1. SCOPE

1.1. Description of Test

This method describes the Portland Cement Association short-cut procedure for determining the minimum cement content requirement for a soil cement using a sandy soil.

1.1.1. Advantage

Using the short-cut procedure, all tests except for the 7 day compressive strength test can be completed in one day. Otherwise, the conventional wet-dry, freeze-thaw soil cement design procedure using the standard 12 cycles takes 43 days to complete.

1.1.2. Disadvantage

The short-cut procedure makes use of relating the grain size of a soil to cement demand and compressive strength. Although the Portland Cement Association claims that using the short-cut soil cement design procedure will result in a cement content requirement that will be adequate as far as compressive strength is concerned. Saskatchewan experience is that the freeze-thaw cement content requirement will exceed it by 0.5 to 1.0 percent. Thus, the short-cut procedure should be deemed as in providing an absolute minimum cement content requirement for a soil cement design in Saskatchewan.

1.1.3. Limitations

The short-cut procedure can only be used with soils containing less than 45 percent of the material retained on the 5 mm sieve and less than 50 percent passing the 50 um sieve and less than 20 percent passing the 5 mm sieve.
1.1.4. Supplemental Information

Soil cement is a mixture of soil and normal portland cement which, when compacted to standard density and optimum moisture content, will meet the Portland Cement Association strength and durability criteria.

In Saskatchewan, the soil selected for cement stabilization is usually a well graded sand or gravel because this material has the lowest cement demand and is therefore the most economical soil cement. The minimum cement content requirement for sandy soils is around 6 percent as compared to probably around 8 percent or more for clayey soils.

2. APPARATUS AND MATERIALS

2.1. Equipment

Sieves - Canadian Metric Standard square mesh sieves of size as required for the type of gradation for the material being tested (5.00 mm, 2.00 mm, 900 µm, 400 µm, 160 µm, 71 µm and 50 µm).

Drying apparatus - suitable pans and stove for drying the sample.

Containers - pans suitable for washing the sample.

Balance - a balance sensitive to 0.1 g.

Standard Proctor mold. A cylindrical metal mold with a nominal internal diameter of 101.6 mm and a height of 116.3 mm. The mold will be fitted with a detachable collar and base plate. The exact volume of the mold without the collar but including a lucite liner is determined by weighing the amount of water required to fill it.

Base Course Standard Proctor mold. A cylindrical metal mold with a nominal internal diameter of 152.4 mm and a height of 116.3 mm. The mold will be fitted with a detachable collar and base plate. The exact volume of the mold without the collar is determined by weighing the amount of water required to fill it.

Hammer. A metal hammer having a 50.8 mm diameter circular face with a 2.5 kilogram weight which will drop freely for a distance of 305 mm.

Compaction base. A cube of concrete weighing not less than 45.0 kg.

Straight-edge. A steel straight-edge approximately 300 mm in length.
Mixing tools - mixing pans, trowel, and a water bottle with sprinkler top and a 500 ml graduated cylinder.

Loading machine. A loading machine with a capacity of at least 53.4 kN (12000 lb) and equipped with a movable head or base that travels at a uniform (not pulsating) rate of 1.27 mm (0.05 inches) per minute (ie. CBR loading rate). The machine shall be equipped with a load indicating device that can be read in 89 N (20 lb) increments or less.

2.2. **Sample To Be Used**

At least a 40 kg representative sample of soil is required to do a soil cement design.

2.3. **Associated Test Procedure**

The Standard Test Procedures associated with this short cut soil cement design procedure are the moisture-density Proctor test (STP 205-5), a grain size or sieve analysis (STP 206-1) and compressive strength test.

3. **PROCEDURE**

3.1. **Preliminary**

Before starting on the short cut test procedure, it is necessary to perform a sieve analysis to determine the gradation of the soil, including the percent passing the 50 µm sieve as per STP 206-1.

If all the soil passes the 5.00 mm sieve, the procedure for fine-grained soils should be used.

If any material is retained on the 5.00 mm sieve, the procedure for coarse-grained soils should be used.

3.2. **Test Procedure for Fine Grained Soil**

Perform a Standard Proctor Moisture Density test (STP 205-5) using a 101.6 mm diameter mold to determine the optimum moisture and maximum dry density.

Determine the percent passing the 50 µm sieve using the sieve analysis result.

Determine the deemed required cement content using Figure 208-7-1.
If the maximum density and percent passing the 50 µm sieve values are such as to result in the deemed required cement content to fall in between two whole numbered percent cement by weight content lines, then the deemed required cement content is taken to the next largest whole number percent cement by weight line.

The percent cement by weight content is defined as follows:

\[
\text{percent cement by weight content} = \frac{\text{weight of dry cement}}{\text{weight of dry soil}} \times 100
\]

If blender material is added to the soil so as to enhance it in a soil cement mixture, then the percent cement by weight content is defined as follows:

\[
\text{percent cement by weight content} = \frac{\text{weight of dry cement}}{\text{weight of dry soil and blender}} \times 100
\]

Weigh out nine 2300 gram samples of dry soil including blender if any is being used. Please note that 2300 grams of dry material is used to prepare each test specimen instead of the normal 2200 grams due to the fact that sandy type soils compact more than clayey type soils and as such, more materials is required. Also, if any blender is used, the weight of the dry soil is reduced equal to the weight of the dry blender material being added to the soil so that the weight of the sample remains unchanged (ie 2300 grams).

Identify the nine 2300 gram samples of dry soil material as sample no. 1 to 9.

Weigh out the three different amounts of normal portland cement in triplicate. The three different amounts are to represent the three different cement contents when added to the 2300 gram soil samples.

The three different cement contents are the deemed required cement content as well as one percent both above and below the deemed required cement content.

The appropriate amounts of cement to be weighed out so as to represent the required cement content when added to the 2300 gram sample of dry soil is defined as follows:

\[
\text{cement content} = \text{Cement content in percent} \times 2300 \text{ grams}
\]

Identify cement samples whose weight represent one percent below the deemed required cement content as sample no. 1 to 3, whose weight represent the deemed required cement content as sample no. 4 to 6 and whose weight represent one percent above the deemed required cement content as sample no. 7 to 9.
Add cement sample no. 1 to the 2300 gram soil sample no. 1 and mix thoroughly.

Repeat the above step for sample no. 2 to 9.

Check the weight of the dry soil cement mixture no. 1 to 9 to ensure that proper amount of cement was added to the right numbered samples. Soil cement mixture sample no. 1 to 3 should weigh the least since the amount of cement added to the 2300 gram soil sample represents one percent below the deemed required cement content, sample no. 4 to 6 should be of medium weight since the amount of cement added to the 2300 gram soil sample represents the deemed required cement content, and sample no. 7 to 9 should weigh the most since the amount of cement added to the 2300 gram soil samples represent one above the deemed required cement content.

Add water to the soil cement mixture sample no. 1 so as to result in the mixture to be at optimum water content.

The appropriate amount of water to be added so as to result in the dry soil cement mixture to be at optimum water content is defined as follows:

\[
\text{Optimum water content of} \quad \frac{\text{Weight of dry soil}}{\text{soil sample from Standard Proctor Test}} = \text{Weight of dry soil cement mixture}
\]

After having added the appropriate amount of water to the dry soil cement mixture, mix thoroughly. When finished, cover the wet soil cement mixture with plastic to prevent water from evaporating.

Repeat the above step for sample no. 2 to 9.

Assemble the Standard Proctor Test mold and insert lucite liner. Place the assembly on the compaction base.

Prepare test specimen no. 1 by taking wet soil cement mixture no. 1 and compact it in a standard Proctor mold in three equal layers to give a total compacted depth of approximately 127 mm.

Compact each layer with 25 blows from the 2.5 kg hammer dropping freely from a height of 305 mm. Distribute the blows uniformly over the surface of the layer being compacted.

Make sure to scarify the top of each layer before proceeding with the next layer. Avoid bouncing the weight off the handle at the top of the stroke when operating the hammer.

After the test specimen has been compacted, remove the collar from the mold and use the straight-edge to trim the compacted soils even with the top.
Remove the mold from the base plate, remove the compacted test specimen and remove the liner.

Weigh the test specimen and record the weight to the nearest gram.

Cover the test specimen with saran wrap and mark as compressive strength test specimen no. 1.

Prepare compressive strength test specimens for wet soil cement mixture for sample no. 2 to 9.

Place compressive strength test specimens in the moist curing room for 7 days. Please note to remove the saran wrap while test specimens are in moist curing room. Care should be taken so as not to lose track of test specimen numbers.

Remove the compressive strength test specimens and place in a compression testing machine.

Apply a load on the test specimens at a rate of strain of 1.27 mm per minute (i.e., CBR rate).

Record load at which each compressive strength test specimen fails.

Determine compressive strength of each test specimen which is defined as follows:

\[ \text{Compressive Strength} = \frac{\text{Load to Failure}}{\text{X-Sectional area of test specimen}} \]

Average the compressive strength of test specimen no. 1 to 3 which represent one percent below required cement content, test specimen no. 4 to 6 which represent the required cement content and test specimens no. 7 to 9 which represent one percent above the required cement content.

Plot the average compressive strength of the test specimens at each of the three different cement contents versus each cement content on a graph with the average compressive strength along the vertical axis and the cement content along the horizontal axis.

Use Figure 208-7-2 to determine the minimum 7 day compressive strength required for soil cement mixture based on the amount of material passing the 50 µm sieve obtained from the sieve analysis.
Determine minimum cement content by plotting minimum 7 day compressive strength required obtained from previous step on compressive strength versus cement content graph.

3.3. **Test Procedure for Coarse Grained Soil**

Perform a Standard Proctor Moisture Density test using a 152.6 mm diameter mold to determine the optimum moisture and maximum dry density of a soil intended for use on a soil cement project.

Determine the percent passing both the 50 and 5 µm sieve using the sieve analysis result done on the soil intended for use on a soil cement project.

Determine the deemed required cement content using Figure 208-7-3.

If the maximum density and percent passing both the 50 and 5 µm sieve values are such as to result in the deemed required cement content to fall in between two whole numbered percent cement by weight content lines, then the deemed required cement content is taken to the next largest whole number percent cement by weight line.

The percent cement by weight content is defined as follows:

\[
\text{Percent cement by weight content} = \frac{\text{weight of dry cement}}{\text{weight of dry soil}} \times 100
\]

If blender material is added to the soil so as to enhance it in a soil cement mixture, then the percent cement by weight content is defined as follows:

\[
\text{Percent cement by weight content} = \frac{\text{weight of dry cement}}{\text{weight of dry soil and blender}} \times 100
\]

Weigh out nine 2300 gram samples of dry soil including blender if any is being used. Please note that if any blender is used, the weight of dry soil is reduced equal to the weight of dry blender material being added to the soil so that the weight of the sample remains unchanged (ie 2300 grams). Also, the soil sample for the test shall contain the same percentage of material retained on the 5.00 mm sieve as the original soil sample. The maximum size material used is 18 mm. Should there be material larger than this in the original soil sample, it should be replaced in the test sample with an equivalent weight of material passing the 18 mm sieve and retained on the 5.00 mm sieve.

Identify the nine 2300 gram samples of dry soil material as sample no. 1 to 9.
Weigh out the three different amounts of normal portland cement in triplicate. The three different amounts are to represent the three different cement contents when added to the 2300 gram soil samples.

The three different cement contents are the deemed required cement content as well as one percent both above and below the deemed required cement content.

The appropriate amounts of cement to be weighed out so as to represent the required cement content when added to the 2300 gram sample of dry soil is defined as follows:

\[
= \text{Cement content in percent} \times 2300 \text{ grams}
\]

Identify cement samples whose weight represent one percent below the deemed required cement content as sample no. 1 to 3, whose weights represent the deemed required cement content as sample no. 4 to 6 and whose weight represent one percent above the deemed required cement content as sample no. 7 to 9.

Add cement sample no. 1 to the 2300 gram soil sample no. 1 and mix thoroughly.

Repeat the above step for sample no. 2 to 9.

Check the weight of the dry soil cement mixture no. 1 to 9 to ensure that proper amount of cement was added to the right numbered samples. Soil cement mixture sample no. 1 to 3 should weigh the least since the amount of cement added to the 2300 gram soil sample represents one percent below the deemed required cement content, sample no. 4 to 6 should be of medium weight since the amount of cement added to the 2300 gram soil sample represents the deemed required cement content, and sample no. 7 to 9 should weigh the most since the amount of cement added to the 2300 gram soil samples represent one above the deemed required cement content.

Add water to the soil cement mixture sample no. 1 so as to result in the mixture to be at optimum water content.

The appropriate amount of water to be added so as to result in the dry soil cement mixture to be at optimum water content is defined as follows:

\[
\text{Optimum water content of soil sample from base course Standard Proctor Test} \times \text{Weight of dry soil cement mixture}
\]
After having added the appropriate amount of water to the dry soil cement mixture, mix thoroughly. When finished, cover the wet soil cement mixture with plastic to prevent water from evaporating.

Repeat the above step for sample no. 2 to 9.

Assemble the Standard Proctor Test mold and insert lucite liner. Place the assembly on the compaction base.

Prepare test specimen no. 1 by taking wet soil cement mixture no. 1 and compact it in a 101.6 mm Proctor mold in three equal layers to give a total compacted depth of approximately 127 mm.

Compact each layer with 25 blows from the hammer dropping freely from a height of 305 mm. Distribute the blows uniformly over the surface of the layer being compacted.

Make sure to scarify the top of each layer before proceeding with the next layer. Avoid bouncing the weight off the handle at the top of the stroke when operating the hammer.

After the test specimen has been compacted, remove the collar from the mold and use the straight-edge to trim the compacted soils even with the top.

Remove the mold from the base plate, remove the compacted test specimen and remove the liner.

Weigh the test specimen and record the weight to the nearest gram.

Cover the test specimen with saran wrap and mark as compressive strength test specimen no. 1.

Prepare compressive strength test specimens for wet soil cement mixture for sample no. 2 to 9.

Place compressive strength test specimens in the moist curing room for 7 days. Please note to remove saran wrap while test specimens are in moist curing room. Care should be taken so as not to lose track of sample numbers.

Remove the compressive strength test specimens and place in a compression testing machine.

Apply a load on the test specimens at a rate of strain of 1.27 mm per minute (ie CBR rate).

Record load at which each compressive strength test specimens fails.
Determine compressive strength of each test specimen which is defined as follows:

\[ \text{Compressive Strength} = \frac{\text{Load to Failure}}{\text{X-Sectional area of test specimen}} \]

Average the compressive strength of test specimen no. 1 to 3 which represent one percent below required cement content, test specimen no. 4 to 6 which represent the required cement content and test specimens no. 7 to 9 which represent one percent above the required cement content.

Plot the average compressive strength of the test specimens at each of the three different cement contents versus each cement content on a graph with the average compressive strength along the vertical axis and the cement content along the horizontal axis.

Use Figure 208-7-4 to determine the minimum 7 day compressive strength required for soil cement mixture based on the amount of material retained on the 5 mm sieve and percent passing the 50 um sieve obtained from the sieve analysis.

Determine minimum cement content by plotting minimum 7 day compressive strength required obtained from previous step on compressive strength versus cement content graph.
Figure 208-7-1: Indicated cement contents of soil-cement mixtures not containing material retained on the 5.00 mm sieve. (From 'Soil cement laboratory handbook', P.C.A., 1971).

Figure 208-7-2: Minimum 7 day compressive strengths required for soil-cement mixtures not containing material retained on the 5.00 mm sieve. (From 'Soil cement laboratory handbook', P.C.A., 1971).
4. ADDITIONAL INFORMATION

4.1. Precautions

A second Standard Proctor Moisture Density Test (STP 205-5) should be run on soil-cement mixture at design cement content to confirm the actual optimum moisture and dry density for the soil cement mixture.

The optimum water content of a soil-cement mixture could be increased by 0.2 percent over that determined by the Standard Proctor Moisture Density Test (STP 205-5) test to compensate for moisture lost to hydrate cement.

4.2. Reference

Indicated cement contents of soil-cement mixtures containing material retained on the No. 4 sieve.

Minimum 7-day compressive strengths required for soil-cement mixtures containing material retained on the No. 4 sieve.
APPROVAL SHEET

New __ Revision __X__ Date of Previous Document __-__
Description of Revision (Reason for Revision):

__Format of test procedure updated.__

Review/Implementation Process:
Reviewed by the Materials Section of the Technical Standards and
Policies Branch.

Other Manuals/Policies Affected:
__Nil__

Follow Up/Training Required:
__Nil__

Comments/Concerns/Implications (Budget/Environment/Stakeholders):

Prepared and Recommended by __D. MacLeod__
Quality Control Engineer Date 92-05-20

Approval Recommended by __R.A. Widger__
Senior Materials Engineer Date 92-12-03

Approval Recommended by __A.R. Gerbrandt__
Dir., Technical Standards & Policies Br. Date 92-12-15

Approved by __D.G. Metz__
Assistant Deputy Minister, Infrastructure Date 92-12-15

Electronic File Updated 93-02-10
Update Mailed __-__