THE IMPORTANCE OF A GOOD FOUNDATION FOR OPTIMUM PAVEMENT PERFORMANCE

TxAPA MAPS Conference 2023
Waco, Texas
May 16, 2023

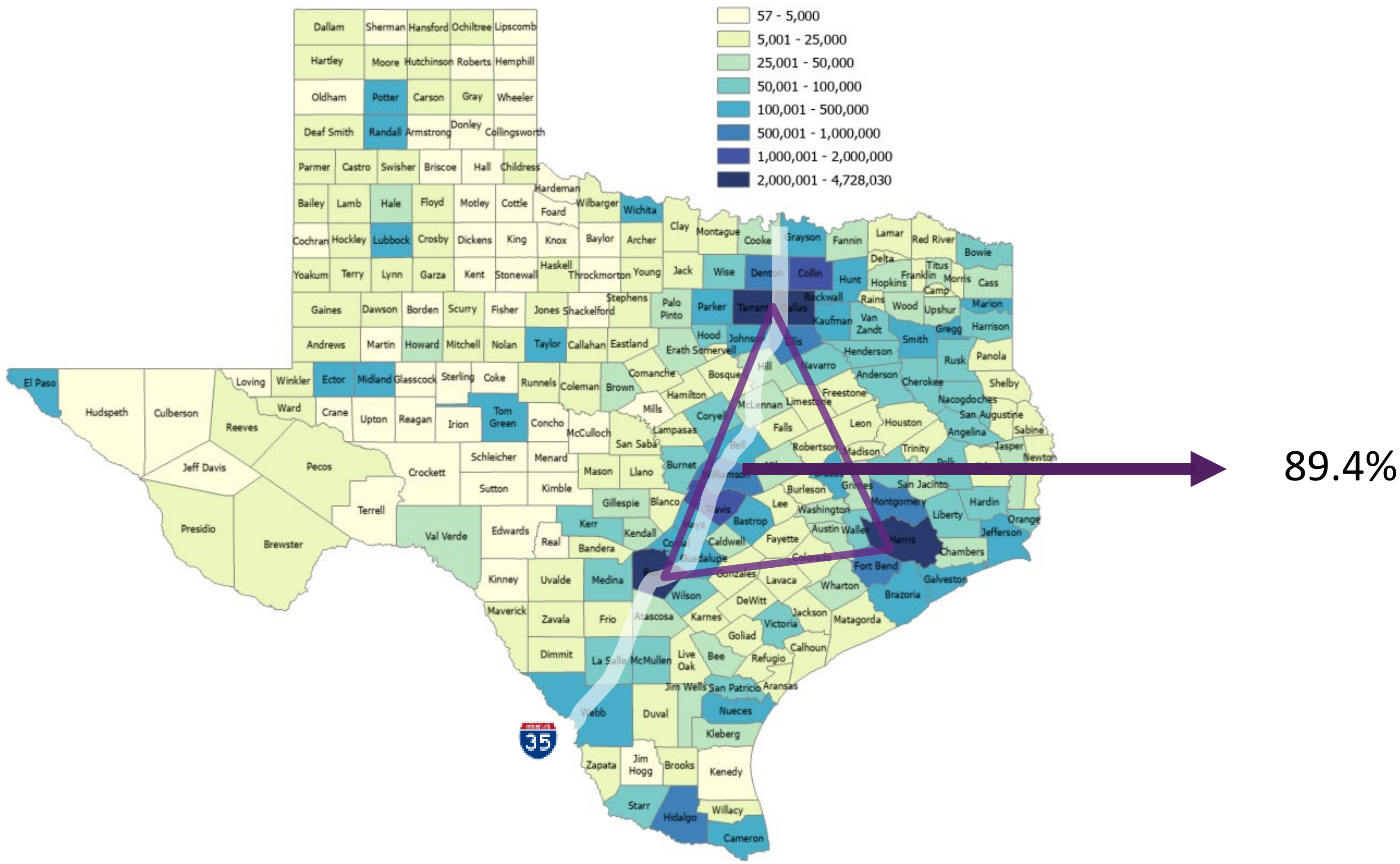
Larry Peirce

OPTIMUM PAVEMENT PERFORMANCE

Depends On A Combination Of Factors

- Understanding of Your Objectives
- Choosing the Right Construction Materials
- Properly Designing Those Materials
- **Ensuring That You Have Created an Adequate Foundation**
- Treatment (Stabilization) of The Base and Subgrade Soils

2021 Estimated Population, Texas Counties

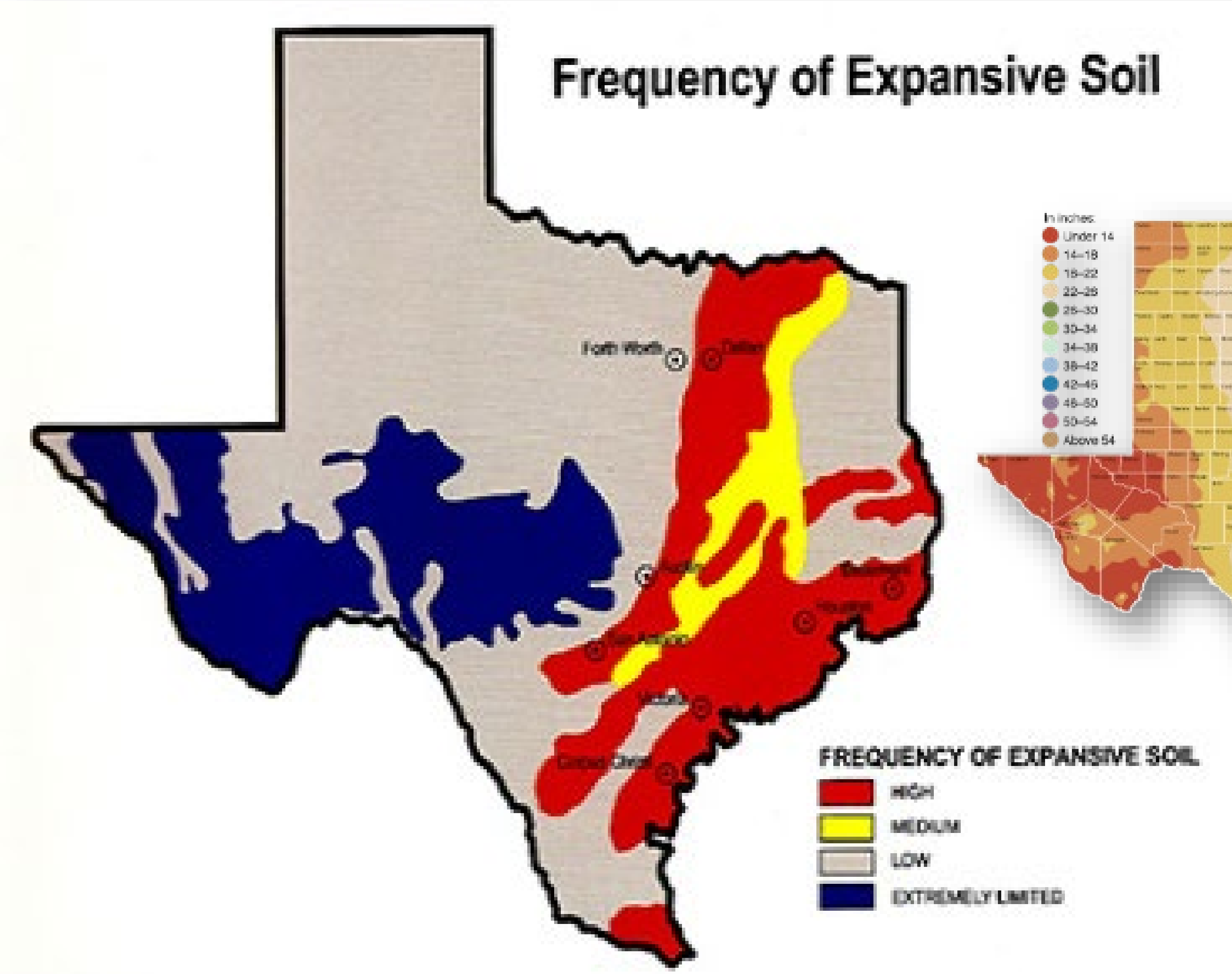


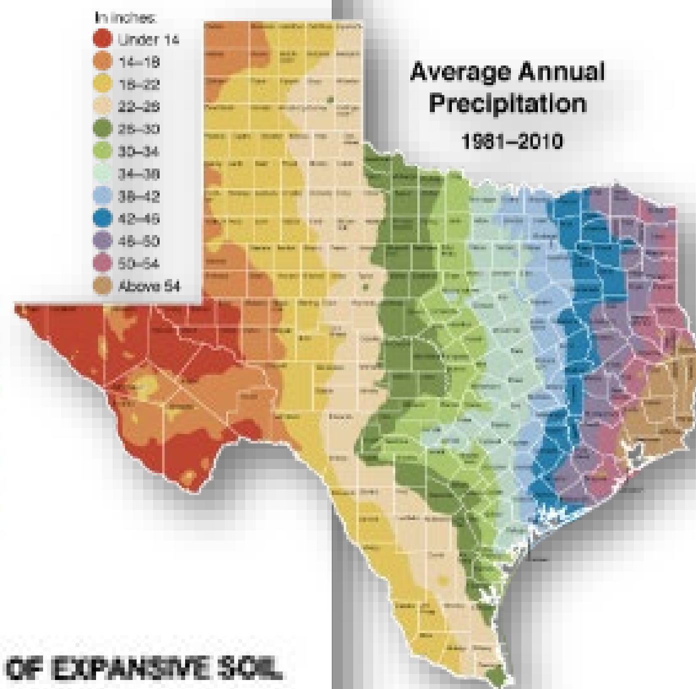
Source: US Census Bureau, 2021 Population Estimates

IDENTIFY GOALS TO ENSURE AN ADEQUATE FOUNDATION

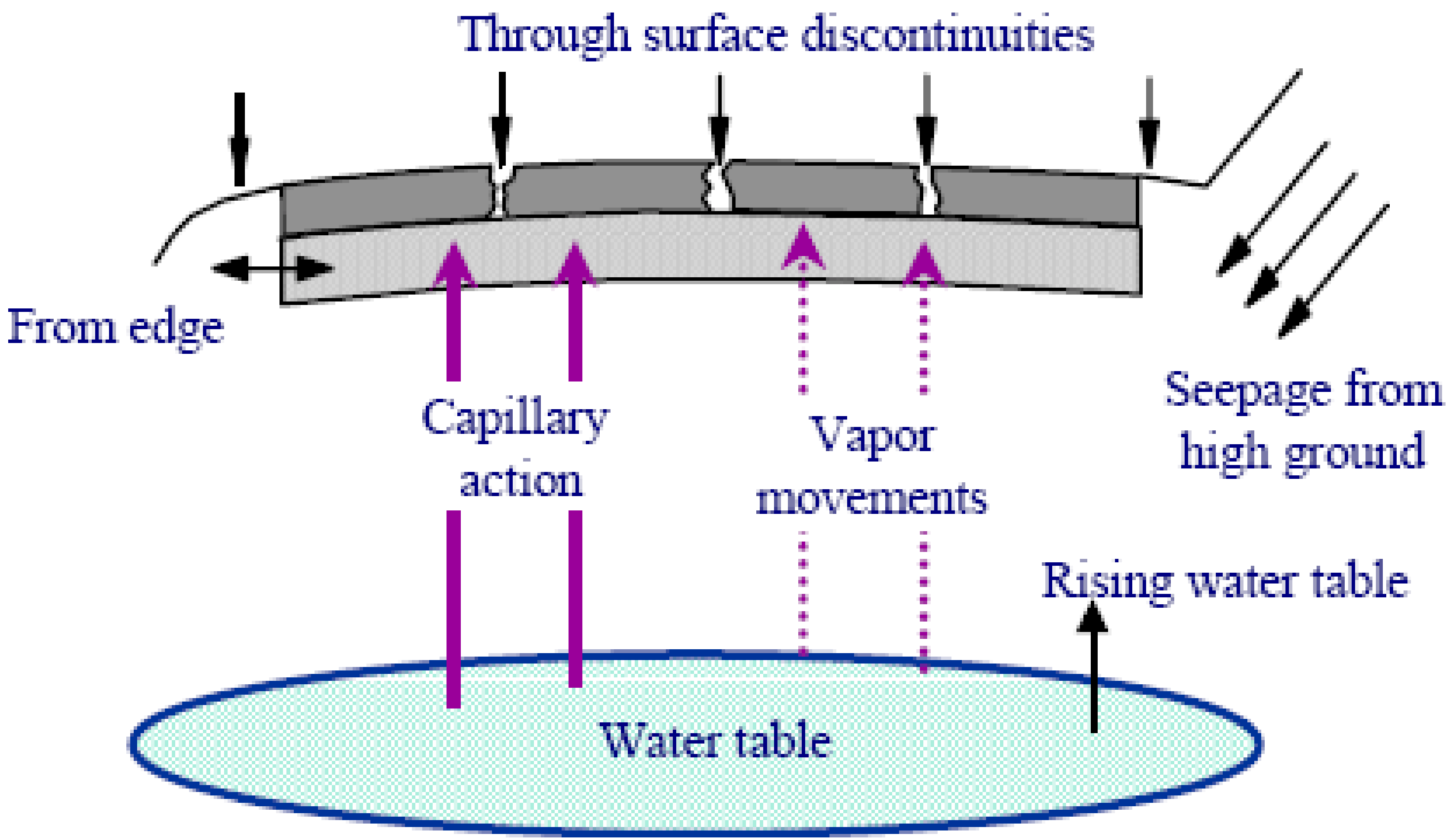
- Reduce soil PI and clay/silt-sized particles
- Improve workability and constructability
- **Reduce shrink/swell characteristics of expansive soils**
- **Improve strength and stiffness/modulus**
- Improve stability and durability
- **Reduce moisture susceptibility**

EXPANSIVE SOIL AND EXPANSIVE CLAY





MOISTURE IS THE ENEMY OF SUCCESSFUL PAVEMENT PERFORMANCE

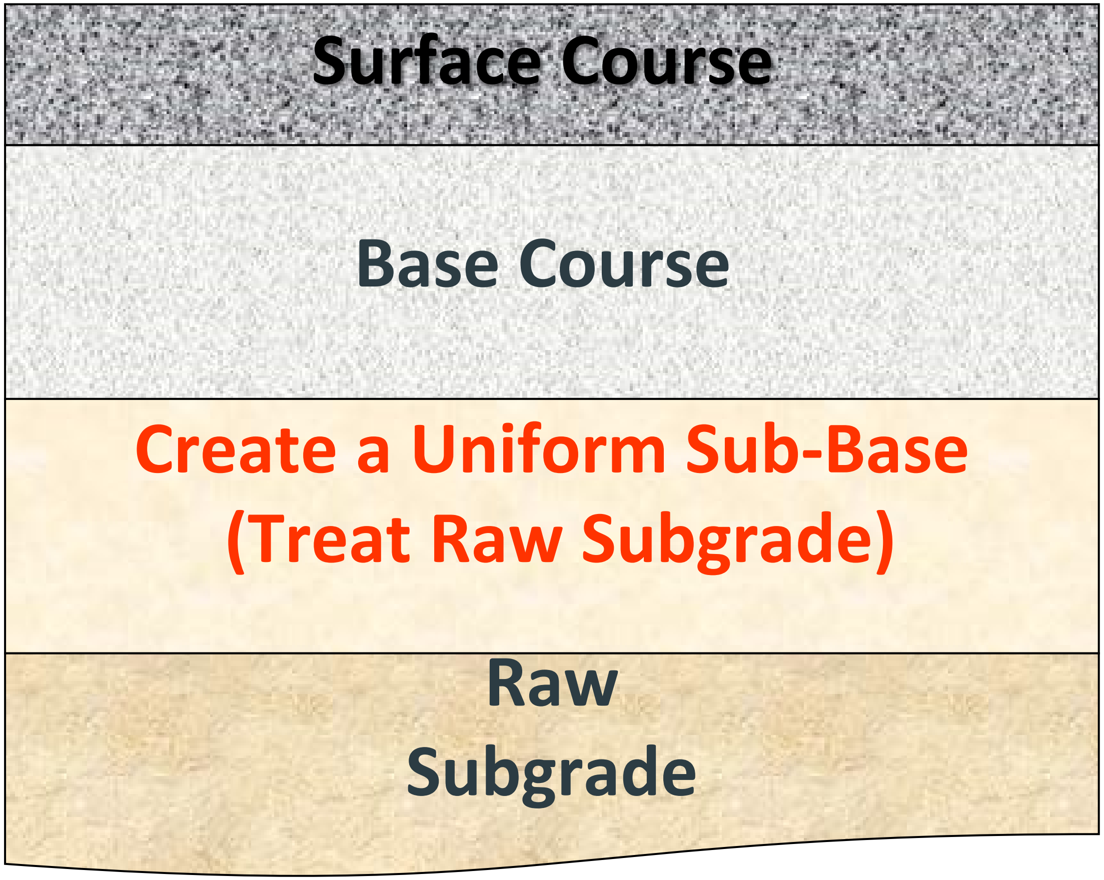


Problems Associated w/Clay Soils

- **Typically moisture sensitive**
  - **expansion potential & swell pressure**
- **Exhibit poor pavement support**
  - **low R-values, CBRs, & unconfined compressive strengths**
- **Constructability problems**
  - **highly plastic - poor workability**
  - **hard to compact**
  - **yield or pump when wet**
  - **shrink when dry**

FOUNDATION PROBLEMS – SOIL MOISTURE FLUCTUATION

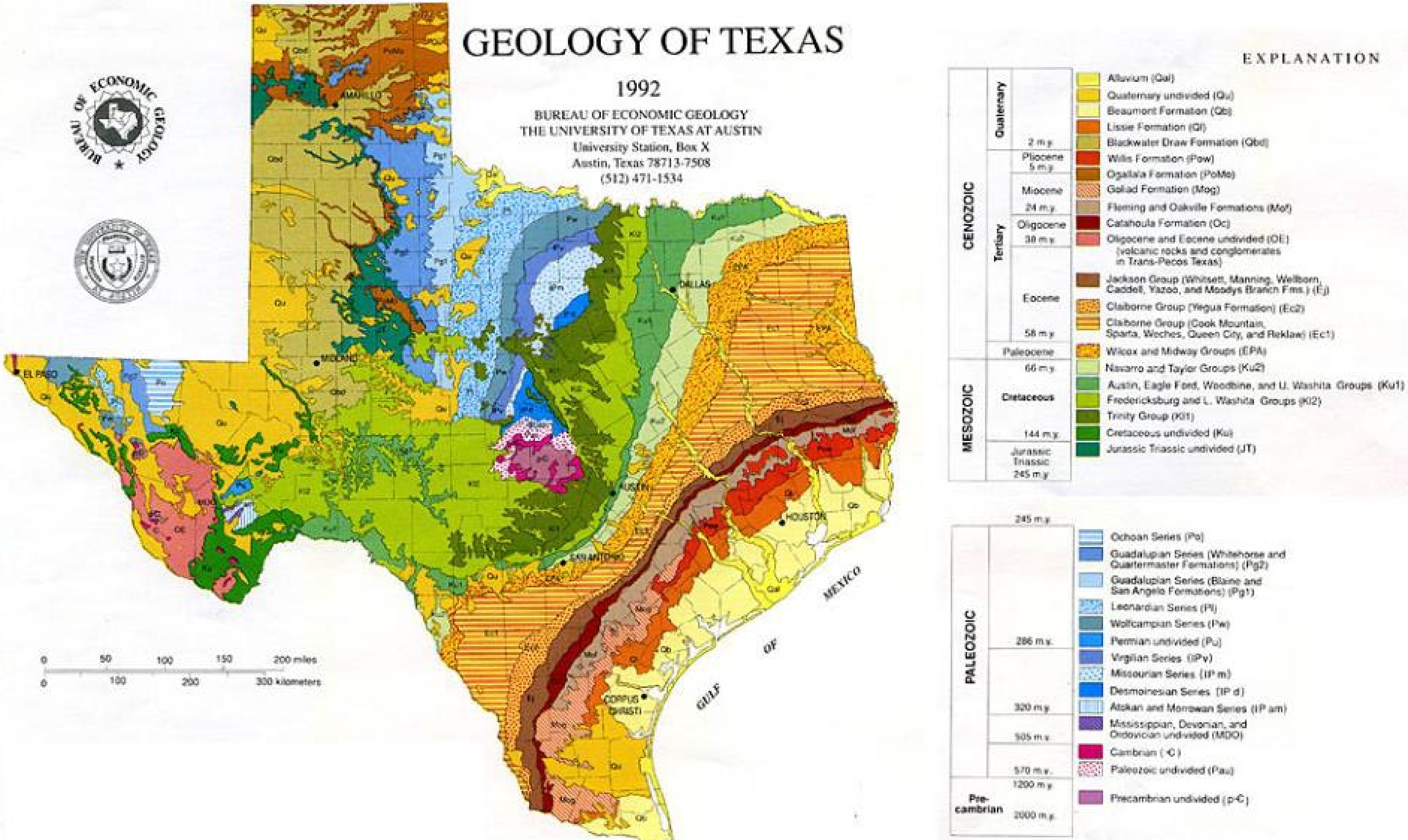
Need Uniform, Quality Layers Beneath HMA Surface



Moduli = 10 ksi

BASE MATERIALS

- Provide structure and support for asphalt layer
- Bases can be untreated, utilizing good source material
- Marginal quality materials used for bases
  - Can be treated w/ stabilizers if they are marginal in quality
- **Improve strength and stiffness/modulus**
- Improve stability and durability
- **Reduce moisture susceptibility**


GEOLOGY OF TEXAS
1992
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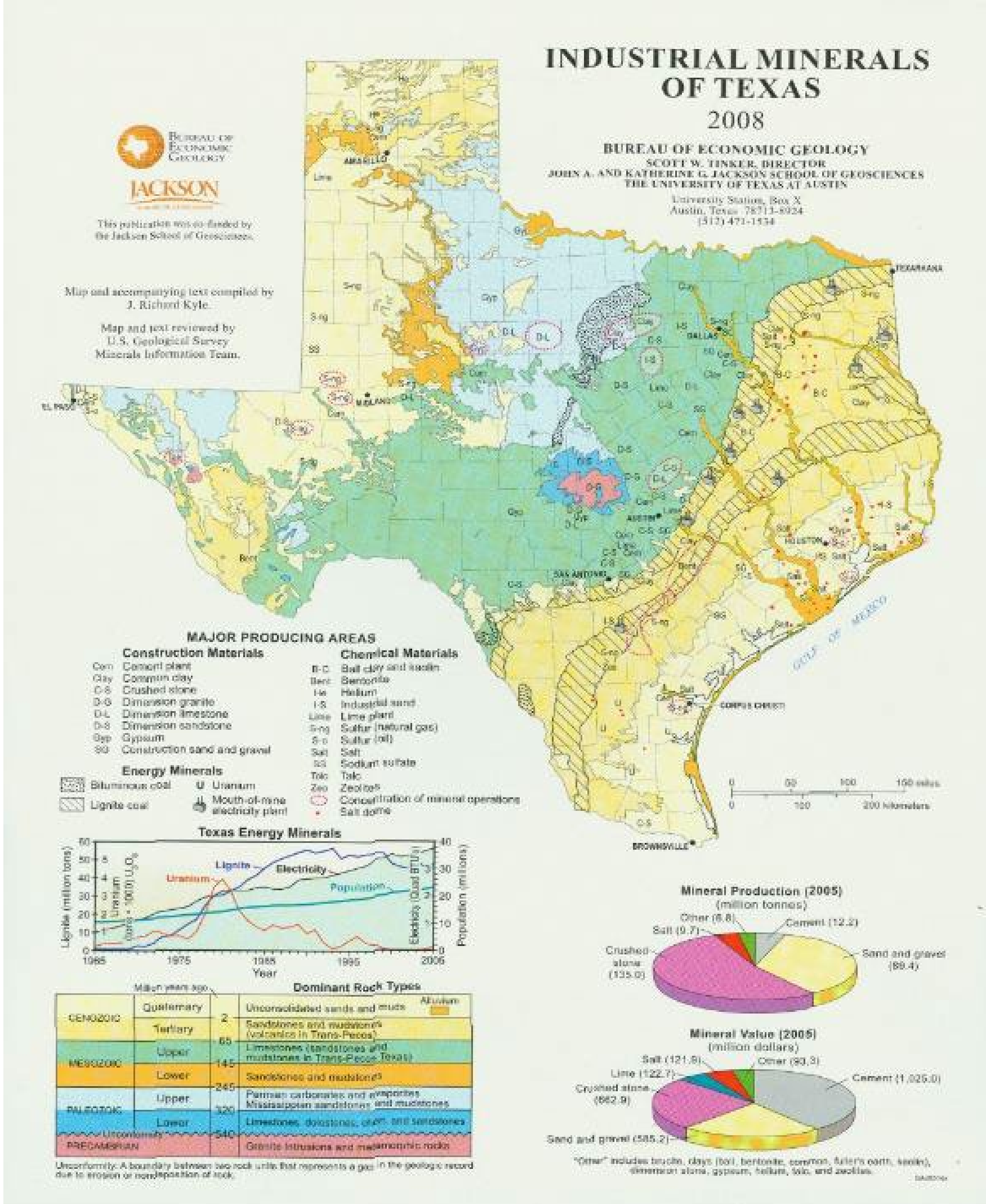
BUREAU OF ECONOMIC GEOLOGY
AMARILLO
MIDLAND
EL PASO
DALLAS
AUSTIN
SAN ANTONIO
HOUSTON
CORPUS CHRISTI
GULF OF MEXICO
0 50 100 150 200 miles
0 100 200 300 kilometers
EXPLANATION
CENOZOIC
Quaternary
Tertiary
2 m.y.
Pliocene 5 m.y.
Miocene 24 m.y.
Oligocene 38 m.y.
Eocene 58 m.y.
Paleocene
66 m.y.
MESOZOIC
Cretaceous
144 m.y.
Jurassic Triassic 245 m.y.
Alluvium (Qal)
Quaternary undivided (Qu)
Beaumont Formation (Qb)
Lissie Formation (Ql)
Blackwater Draw Formation (Qbd)
Willis Formation (Pow)
Ogallala Formation (PoMo)
Goliad Formation (Mog)
Fleming and Oakville Formations (Mof)
Catahoula Formation (Oc)
Oligocene and Eocene undivided (OE) (volcanic rocks and conglomerates in Trans-Pecos Texas)
Jackson Group (Whitsett, Manning, Wellborn, Caddell, Yazoo, and Moodys Branch Fms.) (Ej)
Claiborne Group (Yegua Formation) (Ec2)
Claiborne Group (Cook Mountain, Sparta, Weches, Queen City, and Reklaw) (Ec1)
Wilcox and Midway Groups (EPA)
Navarro and Taylor Groups (Ku2)
Austin, Eagle Ford, Woodbine, and U. Washita Groups (Ku1)
Fredericksburg and L. Washita Groups (Kl2)
Trinity Group (Kl1)
Cretaceous undivided (Ku)
Jurassic Triassic undivided (JT)
245 m.y.
PALEOZOIC
286 m.y.
320 m.y.
505 m.y.
570 m.y.
1200 m.y.
Pre-cambrian
2000 m.y.
Ochoan Series (Po)
Guadalupian Series (Whitehorse and Quartermaster Formations) (Pg2)
Guadalupian Series (Blaine and San Angelo Formations) (Pg1)
Leonardian Series (Pl)
Wolfcampian Series (Pw)
Permian undivided (Pu)
Virgilian Series (IPv)
Missourian Series (IP m)
Desmoinesian Series (IP d)
Atokan and Morrowan Series (IP am)
Mississippian, Devonian, and Ordovician undivided (MDO)
Cambrian (-C)
Paleozoic undivided (Pau)
Precambrian undivided (p-C)


INDUSTRIAL MINERALS OF TEXAS
2008
BUREAU OF ECONOMIC GEOLOGY
SCOTT W. TINKER, DIRECTOR
JOHN A. AND KATHERINE G. JACKSON SCHOOL OF GEOSCIENCES
THE UNIVERSITY OF TEXAS AT AUSTIN
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Bureau of Economic Geology
JACKSON
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Map and accompanying text compiled by J. Richard Kyle.
Map and text reviewed by U.S. Geological Survey Minerals Information Team.
AMARILLO
EL PASO
MIDLAND
DALLAS
AUSTIN
SAN ANTONIO
HOUSTON
TEXARKANA
CORPUS CHRISTI
BROWNSVILLE
GULF OF MEXICO
MAJOR PRODUCING AREAS
Construction Materials
Cem Cement plant
Clay Common clay
C-S Crushed stone
D-G Dimension granite
D-L Dimension limestone
D-S Dimension sandstone
Gyp Gypsum
SG Construction sand and gravel
Chemical Materials
B-C Ball clay and kaolin
Bent Bentonite
He Helium
I-S Industrial sand
Lime Lime plant
S-ng Sulfur (natural gas)
S-o Sulfur (oil)
Salt Salt
SS Sodium sulfate
Talc Talc
Zeo Zeolites
Concentration of mineral operations
Salt dome
Energy Minerals
Bituminous coal
Lignite coal
U Uranium
Mouth-of-mine electricity plant
Texas Energy Minerals
Lignite
Electricity
Uranium
Population
Lignite (million tons)
Electricity (Quad BTU)
Population (millions)
Year
1965
1975
1985
1995
2006
Dominant Rock Types
Million years ago
CENOZOIC
Quaternary
Tertiary
MESOZOIC
Upper
Lower
PALEOZOIC
Upper
Lower
PRECAMBRIAN
Unconsolidated sands and muds
Alluvium
Sandstones and mudstones (volcanics in Trans-Pecos)
Limestones (sandstones and mudstones in Trans-Pecos Texas)
Sandstones and mudstones
Permian carbonates and evaporites Mississippian sandstones and mudstones
Limestones, dolostones, chert, and sandstones
Granite intrusions and metamorphic rocks
Unconformity
2
65
145
245
320
540
Unconformity: A boundary between two rock units that represents a gap in the geologic record due to erosion or nondeposition of rock.
Mineral Production (2005)
(million tonnes)
Other (8.8)
Salt (9.7)
Cement (12.2)
Crushed stone (135.0)
Sand and gravel (89.4)
Mineral Value (2005)
(million dollars)
Salt (121.8)
Other (93.3)
Lime (122.7)
Cement (1,025.0)
Crushed stone (662.9)
Sand and gravel (585.2)
"Other" includes brucite, clays (ball, bentonite, common, fuller's earth, kaolin), dimension stone, gypsum, helium, talc, and zeolites.
0 50 100 150 miles
0 100 200 kilometers

Texas Department of Transportation

Flexible Base Selection and Information Guide

Materials & Tests Division

Soils & Aggregates Section

August 2019

Table 1: Flexible Base Material Types

Type	Description
A	Crushed stone produced and graded from oversize quarried aggregate that originates from a single, naturally occurring source. This does not include gravel or multiple sources.
B	Crushed or uncrushed gravel. Blending of two or more sources is allowed.
C	Crushed gravel with a minimum of 60% of the particles retained on a No. 4 sieve with two or more crushed faces as determined by Tex-460-A, Part I. Blending of two or more sources is allowed.
D	Type A material or crushed concrete. Crushed concrete containing gravel will be considered Type D material. Crushed concrete must meet requirements for recycled materials and be managed in a way to provide for uniform quality. The engineer may require separate dedicated stockpiles to verify compliance.
E	Caliche, iron ore, or as otherwise shown on the plans.

Table 2: Basic Recommendations for Type Selection

Type	Description
A or D*	Strongest, most durable base
B or C	Marginal base
E	Non-standard requirements

* When crushed concrete is allowed.

Type A and D materials are generally considered high-quality base since crushed materials have, in general, higher stability than rounded materials. Type A and D are often used in combination with Grade 1–2, which has the most stringent material requirements. Type D allows the use of Type A or crushed concrete. This option provides an alternative where crushed concrete may be used if economically feasible.

Types B and C are generally used for areas that have gravel as a local material.

Type E may be used for new or unspecified materials.

Table 3: Flexible Base Material Requirements from Item 247

Property	Test Method	Grade 1–2	Grade 3	Grade 4	Grade 5
Master gradation sieve size (cumulative % retained)	Tex-110-E			As shown on the plans	
2½"		0	0		0
1¾"		0–10	0–10		0–5
⅞"		10–35	–		10–35
⅜"		30–65	–		35–65
#4		45–75	45–75		45–75
#40		65–90	50–85		70–90
Liquid limit, % max[1]	Tex-104-E	40	40	As shown on the plans	35
Plasticity index, max[1]	Tex-106-E	10	12	As shown on the plans	10
Plasticity index, min[1]	Tex-106-E	As shown on the plans			
Wet ball mill, % max[2]	Tex-116-E	40	–	As shown on the plans	40
Wet ball mill, % max increase passing the #40 sieve	Tex-116-E	20	–	As shown on the plans	20
Compressive strength, psi, min	Tex-117-E			As shown on the plans	
Lateral pressure, 0 psi		35	–		–
Lateral pressure, 3 psi		–	–		90
Lateral pressure, 15 psi		175	–		175

[1] Determine plastic index in accordance with Tex-107-E (linear shrinkage) when liquid limit is unattainable, as defined in Tex-104-E.

[2] Grade 4 may be further designated as Grade 4A, Grade 4B, etc.

FULL DEPTH RECLAMATION (FDR)

Special Specification 3088

Full Depth Reclamation Using Foamed Asphalt (Road-Mixed)

1. DESCRIPTION

Perform full depth reclamation (FDR) using an in-place mixing process to obtain a homogenous mixture of the existing surface and the underlying base material (with or without new material and additive added) using a foamed asphalt.

Special Specification 3089

Full Depth Reclamation Using Asphalt Emulsion (Road-Mixed)

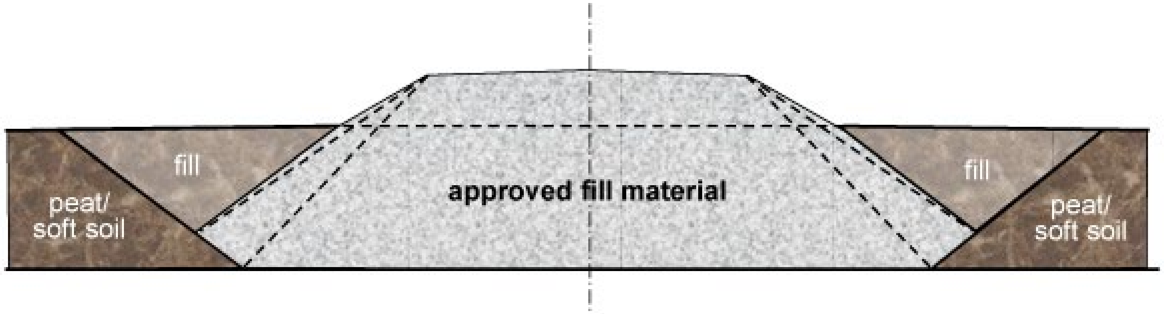
1. DESCRIPTION

Perform full depth reclamation (FDR) using an in-place mixing process to obtain a homogenous mixture of the existing surface and the underlying base material (with or without new material and additive added) using an emulsified asphalt.

COMMON METHODS USED TO ADDRESS PROBLEM BASES AND SOILS

- Lime
- Cement
- Asphalt emulsion / foamed
- Remove and Replace Existing Subgrade / Embankment
- Add Additional Base or Pavement Thickness Instead of Treating the Subgrade
- Geo-Grid Products
- Alternative Stabilizers (Proprietary Liquids or Dry)
- Recycling Existing Pavement and Base (FDR)

REMOVE POOR SOILS AND IMPORT SELECT FILL OR BASE MATERIAL



REMOVE POOR SOILS AND IMPORT SELECT FILL OR BASE MATERIAL (CUT AND FILL)

- This is almost never cost effective compared to lime treatment
- Removal and replace costs alone are typically > than $10/CY
- Highly variable determining cost of import material due to source and haul distance
- **This is often a strategy when sulfates are present in the clay**
- Can be other problems associated with this concept that aren’t considered (variability of import fill source that isn’t properly monitored)

REMOVE POOR SOILS AND IMPORT SELECT FILL OR BASE MATERIAL (CUT AND FILL)

- For 8" Lime:
  - 1800 tons ($275/ton) = $495,000
  - 100,000 SY @$4.00 = $400,000

Total = $895,000

- Removal and replace costs alone are > than $10/CY
  - 100K SY @ 2' deep = 67K CY
  - 67,000 CY @$14.00 = $938,000
    - Disposal @$5.00 = $335,000
    - Select Fill @$5.00 = $335,000

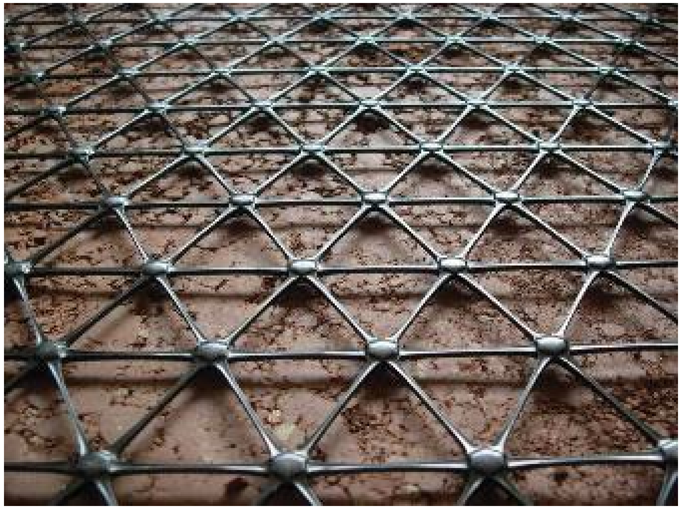
Total = $1,608,000

***The above case is an example and varies based on fill sources and costs**

INCREASING THICKNESS OF OTHER LAYERS IN THE PAVEMENT SECTION

- This alternative appears most commonly in commercial and subdivision type projects
- The engineer/architect or sometimes a contractor will convince a developer or a smaller local agency to do away with lime treatment by adding an extra inch of concrete pavement, or extra flex base and sometimes Hot Mix Asphalt (HMA)
- This is a strategy that is driven purely by cost and time
- This will, in almost all cases, lead to poor performance for roadways, parking lots, and foundations because nothing has been done to treat the underlying problems of highly plastic swelling clays

THE USE OF GEOGRID IN PLACE OF SOIL STABILIZATION



THE USE OF GEOGRID IN PLACE OF SOIL STABILIZATION

- Geogrids are Polypropylene products that are being used in a variety of ways
- Geogrid is a very good technology, when used in the proper situation
- They base their value add on improving tensile strength in the pavement base layer. Coupled with cost savings and speed of construction

THE USE OF GEOGRID IN PLACE OF SOIL STABILIZATION

- Using Geogrid directly on compacted but untreated high PI subgrade will not provide the benefits achieved by creating a uniform lime stabilized layer.

  - Moisture and the fines in the untreated subgrade layer will work their way up into the crushed stone base (fluctuations in moisture condition and capillary rise). This weakens the base layer significantly over time and can lead to premature failure of the pavement structure.
  - A properly treated sub-base layer provides significant protection for the overlying base layer by adding strength, waterproofing and stopping the swell potential of the treated layer that will not happen using Geogrid alone
  - The use of GeoGrid on top of a properly stabilized subgrade is a very good option

USE OF PROPRIETARY LIQUID OR DRY STABILIZATION PRODUCTS

(1.) ionic stabilizers, reported to work through cation exchange within the clay mineral

(2.) enzyme stabilizers, described as consisting of various organic catalysts

(3.) polymer and “Bio-Polymer” stabilizers, comprised of various organic and inorganic polymers

USE OF PROPRIETARY LIQUID OR DRY STABILIZATION PRODUCTS

"Supplier claims of product effectiveness are often not well substantiated with independent field or laboratory evaluations performed under controlled conditions. The chemical composition of these products is usually considered proprietary, and the suppliers often give minimal or incomprehensible information regarding the mechanisms of soil modification."

AN ANALYSIS OF THE MECHANISMS AND EFFICACY OF THREE LIQUID CHEMICAL SOIL STABILIZERS: VOLUME 1

May 2003

Alan F. Rauch, Lynn E. Katz, and Howard M. Liljestrand

What is Soil Treatment ?

- **Soil Treatment :** general term to indicate a process aimed at physically modifying a soil so that it can fulfill the purpose intended. (i.e. – moisture conditioning, scarify & re-compact, soil modification, soil stabilization & etc.).

- **Soil Modification :** operation which improves the engineering properties of a soil by addition of lime. The additive is added in a quantity insufficient to induce a significant permanent chemical change. Improves texture and creates stable working platform.

What is Soil Treatment ? Continued

- **Soil Stabilization :** operation which permanently alters the chemical and physical characteristics of the soil in a way that renders it stable, particularly with respect to the action of water and frost. It gives a permanent strength that can be measured by typical methods such that target moduli is achieved.

Soil Treatment
(know your goals):

Very wet jobsite

Soil Modification/ Dry Up:

Useful to expedite construction or to create a stable working platform

May not result in permanent changes to soil

(intentional i.e. – temporary haul road or storage yard & not intentional i.e. – over mixing of depth & inconstant application rate resulting in dilution)

Soil Treatment
(know your goals):

Soil Stabilization:

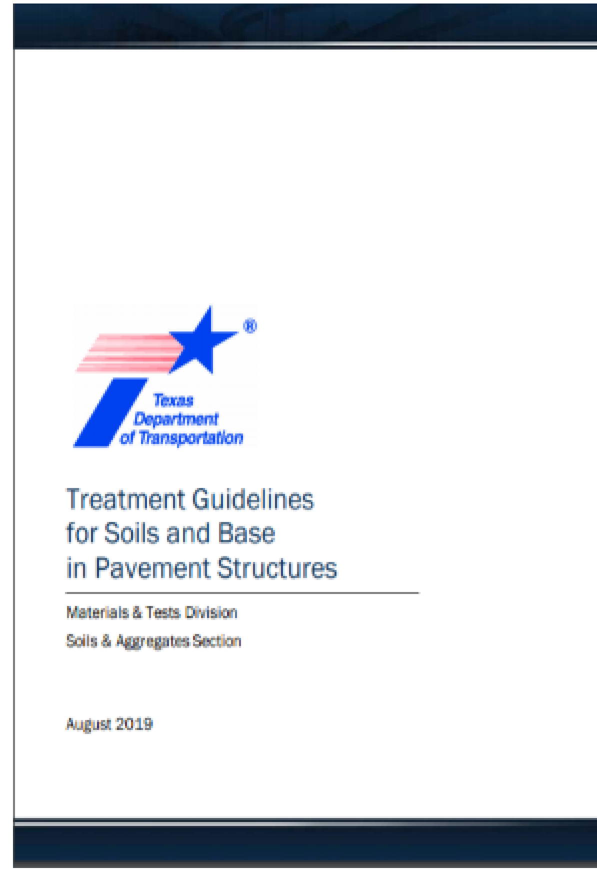
engineered system designed to maximize structural strength and permanently alter soil system

PURPOSE OF THE TREATMENT GUIDELINES

http://ftp.dot.state.tx.us/pub/txdot/mtd/treatment-guidelines.pdf

- Provide personnel with all levels of experience with enough information to
-
  - Determine project suitability,
  - Identify goals of treatment,
  - Select appropriate type of additives,
  - Determine optimum amount of selected additives, and
  - Identify appropriate construction processes.

- The information in this document is applicable to both construction and maintenance.


Texas Department of Transportation

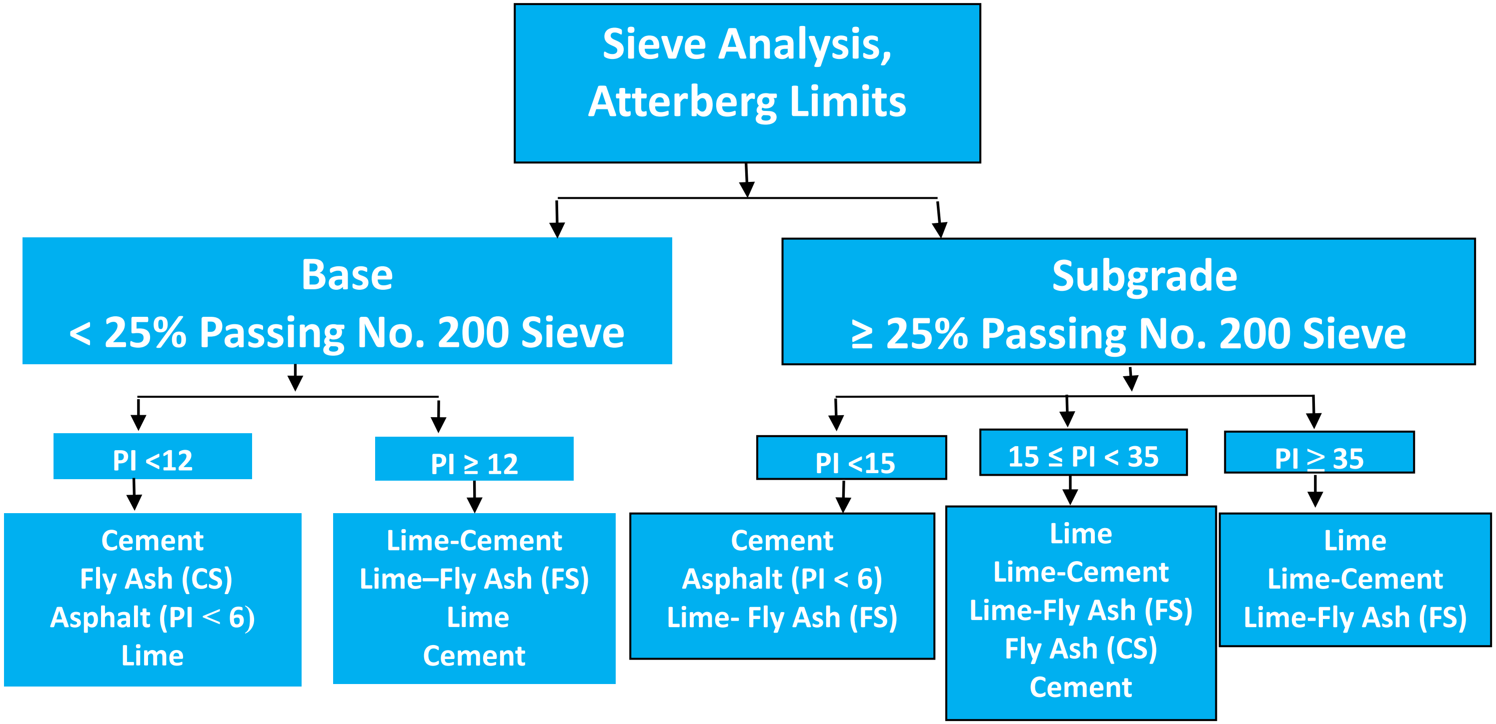
Treatment Guidelines for Soils and Base in Pavement Structures

Materials & Tests Division

Soils & Aggregates Section

August 2019

TXDOT GUIDELINES FOR SOIL TREATMENT



TxDOT Specs (Road or Plant Mixed)		TxDOT Lab Mix Design Test Methods
Lime	Items 260 or 263	Tex-121-E
Cement	Items 275 or 276	Tex-120-E
Fly Ash	Item 265	Tex-127-E
Asphalt	Item 292	Tex-126-E

KEY POINTS OF GUIDELINES

- Soils are different
- Additives are different
- Reactions between soils and additives are different
- **DO A MIX DESIGN**
- Evaluate the material engineering properties and field performance

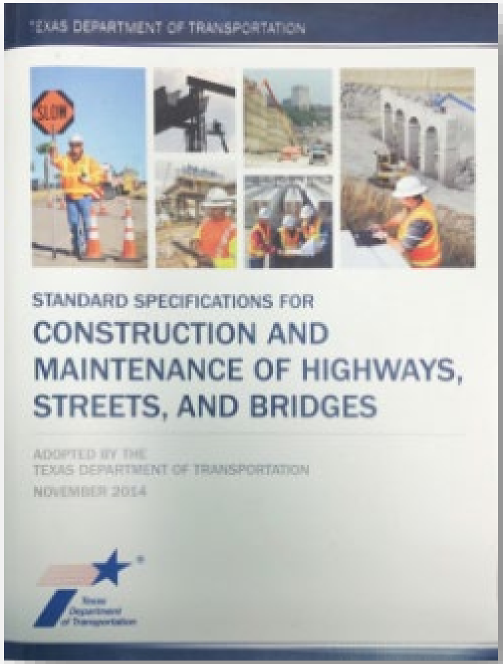
SELECT ADDITIVE(S) – LAB MIX DESIGN

Select Additives

- Select the appropriate type of additive based on the goals of soil treatment and the project-specific soil classification (gradation and PI)
- Perform the lab mix designs to determine the optimum amount of the selected additive on a project basis for the desired engineering properties
  - Soil-Lime (Tex-121-E); DMS 6350
  - Soil-Cement (Tex-120-E); DMS 4600
  - Lime-Fly Ash (Tex-127-E); DMS 4615
  - Asphalt Treated Base (Tex-126-E)

CONSTRUCTION SPECIFICATIONS

- A Perfect Laboratory Mix Design Will Only Work in the Field if Proper Construction Procedures Are Followed



TXDOT SOIL TREATMENT CONSTRUCTION SPECIFICATIONS

Item	Treatment	Special Requirements
260	Lime (road mixed)	Mellowing requirements apply depending on the type of lime and sulfate content of the material.
263	Lime (plant mixed)	Cure at least 7 days by sprinkling or by asphalt membrane.
265	Fly ash or lime-fly ash (road mixed)	Complete compaction within 6 hours of application of Class FS ash and within 2 hours of application of Class CS ash. Cure FS ash 7 days; CS at least 24 hours.
275	Cement (road mixed)	Complete compaction within 2 hours. Microcrack to reduce shrinkage cracks. Cure at least 3 days by sprinkling or asphalt membrane.
276	Cement (plant mixed)	Microcrack to reduce shrinkage cracks. Cure at least 3 days by sprinkling or asphalt membrane.
Asphalt Emulsion	Emulsion (road mixed)	Cure to 2 percentage points below optimum before placing the next course.
Foamed Asphalt	Foamed Asphalt (road mixed)	Special equipment is needed. Cure a minimum of 2 hours.

Lime Stabilization is Not to Hard to Achieve

Do These Things

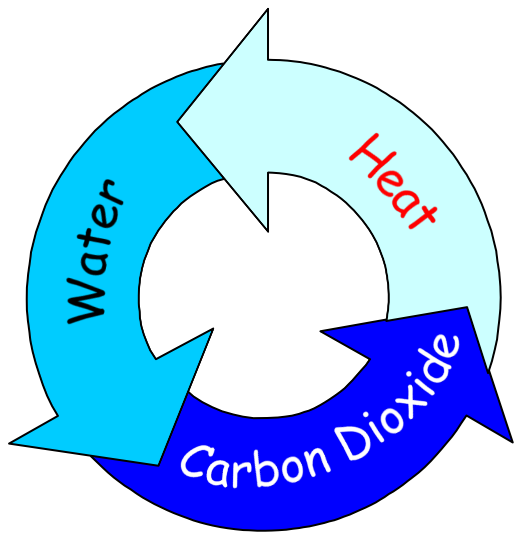
- Apply right amount of lime
- Control mix depth
- Use plenty of water

Hard to mess up!

The Lime Cycle

CaO
Quicklime

$Ca(OH)_2$
Hydrated Lime



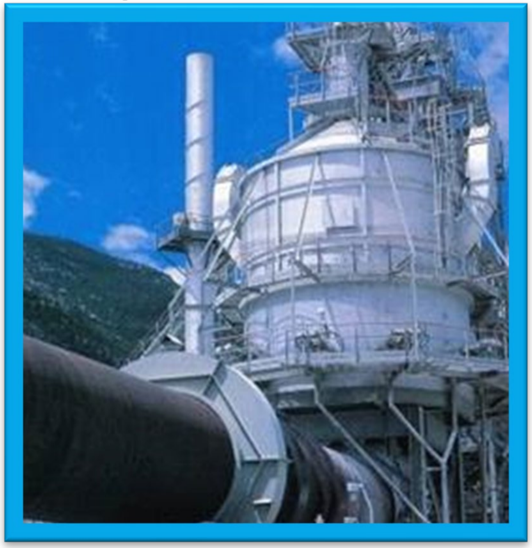
$CaCO_3$
Limestone

Manufacture of Lime

Lime Reserves

Blasting

Mining Operations



Rotary Kiln w/Preheater

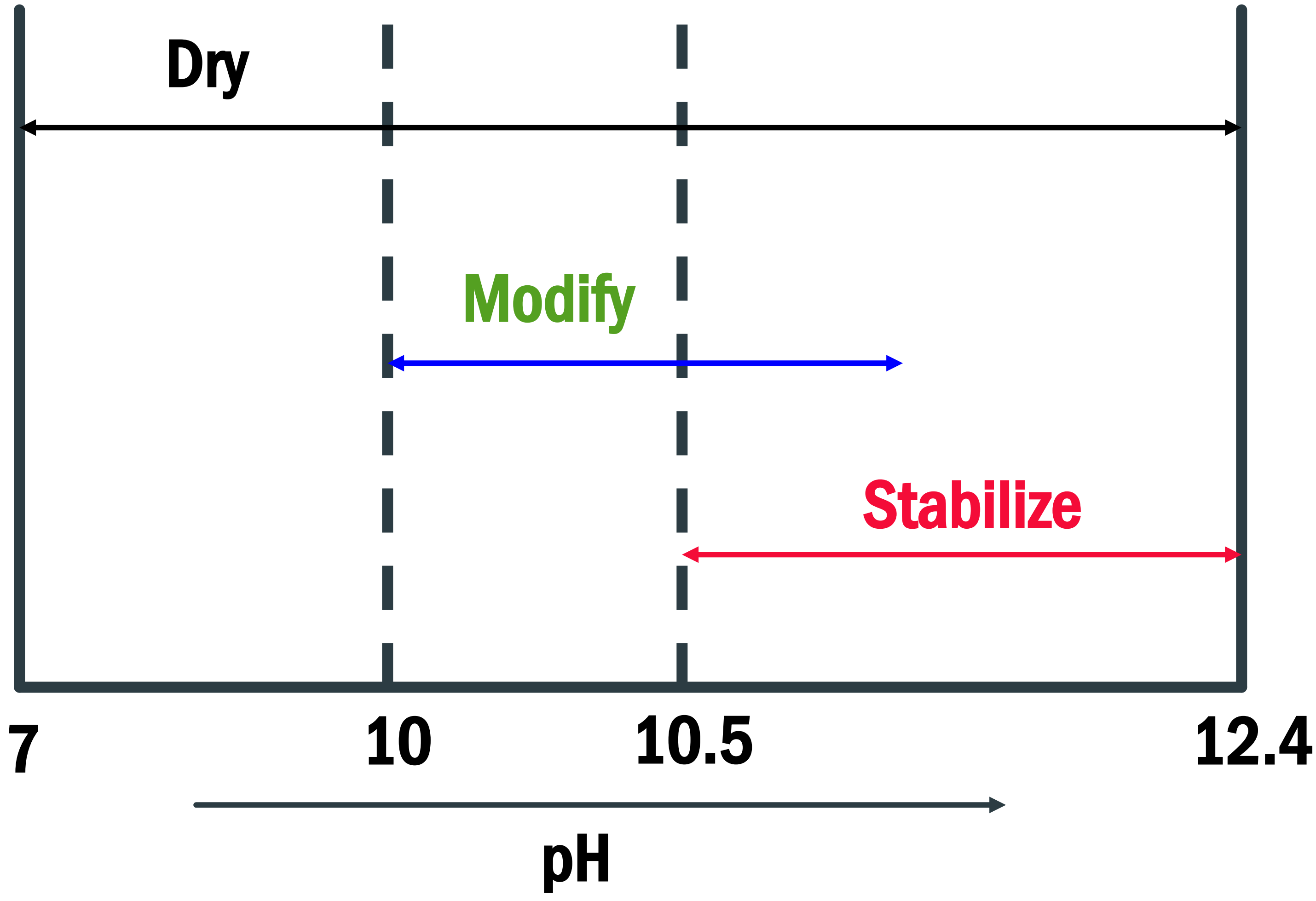
Manufacture of Lime

- To transform $CaCO_3$ to CaO takes temperatures > 1800 °F.
- Most US kilns are rotary designs, up to 400 feet long and 16 feet in diameter producing 100 - 1,300 tpd
- Vertical Kilns (Mertz) are also used and are very efficient

Manufacture of Lime

- Lhoist also operates Vertical Kilns and has commissioned 3 of these new kilns in the U.S. in the last 2 years. They are more efficient

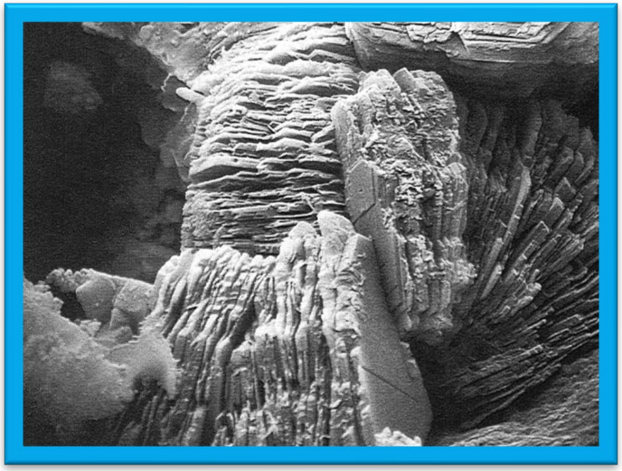
USES OF LIME



Benefits of Lime Stabilization

- The addition of lime can permanently change the clay soils, stabilizing and strengthening them into high performance pavement foundations
- Lime permanently reduces the plasticity of expansive soils
- A properly stabilized layer improves the uniformity of the subgrade (layer beneath base)

Structure of Clay Minerals



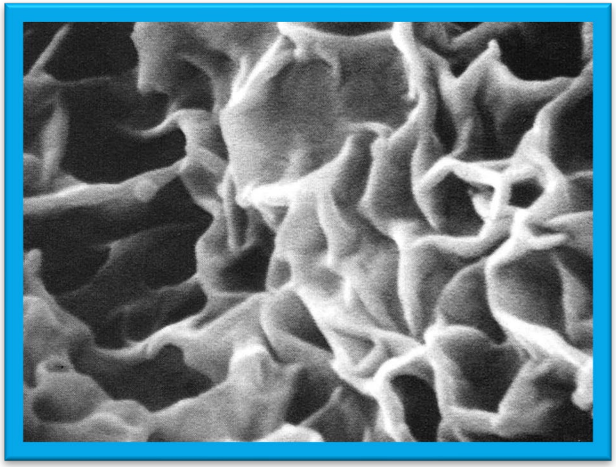
Kaolinite:

Hexagonal crystals

Size: 0.2 - 2 μm

Surface Area: 10 - 30 m^2/g

[Magn: 2000 x]



Montmorillonite:

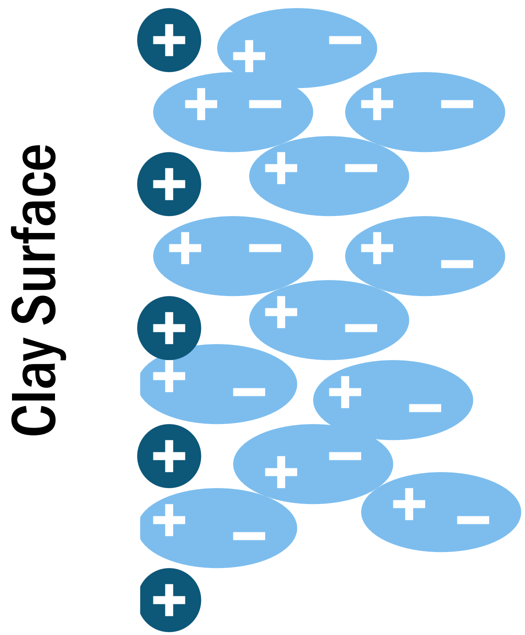
Flakes

Size: 0.01 - 1 μm

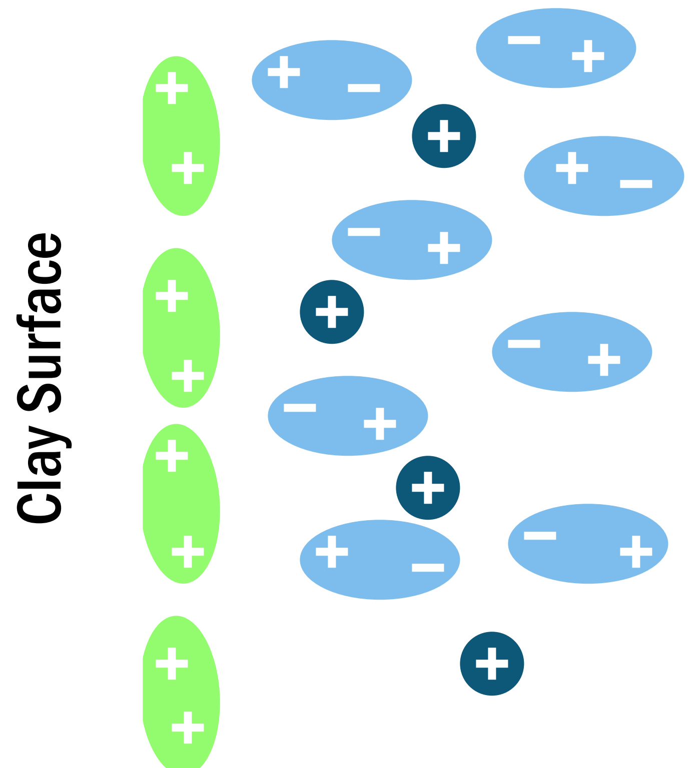
Surface Area: 650 - 800 m^2/g

[Magn: 20000 x]

THE SYSTEM:
CLAY – WATER - CALCIUM



Negatively charged clay surface attracts cations (+) & water molecules (dipole), causing formation of a 'double diffused water layer'



Calcium cations (++) replace water and lessens ions so soil becomes more workable

Lime - Soil Reactions (1):

Immediate Reactions (within hours)

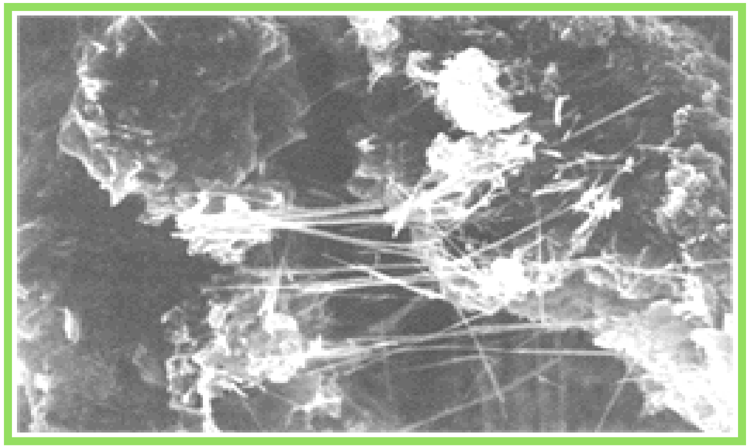
- **Reduction in Water Content**
  chemical reaction ($CaO + H_2O \rightarrow Ca(OH)_2$ + heat)* and mixing effect *: not for Hydrated Lime

- **Flocculation / Agglomeration of Clay particles**
  textural change leads to decrease in PI & increase in workability

Lime - Soil Reactions (2):

Medium & Long Term Reaction (weeks, months, years)

- **Pozzolanic reaction between lime and clay particles**
  - Rate of pozzolanic reaction depends on
    - amount and type of clay mineral
    - temperature (increase by 50^0F doubles speed of reaction)
    - high pH (> 12) and availability of calcium and water



Pozzolanic Reaction

Pozzolan:

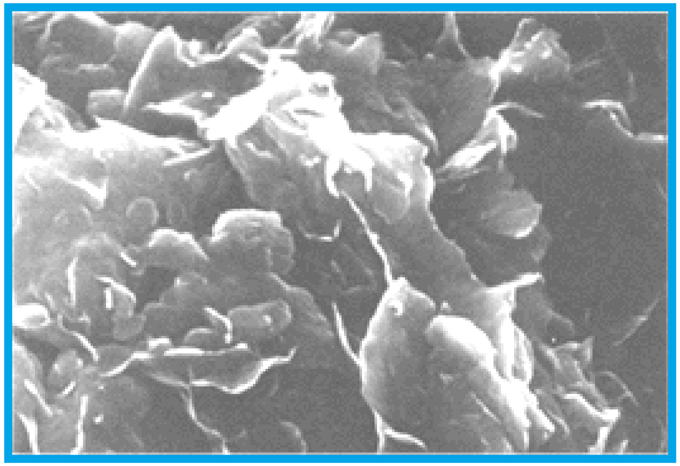
Siliceous or aluminous material that reacts in presence of water and Lime (Ca^{2+} & OH^{-}) to produce stable, water-insoluble hydrates

- Calcium-Silicate-Hydrates (CSH)
- Calcium-Aluminate-Hydrates (CAH)

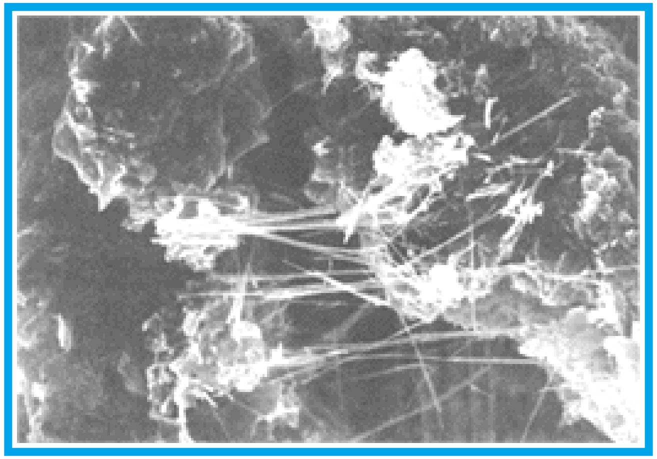
These products are essentially the same hydrates that form during the hydration of Portland cement.

LIME STABILIZATION PROCESS

Hydrated lime ($Ca(OH)_2$ ⟶ high pH)
+ water (H_2O)
+ Clay (Silica & Alumina dissolve)
= Cementitious material (CSH & CAH)

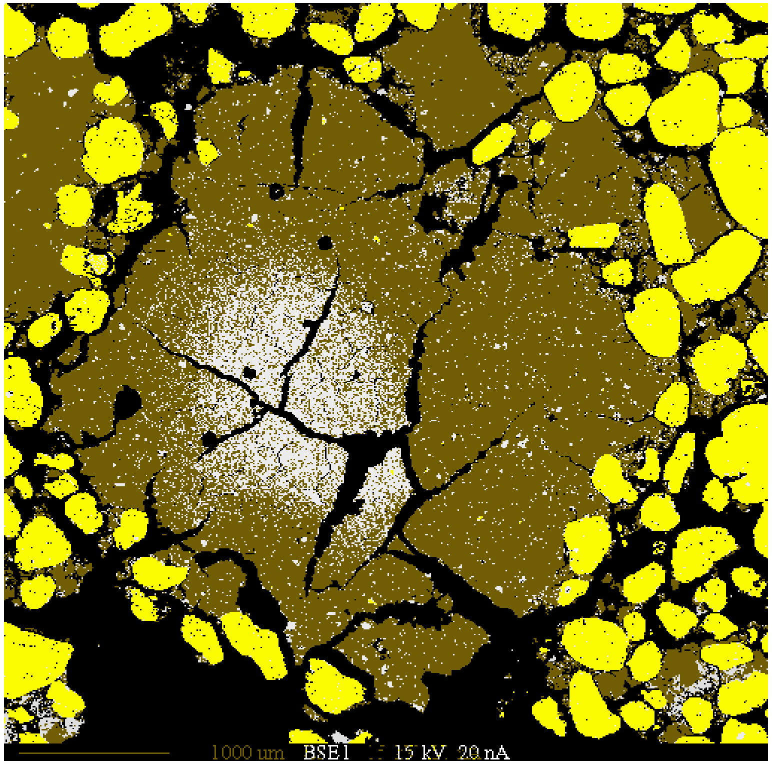


Natural Clay

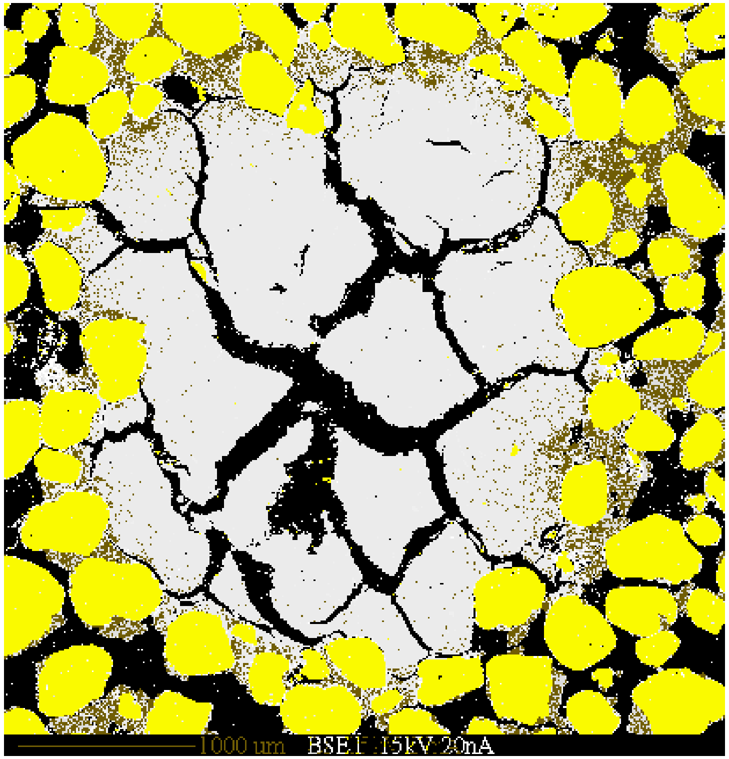


Pozzolanic Reaction Increases Bonds by Formation of Crystals

CALCIUM DIFFUSION INTO CLAY – 365 DAYS



Lime treated, 5mm



Cement treated, 4mm

Si bearing

Porosity

Ca + Si + Al bearing

Si + Al bearing

Ref: Harris, et al

Tests for Lime Stabilization

Tex-104, 105, & 106-E

Tex-121-E Part III

Tex-113-E

Tex-121-E Part I

SOIL – LIME TESTING:

Determine Lime Demand

- Tex-121-E Part III (Eades & Grim pH test) to determine Lime demand

Determine MD Curve & Optimum Moisture Content

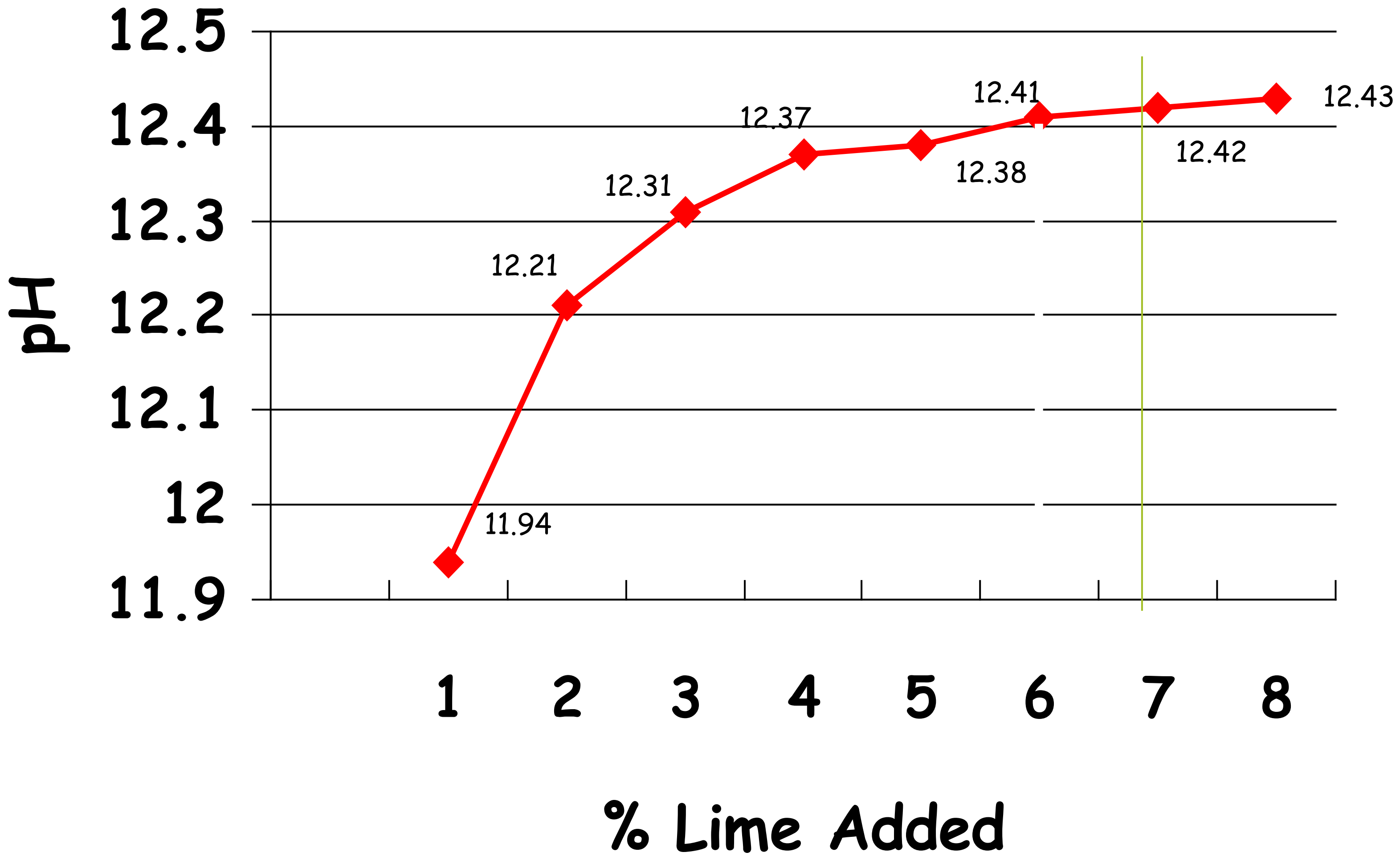
- Tex-113-E

Determine Strength

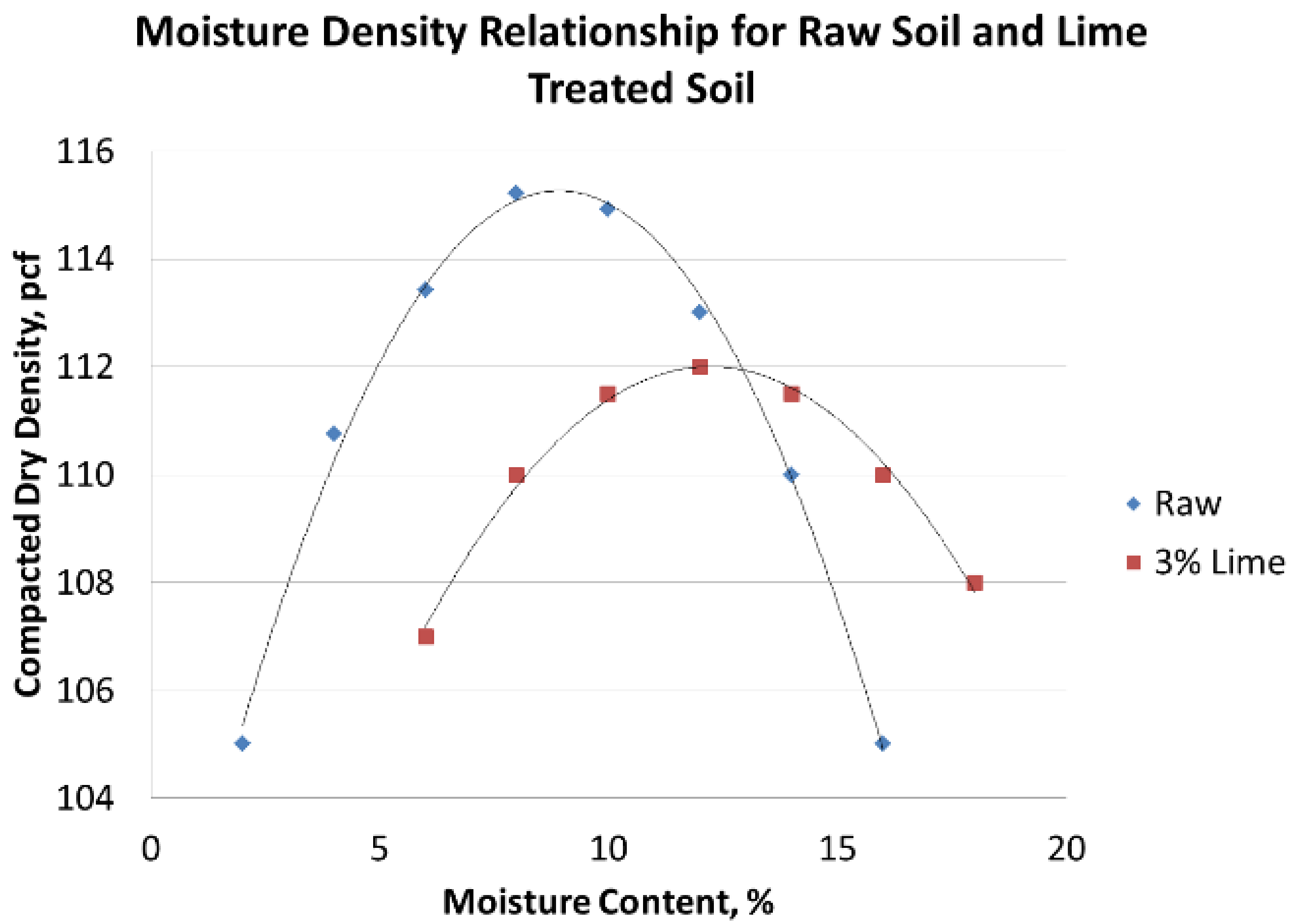
- Tex-121-E Part I to determine Unconfined Compressive Strength (UCS)

TEX-121-E PART III

Tex-121-E Part III



Influence on Moisture-Density Relation:



RAPID CHANGE IN SOIL TEXTURE

BIG DIFFERENCE!

Before

After

CHANGING IT FROM BAD TO GOOD

Before Lime Stabilization

After Lime Stabilization

QUESTIONS?

LIME STABILIZATION CONSTRUCTION

Lime Soil Stabilization

- Lime spread rate
- Pulverization
- Mixing efficiency
- Lime content
- Depth of lime treatment
- Moisture content
- Density
- Slurry composition
- Weather limitations

Lime Slurry

Jobsite Porta Batch

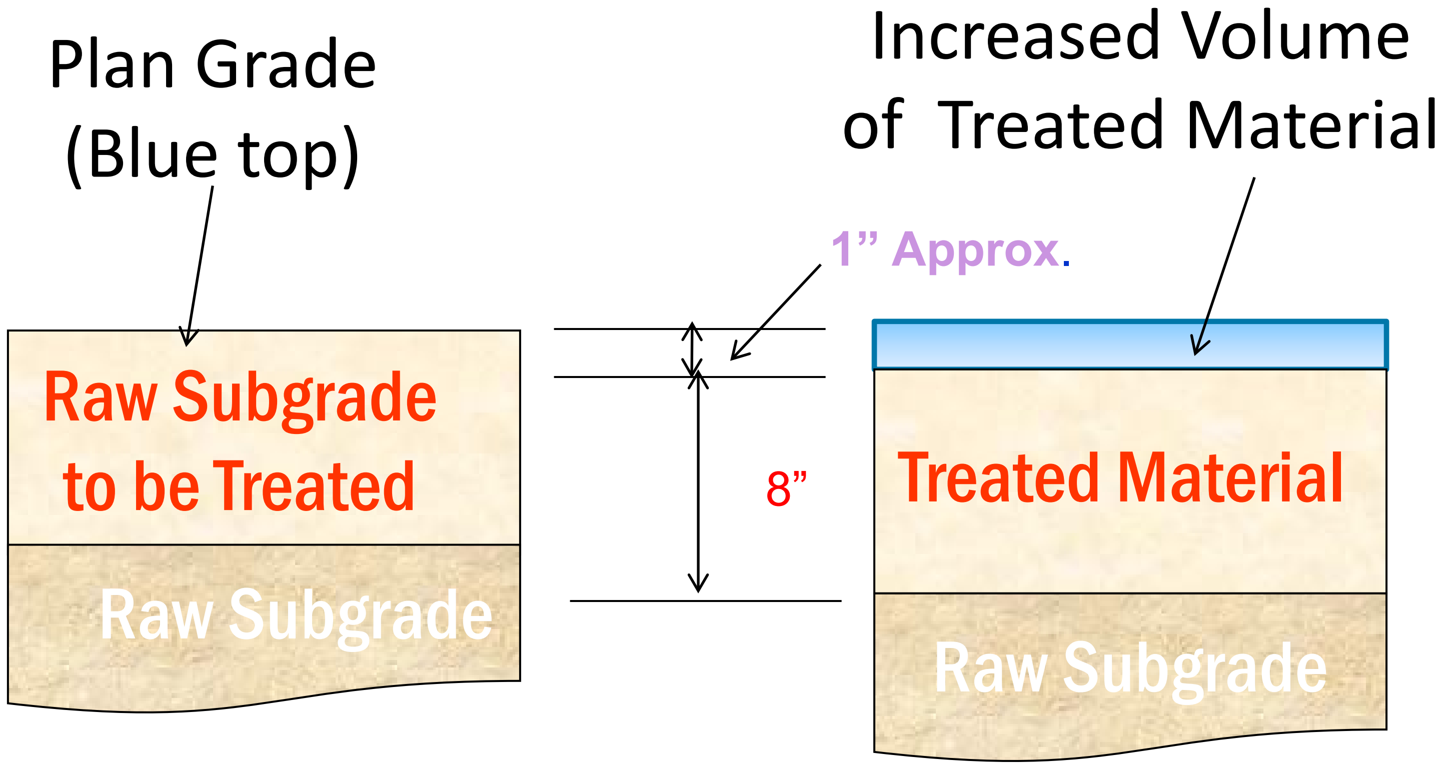
After Application

SOIL PREPARATION

- Bring to final grade and alignment
- Adjust for fluff - minimize by using adequate water and mixing immediately
- Blade trim top 0.25-in. (BMP or Spec)

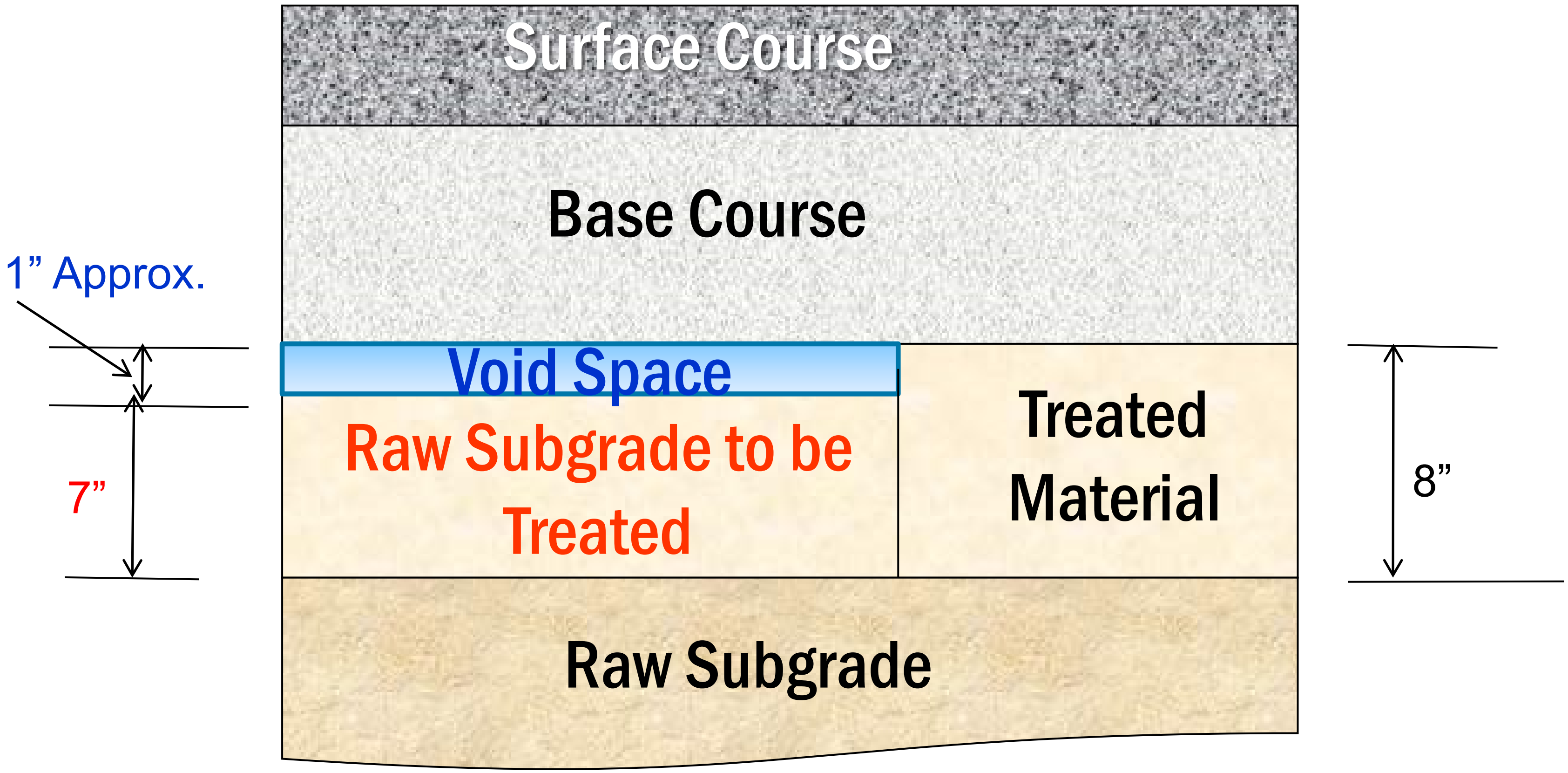
In-situ subgrade before stabilization

Subgrade Adjustment for Fluff



Rule of Thumb: 1” of fluff for every 8” of treatment

Subgrade Adjustment for Fluff



LIME APPLICATION

- Dry lime - scarify to stabilization depth before lime is added (use BMP's or specs)

- Slurry - scarify prior to addition

SPREADING OF LIME

- Apply only to an area where mixing can be completed on the same working day.

- Whether using dry lime or lime slurry it needs to be mixed into soil and additional water needs to be added on the same working day.

DISTRIBUTION OF QUICKLIME

Be sure to add enough water to hydrate/slake pebbles before mixing

SPREADING LIME SLURRY

BMP's for controlling stabilization limits

LIME SLURRY BEING APPLIED

INITIAL MIXING

PULVERIZATION AND MIXING

- Two-stage
  - preliminary - distribute and wet
    - mellowing period – Refer to TxDOT spec for Item 260
  - final gradation:
    - 100% passing 1.75-in.
    - 85% passing 3/4-in.
    - 60% passing No. 4
- Mix 3% to 5% above optimum moisture content (BMP or TxDOT Spec)

ADJUSTMENT MOISTURE CONTENT

Mix in lime using mixer

MOISTURE CONTENT ADJUSTMENT

Add more water if needed

"MELLOWING PERIOD" (1)

- Allows for cationic exchange and formation of initial pozzolanic reaction products
- "Breaks down" clay particles
- Optimized at 3-5 % over optimum moisture of treated soil. (see TxDOT spec for requirement)

"MELLOWING PERIOD" (2)

- Minimum of 24 hours for Slurry, preferably overnight mellowing. (see TxDOT Spec for requirement).
- 48 Hours or more for dry placed quicklime or higher P.I. Clays with either slurry or dry.

Importance of Mix Depth & Mellowing

- Depth Of Mixing
- Mellowing – Need to have the time for lime to have thorough contact with clay layers (Remember Huge Surface Area)
- Moisture Control – Water is needed for chemical reaction between lime and soil. Use more water if using quicklime.

UNIFORMITY OF MIXING & PARTICLE SIZING

After Mellowing

- Additional water
- Additional mixing
- check mixing depth, homogeneity (using phenolphthalein in field or pH test in lab)
- check particle sizing

INSPECTION OF STABILIZATION

- Dig small hole and test with phenolphthalein pH solution in loose or compacted material
- Spray solution along face of hole to determine depth of treatment (soil will turn pink color at a pH 9 or higher)
- Measure compacted depth using Tex–140-E

REMIXING

After mellowing

Reworking treated soil

- Remix soil-lime mixture after mellowing period to achieve gradation
- Moisture condition to a minimum +2 above OMC (or TxDOT spec) prior to compaction

COMPACTION (1)

- Prior to mellowing intermediate light compaction - seal to reduce carbonation
- 95% of Maximum Dry Density in accordance with Tex-121-E or as specified
- Compact as soon as possible after mixing
- Most common to compact in one lift with a padfoot followed by a pneumatic roller

COMPACTION (2)

COMPACTION (3)

Remember:

Density (dry unit weight) of treated soil will be lower than native soil

Optimum moisture content of treated soil will be higher than native soil

CURING (1)

- After mellowing and compaction
- Additional water
- Prevents stabilized section from drying out
    - prevents cosmetic shrinkage cracking
    - allows progress of pozzolanic reaction

Moisture Cured Subgrade

CURING (2)

- During curing period
  - emulsion curing seal
  - aggregate Base Course section

BENEFITS OF SOIL STABILIZATION

- Eliminates excavation & disposal costs
- Provides a stable & uniform layer or paving structure
- Decreases expansion/swelling
- Improves foundation support
- Achieves long term strength & performance

QUESTIONS?