ENGINEERING ECONOMY AND ENERGY CONSIDERATIONS

STABILIZATION GUIDELINES

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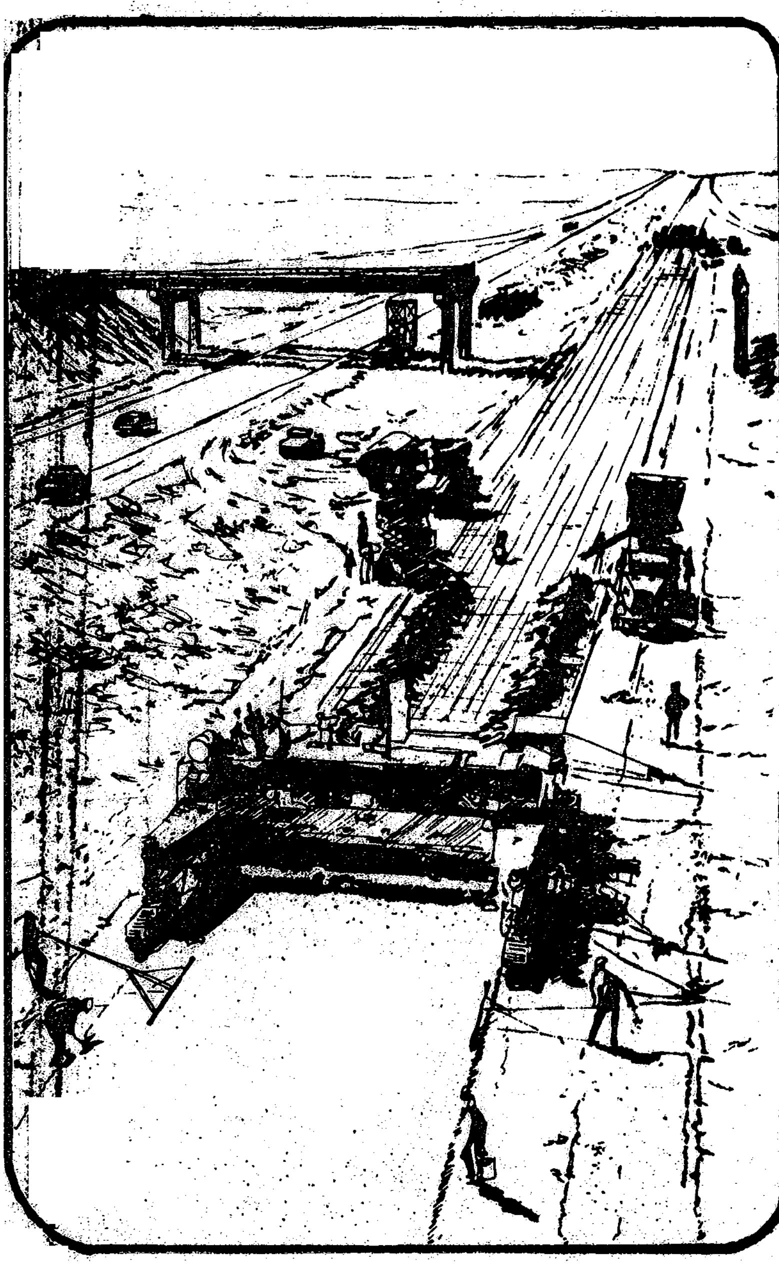

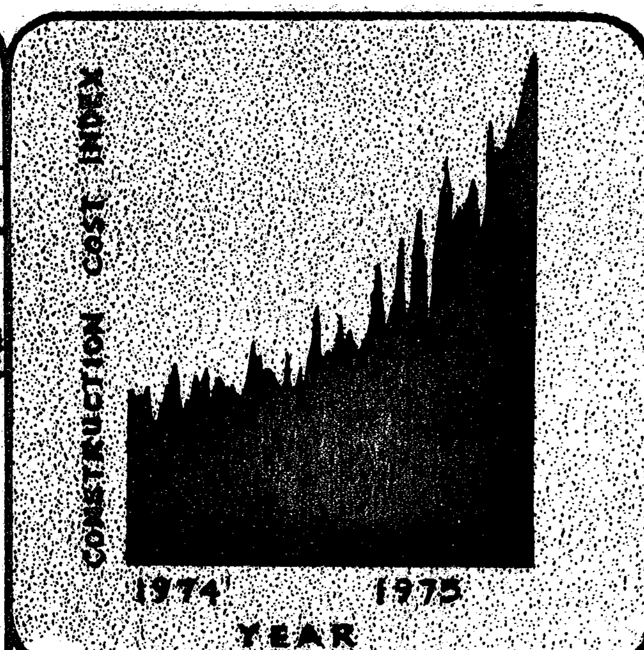

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"ENGINEERING, ECONOMY AND ENERGY CONSIDERATIONS IN DESIGN, CONSTRUCTION AND MATERIALS"

TEXAS STATE DEPARTMENT
OF HIGHWAYS
AND PUBLIC TRANSPORTATION

AND

TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY

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STABILIZATION GUIDELINES

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Introduction

Proper use of stabilization can produce savings in cost and, in many cases, energy utilization. Stabilization is the improvement of engineering properties of soils and soil aggregate systems. This study is directed toward proper use of lime, cement, and asphalt for improving material properties and gives guidelines for selection of a stabilization approach and construction methods.

Stabilization can be used to:

1. Upgrade local materials to be used in lieu of imported higher quality base materials.
2. Strengthen existing subgrades for design purposes or provide a working table as a construction expediency.
3. Extend the construction season as well as expediting work during, or immediately following, wet weather.
4. Provide improvement of other desirable engineering properties, including volume change, permeability, compressibility and frost susceptibility.

The designer should evaluate the potential savings that may result on any project by using stabilization of subgrades and/or other materials.

This involves making a cost analysis of the various alternatives and defining the advantages and disadvantages of each possible stabilization alternative.

Figure 1 provides a framework that will assist the engineer in making this analysis, as it defines the important interaction between soil stabilization and pavement design.

The engineer must first locate and obtain samples of the subgrade soil or soils and other materials that are available for use with or without stabilizers. The engineer should concentrate his search for those materials which are locally available, as transportation costs are usually a major portion of the in-place costs of subbases and bases.

Sieve analyses and Atterberg Limits tests which are performed in the laboratory should be obtained on the sampled materials. These test results are utilized, together with Figure 2, to determine appropriate types and amounts of stabilizers. It is possible that several types of stabilizers can be used with a single soil; thus, a wide variety of materials will exist with which to construct the pavement. If not previously developed, a "data bank" should be developed to store and retrieve information on the location, properties, amounts, and costs of pavement materials within a District. This information will prove invaluable to future construction or reconstruction projects, as somewhat detailed and costly testing may be involved in adequately defining the type and amount of stabilizer to be utilized with a certain soil.

Estimates of in-place costs for available treated and untreated materials should be made. This information may be used to reduce the number of alternatives that must be considered in the pavement design process.

FIGURE 1: INTERACTION BETWEEN SOIL STABILIZATION AND PAVEMENT DESIGN

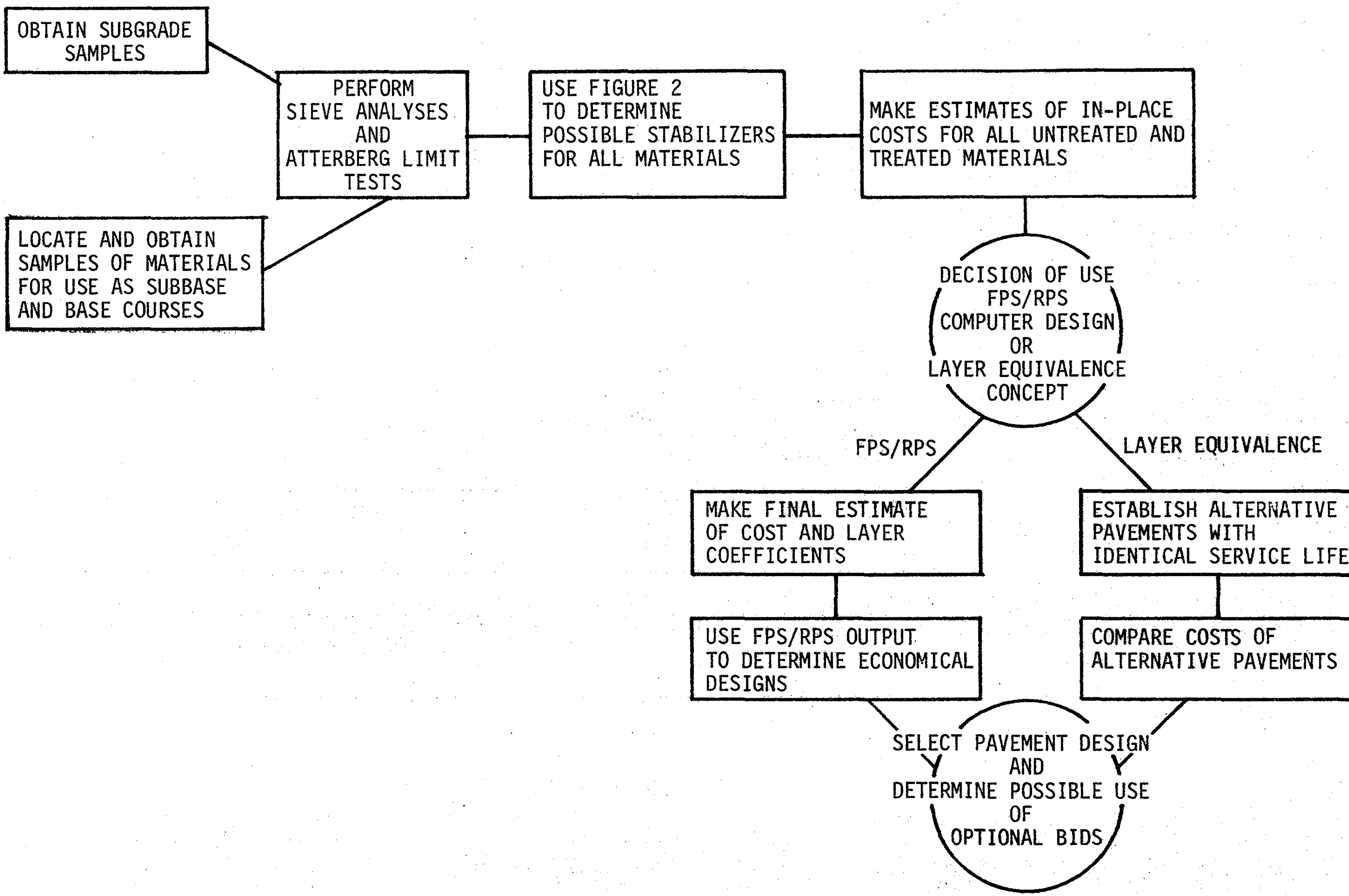


FIGURE 2: Selection of stabilizer

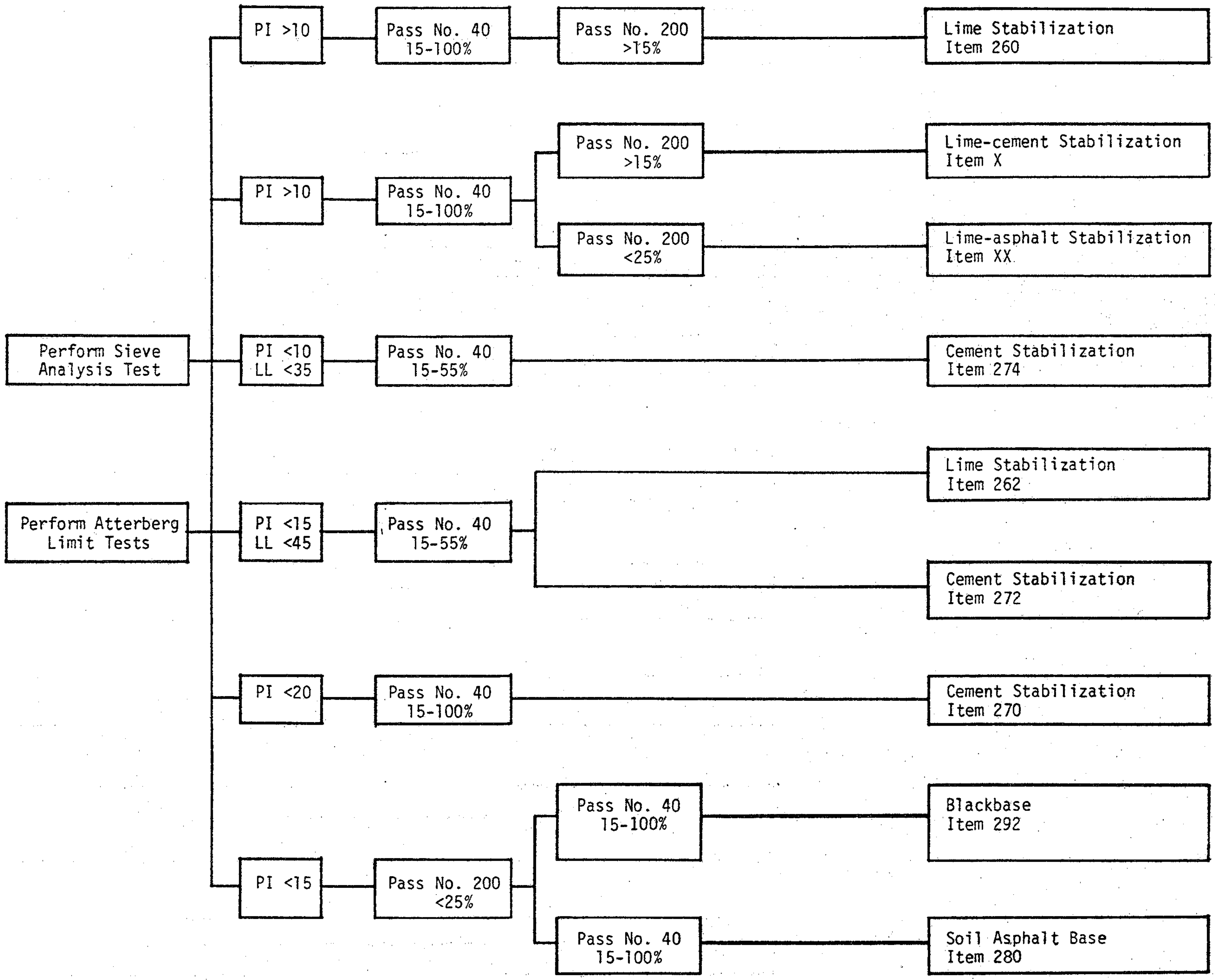
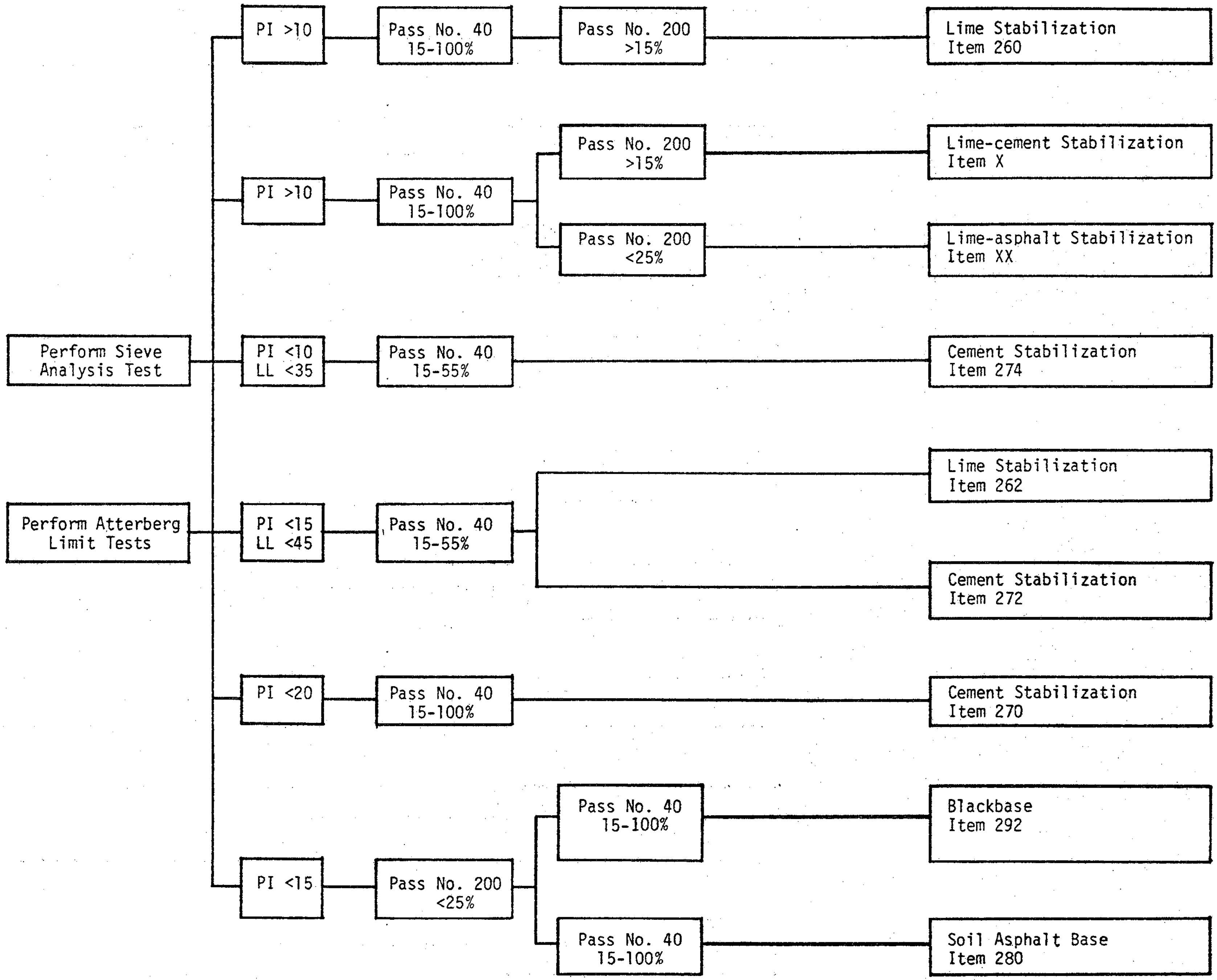


FIGURE 2: Selection of stabilizer



Typical prices per square yard for 1-inch depths are given in Table 1. These prices reflect normal stabilization practices which are typically 6 inches for in-place stabilization with lime, cement, and asphalt.

The type and thickness of the layers comprising the pavement action should be determined by the Texas State Department of Highways and Public Transportation Triaxial Design method, by use of the computer-oriented Flexible Pavement Design System (FPS). Since the triaxial design method cannot adequately define the properties of stabilized materials, it is suggested that FPS be utilized or that use be made of established layer equivalencies. The FPS system is the preferred method and should be utilized to make the final design, if possible. However, utilization of the layer equivalency approach may be adequate, if the computer approach is not available.

The layer equivalency method, as the name implies, allows the utilization of material equivalencies. For example, one inch of dense graded asphalt concrete base may be substituted for two inches of untreated flexible base. The magnitude of the layer equivalencies is difficult to determine for a wide variety of cases; however, several states and producer agencies have suggested certain values which are summarized in Table 2. Ideally, layer equivalencies for all materials under consideration should be determined rather than using the general values shown in Table 2, as the coefficient will depend upon the following factors:

1. Wheel load and contact pressure,
2. Stiffness characteristics of the particular material,
3. Stiffness characteristics of other materials in the structural section,

TABLE 1: Typical Untreated and Treated In-Place Costs

MATERIAL	IN-PLACE COST PER SQUARE YARD OF MATERIAL ONE INCH IN DEPTH, DOLLARS
Caliche Flexible Base	0.35
Gravel Flexible Base	0.10
Iron Ore Flexible Base	0.10
Crushed Stone Flexible Base	0.20
Unspecified Flexible Base	0.35
Lime Stabilized Subgrade	0.20
Lime-Cement Stabilized Subgrade or Subbase	0.25
Cement Stabilized Subgrade or Subbase	0.25
Cement Stabilized Base	0.95
Emulsion or Cutback Stabilized Subgrade	0.40
Hot Sand Asphalt	0.60
Black Base	0.80
Asphalt Concrete	1.00
Portland Cement Concrete	3.25

TABLE 2: Layer Equivalencies*

MATERIAL	EQUIVALENCY**
Dense Graded Hot-Mix Asphaltic Base	0.50
Hot-Mix Sand Asphalt Base	0.65
Liquid and Emulsified Asphalt Base	0.70
Cement Stabilized Base	0.50
Cement Stabilized Soil	0.70
Lime Stabilized Soil	0.90
Lime-Cement Stabilized Soil	0.80
Low Quality Untreated Granular Base	1.35
High Quality Untreated Granular Base	1.00

*These layer equivalencies are representative values and are not necessarily design values for a given job. A more complete listing of layer equivalencies can be found in Texas Transportation Institute Report 14-1F "Design and Economics of Bituminous Treated Bases in Texas."

**The equivalency given is expressed in terms of stated material required to replace one inch of high quality untreated granular base.

4. Subgrade characteristics,

5. Thickness of the various components of the structural sections, and

6. Position of the material in the structural section.

A possible design method would be to design a pavement section utilizing an unstabilized base and subbase by use of the triaxial design method. Appropriate stabilized materials would then be substituted for those materials in the conventional section by use of appropriate layer coefficients. Final material and thickness selection should be based on a cost analysis which would include initial cost, expected maintenance cost, and salvage value.

Utilization of the FPS program involves establishing layer coefficients for all stabilized and unstabilized materials under consideration and making final estimates of in-place costs. Among other input data, the computer analysis will select several economic pavement sections; the engineer will then select an appropriate pavement design.

Layer coefficients are established from dynaflect tests performed on pavements containing a material similar to that proposed in the structural section. If the proposed material does not exist in an existing pavement, values must be estimated, based on experience or trial sections placed with the proposed material, and dynaflect test results obtained.

A method of establishing an economic solution utilizing the layer equivalency approach is given below.

Economic Analyses

Subgrade samples from a proposed pavement site have been obtained and tests performed. The silty clay subgrade has 100 percent passing the number 200 sieve and has a plasticity index of 25. From Figure 2 and the attached reference material, it can be determined that the following types and amounts of stabilizers could be used with this soil:

1. 3.5 percent lime
2. 2 percent lime and 4 percent cement
3. 9 percent cement (field mixing may be a problem).

Materials available for subbase and base courses, together with their expected cots and layer coefficients,are shown in Table 3. The untreated materials available included a high quality flexible base, a locally available low quality flexible base and a locally available sand. The high quality flexible base can be treated with Portland cement or asphalt cement. The low quality iron ore can be treated with Portland cement, lime or a lime-cement combination; and, the sand can be treated with asphalt cement, an emulsified asphalt or Portland cement.

The pavement section as determined from triaxial design requires 3 inches of asphalt concrete and 12 inches of high quality flexible base on a a prepared subgrade. The triaxial test method determined that the low quality flexible base must be stabilized with either lime or cement to be utilized as a base course. From Table 2 it is obvious that a number of sections will be considered.

The section described above will be referred to as alternate section A and will cost $7.20 per square yard if the subgrade preparation costs are not considered. Alternate section B will consist of 3 inches of asphalt concrete and 6 inches of high quality black base made from flexible base material. The cost of alternate B will be $8.70 per square yard if the subgrade preparation costs are not considered. Alternate C will consist of 3 inches of asphalt concrete and 8 inches of sand treated with asphalt cement. The cost of alternate C will be $7.80 per square yard if the subgrade preparation costs are not considered. From a first cost stand-

TABLE 3: Available Pavement Materials

Material	Plasticity Index	Percent Pass No. 40 Sieve	Percent Pass No. 200 Sieve	Expected Layer Coefficients	Expected Cost per inch of thickness
High quality flexible base (considerable haul)	8	50	12	1.0	0.35
Low quality iron ore flexible base (locally available)	15	60	20	1.35	0.10
Sand-locally available	6	60	2	1.35 or higher	0.07
High quality flexible base treated with cement				0.50	0.95
High quality flexible base treated with asphalt cement (black base)				0.50	0.80
Sand stabilized with emulsified asphalt				0.70	0.40
Sand treated with asphalt cement				0.65	0.60
Sand treated with cement				0.70	0.35
Low quality iron ore flexible base treated with cement				0.60	0.75
Low quality iron ore flexible base treated with lime				0.85	0.30
Low quality iron ore flexible base treated with lime-cement				0.75	0.40

point, the engineer would select alternate A; however, due consideration should be given to the performance life of the pavement and the pavement salvage value.

Certainly the engineer should investigate alternative pavements other than those discussed above; and, a more rigorous pavement analysis method and more realistic cost data based on local conditions should be utilized before a final decision is reached. However, the methodology utilized to integrate soil stabilization and pavement design deserves consideration.

General Guidelines for Successful Stabilization

Regardless of the kind of stabilizer being used, there are several points that should be remembered as they apply equally well whether in asphalt, cement, or lime work.

1. Use the best soils that can be economically obtained for the job.
2. Use good techniques to accurately determine optimum moistures and densities.
3. Use equipment and construction techniques which give good distribution of stabilizer within the soil.
4. Compact in the field at or near optimum moisture conditions and achieve the highest density possible (This usually means that one must start compaction on the wet side of optimum). In general, the higher the density, the higher the strength.
5. Cure the stabilized layers properly and keep excessive loads off "green" bases as long as possible, consistent with the specifications and job conditions. Black base is the exception to this point; it can be used as soon as it has been rolled and has cooled sufficiently.

6. Good inspection procedures and attention to details usually pay off in a better pavement layer.

7. Where possible, the stabilization of soils which are high in organic matter should be avoided. Most of these soils require excessive amounts of stabilizer and do not respond well to treatment. Where such soils must be treated, complete laboratory tests should be run to insure adequate strengths and/or performance.

Note: It should be emphasized that all economic examples, costs, and cost computations are based on the assumptions stated and are subject to change. They are used for illustrative purposes only.

APPENDIX A

STABILIZATION ITEMS

ITEM 260: LIME TREATMENT FOR MATERIALS IN PLACE

ITEM 262: LIME TREATMENT FOR BASE COURSES

ITEM 270: PORTLAND CEMENT TREATMENT FOR MATERIALS IN PLACE

ITEM 272: PORTLAND CEMENT TREATMENT FOR BASE COURSES

ITEM 274: CEMENT STABILIZED BASE

ITEM 280: SOIL ASPHALT BASE (ROAD MIX)

ITEM 292: ASPHALT STABILIZED BASE (PLANT MIX)

ITEM X: LIME-CEMENT STABILIZATION

ITEM XX: LIME-ASPHALT STABILIZATION

ITEM 260

LIME TREATMENT FOR MATERIALS IN PLACE

Description

This item shall consist of treating the subgrade, existing subbase, or existing base by pulverization, addition of lime, and mixing and compacting the mixed material to the required density.

Approximate Stabilizer Content

An approximate lime content expressed as a percentage by dry weight of soil can be obtained from Figure 3. An estimate of the lime content can also be obtained by dividing the plasticity index by seven for soils with a large amount of material passing the No. 40 sieve. However, lime contents in excess of 6 percent are seldom used except in very poor soils. Amounts less than 1.5 percent are not recommended due to the difficulty in obtaining good distribution during field mixing.

General Requirements

Strength gain of lime stabilized soils is dependent upon the presence of a pozzolanic material and proper thermal condition. Clay minerals are pozzolans, and thus, for a soil to be effectively stabilized with lime, clays must be present, and the plasticity index and the percentage passing the No. 200 sieve must be above some minimum value. A suggested minimum plasticity index is 10, and suggested minimum percent passing the No. 200 sieve is 15. A soil with these minimums would require a relatively small amount of lime.

Appropriate Test Methods

Tex-121-E -- Soil-Lime Compressive Strength Test Methods.

Tex-122-E -- Cohesiometer Test Method for Stabilized Mixtures of Soil-Asphalt, Soil-Lime or Soil-Cement.

Summary of Test Methods

An impact compaction method is utilized to mold 6-inch diameter by 8-inch high samples at various lime contents and at their respective optimum moisture contents which are determined by method Tex-113-E. A seven-day moist curing period is followed by an air drying period of about 6 hours at a temperature less than 140°F, until one-third to one-half the molding moisture has been removed. The Texas Triaxial Class is determined on the prepared samples after they are subjected to capillary water for 10 days. Cohesiometer tests may be performed on the soil-lime mixtures at selected lime contents (Tex-122-E). Three samples, 6 inches in diameter and 2 inches in height are prepared at optimum moisture and density conditions. Sample curing is that utilized in Tex-121-E.

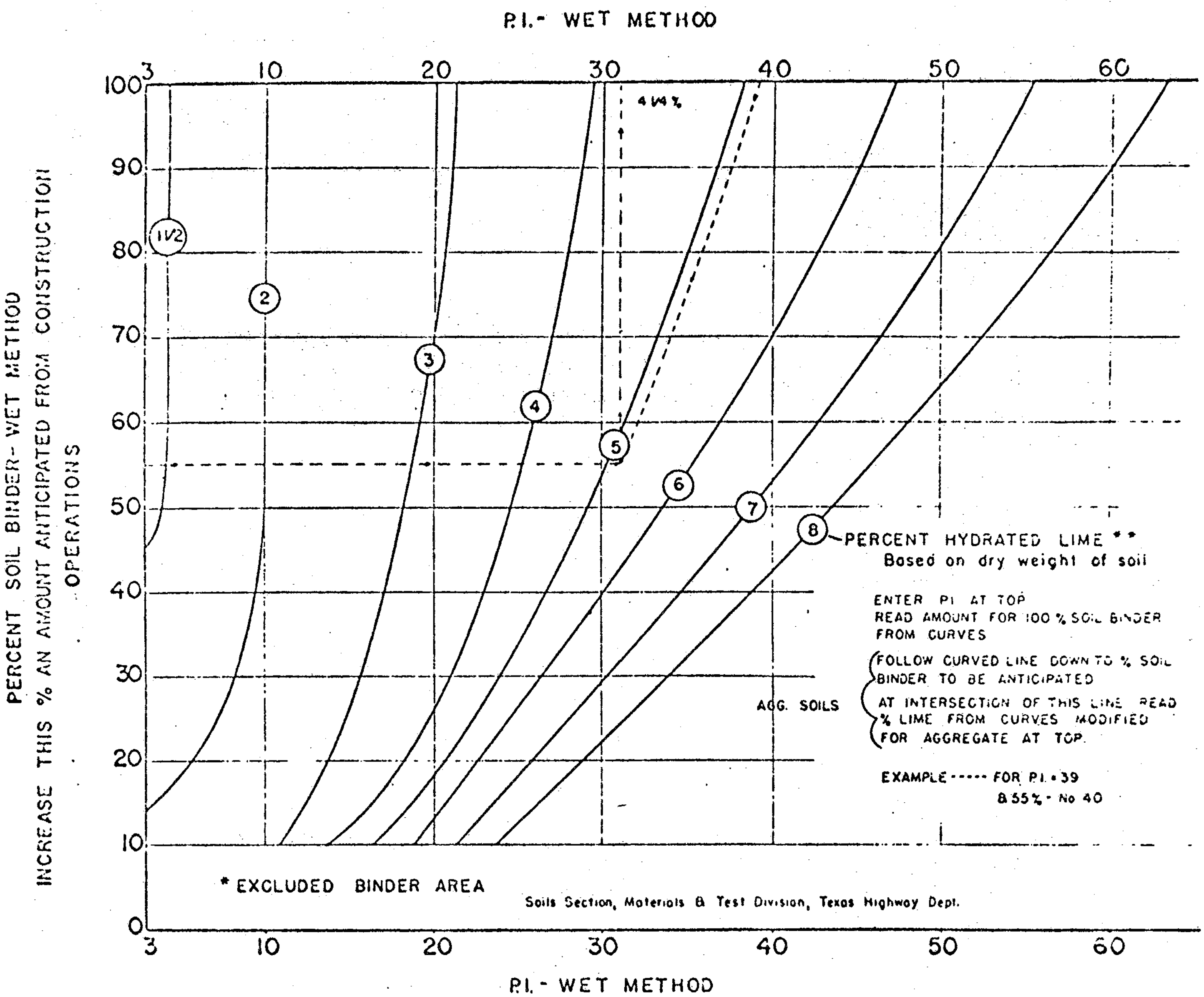
Comments

Application of lime by dry or slurry placing methods is permissible. A one- to four-day curing period is normally allowed after the first mixing operation. The final mixing process should pulverize the soil such that 100 percent passes the 1 3/4-inch sieve and a minimum of 60 percent passes the No. 4 sieve, exclusive of gravel or stone retained on these sieves. Compaction should be at optimum moisture content immediately after final mixing, and in no case later than 3 days after final mixing. The optimum moisture content should be approached from the wet side of optimum. Moist curing should be for a minimum period of 7 days before further courses are added or any traffic is permitted.

Unconfined compressive strength of 100 psi is satisfactory for the final course of base construction, and it is desirable that materials for such courses contain a minimum of over 50 percent No. 40 material before treatment. Unconfined compressive strengths of at least 50 psi are suggested as adequate for subbase soils treated with lime.

The stabilization of clay soils to provide a construction working platform is common in many areas. This stabilization process is often a single pass operation without curing and without density control. Special Provision 006 to Item 260 is an example of this stabilization process.

FIGURE 3: Recommended amounts of lime for stabilization of subgrades and bases. (These percentages should be substantiated by approved testing methods on any particular soil material.)



* Exclude use of chart for materials with less than 10% - No 40 and cohesionless materials (P.I. less than 3)

** Percent of relatively pure lime usually 90% or more of Ca and/or Mg hydroxides and 85% or more of which pass the No 200 sieve. Percentages shown are for stabilizing subgrades and base courses where lasting effects are desired. Satisfactory temporary results are sometimes obtained by the use of as little as 1/2 of above percentages. Reference to cementing strength is implied when such terms as "Lasting Effects" and "Temporary Results" are used.

ITEM 262

LIME TREATMENT FOR BASE COURSES

Description

This item shall consist of treating base and subbase by the addition of lime and mixing and compacting the mixed material in accordance with the specifications governing the base and subbase courses.

Approximate Stabilizer Content

An approximate lime content expressed as a percentage by dry weight of soil can be obtained from Figure 3. Amounts less than 1.5 percent are not recommended due to the difficulty in obtaining good distribution during field mixing.

General Requirements

Strength gain of lime stabilized soils is dependent upon the presence of a pozzolanic material. Clay minerals are pozzolans. Thus, for a soil to be effectively stabilized with lime, clays must be present. Also, the plasticity index and the percentage passing the No. 200 sieve must be above some minimum values. A suggested minimum plasticity index is 10 and suggested minimum percentage passing the No. 200 sieve is 15.

Appropriate Test Methods

Tex-121-E -- Soil-Lime Compressive Strength Test Methods.

Tex-122-E -- Cohesiometer Test Method for Stabilized Mixtures of Soil-Asphalt, Soil-Lime or Soil-Cement.

Summary of Test Methods

An impact compaction method is utilized to mold 6-inch diameter by 8-inch high samples at various lime contents and at their respective optimum moisture contents which are determined by method Tex-113-E. A seven-day, moist curing period is followed by an air drying period of about 6 hours at a temperature less than 140°F, until one-third to one-half the molding moisture has been removed. The Texas Triaxial Class is determined on the prepared samples after they are subjected to capillary water for 10 days. Cohesiometer tests may be performed on the soil-lime mixtures at selected lime contents (Tex-122-E). Three samples, 6 inches in diameter and 2 inches in height are prepared at optimum moisture and density conditions. Sample curing is that utilized in Tex-121-E.

Comments

Application of lime by dry or slurry placing methods for the first mixing operation is permissible. A one- to four-day curing period is normally allowed after the first mixing operation. The final mixing process should pulverize the soil such that 100 percent passes the 1 3/4-inch sieve and a minimum of 60 percent passes the No. 4 sieve, exclusive of gravel or stone retained on these sieves. Compaction should be at optimum moisture content immediately after final mixing, and in no case later than 3 days after fianl mixing. The optimum content should be approached from the wet side of optimum. Moist curing should be for a minimum period of 7 days before further courses are added or any traffic is permitted.

Unconfined compressive strength of 100 psi is satisfactory for the final course of base construction, and it is desirable that materials for such courses contain a minimum of over 50 percent No. 40 material before treatment. Unconfined compressive strengths of at least 50 psi are suggested as adequate for subbase soils treated with lime.

ITEM 270

PORTLAND CEMENT TREATMENT FOR MATERIALS IN PLACE

Description

This item shall consist of treating the subgrade, existing subbase, or existing base by pulverizing, addition of Portland cement, and mixing, wetting and compacting the mixed material to the required density. This item applies to natural ground, embankment, or existing pavement structure.

Approximate Stabilizer Content

Approximate stabilizer contents expressed as a percentage by dry weight of soil may be found by classifying the soil according to the AASHTO Soil Classification system and referring to the information given on Table 3 . As noted on this table, high cement content is required for the fine grained, high plasticity index soils.

General Requirements

Provided proper distribution of cement can be achieved during the mixing operation, all types of soils can be stabilized with cement. However, field experience has indicated that it is difficult to obtain proper distribution in soils with a plasticity index greater than 20.

Appropriate Test Methods

Tex-120-E -- Soil-Cement Compressive Strength Test Methods.

Tex-122-E -- Cohesiometer Test Method for Stabilizing Mixtures of Soil-Asphalt, Soil-Lime or Soil-Cement.

Summary of Test Method

An impact compaction method is utilized to mold 6-inch diameter by 8-inch high samples at cement contents of 4, 6, 8 and 10 percent

TABLE 3: Cement Requirements For Various Soils

AASHTO Soil Classification System	Usual Range in Cement Requirement*		Estimated Cement Content
	Percent by volume	Percent by dry weight	Percent by dry weight
A-1-a	5-7	3-5	5
A-1-b	7-9	5-8	6
A-2	7-10	5-9	7
A-3	8-12	7-11	9
A-4	8-12	7-12	10
A-5	8-12	8-13	10
A-6	10-14	9-15	12
A-7	10-14	10-16	13

* For most A horizon soils the cement content should be increased four percentage points if the soil is dark gray to gray and six percentage points if the soil is black.

Source: After Portland Cement Association.

cement and at their respective optimum moisture contents which are determined by method Tex-113-E. Unconfined compression tests are performed on the samples after a 7-day moist curing period. Cohesiometer tests may be performed on the soil-cement mixtures at selected cement contents (Tex-122-E). Three samples, 6 inches in diameter and 2 inches in height, are prepared at optimum moisture and density conditions. Samples are moist cured for 7 days prior to testing.

Comments

The soil and cement shall not be mixed when the air temperature is below 40°F and falling, but they may be mixed with the air temperature above 35°F and rising. The soil shall be pulverized at the end of moist-mixing such that 100 percent will pass the 1-inch sieve and a minimum of 80 percent will pass a No. 4 sieve, exclusive of gravel or stone retained on these sieves. Application of cement, mixing, watering, and compaction shall be a continuous operation and shall be completed within six hours. Moist curing shall be for a minimum period of 3 days.

ITEM 272

PORTLAND CEMENT TREATMENT FOR BASE COURSES

Description

This item shall consist of treating base and subbase by addition of Portland cement, and mixing, wetting, and compacting the mixed material in accordance with the specification governing base and subbase courses. Roadmixer or central mixing plant operations are permissible.

Approximate Stabilizer Content

Stabilizer contents in the range of 4 to 8 percent by dry weight of soil are common.

General Requirements

Materials may be stabilized under this item to meet existing base and subbase specifications. Thus, the plasticity index should be less than 15, the liquid limit less than 45 and the percentage passing the No. 40 sieve between 15 and 55 percent.

Appropriate Test Methods

Tex-120-E -- Soil-Cement Compressive Strength Test Methods.

Tex-122-E -- Cohesiometer Test Method for Stabilizing Mixtures of Soil-Asphalt, Soil-Lime, or Soil-Cement.

Summary of Test Methods

An impact compaction method is utilized to mold 6-inch diameter by 8-inch high samples at cement contents of 4, 6, 8 and 10 percent cement and at their respective, optimum moisture contents which are determined by method Tex-113-E. Unconfined compression tests are performed on the samples after a 7-day moist curing period. Cohesiometer tests may be performed on the soil-cement mixtures at selected cement contents (Tex-122-E). Three samples, 6 inches in diameter and 2 inches in height, are prepared at optimum moisture and density conditions. Samples are moist cured for 7 days prior to testing.

Comments

The soil and cement shall not be mixed when the air temperature is below 40°F and falling, but they may be mixed when the air temperature is above 35°F and rising. Application of cement, mixing, watering, and compaction for road mixing shall be a continuous operation and shall be completed within six hours. Central mixing and compaction shall be completed in 3 hours after the addition of cement. Moist curing shall be for a minimum period of 3 days.

If, in the opinion of the engineer, pulverization is required, the same requirements as in Item 270 shall apply.

ITEM 274

CEMENT STABILIZED BASE

Description

This item shall consist of a foundation for surface course or for other base courses and shall be composed of a mixture of flexible base material, Portland cement and water. Central plant mixing must be utilized.

Approximate Stabilizer Content

Approximate stabilizer contents expressed as a percent by dry weight of soil may be obtained from the table given below.

Material	% Cement, Dry Wt.	Material	% Cement, Dry Wt.
Synthetic Aggr.	8.0	Iron Ore Gravel	6.0
Sand-Shell	7.0	Crushed Stone	5.0
Processed Gravel	7.0	Crushed Blast	
Bank-Run Gravel	6.0	Furnace Slag	5.0

General Requirements

Gradation and Atterberg limit requirements are given below.

Type	A	B	C	D	E		F	G	H
Square Sieve	Sand Shell	Synthetic Aggregate	Iron Ore Gravel	Crushed Stone	Processed Gravel		Crushed Blast Furnace Slag	Bank-run Gravel	As Shown on Plans
					Gr. 1	Gr. 2			
2 1/2"			0						
1 3/4"		0		0-10	0-5		0	0-5	
1 1/4"	0-10								
1/2"						0			
3/8"							25-45		
No. 4	30-65			45-75	30-75	15-35	45-65	30-75	
No. 40	50-75	60-80	45-65	55-80	60-85	55-85	70-85	65-85	
P.I. less than 10 L.L. less than 35									

Appropriate Test Methods

Tex-120-E -- Soil-Cement Compressive Strength Test Methods.

Tex-122-E -- Cohesiometer Test Method for Stabilizing Mixtures of Soil-Asphalt, Soil-Lime or Soil-Cement.

Summary of Test Methods

An impact compaction method is utilized to mold 6-inch diameter by 8-inch high samples at cement contents of 4, 6, 8 and 10 percent cement and at their respective optimum moisture contents which are determined by method Tex-113-E. Unconfined compression tests are performed on the samples after a 7-day moist curing period. Cohesiometer tests may be performed on the soil-cement mixtures at selected cement contents (Tex-122-E). Three samples, 6 inches in diameter and 2 inches in height, are prepared at optimum moisture and density conditions. Samples are moist cured for 7 days prior to testing.

Comments

The soil and cement shall not be mixed when the air temperature is below 40°F and falling, but they may be mixed when the air temperature is above 35°F and rising. Compaction should be complete within two hours of the time water is added to the mixture. Moist curing shall be for a period of 3 days. Unconfined compressive strengths of 650 psi are normally required for this item.

ITEM 280

SOIL ASPHALT BASE (ROAD MIX)

Description

This item shall consist of a foundation for a surface course or for other base courses and shall be composed of a compacted mixture of soil and asphaltic material. Cutback asphalts or emulsified asphalts are utilized in a road mixing process.

Approximate Stabilizer Content

An approximate stabilizer content can be obtained from the following equation:

$$p = k + 0.005(a) + 0.01(b) + 0.06(c)$$

where: p = percent by weight of residual asphalt to be added (based on dry weight of soil)
k = 1.5 if plasticity index is less than or equal to 8, and 2.0 if plasticity index is greater than 8
a = percent mineral aggregate passing No. 10 sieve
b = percent mineral aggregate passing No. 40 sieve
c = percent mineral aggregate passing No. 200 sieve.

General Requirements

The soil to be stabilized shall consist of approved soil, free from vegetation or other objectionable matter. It may be either the material encountered in the existing roadbed, the material secured from sources shown on the plans or approved by the engineer, or a combination of existing material and additional soil from approved sources.

Appropriate Test Methods

Tex-119-E -- Soil-Asphalt Strength Test Methods.

Tex-122-E -- Cohesiometer Test Method for Stabilized Mixtures of Soil-Asphalt, Soil-Lime or Soil-Cement.

Summary of Test Methods

An impact compaction method is utilized to mold 6-inch diameter by 6-inch high samples at various liquid asphalt contents and at a single moisture content referred to as the cohesive moisture content. Density measurements are made on the compacted samples, and a curve of dry density of soil, plus residual asphalt versus percentage liquid asphalt, is prepared (Figure 4). A maximum percentage of asphalt, selected as the peak of this curve, is determined.

A set of samples, utilizing a range of moisture contents, is molded for liquid asphalt contents of 50, 75, and 100 percent of the previously selected maximum percentage of asphalt. Density measurements are made on the compacted samples and a curve of dry density of soil plus residual asphalt versus percentage moisture and volatiles is prepared. Optimum moisture contents for the various liquid asphalt contents are selected at the peak of each of these curves (Figure 5).

At the optimum condition as determined by these curves, five samples are molded for triaxially testing (6-inch diameter by 6-inch high samples are utilized). These samples are cured for 5 days at 140°F after pressure wetting. The liquid asphalt content is determined from the following plots: percentage moisture and volatiles versus percentage liquid asphalt, and triaxial strength class versus liquid asphalt (Figure 6).

Cohesiometer tests may be performed on the soil asphalt mixtures at selected liquid asphalt contents (Tex-122-E). Three samples, 6 inches in diameter by 2 inches in height, are molded, cured at 140°F for five days, subjected to moist curing and tested at 140°F for each liquid asphalt content investigated.

FIGURE 4: Liquid asphalt-density curve

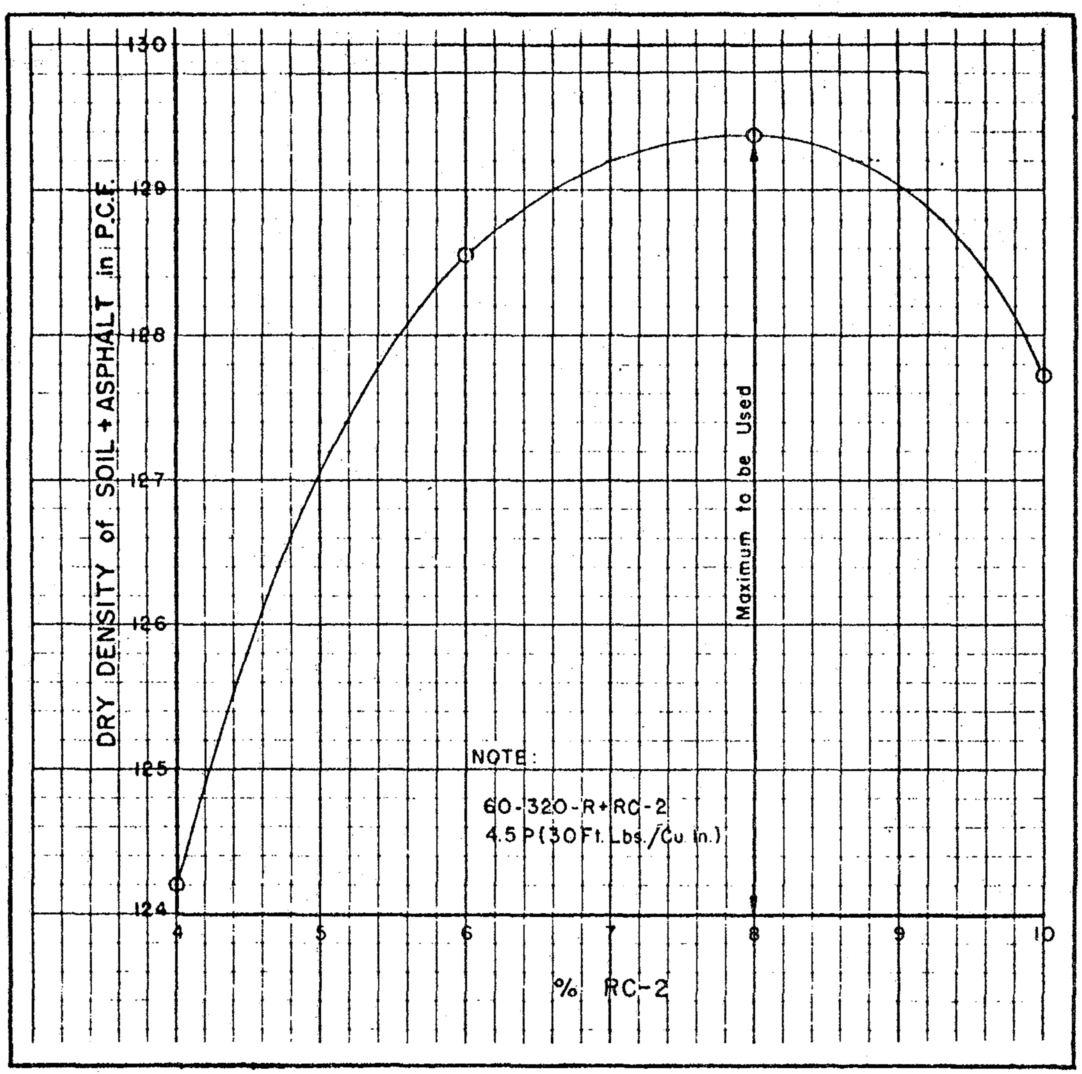


FIGURE 4: Liquid asphalt-density curve

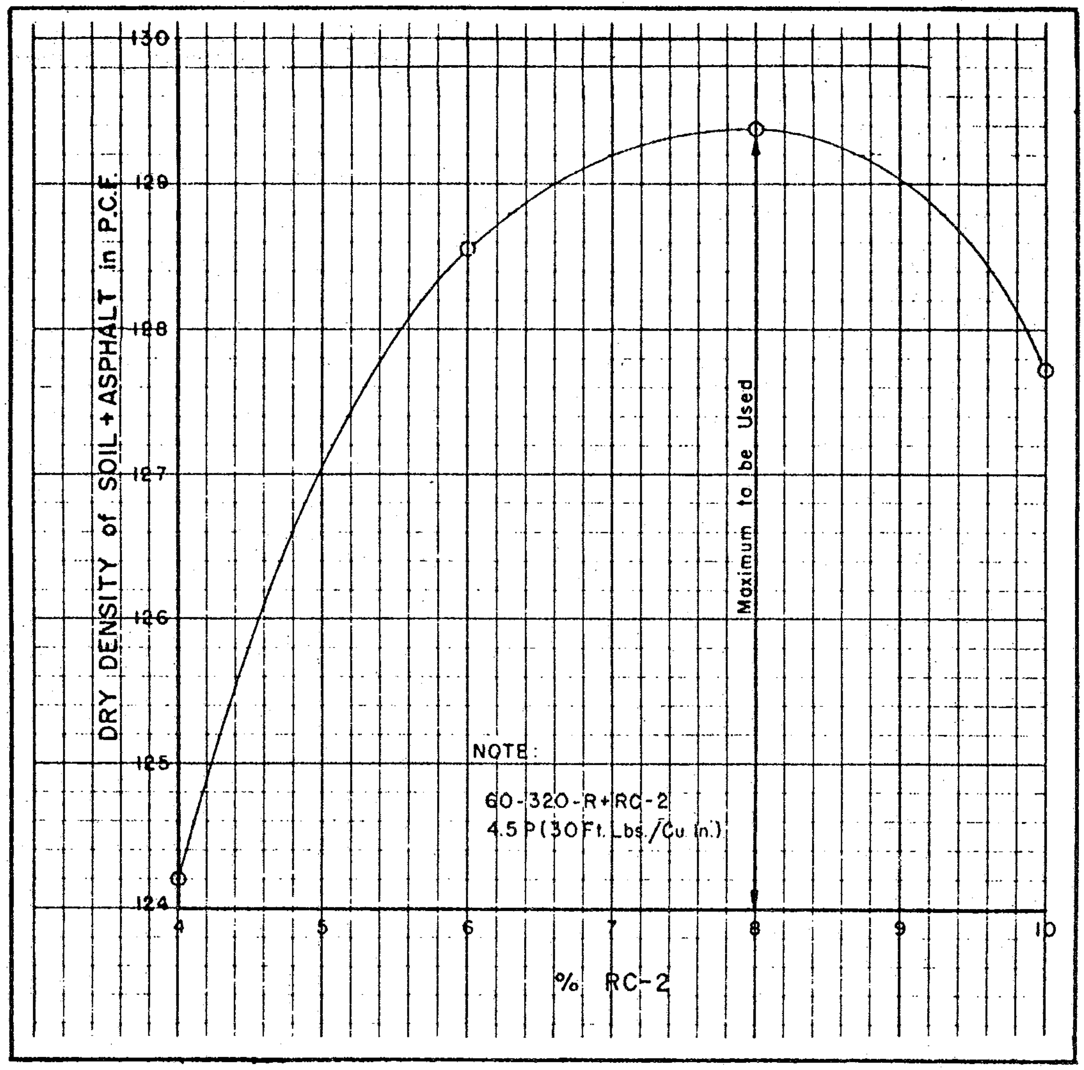


FIGURE 5: Moisture-density curves

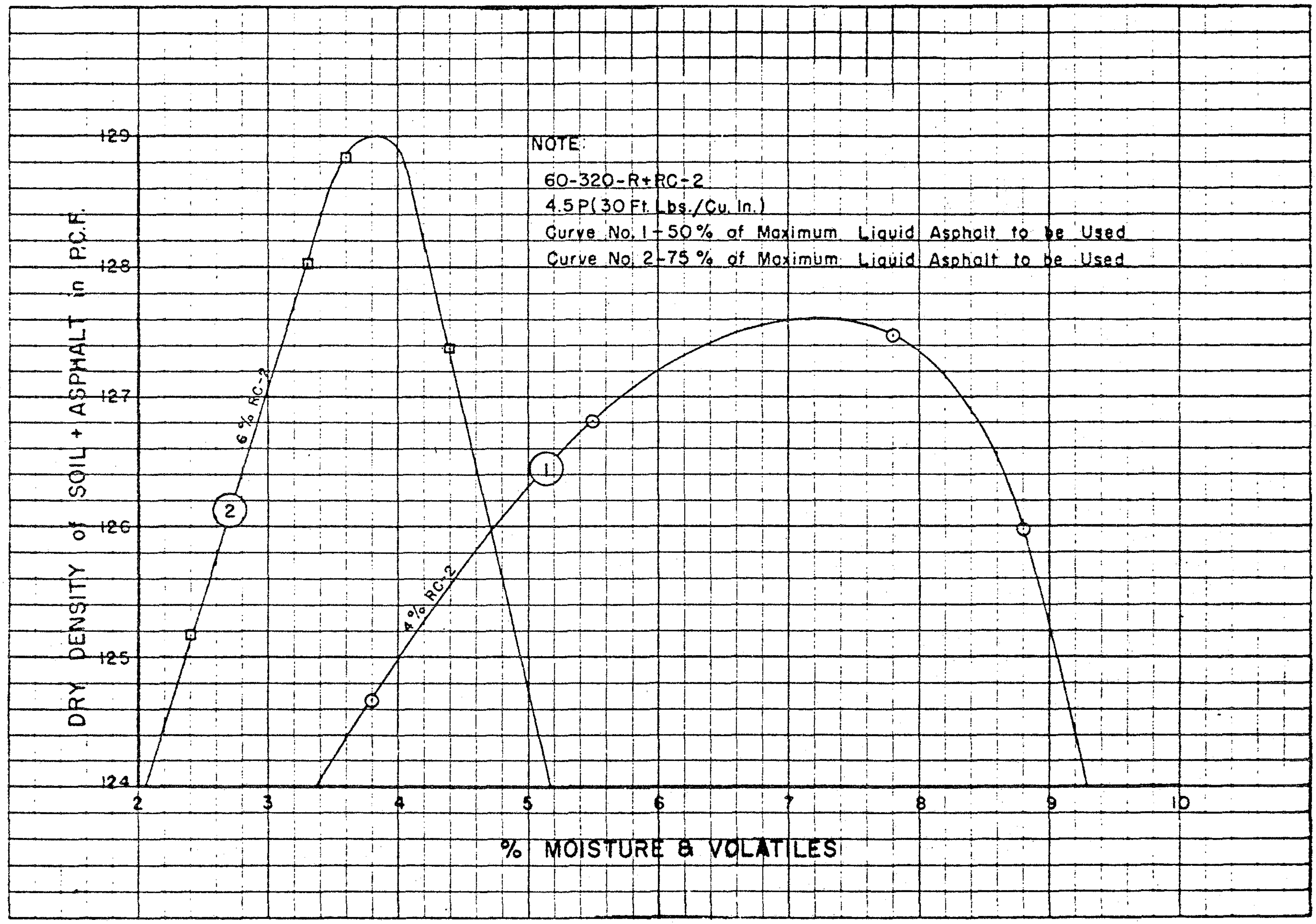
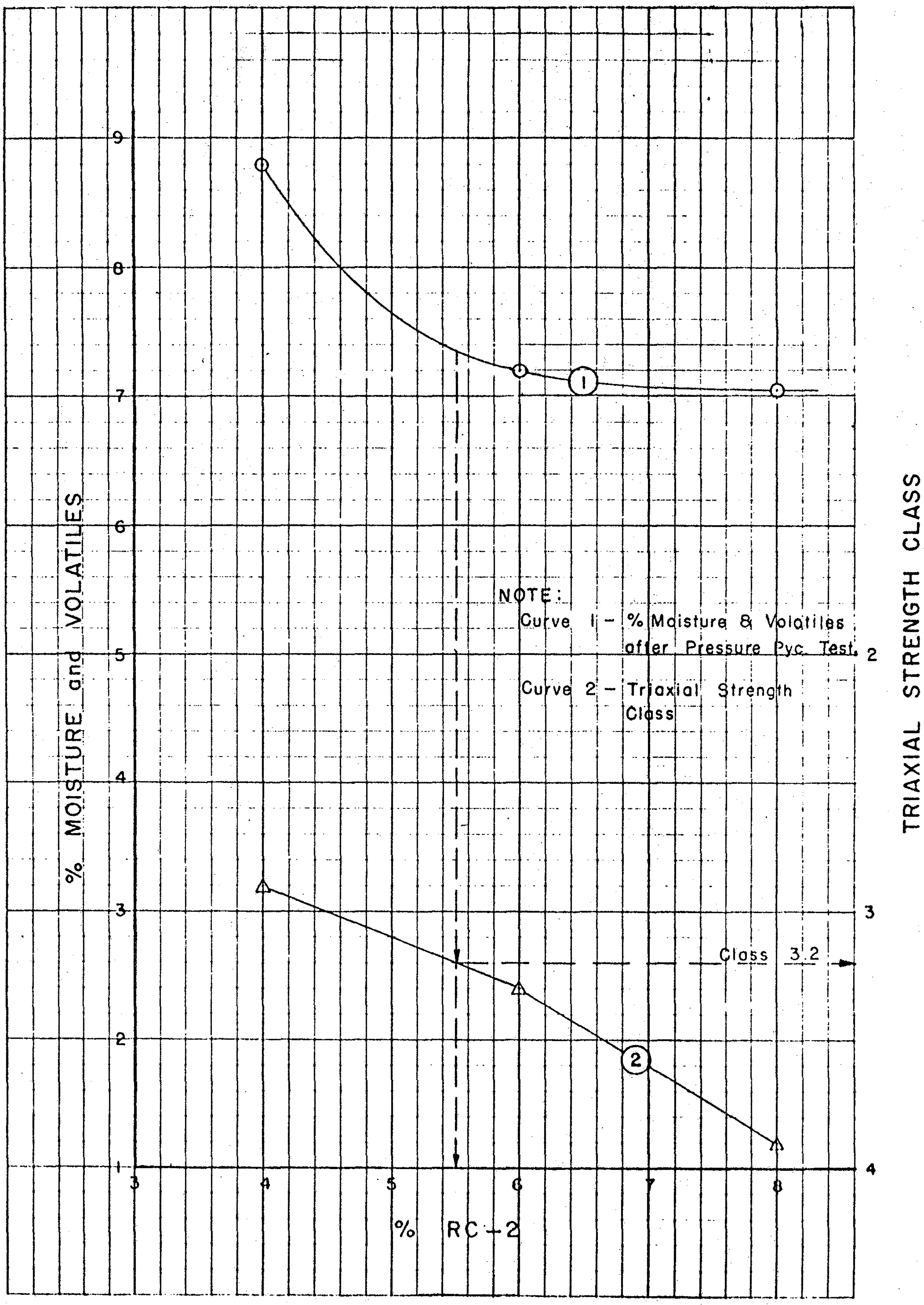


FIGURE 6: Triaxial strength classification



<u>Comments</u>

The soil and asphaltic material shall not be mixed when the air temperature is below 60°F and falling, but they may be mixed when the air temperature is above 50°F and rising.

ITEM 292

ASPHALT STABILIZED BASE (PLANT MIX)

Description

This item shall consist of base courses, subbase courses or foundation courses to be composed of a compacted mixture of mineral aggregate and asphaltic material mixed hot in a mixing plant.

Approximate Stabilizer Content

Stabilizer content should be four to nine percent, based on total dry weight of mixture.

General Requirements

A. Gradation

Sieve Size	Accumulative Percent Retained			
	Grade			
	1	2	3	4
1 3/4 inch		0	0	as shown on plans
1 1/2 inch	0	0-10		
1 inch	0-10			
3/8 inch	30-55			
No. 4	45-70	45-75		
No. 40	70-85	60-85	60-85	

B. Other Requirements

Plasticity Index - 15 maximum Sand Equivalent - 40 minimum

Liquid Limit - 40 maximum Wet Ball Mill - 50 maximum

Appropriate Test Method

Tex-126-E -- Molding, Testing and Evaluation of Bituminous Black Base Materials.

Summary of Test Method

A gyratory compactor is utilized to mold 6-inch diameter by 8-inch high samples at various asphalt contents. Air voids are calculated at each asphalt content, and a percentage total air voids versus percentage asphalt content curve is prepared from which a design asphalt content is selected. Unconfined compression tests may be performed after pressure wetting. Both a slow loading rate (0.15 inch per minute) and a fast rate (10 inches per minute) are utilized to define the black base grade.

Comments

The apshalt stabilized base material shall not be placed when the air temperature is below 50°F and falling, but it may be placed when the air temperature is above 40°F and rising.

The use of emulsions and cutbacks in cold central plant operations is being utilized in several states with success. This option should not be overlooked in an analysis of alternatives for a project.

ITEM X

LIME-CEMENT STABILIZATION

Description

This item shall consist of treating the subgrade, existing subbase, or existing base by the pulverization, addition of lime and Portland cement, and mixing and compacting the mixed material to the required density. State Department of Highways and Public Transportation Items 260 and 270 should be utilized as guides.

Approximate Stabilizer Content

Three percent lime by dry weight of soil is usually sufficient to reduce the plasticity index of a soil to a level where mixing with Portland cement is possible. Six to eight percent cement by dry weight of soil will be a usual cement content.

General Requirements

Lime is added to the soil to reduce the plasticity, to make the soil more friable and thus easier to work, and to reduce the amount of cement necessary for stabilization. After the addition of lime, a one- to four-day curing period is often necessary. The addition of cement follows. The plasticity index of the soil should be reduced to a value of 20 or below by the addition of lime.

Appropriate Test Methods

Tex-112-E -- Methods of Admixing Lime to Reduce Plasticity Index of Soil.

Tex-120-E -- Soil-Cement Compressive Strength Test Methods.

Tex-122-E -- Cohesiometer Test Method for Stabilized Mixtures of Soil-Asphalt, Soil-Lime or Soil-Cement.

Summary of Test Methods

Test Method Tex-112-E can be utilized to determine the proper lime content to reduce the plasticity to a level that will allow cement to be effectively mixed with the soil. Test Method Tex-120-E can be utilized to determine lime-cement contents that will economically provide the desired strength. This test method utilized impact compaction to mold 6-inch diameter by 8-inch high samples at selected lime-cement contents and at their respective optimum moisture contents which are determined by method Tex-113-E. Unconfined compression tests are performed on the samples after a 7-day moist curing period.

Cohesiometer tests may be performed on the soil and lime-cement mixture at selected lime-cement contents (Tex-122-E). Three samples, 6 inches in diameter and 2 inches in height, are prepared at optimum moisture and density conditions. Samples are moist cured for 7 days prior to testing.

Comments

The soil and lime-cement stabilizer shall not be mixed when the air temperature is below 40°F and falling, but they may be mixed when the air temperature is above 35°F and rising. The final pulverization of the soil will be such that 100 percent will pass the 1-inch sieve and a minimum of 80 percent will pass a No. 4 sieve, exclusive of gravel or stone retained on these sieves. Moist curing for a 3-day period shall follow compaction.

The State Department of Highways and Public Transportation has very little experience with lime-cement stabilization. The use of 3 percent lime and 6 to 8 percent cement is usually more expensive than the usual 6 percent lime required in many heavy clays. The use of a 50-50 proportion of lime and cement may reduce cracking.

ITEM XX

LIME-ASPHALT STABILIZATION

Description

This item shall consist of a foundation for surface course or for other base courses and shall be composed of a compacted mixture of soil, lime and asphaltic material. State Department of Highways and Public Transportation Items 260 and 280 shall be utilized as guides.

Approximate Stabilizer Contents

Three percent lime by dry weight of soil is usually sufficient to reduce the plasticity index of a soil to a level where mixing with asphalt is possible. An approximate asphalt stabilizer content can be obtained from the following equation:

$$p = k + 0.005(a) + 0.01(b) + 0.06(c)$$

where: p = percent by weight of residual asphalt to be added (based on dry weight of soil)
k = 1.5 if plasticity index is less than or equal to 8 and 2.0 if plasticity index is greater than 8
a = percent mineral aggregate passing No. 10 sieve
b = percent mineral aggregate passing No. 40 sieve
c = percent mineral aggregate passing No. 200 sieve.

General Requirements

Lime is added to the soil to reduce the plasticity and make the soil more friable and thus easier to work. After the addition of lime, a one- to four-day curing period is often necessary. The addition of asphalt follows. The plasticity index of the soil should be reduced to a value of 15 or below by the addition of lime. The percentage passing the No. 200 sieve should be less than 25 percent.

Appropriate Test Methods

Tex-112-E -- Methods of Admixing Lime to Reduce Plasticity Index of Soil.

Tex-119-E -- Soil-Asphalt Strength Test Methods.

Tex-122-E - Cohesiometer Test Method for Stabilized Mixtures of Soil-Asphalt, Soil-Lime or Soil-Cement.

Summary of Test Methods

Test Method Tex-112-E can be utilized to determine the proper lime content to reduce the plasticity to a level that will allow asphalt to be effectively mixed with the soil. Test Method Tex-119-E and Tex-122-E can be utilized to determine lime-asphalt contents that will economically provide the desired properties.

Comments

A soil and lime-asphalt stabilizer shall not be mixed when the air temperature is below 60°F and falling, but they may be mixed when the air temperature is above 50°F and rising.

The State Department of Highways and Public Transportation has very little experience with lime-asphalt stabilization. The economics of the form of stabilization should be carefully examined prior to its use.