solution injected at maximum twelve (12) inch vertical intervals down to the total injection depth. Injection refusal shall determine the completion of injection at each depth and injection location. Injection refusal is considered the onset of ion exchange chemical solution flowing up to the ground surface or through previous injection holes.

- (v) Inclement Weather Conditions.** Injection can be performed during inclement weather, but the surface of the compacted fill or natural soils must be able to support the weight of the injection equipment. The treated surface shall be rolled and sealed after injection is completed each day during inclement weather, if applicable.

Scarification and recompaction of the treated surface shall not be performed if the moisture content of the soil will exceed those specified in Subarticle 268.5(4)(a)(iii).

Side drains shall be installed to collect excess moisture, as necessary.

The dilution rate of the ion exchange chemical solution may be adjusted by the chemical application specialist during or after inclement weather or for high soil moisture content conditions, but the quantity of undiluted ion exchange chemical for the specified volume of soil to be treated shall not change from the original specification.

(c) **Method C – Treatment by Pressure Injection Using Self-Propelled Equipment.**

- (i) **General.** The row of injection rods is placed directly onto the prepared subgrade and the underlying clay soils are injected with the ion exchange chemical solution to the specified depth. The chemical application specialist employed by or subcontracted with the Contractor based on the field conditions and approved by the Engineer shall determine injection pressure, spacing, and adjustments to the composition of the ion exchange chemical solution based on soil moisture conditions.

After injection has been completed and a minimum 72-hour curing period has elapsed, the surface of the treated subgrade shall be compacted, fine-graded, and tested as described in Subarticle 268.5(4)(a)(vii).

- (ii) **Injection Pressure.** The injection pressure shall be adjusted to inject the ion exchange chemical solution from the pump unit to the injection rods, depending upon the site conditions, within the constant pressure range of 125 to 250 pounds per square inch. Pressures and ion exchange chemical solution flow shall be adjusted based on field conditions to provide for solution penetration into the soil and soil fractures.

- (iii) **Injection Spacing.** Injection rods, with a maximum spacing of three (3) feet between each rod, shall be used for the injection operation at each injection vehicle. Injections shall be made in a grid pattern, where the grid spacing is equal in all directions. Therefore, after injection is completed at a single row of up to six (6) injection points, the injection vehicle shall move forward a maximum of three (3) feet for injection of the next row.

- (iv) **Injection Depth.** The injection depth shall be as specified on the plans but in no case less than two (2) feet below the finished subgrade elevation. The rods shall be forced downward and the chemical solution shall be injected at maximum twelve (12) inch vertical intervals down to the total injection depth. Injection refusal shall determine the completion of injection at each depth and location. Injection refusal is considered to be the onset of chemical solution flowing up to the ground surface or through previous injection holes. The injection jets shall be turned off when the injection vehicle is moving to the next injection row, to minimize ion exchange chemical solution runoff.

- (v) **Inclement Weather Conditions.** Injection can be performed during inclement weather, but the surface of the compacted fill or natural soils must be able to support the weight of the injection equipment. The treated surface shall be rolled and sealed after injection is completed each day during inclement weather, if applicable.

Scarification and recompaction of the treated surface shall not be performed if the moisture content of the soil will exceed those specified in Subarticle 268.5(4)(a)(iii).

Side drains shall be installed to collect excess moisture, as necessary.

The dilution rate of the ion exchange chemical solution may be adjusted by the chemical application specialist during or after inclement weather or for high soil moisture content conditions, but the quantity of undiluted ion exchange chemical for the specified volume of soil to be treated shall not change from the original specification.

- (5) **Finishing and Curing.** All placing, compacting and finishing operations shall be completed within the guidelines of Section 268.5 “Construction Methods”. After the treated material is compacted, the surface shall be finished to grade by blading and shall be smoothed with an approved pneumatic or other suitable roller as approved by the Engineer. After smoothing by the roller, the treated subgrade is ready for further pavement construction.

- (6) **Reworking a Section.** After application of the ion exchange chemical solution and mixing operations have been completed, the Contractor may rework an area within the 72-hour curing period with the approval of the Engineer. The Contractor shall follow and maintain the moisture tolerances as outlined in Subarticle 268.5(4)(a)(iii). Water, as described in Subarticle 268.3(2), can be used if additional moisture is required. Upon completion of the rework and approval of the Engineer, the Contractor shall follow guidelines in Subarticle 268.5(4)(a)(vii) and 268.5(5). Rework of treated materials shall be at the expense of the Contractor.

268.6. JOB CONTROL AND TOLERANCES.

- (1) **Application Control.** Both methods of treatment (mixing/pulverizing and pressure injection) shall be at the rates described in these specifications and/or as shown on the plans. The ion exchange chemical composition may be adjusted as described in Subarticle 268.5(1).
- (2) **Density Control.** The ion exchange chemical solution applied to a subgrade material for stabilization shall follow the standard density control as specified in the plans or as directed by the Engineer. Density control shall apply full depth for the mixing and pulverizing work (**Method A**) and, as a minimum, the top 8 inches for the pressure injection work (**Methods B and C**), except for the case where injection is performed through existing in place pavement. Each layer shall be compacted uniformly to the extent necessary to provide not less than 95 percent of the optimum density as determined by Test Method 113-E. Field density determination will be made in accordance with Test Method 115-5.

If the material fails to meet the density requirements or should the material lose the required stability, density or finish before the next course is placed or the project is accepted, it shall be reworked in accordance with Subarticle 268.5(6)

- (3) **Density Tolerances.** The Engineer may accept the work providing that not more than one (1) out of the most recent five (5) consecutive density tests performed is below the specified density and providing that the failing test is no more than three (3) pounds per cubic foot below the specified density.
- (4) **Temperature Tolerances.** Unless otherwise approved by the Engineer, the ion exchange chemical solution treatment (mixing and pulverizing method – **Method A**) shall not be started when the air temperature is below 40 F and falling, but may be started when the temperature is 35 F and rising or stable. The temperature shall be measured in the shade away from artificial heat.

Pressure injection of the ion exchange chemical solution (**Methods B and C**) can be performed as long as the solution can be pumped in accordance with the requirements of Subarticle 268.5(4)(b) and 268.5(4)(c) and the ground to be injected is not frozen.

- (5) **Thickness Tolerances of Treated Subgrade for Mixing and Pulverizing Method (Method A).** At no time during the mixing process shall the Contractor increase or decrease the depth of the treated subgrade section as detailed on the plans without approval of the Engineer. Should any deviation occur, that section shall be reworked as follows:

(a) **Depth is less than plan depth by one (1) inch or more:**

The Contractor, at his expense, shall remix to achieve proper depth as directed by the Engineer, maintaining moisture tolerances as outlined in Subarticle 268.5(4)(a)(iii).

268.7. MEASUREMENT.

Ion Exchange Chemical Treatment will be measured by the square yard of the depth specified to the lines and grades shown on the plans.

This is a plans quantity measurement Item and the quantity to be paid for will be that quantity shown in the proposal and on the "Estimate and Quantity" sheet of the contract plans, except as may be modified by Article 268.8. If no adjustment of quantities is required, additional measurements or calculations will not be required.

268.8. PAYMENT.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for as follows:

"Ion Exchange Chemical Treatment" of the depth specified will be paid for at the unit price bid per square yard. This price shall be full compensation for shaping existing subgrade soils, scarifying, watering, applying ion exchange chemical/water solution, mixing, pulverizing, compacting, fine grading, shaping and maintaining, reworking if required and for all materials, equipment, labor and incidentals required to complete the work as specified.

When proof rolling is shown on the plans or directed by the Engineer, it will be paid in accordance with Item 216, Rolling (Proof).

When subgrade is not constructed under this contract, correction of soft spots in the subgrade will be in accordance with Article 268.3.

When subgrade is constructed under this project, correction of soft spots in the subgrade will be at the Contractor's expense.