



INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

Design Memorandum No. 10-15 Technical Advisory

April 22, 2010

TO: All Design, Operations, and District Personnel, and Consultants

FROM: /s/ Anthony L. Uremovich
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SUBJECT Subgrade-Treatment Types

REVISES: *Indiana Design Manual Section 17-4.02(01)*

EFFECTIVE: September 1, 2010, Letting

The subgrade treatment type I chemical soil modification depth is now 14 in. (350 mm). The other contractor options are unchanged.

The subgrade treatment type IA chemical soil modification depth is now 14 in. (350 mm). The other contractor option is unchanged.

Subgrade treatment type IB has been added. It consists of 14 in. (350 mm) chemical soil modification. Its pay-item code number is 207-09934, pay unit SYS (m2).

Subgrade treatment type IC has been added. It consists of 12 in. (300 mm) of subgrade excavated and replaced with coarse aggregate No. 53. Its pay-item code number is 207-09935, pay unit SYS (m2).

Recurring special provision 207-R-577 should be called for if the project includes at least one pay-item code number with a Standard Specifications reference of 207 or 215. It is attached herewith.

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207-R-577 SUBGRADE AND CHEMICALLY MODIFIED SOILS

(Adopted 04-15-10)

The Standard Specifications are revised as follows:

SECTION 207, BEGIN LINE 9, INSERT AS FOLLOWS:

207.02 Materials

Materials shall be in accordance with the following.

Chemical Modifiers

<i>Cement By-Products</i>	913.05
Fly Ash.....	901.02
Lime	913.04(b)
Portland Cement, Type I.....	901.01(b)

SECTION 207, BEGIN LINE 26, DELETE AS FOLLOWS:

207.03 General Requirements

The subgrade shall be constructed uniformly transversely across the width of the pavement including ~~2 ft (0.6 m) outside the edge of~~ shoulders or curbs unless shown otherwise on the plans, by one of the following methods:

SECTION 207, BEGIN LINE 82, DELETE AND INSERT AS FOLLOWS:

Type I. ~~16 14 in. (400 350 mm)~~ chemical soil modification, 12 in. (300 mm) of the subgrade excavated and replaced with coarse aggregate No. 53, or by 24 in. (600 mm) of soil compacted to density and moisture requirements.

Type IA. ~~16 14 in. (400 350 mm)~~ chemical soil modification or 12 in. (300 mm) of the subgrade excavated and replaced with coarse aggregate No. 53.

Type IB. *14 in. (350 mm) chemical soil modification.*

Type IC. *12 in. (300 mm) of the subgrade excavated and replaced with coarse aggregate No. 53.*

Type II. 8 in. (200 mm) chemical soil modification, 6 in. (150 mm) of the subgrade excavated and replaced with coarse aggregate No. 53, or 12 in. (300 mm) of soil compacted to density and moisture requirements.

Type IIA. 8 in. (200 mm) chemical soil modification or 6 in. (150 mm) of the subgrade excavated and replaced with coarse aggregate No. 53.

SECTION 215, BEGIN LINE 1, DELETE AND INSERT AS FOLLOWS:

SECTION 215 – CHEMICAL MODIFICATION OF SOILS**215.01 Description**

This work shall consist of the modification of soils by uniformly mixing ~~dry~~ portland cement, fly ash, lime, *cement by-product* or a combination of the materials with soil to aid in achieving the workability of soils having excessive moisture content.

MATERIALS

215.02 Materials

Materials shall be in accordance with the following:

<i>Cement By-Products</i>	913.05
Fly Ash.....	901.02
Lime	913.04(b)
Portland Cement, Type I.....	901.01(b)
Water.....	913.01

Soils containing greater than 6% by dry weight calcium, magnesium carbonate or organic material, or having a maximum dry density of less than 95 pcf (1520 kg/m³), or with a soluble sulfate content greater than 1000 ppm will not be permitted in the subgrade. The density shall be determined in accordance with AASHTO T 99, the loss on ignition shall be determined in accordance with AASHTO T 267, and the sulfate content shall be determined in accordance with AASHTO T 289.

CONSTRUCTION REQUIREMENTS

215.03 Testing and Mix Design

The Contractor shall be responsible for all tests required to determine the chemical modifier type and optimum chemical modifier content for modification of the soils. The modifier selection, laboratory testing, and mix design shall be performed by an approved geotechnical consultant in accordance with the Department's Design Procedures for Soil Modification or Stabilization.

The quantities for hydrated lime, quicklime, or portland cement shall be based on $4.0 \pm 0.5\%$ by dry unit weight (mass) of the soils. The quantities for lime *and cement* by-products shall be based on $5.0 \pm 1.0\%$ by dry unit weight (mass) of the soils. The quantities for fly ash class C shall be based on $12.0 \pm 2.0\%$ by dry unit weight (mass) of the soils. Class F fly ash shall not be used except in combination with lime or cement.

If hydrated lime, quick lime, or *portland* cement are used, test results *and the geotechnical consultant* recommendations, ~~and a type A certification for the chemical modifiers, except for cement,~~ shall be submitted to the Engineer prior to use. If fly ash, ~~lime,~~ lime by-products, *cement by-products* or any combination of chemical modifiers are used, *the test results, and the geotechnical consultant* recommendations, ~~and type A certifications for the chemical modifiers~~ shall be submitted to the Engineer and to the ~~Materials and Tests Division~~ *Office of Geotechnical Engineering* for approval at least ~~five~~5 business days prior to use. *If the modifier as bid is not an appropriate chemical modifier for the soils encountered on the project, a cement by-product shall be tested if the cement by-product was not the modifier as bid by the Contractor. If the cement by-product is not appropriate, portland cement shall be used. Portland Cement, fly ash,*

lime and cement by-products if used, shall be from the Department's list of approved ~~Cement~~ Sources.

The quantity of chemical modifier may be adjusted for different soil types. However, the source or type of chemical modifier shall not be changed during the progress of the work without approval. A change in source or type shall require a new mix design.

215.04 Storage and Handling

The chemical modifier shall be stored and handled in accordance with the manufacturer's recommendations.

215.05 Weather Limitations

The chemical soil modification shall be performed when the soil has a minimum temperature of 45°F (7°C), measured 4 in. (100 mm) below the surface, and with the air temperature rising. The chemical modifier shall not be mixed with frozen soils or with soil containing frost.

215.06 Preparation of Soils

The soils shall be prepared in accordance with 207.03. All aggregates which are larger than approximately 3 in. (75 mm) encountered before or after mixing the soils and chemical modifiers shall be removed.

215.07 Spreading of Chemical Modifiers

Where type A-6 or A-7 soils are used or encountered, the surface shall be scarified or disked to the specified depth prior to distribution of the chemical modifier. If a combination of modifiers is used, it shall be mixed mechanically prior to being incorporated. The chemical modifier shall be distributed uniformly by a cyclone, screw-type, or pressure manifold type distributor. The chemical modifier shall not be applied when wind conditions create problems in adjacent areas or create a hazard to traffic on any adjacent roadway. The spreading of the chemical modifier shall be limited to an amount which can be incorporated into the soil within the same work day. If weather causes stoppage of work or exposes the chemical modifier to washing or blowing, additional chemical modifier may be spread when the work resumes.

215.08 Mixing

The chemical modifier, soil, and water when necessary, shall be thoroughly mixed by rotary speed mixers or a disc harrow. The mixing shall continue until a homogenous layer of the required thickness has been obtained. One hundred percent of the material, exclusive of rock particles, shall pass a 1 in. (25 mm) sieve and at least 60% shall pass a No. 4 (4.75 mm) sieve. The mixing depth shall be ~~16~~14 in. (~~400~~350 mm).

215.09 Compaction

The moisture content of the mixture shall be at the optimum moisture content or above the optimum moisture content as determined by the mix design in accordance with 215.03. Moisture content will be determined in accordance with ITM 506. Aeration or drying by further mixing, or the addition of water and further mixing, may be done to obtain the required moisture content.

Compaction of the mixture shall begin as soon as practicable after mixing. Compaction after mixing shall be as follows:

- (a) For *portland* cement modified soils, mixing shall be completed within 30 min of *portland* cement placement and compaction shall be completed within 3 h after mixing.
- (b) Fly ash *or cement by-product* modified soils shall be compacted within 4 h.
- (c) Lime modified soils shall be compacted within 24 h.

Compactive efforts shall be in accordance with 203 or 207.03 as applicable.

~~Maximum dry densities will be determined in accordance with AASHTO T 272 at the same time and location as each in place density test is performed when in place densities do not meet AASHTO T 99. The field in place dry density shall be in accordance with AASHTO T 191 or AASHTO T 310.~~

~~The moisture content of the mixture shall be between the optimum moisture and the optimum moisture plus 2.0%. Aeration or drying by further mixing, or the addition of water and further mixing, may be required to obtain the optimum moisture content.~~

Acceptance testing for compaction of chemically modified soils will be performed on the finished grade with a Dynamic Cone Penetrometer (DCP) in accordance with ASTM D 6951. A 17.6 lbm (8 kg) hammer and disposable cone tip shall be used. The chemically modified soil lift shall meet the following requirements for compaction:

- (a) A minimum DCP blow count of 17 for the top 6 in. (150 mm) of a 14 in. (350 mm) lift*
- (b) A minimum DCP blow count of 16 for the bottom 8 in. (200 mm) of a 14 in. (350 mm) lift*
- (c) A minimum DCP blow count of 20 for an 8 in. (200 mm) lift*
- (d) A minimum of one passing test for each 1500 lft (450 m) of chemically modified soil for each two-lane pavement*

Construction traffic or equipment shall not be on the treated soils within 72 h after compaction.

215. 10 Method of Measurement

The accepted quantity of chemically modified soils will be measured by the square yard (square meter), complete in place. All excavation required to modify the soils below the specified depth will be measured in accordance with 203.27(b).

215. 11 Basis of Payment

The accepted quantity of chemically modified soils will be paid for by the square yard (square meter), complete in place. All excavation required to modify the soils below the specified depth will be paid for in accordance with 203.28.

Adjustment of materials for chemical modification that exceeds the limits of 215.03 will be included in a change order for materials only and paid for as chemical modifier adjustments. If mix design test results show that ~~hydrated lime, quicklime, lime by-products, or fly ash~~ are the chemical modifier as bid by the Contractor is not appropriate and ~~the strength of the modified soil-moisture density compaction~~ can not be achieved, a price adjustment will be made for the use of *a cement by-product or portland cement, whichever is appropriate*. The price adjustment will be calculated at a cost equal to the difference in the invoice cost of the ~~cement~~ *chemical modifier found to be appropriate for use* and the invoice or quoted delivered cost of the ~~hydrated lime~~ *chemical modifier as bid by the Contractor*. This adjustment will be included in a change order and will be paid for as chemical modifier adjustments. Payment for chemical modifier adjustments will be made for direct *delivered* material costs incurred by the Contractor and shall not include any other markups.

Payment will be made under:

Pay Item	Pay Unit Symbol
Chemical Modification, Soils.....	SYS (m2)

The cost of performing the laboratory tests, providing an approved geotechnical consultant, scarification of the subgrade, spreading and mixing of the chemical modifier and soil, compaction of the resultant mixture, shaping the subgrade, work required due to adjustments of modifier proportioning, additional modification required due to weather conditions, correction of deficient areas, water required for the modification process, modified subgrade trimming, and all operations needed to meet the requirements of this specification shall be included in the cost of the pay items of this section.

SECTION 913, BEGIN LINE 33, DELETE AND INSERT AS FOLLOWS:

913.04 Lime

Lime shall be a hydrated lime when used in masonry or a hydrated lime, quicklime, or lime by-product when used for soil modification.

(a) Hydrated Lime for Masonry

Hydrated lime used in masonry shall be in accordance with ASTM C 207, Type N.

(b) Lime for Soil Modification

Hydrated lime, quicklime, or lime by-product used for soil modification shall be approved in accordance with ITM 806, Procedure P and shall meet the following requirements.

1. Hydrated Lime and Quicklime

Hydrated lime and quicklime shall be in accordance with AASHTO M 216.

2. Lime By-Products

Lime by-products shall be hydrated lime or quicklime by-products in accordance with ASTM C 25 having the following requirements.

- a. The lime by-products shall contain a minimum of 60% total available calcium and magnesium oxides (non-volatile basis).
- b. Available calcium hydroxide plus magnesium oxide calculated as calcium hydroxide shall be a minimum of 30%.
- c. Sieve analysis shall be performed in accordance with ASTM C 110. The lime by-products gradation shall be as follows:

Sieve	% Retained (Max)
No. 4 (4.75 mm)	5
No. 30 (600 μ m)	10
No. 100 (150 μ m)	25

913.05 Cement By-Products

Cement by-products used for soil modification shall be approved in accordance with ITM 806, Procedure P and shall meet the following requirements.

- (a) *The cement by-product shall contain a minimum of 50% calcium oxide as reported.*
- (b) *Available free lime (CaO) shall be a minimum of 5%.*
- (c) *Loss on ignition shall be a maximum of 30%.*

Sieve analysis shall be performed in accordance with ASTM C 110. The cement by-products gradation shall be as follows:

Sieve	% Retained (Max)
<i>No.4 (4.75 mm)</i>	<i>5</i>
<i>No. 30 (600 μm)</i>	<i>10</i>
<i>No. 100 (150 μm)</i>	<i>25</i>