Slope Stability in Harris County

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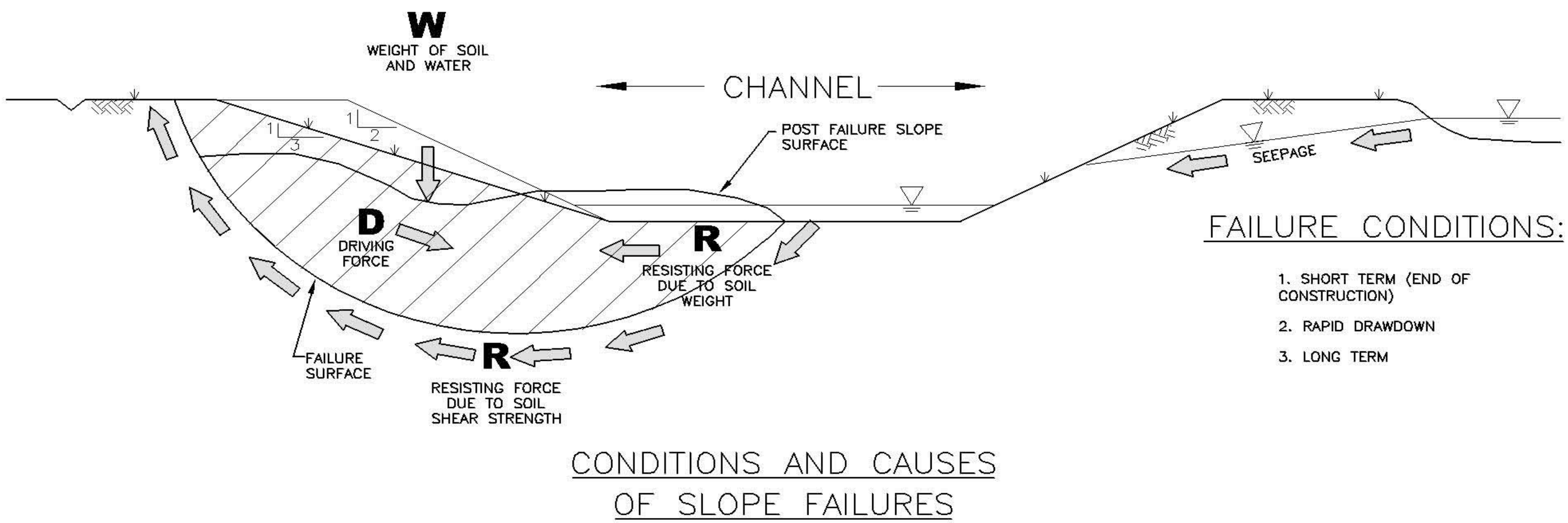
Slope Stability in Harris County

- **Overview of slope stability.**
- **Conditions, causes, and types of slope failures.**
- **HCFCD geotechnical investigation requirements.**
- **Variables in analyzing slope stability.**
- **HCFCD Research.**

Harris County and Its Channels

- Harris County's population of 3.7 million is the third largest in the United States.
- The drainage and flood control infrastructure of Harris County are extensive and include more than 1,500 channels and about 2,500 miles of channels (about the distance from New York to Los Angeles).
- The HCFCD spends $7M to $8M each year to repair these 2,500 miles of channels, most of which are earthen channels.

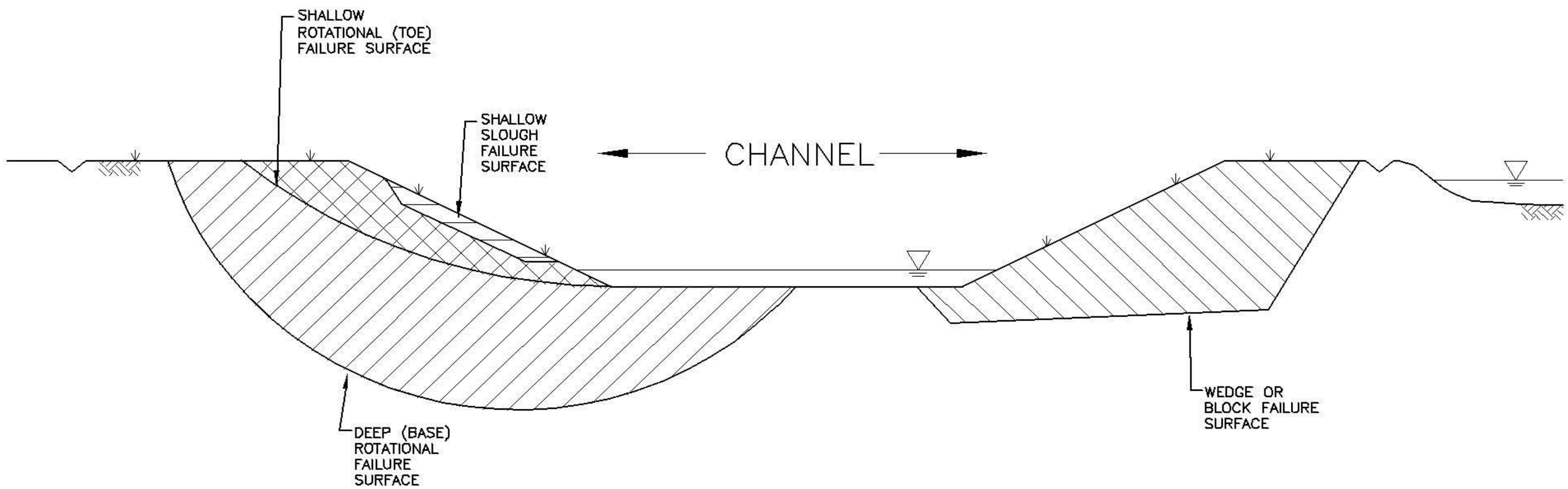
Conditions and Causes of Slope Failures



Types of Slope Failures

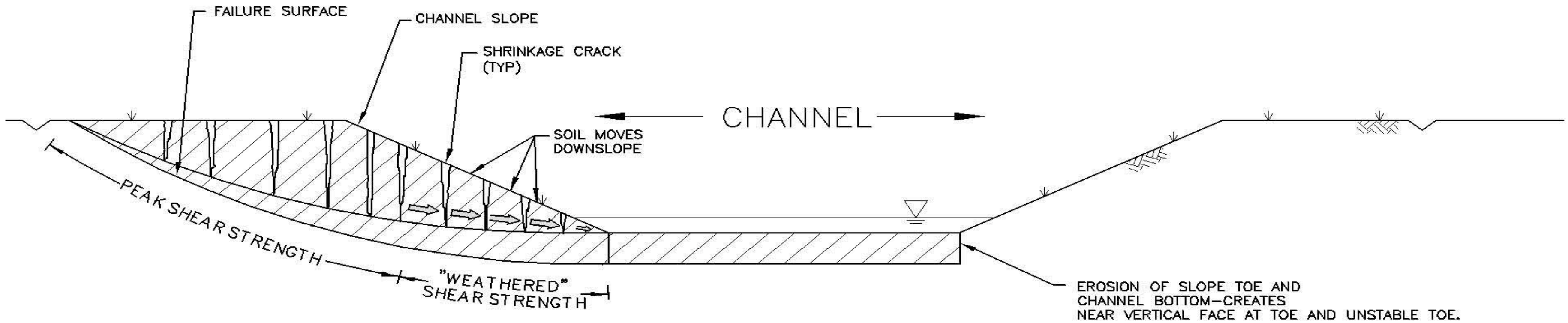
- Deep rotational failure.
- Shallow rotational failure – toe failure.
- Shallow sloughing failure.
- Wedge or block failure.
- Erosion failure.
- Failure due to presence of dispersive soil.

Types of Slope Failures



TYPES OF CHANNEL
SLOPE FAILURES

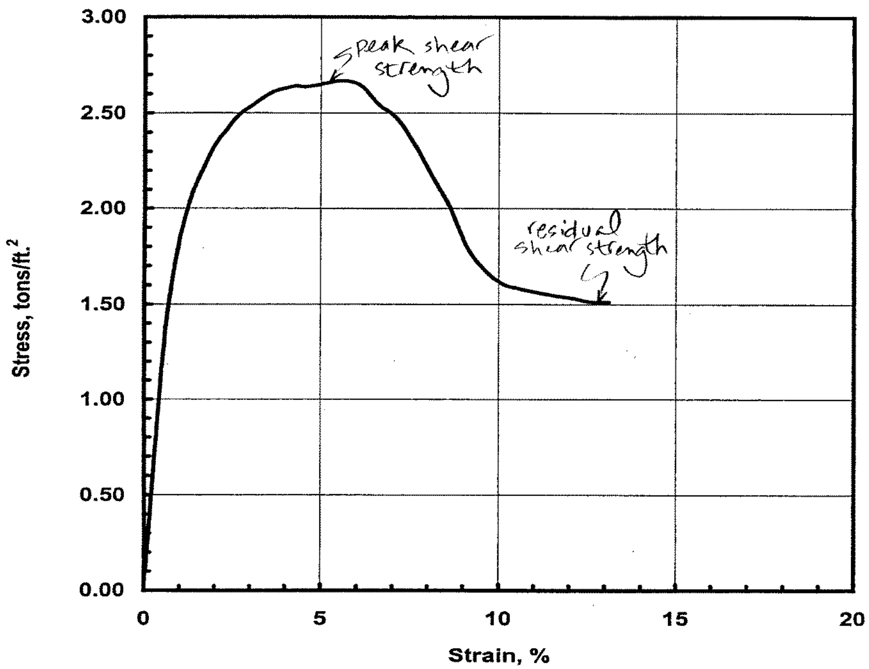
Types of Slope Failures – Failures Due to Soil Weathering



TYPES OF CHANNEL
SLOPE FAILURES

Peak vs. Residual Shear Strength

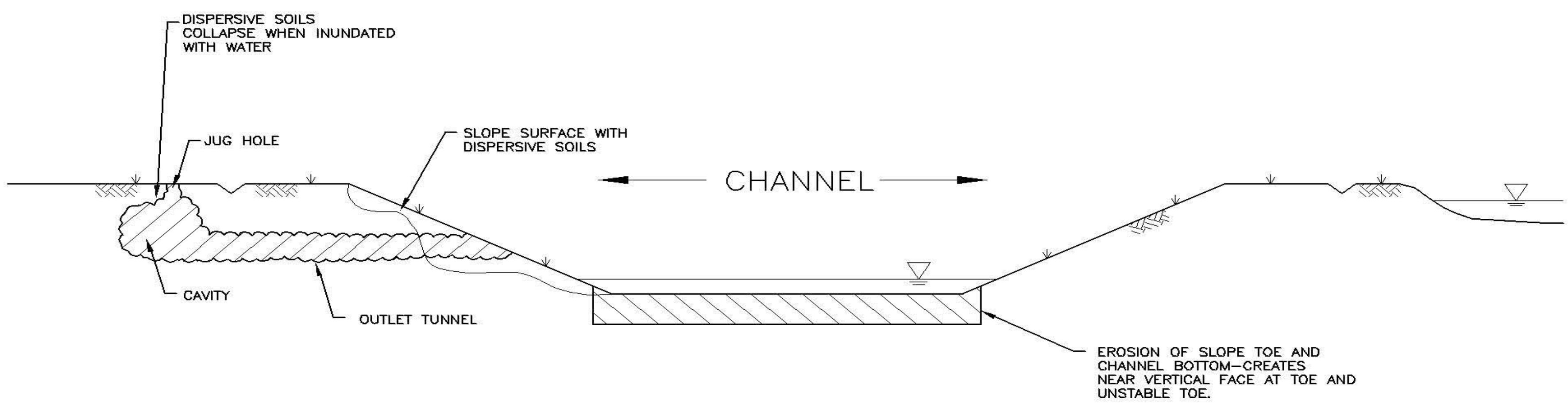
Unconsolidated-Undrained Triaxial Test
ASTM D 2850



Undrained Shear Strength: **1.33 tsf**

Boring No.:	*B-10*	**Confining Pressure:**	*16 lbs./in²*
Depth:	*14-16 ft.*	**Dry Density:**	*107.8 lbs./ft³*
Material:	FAT CLAY (CH), reddish brown	**Moisture Content:**	*18 %*
		Liquid Limit:	*N/A*
Project:	*H.C.F.C.D. # D100-00-00*	**Plastic Limit:**	*N/A*
Project No.:	*286-45068*	**Plasticity Index:**	*N/A*
		% Passing No. 200:	*N/A*

Types of Slope Failures – Failures Due to Dispersive Clays



TYPES OF CHANNEL SLOPE FAILURES

Deep Rotational Failure

Shallow Rotational Failure

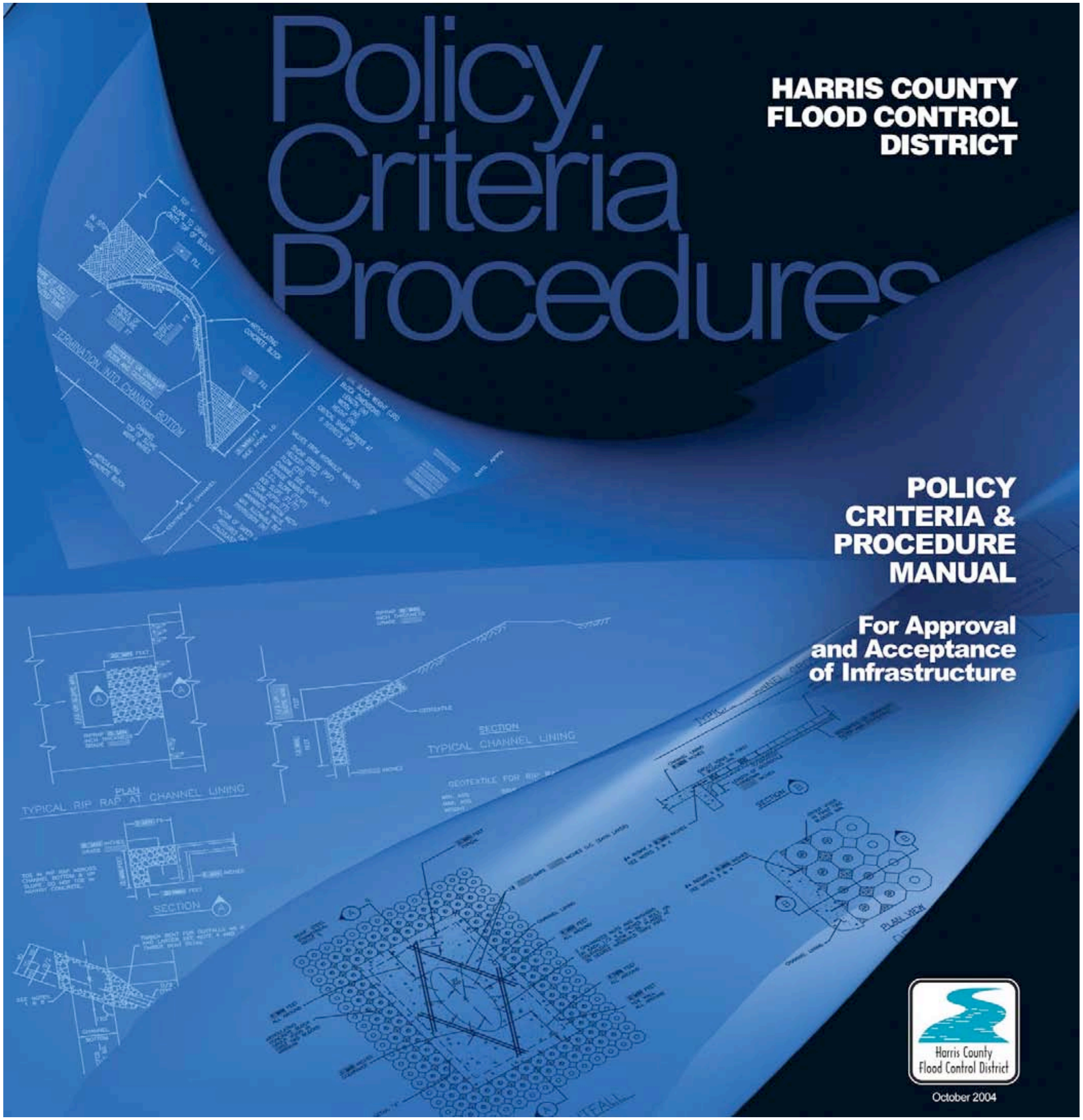
Progressive Shallow Rotational Failure

Seepage Through Sandy Soil Slope

Wedge or Block Failure

Channel Erosion

Slope Failure - Dispersive Clays



Policy Criteria Procedures

HARRIS COUNTY FLOOD CONTROL DISTRICT

POLICY CRITERIA & PROCEDURE MANUAL

For Approval and Acceptance of Infrastructure

Harris County Flood Control District

October 2004

Background

- Adopted on October 5, 2004.
- Updates will be posted on www.hcfcd.org.
- It is not a cookbook.
- Good engineering practice and judgment are still necessary.

Manual Applies When …

Manual applies for all flood control features such as channels and basins that the HCFCD will maintain. This includes:

- **New HCFCD Facilities**
- **Modification of Existing HCFCD Facilities**

Geotechnical Investigation Requirements

- **For HCFCD maintained facilities, a geotechnical investigation must be performed.**
- **Geotechnical investigation must follow guidelines in Appendix D of manual.**
- **Appendix D requires minimum numbers and minimum depths of borings; lab tests to include CU triaxial tests and pinhole dispersion tests; and, stability analyses must be performed for the short term, rapid drawdown, and long term conditions.**
- **Deviation from HCFCD design criteria requires a variance.**

HCFCD Design Requirements for Channels and Basins

- Grass-lined earthen slopes of 4(H):1(V) or flatter for channels.

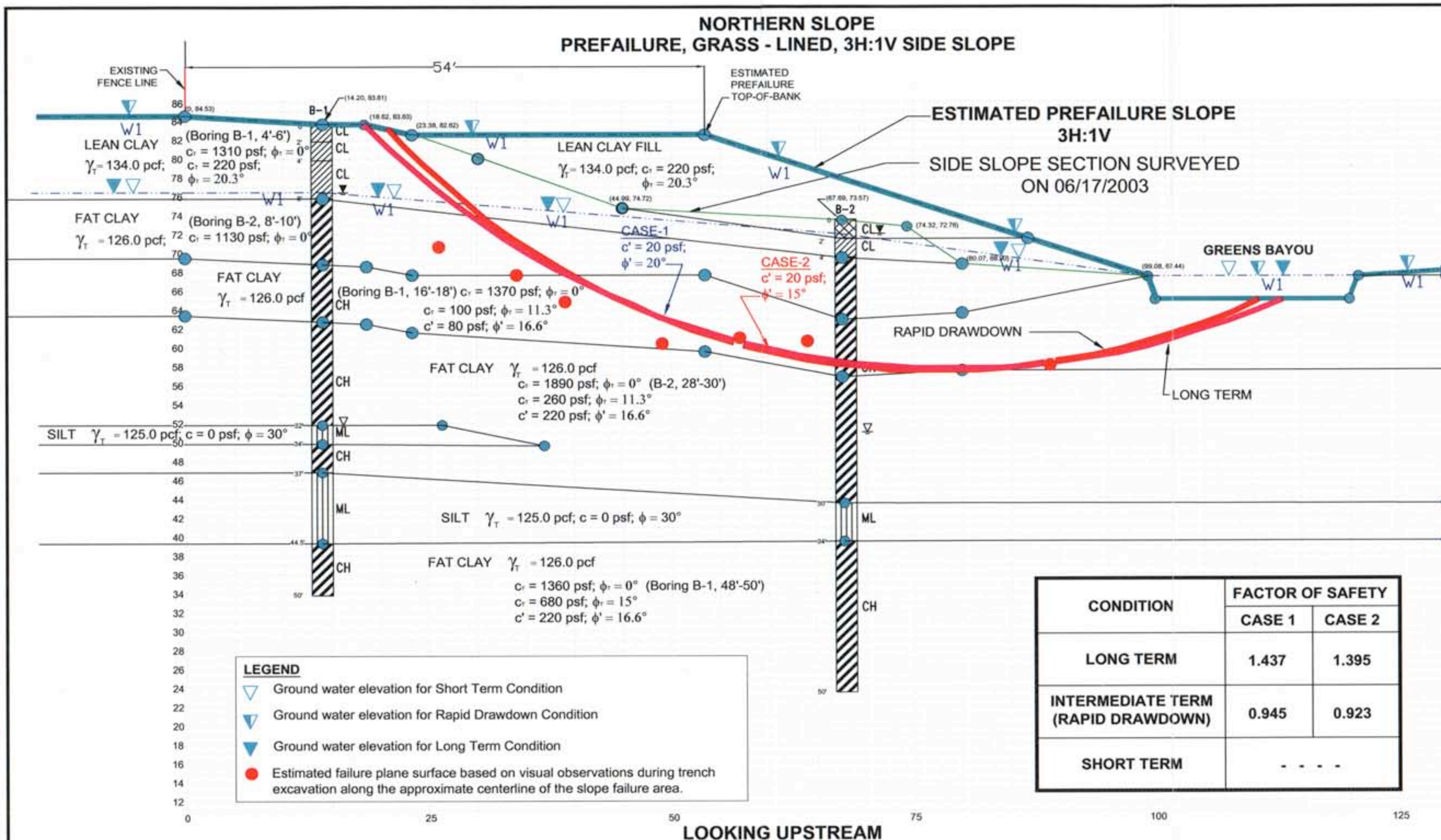
- Concrete lined slopes of 2(H):1(V) or flatter for channels.

- Grass-lined earthen slopes of 3(H):1(V) or flatter for detention basins.

Why Do We Require Channel Slopes 4(H):1(V) or Flatter?

- **Stability analysis results vs. observations.**
- **Weathered soil shear strength.**
- **Weathered soil shear strength and rapid drawdown.**
- **Back-calculated weathered soil shear strength for failed slopes.**

Back-calculated Weathered Soil Shear Strength for Failed Slope



CONDITION	FACTOR OF SAFETY	
	CASE 1	CASE 2
LONG TERM	1.437	1.395
INTERMEDIATE TERM (RAPID DRAWDOWN)	0.945	0.923
SHORT TERM	- - - -	

REPAIR OF THREE SLOPE FAILURES AT HCFCD P100-00-00 (GREENS BAYOU)
HCFCD PROJECT ID # P100-00-00-X048
HOUSTON, HARRIS COUNTY, TEXAS

HARRIS COUNTY FLOOD CONTROL DISTRICT
HOUSTON, TEXAS

NORTHERN SLOPE SECTION

PROJECT NO.:	DATE:	
03-386	07-02-04	FIGURE 5

Why Do We Allow Concrete Lined Channel Slopes 2(H):1(V) or Flatter?

- Very few failures of 2(H):1(1) concrete lined slopes.
- Soil weathering inhibited.
- Toe erosion precluded.
- Rapid drawdown condition precluded.

Why Do We Require Detention Basin Grass-Lined Earthen Slopes 3(H):1(V) or Flatter?

- Basin slope toe erosion not as prevalent as with channels.
- Wetting and drying of basin slope toe not as frequent as with channels.
- Basin slope failures may not be as critical as with channels.
- Observations of performance of basin channels with 3(H):1(V) slopes.

Back Slope Drainage and Dispersive Clays

- Mechanism for dispersive soil collapse.
- Goal is to keep water from ponding and infiltrating into dispersive clays.
- Decrease interceptor structure spacing and increase backslope swale gradient.
- Lime treatment or clay lining backslope swale and/or maintenance berm.

Variables

- **Slope inclination.**
- **Soil types, soil strengths, soil plasticity, and layer thicknesses.**
- **Extent of strength loss due to weathering.**
- **Duration of periods of dry weathering.**
- **Ground water conditions.**
- **Surface water conditions.**
- **Shrinkage crack patterns, crack depths.**
- **Degree and rate of erosion – channel hydraulics.**

Mesri and Abdel-Ghaffar (August 1993 Geotechnical Journal)

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GEOTECHNICAL ENGINEERING DIVISION

Friction Angle vs PI

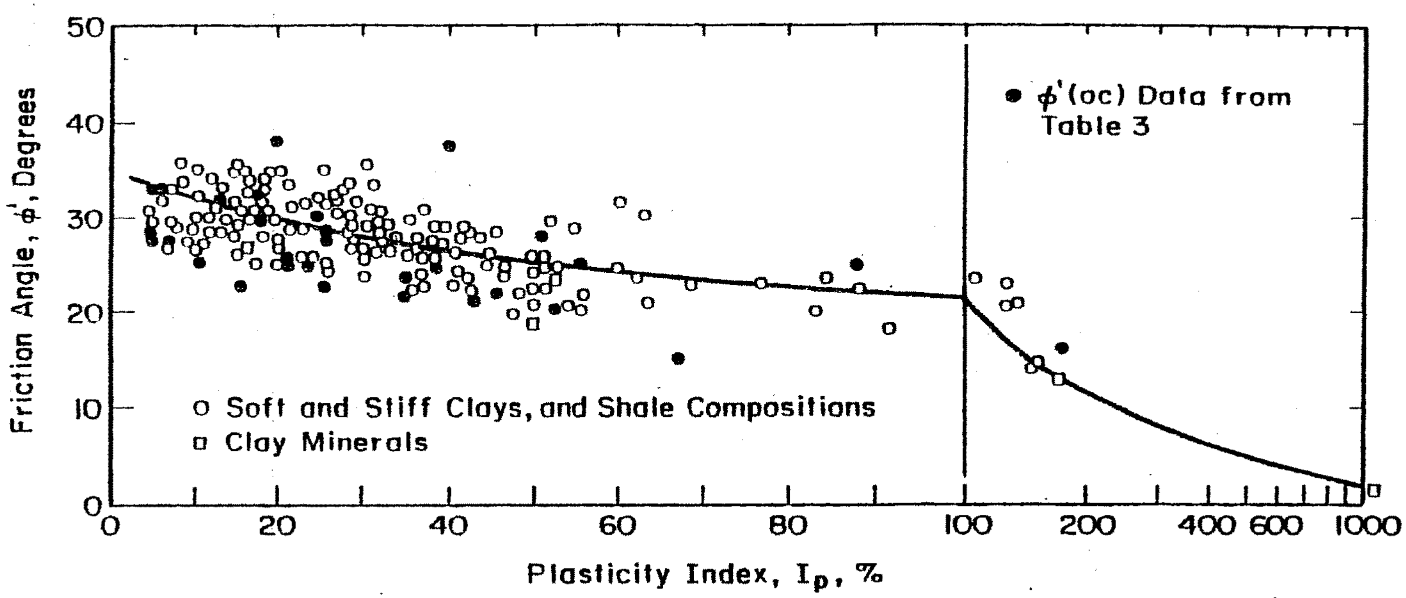


FIG. 2. Values of Friction Angle ϕ' for Natural Clay Compositions

Correction Factor for Mobilized (“Weathered”) Shear Strength (c’)

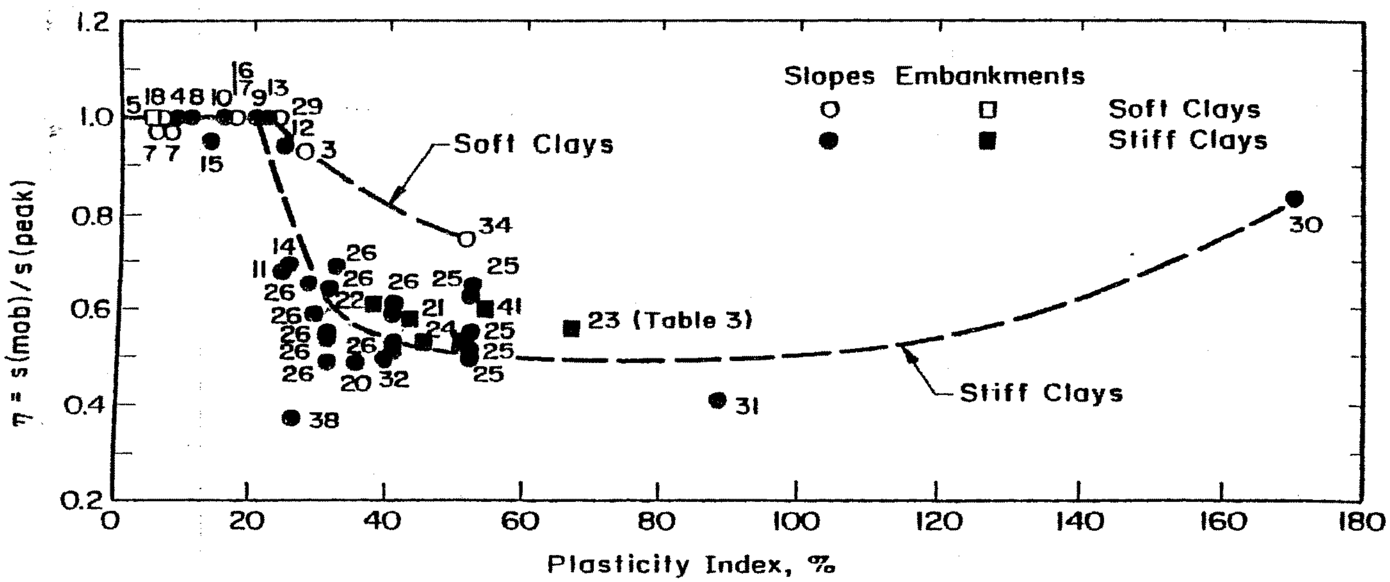


FIG. 13. Correction Factor for Peak Shear Strength Used in Effective Stress Stability Analysis

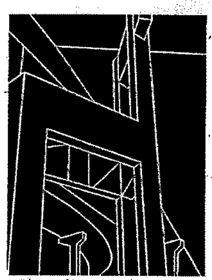
Research for Highway Embankments

RESEARCH REPORT 1435-2F

SHEAR STRENGTH CORRELATIONS AND REMEDIAL MEASURE GUIDELINES FOR LONG-TERM STABILITY OF SLOPES CONSTRUCTED OF HIGHLY PLASTIC CLAY SOILS

PB99-113409

A. A. Saleh and Stephen G. Wright



CENTER FOR TRANSPORTATION RESEARCH
BUREAU OF ENGINEERING RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

OCTOBER 1997

Residual Secant Friction Angle vs. Effective Pressure and LL

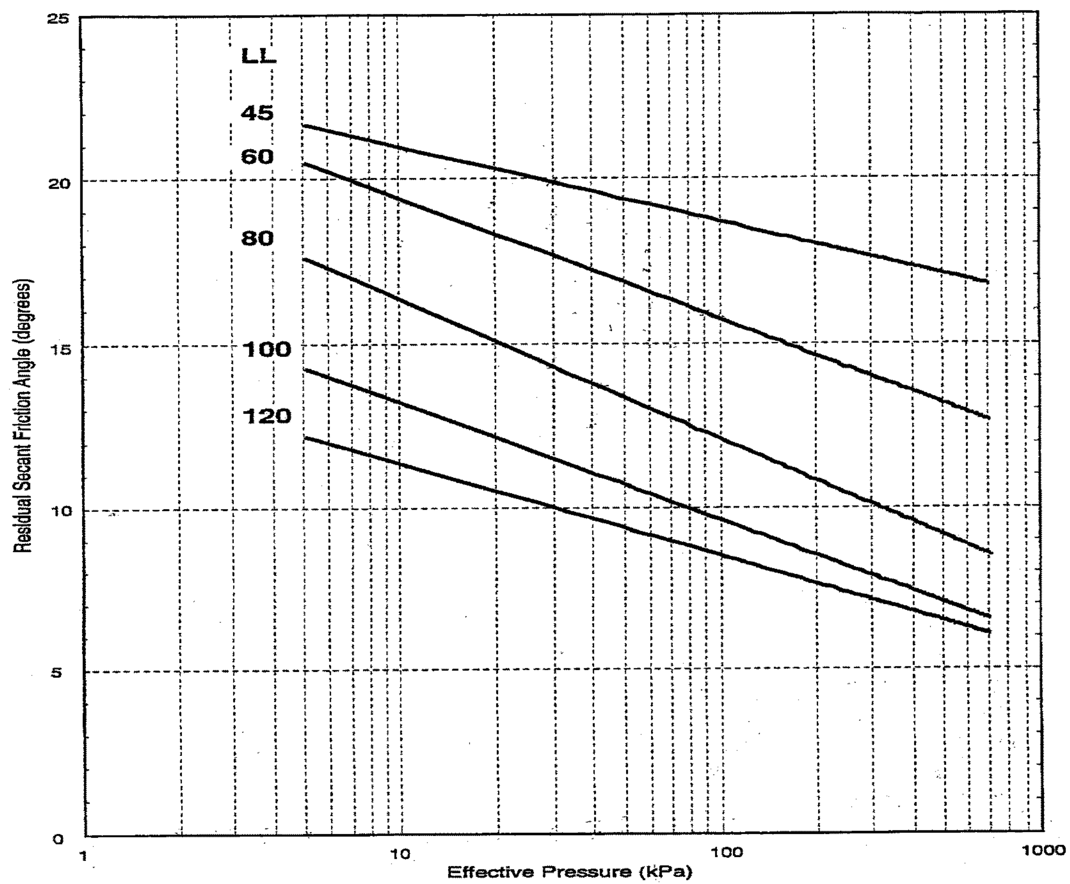
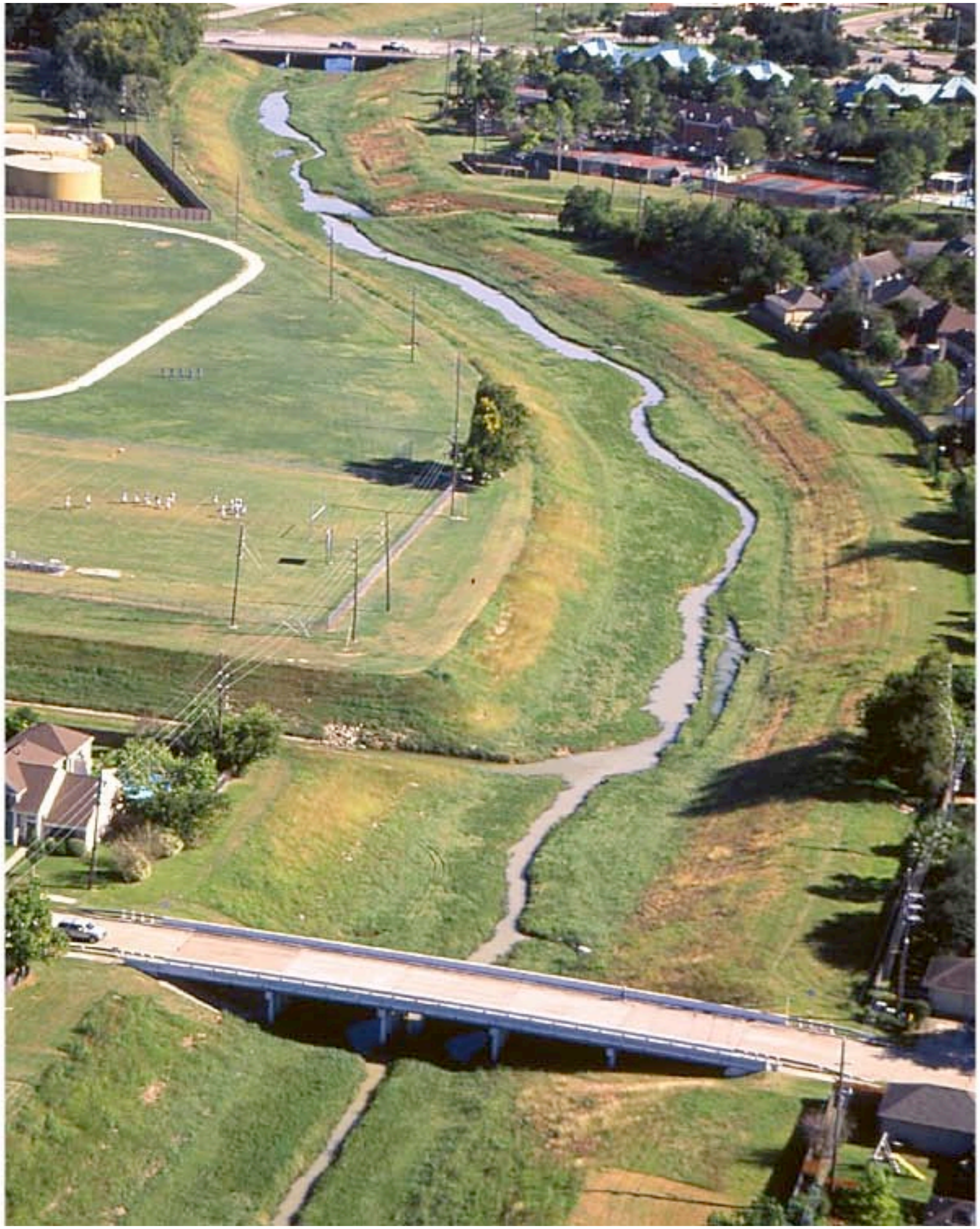


Figure 3.2 Correlation between residual secant friction angle and effective stress for selected values of liquid limit



Questions?