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Design and Construction of Pavements in Cold Regions: State of the Practice

Brad Steven Smith
Brigham Young University - Provo

DESIGN AND CONSTRUCTION OF PAVEMENTS IN COLD REGIONS: STATE OF THE PRACTICE

by

Brad Steven Smith

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of a thesis submitted by

Brad Steven Smith

This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

Date	W. Spencer Guthrie, Chair
Date	Mitsuru Saito
Date	Travis M. Gerber

BRIGHAM YOUNG UNIVERSITY

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____________________ Date	____________________ W. Spencer Guthrie Chair, Graduate Committee

Accepted for the Department

____
E. James Nelson
Graduate Coordinator

Accepted for the College

____
Alan R. Parkinson
Dean, Ira A. Fulton College of Engineering and Technology

ABSTRACT

DESIGN AND CONSTRUCTION OF

PAVEMENTS IN COLD REGIONS:

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Brad Steven Smith

Department of Civil and Environmental Engineering

Master of Science

The effects of frost action introduce many challenges in the design and construction of roadways in cold regions throughout the United States. The penetration of frost into pavement structures can lead to differential frost heave during winter and thaw weakening during spring. Both of these damage mechanisms lead to premature pavement distress, structural deterioration, and poor ride quality. Because the availability of naturally occurring non-frost-susceptible pavement base materials is rapidly diminishing in many areas while project budgets remain largely inadequate, pavement engineers are utilizing alternative materials and techniques to minimize such damage.

The purpose of this research was to investigate and document the state of the practice concerning the design and construction of pavements in cold regions. In

particular, the various methods and standards employed for characterizing materials, improving soils and aggregates, and determining pavement layer thicknesses were explored. A comprehensive literature review was performed, and a questionnaire survey was conducted of various state DOTs throughout the United States that are involved with the design and maintenance of roadways. The study was directed primarily at identifying practices utilized by state DOTs in climates with freezing temperatures.

The information obtained in this research represents a unique compilation of standards of practice that have been developed by DOTs based on years of experience and research in their respective jurisdictions. While this research allows engineers at state DOTs to compare their pavement design and construction practices with those of other states represented in the survey, consulting engineers and engineers in local governments involved in characterizing materials, improving soils and aggregates, and determining pavement layer thicknesses can also benefit from this work.

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CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

The effects of frost action introduce many challenges in the design and construction of roadways in cold regions throughout the United States. The penetration of frost into pavement structures can lead to differential frost heave during winter and thaw weakening during spring. Both of these damage mechanisms lead to premature pavement distress, structural deterioration, and poor ride quality. For example, a pavement designed to last 12 to 15 years under non-frost-susceptible conditions could require major maintenance in just 5 years in an area with frost-susceptible subgrades (*1*). Because the availability of naturally occurring non-frost-susceptible pavement base materials is rapidly diminishing in many areas while project budgets remain largely inadequate, pavement engineers are utilizing alternative materials and techniques to minimize such damage. Although individual state departments of transportation (DOTs) have occasionally published information about specific projects, a document summarizing the pavement design practices of transportation agencies in cold regions has not been previously available.

Therefore, the purpose of this research was to investigate and document the state of the practice concerning the design and construction of pavements in cold regions within the United States. In particular, the various methods and standards employed for characterizing materials, improving soils and aggregates, and determining pavement layer thicknesses were explored. A comprehensive literature review was performed, and a questionnaire survey was conducted of various state DOTs throughout the United States that are involved with the design and maintenance of roadways.

1.2 OUTLINE OF REPORT

Chapter 1 describes the objectives of this research and outlines the report. Methods for determining the frost-susceptibility of soils and aggregates are discussed in Chapter 2, and Chapter 3 describes some of the common techniques used for soil and aggregate improvement. Specific issues pertaining to pavement design for cold regions are discussed in Chapter 4, and the results of the questionnaire survey are presented in Chapter 5. Chapter 6 provides a summary of the research findings.

CHAPTER 2

MATERIALS CHARACTERIZATION

2.1 LABORATORY TEST METHODS

Materials characterizations performed for cold-regions pavement projects usually include assessments of frost susceptibility. If the materials exhibit inadequate resistance to damage under frost action, special design considerations may be required. During the last several decades, more than 100 methods have been developed for determining the frost-susceptibility of a material (*2*, *3*, *4*). While discussion of all of these methods is outside the scope of this report, the existence of such a large number of methods does emphasize the fact that no single method has been generally accepted (*5*). Indeed, very few of the existing soil characterization methods properly consider the effects of moisture supply, mineralogy, structure, density, freezing conditions, surcharge, or other factors that directly impact the behavior of materials subjected to frost action (*6*). Brief descriptions of selected methods that have been developed for specifically evaluating the susceptibility of pavement materials to frost heave, thaw weakening, and freeze-thaw cycling are provided in the following sections.

2.2 FROST HEAVE

Generally, three conditions are required for frost heave to occur: freezing temperatures, frost-susceptible soils, and a water supply (*7*). The assessment of frost-heave susceptibility usually involves subjection of laterally insulated cylindrical test specimens to controlled freezing temperatures on one end while water is made available to the other end. As a frost-susceptible specimen freezes, the matric suction in the frozen zone increases dramatically and causes water to flow toward the freezing front. Upon its arrival in the frozen zone, the water freezes and simultaneously increases 9 percent in volume. When the volume of ice exceeds the available pore space within the material, frost heave occurs. With sustained freezing temperatures and a continuous supply of water, ice lenses form in the soil or aggregate matrix. The vertical displacement of the soil is then approximately equal to the cumulative thickness of the ice lenses (*8, 9*).

While the exact configurations of frost heave tests vary by agency, most test setups are designed with the same basic elements, including a specimen container with lateral insulation to control the direction of frost penetration, a cold plate or freezing chamber for removing heat from the specimen, a water supply, and a method of measuring vertical displacements of the specimen during testing (*10*). Criteria for ranking the frost susceptibility are usually derived from the frost heave rate exhibited by the specimen under a specified set of testing conditions.

For example, Table 2.1 gives the frost heave classifications associated with frost heave rates measured using the United States Army Corps of Engineers (USACE) method (*3*). This test is conducted on cylindrical specimens of 6-in. height and 6-in. diameter and performed in an open system, meaning that free water is always available at the base of the samples. The containers are insulated and slightly tapered on the sides, making the top slightly wider than the base, and the sides are also lubricated to reduce friction. A 0.5-psi surcharge is applied to simulate the pressure of overlying pavement

TABLE 2.1 Frost Susceptibility Classification with Respect to Heave Rate (*3*)

Average Heave Rate, mm/day	Frost Susceptibility Classification
0.0-0.5	Negligible
0.5-1.0	Very Low
1.0-2.0	Low
2.0-4.0	Medium
4.0-8.0	High
Greater than 8.0	Very High

layers, and freezing occurs unidirectionally from the top down at a frost penetration rate of 6.4 in. to 12.7 in. per day. The rate of heave is recorded for classification of the tested material.

In another method of analysis, the segregation potential (SP) is computed for ranking the material. The SP is the ratio of the rate of frost heave to the temperature gradient across the frozen fringe of a tested specimen, where the frozen fringe is defined as the zone between the frost front and the lowest ice lens (*11*). Proposed SP criteria developed for the Canadian Province of Quebec are shown in Table 2.2 (*5*).

TABLE 2.2 Anticipated Heave with Respect to Segregation Potential (*5*)

Segregation Potential, mm^2/°C-day	Anticipated Heave
Less than 100	Low (Less than 30 mm)
Between 100 and 200	Medium (Less than 60 mm)
Greater than 200	High (Greater than 60 mm)

A third set of criteria is based upon the final surface dielectric value measured in the tube suction test (TST). In this procedure, a specimen is subjected to a 10-day capillary soak in the laboratory, and dielectric values are measured daily with a surface probe (*12*, *13*). Soils or aggregates with sufficiently high matric suction and permeability readily imbibe water from the bath and are characterized at the end of the test by elevated moisture contents near the surface that correspond to high dielectric values. On the other hand, materials with comparatively low matric suction and extremely low or high permeability maintain steep moisture gradients during the test and exhibit low dielectric values after the 10-day soak. Table 2.3 presents the TST rating criteria.

TABLE 2.3 Frost Susceptibility Classification with Respect to Dielectric Value (*12*)

Dielectric Value	Frost Susceptibility Classification
Less than 10	Non-Frost-Susceptible
Between 10 and 16	Marginally Frost-Susceptible
Greater than 16	Frost-Susceptible

2.3 THAW WEAKENING

Thaw weakening of frost-susceptible soils generally occurs in the spring when the ground begins to thaw. As the thawing front begins to penetrate the pavement structure, meltwater can become trapped above the still-frozen underlying soil, creating conditions of super-saturation. During loading under traffic, the development of positive pore water pressure reduces the interparticle friction between soil particles and subsequently lowers the effective strength of the soil (*14, 15*). Indeed, field tests performed by the USACE suggest that frost-susceptible base materials can experience a reduction in bearing capacity of 13 to 62 percent during the thaw-weakening period (*16*). Similarly, studies performed in Japan have shown that layer coefficients used in the American Association of State and Highway Officials (AASHTO) pavement design method can decrease 16 to 35 percent during the thaw-weakening period (*8*).

American Society for Testing and Materials (ASTM) D 5918 (Standard Test Methods for Frost Heave and Thaw Weakening Susceptibility of Soils) can be used to determine both the frost-heave and thaw-weakening susceptibility of a soil. In the test, a specimen is placed at the desired density in a cylinder 6 in. in diameter and 6.5 in. in height. A 10.0-lb surcharge is then placed on top of the specimen. After a conditioning period of 24 hours at 37.4ºF, the specimen is subjected to two freeze-thaw cycles. Each cycle consists of freezing the sample for a 24-hour period at specific temperatures for certain amounts of time and then thawing the sample for 24 hours at specific temperatures for certain amounts of time. The temperatures and durations of testing are given in Table 2.4. Between the first and second freeze-thaw cycle, air is purged from the base of the sample. During both cycles, temperature sensors and displacement transducers are monitored to measure both frost penetration and frost heave. After the second freeze-thaw cycle, a California bearing ratio (CBR) test is performed on the specimen. Table 2.5 indicates the tentative frost-susceptibility criteria associated with the test.

Another proposed method for determining the thaw-weakening potential of a soil is estimating the amount of time needed for the soil to drain from 100 to 80 percent saturation (*16*). Under repeated loadings, granular materials have been shown to become unstable when the saturation level is greater than 80 percent (*16*).

TABLE 2.4 Boundary Temperature Conditions (ASTM D 5918)

Day	Elapsed Time, hr	Top Plate Temperature, ºF	Bottom Plate Temperature, ºF	Comments
1	0	37.4	37.4	24-hour conditioning
2	24	26.6	37.4	First 8-hour freeze
	32	10.4	0.0	Freeze to bottom
3	48	53.6	37.4	First thaw
	64	37.4	37.4	
4	72	26.6	37.4	Second 8-hour freeze
	80	10.4	0.0	Freeze to bottom
5	96	53.6	37.4	Second thaw
	112 to 120	37.4	37.4	

TABLE 2.5 Tentative Frost-Susceptibility Criteria* (ASTM D 5918)

Frost-Susceptibility Classification	Symbol	8-hr Heave Rate, mm/day	Bearing Ratio after Thaw, %
Negligible	NFS	<1	>20
Very Low	VL	1 to 2	20 to 15
Low	L	2 to 4	15 to 10
Medium	M	4 to 8	10 to 5
High	H	8 to 16	5 to 2
Very High	VH	>16	<2

* The criteria will be updated with experience. The bearing ratio should be used only as a guide; if the CBR test is used for design, it should be noted that the thaw occurs only for a few weeks per year.

2.4 FREEZE-THAW CYCLING

Freeze-thaw cycling is the repeated freezing and subsequent thawing of a material. Test protocols for assessing durability against freeze-thaw cycling have been most frequently prepared for stabilized materials. One of the most common tests is ASTM D 560 (The Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures). In this test procedure, soil-cement specimens cured for 7 days in a fog room are subjected to 12 freeze-thaw cycles, where each cycle is comprised of 24 hours of freezing followed by 24 hours of thawing. At the conclusion of each thawing period, two firm strokes with a wire brush are made in every location along the length of the sample, and four strokes are made across each end of the specimen. The weight loss of the specimen due to the wire brushing is compared to the criteria given in Table 2.6 or Table 2.7 to determine the durability of the soil-cement mixture (*17*).

Because the brushing action used in this test can be a major source of test variability, the residual compressive strength of specimens used in the freeze-thaw test, but not subjected to brushing, has been proposed as an alternative indicator of soil-

TABLE 2.6 Allowable Weight Loss As Recommended by the Portland Cement Association (PCA) (*18*)

AASHTO	Unified Soil Group	Maximum Allowable Weight Loss, %
A-1-a	GW, GP, GM, SW, SP, SM	14
A-1-b	GM, GP, SM, SP	14
A-2	GM, GC, SM, SC	14*
A-3	SP	14
A-4	CL, ML	10
A-5	ML, MH, CH	10
A-6	CL, CH	7
A-7	OH, MH, CH	7

*10 percent is the maximum allowable weight loss for A-2-6 and A-2-7 soils.
Additional criteria:

1. Maximum volume changes during durability test should be less than 2 percent of the initial volume.
2. Maximum water content during the test should be less than the quantity required to saturate the sample at the time of molding.
3. Compressive strength should increase with age of specimen.
4. The cement content determined as adequate for pavement, using the Portland Cement Association's (PCA) criteria above, will be adequate for soil-cement slope protection that is five feet or more below minimum water elevation. For soil-cement that is higher than that elevation, the cement content should be increased 2 percentage points.

TABLE 2.7 Allowable Weight Loss As Recommended by the United States Army Corps of Engineers (*18*)

Type of Soil Stabilized*	**Maximum Allowable Weight Loss, %**
Granular, Plastic Limit (PI) < 10	11
Granular, PI > 10	8
Silt	8
Clays	6

*Refer to MIL-SDT-619B and MIL-SDT-621A, U.S. Army Corps of Engineers.

cement durability instead of the percent mass loss (*18, 19*). Previous research has shown that the percent mass loss and residual compressive strengths are correlated (*18*), but the approach using strength measurements has not become common practice despite its clear advantages over the brush test.

The vacuum saturation test is another procedure that has been shown to be a good indicator of the freeze-thaw durability of a stabilized soil. In this procedure, cured specimens are placed upright on a perforated table within a vacuum vessel to ensure that all surfaces will be equally exposed to the vacuum pressure. The vessel is then evacuated for 30 minutes to remove the air from the voids in the specimens, after which the vessel is flooded with deionized water to completely submerge the specimens. The vacuum is then removed, and the specimens are allowed to soak for 1 hour at atmospheric pressure. After this soaking period, the specimens are removed from the water, allowed to drain for approximately 2 minutes on a non-absorptive surface, and immediately subjected to unconfined compressive strength (UCS) testing. The moisture contents of the specimens are then determined (20).

Compared with ASTM D 560, the vacuum saturation test is very fast and inexpensive. However, some researchers suggest that vacuum saturation tests should be supplemented with brush tests if the project requires very accurate durability data (*20*).

2.5 SUMMARY

Because the use of frost-susceptible materials in pavement construction projects may require special design considerations, materials testing to assess frost heave, thaw weakening, and freeze-thaw deterioration are often appropriate. While frost heave rates and SP values computed from actual frost heave tests have been used to classify the frost susceptibility of soils and aggregates, the TST has also been used to rank the susceptibility of pavement materials to frost damage. In ASTM D 5918, the thaw-weakening potential of pavement materials is assessed using CBR tests performed following thawing of specimens previously subjected to frost. Although ASTM D 560 is probably the most commonly used test for evaluating the resistance of soil-cement specimens to freeze-thaw cycling, the brushing action required in the test can be a major source of test variability. Some researchers have suggested using a residual compressive strength test instead of percent mass loss under brushing to assess the freeze-thaw durability of soil-cement specimens. The vacuum saturation test has also been suggested as a faster and less expensive method for assessing the resistance of stabilized materials to freeze-thaw damage.

CHAPTER 3

SOIL AND AGGREGATE IMPROVEMENT

3.1 STABILIZATION OF SOILS AND AGGREGATES

As previously stated, the availability of naturally occurring non-frost-susceptible pavement base materials is rapidly diminishing in many areas. The problem of obtaining good quality base materials has led to the practice of stabilizing lower quality materials using either chemical or physical methods (*21*). Stabilization has also been increasingly used in conjunction with pavement recycling techniques designed to utilize existing pavement materials in pavement reconstruction (*22*).

Various chemical or physical additives can be mixed with soils and aggregates to improve their engineering properties. The following sections specifically discuss portland cement, cement kiln dust (CKD), lime, lime kiln dust (LKD), fly ash, lime and fly ash (LFA), blast furnace slag, bituminous materials, calcium chloride, and proprietary products.

3.2 PORTLAND CEMENT

Portland cement can be added to a soil or aggregate to produce soil-cement or a cement-aggregate mixture (23). Soil-cement is defined as a hardened material with certain engineering properties that is produced by blending, compacting, and curing a mixture of soil or aggregate with portland cement, water, and possibly admixtures (*23*).

The types and proportions of soil and cement, mixing quality, compaction quality, curing conditions, and age of the compacted mixture all affect the soil-cement properties (23).

The majority of soils can be stabilized with cement, but granular soils are generally preferred. The only types of materials not suitable for cement stabilization are soils that are organic, highly plastic, poorly reacting sands, or comprised of deleterious compounds such as sulfate (*3, 23*). However, soils that are highly plastic can be pre-treated with hydrated lime or quicklime to decrease the plasticity prior to being stabilized with cement (*23*). ASTM D 4318 (Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils) can be used to determine the suitability of a particular soil for cement stabilization.

Cement stabilization has proven to be a very effective method by which to increase the strength and durability of an otherwise inadequate base material. In some areas where adequate road building materials are difficult to obtain, such as in the state of Louisiana, cement-stabilized bases are used for the majority of non-interstate flexible pavements (*24*). Concerning the performance of cement-treated bases (CTBs) in cold regions, a survey conducted in 1963 of most of the state DOTs indicated that to that date only pavement base layers stabilized with portland cement had been able to survive the spring thaw (*4*).

When properly designed and constructed, CTBs will not usually consolidate, they have a higher resilient modulus than that typical of unbound materials, and they are resistant to frost damage (*10, 16, 23*). Although PCA provides guidelines regarding selection of cement contents for various soil and aggregate types, laboratory testing should be conducted to determine the optimum cement content for a given material. For example, many agencies require a minimum 7-day UCS and satisfactory performance in a specified durability test (*21*). The minimum amount of cement that passes both criteria becomes the design cement content (*17*, *23*).

While minimum 7-day UCS values for CTB layers were previously recommended by the USACE to be 750 psi and 500 psi for use in flexible and rigid pavement systems (*23*), respectively, recent research suggests that reducing target 7-day UCS values to approximately 300 psi will provide improved performance by reducing the occurrence of reflective cracking in flexible pavements (*25, 26, 27*). Seven-day UCS values historically recommended for subbase materials are 250 psi and 200 psi for use in flexible and rigid pavement systems, respectively (23).

Reflective cracking in asphalt pavements comprised of CTB layers is primarily caused by base shrinkage resulting from self-dessication associated with cement hydration and moisture loss due to drying. Therefore, the amount of cement used and the moisture content at the time of construction directly influence the extent and severity of cracking. Other potentially influential factors include aggregate properties, curing procedures, weather, subgrade conditions, and type and time of placement of the final surfacing (*25*). The reflective cracking may not initially present a structural problem, but with time the combined effects of moisture and trafficking can lead to premature failure of the pavement (*28*).

In addition to reducing the design cement content, other methods can also be used to minimize the occurrence of reflective cracking in asphalt layers constructed on CTB layers. For example, passing a vibratory roller over a cement-stabilized layer within 24 to 72 hours after placement creates hairline microcracks in the layer that have been shown in field studies to significantly reduce the amount of reflective cracking (*25, 27*). Delaying placement of the pavement surfacing for as long as possible has also been suggested as a method to reduce the appearance of reflective cracking (*25*). However, others have recommended that the cement-stabilized base course layer be overlaid with asphalt as early as practical, not less than 3 days or more than 7 days following compaction of the CTB material (*27*). Another recommendation is to place a 4-in. crushed stone layer between the asphalt surface layer and the CTB layer to serve as a crack arrestor (*24*). One study indicates that a CTB with 7 percent portland cement by weight, in addition to 25 percent Class F fly ash and 10 percent expansive additive by weight of the total cementitious material, significantly reduced the amount of shrinkage. The study also indicated that the CTB with both fly ash and the expansive additive performed similarly to typical CTB in freeze-thaw resistance tests (*29*).

If trafficking is permitted on a newly constructed CTB before the layer has had sufficient time to cure, permanent deformation, marring, or other damage can occur. For this reason, most agencies require a curing period of between 3 and 7 days before truck trafficking is allowed, although light, local traffic is frequently allowed to travel on the soil-cement layer immediately after construction (23, *30*).

3.3 CEMENT KILN DUST

CKD has also been used as a soil and aggregate stabilizer. CKD is a waste product associated with the manufacture of portland cement and is generally discarded in landfills. Using this material for soil improvement is therefore not only cost effective, but also environmentally friendly (*31*). Soils such as silts and silty clays, which have comparatively low plasticity indices (PIs), are most suitable for treatment with CKD (*31*). The addition of CKD to a soil with a high PI, such as a plastic clay, can achieve significant benefit by lowering the PI of the particular soil (*31*). Like cement, CKD can be used to increase the UCS of a soil or aggregate. However, studies have shown that the strength of a CKD-stabilized material subjected to wetting, freezing, and thawing appears to decrease substantially so that it assumes values close to or lower than those of the untreated material subjected to the same wetting, freezing, and thawing (*32*).

3.4 LIME

Lime, or calcium hydroxide in its hydrated form, has proven to be a very effective stabilizer for improving fine-grained soils. The improvement can be linked to the reduction in PI that occurs in clayey materials and the increase in strength that results from the ensuing pozzolanic reaction. Soils to be stabilized with lime should have at least 25 percent passing the No. 200 sieve, a PI of at least 10, less than 1 percent organics by dry weight of soil, and less then 0.3 percent soluble sulfates by dry weight of soil (*33*). Typically, the best types of materials for lime stabilization are clays (*3*). When added to reactive soils, lime reduces the PI, improves workability, increases water repellency, increases shear strength, reduces compressibility, reduces shrink-swell potential, and increases resistance to abrasion and erosion (*3, 34, 35*). Even when added to non-reactive soils, lime reduces the PI, improves workability, and reduces shrink-swell potential, although relatively insignificant increases in strength are achieved. Furthermore, like cement treatment, the effects of lime treatment become more pronounced with longer curing periods.

After the addition of a minimum amount of lime to a frost-susceptible soil, increasing quantities of lime usually correspond to further reductions in frost heave exhibited by the treated soil (*36*). For example, previous research has shown that treatment of a frost-susceptible soil with 6 percent lime significantly reduced frost heave compared to the untreated condition (*34*). However, when only 2 percent lime was added, increases in both frost heave and permeability occurred. In this case, the lime treatment effected a coarsening of the pore structure and the opening of capillary channels through particle flocculation, but insufficient lime was available for production of cementitious products that would otherwise fill the voids (*34*).

The design lime content should be determined following ASTM D 6276 (Standard Test Method for Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization). Specimens are cured for 7 days and then subjected to capillary soaking for 24 to 48 hours before the strength or stiffness is measured. For most designs, the UCS test described in ASTM D 5102 (Standard Test Method for Unconfined Compressive Strength of Compacted Soil-Lime) can be used (*33*), but for pavements that will receive high traffic volumes, AASHTO T 294 (Resilient Modulus Testing of Unbound Granular Base/Subbase Materials and Subgrade Soils) or the Rapid Triaxial Test (RaTT) should be used to determine the resilient modulus of the lime-treated soil (*33*).

If soluble sulfates become available to react with the calcium in the lime and alumina in the soil, ettringite, an expansive calcium-aluminate-sulfate-hydrate compound, can form in the soil. The amount of ettringite that forms typically depends on the availability of soluble sulfate, which can either be a constituent of the soil or an ion in the groundwater. Nonetheless, ettringite formation can cause the soil system to expand many times greater than its original volume and therefore generate significant upward heaving pressures potentially leading to severe pavement damage (*37*, *38*).

3.5 LIME KILN DUST

LKD, a by-product of lime, can also be used to improve the engineering properties of a soil (*39*). A comparison performed between soils stabilized with 5 percent lime and 5 percent LKD indicates that both lime and LKD improve the UCS and increase the CBR value of the soil. The results of the comparison indicate that LKD could potentially be used as an alternative to lime (*39*).

3.6 FLY ASH

Fly ash can be used by itself or with lime to achieve stabilization of a soil or aggregate. Fly ash is a cementitious, inorganic, non-combustible residue of powdered coal and is a by-product of the power industry. Depending on the composition of the inorganic fractions, fly ash can be classified as either Class F or Class C. Fly ash that is produced from bituminous and subbituminous coals found east of the Mississippi River is Class F, while Class C fly ash is produced from lignite coals located mainly in the western states (*40*). In 2002, 76.5 tons of fly ash were produced in the United States (*41*).

A laboratory investigation showed that the resilient modulus of a material treated with 10 percent Class C fly ash and cured for 28 days increased with wet-dry cycling up to 12 cycles, after which the modulus began to decrease. Each wet-dry cycle consisted of immersing the specimen in a water bath for 5 hours and then oven-drying it at 160°F for

24 hours (*42*). Similar wet-dry cycling of specimens initially cured for 3 days led to a 55 percent increase in resilient modulus after 30 cycles, suggesting that the wet-dry cycling must not have markedly interrupted the curing process (*42*).

A study performed on fly-ash-stabilized subgrades indicates that stabilization of subgrades with Class C fly ash yields comparatively quick increases in the strength and stiffness of a pavement section. After a 28-day curing period, the fly-ash-stabilized soils exhibited strengths on the order of 100 to 300 percent greater than those of the untreated soil (*43*). The same study showed that the use of Class C fly ash can reduce both the PI and the swell potential of some plastic soils. In a 9-year research study on roadways constructed with and without stabilization, the subgrade soils stabilized with Class C fly ash had not experienced a decline in performance and were generally significantly stronger than the unstabilized subgrade soils (*43*).

Mixing Class C fly ash with reclaimed asphalt pavement (RAP) to produce a stabilized base has been shown to be an economical method of recycling pavements compared to the use of new base material. The strength derived from the addition of fly ash to the RAP is reflected by its AASHTO layer coefficient of 0.16 compared to values of 0.11, 0.13, and 0.14 for an untreated recycled base, emulsion-treated recycled pavement, and traditional base course, respectively (*44*, *45*). Class C fly ash mixed with RAP has also been shown to continue to gain strength with time, most notably during the first year after construction (*44*, *45*).

3.7 LIME AND FLY ASH

LFA can be both economical and effective for pavement base material stablization, although some instances have been noted where severe service conditions caused deterioration of these materials with time (*46*). The requirements for an LFA mixture design are given in ASTM C 593 (Standard Test Specification for Fly Ash and Other Pozzolans for Use with Lime), which requires among other properties a minimum UCS of 600 psi after 7 days of curing at 130°F. For stabilization of well-graded aggregates, a normal mixture generally consists of 12 to 16 percent of LFA by dry weight of aggregate. The suggestion has also been made to use a ratio of LFA to total fines of 1:4 to 1:7 by mass in LFA mixture designs, where fines are defined as the fraction of aggregate materials passing the No. 4 sieve (*46*).

A long-term performance study of LFA-stabilized base course in Mississippi indicates that an AASHTO layer coefficient of 0.20 is appropriate when the material is compacted to 100 percent of the standard Proctor density and the in-situ UCS is at least 400 psi (*47*). The study further recommends that the thickness of a typical LFA-stabilized base layer be increased from 6 in. to 8 in. in Mississippi (*47*).

3.8 BLAST FURNACE SLAG

Blast furnace slag, a by-product of either the production of ore or the refinement of pure metals (*40*), can be used to stabilize soils through pozzolanic reactions. Although limited information is available on the performance of slag as a stabilizing agent, one study indicates that slag can be used as a complete replacement of traditional base materials. The results of the study show that a pavement section constructed with slag compared favorably with a traditional pavement section designed to have the same AASHTO structural number (*48*, *49*).

3.9 BITUMINOUS MATERIALS

The process of using a bituminous material to stabilize a soil or aggregate is known as bituminous soil stabilization (*50*). Bituminous stabilization can be used to both stabilize and waterproof a base material. In this process, the bituminous product is usually mixed with water and applied as an asphalt emulsion, but it can also be applied as a foam. Bituminous stabilization increases water repellency, improves material stability even after repeated saturation, increases strength and stiffness, and reduces frost heave (*50, 51*, *52, 53*). In fact, for frost-susceptible soils, the addition of as little as 3 percent asphalt emulsion can reduce the amount of frost heave experienced by the soil to a negligible level (*16*).

The addition of a bituminous stabilizer to a soil usually decreases the maximum density and increases the optimum fluid content, where the fluid is defined as the water and the liquid bitumen together (*50*). Because of the decrease in the maximum density, only a minimum amount of stabilizer should be added. Generally, the UCS increases with increasing bitumen content to about 3 percent bitumen by weight of dry aggregate, and the addition of more than 3 percent bitumen by weight of dry aggregate can cause the stabilized material to become more deformable and exhibit reduced UCS values (*50*).

When an asphalt emulsion is used to stabilize a soil, the soil must first be pulverized, or broken down into small workable particles. After pulverization, the asphalt emulsion is spread evenly over and mixed into the soil with a rotor. For adequate mixing to occur, the mixing process should begin immediately after placement of the asphalt emulsion. Laboratory work on sands has shown that mixing the emulsion into a sand that has a slight excess of water helps to increase the density and shear strength of the compacted mixture. Aeration, which can be achieved with a disc harrow, has also been shown to help obtain the highest possible stability (*52*).

Foamed asphalt has been only recently introduced in the United States, although it has been used for some time in Europe (*54*). Foamed asphalt is produced by using a special nozzle that mixes heated asphalt with cold water. This process reduces the asphalt cement viscosity, increases the volume of the asphalt cement to 10 to 12 times its normal volume, and reduces the surface energy of the asphalt. These changes allow the foamed asphalt to intimately coat the soil particles (*55*). Foamed asphalt has been shown to have about the same effect on base stabilization as a traditional asphalt emulsion for both crushed stone and cold in-place recycled (CIR) base materials (*55*, *56*).

According to one study, foamed-asphalt-stabilized materials can become as stiff as asphaltic concrete (*57*). The same study also indicates that adding 2 percent portland cement to a foamed-asphalt-stabilized base can increase the rate of strength gain and the resilient modulus with time (*57*). Little information on the performance of foamed asphalt in cold climates is available in the literature. However, an evaluation of a CIR pavement section in Ontaria, Canada, is currently underway. That section was constructed with a cold in-place recycled expanded asphalt mix (CIREAM), which has performed satisfactorily thus far (*55*).

Although foamed asphalt has repeatedly performed very well in both Europe and the state of Georgia in the United States (*54*), a forensic study performed on a failed base layer stabilized with foamed asphalt determined that moisture ingress caused weakening of the stabilized layer (*58*). According to the investigators, the failure was attributable to poor construction and emphasizes the need for proper construction monitoring.

3.10 CALCIUM CHLORIDE

Calcium chloride has also been used to improve aggregate properties. Proponents of calcium chloride report that the hygroscopic nature of calcium chloride facilitates water retention in treated materials during compaction. That is, the dissolution of calcium chloride crystals in the pore water of a soil or aggregate produces a solution that is very resistant to evaporation (*59*). Consequently, the maximum dry density of an aggregate treated with calcium chloride is reportedly higher than that of an untreated aggregate after the same amount of compaction (*59*). Calcium chloride has also been shown to reduce the thickness of the double-diffuse layer of clay particles and therefore potentially decrease the amount of free water that enters the aggregate layer, although the basis for the latter suggestion was not given by the authors in their report (*59*).

In a research project designed to compare several types of stabilizers, a test pavement section stabilized with calcium chloride was constructed in Maine in 1991 (*60*). The pavement section consisted of 4.75 in. of hot mix asphalt (HMA), 6 in. of stabilized base treated with calcium chloride at a rate of about 0.25 gal/yd^2, and a granular subbase 18 in. thick. Results from an interim report on the project indicate that the test section stabilized with calcium chloride exhibited comparatively high evidence of pavement distress and low strength, indicating that calcium chloride was not an effective stabilizing agent in that particular case (*60*). Because relatively little published research is available on the long-term performance of soil or aggregate materials stabilized with calcium chloride, engineers should use extreme care when specifying its use.

3.11 PROPRIETARY PRODUCTS

Proprietary products, or non-traditional additives, can be used for soil or aggregate stabilization. Little research has been performed on such stabilizers to evaluate their efficacy or to develop standard mixture design protocols. Because of this lack of information, engineers should exercise caution when specifying or permitting the use of proprietary products as stabilizing agents. Typical classifications of proprietary products include polymers emulsions, acids, bases, and oxidizers of various types. Polymer emulsions can be anionic, cationic, or non-ionic; can vary in solids content; and may be basic, acidic, or pH-neutral (*61*).

Limited testing of soils stabilized with different polymer emulsions indicates that increases in both the UCS and the modulus of toughness of stabilized soils are possible. For example, one study indicates that the addition of 2.75 percent of certain polymer emulsions yields approximately the same 28-day UCS as treatment with 9 percent portland cement (*61, 62*). Furthermore, the same study indicates that some of the polymer emulsions had likely not reached their ultimate strength at 28 days. A similar study indicates that a combination of 2.75 percent of certain polymer emulsions and 3 percent portland cement can increase the UCS and modulus of toughness to values higher than those obtained on soils stabilized solely with polymer emulsions or portland cement (*62*). Unfortunately, the types and manufacturers of the polymer emulsions used for the studies were not provided in the publications, and none of the studies on the proprietary admixtures included tests that would demonstrate the ability of soils or aggregates stabilized with polymer emulsions to withstand frost action.

The lack of significant information regarding the chemical composition, engineering characteristics, long-term strength properties, and ability of proprietary products to provide adequate material resistance to frost damage suggests that engineers may need to conduct extensive testing prior to specifying the use of such stabilizers. In addition, occasional reformulations and changes in brand names can make using these products difficult (*63*).

3.12 SUMMARY

Because the availability of naturally occurring non-frost-susceptible pavement base materials is rapidly diminishing in many areas, the use of chemical or physical methods to stabilize lower quality materials is increasing. Available stabilizers include portland cement, CKD, lime, LKD, fly ash, LFA, blast furnace slag, bituminous materials, calcium chloride, and proprietary products, which may each be utilized in conjunction with pavement recycling techniques.

The addition of a stabilizer to a soil or aggregate generally improves the strength and durability of the mixture, but the proper amount to be added should be determined using the specific laboratory tests recommended for each product. Proper construction techniques must also be followed to ensure that the desired engineering properties are obtained. Because of the adverse effects of frost heave, thaw weakening, and freeze-thaw cycling associated with cold regions, selecting stabilizer types and contents for improving soils and aggregates is an important aspect of materials characterization in the pavement design process.

CHAPTER 4

PAVEMENT DESIGN CONSIDERATIONS

4.1 PAVEMENT DESIGN

Three main elements must be considered in pavement design, including the volume and type of traffic, the types of materials available for construction, and climatic factors such as temperature and moisture. Based on these inputs, many different methods can be used to design pavement structures. The following sections summarize several of the most common pavement design methodologies for determining adequate layer thicknesses and present considerations related to drainage, geomaterials, insulation, winter maintenance, and spring load restrictions and winter load premiums.

4.2 LAYER THICKNESS

The thickness of a pavement structure can play an important role in the performance of a roadway, especially in cold regions. If the frost penetration depth exceeds the thickness of the pavement structure in areas with frost-susceptible soils, frost heave, thaw weakening, and freeze-thaw cycling can cause substantial damage to the roadway (*1*).

Most of the primary pavement design methods do not explicitly account for the effects of seasonal freezing or thawing; instead, they leave the decision to increase the pavement layer thickness or otherwise modify the design of the pavement to the engineer

(*3*). For example, while the AASHTO flexible pavement design method (*64*) accounts for seasonal variation in the strength of the subgrade, variability in the strength of the base and subbase materials is not addressed. The effects of climate are introduced in the Asphalt Institute (AI) method (*64*) only with respect to maximum temperatures, and material properties typical of late summer or early fall are recommended for use. The National Stone Association (NSA) method (*65*) is the only flexible pavement design procedure that explicitly accounts for frost-susceptible subgrades and provides guidance about minimizing frost damage, but it is not widely utilized. With respect to rigid pavement design, the AASHTO (*64*), American Concrete Pavement Association (ACPA) (*66*), and PCA (*64*) methods all fail to permit direct consideration of frost effects in determination of layer thicknesses, and criteria presently associated with mechanistic-empirical design methodologies are based solely on stress distributions associated with trafficking rather than with frost heave, thaw-weakening, or freeze-thaw cycling.

Although many agencies design for frost action using strictly empirical methods in which pavement layer thicknesses are determined based on past experience and anecdotal evidence (*67*), the USACE has developed three design methods to account for frost action, including complete-protection, limited-subgrade-frost-penetration, and reduced-strength methods (*68*). In the complete-protection method, the frost penetration depth is calculated, and non-frost-susceptible material is specified to that depth. The limited-subgrade-frost-penetration method attempts to limit the deformation that occurs to an acceptable amount by limiting the depth of frost penetration into the subgrade. The reduced-strength method incorporates into the design the reduced strength of the subgrade material during the thawing period to prevent structural failure of the pavement, but the potential occurrence of frost heave and pavement roughness is not considered (*68*).

Although much damage can occur from frost action, many agencies in both the United States and Canada do not design pavements sufficiently thick to prevent subgrade freezing; in many instances, the effects of frost heave on pavement serviceability are considered by these agencies to be minor (*3*). However, some agencies have developed more aggressive methods for controlling problems related to frost action. For example, comparing the cost of construction to the cost of repairs, road officials in Germany have found that if frost damage is considered to be a problem, removal and replacement of 50 percent of the frost-susceptible soil within the freezing zone with non-frost-susceptible soil is appropriate. They have found that, although some frost heave does occur, significant pavement distress does not develop (*69*).

Other agencies taper the depth of the non-frost-susceptible soils, with the deepest point in the middle of the roadway and the shallowest point at the edges (*1*). The center of the road can be expected to experience more freeze-thaw cycles, especially if sufficient snow is alongside the road acting as insulation. At times, drainage lines are placed in either the bottom of the center of the non-frost-susceptible layer or along the edges of the roadway to reduce the amount of free water that enters the subgrade (*1*).

4.3 DRAINAGE

Proper drainage can significantly increase pavement life and minimize the detrimental effects of frost action (*70*). Typically, open-graded base materials are used as drainage layers. With negligible fines in the base material, water can travel through and out of the pavement structure relatively easily, which can eliminate much of the free water in the base and subgrade layers.

Drainage layers are typically placed below the base or subbase course. However, in this position, the drainage layer cannot readily drain meltwater from base or subbase layers that begin to thaw but are still frozen at depths shallower than the drainage layer. Thus, the drainage layer will not mitigate damage caused during the spring thaw. Instead, a study has shown that drainage layers should be placed on top of the base course to be effective in cold regions, thus allowing for the melted free water to drain out of the pavement structure as soon as it begins to thaw (*3*).

Using open-graded materials can be somewhat difficult; without sufficient fines, materials are not very stable and can be extremely difficult to compact. For this reason, asphalt and portland cement have been used to improve the constructability of these layers without significantly reducing the permeability of the material. When an additive such as portland cement is used in an open-graded base, care should be taken to ensure that too much portland cement is not added. The addition of too much portland cement can lead to shrinkage cracking in the drainage layers and reflective cracking in the asphalt (*70*). Also, attention must be given to the slope of the drainage layer and to ensuring that free outlets exist on the edges of the roadway. If the excess water does not flow away and cannot escape from the structure, the benefits of the drainage layer are greatly reduced (*71*).

4.4 GEOMATERIALS

Geomaterials are products such as geotextiles, geogrids, and geocomposites that are sometimes used in addition to traditional or non-traditional base materials to improve the engineering properties or the constructability of a pavement section.

Geotextiles are generally blanket-type products used as filters or soil reinforcement and are composed of a either woven or non-woven synthetic material (*72*). Geotextiles are typically used in roadway construction to separate two different pavement layers or to stabilize base or subbase layers against cracking; as little as 10 percent contamination of a base material by subgrade fines can cause the strength of the base to collapse to that of the subgrade (*73*). Geotextiles can be used to minimize this problem by serving as a filter fabric between the two different layers. Some engineers also believe that geogrids provide structural pavement reinforcement and therefore specify thinner base layers when a geogrid is used (*73*).

The effect of geotextiles on pavement performance was evaluated in a research study investigating two different pavement structures. One of the pavement structures was built with 2 ft of lime-stabilized soil and the other with a geotextile. The pavement section with the lime-stabilized soil consisted of a chip seal underlain by 6 in. of base course overlying 24 in. of lime-treated subbase. The pavement section with the geotextile consisted of chip seal underlain by 6 in. of base course overlying the geotextile. The same silty clay subgrade was present below both pavement structures. Overall, both sections performed very well. Over the course of the research project, the geotextile-stabilized section actually needed less maintenance than did the section with the 2-ft layer of lime-stabilized soil, but the major difference between the two at the time of the study was the cost. The section built with the geotextile had a total cost of about 35 percent of the total cost of the section constructed with the lime-stabilized layer (*74*).

A concern when using a geotextile is that in some situations water can travel laterally through the geotextile. Free water could then travel to a section of subgrade or subbase material that is freezing and contribute water (*75*). The additional water could in turn exacerbate frost damage in the affected area.

Geogrids, another type of geomaterial, are polymeric materials formed by intersecting ribs joined at the junctions in a grid-like fashion (*76*). Geogrids are most commonly used for structural reinforcement of base layers and prevention of cracking. For example, in Texas, geogrids have proven effective at minimizing longitudinal reflection cracking in granular base layers that otherwise occurs upon drying of the underlying clayey subgrade soils (*77*). The ability of geogrids to actually increase the structural capacity of pavements is still under investigation, however.

Geocomposites are also manufactured in sheet form and typically consist of two or more geomaterials assembled to create a single product (*76*). Geocomposites have been used for frost heave reduction, but with mixed success. The basic idea is that geocomposites can perform as capillary barriers, reducing both the upward flow of water and the amount of water that can infiltrate downward from the overlying layer (*7*). In suitable conditions, geocomposites have been shown to be effective in reducing frost heave and acting as capillary barriers in highly frost-susceptible soils such as silt and silty sand. However, a study has shown that geocomposites are unsuccessful in reducing frost heave when the moisture suction head in the soil overlying the geocomposite was 31.5 in. or less. However, when the moisture suction head levels were 70.9 in. or more, the geocomposite successfully reduced frost heave (*7*). In an additional study, the determination was made that, while thicker geotextiles do considerably break capillary rise (*78*), geocomposite materials appear to work somewhat better than geotextiles at minimizing frost heave (*79*, *80*).

4.5 INSULATION

Insulation has been used in pavement structures both to limit the depth of frost penetration and also to maintain freezing temperatures within permafrost zones (*81*). In permafrost areas, roadways can cause progressive thawing of the permafrost through time. The continually deepening thaw zone under the center of the roadway is caused by the warming influence of the road. The soils under the embankments are not fully refrozen during the winter, which allows the thawing to progress deeper and deeper into the ground with time. As the permafrost recedes, problems with both frost heave and settlement can be exacerbated (*82*). To reduce the effects of continually thawing permafrost, insulation has been used with much success, especially in very cold climates. Insulation has also been used as a corrective measure in roads that have experienced frost heave problems.

Various laboratory and field studies in Alaska have shown that extruded polystyrene performs very well as insulation in airfields and roads (*81*). That research indicates that pavement structures with extruded polystyrene insulation foam can have an expected design life of more than 25 years (*81*). On the other hand, insulation constructed of foamed-in-place polyurethane does not reportedly perform well. The poor performance of the foamed-in-place polyurethane is possibly explained by the fact that the polyurethane absorbs as much as 70 percent water by volume (*81, 83*).

When specifying insulation, engineers should consider both the deformation that can occur in the insulation and the potential for near-surface differential icing. Deformation can occur because the resilient modulus of insulation is lower than typical subgrade materials. However, this potential problem can be overcome through proper pavement design; typical methods used to account for the lower strength of the insulation include increasing pavement layer thicknesses overlying the insulation and using stiffer overlying materials (*83*). Because the flow of heat from the subgrade soils to the pavement surface is inhibited when an insulation layer is used, the possibility exists for the pavement surface to become colder than the surface of a conventional pavement section. Therefore, roadways containing both insulated and conventional pavement sections may exhibit differential icing, in which ice forms first on the surface of the pavement section containing insulation (*84, 85*). In such instances, granular layers may be placed on top of the insulation layers to reduce the potential for differential freezing. The granular layer acts as a heat reservoir that lowers the potential for a difference in near-surface temperatures between the two pavement sections (*82*).

4.6 WINTER MAINTENANCE

Roads that experience snow and ice usually require significant winter maintenance efforts. In 1995, state highway agencies spent about $1.5 billion on salting, plowing, and sanding roads in the United States (*86*). Proper roadway design can make the process of maintaining road safety in the winter much easier and less time-consuming.

A roadway that has been properly designed provides space for snowplows to pile snow off the road or incorporates openings along the shoulder for snow to be pushed off the roadway (*87*). If space has not been provided on the pavement for snow accumulation, or if the locations to place the excess snow are spaced too far apart, snow removal can become extremely difficult, time-consuming, and expensive. For example, in locations with inadequate snow storage capacity, excess snowfall must be hauled away by truck. Widths of snow plow blades are also sometimes considered in determinations of overall pavement width to maximize plowing efficiency.

Blowing snow should also be another cold-regions pavement design consideration. Blowing snow can cause snow drifts to build up on the roadway and can also cause visibility problems (*88*). One mitigation measure often used for blowing snow is snow fences. Snow fences are typically constructed alongside a roadway to reduce the accumulation of snow on the pavement.

4.7 SPRING LOAD RESTRICTIONS AND WINTER LOAD PREMIUMS

Because of the thaw-weakened state that can develop in subsurface pavement layers during the spring season in cold regions, many agencies have implemented spring load restrictions (*89*). In this weakened state, flexible pavements can exhibit rutting and fatigue cracking under heavy trafficking, and rigid pavements are susceptible to problems with pumping and cracking (*8*). Agencies therefore place maximum weight limits on trucks that can be driven over the weakened roadway during certain weeks in the spring.

According to the results of a questionnaire survey addressing practices within the United States and Canada, the critical period of time in which spring load restrictions should be implemented is when the thaw depth is shallower than 3.9 feet (90). Ideally, an agency should enforce spring load restrictions from the onset of thawing until this critical thaw depth is achieved. However, many agencies do not utilize actual thaw depth measurements to determine the time that spring load restrictions are applied; instead, they follow a fixed calendar timeline or their own in-house criteria (*89*). Because of their importance to the economy and military, interstates and other major highways are typically designed to withstand heavy trafficking without spring load restrictions (*89*).

During the winter months before the spring-thaw period, freezing of the pavement layers can significantly increase the pavement strength. Because of this added strength, many agencies throughout both the northern United States and Canada allow winter load premiums, or increased maximum weight limits for trucks. This practice offers economic benefits because of the possibility of more efficient trucking (*89*).

Care must be taken to ensure that the application of a spring load restriction, or that the removal of a winter load premium, does not occur too late in the spring. Studies have shown that even one week delay in placing spring load restrictions in a given year can shorten the service life of a pavement by 4 to 8 percent. Even more damaging is being one week late in removing winter load premiums, which can shorten pavement life from 5 to 12 percent (*89*).

4.8 SUMMARY

With traffic, materials, and climatic inputs, pavement design for cold regions involves determination of layer thicknesses and specification of features addressing drainage, geomaterials, insulation, winter maintenance, and spring load restrictions and winter load premiums. Although most of the primary pavement design methods do not explicitly account for the effects of seasonal freezing or thawing, the USACE has developed three design methods to account for frost heave and thaw weakening.

Drainage layers comprised of open-graded aggregates should be placed above any frost-susceptible layers to ensure that meltwater can exit the pavement as thawing commences. Geotextiles may be used as filter fabrics to prevent migration of fines between pavement layers, geogrids may be useful for strengthening base layers, and geocomposites may be specified to enhance drainage. Insulation may be needed on specific projects to either limit the depth of frost penetration or to maintain freezing temperatures within permafrost zones, but it should be placed deep enough to minimize surface icing problems. The width and shoulders of the roadway should be designed for efficient snow storage and removal during winter maintenance activities, and snow fences should be erected in areas susceptible to snow drifting. Spring load restrictions may be implemented by transportation agencies to minimize pavement damage during the spring thaw period, while winter load premiums may be permitted to facilitate more efficient trucking during winter. However, the timing of these programs must be carefully determined to achieve maximum benefit.

CHAPTER 5

QUESTIONNAIRE SURVEY RESULTS

5.1 SURVEY PURPOSE

A questionnaire survey was conducted to investigate the state of the practice concerning identification of frost-susceptible materials and the use of soil and aggregate stabilization in cold regions within the United States. The study was directed primarily at identifying practices utilized by state DOTs in climates with freezing temperatures. Individuals most capable of describing the state of the practice concerning the identification and treatment of frost-susceptible materials were identified through telephone calls to each state DOT office. Surveys were e-mailed to 42 DOTs (all except Alabama, Delaware, Florida, Georgia, Hawaii, Louisiana, Mississippi, and New Jersey), and responses were received from the following 23 DOTs: Alaska, Arizona, Colorado, Connecticut, Idaho, Indiana, Kansas, Maine, Maryland, Minnesota, Montana, Nevada, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Dakota, Texas, Utah, Vermont, and West Virginia. The response rate associated with the survey was 55 percent. The survey included five questions intended to solicit information about the respondent, such as the person’s name, job title, and contact information, and 19 questions regarding the experiences of the respondent with frost-susceptible materials, pavement design, and stabilization techniques. A copy of the questionnaire survey form is provided in Appendix A, while the questionnaire survey responses are included in Appendix B. The survey responses are summarized in the following sections.

5.2 PARTICIPANTS

The majority of the survey respondents were state transportation engineers and maintenance specialists. Specific participant information is not included in this report, as the purpose of obtaining contact information from those who participated in the survey was to facilitate follow-up questioning as needed. The following questions 1 to 5 were used to obtain information about the respondent:

Question 1. *What is your name?*

Question 2. *What is your job title?*

Question 3. *For which state department of transportation do you work?*

Question 4. *What is your phone number?*

Question 5. *What is your e-mail address?*

5.3 SURVEY RESULTS

The survey included 19 questions related to the identification of frost-susceptible soils and the use of stabilization methods for improving frost-susceptible soils in cold regions. Most of these questions had multiple-choice answers, but others required short-answer responses. The following sections present the survey questions and a summary of the results obtained for each question. The 19 survey questions are presented in three different sections: climate, design and construction, and policies.

5.3.1 Climate

This section discusses the results of two questions addressing the climate in the regions of the different respondents.

Question 1: *What is the typical air freezing index for the weather in your jurisdiction?*

Figure 5.1 shows that the air freezing indices reported by the responding agencies range from negligible to 3000ºF-days. Eight surveys were received without a response.

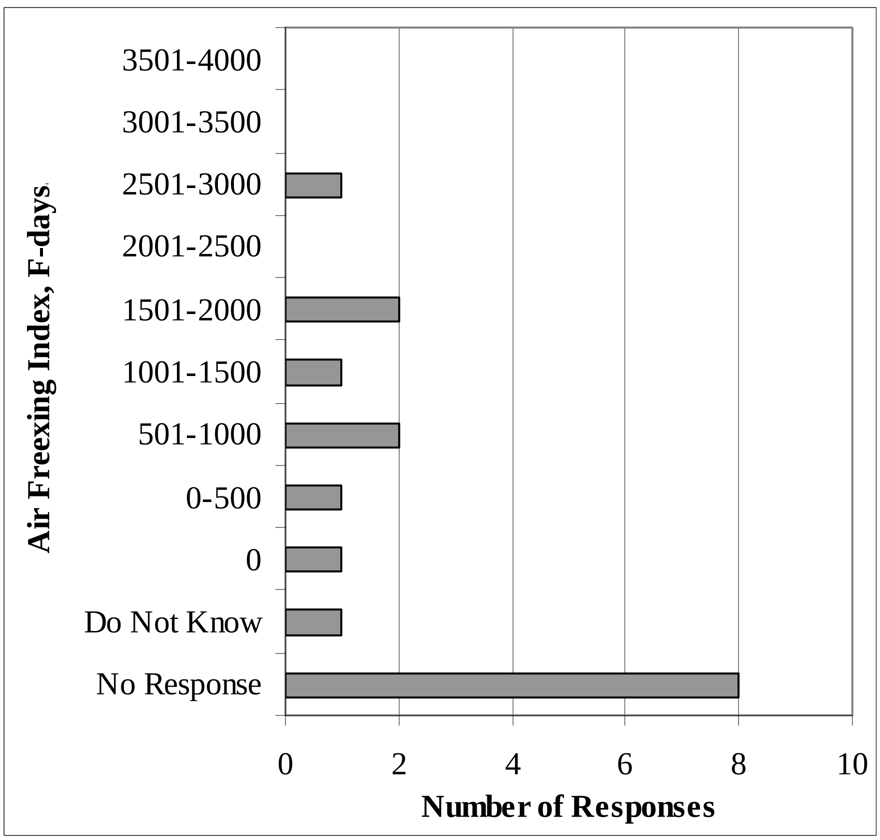

Figure 5.1 Average air freezing indices.

Question 2: *What is the typical depth of frost penetration in your area?*

The respondents to this question generally answered with both a minimum and a maximum penetration depth for their respective regions. Figure 5.2 shows the minimum values of frost penetration depth, while Figure 5.3 shows the maximum values. Values for minimum and maximum frost penetration depths ranged from 0 ft to 8 ft. Only one survey participant did not respond.

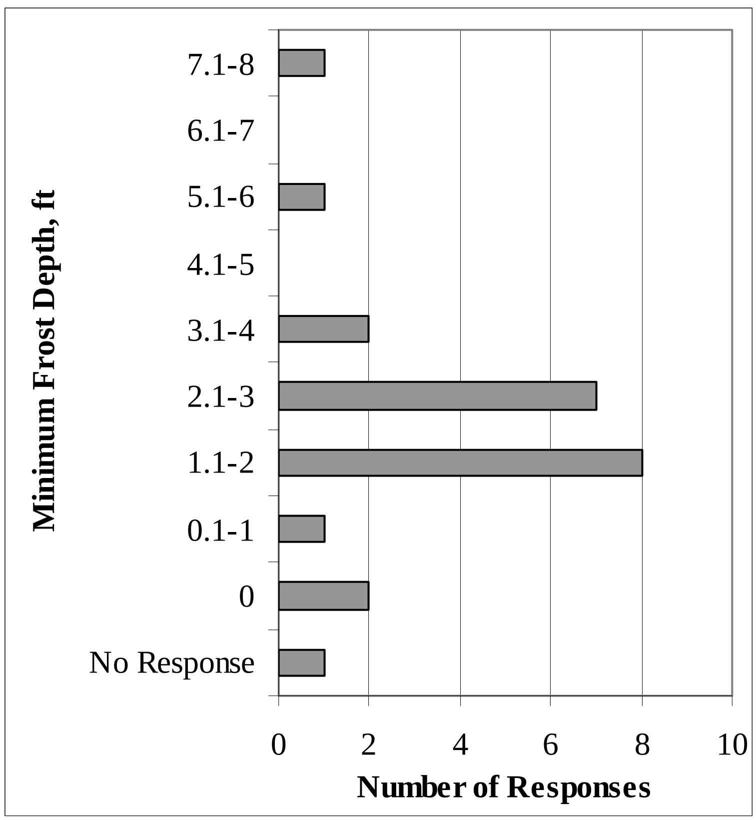

Figure 5.2 Minimum frost penetration depths.

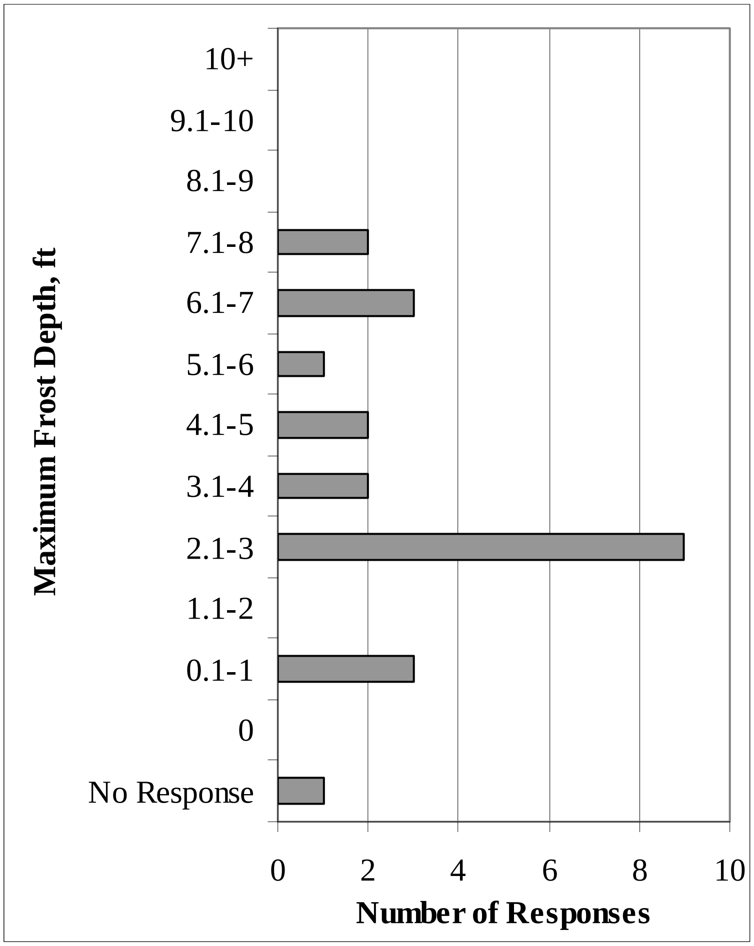

Figure 5.3 Maximum frost penetration depths.

5.3.2 Design and Construction

This section discusses the results of the 15 questions regarding design and construction of roadways included in the survey. For many of the questions, more than one response was given by each agency.

Question 1: *What kind of pavement design methodology do you use for areas that experience frost action?*

Figure 5.4 shows the different methodologies listed as choices in the survey and the responses received from the participants. The AASHTO method is used more frequently than the other methodologies. Four of the agencies that responded do not consider frost action in their pavement designs. Responses in the “Other” category include placing 2 ft of expanded foam followed by 6 in. of granular base course for areas that experience frost action. Arizona, Minnesota, New York, Pennsylvania, and Vermont each had specific in-house methodologies that were included in the “Other” response category.

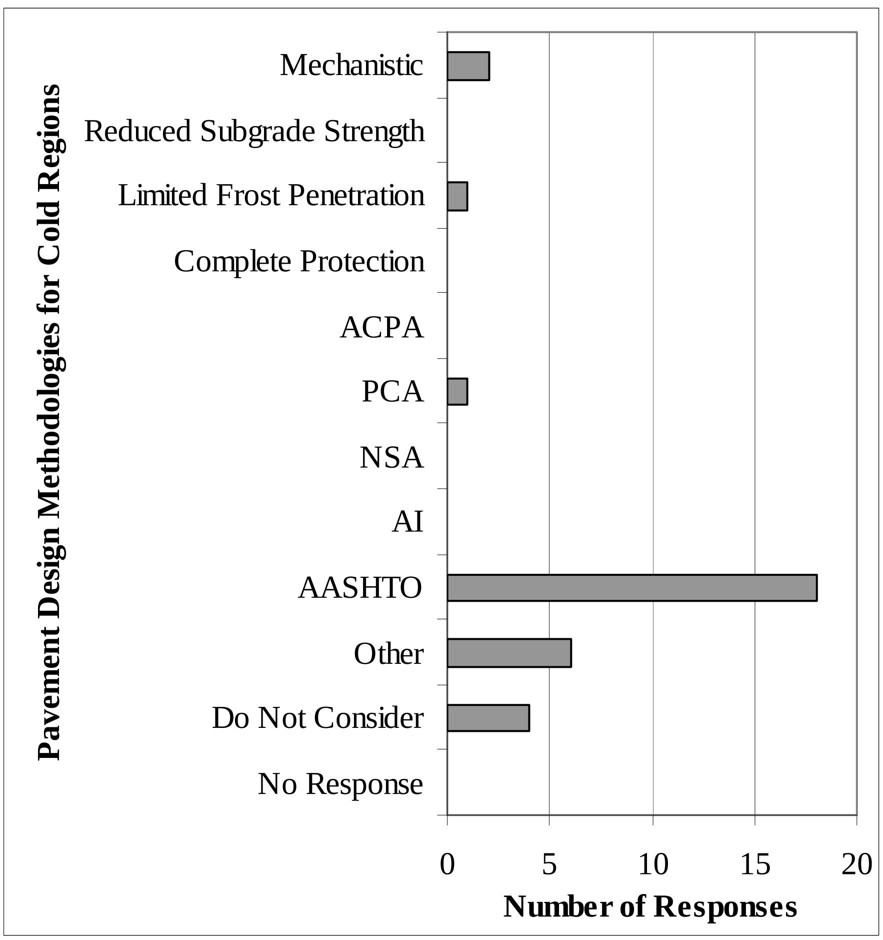

Figure 5.4 Pavement design methodologies used.

Question 2: *What are the layer types and thicknesses of a typical flexible (asphalt) highway pavement in your jurisdiction?*

Of the 23 survey respondents, 22 reported that they use HMA for their highway pavements. The remaining one survey participant did not respond. As indicated by 12 of the surveys, dense-graded aggregate is the most commonly used base material for flexible highway pavements. The next most commonly used base material is stabilized base, which is routinely specified by five of the respondents. Crushed aggregate is utilized by four respondents. Two respondents indicated the use of existing material, gravel, or asphalt, and one respondent indicated the use of sand or RAP.

Twelve responses were received regarding the type of subbase materials generally used in flexible pavement sections. Eleven of the 12 respondents indicated the use of granular material for subbases, while three of the respondents indicated the use of stabilized layers as subbases. The remaining respondents indicated that a subbase layer is not used as part of the flexible highway pavement sections in their jurisdiction.

Figures 5.5, 5.6, and 5.7 show the typical thicknesses used by the respondents for asphalt, base, and subbase layers, respectively, in flexible highway pavements. Although the thicknesses of the asphalt, base, and subbase vary widely among the respondents, the survey results indicate that 4 in. to 6 in. or greater than 9 in. of HMA, 5 in. to 8 in. of base material, and 7 in. to 12 in. of subbase material are the most commonly specified.

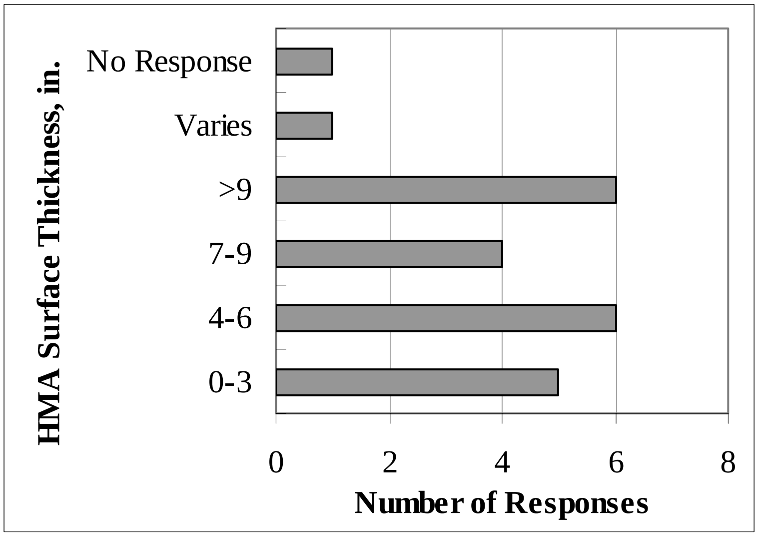

Figure 5.5 Asphalt thicknesses in flexible highway pavements.

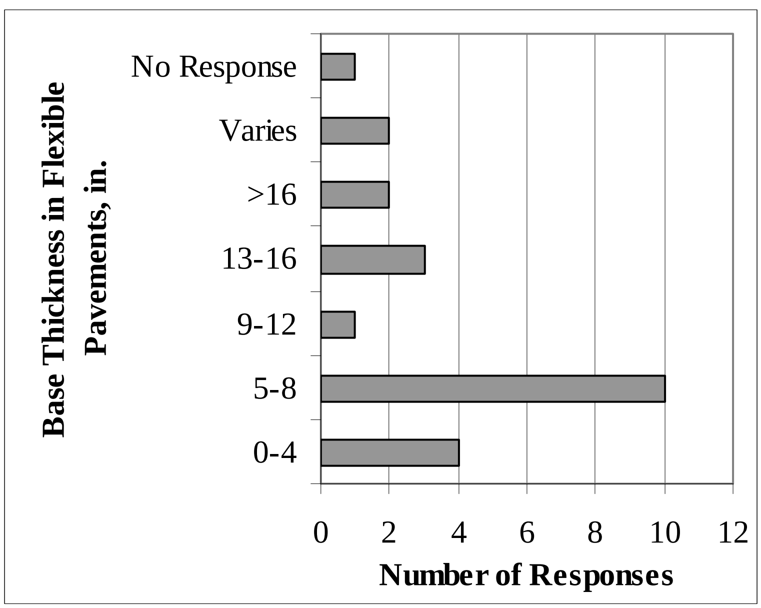

Figure 5.6 Base thicknesses in flexible highway pavements.

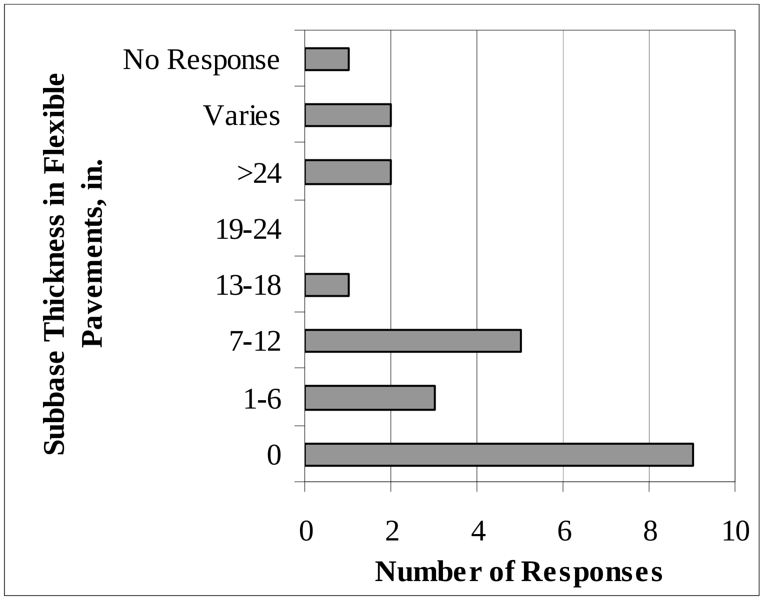

Figure 5.7 Subbase thicknesses in flexible highway pavements.

Question 3: *What are the types and thicknesses of a typical rigid (concrete) highway pavement in your jurisdiction?*

Of the 23 survey respondents, nine reported the use of rigid pavement sections for their highways; the remaining 14 survey participants did not address this question. Of the nine surveys received, two indicated the use of granular material as the base layer, while two of the respondents reported the use of crushed aggregate. Stabilized base, cement-treated base, lean concrete, and asphalt bases were all used by at least one respondent.

Of the surveys received, six included information regarding subbase layers. Three of the six survey respondents indicated that subbase layers are not typically used in rigid pavement sections in their jurisdictions. Two responses indicated the use of granular subbase, while the remaining respondent reported the use of chemically-treated subbases.

Figures 5.8, 5.9, and 5.10 show the typical portland cement concrete (PCC), base, and subbase thicknesses, respectively, used in rigid highway pavements. Although the frequency of use is essentially equal across the base and subbase thickness categories, the data show that a PCC thickness of between 9 in. and 12 in. thick is most commonly specified.

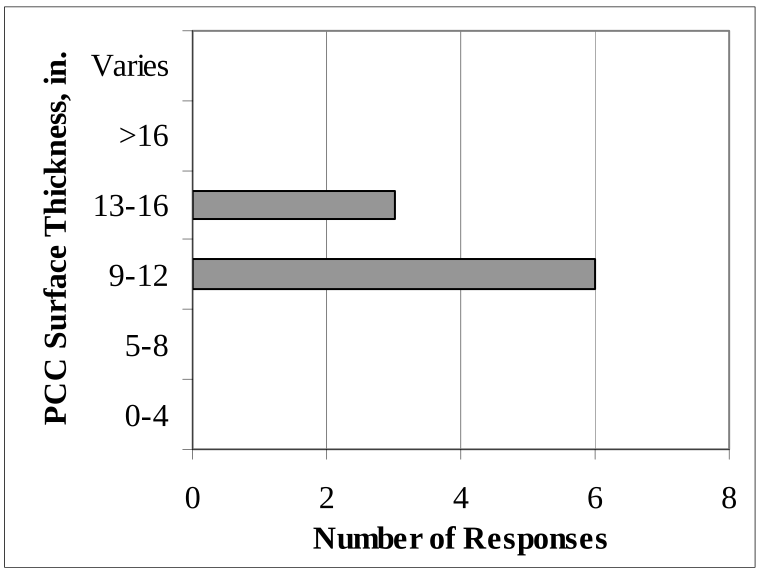

Figure 5.8 Portland cement concrete thicknesses in rigid highway pavements.

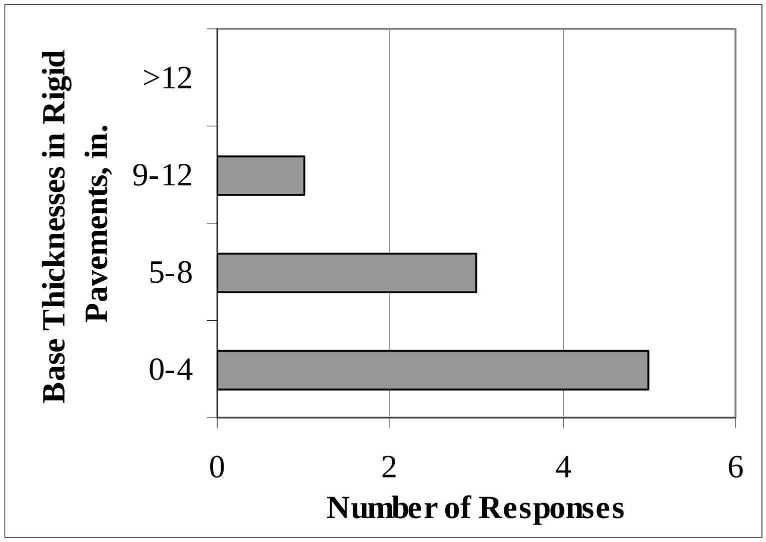

Figure 5.9 Base thicknesses in rigid highway pavements.

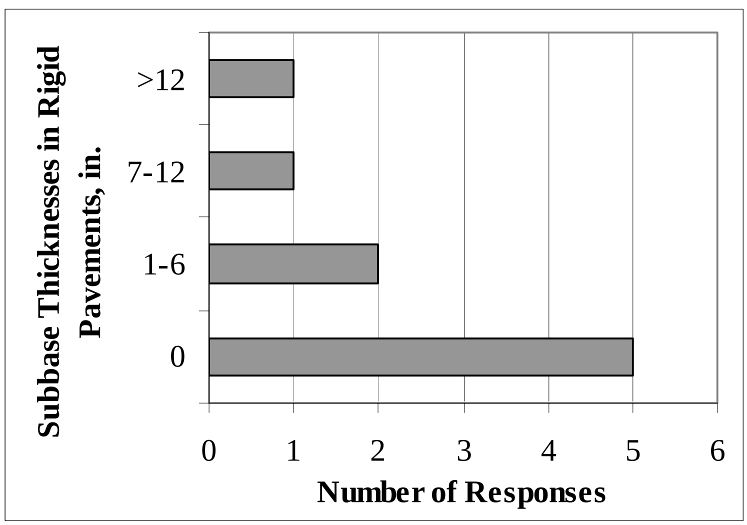

Figure 5.10 Subbase thicknesses in rigid highway pavements.

Question 4: *How do you determine whether a given aggregate base or subgrade material is frost susceptible?*

Figure 5.11 shows that the most commonly used methods for identifying frost-susceptible soils are field experience, laboratory testing, and particle-size distribution.

Responses for “Other” were received from an agency that is currently conducting research to upgrade the existing method and an agency that uses solely granular bases to reduce the need to identify frost-susceptible soils.

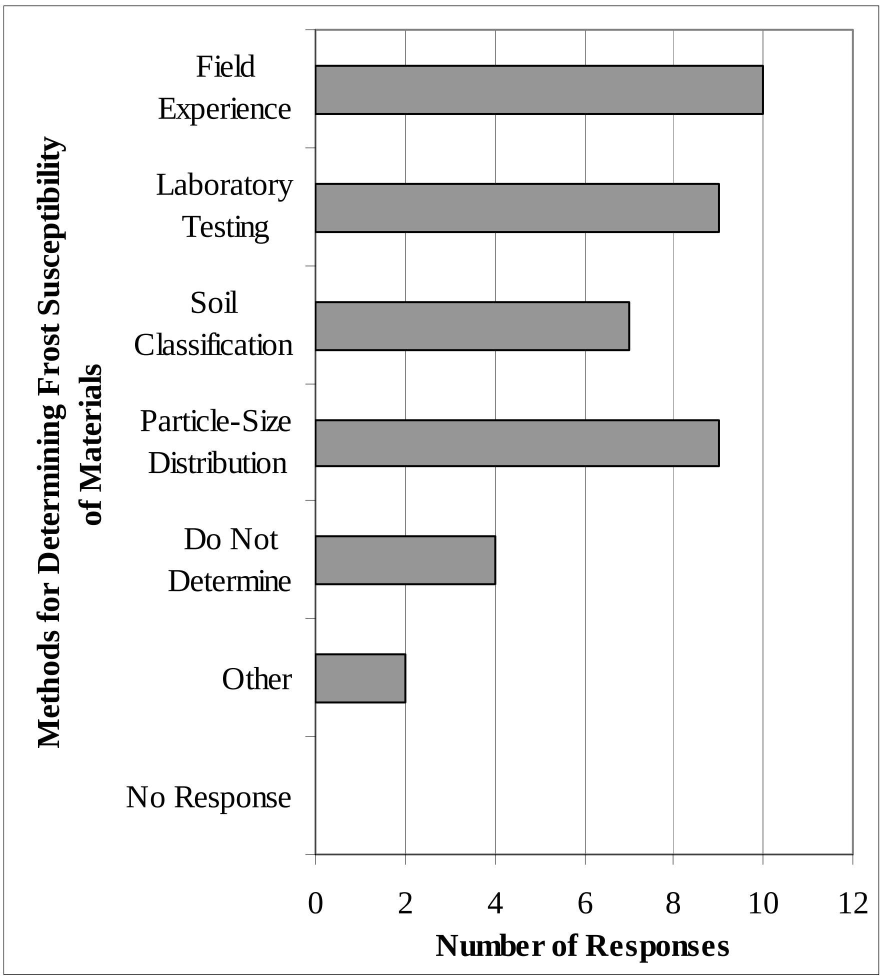

Figure 5.11 Methods used to determine if a material is frost-susceptible.

Question 5: *For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use?*

Figure 5.12 displays the pavement construction practices used in areas characterized by frost-susceptible soils. Excavation and replacement of the frost-susceptible soils is the most frequently cited method of constructing pavements on frost-susceptible subgrades. Only one survey participant did not respond. The response "Other" includes use of bituminous-treated bases, underdrains, rock subgrade fragmentation, and broken rock trenches. Figure 5.13 presents the depths of excavation and replacement typically specified by the agencies that employ this method. Both of the respondents who cited the use of subgrade processing to remove large stones indicated removal of stones larger than 12 in. in diameter.

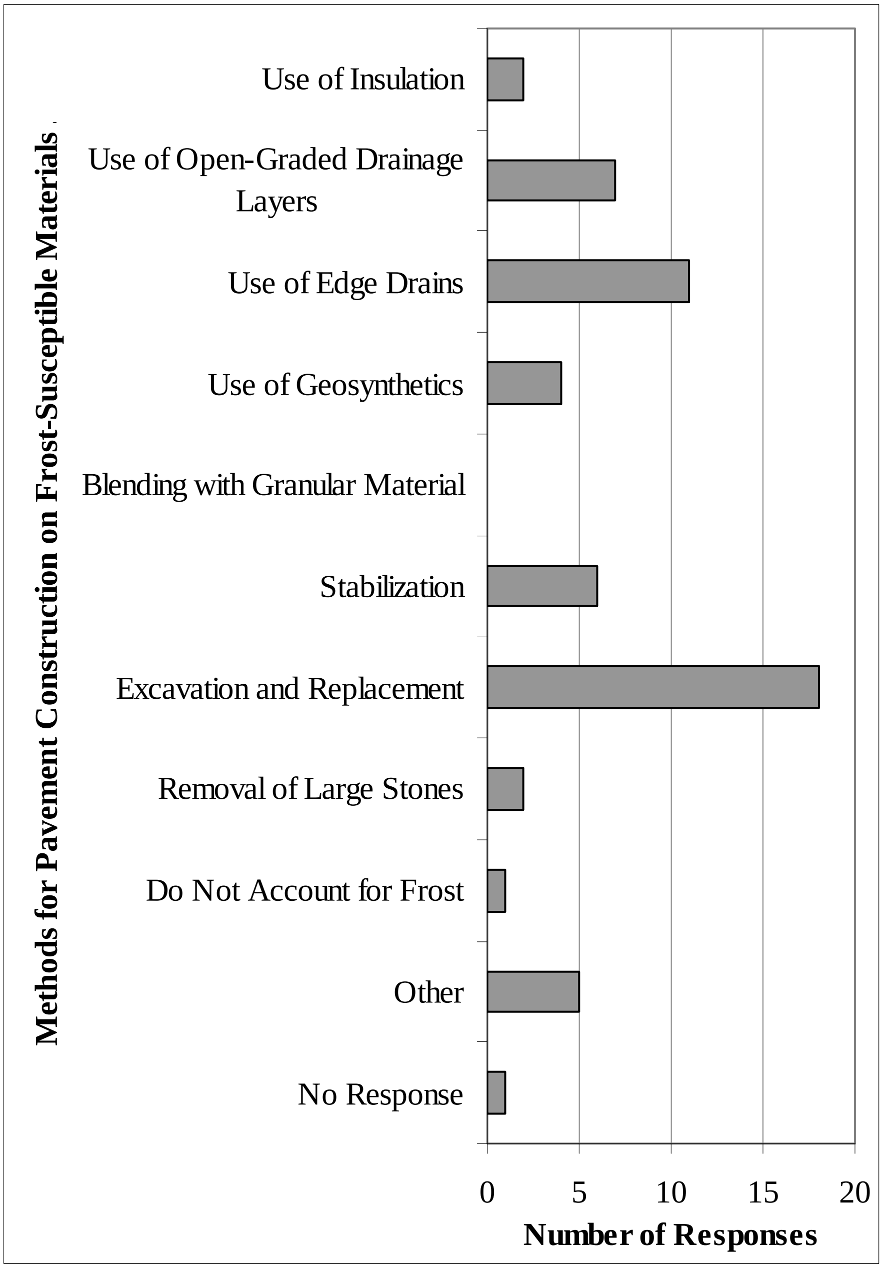

Figure 5.12 Construction methods used for frost-susceptible materials.

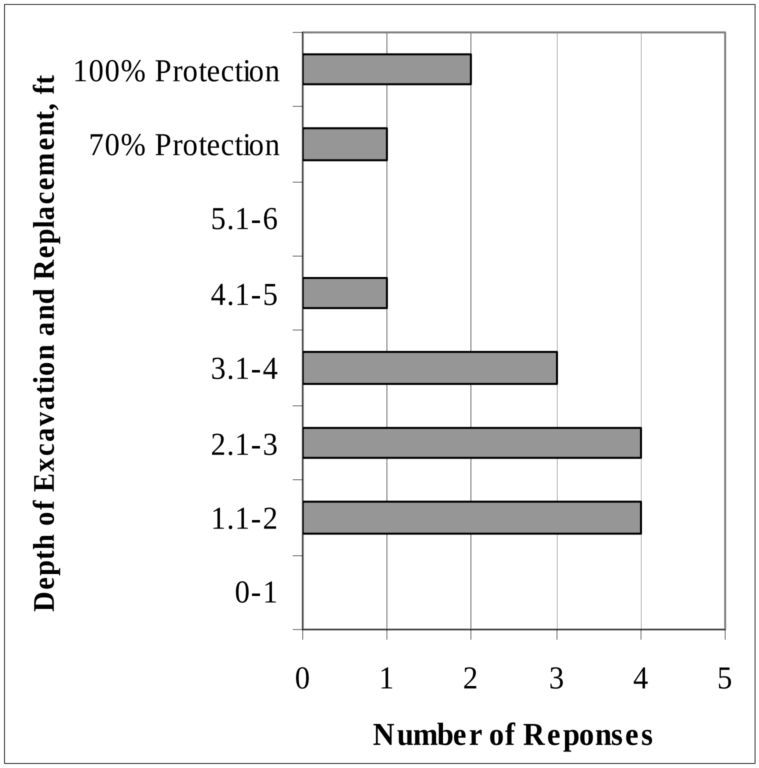

Figure 5.13 Depths of excavation and replacement generally used.

Question 6: *When stabilization is selected, which types of stabilizers do you most commonly use?*

Figure 5.14 clearly indicates that portland cement and lime are the two most commonly used stabilizers. Proprietary admixturess was the only choice not cited by a respondent. The responses for "Other" indicated that stabilization was used only for constructability purposes and that 1 to 2 percent cement was added to all treated materials. Seven survey respondents did not respond.

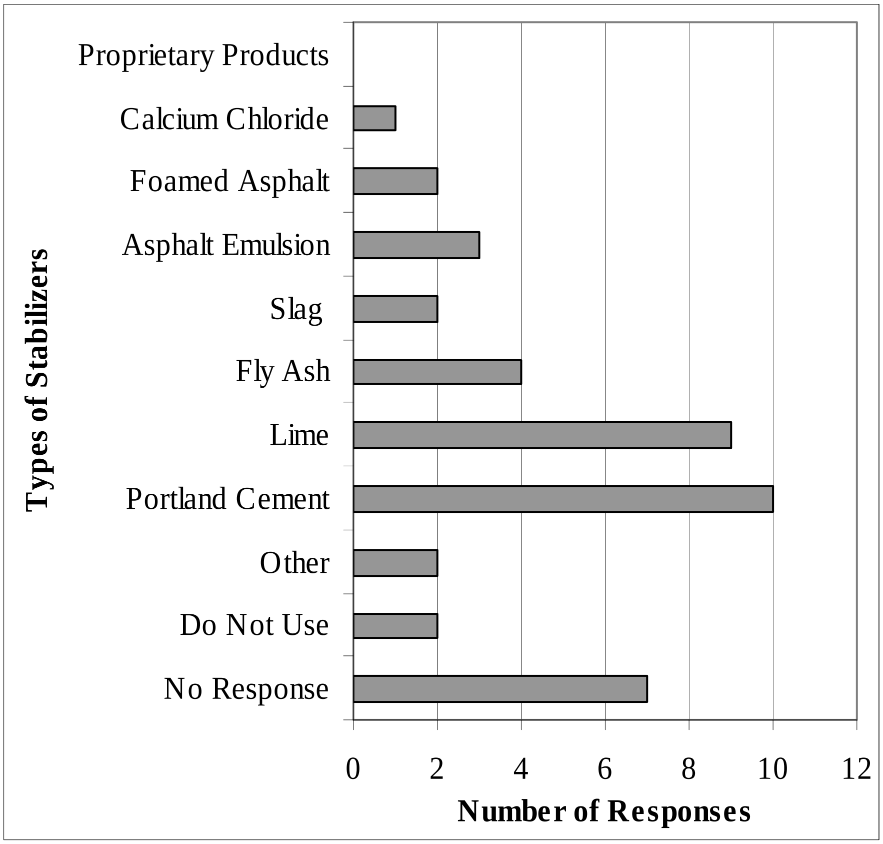

Figure 5.14 Stabilizers most commonly used.

Question 7: *How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material?*

As shown in Figure 5.15, field experience, UCS, and "Other" are the most commonly cited methods for determining the optimum amount of chemical stabilizer to add to a base or subgrade material. Many agencies that use UCS for determining lime content use different target strength values in selecting the optimum content. For example, while one agency specifies strength values of greater than 50 psi at 3 days, another agency requires strengths greater than 60 psi at 7 days. A third agency adds sufficient lime to achieve an increase of 50 psi over the untreated soil strength. Target

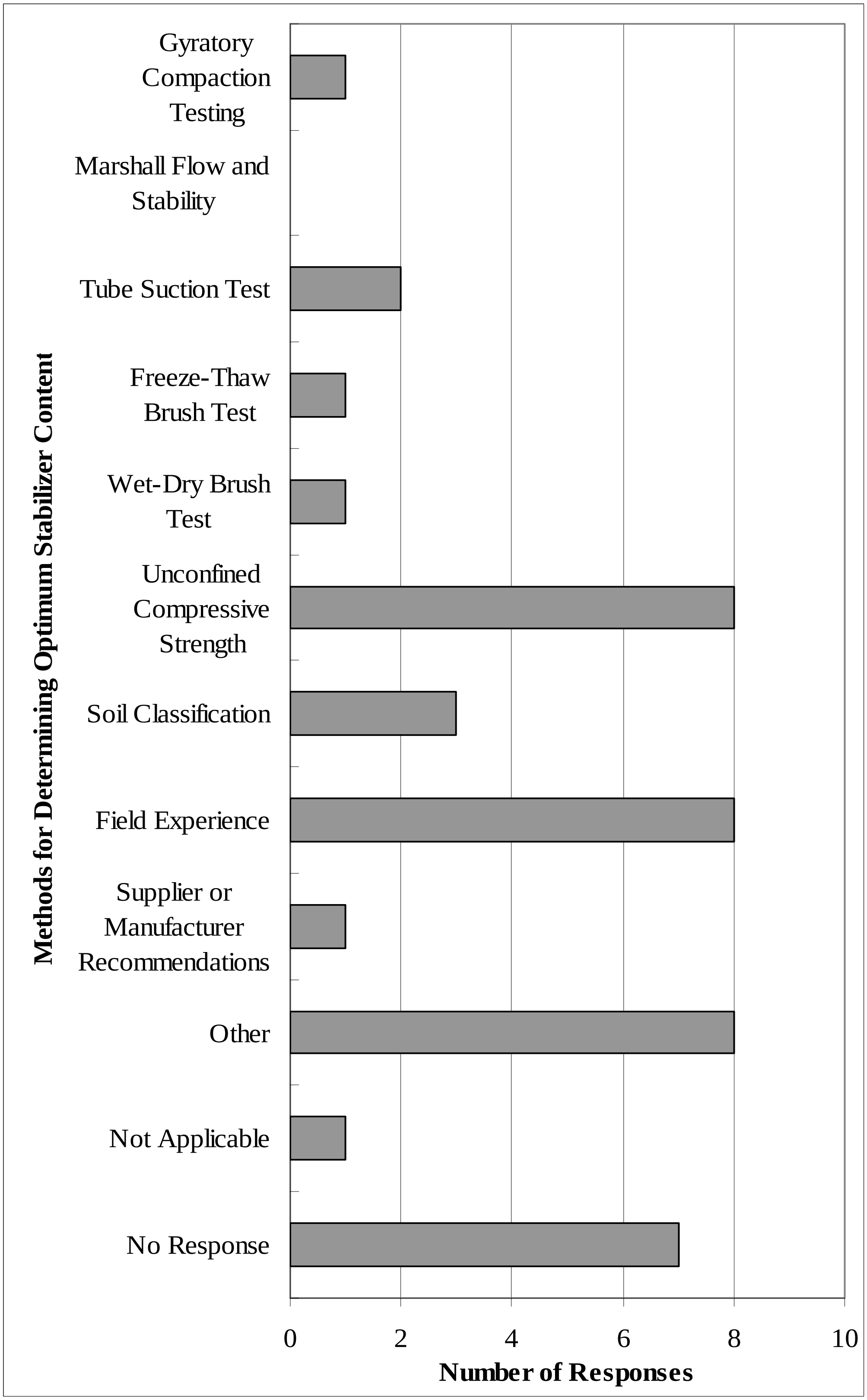

Figure 5.15 Methods used to determine optimum amount of chemical stabilizer.

UCS values for cement stabilization ranged from 3-day values between 100 psi and 150 psi and 7-day values between 125 psi and 750 psi. The responses for "Other" include plasticity index reduction, indirect tensile strength, VDOT in-house testing procedure, Eades and Grimm procedure, 10 percent by weight, and the Wirtgen process for foamed asphalt. Seven survey respondents did not respond to the question.

Question 8: *When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics?*

Of the 23 surveys received, one did not respond, five indicated that they do permit thinner pavement sections to be constructed when geosynthetics are incorporated in the design, and 17 indicated that they do not allow thinner pavement sections. Of the respondents that indicated that they do not allow thinner pavement sections, many indicated that they do not have research supporting the effectiveness of geosynthetics. Many of the agencies that do not allow thinner pavement sections do apparently use geosynthetics in problematic areas and for constructability purposes, however. Those that do permit the use of thinner pavement sections reported increasing the subgrade R-value by 10 points in design, reducing subbase thicknesses by 6 in., and using Spectrapave software for designing with geogrids.

Question 9: *For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60.*

The most common answer to this question was that full-depth recycling is not used. However, as shown in Figure 5.16, agencies that do utilize this technique indicate that the typical RAP content is 50 percent, which corresponds to a 50:50 ratio of RAP to base, or that it varies by project. Three survey participants did not respond to the question.

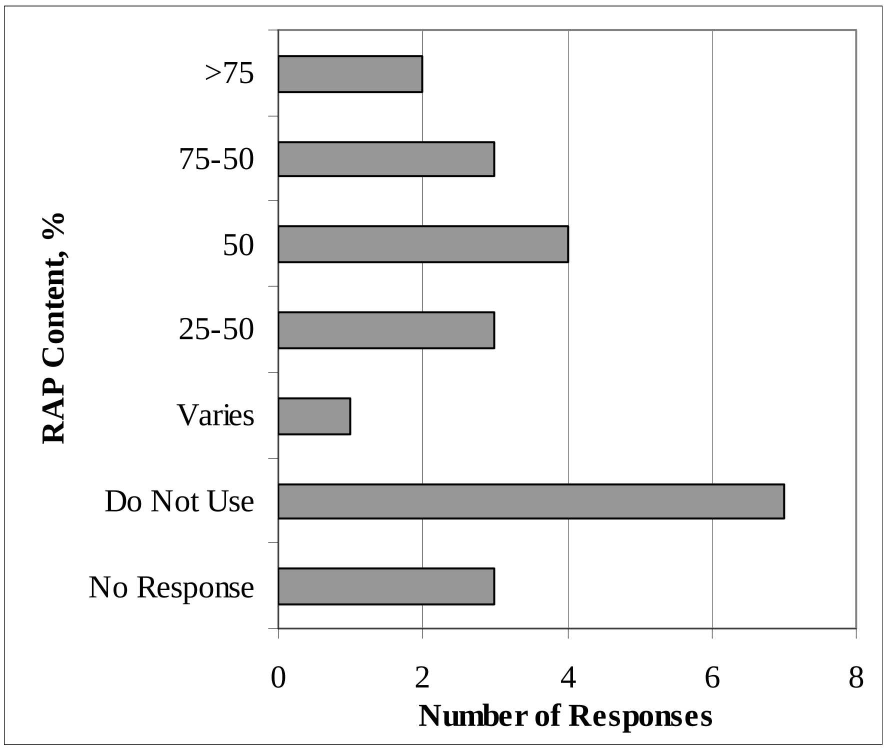

Figure 5.16 RAP contents used.

Question 10: *For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize?*

Eighteen survey participants responded to this question, eight of whom indicated that the question was not applicable. Five survey participants did not respond. Among the remaining respondents, seven indicated the use of in-house specifications. Other responses indicated individual requirements for specific gradations and/or the use of portland cement, crushed stone, gravel, or asphalt.

Question 11: *Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction?*

As depicted in Figure 5.17, the majority of the agencies that answered this question indicated that the performance of full-depth-recycled pavements was good. Only one agency cited bad experience with full-depth-recycled pavements. Also, only one agency did not respond.

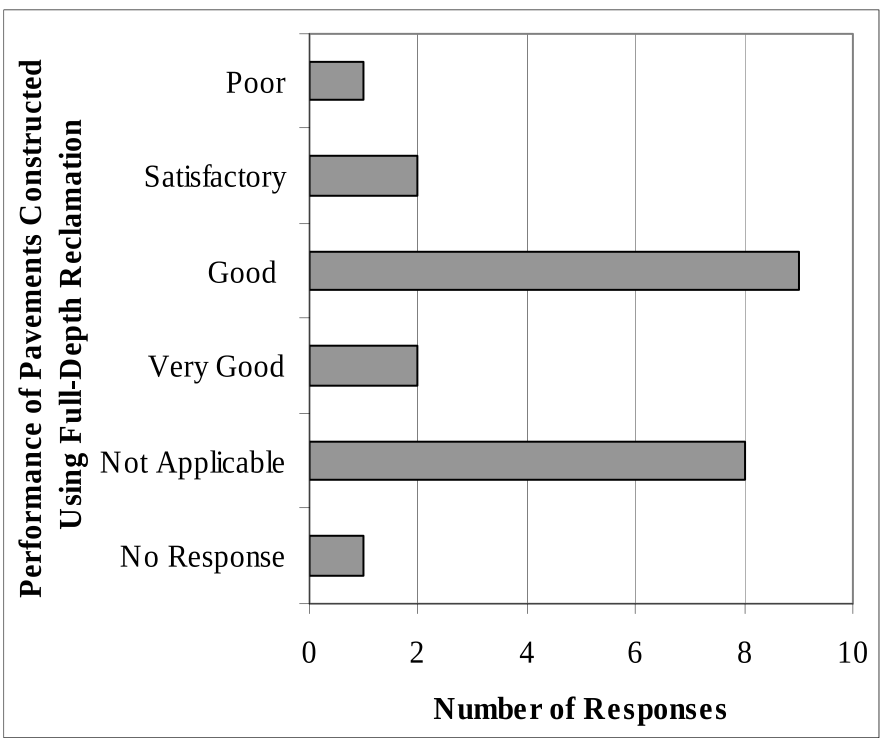

Figure 5.17 Overall opinion of full-depth-recycled pavement.

Question 12: *In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures, if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices.*

Ten of the respondents indicated that the question was not applicable, and two did not respond. Of the answers received, curing seal was the most commonly used, as indicated by five respondents. Maintaining moisture levels and using minimum amounts of portland cement were reported by four respondents. Using geogrids, requiring lower UCS values, precracking, and only stabilizing the subbase layer were all responses given. One of the respondents indicated that they do not require any method for minimizing shrinkage cracking.

Questions 13: *Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic?*

Figure 5.18 indicates that specifying a curing time is the method most frequently used by the survey respondents. Curing times of 3 days and 7 days are most common as indicated by three respondents for each curing time. A 2-day curing time is used by one agency, while another agency requires that paving occur within 2 days of placing the cement-treated layer. Six survey participants did not respond to the question.

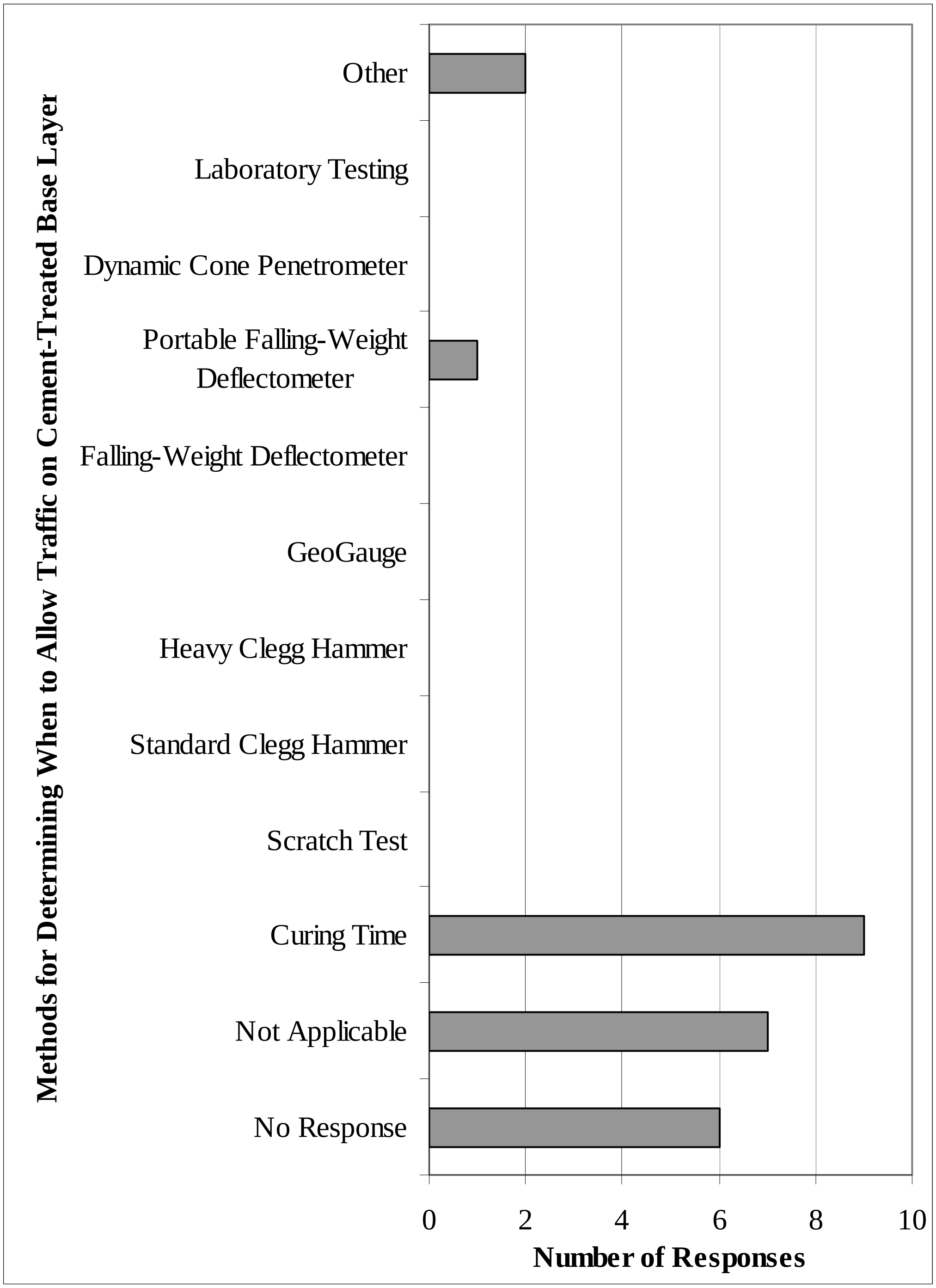

Figure 5.18 Methods used to determine when to open a cement-treated pavement layer to traffic.

Question 14: *Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction?*

Two survey respondents reported very good performance, and five respondents reported good performance. Six participants indicated satisfactory performance. Only one agency reported poor performance of stabilized layers. Three survey participants did not respond.

Question 15: *Do you have pavement projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization?*

Only five agencies indicated plans to utilize full-depth recycling in conjunction with cement stabilization during the next construction season. Only one survey participant did not respond.

5.3.3 Policies

This section discusses responses to the two survey questions that addressed spring and winter pavement loading policies.

Question 1: *Do you require spring load restrictions for pavements in your jurisdiction? If yes, please discuss the restriction and the timing of its placement and removal.*

Thirteen of the 23 agencies that responded to the question reported that they do not require spring load restrictions in their jurisdictions. Nine of the agencies indicated that they do require some type of spring load restriction. Of the agencies that do require spring load restrictions, past experience was the most common method used to determine the timing and duration of the restrictions, as listed by four respondents. Computer modeling and use of a predetermined period of time were methods listed by two and three surveys, respectively. In addition, evaluations of soil and air temperature were cited as methods used by different agencies to determine both the timing and duration of the spring load restrictions.

Question 2: *Do you permit winter load premiums? If yes, please discuss the premium and the timing of its placement and removal.*

Only one of the 23 agencies surveyed allows a winter load premium. One survey participant did not respond to the question.

5.4 SUMMARY

A questionnaire survey was conducted to investigate and document the state of the practice concerning the design and construction of pavements in cold regions. In particular, the various methods and standards employed for characterizing materials, improving soils and aggregates, and determining pavement layer thicknesses were explored. The survey was e-mailed to 42 DOTs, and 23 responses were received. The response rate for the survey was 55 percent.

The survey included 19 questions regarding the experiences of the respondent with frost-susceptible materials, pavement design, and stabilization techniques. Air freezing indices in the various geographic areas represented by the survey participants varied up to 3000ºF-days, and frost penetration ranged from about 1 ft to 8 ft. Among the regions represented by the survey respondents, the AASHTO pavement design method is most commonly used, although many agencies use their own in-house methods for pavement design. A majority of the respondents indicated the use of HMA for surface layers of flexible pavements together with the use of dense-graded aggregate base material and granular subbase material. A few respondents utilize stabilized base or subbase materials. Among the participants specifying the use of rigid pavement sections, granular, stabilized, lean concrete, and asphalt bases were all reported.

The most common methods employed to identify frost-susceptible soils include field experience, laboratory testing, and particle-size distribution. Excavation and replacement of frost-susceptible soils was the most frequently cited method of constructing pavements on frost-susceptible subgrades. Other commonly used methods include the use of edge drains, open-graded drainage layers, and stabilization. The most commonly specified stabilizers are portland cement and lime, but agencies are also using fly ash, asphalt emulsion, foamed asphalt, slag, and calcium chloride. Field experience and UCS testing are the methods most often used for determining the optimum amount of stabilizer to add to a given base or subgrade material. When geogrids are incorporated into the pavement structure, several of the survey respondents indicated that they permit construction of thinner pavement sections.

The majority of the survey participants do not use full-depth recycling. However, when full-depth recycling is used, the typical RAP content is 50 percent, which corresponds to a 50:50 ratio of RAP to base. Common materials and processing specifications utilized for full-depth recycling projects include gradations and the use of specific stabilizers. The majority of the survey respondents reported good, very good, or satisfactory performance of pavements constructed using the full-depth recycling process, but a few indicated poor performance.

The survey results suggest that the most commonly used method for minimizing shrinkage cracking of cement-treated layers is placement of a curing seal. Maintaining moisture levels and using minimum amounts of portland cement were also common responses. In addition, using geogrids, requiring lower UCS values, pre-cracking, and only stabilizing subbase layers are methods employed to minimize cracking.

Curing times typically ranging from 3 to 7 days are most frequently required before a cement-treated pavement layer can be opened to traffic. The majority of the respondents reported very good, good, or satisfactory performance of pavements constructed using chemically or mechanically stabilized layers. At the time the survey was conducted, only a few agencies indicated plans to utilize full-depth recycling in conjunction with cement stabilization during the next construction season.

Spring load restrictions are used by approximately half of the respondents to prevent accelerated damage to pavements during thawing, but only one agency permits winter load premiums. Among the agencies that do require spring load restrictions, past experience was the most common method used to determine the timing and duration of the restrictions. Other responses included computer modeling, use of a predetermined period of time, and evaluation of soil and air temperature.

Although the results of the questionnaire survey reveal a variety of practices, the data suggest that many DOTs utilize similar methods for the design and construction of pavements in cold regions. The information obtained in this research represents a unique compilation of standards of practice that have been developed by DOTs based on years of experience and research in their respective jurisdictions. While this research allows engineers at state DOTs to compare their pavement design and construction practices with those of other states represented in the survey, consulting engineers and engineers in local governments involved in characterizing materials, improving soils and aggregates, and determining pavement layer thicknesses can also benefit from this work.

CHAPTER 6

CONCLUSION

6.1 SUMMARY

Frost-susceptible materials can cause significant damage to roadways in areas that experience cold climates. Repairing damaged areas and constructing adequately for frost action can be very costly. For these reasons, determining if available materials are frost-susceptible and then properly designing the pavement section are extremely important. In this research, a comprehensive literature review was conducted to explore the different methods available for determining the frost susceptibility of soils and aggregates, techniques used for soil and aggregate improvement, and approaches utilized in pavement design to minimize the effects of frost action. In addition, a questionnaire survey was conducted of various state DOTs throughout the United States that are involved with the design and maintenance of roadways.

6.2 FINDINGS

Material testing to assess frost heave, thaw weakening, and freeze-thaw deterioration are often appropriate for cold-regions pavement construction projects. While frost heave rates and SP values computed from actual frost heave tests have been used to classify the frost susceptibility of soils and aggregates, the TST has also been used to rank the susceptibility of pavement materials to frost damage. In ASTM D 5918, the thaw-weakening potential of pavement materials is assessed using CBR tests performed following thawing of specimens previously subjected to frost. Some researchers have suggested using a residual compressive strength test instead of percent mass loss under brushing to assess the freeze-thaw durability of soil-cement specimens. The vacuum saturation test has also been suggested as a faster and less expensive method for assessing the resistance of stabilized materials to freeze-thaw damage.

Because the availability of naturally occurring non-frost-susceptible pavement base materials is rapidly diminishing in many areas, the use of chemical or physical methods to stabilize lower quality materials is increasing. Available stabilizers include portland cement, CKD, lime, LKD, fly ash, LFA, blast furnace slag, bituminous materials, calcium chloride, and proprietary products, which may each be utilized in conjunction with pavement recycling techniques. The addition of a stabilizer to a soil or aggregate generally improves the strength and durability of the mixture, but the proper amount to be added should be determined using the specific laboratory tests recommended for each product. Proper construction techniques must also be followed to ensure that the desired engineering properties are obtained.

Given traffic, materials, and climatic inputs, pavement design for cold regions involves determination of layer thicknesses and specification of features addressing drainage, geomaterials, insulation, winter maintenance, and spring load restrictions and winter load premiums. Although most of the primary pavement design methods do not explicitly account for the effects of seasonal freezing or thawing, the USACE has developed three design methods to account for frost heave and thaw weakening.

According to the questionnaire survey conducted in this research, the most common methods employed to identify frost-susceptible soils include field experience, laboratory testing, and particle-size distribution. Excavation and replacement of frost-susceptible soils was the most frequently cited method of constructing pavements on frost-susceptible subgrades. The most commonly specified stabilizers are portland cement and lime, but agencies are also using fly ash, asphalt emulsion, foamed asphalt, slag, and calcium chloride. Field experience and UCS testing are the methods most often used for determining the optimum amount of stabilizer to add to a given base or subgrade material. When geogrids are incorporated into the pavement structure, several of the survey respondents indicated that they permit construction of thinner pavement sections.

The majority of the survey participants do not use full-depth recycling. However, when full-depth recycling is used, the typical RAP content is 50 percent, which corresponds to a 50:50 ratio of RAP to base. The survey results suggest that the most commonly used method for minimizing shrinkage cracking of cement-treated layers is placement of a curing seal. Curing times typically ranging from 3 to 7 days are most frequently required before a cement-treated pavement layer can be opened to traffic.

Spring load restrictions are used by approximately half of the respondents to prevent accelerated damage to pavements during thawing, but only one agency permits winter load premiums. Among the agencies that do require spring load restrictions, past experience was the most common method used to determine the timing and duration of the restrictions.

Although the results of the questionnaire survey reveal a variety of practices, the data suggest that many DOTs utilize similar methods for the design and construction of pavements in cold regions. The information obtained in this research represents a unique compilation of standards of practice that have been developed by DOTs based on years of experience and research in their respective jurisdictions. While this research allows engineers at state DOTs to compare their pavement design and construction practices with those of other states represented in the survey, consulting engineers and engineers in local governments involved in characterizing materials, improving soils and aggregates, and determining pavement layer thicknesses can also benefit from this work.

6.3 RECOMMENDATIONS

The findings of this research suggest that further development is needed in the areas of determining frost susceptibility classifications, understanding the effects of specific stabilizers on strength and durability of treated materials, and the efficacy of particular pavement features in reducing the effects of frost action. Once established, appropriate methodologies should be standardized for consistent use.

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APPENDIX A

QUESTIONNAIRE SURVEY FORM

This survey is part of a research effort sponsored by the Portland Cement Association and the Recycled Materials Resource Center of the Federal Highway Administration. The principal investigators are Dr. Spencer Guthrie at Brigham Young University and Dr. Heather Miller at the University of Massachusetts at Dartmouth. In this survey, "frost-susceptible" materials are defined as materials that experience damage due to frost action, including but not limited to frost heave, thaw-weakening, or freeze-thaw cycling. All participants will receive a summary of the survey results by e-mail after all of the responses have been compiled. Thank you for your willingness to participate!

INSTRUCTIONS: This survey should be completed using Microsoft Word or equivalent word processing software that supports the automatic formatting features used in this document. Please provide responses that are representative of highways within your jurisdiction. To input your responses, select an item from a drop-down menu, check a box, or type comments directly into a gray text box. In all of the questions using check boxes, more than one answer is permitted. Pressing the tab key or the arrow keys is a convenient method of advancing through the survey and automatically highlights the "Type here" labels for overwriting in the text boxes. When you have completed the survey, save the file and e-mail it to Dr. Guthrie at guthrie@byu.edu. You may also reach him by telephone at (801) 422-3864 or Dr. Miller at (508) 999-8481 should you have questions.

PARTICIPANT:

1. What is your name? Type here

2. What is your job title? Type here

3. For which state department of transportation do you work? Type here

4. What is your phone number? (   )   -

5. What is your e-mail address? Type here

6. Are you interested in sending a 500-lb sample of frost-susceptible aggregate base or subgrade material to Brigham Young University or the University of Massachusetts at Dartmouth for testing as part of this project? Click here; if yes, please briefly describe the material: Type here

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Type here

2. What is the typical depth of frost penetration in your area? Please include units. Type here

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☐ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical flexible (asphalt) highway pavement in your jurisdiction? Please include units.

Surface: Material description: Type here; thickness: Type here
Base: Material description: Type here; thickness: Type here
Subbase: Material description: Type here; thickness: Type here
Other features: Type here

3. What are the layer types and thicknesses of a typical rigid (concrete) highway pavement in your jurisdiction? Please include units.

Surface: Material description: Type here; thickness: Type here
Base: Material description: Type here; thickness: Type here
Subbase: Material description: Type here; thickness: Type here
Other features: Type here

4. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Laboratory testing (Describe: Type here)
- ☐ Field experience (Describe: Type here)
- ☐ Other: Type here

5. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

- ☐ Subgrade processing to remove large stones (Diameter greater than Type here)
- ☐ Excavation and replacement (To a depth of Type here)
- ☐ Chemical or mechanical stabilization
- ☐ Blending with higher quality granular material
- ☐ Use of geosynthetics (Describe type and placement depth: Type here)
- ☐ Use of edge drains
- ☐ Use of open-graded drainage layers (Describe thickness and location:)
- ☐ Use of insulation (Describe thickness and location: Type here)
- ☐ Other: Type here

6. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

- ☐ Portland cement (Applied as Click here)
- ☐ Lime (Applied as Click here)
- ☐ Fly ash (Types: Type here)
- ☐ Slag (Types: Type here)
- ☐ Asphalt emulsion (Types: Type here)
- ☐ Foamed asphalt (Types: Type here)
- ☐ Calcium chloride (Applied as Click here)
- ☐ Proprietary products (Types: Type here)
- ☐ Other: Type here

7. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

- ☐ Supplier or manufacturer recommendations
- ☐ Field experience (Describe: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Unconfined compressive strength (Target value: Type here)
- ☐ Wet-dry brush test (ASTM D 559)
- ☐ Freeze-thaw brush test (ASTM D 560)
- ☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
- ☐ Marshall flow and stability (Describe: Type here)
- ☐ Gyratory compaction testing (Describe: Type here)
- ☐ Other: Type here

8. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? Click here; please discuss the basis for your answer: Type here

9. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an

aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Type here(RAP): Type here(Base)

10. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Type here

11. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Type here

12. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Type here

13. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

14. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Type here

15. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? Click here; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Click here; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? Click here; if yes, please discuss the premium and the timing of its placement and removal: Type here

THANK YOU! Please save this file and e-mail it to Dr. Spencer Guthrie at guthrie@byu.edu. Your participation is greatly appreciated.

APPENDIX B

QUESTIONAIRE SURVEY RESPONSES

ALASKA

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 2,000 to 5,000 degree days F

2. What is the typical depth of frost penetration in your area? Please include units. 8 feet

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☐ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☒ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☒ Mechanistic (Describe software and critical stresses and strains: Alaska Flexible Pavement Design 2003)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Hot Mix Asphalt; thickness: 2 in
Base: Material type: Asphalt Treated Base; thickness: 4 in
Subbase: Material type: GW or GP; thickness: 36 in to 55 in
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Not more than 6% by weight passing the No. 200)

☐ Soil classification (Describe: Type here)
☒ Laboratory testing (Describe: Percent by weight smaller than 0.020 mm)
☐ Field experience (Describe: Type here)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of 5 feet)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☒ Asphalt emulsion (Types: HF-MS-2S)
☒ Foamed asphalt (Types: PG 52-28)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☒ Other: Indirect Tensile Strength

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with

geosynthetics? Yes; please discuss the basis for your answer: Geogrid is used at remote gravel surface runways

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 50(RAP): 50(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? 100% by weigth passing the 2-inch sieve and 95-100% by weight passing the 1.5 inch sieve.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Good

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. I have no experience with cement-treated bases

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Type here

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:
1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: Load restrictions are placed after subsurface temperture probes indicate a temperature rise above 32 F in the seasonal frost zone. Load restrictions are removed after the temperature probes indicate the seasonal frost zone is above 32 F.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

ARIZONA

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 600 - 700 is a typical value for areas with freezing. Units - Degree Days?.

2. What is the typical depth of frost penetration in your area? Please include units. 24.5 - 26.5 inches.

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☒ Other: Arizona DOT - Preliminary Engineering and Design Manual.

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Dense Graded HMA; thickness: 6" - 10"
Base: Material type: Aggregate Base Material; thickness: 6" - 10"
Subbase: Material type: Type here; thickness: Type here
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☒ Soil classification (Describe: Type here)

☒ Laboratory testing (Describe: Type here)
☒ Field experience (Describe: Type here)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of Type here)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☒ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☒ Other: Use of Bituminous Treated Bases.

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☒ Lime (Applied as Slurry)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☒ Supplier or manufacturer recommendations
☒ Field experience (Describe: recommendation of the Designer or Resident Engineer)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☒ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with

geosynthetics? Yes; please discuss the basis for your answer: When using geogrids, we generally will increase the R-Value of the soil by approximately 10 points. This usually will allow for a reduction in AB thickness of around 3 inches.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) We have not performed full depth recycling to my knowledge.(RAP): Type here(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? N/A - see question #8.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? N/A - See question #8.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. No pre-cracking procedure is used according to our ADOT Spec. Section 304.

After final compaction, the CTB will be covered with a bituminous curing seal, applied uniformly to the surface at an approx. rate of 0.15 gallons per square yard. The curing seal is applied on the same day that the final compaction is performed. After the curing seal has been applied, the CTB is kept free of traffic for a period of at least three days. Subsequent subbase, base or pavement course should be placed within 10 days after the curing seal is applied. Type here

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)

☒ Other: After final compaction, the CTB will be covered with a bituminous curing seal, applied uniformly to the surface at an approx. rate of 0.15 gallons per square yard. The curing seal is applied on the same day that the final compaction is performed. After the curing

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. The Department has utilized Cement Treated Bases, Lime stabilization, the use of Geotextile Fabrics and Geogrids. For the most part these treatments have worked satisfactorily.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

<u>COLORADO</u>

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 0 to 2,000 degree-days below 32 degrees F.

2. What is the typical depth of frost penetration in your area? Please include units. 3 feet

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

☒ American Association of State Highway and Transportation Officials (AASHTO)
☐ Asphalt Institute (AI)
☐ National Stone Association (NSA)
☐ Portland Cement Association (PCA)
☐ American Concrete Pavement Association (ACPA)
☐ Corps of Engineers complete protection method
☐ Corps of Engineers limited subgrade frost penetration method
☐ Corps of Engineers reduced subgrade strength method
☐ Mechanistic (Describe software and critical stresses and strains: Type here)
☒ Other: In areas of heaving due to frost, we mitigate the area with 2 feet of expanded foam for insulation and 6 inches of aggregate base course.

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Hot Mixed Asphalt or Portland Cement Concrete ; thickness: 4 to 16 inches of HMA or 5 to 13 inches of PCC
Base: Material type: Crushed Aggregate ; thickness: 4 to 12 inches
Subbase: Material type: ; thickness:
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
☐ Soil classification (Describe: Type here)
☐ Laboratory testing (Describe: Type here)
☒ Field experience (Describe: Type here)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☐ Excavation and replacement (To a depth of Type here)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☒ Use of open-graded drainage layers (Describe thickness and location: Type here)
☒ Use of insulation (Describe thickness and location: 2 feet in the affected area)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☒ Lime (Applied as Slurry)
☒ Fly ash (Types: Class C)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations

☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☒ Unconfined compressive strength (Target value: minimum 125 psi in 7 days)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: The Colorado Department of Transportation does not have any performance data or test locations to support the thinner sections.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Job Specific per Materials Engineer - 8" total depth Max(RAP): Job Specific per Materials Engineer - 8" total depth max typically(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Following is from our current DRAFT spec for FDR: A minimum of two weeks prior to start of the work, the Contractor shall submit in writing a detailed method for maintaining centerline geometry, profile elevations, and cross-slope of the existing roadway to the Engineer. Work will not commence until approval is received from the Engineer. The contractor shall be required to follow the approved plan.

The existing asphalt mat shall be cut at neat lines as shown in the plans by the use of a cutting wheel attached to a blade or by another approved method. The existing asphalt mat shall be pulverized, and mixed with the existing subgrade, base course, or both to a specified depth of up to 8 inches or as directed by the Engineer, with a self propelled rotary type mixing machine. Existing asphalt mat thicknesses and core information will be available upon request. The mixing machine shall make as many passes as required to uniformly mix the asphalt, subgrade, base materials, or both to the required thickness. Mixing of the different materials shall create a homogenous mixture. The particle size of the pulverized asphalt mat shall be a minimum of 99 percent passing the 1 1/2 inch sieve. Unless otherwise approved by the Engineer, the initial addition of water for compaction purposes shall be added through the mixing machine with the capability to uniformly distribute water through the mixed materials to within two percent of the optimum moisture as determined in accordance with AASHTO T-180 Method D.

When proper mixing has been accomplished, the mixture shall then be bladed, shaped, wetted or dried, and rolled to meet a minimum of 95 percent of the maximum dry density determined in accordance with AASHTO T-180 Method D. Grading equipment used to establish the final surface elevations shall have automatic controls for transverse slope. The transverse slope controls shall be capable of maintaining the final surface within 0.1 percent of the specified slope. Variations from the subgrade plane shall not be more than ¼ inch. The work shall be maintained and tested for conformance to these requirements immediately prior to placing additional pavement layers. An application of diluted emulsified asphalt may be required before placement of the bottom layer of hot bituminous pavement.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Performing according to expectations

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Portland cement has not been used in Colorado for a number of years.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Lime stabilized bases appear to be perfoming well.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

<u>CONNECTICUT</u>

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 20-yr (95%) probabilities: Station data ranges from 638 ºF-days (Norwalk) to 1474ºF-days (Norfolk) depending on location within the state. (Source: http://www.ncdc.noaa.gov/oa/fpsf/fpsfpublications.html)

2. What is the typical depth of frost penetration in your area? Please include units. 19 - 30 inches

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Hot-mix asphalt (HMA); thickness: Varies, 3-4 inches
Base: Material type: Varies: Existing Portland Cement Concrete pavement (8-10 inches), HMA, Existing macadam bases (bituminous-penetrated), Processed Aggregate Base (Manufactured, crushed gravel); thickness: Varies, 4-10 inches
Subbase: Material type: Subbase (gravel with certain specifications); thickness: Varies, 10-14 inches
Other features: Base layer type and thickness depends on traffic loading, minimum thickness for frost protection, and existing pavement.

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☐ Soil classification (Describe: Type here)
- ☒ Laboratory testing (Describe: AASHTO T104-Soundness Test)
- ☐ Field experience (Describe: Type here)
- ☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

- ☐ Subgrade processing to remove large stones (Diameter greater than Type here)
- ☒ Excavation and replacement (To a depth of (below frost and or water table). Usually accompanied with some type of underdrain system or methodology)
- ☐ Chemical or mechanical stabilization
- ☐ Blending with higher quality granular material
- ☐ Use of geosynthetics (Describe type and placement depth: Type here)
- ☒ Use of edge drains
- ☒ Use of open-graded drainage layers (Describe thickness and location: Only used in isolated very problematic high water table areas - such as areas where springs or seepage are intruding into the roadbed)
- ☐ Use of insulation (Describe thickness and location: Type here)
- ☒ Other: Use a minimum total pavement-structure thickness (including unbound layers) of 19 inches; also, use of underdrains where appropriate.

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

- ☐ Portland cement (Applied as Click here)
- ☐ Lime (Applied as Click here)
- ☐ Fly ash (Types: Type here)
- ☐ Slag (Types: Type here)
- ☐ Asphalt emulsion (Types: Type here)
- ☐ Foamed asphalt (Types: Type here)
- ☐ Calcium chloride (Applied as Click here)
- ☐ Proprietary products (Types: Type here)
- ☒ Other: Do not use

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

- ☐ Supplier or manufacturer recommendations
- ☒ Field experience (Describe: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Unconfined compressive strength (Target value: Type here)
- ☐ Wet-dry brush test (ASTM D 559)
- ☐ Freeze-thaw brush test (ASTM D 560)

☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Does not apply

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Geosynthetics have not been used in Connecticut for structural reinforcement in the pavement structure, except for experimental sections for reflection crack retardation. Geofabrics have been used as a filter layer to prevent the intrusion of fines into the subbase layer. They are occasionally used to stabilize subgrade areas. In summary, they are used to fix problematic areas - usually in the deeper granular layers (subgrade). They are never used to enhance already "adequate" subgrade, subbase, or other pavement layers and therefore used as a mechanism for reducing granular base and/or bituminous layer thicknesses.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) No set standard ratio. Ratio dictated very much by existing roadway composition. Not to exceed 50 %(RAP): Minimum greater than 50 %(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? We will stabilize by adding virgin crushed stone to improve recycled base material characteristics. We almost never chemically stabilize.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Connecticut DOT considers this construction methodology a cost-effective way of upgrading the pavement structure for existing roadways that exhibit substantial deterioration and a structural capacity deficiency (many roads that over the years have been "accepted" into the State highway system, rather than built to more stringent design standards.) Many of our local roadways are just "worn out". They were built with thin asphaltic surfaces on natural gravel bases. Much of the distress is drainage related or just simply old age related (thermal/block cracking). Reclamation is an excellent alternative because existing roadway materials, when recycled, almost never need any enhancement or modification (stabilizing agents). With other improvements, such as drainage (both surface and subsurface), many roadways in CT can be simply pulverized, graded, compacted and repaved.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking

procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Connecticut DOT does not build cement-treated base layers.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☒ Other: Does Not Apply

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Does not apply

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

IDAHO

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Air freezing index varies from 2 to 1400 degree F-days in Idaho.

2. What is the typical depth of frost penetration in your area? Please include units. 18 inches to 3 feet typical frost penetration.

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☐ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☒ Other: Frost action is not directly designed for.

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Hot Mix Asphalt; thickness: 0.35'
Base: Material type: 3/4' crushed aggregate base; thickness: 0.6'
Subbase: Material type: 4' minus granular subbase; thickness: 1' or more
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Laboratory testing (Describe: Type here)
- ☐ Field experience (Describe: Type here)
- ☒ Other: Frost action is not designed for.

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

- ☐ Subgrade processing to remove large stones (Diameter greater than Type here)
- ☒ Excavation and replacement (To a depth of 18" to 3')
- ☐ Chemical or mechanical stabilization
- ☐ Blending with higher quality granular material
- ☐ Use of geosynthetics (Describe type and placement depth: Type here)
- ☒ Use of edge drains
- ☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
- ☐ Use of insulation (Describe thickness and location: Type here)
- ☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

- ☐ Portland cement (Applied as Click here)
- ☐ Lime (Applied as Click here)
- ☐ Fly ash (Types: Type here)
- ☐ Slag (Types: Type here)
- ☐ Asphalt emulsion (Types: Type here)
- ☐ Foamed asphalt (Types: Type here)
- ☐ Calcium chloride (Applied as Click here)
- ☐ Proprietary products (Types: Type here)
- ☒ Other: None

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

- ☐ Supplier or manufacturer recommendations
- ☐ Field experience (Describe: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Unconfined compressive strength (Target value: Type here)
- ☐ Wet-dry brush test (ASTM D 559)
- ☐ Freeze-thaw brush test (ASTM D 560)
- ☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
- ☐ Marshall flow and stability (Describe: Type here)
- ☐ Gyratory compaction testing (Describe: Type here)
- ☒ Other: N/A

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? Yes; please discuss the basis for your answer: We use Tensar's Spectrapave software and apply a traffic benefit ratio.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 80(RAP): 20(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? ITD has developed a standard special provision for full depth reclaimaion.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? The process has worked very well in Idaho. Almost all of the projects have performed well so far with the oldest projects approaching ten years old.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Idaho uses small amounts of cement, 2%, to bind up fine particles and to ensure the mixture does not achieve high strengths.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☒ Curing time (Describe specification: Contractor keeps the material moist until he applys a CSS-1 curing seal. The contractor must pave within 48 hours of applying cement.)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Performance has been good for projects using cement stabilization. We have been able to turn thick cracked pavement with very little base into thinner pavement and a thick stabilized base.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? Yes; if yes, please briefly describe the projects: These types of projects are very common in Idaho. They are used when we need to rehabilitate old pavement and create a uniform stabilized base which to place a thinner pavement on.

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: Restrictions and timing are primarily based on the experience of the individual maintence personnel involved.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

INDIANA

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Type here

2. What is the typical depth of frost penetration in your area? Please include units. 24 inches South to 36 inches North

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.
   - ☒ American Association of State Highway and Transportation Officials (AASHTO)
   - ☐ Asphalt Institute (AI)
   - ☐ National Stone Association (NSA)
   - ☐ Portland Cement Association (PCA)
   - ☐ American Concrete Pavement Association (ACPA)
   - ☐ Corps of Engineers complete protection method
   - ☐ Corps of Engineers limited subgrade frost penetration method
   - ☐ Corps of Engineers reduced subgrade strength method
   - ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
   - ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

   Surface: Material type: PCCP; thickness: 10 TO 14 Inches
   Base: Material type: Type here; thickness: Type here
   Subbase: Material type: Unbounded Aggregate; thickness: 9 inches
   Other features: HMA Full depth 12 inches (1.5 inch Surface,2.5 inches Intermediate, 8 inches base)

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.
   - ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
   - ☒ Soil classification (Describe: Type here)
   - ☒ Laboratory testing (Describe: Type here)
   - ☐ Field experience (Describe: Type here)
   - ☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.
   - ☐ Subgrade processing to remove large stones (Diameter greater than Type here)
   - ☒ Excavation and replacement (To a depth of 24 inches)

☒ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☒ Use of edge drains
☒ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Click here)
☒ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☒ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☒ Soil classification (Describe: Type here)
☒ Unconfined compressive strength (Target value: >50 PSI FOR LIME & 100 PSI FOR CEMENT)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☒ Other: By PH Test for Lime

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Type here

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Don't do(RAP): Type here(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Don't do

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? don’t do

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. don’t require

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: don’t do)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. none

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

KANSAS

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Type here

2. What is the typical depth of frost penetration in your area? Please include units. 30"

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☐ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☒ Other: We do not consider frost action in our designs. We have not seen much freezing below the bound pavement layers.

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: 9" PCCP (NRDJ); thickness: 15" HMA
Base: Material type: 4" PCTB; thickness:
Subbase: Material type: ; thickness:
Other features: 6" Lime Treated Subgrade

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Laboratory testing (Describe: Type here)
- ☐ Field experience (Describe: Type here)
- ☒ Other: Not concerned

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

- ☐ Subgrade processing to remove large stones (Diameter greater than Type here)
- ☐ Excavation and replacement (To a depth of Type here)
- ☒ Chemical or mechanical stabilization

☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☒ Lime (Applied as Click here)
☒ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☒ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☒ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: We have used geogrids twice where we have thinned up our base. Both sections failed. We do not plan to thin up our bases when a geogrid is used.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Type here(RAP): Type here(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Type here

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? We do not full depth recycle.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Protection and Curing. Keep the surface of the CTB moist until the curing material is applied. Apply the curing material immediately after completing the trimming and finishing. Protect the CTB against the loss of moisture for a curing period of 7 days (unless the Contractor’s mix design test results justify a different curing period). Protect the CTB against freezing during the curing period.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☒ Other: Keep all traffic and construction equipment off of the CTB. The only exception is the equipment used to apply the curing material.

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Bases using both asphalt and cement used as a binder perform satisfactorily. Bases with asphalt binders must be designed to withstand stripping and bases with cement binders must be monitored to avoid creating too stiff of a base resulting in premature cracking in the base or loss of support due to curling and warping.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:
1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

MAINE

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 1100 degree-days(coastal) to 2500 degree days (inland, mountains)

2. What is the typical depth of frost penetration in your area? Please include units. under snow-free pavements, 3 feet (coastal) to 7 feet (inland, mountains)

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: HMA; thickness: 6 inches
Base: Material type: Type here; thickness: Type here
Subbase: Material type: aggregate, A-1-b; thickness: 24 inches
Other features: NOTE: Maine has a wide range of traffic conditions and the HMA thicknesses can vary greatly. Using the AASHTO design method, Arterial highways typically have an HMA range of 6 inches to 10 inches. When HMA layer become thick, we typically look at using various materials (select aggregates, geosynthetics, recycled asphalt with stabilizers) in the pavement structure to reduce the HMA thickness.

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: #200, 7 %)
- ☐ Soil classification (Describe:)
- ☒ Laboratory testing (Describe: MaineDOT and Army Corp of Engineers Classification Systems)
- ☒ Field experience (Describe: Monitoring of frost action)
- ☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

- ☒ Subgrade processing to remove large stones (Diameter greater than 12")
- ☒ Excavation and replacement (To a depth of 30 inches)
- ☐ Chemical or mechanical stabilization
- ☐ Blending with higher quality granular material
- ☒ Use of geosynthetics (Describe type and placement depth: Drainage geocomposites, geotextiles, and geogrids between subbase and subgrade.)
- ☒ Use of edge drains
- ☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
- ☐ Use of insulation (Describe thickness and location: Type here)
- ☒ Other: Underdrains at approximately 4.5 feet in depth to extend the groundwater depth below subbase. We have used some of the other methods described above, but only in a research application.

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

- ☒ Portland cement (Applied as Click here)
- ☐ Lime (Applied as Click here)
- ☐ Fly ash (Types: Type here)
- ☐ Slag (Types: Type here)
- ☒ Asphalt emulsion (Types: Type here)
- ☒ Foamed asphalt (Types: Type here)
- ☐ Calcium chloride (Applied as Click here)
- ☐ Proprietary products (Types: Type here)
- ☒ Other: We typically add 1-2% cement with the above treatments/

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

- ☐ Supplier or manufacturer recommendations
- ☒ Field experience (Describe: Keep trying to improve each year as we progress)
- ☐ Soil classification (Describe: Type here)
- ☐ Unconfined compressive strength (Target value: Type here)
- ☐ Wet-dry brush test (ASTM D 559)

☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☒ Gyratory compaction testing (Describe: Run samples at 50 gyrations and look for 6% +- air voids)
☒ Other: Use the Wirtgen process for foam asphalt

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? Yes; please discuss the basis for your answer: Geogrids are considered eqivalent to 6 inches of gravel.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 80%(RAP): 20%(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? We take 100% recycled pavement with 100% passing the 11/2" screen and mix it with 1.5% cement, 3-3.5 % emulsion and 3-6% water in a pug mill and lay 3" thick with a paver. We call this process PM-RAP.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction?   Very positive. Treatments that last and are economical as long as good construction practices are used.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. We do not do cement only treated pavement layers.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.
☐ Curing time (Describe specification: Type here)
☐ Scratch test (Describe method and decision-making approach: Type here)
☐ Standard Clegg hammer (Provide threshold value: Type here)
☐ Heavy Clegg hammer (Provide threshold value: Type here)
☐ GeoGauge (Provide threshold value: Type here)
☐ Falling-weight deflectometer (Provide threshold value: Type here)
☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)

☐ Dynamic cone penetrometer (Provide threshold value: Type here)
☐ Laboratory testing (Describe tests and provide threshold values: Type here)
☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Foamed asphalt with 1-2% cement is a long lasting economical treatment. Once constructed we do not cover with pavement for at least 48 hours. We have had two experiences where foamed did not work well and both were constructed late in the year when the weather was cold and wet. Our specifications have been changed to address this problem. PM-RAP (see question #9) works very well when you want to raise or lower the grade of the road. Geotextiles have performed exceptionally well in base and subgrade stabilization.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? Click here; if yes, please briefly describe the projects: Type here

POLICIES:
1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: Only on certain roads and during Mid-March through Mid-May.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

<u>MARYLAND</u>

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 250-1000 °F-Days

2. What is the typical depth of frost penetration in your area? Please include units. varies from 15" to 45"

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

☒ American Association of State Highway and Transportation Officials (AASHTO)
☐ Asphalt Institute (AI)
☐ National Stone Association (NSA)
☐ Portland Cement Association (PCA)
☐ American Concrete Pavement Association (ACPA)

☐ Corps of Engineers complete protection method
☐ Corps of Engineers limited subgrade frost penetration method
☐ Corps of Engineers reduced subgrade strength method
☐ Mechanistic (Describe software and critical stresses and strains: Type here)
☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Hot Mix Asphalt Superpave 9.5 mm or 12.5 mm ; thickness: 1.5"-2"
Base: Material type: Hot Mix Asphalt Superpave 19.0 mm or 25.0 mm; thickness: 6"-12"
Subbase: Material type: Graded Aggregate Base or Sand; thickness: 6"-12"
Other features: Longidudinal Underdrain

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
☒ Soil classification (Describe: Silts (MD Soil Classifications A-4, A-5); Silty Clays (MD Soil Classification A-7-4); Clayey Silts (MD Soil Classification A-4-7); Sandy Silt (MD Soil Classification A-4-2))
☐ Laboratory testing (Describe: Type here)
☒ Field experience (Describe: Type here)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of local average frost depth)
☒ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☒ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☒ Other: increase total pavement section thickness to atleast 2/3 of local average frost depth

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☒ Lime (Applied as Dry powder)
☐ Fly ash (Types: Type here)

☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☒ Unconfined compressive strength (Target value: Cement Modified Subgrade - 300 psi; Soil Cement Base Course - 450 psi; Cement Treated Aggregate Base - 750 psi; Lime Treated Subgrade - 5o psi increase over raw soil value)
☒ Wet-dry brush test (ASTM D 559)
☒ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☒ Other: Lime Treated Subgrade - Eades & Grimm procedure

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: no proven structural value for geosynthetics

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Full depth recycling not used. (RAP): Full depth recycling not used. (Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? N/A

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? N/A

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Soil-Cement Base Course - Limit cement content to 9%, use a select

base soil; Cement Modified Subgrade - Limit cement content to 5-7%, use granular layer between cement modified subgrade and HMA, use thick (greater than 6") HMA layer,

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☒ Curing time (Describe specification: 7 days)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Cement Modified Subgrade - good, pavement performs as expected through design life; Soil-Cement Base Course - good (pavement performs as expected through design life) to very poor (excessive reflective cracking); Cement Treated Base Course - good, pavement performs as expected through design life; Lime Treated Subgrade - good, pavement performs as expected through design life; Cement-Flyash Base - good performance (one project in place less than 5 years)

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

<u>MINNESOTA</u>

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Ranges from 1800 F-days (south) to 2700 F-days (north).

2. What is the typical depth of frost penetration in your area? Please include units. 4 to 8 feet

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☒ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ U.S. Army Corps of Engineers complete protection method
- ☐ U. S. Army Corps of Engineers limited subgrade frost penetration method
- ☐ U. S. Army Corps of Engineers reduced subgrade strength method
- ☒ Mechanistic (Describe software and critical stresses and strains: MnPAVE - developed in house, is used for smaller construction jobs and rehabilitation jobs on a trial basis.)
- ☒ Other: Modified AASHO design is used for flexible pavements. AASHO results modified based on Mn/DOT Investigation 183.

2. What are the layer types and thicknesses of a typical flexible (asphalt) highway pavement in your jurisdiction? Please include units.

Surface: Material description: Gyratory HMA; thickness: 4 to 10 inches
Base: Material description: Dense-graded agg base; thickness: 3 to 10 inches
Subbase: Material description: Granular material; thickness: 12 to 36 inches
Other features: subsurface drainage utilized in areas with soils having greater than 20 percent passing #200.

3. What are the layer types and thicknesses of a typical rigid (concrete) highway pavement in your jurisdiction? Please include units.

Surface: Material description: PCC; thickness: 7 to 14 inches
Base: Material description: Dense-graded agg base; thickness: 3 to 6 inches
Subbase: Material description: Granular material; thickness: 12 to 48 inches
Other features: subsurface drainage utilized in areas with soils having greater than 20 percent passing #200.

4. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☐ Soil classification (Describe: Type here)
- ☒ Laboratory testing (Describe: A limited amount of lab testing has been performed by the US Army CRREL)
- ☒ Field experience (Describe: Our bases are mostly non-frost susceptible. It has been shown that materials meeting our subbase specification can be moderately

frost susceptible but any heave has been measured to be fairly uniform. Spring thaw-weakening has been observed in bases on lighter designs.)

☐ Other: Type here

5. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of 3 to 4 feet)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☒ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

6. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

7. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

8. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Geosynthetics are typically

used in areas of problematic soils such as organics or saturated mineral soils. In these cases geosynthetics are used to provide constructability in a situation where construction would otherwise not be possible.

9. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 40 to 60(RAP): 60 to 40(Base)

10. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Type here

11. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Experience is new with this approach but so far they exhibit performance similar to reconstruction by remove and replace methods.

12. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Type here

13. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

14. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. We have not done many projects using chemically stabilized layers.

15. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: Restrictions are used as a preservation approach on older roads that are in poor condition. Less than 10 percent of Mn/DOT network is restricted on an annual basis. Efforts are made to improve these roads when funding allows.

2. Do you permit winter load premiums? Yes; if yes, please discuss the premium and the timing of its placement and removal: Placement and removal timing are based on air temperature freezing and thawing indices. Procedures and criteria can be found at www.mrr.dot.state.mn.us.

MONTANA

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. The air freezing index ranges from 1500 in the western portion of the state to 3500 in the eastern portion.

2. What is the typical depth of frost penetration in your area? Please include units. 32 in. +/-

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Asphalt Concrete; thickness: 150 mm minimum on Interstates, 90 mm elsewhere

Base: Material type: Crushed Aggregate; thickness: 200 mm minimum

Subbase: Material type: N/A; thickness:
Other features: We use the 1993 AASHTO Pavement Design Guide to determine layer thicknesses. We also use cement treated base (CTB) where gravel sources are scarce.

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
☐ Soil classification (Describe: Type here)
☐ Laboratory testing (Describe: Type here)
☒ Field experience (Describe: We may remove and replace subgrade material based on observed pavement distress causes by frost.)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of based on recommendations from the geotechnical bureau)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☒ Other: We stabilize for constructibility issues only. Typically this involves removing 600mm of the existing material and replacing with special borrow material.

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

- ☐ Supplier or manufacturer recommendations
- ☐ Field experience (Describe: Type here)
- ☐ Soil classification (Describe: Type here)
- ☒ Unconfined compressive strength (Target value: 400 psi @ 7 days)
- ☐ Wet-dry brush test (ASTM D 559)
- ☐ Freeze-thaw brush test (ASTM D 560)
- ☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
- ☐ Marshall flow and stability (Describe: Type here)
- ☐ Gyratory compaction testing (Describe: Type here)
- ☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: We use geosynthetics under our "digouts" (excavation and replacement of unsuitable subgrade) as a seperation layer between the existing subgrade and the replacement materials. We do not typically use geogrids within embankments.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 50(RAP): 50(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? We also specify "in-place cement treated base" where we pulverize porland cement into the reclaimed asphalt/base mixture.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? We are satisfied with the performance.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. During compaction and finishing of cement treated base (CTB) we do not permit the moisture content to fall below the specified optimum. When needed, moisture is applied using a uniform fog spray. After the surface of the CTB is finished, bituminous curing seal is appled at 0.2 gallons per square yard. Before applying the curing seal, we make sure that the CTB has sufficient moisture to prevent asphalt

penetration. Blotter material is applied before traffic is applied to base. We do not pave over the CTB until at least 7 days after the curing seal is applied.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☒ Other: We apply traffic to the cement treated base (CTB) as soon as the compaction requirements are met, curing material is applied, and blotter material is applied.

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. We have constructed numerous pavements utilizing cement treated base (CTB). Typically we use an 8-inch thick CTB layer as a mininum but increase the thickness where needed. CTB is used where aggregate is scarce as a way to save on the amount of aggregate hauled to the work site. We have been happy with the performance of CTB.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: The spring load restriction is placed by the maintenance section. The maintenance chief from each of our five districts will assess when the spring thaw is occuring. They then contact the motor carrier section to enforce the spring load restriction. The maintenance chief also accesses when the spring thaw is over and the restrictions can be lifted. Typically the spring load restrictions are only placed on secondary roads that do not have enough structure support heavy loads during the thaws. Primary roads do not have spring load restrictions.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

NEVADA

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Type here

2. What is the typical depth of frost penetration in your area? Please include units. 0 to 3 inches

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☐ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☒ Other: N/A

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Open Grade; thickness: 3/4"
Base: Material type: Plantmix Bituminous Mix; thickness: 6"
Subbase: Material type: Base Aggregate; thickness: 16"
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Laboratory testing (Describe: Type here)
- ☐ Field experience (Describe: Type here)
- ☒ Other: N/A

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

- ☐ Subgrade processing to remove large stones (Diameter greater than Type here)
- ☐ Excavation and replacement (To a depth of Type here)
- ☐ Chemical or mechanical stabilization

☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☒ Field experience (Describe: 2% for roadbed modification)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Layers are only reduced due to utility conflicts or profile conflicts.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 40(RAP): 60(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? NDOT specifications for Roadbed Modification

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Performance varies with climate but best performance is areas with lower precipitation.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. We limit the cement content to 2%. Although some cracking is still observed.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☒ Curing time (Describe specification: 48 hours)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. We only use cement with our roadbed modificiaton process. We have the best performance in areas of low moisture and percipitation.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? Yes; if yes, please briefly describe the projects: Us 95 in Searchlight, NV that includes roabed modify 8" abd okace a 6" Plantmix Overlay with open Grade.

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: In effect on certain identified roads from 1st Monday in February to last Friday in April. Restriction are that loads must meet legal axle weights.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: I assume you mean increased loads due to frozen ground. However at any time the public can submit for an overlaod permit for evaluation except as noted above.

NEW HAMPSHIRE

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Don't know

2. What is the typical depth of frost penetration in your area? Please include units. 2 to 6 feet and more.

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Asphalt pavement; thickness: 6"
Base: Material type: Sand, gravel, crushed aggregate; thickness: 2-3 feet
Subbase: Material type: None; thickness: Type here
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: <12% of matewrial passing the #4 passing #200)
- ☐ Soil classification (Describe: Type here)
- ☐ Laboratory testing (Describe: Type here)
- ☐ Field experience (Describe: Type here)
- ☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

- ☐ Subgrade processing to remove large stones (Diameter greater than Type here)
- ☒ Excavation and replacement (To a depth of depth required based on climate)
- ☐ Chemical or mechanical stabilization
- ☐ Blending with higher quality granular material
- ☐ Use of geosynthetics (Describe type and placement depth: Type here)
- ☐ Use of edge drains
- ☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
- ☐ Use of insulation (Describe thickness and location: Type here)
- ☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

- ☐ Portland cement (Applied as Click here)
- ☐ Lime (Applied as Click here)
- ☐ Fly ash (Types: Type here)
- ☐ Slag (Types: Type here)
- ☐ Asphalt emulsion (Types: Type here)
- ☐ Foamed asphalt (Types: Type here)
- ☐ Calcium chloride (Applied as Click here)
- ☐ Proprietary products (Types: Type here)
- ☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

- ☐ Supplier or manufacturer recommendations
- ☐ Field experience (Describe: Type here)
- ☐ Soil classification (Describe: Type here)
- ☐ Unconfined compressive strength (Target value: Type here)
- ☐ Wet-dry brush test (ASTM D 559)
- ☐ Freeze-thaw brush test (ASTM D 560)
- ☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
- ☐ Marshall flow and stability (Describe: Type here)
- ☐ Gyratory compaction testing (Describe: Type here)
- ☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Type here

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60

percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 60(RAP): 40(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Type here

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Sometimes early fatigue of pavement layers

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Don't use

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Type here

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: Based on when thaw occurs, usually based on experience of the person making the decision on local level.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

NEW JERSEY

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Type here

2. What is the typical depth of frost penetration in your area? Please include units. <12 inches typically

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Hot Mix Asphalt; thickness: 8-12 inches
Base: Material type: Dense Graded Aggregate Base; thickness: 6 inches
Subbase: Material type: Soil Aggregate; thickness: variable
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: >25% passing #200)
- ☒ Soil classification (Describe: silty or clayey soil classifications)
- ☒ Laboratory testing (Describe: gradations and atteberg limits done on borings)
- ☐ Field experience (Describe: Type here)
- ☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of 2 feet)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☒ Use of geosynthetics (Describe type and placement depth: Below subbase)
☒ Use of edge drains
☒ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: grids and fabrics

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base

material to create a new base layer.) Do not use full-depth recycling rountinely. (RAP): n/a(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? n/a

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? n/a

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. n/a

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. We don't use these techniques.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

NEW YORK

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 500 to 1100 freezing-degree-days Celsius

2. What is the typical depth of frost penetration in your area? Please include units. 2 to 5 feet

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

   ☒ American Association of State Highway and Transportation Officials (AASHTO)
   ☐ Asphalt Institute (AI)
   ☐ National Stone Association (NSA)
   ☐ Portland Cement Association (PCA)
   ☐ American Concrete Pavement Association (ACPA)
   ☐ Corps of Engineers complete protection method
   ☐ Corps of Engineers limited subgrade frost penetration method
   ☐ Corps of Engineers reduced subgrade strength method
   ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
   ☒ Other: New York State empirical

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

   Surface: Material type: PCC&HMA; thickness: 6 to12 inches
   Base: Material type: Stabilized drainage layer; thickness: 4 inches
   Subbase: Material type: Dense-graded granular; thickness: 12 inches
   Other features: Continuous edge drains and 1 to 2 feet of select granular subgrade

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

   ☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: 10% passing 200 sieve)
   ☒ Soil classification (Describe: Silts and fine sands)
   ☐ Laboratory testing (Describe: Type here)
   ☐ Field experience (Describe: Type here)
   ☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

   ☒ Subgrade processing to remove large stones (Diameter greater than one foot)
   ☒ Excavation and replacement (To a depth of four feet)
   ☐ Chemical or mechanical stabilization

☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☒ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☒ Other: Herringbone drains, rock subgrade fragmentation, broken rock trench

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.
☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.
☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? Yes; please discuss the basis for your answer: Only used in urban areas with extensive buried utilities which make removal & replacement to depth impractical, primarily a structural solution.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Type here(RAP): Type here(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Type here

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Type here

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Haven't used for thirty years due to cracking problems.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Cement works better for silts, lime works better for clays, both crack thermally and are more expensive than removal and replacement with good granular materials so we don't use them anymore.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

NORTH CAROLINA

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Type here

2. What is the typical depth of frost penetration in your area? Please include units. Type here

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ U.S. Army Corps of Engineers complete protection method
- ☐ U. S. Army Corps of Engineers limited subgrade frost penetration method
- ☐ U. S. Army Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical flexible (asphalt) highway pavement in your jurisdiction? Please include units.

Surface: Material description: Surface and BinderType here; thickness: 6 in.
Base: Material description: Dense Graded Aggregate Base Course; thickness: 8 in.
Subbase: Material description: Cement or Lime Stabilized Soils; thickness: 8 in.
Other features: Type here

3. What are the layer types and thicknesses of a typical rigid (concrete) highway pavement in your jurisdiction? Please include units.

Surface: Material description: Jointed Plain Concrete; thickness: 11" to 14"
Base: Material description: Asphalt Base; thickness: 4'
Subbase: Material description: Cement or Lime Stabilized Soil; thickness: 8"
Other features: Type here

4. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: For Aggregate Base Course #10 = 45%, #40= 30% and #200=12%)
- ☐ Soil classification (Describe: Type here)
- ☐ Laboratory testing (Describe: Type here)

☐ Field experience (Describe: Type here)
☐ Other: Type here

5. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☐ Excavation and replacement (To a depth of Type here)
☒ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

6. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☒ Lime (Applied as Slurry)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

7. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☒ Unconfined compressive strength (Target value: Lime=60psi Cement = 250psi)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

8. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? Click here; please discuss the basis for your answer: Type here

9. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Type here(RAP): Type here(Base)

10. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? Type here

11. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Very good performance so far.

12. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. We stopped stabilizing Base material with cement. We generally cement stabilize the subgrade soils and then place a Dense Graded Aggregate Base layer on top. This arrests propagation of cracks

13. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☒ Curing time (Describe specification: 7 days at temperatures above 40 degrees F)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☒ Portable falling-weight deflectometer (Describe type and provide threshold value:Currently investigating use of this device)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

14. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Lime and Cement have performed very well.

15. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement

stabilization? Yes; if yes, please briefly describe the projects: Mainly 2 lane rural highways

POLICIES:
1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

OHIO

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Ranges from 220 to 370 C-days

2. What is the typical depth of frost penetration in your area? Please include units. 30" in central Ohio

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: PCC or AC; thickness: PCC: 9" to 14", AC: 7" to 17"
Base: Material type: crushed aggregate; thickness: 6"
Subbase: Material type: Type here; thickness: Type here
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: aggregate base - no more than 15% passing the # 200 sieve)
- ☐ Soil classification (Describe: Type here)

☐ Laboratory testing (Describe: Type here)
☒ Field experience (Describe: A-4b soils)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of varies, typically 2' to 3')
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Do not have the research to support a reduction in pavement thickness

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) N/A(RAP): N/A(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? N/A

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? N/A

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Type here

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Our stabilized sections are only a few years old. Do not have enough performance data to make any conclusions at this time.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:
1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

PENNSYLVANIA

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Design freezing index values in PA range from 184 (Pt. Breeze in Philadelphia County) to 1585 (Titusville Water Works in Crawford County). PA's median value is 920 and the average is 909. Units are degree days.

2. What is the typical depth of frost penetration in your area? Please include units. 3'

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☒ Other: Commonwealth of PA, Publication 242, Pavement Policy Manual

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: surface; thickness: 3.5 - 4"
Base: Material type: RCCP & HMA; thickness: 5 - 15"
Subbase: Material type: 2A; thickness: 8" to As Required
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☒ Soil classification (Describe: Type here)
- ☒ Laboratory testing (Describe: Type here)

☒ Field experience (Describe: Type here)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of depth of material up to 4')
☒ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☒ Use of geosynthetics (Describe type and placement depth: geogrids and geotextiles)
☒ Use of edge drains
☒ Use of open-graded drainage layers (Describe thickness and location: 2B or AASHTO 1)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☒ Lime (Applied as Dry powder)
☒ Fly ash (Types: Type here)
☒ Slag (Types: Type here)
☒ Asphalt emulsion (Types: Prime coats more commonly used 15 years ago)
☐ Foamed asphalt (Types: Type here)
☒ Calcium chloride (Applied as Dry crystals)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☒ Field experience (Describe: Soils technician on job during operations)
☒ Soil classification (Describe: primarily silts and clays)
☒ Unconfined compressive strength (Target value: approx. 150 psi 3-day strength)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☒ Other: VDOT testing procedure (customized) to do the design, write spec to allow different agents if contractor follows same methodology

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: we do not reduce pavement strenghts because of it

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Don't do full depth, as approximately 90% of roads are composite. Some maintenance units have done a little with mixed results. (RAP): Type here(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? NA

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? NA

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Use plastic sheeting for curing. New spec will allow watering.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☐ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☒ Other: period of at least 3 days after placement

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Both mechanical & chemical: Not answer for all situations, but on the right projects it saves

the cost of overexcuvating. It is critical that work must be done in design to determine best product and procedure.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: A few on low volume, local roads between February and May.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

SOUTH DAKOTA

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Dry Freeze

2. What is the typical depth of frost penetration in your area? Please include units. @ 5.5"

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Asphalt & PCC Pavement;
thickness: 4" to 6" & 8" to 12"
Base: Material type: Granular Base;
thickness: 12" to 14" under Asphalt & 5" under PCCP
Subbase: Material type: Granular Base;

thickness: 6"
Other features: Type here

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: more than 60% passing #200 sieve & < 20 Plasticity Index)
☐ Soil classification (Describe: Type here)
☐ Laboratory testing (Describe: Type here)
☐ Field experience (Describe: Type here)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of 2' to 3')
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☒ Use of insulation (Describe thickness and location: Typically used under Box Culvert Installations)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)

☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Type here

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 50(RAP): 50(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? See our Standard Specification Section 280 - Process In Place Surfacing

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Good Performance when the ratio is at or near 50:50

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. We do not construct CTB Bases

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.
☐ Curing time (Describe specification: Type here)
☐ Scratch test (Describe method and decision-making approach: Type here)
☐ Standard Clegg hammer (Provide threshold value: Type here)
☐ Heavy Clegg hammer (Provide threshold value: Type here)
☐ GeoGauge (Provide threshold value: Type here)
☐ Falling-weight deflectometer (Provide threshold value: Type here)
☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
☐ Dynamic cone penetrometer (Provide threshold value: Type here)
☐ Laboratory testing (Describe tests and provide threshold values: Type here)
☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. N/A

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? Yes; if yes, please discuss the restriction and the timing of its placement and removal: The timing of load restrictions and subsequent removal of these restrictions are dependent on the year, and amount of warm days that we have had. Computer modeling is used to signal that we have had sufficient warm days to begin the thawing process. This is backed up by visual field inspections to verify thawing is taking place. The computer modeling is also used to determine if the pavements have been subjected to sufficient warm days to begin the drying process.

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

<u>TEXAS</u>

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 0.0 degree days (from COE EM1110-345-306)

2. What is the typical depth of frost penetration in your area? Please include units. Worst case in panhandle area is 6 inches.

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☐ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☒ Other: We do not design for frost penetration.

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: ACP; thickness: 3inch
Base: Material type: crushed limestone; thickness: 14 inch
Subbase: Material type: lime treated or stabilized subgrade; thickness: 6 inch
Other features: cement treated base or recycled roadway materials

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
☐ Soil classification (Describe: Type here)
☐ Laboratory testing (Describe: Type here)
☒ Field experience (Describe: Observation of base damage after winter months.)
☒ Other: We do not test for or determine frost susceptibility.

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☐ Excavation and replacement (To a depth of Type here)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☒ Other: No specific construction techniques to account for frost susceptibility.

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☒ Lime (Applied as Slurry)
☒ Fly ash (Types: Type C or F or fully hydrated)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☒ Other: Lime placed as quick pebble form.

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations

☒ Field experience (Describe: Dosages are typical in a region and are continued based on material performance.)
☒ Soil classification (Describe: Selection of stabilizer.)
☒ Unconfined compressive strength (Target value: Cement stabilization must meet minium strengths. Some offices require minimum strengths from lime treated materials.)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☒ Tube Suction Test (Maximum permissible dielectric value: Infrequent, but growing usage.)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☒ Other: Plasticity Index reduction

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Observed little to no improvement in deflection testing or modulus of layers.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 30(RAP): 70(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? maximum particle size (2.5 inch), density.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Satisfactory

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. 1. Material design for lower compressive strength while minimizing moisture intrusion. 2. Three day moist cure or asphalt membrane cure 3. Precrack with vibratory roller or allow construction traffic after initial set. 4. Use of geogrid over stabilized subbases in areas of highly plastic clays to retard reflection of cracks due to shrinkage of subgrade soils.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

☒ Curing time (Describe specification: Three day minimum cure unless exempted before traffic other than water trucks or curing operations are allowed.)
☐ Scratch test (Describe method and decision-making approach: Type here)
☐ Standard Clegg hammer (Provide threshold value: Type here)
☐ Heavy Clegg hammer (Provide threshold value: Type here)
☐ GeoGauge (Provide threshold value: Type here)
☐ Falling-weight deflectometer (Provide threshold value: Type here)
☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
☐ Dynamic cone penetrometer (Provide threshold value: Type here)
☒ Laboratory testing (Describe tests and provide threshold values: Minimum strength requirements are not typical but where used, are individually determined.)
☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience.
1. Lime treated subgrades: Variable success depending on amount of stabilizer, clay type, and moisture fluctuation. Good performance where stable.
2. Cement stabilized/lime-flyash combinations for subgrade: good performance especially where subgrade moisture is stable and lower PI materials. Other conditions have good performing pavements where mitigation of shrink/swell of subgrade materials are accounted for.
3. Lime treated base or subbase: Good performance where waterproofing or minimization of moisture intrusion is maintained.
4. Fly-ash stabilized materials or bases from 100% fly-ash: Fair performance but more variable strengths and field stiffness. Where combined with lime, materials stiffen more but are not necessarily superior.
5. Cement stabilized bases: High cement contents have been used successfully but cracking requires constant maintenance; they are good performers on high load corridors. Lower cement contents are good for medium load to lower load corridors or high load with significant hot-mix surfacing. Lower cement contents reduce shrinkage cracking and maintenance requirements. Structural integrity is compromised where shrinkage of subgrade soils reflect cracking through surfacings.
6. Foamed asphalt in base and recycled base materials: Acceptable results where stringent controls on moisture contents and mix design is maintained. Highly dependent on materials.
7. Emulsified asphalt in base: Acceptable results but highly dependent on material consistency and control of application rate. Little variability results in poor performance.
8. Cement kiln dust in base: Exhibits promising results on experimental sections.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? Yes; if yes, please briefly describe the projects: What is planned from 25

separate offices is not always known but typically there are numerous projects in various regions of the state.

POLICIES:
1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: NA

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: NA

UTAH

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. 32 F

2. What is the typical depth of frost penetration in your area? Please include units.
Low Valleys = 20" High Valleys = 32" Mountain areas = 50"

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Asphalt, Concrete; thickness: 5"-11", 9"-13"
Base: Material type: Untreated A-1-a (1"-), Lean concrete; thickness: 4"-8", 4"
Subbase: Material type: GranularA-1-a(3"-); thickness: 12"-48"
Other features: Treated Bases, Rap blended bases

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

- ☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
- ☒ Soil classification (Describe: AASHTO classification)

☐ Laboratory testing (Describe: Type here)
☒ Field experience (Describe: Certain region areas always have a problem)
☒ Other: BYU is evaluating some projects for the DOT. The DOT is interested in upgrading their evaluation methods based on the findings from base study and the availability of their testing methods.

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of 70% of Frost Depth)
☒ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☒ Use of open-graded drainage layers (Describe thickness and location: Make free draining pavement)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other:

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☒ Lime (Applied as Slurry)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☒ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☒ Tube Suction Test (Maximum permissible dielectric value: Being evaluated for the DOT at this time by BYU.)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: Not to date in the North, but some regions have. Mainly grids have been used to support base layers that may have a lower modulus during intermediate seasons or to support constructability issues.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 50, 70(RAP): 50, 30(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize?

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? Encouraging

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. Evaluation of early strength gain and base modulus. The state has done a few jobs specifying 2% Cement in attempt to achieve strength without having to precrack. Sealers are applied within 24 hours to assure proper hydration. Asphalt polymer modifications have been evaluated using beam fatigue. Thermal cracking properties have been evaluated to minimize cracking potential in PG grade asphalts.

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

- ☒ Curing time (Describe specification: Type here)
- ☐ Scratch test (Describe method and decision-making approach: Type here)
- ☐ Standard Clegg hammer (Provide threshold value: Type here)
- ☐ Heavy Clegg hammer (Provide threshold value: Type here)
- ☐ GeoGauge (Provide threshold value: Type here)
- ☐ Falling-weight deflectometer (Provide threshold value: Type here)
- ☐ Portable falling-weight deflectometer (Describe type and provide threshold value:Type here)
- ☐ Dynamic cone penetrometer (Provide threshold value: Type here)
- ☐ Laboratory testing (Describe tests and provide threshold values: Type here)
- ☒ Other: Under investigation. We are looking at support values from clegg, geogauge, and FWD. The state has 2 test projects out at this time where various methods are being evaluated.

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Cement treated bases are looking posative with lower cement amounts not causing reflective cracking in polymer modified ashpalts. There are some concerns about smoothness and curing time. The Salt Lake Region has used lime stabilization and should be contacted for any further details on that item.

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? Yes; if yes, please briefly describe the projects: Interstate Project in Morgan valley using Rap blend with existing base and cement added at 2%. Another project using rap blends in subbase and an A-1-a base with cement blend in the Cache Valley.

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

VERMONT

CLIMATE:

1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Type here

2. What is the typical depth of frost penetration in your area? Please include units. 4-6 feet

DESIGN AND CONSTRUCTION:

1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.

- ☒ American Association of State Highway and Transportation Officials (AASHTO)
- ☐ Asphalt Institute (AI)
- ☐ National Stone Association (NSA)
- ☐ Portland Cement Association (PCA)
- ☐ American Concrete Pavement Association (ACPA)
- ☐ Corps of Engineers complete protection method
- ☐ Corps of Engineers limited subgrade frost penetration method
- ☐ Corps of Engineers reduced subgrade strength method
- ☐ Mechanistic (Describe software and critical stresses and strains: Type here)
- ☒ Other: Vermont guidelines

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: Type here; thickness: Type here
Base: Material type: Type here; thickness: Type here
Subbase: Material type: Crushed Aggregate-unbound; thickness: Type here
Other features: Depending on the class of roadway, we will design for varying percentages of the anticipated frost pentration. We use a sand cushion layer below the subbase layer to account for this frost depth.

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

☒ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Subbase materials are required to have < 6% passing the 200 sieve)
☐ Soil classification (Describe: Type here)
☒ Laboratory testing (Describe: Subgrades are evaluated with sieve analyses and in some cases hydrometer testing is conducted. However, in general, becuase of the variability in subgrades, we design for a specific depth as described above.)
☐ Field experience (Describe: Type here)
☐ Other: Type here

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of depends on class of road, see number two above.)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☐ Use of geosynthetics (Describe type and placement depth: Type here)
☐ Use of edge drains
☐ Use of open-graded drainage layers (Describe thickness and location: Type here)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☐ Portland cement (Applied as Click here)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)
☐ Calcium chloride (Applied as Click here)

☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.

☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: Type here

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: There is no clear indication that frost affects are mitigated when a geosynthetic is used.

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) 75 max, 50 min(RAP): 25 min, 50 max(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? VAOT Standard specifications for construction and associated special provisions.

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? When selected properly and used under the right circumstances, we feel this treatment is a viable alternatvie to other rehabilitation methods.

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. N/A

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.

☐ Curing time (Describe specification: Type here)
☐ Scratch test (Describe method and decision-making approach: Type here)
☐ Standard Clegg hammer (Provide threshold value: Type here)
☐ Heavy Clegg hammer (Provide threshold value: Type here)
☐ GeoGauge (Provide threshold value: Type here)
☐ Falling-weight deflectometer (Provide threshold value: Type here)
☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
☐ Dynamic cone penetrometer (Provide threshold value: Type here)
☐ Laboratory testing (Describe tests and provide threshold values: Type here)
☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. N/A

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: Type here

POLICIES:
1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: Type here

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: Type here

WEST VIRGINIA

CLIMATE:
1. What is the typical air freezing index for the weather in your jurisdiction? Please include units. Unknown

2. What is the typical depth of frost penetration in your area? Please include units. 30" to 36"

DESIGN AND CONSTRUCTION:
1. What kind of pavement design methodology do you use for areas that experience frost action? Please mark all that apply.
☒ American Association of State Highway and Transportation Officials (AASHTO)
☐ Asphalt Institute (AI)
☐ National Stone Association (NSA)
☐ Portland Cement Association (PCA)
☐ American Concrete Pavement Association (ACPA)
☐ Corps of Engineers complete protection method

☐ Corps of Engineers limited subgrade frost penetration method
☐ Corps of Engineers reduced subgrade strength method
☐ Mechanistic (Describe software and critical stresses and strains: Type here)
☐ Other: Type here

2. What are the layer types and thicknesses of a typical highway pavement in your jurisdiction? Please include units.

Surface: Material type: HMA; thickness: 4" up to 17" total
Base: Material type: Aggregate or open-graded free-draining base; thickness: Varies, free-draining base course is 4" thick by policy
Subbase: Material type: Subgrade - granular material less than 3" nominal diameter; thickness: 6" by policy
Other features: N/A

3. How do you determine whether a given aggregate base or subgrade material is frost susceptible? Please mark all that apply.

☐ Particle-size distribution (Describe permissible percent passing limits on critical sieves: Type here)
☐ Soil classification (Describe: Type here)
☐ Laboratory testing (Describe: Type here)
☐ Field experience (Describe: Type here)
☒ Other: We use a granular material for bases

4. For pavement construction on frost-susceptible subgrades or reconstruction of pavements that previously exhibited frost susceptibility, what pavement construction approaches do you use? Please mark all that apply.

☐ Subgrade processing to remove large stones (Diameter greater than Type here)
☒ Excavation and replacement (To a depth of 2' from the bottom of the subgrade)
☐ Chemical or mechanical stabilization
☐ Blending with higher quality granular material
☒ Use of geosynthetics (Describe type and placement depth: Type here)
☒ Use of edge drains
☒ Use of open-graded drainage layers (Describe thickness and location: 4" placed immediately under the pavement (HMA or JPCP)
☐ Use of insulation (Describe thickness and location: Type here)
☐ Other: Type here

5. When stabilization is selected, which types of stabilizers do you most commonly use? Please mark all that apply.

☒ Portland cement (Applied as Dry powder)
☐ Lime (Applied as Click here)
☐ Fly ash (Types: Type here)
☐ Slag (Types: Type here)
☐ Asphalt emulsion (Types: Type here)
☐ Foamed asphalt (Types: Type here)

☐ Calcium chloride (Applied as Click here)
☐ Proprietary products (Types: Type here)
☐ Other: Type here

6. How do you determine the optimum amount of chemical stabilizer to add to a given base or subgrade material? Please mark all that apply.
☐ Supplier or manufacturer recommendations
☐ Field experience (Describe: Type here)
☐ Soil classification (Describe: Type here)
☐ Unconfined compressive strength (Target value: Type here)
☐ Wet-dry brush test (ASTM D 559)
☐ Freeze-thaw brush test (ASTM D 560)
☐ Tube Suction Test (Maximum permissible dielectric value: Type here)
☐ Marshall flow and stability (Describe: Type here)
☐ Gyratory compaction testing (Describe: Type here)
☐ Other: 10% by weight

7. When geosynthetics (geogrids in particular) are used in the pavement structure, do you permit thinner surface or base layers compared to pavement structures not designed with geosynthetics? No; please discuss the basis for your answer: By policy

8. For full-depth recycling of asphalt pavements, what is the typical weight ratio of reclaimed asphalt pavement (RAP) to aggregate base material that you use in the mixture with the underlying base material? For example, a blend of 40 percent RAP and 60 percent base would be a ratio of 40:60. (Full-depth recycling is the process in which an aged asphalt surface is pulverized and blended with some amount of the underlying base material to create a new base layer.) Not commonly used(RAP): Type here(Base)

9. For construction of full-depth-recycled asphalt pavements, what other materials specifications or processing specifications do you utilize? N/A

10. Overall, what are your observations regarding the performance of pavements constructed using the full-depth recycling process in your jurisdiction? N/A

11. In construction of cement-treated pavement layers, what procedures do you follow to minimize shrinkage cracking of the layer? For example, please address pre-cracking procedures if used, the type and timing of sealing, the timing of surface layer paving, use of granular layers or other features to resist reflective cracking into the surface, and other relevant practices. N/A

12. Following construction of a cement-treated pavement layer, what methods or specifications are used to certify that the layer can be opened to traffic? Please mark all that apply.
☐ Curing time (Describe specification: Type here)
☐ Scratch test (Describe method and decision-making approach: Type here)
☐ Standard Clegg hammer (Provide threshold value: Type here)

☐ Heavy Clegg hammer (Provide threshold value: Type here)
☐ GeoGauge (Provide threshold value: Type here)
☐ Falling-weight deflectometer (Provide threshold value: Type here)
☐ Portable falling-weight deflectometer (Describe type and provide threshold value: Type here)
☐ Dynamic cone penetrometer (Provide threshold value: Type here)
☐ Laboratory testing (Describe tests and provide threshold values: Type here)
☐ Other: Type here

13. Overall, what are your observations regarding the performance of pavements constructed using chemically or mechanically stabilized layers in your jurisdiction? Please provide details for each type of stabilizer with which you have experience. Type here

14. Do you have pavement construction projects scheduled for the upcoming construction season that will utilize full-depth recycling in conjunction with cement stabilization? No; if yes, please briefly describe the projects: N/A

POLICIES:

1. Do you require spring load restrictions for pavements in your jurisdiction? No; if yes, please discuss the restriction and the timing of its placement and removal: N/A

2. Do you permit winter load premiums? No; if yes, please discuss the premium and the timing of its placement and removal: N/A