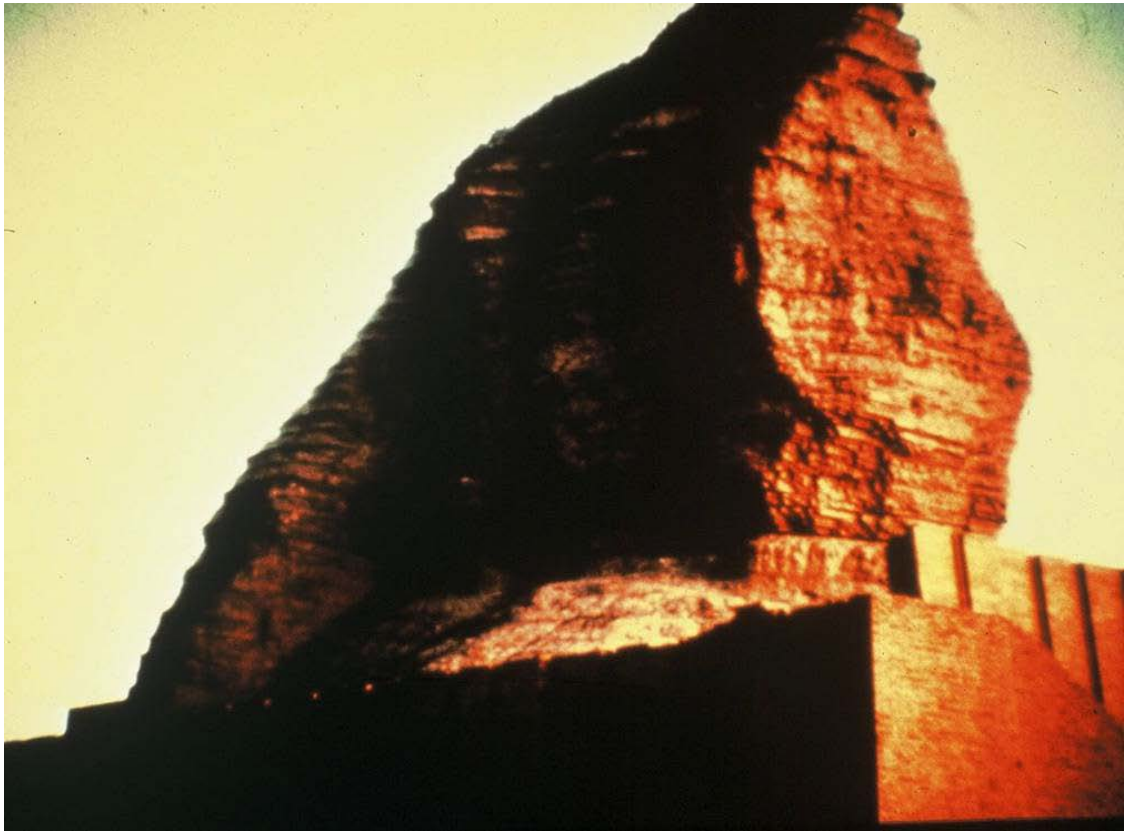
Historic Uses of Reinforced Soil

<u>1000 B.C.</u>

Ancient Mesopotamians

use woven mats of reeds, sand, and gravel to construct temples.



Agar-Quf Ziggurat (Iraq)

Rediscovery in the Modern Era

- Mid – 1970’s – CDOT researchers use Reinforced Earth on I-70 Expansion through Vail Pass and Glenwood Canyon

Rediscovery in the Modern Era

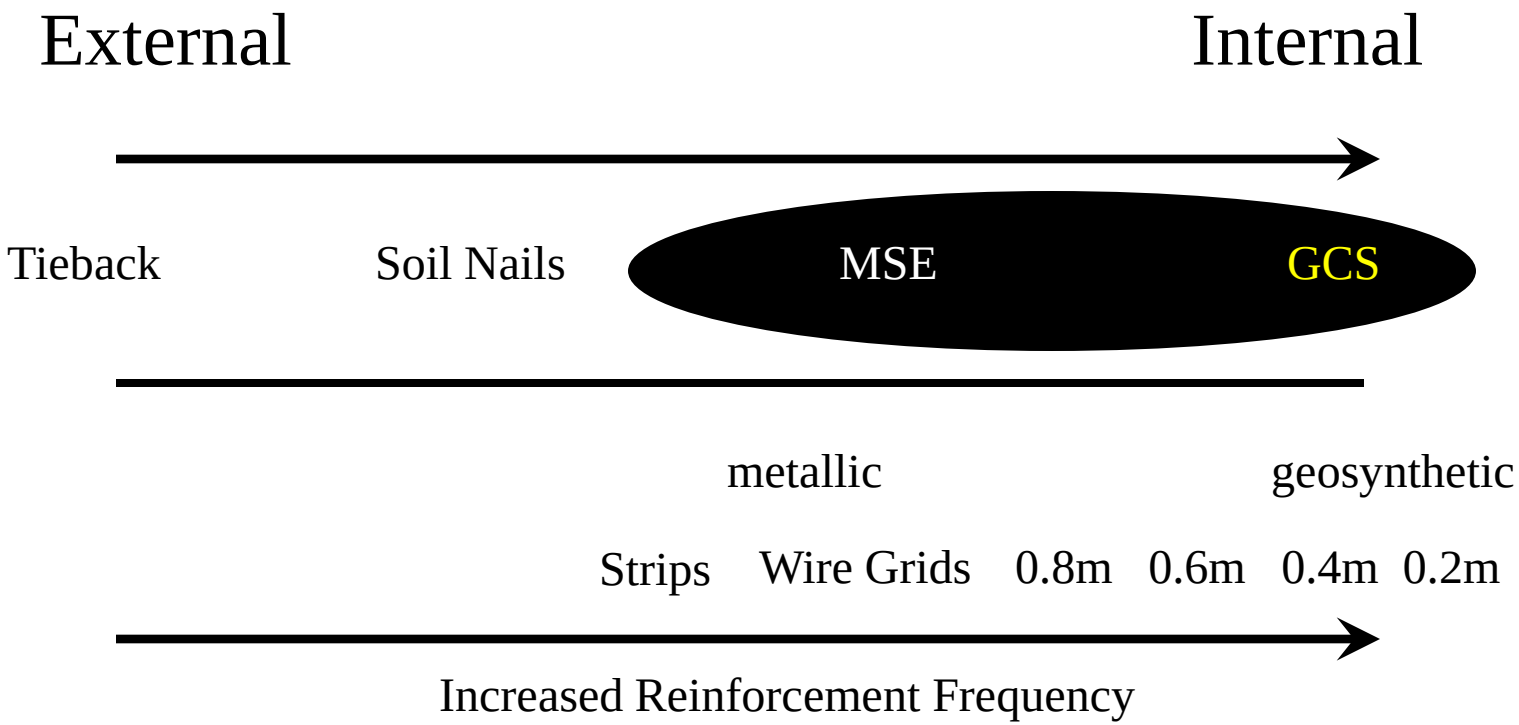
- 1973 – Lee (UCLA) develops the first “tieback-wedge” analysis
- 1974 – John Steward and Dick Bell refine Lee’s analysis to examine the first GRS walls in the US

Rediscovery in the Modern Era

- 1982 – CDOT constructs 4.5m wrapped face GRS wall (S_v = 0.2m) with granular backfill. The calculated FS was 0.33

Definitions

Wall Type



Rediscovery in the Modern Era

- Earth surcharges were added that brought the FS to 0.11. *Failure could not be induced*

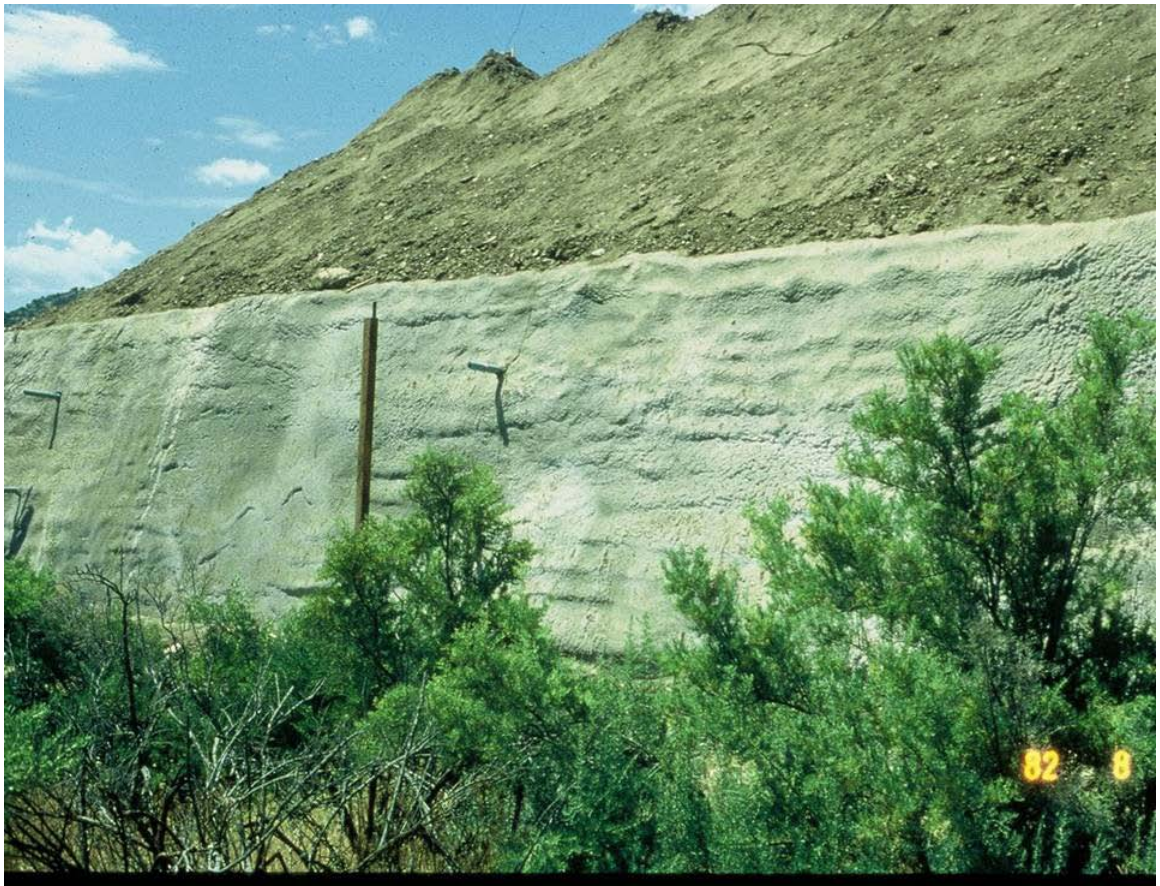
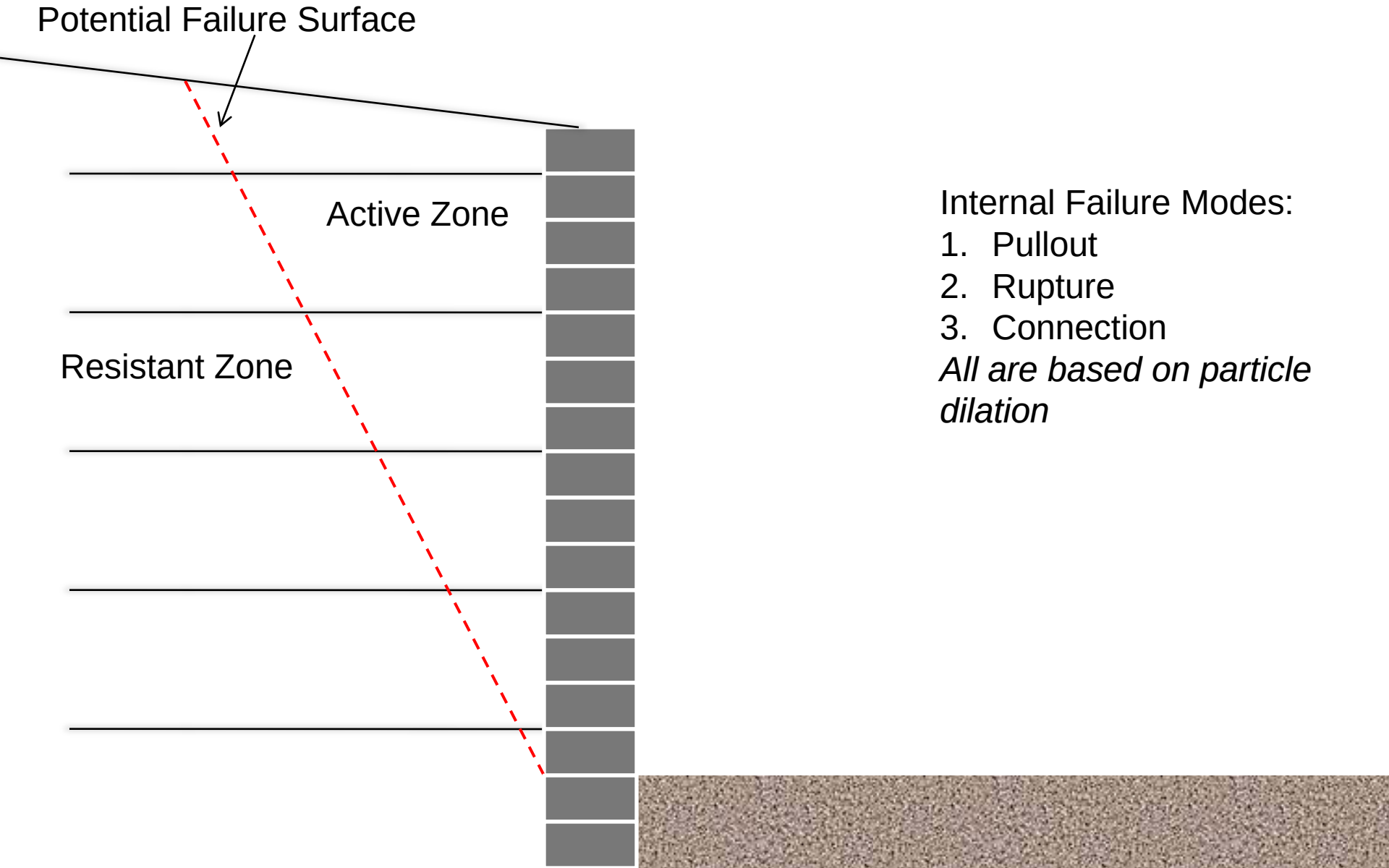


Photo courtesy of M. Adams

Simple Tieback Analogy (MSE)



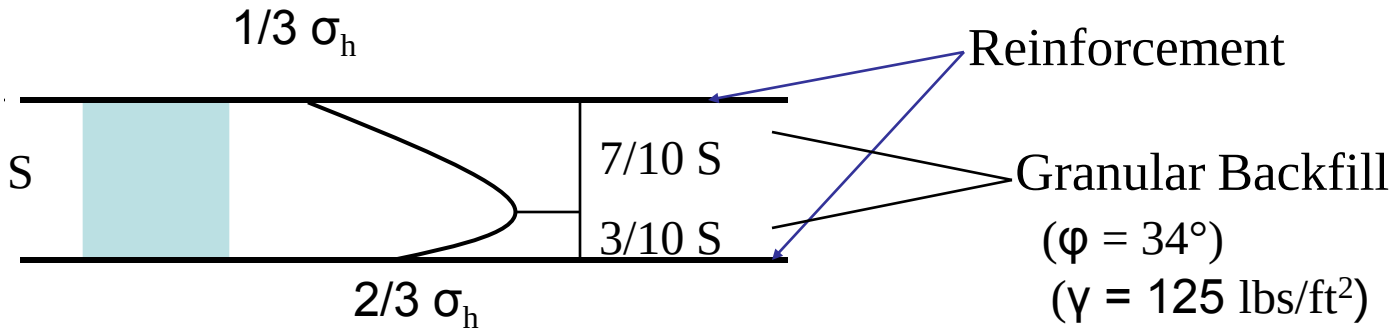
Internal Failure Modes:

1. Pullout
2. Rupture
3. Connection

All are based on particle dilation

Thrust on Facing Elements

Assuming a "yielding" facing



$\sigma_h = \gamma\ S\ K_a = \gamma\ S \tan^2(45° - 34°/2) = 125\ S\ (0.283) = 35.4\ S\ (\text{lbs/ft}^2)$

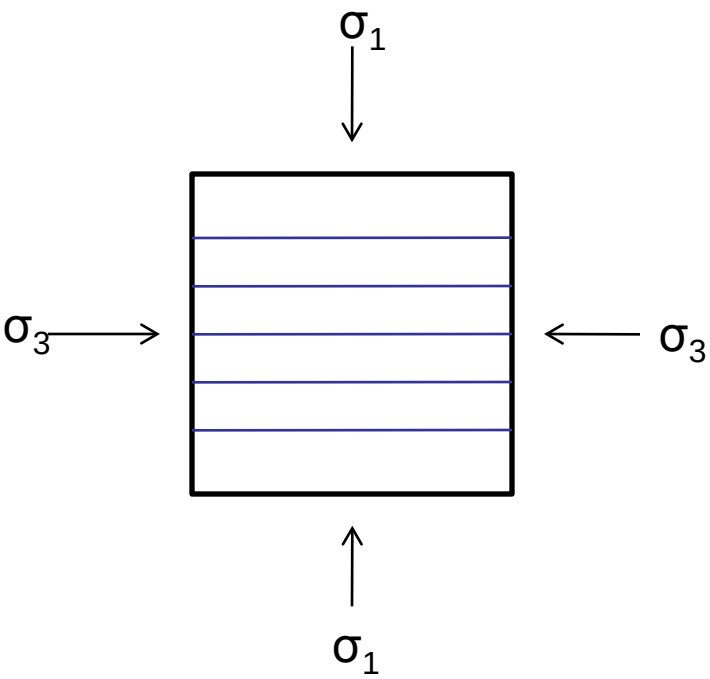
$F = 2/3\ \sigma_h\ (7/10\ S) + 5/6\ \sigma_h\ (3/10\ S)$

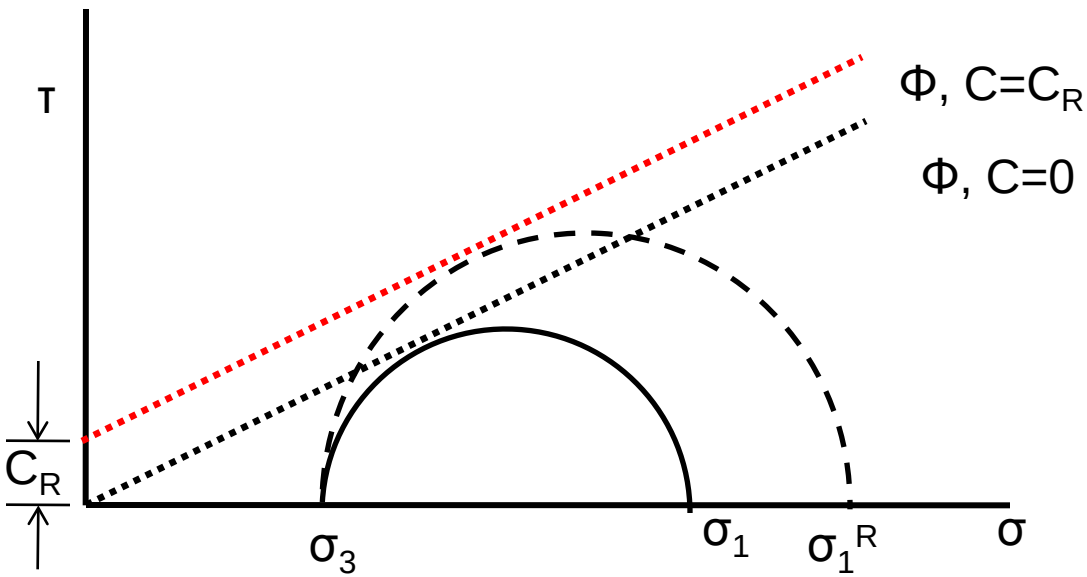
$= 43/60\ \sigma_h\ S$

$= 25.4\ S^2\ \text{lbs/ft}$

Wu, McMullen, and Ruckman

Apparent Cohesion

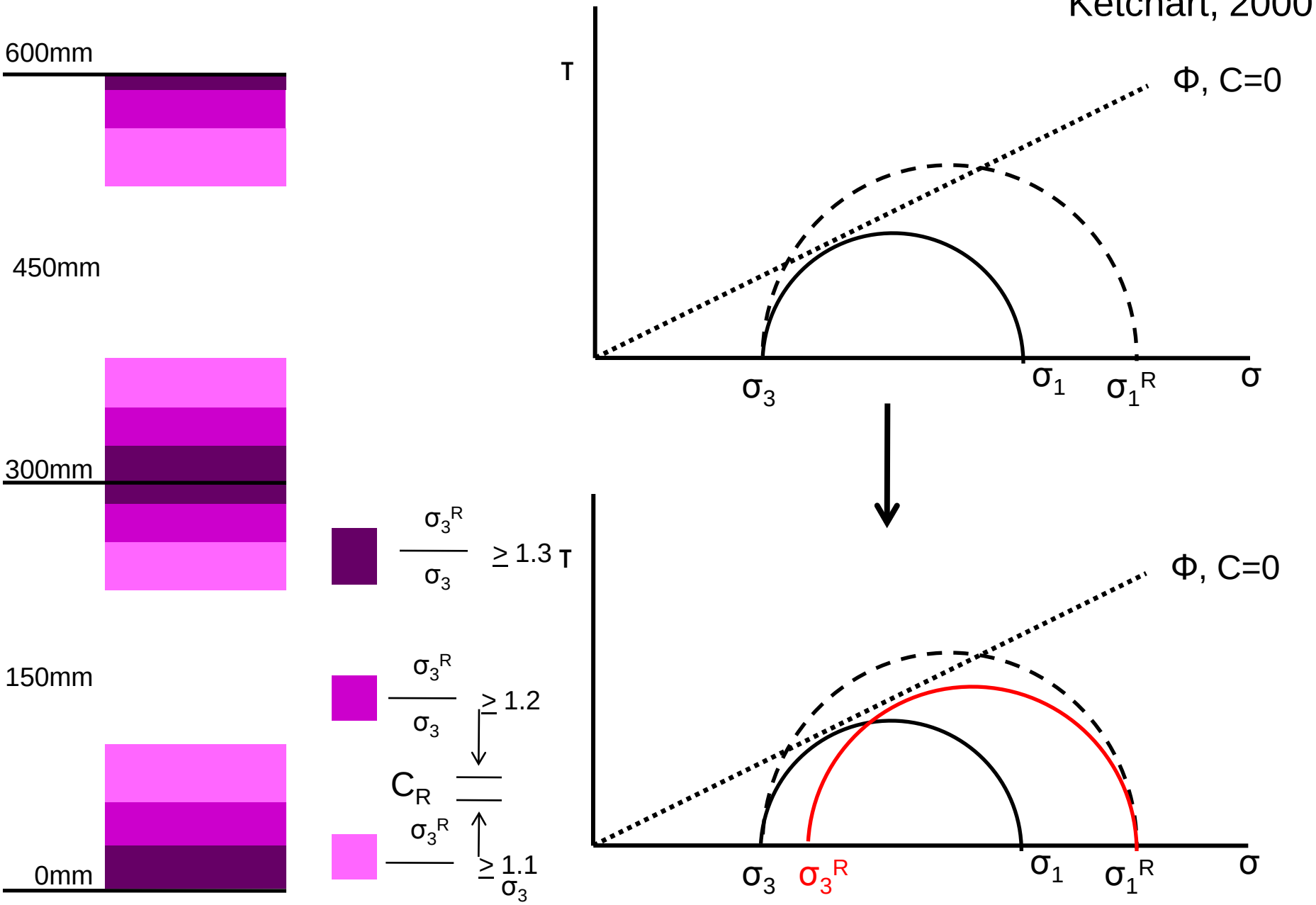




After Stauffer and Holtz (1995)

Increase in Minor Principle Stresses

After Wu and Ketchart, 2000



Composite Failure

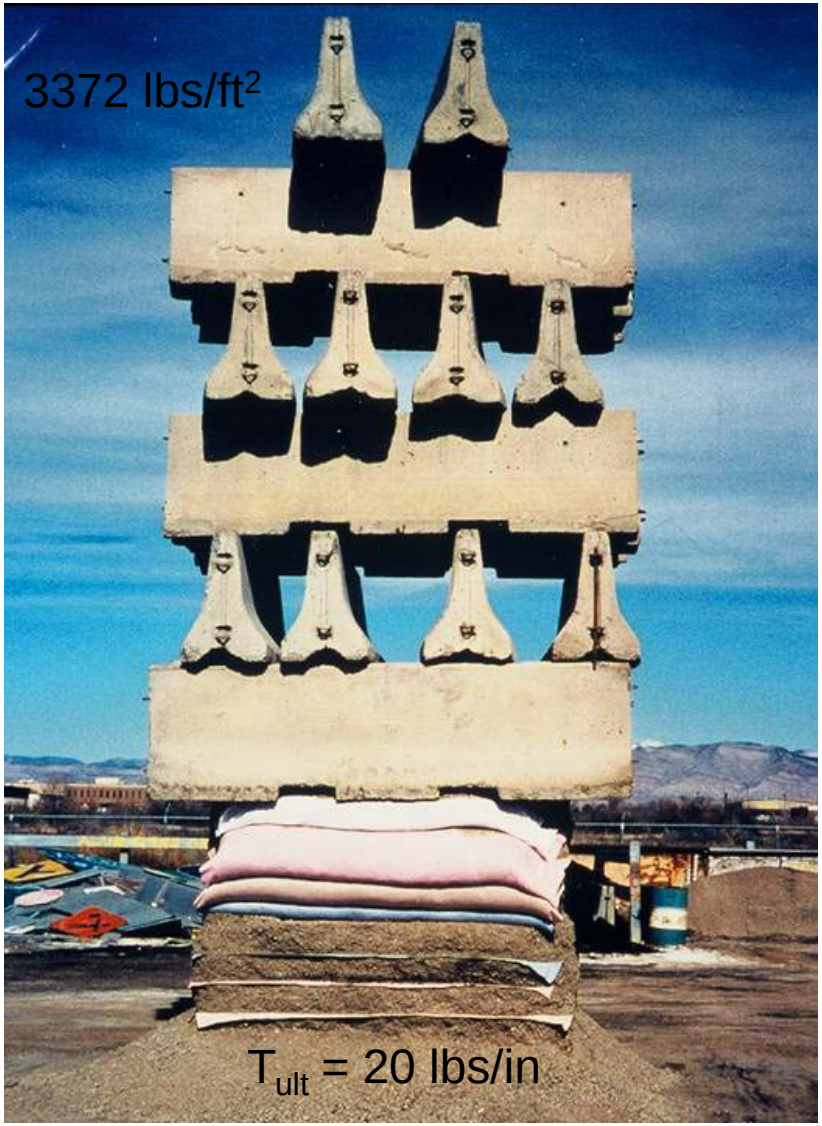
FHWA Mini-Pier Experiment

T_{ult} = 100 lbs/in (silt fence material)
Failure @ 400kPa

Concrete

Photo courtesy of M. Adams

Weak Reinforcement?



Dynamic Loads?

CDOT Rockfall, Debeque Canyon

10.4 *million* ft-lbf (14,087 kJ) impact

Negative Batter?

1000 kPa (~10 tsf) Load?

No Facing?

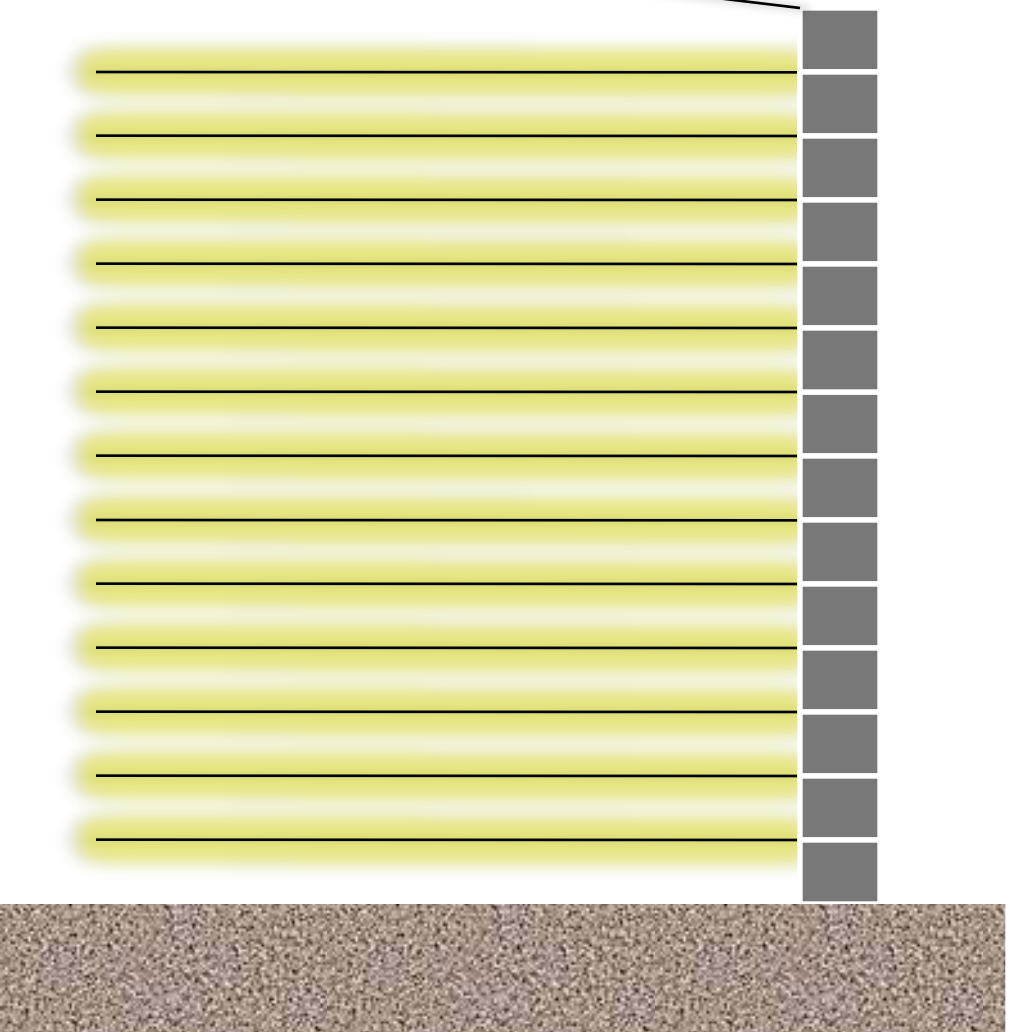
Loss of Bearing Support?

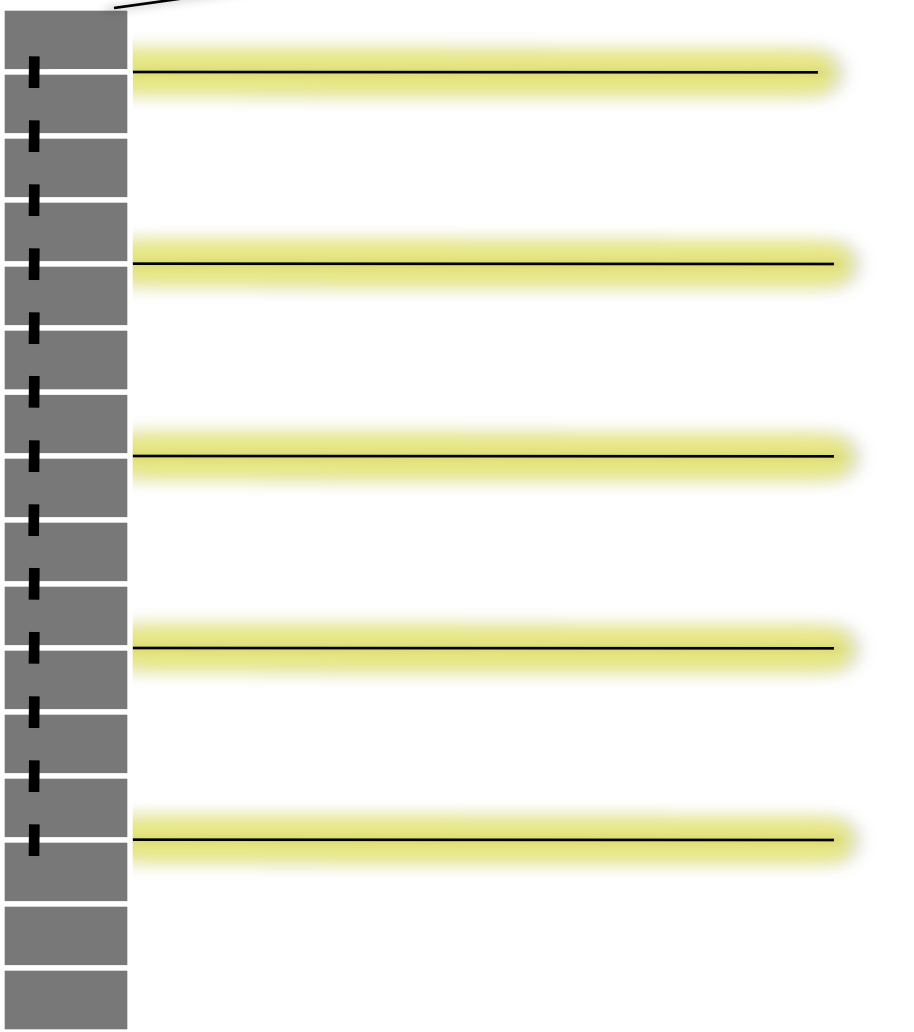
GCS

1. Composite Structure
2. Internally stable
3. Friction Connections
4. Lightweight Inclusions
5. Close spacing

MSE

1. Reinforced Soil Structure
2. Quasi-tieback
3. Pin Connections
4. Strong reinforcement
5. Wide Spacing





2008
NEW
ZEALAND
GCStm
VARIATION

RIVER
-0840

BRIDGES ON GCS™ ABUTMENTS

DEFIANCE COUNTY, OHIO

DESIGNED WITH CRITERIA PROVIDED IN

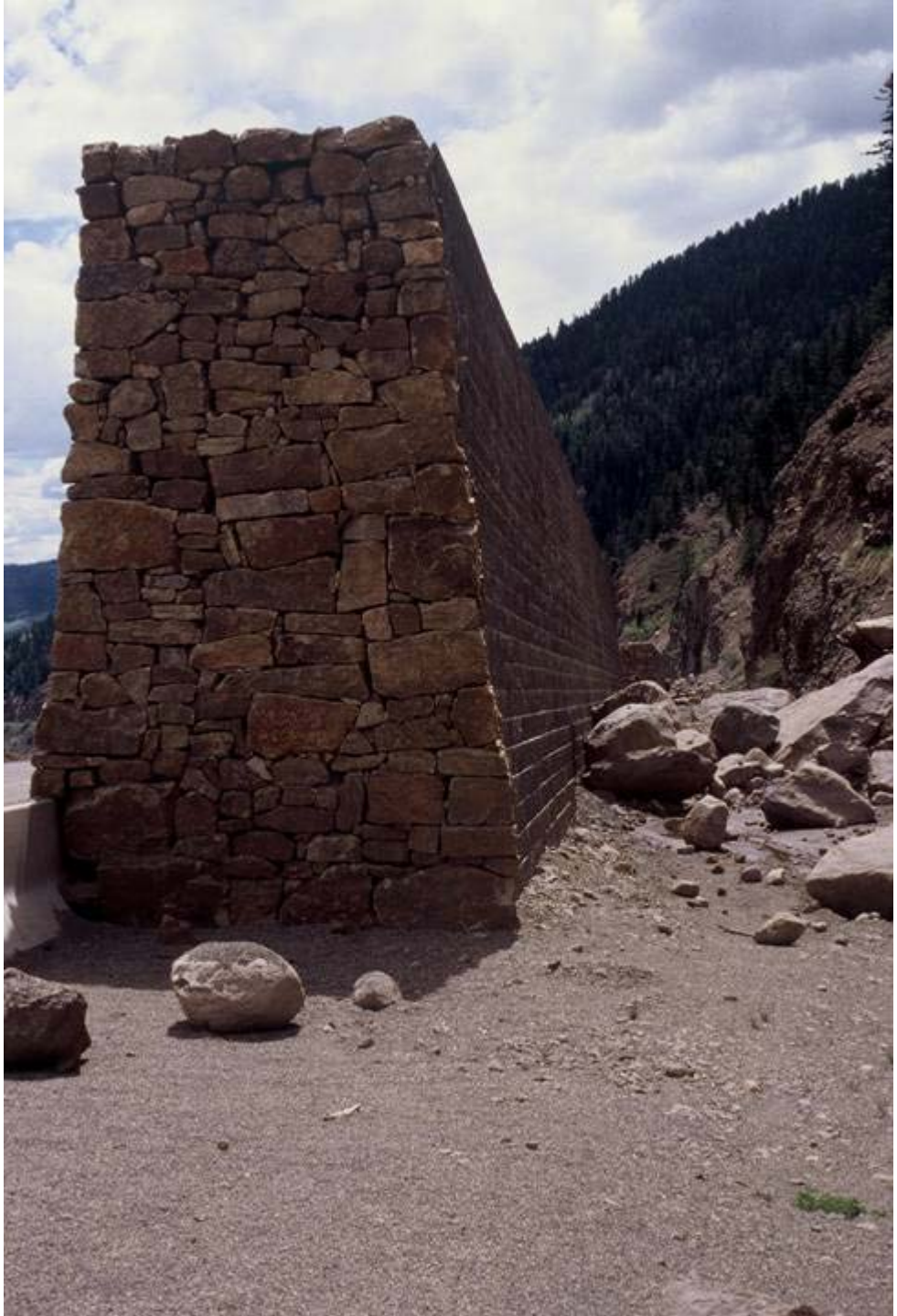
NCHRP REPORT 556

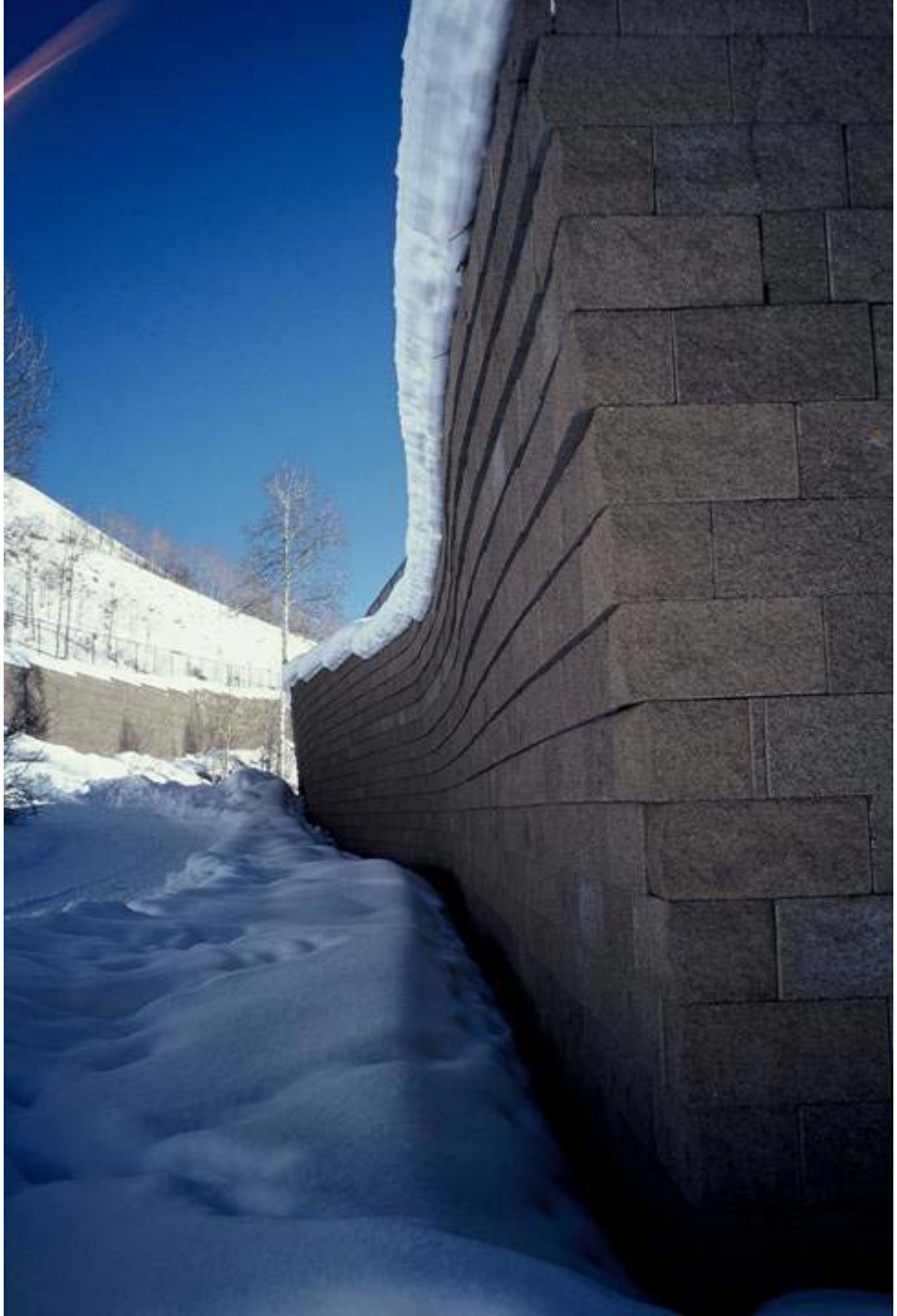
KOBELCO

09/21/20

MEN
WORKING

08/17/2006





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United States
Department of
Agriculture

Forest Service

Engineering Staff

EM 7170-12B

United States
Department of
Transportation

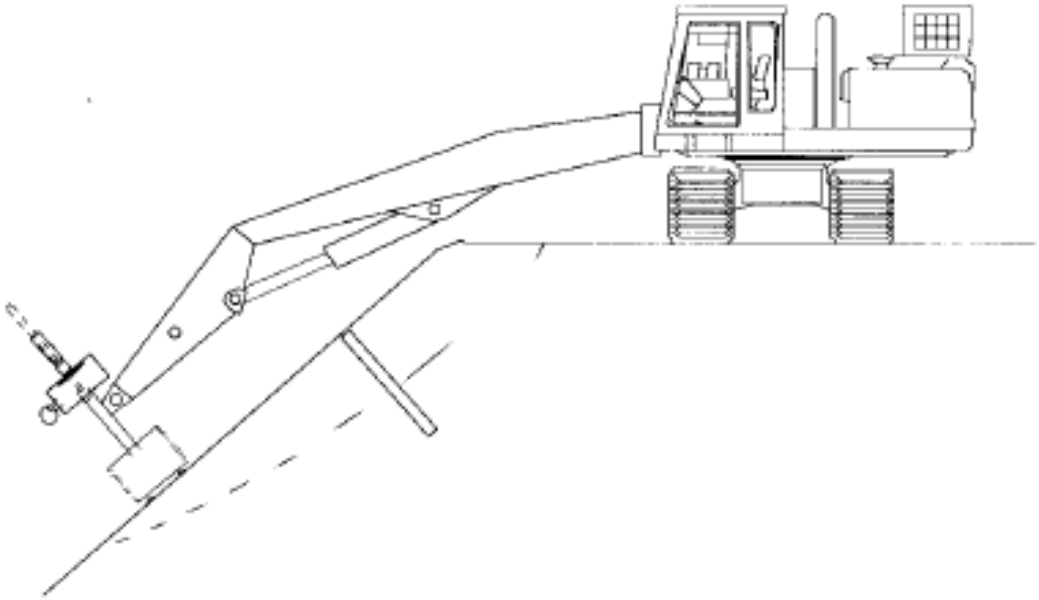
Federal Highway
Administration

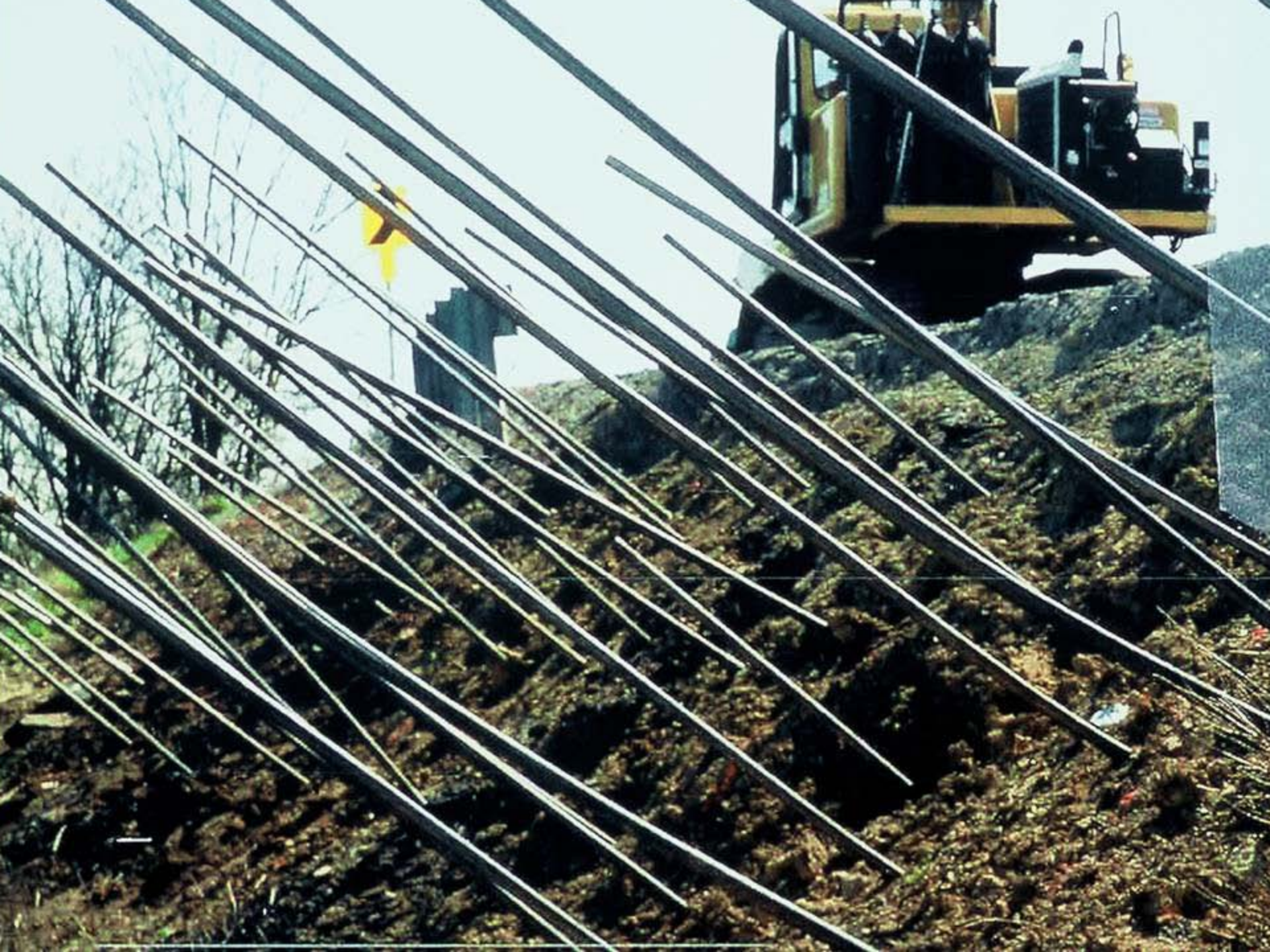
FHWA-FPL-93-004

July 1994

Project Report for Launched Soil Nails—1992 Demonstration Project

Volume 2





PC150LC

KOMATSU
Soil Nail Launcher, Inc
PC150LC

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Soil Nail Launcher, Inc
PC150LC

Rapid Site Ingress/Egress

(Or get run over by a train)

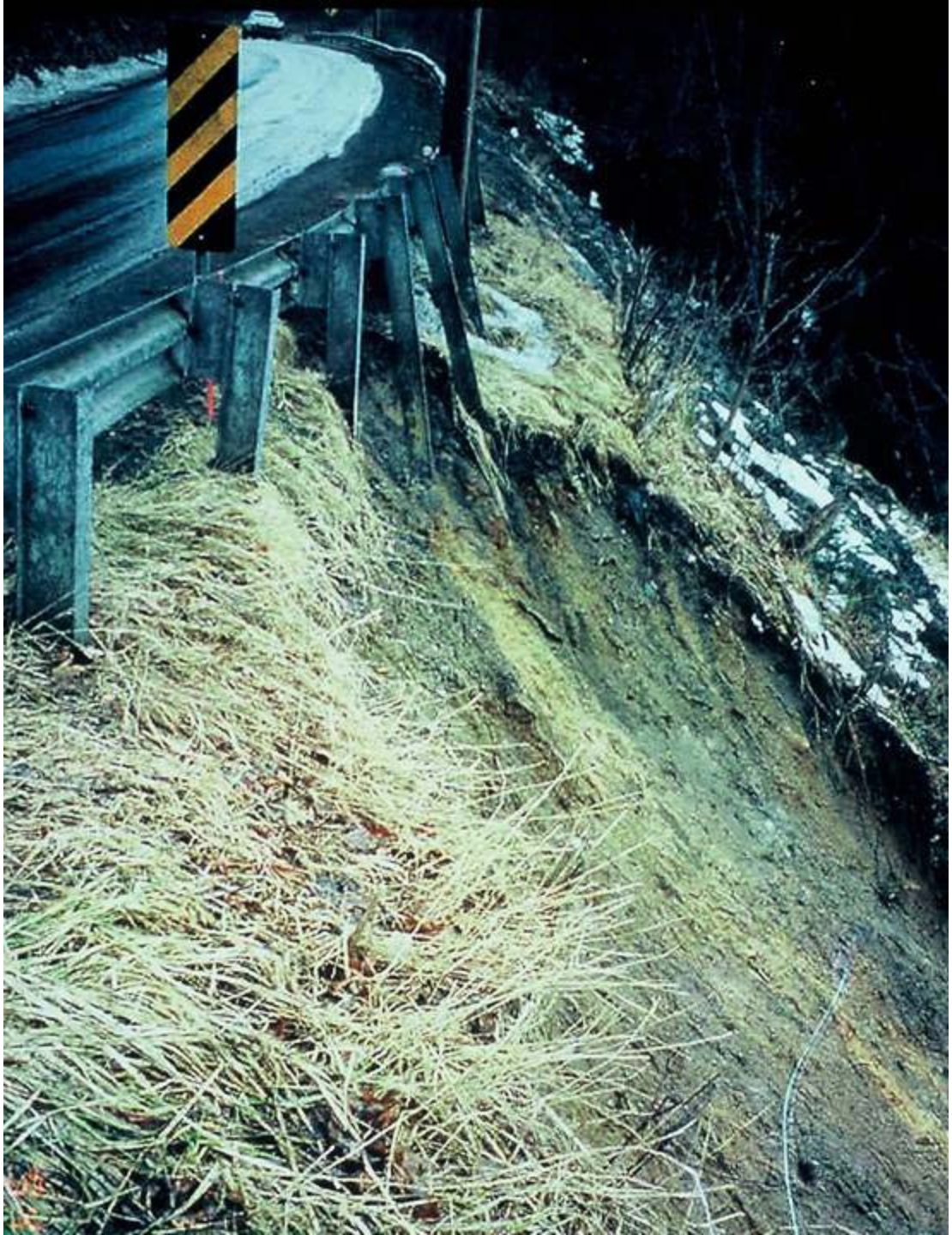
Temporary Shoring for Ohio DOT

3 DAYS AND $45,000
NO PROJECT DELAY
COMPARED TO
$200,000 AND 6 WEEKS
FOR A
PILE WALL

TENNESSEE DOT
CAT
KOMATSU
PC150LC

SURFACE TREATMENTS

08/29/2006



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WINTER WORK AND STILL A SAVINGS OF $300,000

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