Design of Pavements on Expansive Clay Subgrades

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Zachry Department of Civil Engineering
Texas A&M University

Foundation Performance Association
Houston, Texas
December 12, 2012
Outline

- Performance of pavements on expansive clays
  - Roughness
  - Cracking

- Pavement monitoring program

- Suction envelopes for design

- Prediction of movement
  - Edge of pavement
  - Wheel path
Outline, cont.

- Prediction of roughness
- Longitudinal cracking over expansive soils
  - Design countermeasures
  - Crack spacing
- Features of design program WinPRES
- WinPRES demonstration
Guardrail between pavement lanes on expansive clay subgrade IH37, San Antonio, Texas (c. 1974)
MONITORING ANALYSIS OF CROSS SECTION
Vertical displacement across section

Year 1

Distance (cm) versus Vertical displacement (cm)
Vertical displacement across section

Year 1

<table>
<thead>
<tr>
<th>Vertical displacement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>0.0</td>
</tr>
<tr>
<td>-0.0</td>
</tr>
<tr>
<td>-2.5</td>
</tr>
<tr>
<td>-5.0</td>
</tr>
<tr>
<td>-7.5</td>
</tr>
<tr>
<td>-10.0</td>
</tr>
</tbody>
</table>

Distance (cm)
Vertical Barrier Effectiveness
Normal Drainage/Paved Median - Dallas

- Cracked Soils with deep Roots
- Medium Cracked Soils with Deep Roots
- Tight Soils with Shallow Roots

Vertical Movement (cm)

Depth of the Vertical Barrier (m)
Guardrail between pavement lanes on expansive clay subgrade
IH37, San Antonio, Texas (c. 1974)
PROPOSED
TYPICAL MAINLANE PAVEMENT SECTION

CEM. STAB. BACKFILL
GRAVEL BACKFILL
VERTICAL MOISTURE SEAL
TYPICAL CROSS SECTION
WITH MOISTURE BARRIER

POLYPROPYLENE FABRIC

BACK FILL
MATERIAL
(UNCRUSHED STONE)

CRACKS

ASPHALT LAYER

SHOULDER

1'0

1'6

6'6''
Exponential Suction Profile for Extreme Wetting and Drying Condition

\[ U(Z, t) = U_e + U_o \exp \left( -\frac{n\pi}{\alpha} \right) \cos \left( \frac{n\pi Z}{\alpha} \right) \]  
\[ U(Z) = U_e + U_o \exp \left( -\frac{n\pi}{\alpha} Z \right) \]  
Mitchell (1979)

Fort Worth Interstate 820

Moisture Active zone
Figure 1 - Total Soil Suction Histogram for 2006
Physical Meaning of Scales

- Oven Dry
- Airdry (R.H. = 50%)
- Tensile Strength of Confined Water
- Wilting Point
- Clay Plastic Limit
- Clay Wet Limit
- Field Capacity
- Liquid Limit

pF-  pG
# Performance Criteria for Engineering Structures

<table>
<thead>
<tr>
<th>Engineering Structure</th>
<th>Performance Criteria</th>
</tr>
</thead>
</table>
| Foundations           | • Differential movement: vertical and lateral and allowable stresses  
                        • Differential movement and allowable stresses  
                        • Total vertical and lateral movement; lateral pressure; allowable stresses |
| Pavements             | • Roughness spectrum, International Roughness Index, Longitudinal cracking  
                        • Roughness spectrum, Pilot and Passenger acceleration |
| Retaining Walls       | • Lateral pressure and movement, allowable stresses |
### Performance Criteria for Engineering Structures, cont.

<table>
<thead>
<tr>
<th>Engineering Structure</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipelines</td>
<td>• Roughness spectrum, allowable stress, fatigue criteria, corrosion</td>
</tr>
<tr>
<td>Slopes</td>
<td>• Downhill movement, shallow slope failure, slope stability</td>
</tr>
<tr>
<td>Canals</td>
<td>• Combination of the performance criteria of retaining walls, pipelines, and slopes; thermal and shrinkage cracking; permeability of the cracks and joints</td>
</tr>
<tr>
<td>Moisture Barriers</td>
<td>• Reduction of the movement of water in the soil and of total vertical movement</td>
</tr>
<tr>
<td>Land Fill Covers and Liners</td>
<td>• Moisture and leachate transmission (including the effects of cracks)</td>
</tr>
</tbody>
</table>
The Design Problem

How do you design a foundation to perform successfully when you have poor site conditions?

- Vegetation
- Drainage
- Slopes
**Answer: Design for the worst that they can do**

<table>
<thead>
<tr>
<th>Site condition</th>
<th>Problem</th>
<th>Limiting Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td>Drying shrinkage</td>
<td>Wilting point pF=4.5</td>
</tr>
<tr>
<td>Poor drainage</td>
<td>Swelling</td>
<td>Clay wet limit pF&gt;2.5</td>
</tr>
<tr>
<td>Slopes</td>
<td>Downhill creep, shallow slides</td>
<td>Uphill offsets, drainage control</td>
</tr>
</tbody>
</table>

**Table Data:****

<table>
<thead>
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<th>Site condition</th>
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<th>Limiting Condition</th>
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<tr>
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</tr>
<tr>
<td>Slopes</td>
<td>Downhill creep, shallow slides</td>
<td>Uphill offsets, drainage control</td>
</tr>
</tbody>
</table>
Answer: use suction envelopes to determine the worst that they can do
Dry Season

(-)

Suction

Ground Surface

Wet Season

Equilibrium

Depth

Dry Season
<table>
<thead>
<tr>
<th>Depth</th>
<th>Water Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction of the Water</td>
<td>Suction</td>
</tr>
<tr>
<td>Equilibrium</td>
<td>Wet Season</td>
</tr>
<tr>
<td>Ground Surface</td>
<td>Suction of the Water</td>
</tr>
<tr>
<td>(-)</td>
<td>Dry Season</td>
</tr>
</tbody>
</table>

Diagram illustrating the relationship between suction, ground surface, depth, and wet season conditions. The water table is indicated by a line marking the level of water, while suction points to the ground surface.
Field Conditions

\[ U_e = 3.5633 \exp(-0.0051TMI) \]

\[ U(Z) = U_e \pm U_0 \exp \left( -\sqrt{\frac{n\pi}{\alpha}Z} \right) \]

Field capacity \hspace{1cm} Equilibrium \hspace{1cm} pF \hspace{1cm} Wilting point 4.5 pF

Depth (ft)

Root zone

Moisture active zone
Volume Change

\[ \% f_c = \frac{\% - 2 \mu m}{\% - \text{No. 200 sieve}} \]

\[ \gamma_h = \gamma_0 \times \left[ \frac{\% - 2 \mu m}{\% - \text{No. 200 sieve}} \right] \]

\[ \gamma_\sigma = \gamma_h \frac{1}{1 + \frac{h}{\theta \left( \frac{\partial h}{\partial \theta} \right)}} \]

Zone III (Covar and Lytton, 2001)  
(Lytton, 1994)
Volume Change

\[ \frac{\Delta V}{V} = -\gamma_h \log_{10} \left( \frac{h_f}{h_i} \right) - \gamma_\sigma \log_{10} \left( \frac{\sigma_f}{\sigma_i} \right) \]  

(Lytton, 1977)

\[ \frac{\Delta H}{H} = f \left( \frac{\Delta V}{V} \right) \]

\[ f = 0.67 - 0.33\Delta pF \]

\[ \left( f = 0.5 \text{ when drying}; \quad f = 0.8 \text{ when wetting} \right) \]

\[ \Delta = \sum_{i=1}^{n} f_i \left[ \frac{\Delta V}{V} \right]_i \cdot \Delta Z_i \]
Suction vs. Pressure vs. Volume Surface
Formation of Suction vs. Pressure vs. Volume Surface
Calculated Vertical Movement

Fort Worth Interstate 820 B
Transverse Distribution of Vertical Movements

- Section A
- Section B
- Section C

Swelling

- Shrinkage

d (ft)

<table>
<thead>
<tr>
<th>Shrinkage</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.5</td>
<td>-0.5</td>
<td>0</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>(in)</td>
<td>3.5</td>
<td>2.5</td>
<td>1.5</td>
<td>0.5</td>
<td>0</td>
</tr>
</tbody>
</table>
Predicted Roughness vs. Time; Fort Worth I-820 B

Loss of Serviceability

Increase in Roughness

Time (yrs)
Predicting Changes in IRI (R)

\[ \frac{dR}{dt} = \beta_1 (\Delta H) + \beta_2 \]

- Pavement categories:
  - Moisture barriers with paved medians
    \[ \beta_1 = 0.619, \beta_2 = 1.295 \]
  - Moisture barriers with sodded medians
    \[ \beta_1 = 1.583, \beta_2 = 2.011 \]
  - Control section with and without medians
    \[ \beta_1 = 2.701, \beta_2 = 4.015 \]
<table>
<thead>
<tr>
<th>International Roughness Index</th>
<th>Serviceability Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>(m/km) (in/mile)</td>
<td></td>
</tr>
<tr>
<td>0.95 60</td>
<td>4.68</td>
</tr>
<tr>
<td>1.03 65</td>
<td>4.51</td>
</tr>
<tr>
<td>1.10 70</td>
<td>4.35</td>
</tr>
<tr>
<td>1.18 75</td>
<td>4.21</td>
</tr>
<tr>
<td>1.26 80</td>
<td>4.07</td>
</tr>
<tr>
<td>1.34 85</td>
<td>3.94</td>
</tr>
<tr>
<td>1.42 90</td>
<td>3.82</td>
</tr>
<tr>
<td>1.50 95</td>
<td>3.70</td>
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<tr>
<td>1.58 100</td>
<td>3.59</td>
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<tr>
<td>1.66 105</td>
<td>3.48</td>
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<tr>
<td>1.74 110</td>
<td>3.39</td>
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<tr>
<td>1.82 115</td>
<td>3.29</td>
</tr>
<tr>
<td>1.89 120</td>
<td>3.20</td>
</tr>
<tr>
<td>1.97 125</td>
<td>3.11</td>
</tr>
<tr>
<td>2.05 130</td>
<td>3.03</td>
</tr>
<tr>
<td>2.13 135</td>
<td>2.95</td>
</tr>
<tr>
<td>2.21 140</td>
<td>2.87</td>
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<tr>
<td>2.29 145</td>
<td>2.79</td>
</tr>
<tr>
<td>2.37 150</td>
<td>2.72</td>
</tr>
<tr>
<td>2.45 155</td>
<td>2.65</td>
</tr>
</tbody>
</table>
Climatic Conditions
Thornthwaite Moisture Index (TMI, 1948)

\[ TMI = \frac{100R - 60\text{DEF}}{E_p} \]

- \( R \) = runoff moisture depth
- \( \text{DEF} \) = deficit moisture depth
- \( E_p \) = evapotranspiration
Acceptable Predicted Performance

Flexible Pavement
Fort Worth I-820 A
Acceptable Predicted Performance

- LTS 1.5 ft, Inert 1.8 ft
- LTS 2.0 ft, Inert 1.5 ft
- LTS 2.0 ft, Inert 2.0 ft
- LTS 2.0 ft, Inert 3.0 ft

Rigid Pavement

Austin SR-1
Longitudinal Cracking over Expansive Soil

- Expansive soil
  - Experiences volumetric change when subjected to moisture variation

- Longitudinal crack
  - Initiates in shrinking expansive subgrade
  - Propagates to pavement surface
Practice of Lime Treatment
Without Geogrid Reinforcement…

Asphalt

Crack

Base

Subgrade (Expansive soil)

* Rong Luo, Texas A&M University
With Geogrid Reinforcement...
Transverse Stress Distribution in Pavement (Crack at Edge of Shoulder)
Transverse Distribution of Vertical Movements

(in)

3.5

2.5

1.5

0.5

Shrinkage

Swelling

d (ft)

Section A

Section B

Section C

0

10

20

30

40

-0.5

-1.5
Edge Moisture Variation Distance, $e_m$

\[ e_m = \sqrt{\frac{\alpha T}{\pi}} \ln\left( \frac{2u_0}{\Delta pF} \right) \quad \Delta pF = 1 - \sqrt{1 + \frac{3p}{\gamma_h}} \]
Longitudinal Crack Spacing

\[ \Delta pF \propto \text{Tensile Strength of Soil} \]
Shrinkage Strain

\[ \varepsilon_s = \frac{1}{6} (1 + \Delta pF) \left[ -\gamma_h (\Delta pF) \right] \]
Distance to First Shrinkage Crack

\[ x_1 = \sqrt{\frac{\alpha T}{\pi}} \ln\left(\frac{2u_0}{2u_0 - \Delta pF}\right) \]
Diffusivity

\[ \alpha \left( \frac{m^2}{\text{sec}} \right) = \left[ 0.0029 - 0.000162(S) - 0.0122(y_h) \right] \times 10^{-4} \]
\[ S_w = pF(w) - pF_{\text{intercept}} \]

\[ pF_{\text{intercept}} = 5.622 - 0.0041(\% \text{fine clay}) \]
Alternative

- Use built-in empirical expression:
  \[ \alpha = 0.0029 - 0.000162 \, S - 0.0122 \, \gamma_h \]

- where:
  
  S = -20.3 - 0.155 \, (LL) - 0.117 \, (PI) + 0.068 \, (\% - \text{No. 200})

  \[ \gamma_h = \gamma_0 \times \frac{\% - 2\mu m}{\% - \text{No. 200 sieve}} \]
Field to Laboratory Diffusion Coefficient Ratio

Field $\alpha$/laboratory $\alpha_0$
Program WinPRES
Soil Properties

Layer 2 - Natural Soil
- Thickness of Soil Layer: 3.5 ft
- Dry Unit Weight: 100 pcf
- Liquid Limit: 55%
- Plasticity Index: 30%
- % Passing #200 Sieve: 80%
- % Less than 2 Microns: 25%

Soil Profile Table:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Soil Type</th>
<th>Thickness (ft)</th>
<th>Dry Unit Weight (pcf)</th>
<th>LL(%)</th>
<th>PI(%)</th>
<th>% Passing #200 Sieve</th>
<th>% Less than 2 Microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Natural</td>
<td>5</td>
<td>100</td>
<td>40</td>
<td>25</td>
<td>85</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Natural</td>
<td>3.5</td>
<td>100</td>
<td>55</td>
<td>30</td>
<td>80</td>
<td>25</td>
</tr>
</tbody>
</table>
Lane/Barrier configuration

Depth of Vertical Moisture Barrier
- Specify 0 ft
- Zero
- Calculate

Wheel Path and Distance from the Center
- Width of Pavement: 64 ft
- Number of Wheel Path: 1
- Wheel Path: 1
- Distance from the Center of Pavement: 24 ft

Center of pavement

Edge of pavement

Half width of pavement 32 ft
Initial Serviceability

**Initial Roughness**

- **Wheel Path**: 1
- **Initial Serviceability Index**: 4.2
- **Initial International Roughness Index**: 75.2 (in/mi)
- **Years Roughness Calculation Required**: 30 (yr)

**Terminal Roughness (For Calculating the Depth of Vertical Barrier Required)**

- **Wheel Path**: 1
- **Terminal Serviceability Index**: 0
- **Terminal International Roughness Index**: 0 (in/mi)
- **Years to Reach Terminal SI or IRI**: 0 (yr)
Diffusivity

Slope of SWCC

Suction Compression Index

\[ \alpha = 0.0029 - 0.000162(S) - 0.0122(g_h) \]
### Traffic Analysis

- **Wheel Path**: 1
- **Traffic Analysis Period** (yr): 20
- **ADT (Average Daily Traffic) in One Direction** at T=0: 5000
- **ADT (Average Daily Traffic) in One Direction** at T=C: 8000
- **18 kip Single Axles** at T=C: 2500000

### Reliability

- **Reliability for Traffic (AASHTO model)**: 75%
- **Reliability for Expansive Soil Roughness Constants**: 85%
WinPRES Demo
Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific kinds of soil.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEXAS AGRICULTURAL EXPERIMENT STATION
AND
HARRIS COUNTY FLOOD CONTROL DISTRICT

SOIL ASSOCIATIONS

NEARLY LEVEL, CLAYEY AND
LOAMY, PRAIRIE SOILS

1. Lake Charles-Bend association: Somewhat poorly drained, very slowly permeable, loamy and clayey soils

2. Midland-Bowman association: Poorly drained, very slowly permeable, loamy and clayey soils

NEARLY LEVEL, LOAMY, PRAIRIE SOILS

3. Cypionate-Addicks-Gessner association: Somewhat poorly drained, moderately permeable soils

4. Rockley-Gessner association: Somewhat poorly drained and poorly drained, moderately slowly permeable and moderately permeable soils

5. Katy-Aris association: Somewhat poorly drained and poorly drained, very slowly permeable soils

NEARLY LEVEL TO GENTLY SLOPING, LOAMY, FORESTED SOILS

6. Alton-Ozark association: Somewhat poorly drained and poorly drained, very slowly permeable and slowly permeable soils

7. Segro-Hockley association: Moderately well drained, moderately slowly permeable soils

NEARLY LEVEL, FORESTED, BOTTOM LAND SOILS

8. Natichie-Voss-Karman association: Moderately well drained to poorly drained, rapidly permeable to very slowly permeable, loamy, sandy, and clayey soils

Compiled 1975
Soil Survey of Harris County, Texas

- Lake Charles series

Lake Charles series

The Lake Charles series consists of deep, neutral, nearly level to gently sloping, clayey soils on upland prairies. These soils are clayey throughout the profile and have wide deep cracks and intersecting slickensides (fig. 15). They formed in alkaline marine clay.

Undisturbed areas of these soils have gilgai microrelief, in which the microknolls are 6 to 12 inches higher than the microdepressions. When these soils are dry, deep, wide cracks form on the surface. Water enters the cracks rapidly, but when the soils are wet and the cracks are sealed, water enters very slowly. These soils are somewhat poorly drained. Surface runoff is very slow or medium. Internal drainage is very slow. Permeability is very slow, and the available water capacity is high.

These soils are used mainly for rice and pasture. Some are in urban uses.

Representative profile of Lake Charles clay, 0 to 1 percent slopes, at the center of a microdepression, in pasture, from the intersection of Cook Road and Alief Road in...
Lake Charles
series, cont.

Alief, 1.11 miles west along Alief Road, 1.37 miles north on Synott Road, and 75 feet west:

Ap—0 to 22 inches; black (10YR 2/1) clay, very dark gray (10YR 3/1) dry; moderate fine blocky structure; very hard, very firm, very sticky and plastic; many fine roots; few fine iron-manganese concretions; shiny pressure faces; neutral; diffuse wavy boundary.

A12—22 to 36 inches; very dark gray (10YR 3/1) clay, dark gray (10YR 4/1) dry; moderate fine blocky and subangular blocky structure in upper 12 inches and breaking to moderate fine and medium blocky in the lower part; the lower part contains common large wedge-shaped peds having long axes tilted 10 to 60 degrees from the horizontal and bordered by intersecting slickensides; extremely hard, very firm, very sticky and plastic; aggregates have shiny pressure faces; few fine iron-manganese and calcium carbonate concretions; mildly alkaline; diffuse wavy boundary.

AC1g—36 to 52 inches; dark gray (10YR 4/1) clay, gray (10YR 5/1) dry; common fine and medium distinct mottles of olive (5Y 4/3) and few fine distinct mottles of yellowish brown (10YR 5/4); common large wedge-shaped peds having long axes tilted 10 to 60 degrees from the horizontal and bordered by intersecting slickensides, peds break to moderate medium and coarse blocky structure; extremely hard, very firm, very sticky and plastic; few fine roots; aggregates have shiny pressure faces; few fine iron-manganese concretions; few calcium carbonate concretions as much as 1 centimeter in diameter; mildly alkaline; diffuse wavy boundary.

AC2g—52 to 74 inches; gray (5Y 5/1) clay, gray (5Y 6/1) dry; common fine and medium distinct mottles of light olive brown (2.5Y 5/4) and few fine distinct mottles of yellowish brown (10YR 5/6); weak fine angular blocky structure; extremely hard, very firm, very sticky and plastic; few fine iron-manganese concretions; few intersecting slickensides; few irregularly shaped pitted calcium carbonate concretions generally less than 3 centimeters in size; mildly alkaline.

In undisturbed areas, gilgai microknolls are 6 to 12 inches higher than microdepressions. The center of the microknolls is about 4 to 16 feet from the center of the microdepressions. When the soils are dry, cracks 1 to 2 inches wide form on the surface and extend into the ACg horizon. Intersecting slickensides begin at a depth of about 20 to 30 inches. The A horizon is black or very dark gray. It ranges from slightly acid through mildly alkaline. The ACg horizon is very dark gray, dark gray, or gray. Mottles in the ACg horizon are olive, yellowish brown, light olive brown, strong brown, yellow, or red. The ACg horizon is clay or silty clay. It ranges from neutral through moderately alkaline. In some places it is calcareous in the lower part.
Soil Survey of Harris County, Texas

- Engineering properties and classifications

<table>
<thead>
<tr>
<th>Soil name and map symbol</th>
<th>Depth</th>
<th>USDA texture</th>
<th>Classification</th>
<th>Percentage passing sieve number—</th>
<th>Plasticity index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Charles: LcA, LcB</td>
<td>0-22</td>
<td>Clay---------</td>
<td>CH A-7</td>
<td>100 99-100 80-100 75-100  65-80</td>
<td>40-55</td>
</tr>
<tr>
<td></td>
<td>22-74</td>
<td>Clay---------</td>
<td>CH A-7</td>
<td>98-100 98-100 80-100 75-100  55-90</td>
<td>37-60</td>
</tr>
<tr>
<td>¹Lu: Lake Charles part</td>
<td>0-22</td>
<td>Clay---------</td>
<td>CH A-7</td>
<td>100 99-100 80-100 75-100  65-80</td>
<td>40-55</td>
</tr>
<tr>
<td></td>
<td>22-74</td>
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<td>CH A-7</td>
<td>98-100 98-100 80-100 75-100  55-90</td>
<td>37-60</td>
</tr>
</tbody>
</table>
Soil Survey of Harris County, Texas

### Engineering test data

<table>
<thead>
<tr>
<th>Soil name and location</th>
<th>Depth from surface</th>
<th>Shrinkage Linear</th>
<th>Shrinkage Volumetric</th>
<th>Mechanical analysis¹</th>
<th>Plasticity index</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Limit</td>
<td>Ratio</td>
<td>Percentage passing sieve—</td>
<td>Liquid limit—</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
<td>0.02</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td><strong>Kenney loamy fine sand:</strong></td>
<td>9-56</td>
<td>1.7</td>
<td>18.3</td>
<td>1.83</td>
<td>5.2</td>
<td>0.001</td>
</tr>
<tr>
<td>From Spring, 3.75 miles west on Spring-Stuebner Road to Rothwood Road, 1.8 miles north on Rothwood Road and 40 feet west in timber (modal). Texas report no. 1277L-347, 348.</td>
<td>56-80</td>
<td>3.5</td>
<td>18.6</td>
<td>1.71</td>
<td>10.4</td>
<td>0.001</td>
</tr>
</tbody>
</table>

| **Lake Charles clay:** | 0-22              | 26.2             | 12.5                 | 2.02 | 60.0 | 0.001 | 0.99  | 0.21 | 4 | 0 | 0 | 21 | 7 | A-7-6(20) | CH |
| From Alief, 1.11 miles west on Alief Road to Synott Road, then 1.37 miles north on Synott Road and 75 feet west in pasture (modal). Texas report no. 1277L-198, 199, 200. | 36-52             | 29.9             | 6.0                  | 2.23 | 65.7 | 0.001 | 0.99  | 0.34 | 24 | 1 | 12 | 25 | 9 | A-7-6(20) | CH |
|                        | 52-74             | 29.0             | 6.3                  | 2.14 | 64.6 | 0.001 | 0.99  | 0.34 | 24 | 1 | 12 | 25 | 9 | A-7-6(20) | CH |
Soil Survey of Harris County, Texas

- Profile of Lake Charles clay

Figure 15. — Profile of Lake Charles clay, 0 to 1 percent slopes. Wide, deep cracks are in the upper layers, and intersecting slickensides are in the lower layers.
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