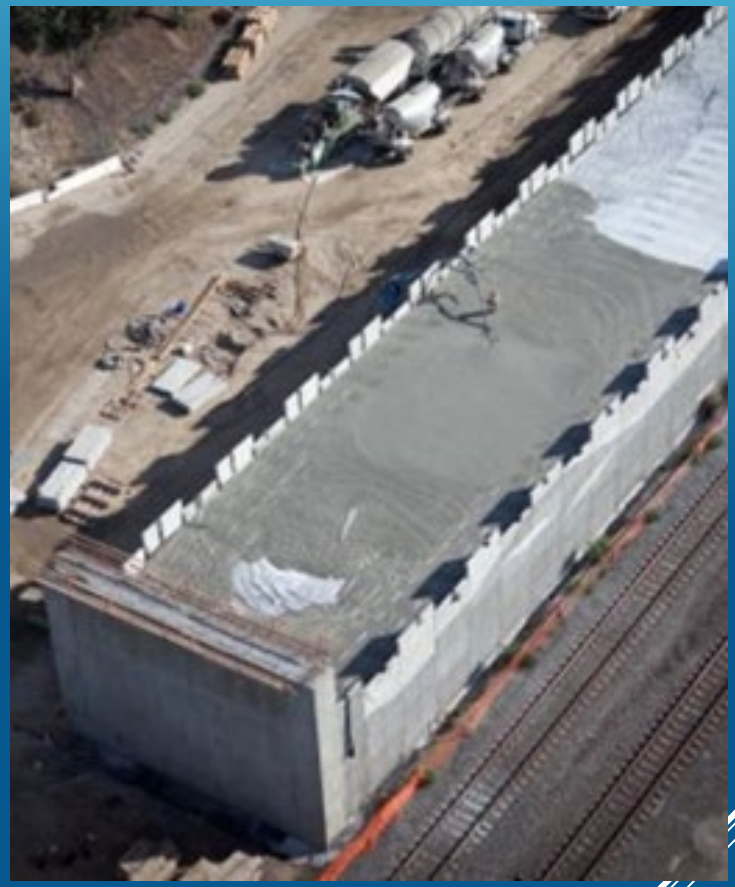
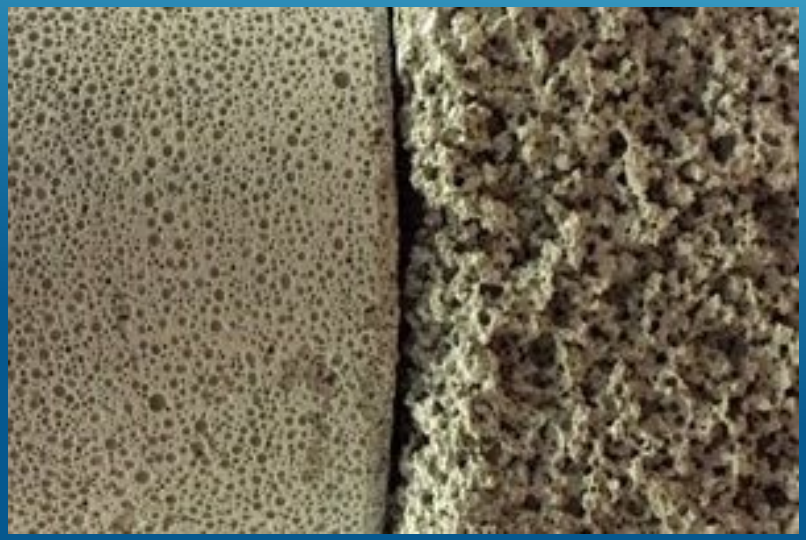
APPLICATION OF LIGHTWEIGHT FILLS IN CIVIL AND TRANSPORTATION ENGINEERING



Steven F. Bartlett, Ph.D. P.E
Associate Chair
Department of Civil and Environmental
University of Utah

IMAGINE THE UNIVERSITY OF UTAH®

LIGHT-WEIGHT MATERIALS



Light-Weight Cellular Concrete

Impermeable (left) (LCC)
Permeable (right) (PLCC)
High porosity 60 to 70 percent
Permeability = c. sand to f. gravel
Unit weight 25 to 30 pcf

Expanded Polystyrene (Geofoam)

Impermeable – but an have flow through joints
Unit weight 1.25 to 1.5 pcf (for most applications)
Compressible under concentrated loads
Can undergo creep strain if over-stressed

PROPERTIES AND FUNCTION OF LIGHT-WEIGHT MATERIALS

Properties

- Light-weight to ultra light-weight
- High strength to mass ratio

Important Functions

- Reduces settlement
- Improves bearing capacity
- Improves foundation and slope stability
- Decreases horizontal and vertical loads
- Rapid construction
- Can saves construction time and money

INTRODUCTION TO EPS MANUFACTURING AND PROPERTIES

raw styrene beads

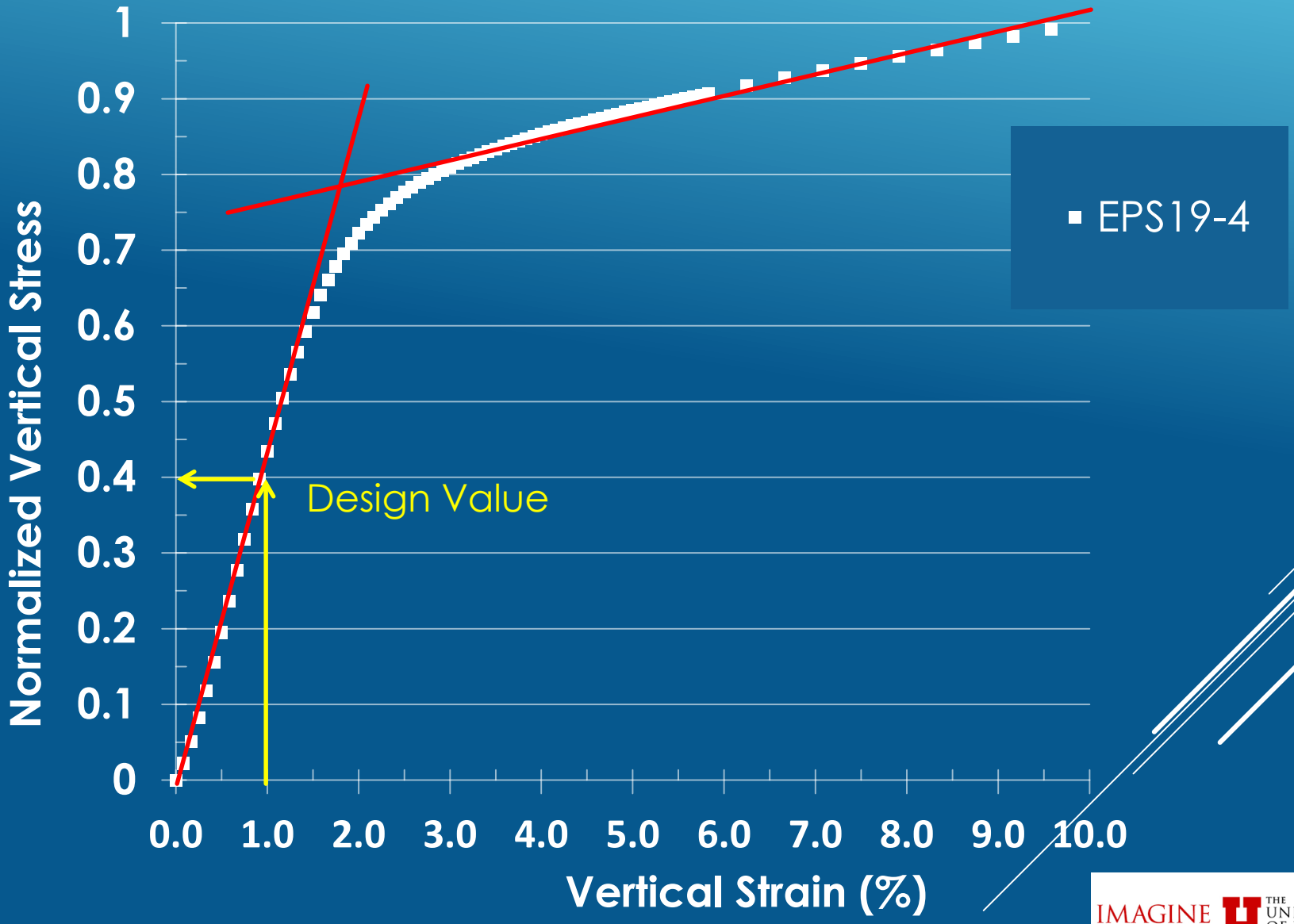
steam expanded
(1st steam heating)

block molding (2nd steam heating)

block placement

IMAGINE THE UNIVERSITY OF UTAH®

COMPRESSIVE RESISTANCE



EASE OF PLACEMENT AND CONSTRUCTION

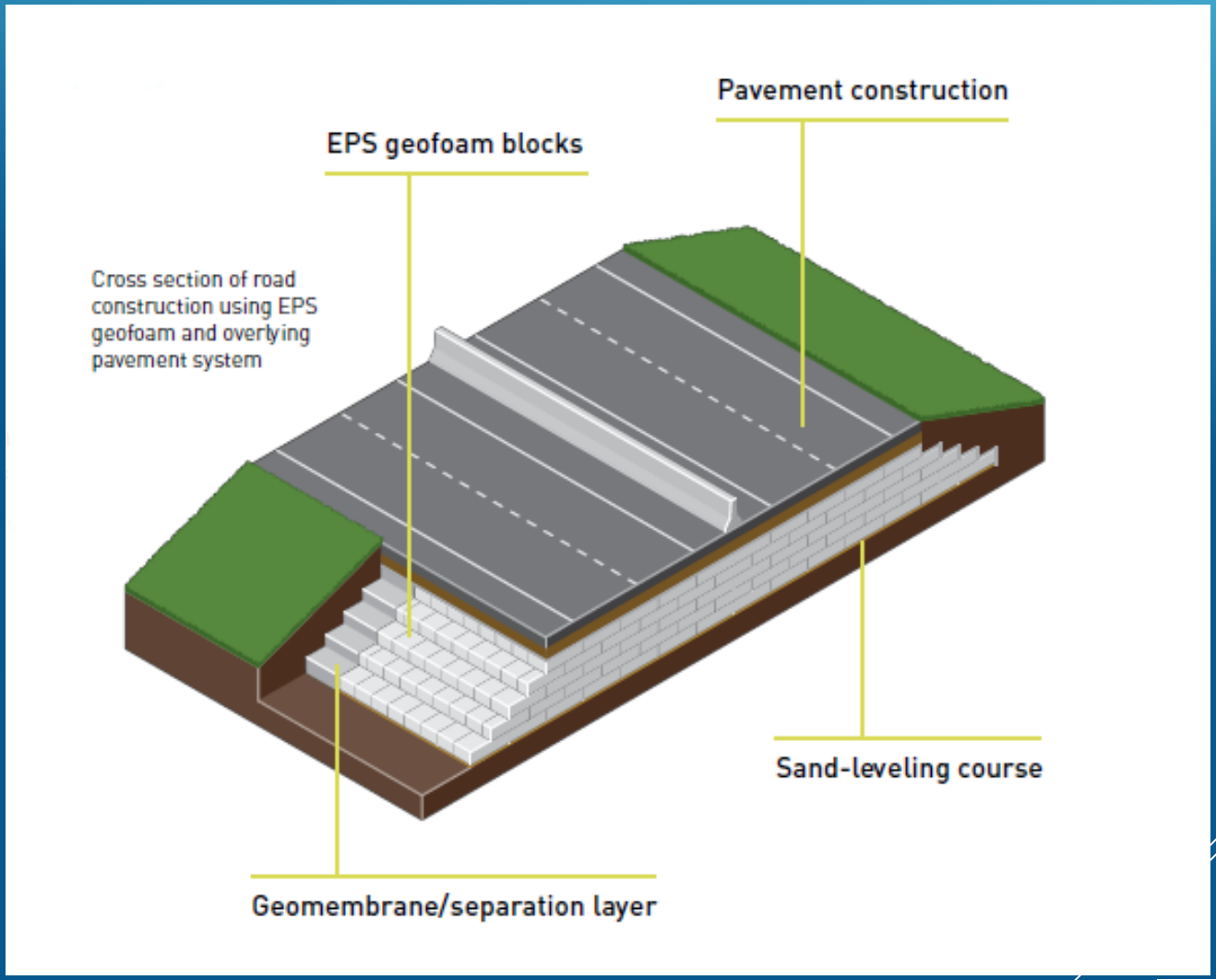
Geofoam Placement
photo courtesy of
BASF- Kuala Lumpur,
Malaysia

Cellular Concrete Placement
photo courtesy of Aerix Industries

SELECTED TOPICS

- Roadway construction over soft soils / reclaimed land
- Bridge abutments and under fill
- Accelerated bridge construction
- Retaining and buried wall backfill
- Culverts, pipelines and buried structures
- Rail embankment
- Slope stabilization
- Landscaping and vegetative green roofs

ROADWAY CONSTRUCTION OVER SOFT SOILS / RECLAIMED LAND



ROAD CONSTRUCTION OVER POOR SOILS

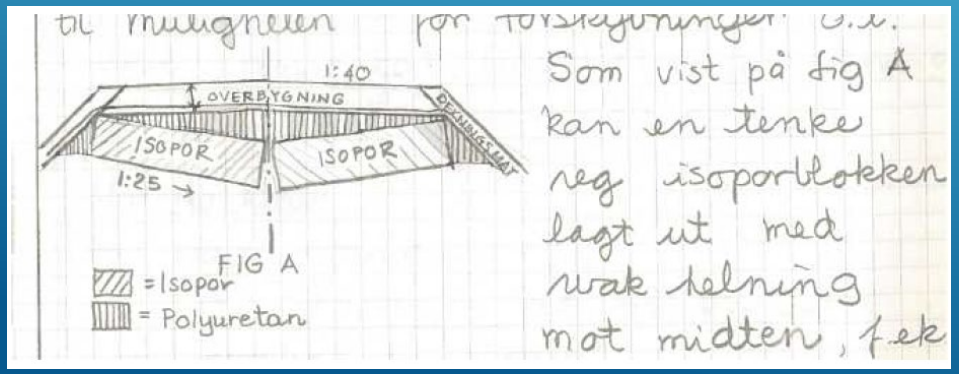


Figure 3. Excavation of the first EPS embankment at Flom bridge (EPS and polyurethane as protective layer).

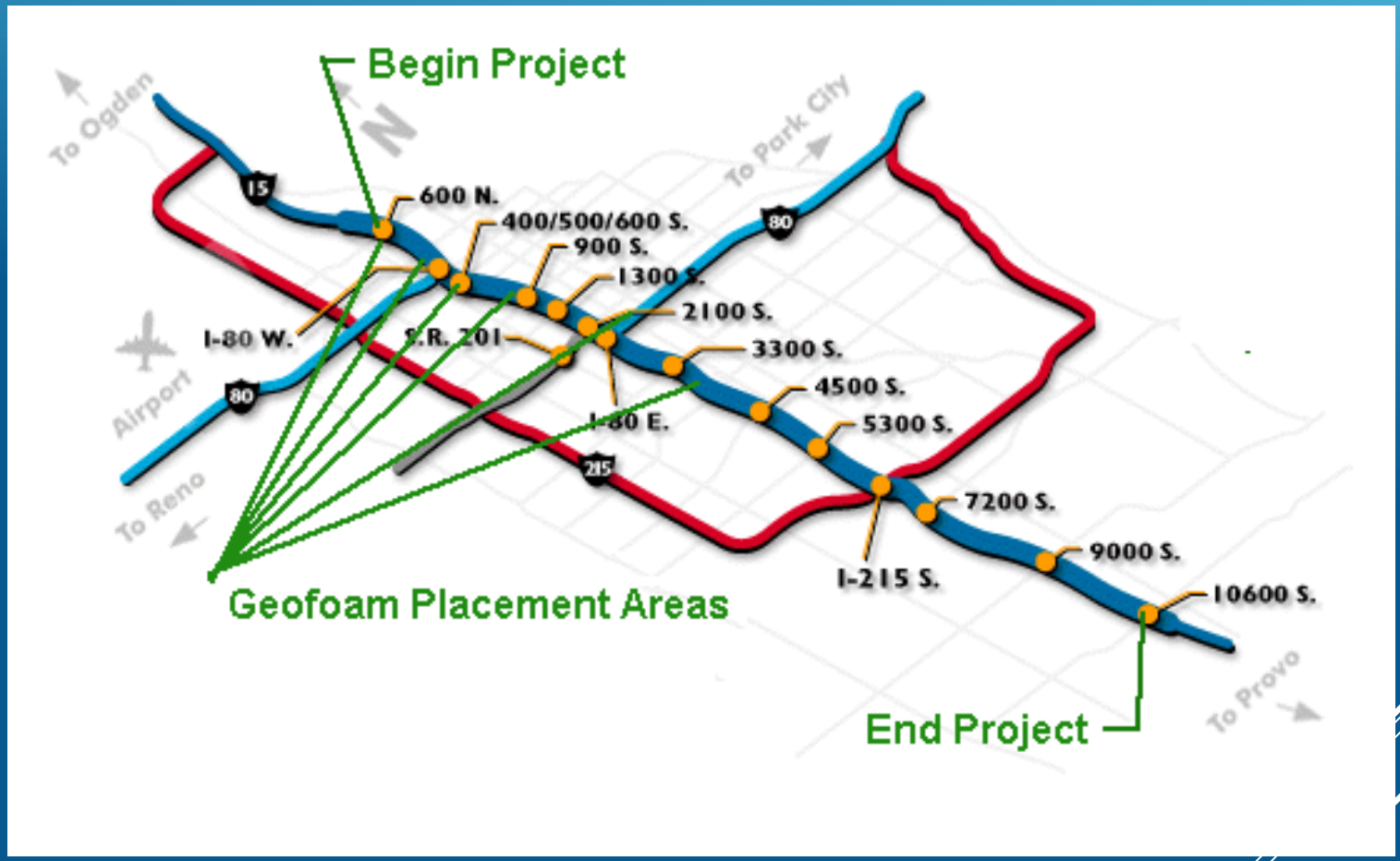
Flom Bridge – 1972 – Lillestrom, Norway

2002 HOST CITY OF WINTER OLYMPICS – SALT LAKE CITY

SALT LAKE 2002

IMAGINE THE UNIVERSITY OF UTAH

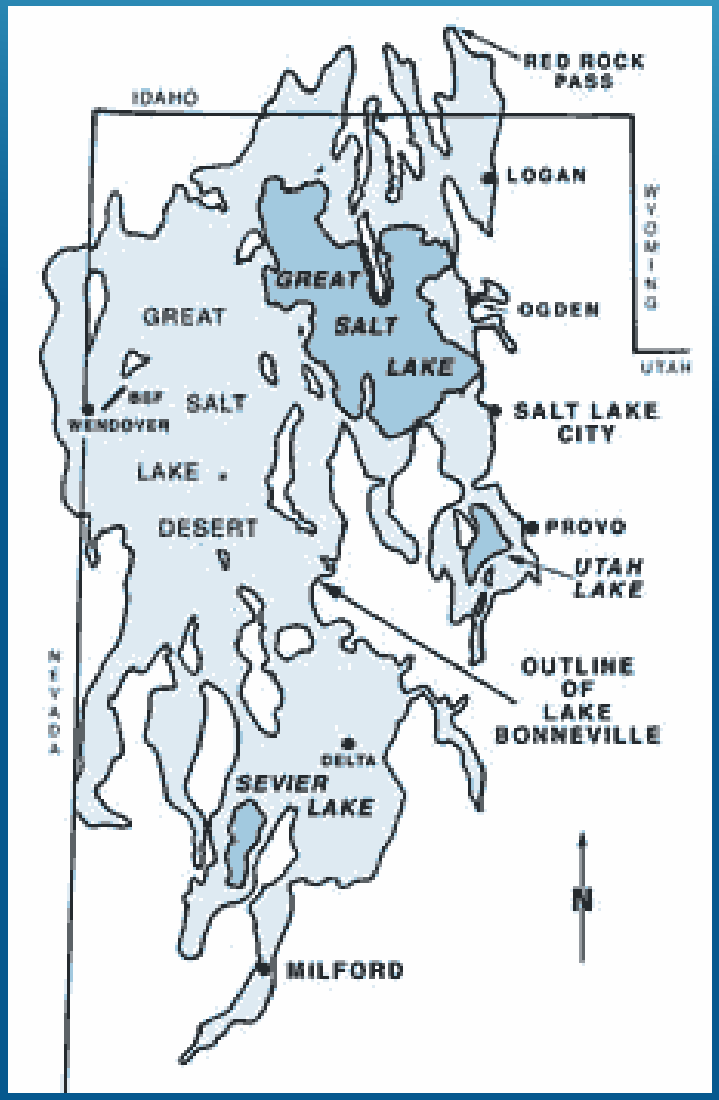
ROADWAY CONSTRUCTION OVER SOFT SOILS
I-15 PROJECT (ROAD WIDENING)

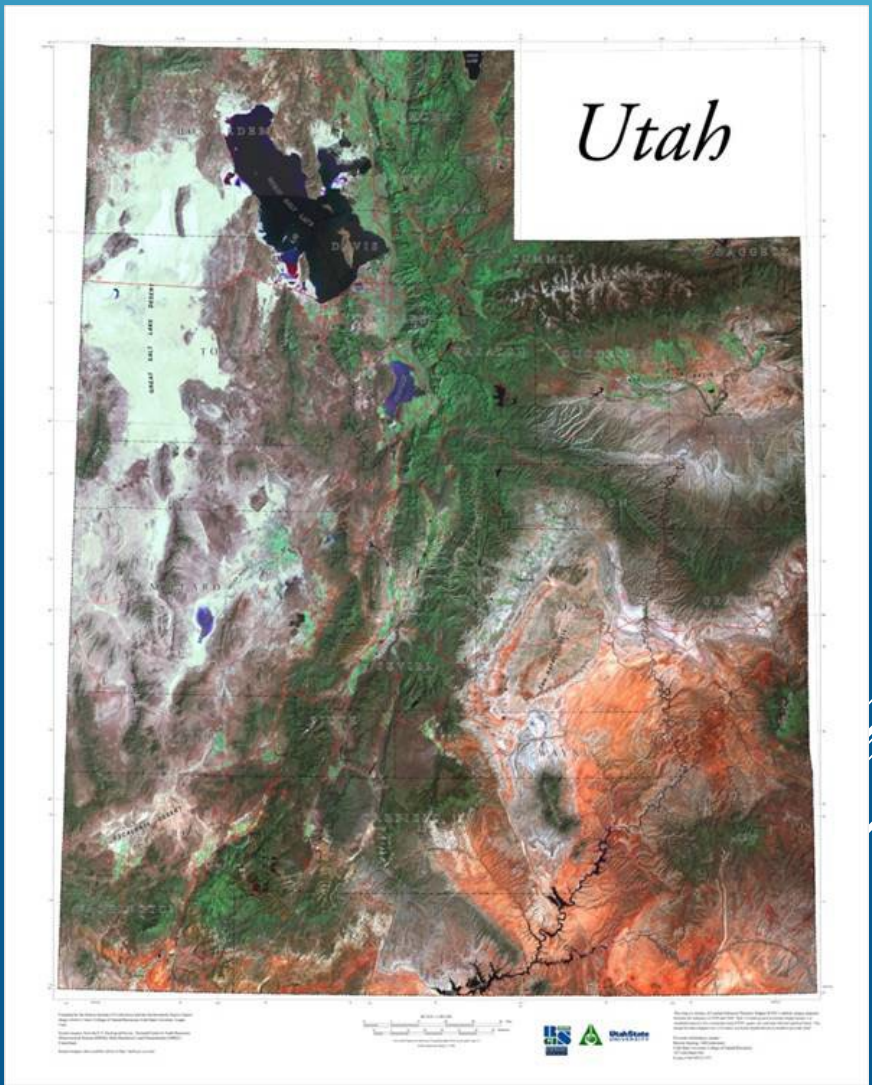


Approx. 100,000 cubic meters of geofoam was placed.
World's largest geofoam project.

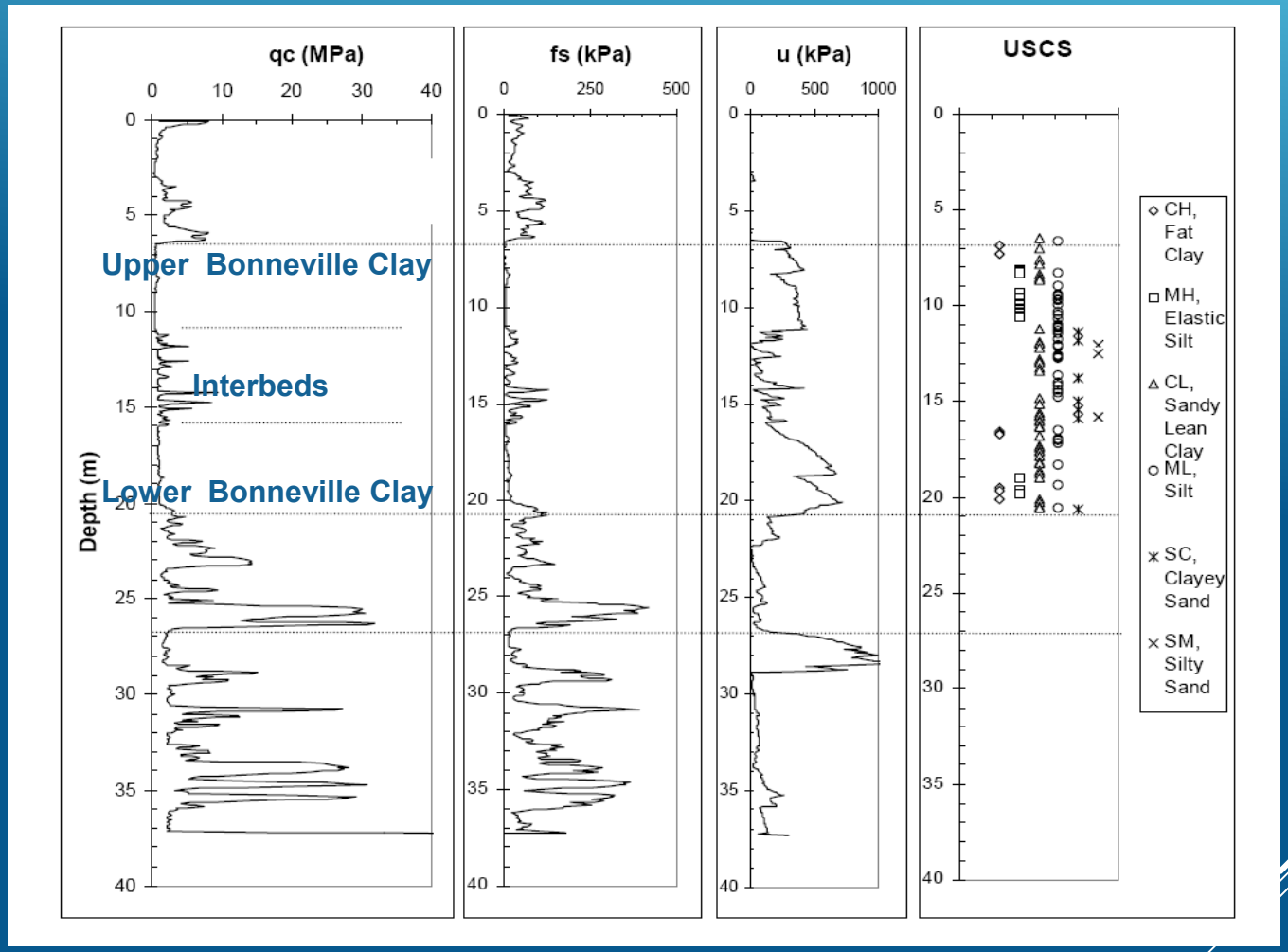
IMAGINE THE UNIVERSITY OF UTAH®

PLEISTOCENE LAKE BONNEVILLE IN UTAH





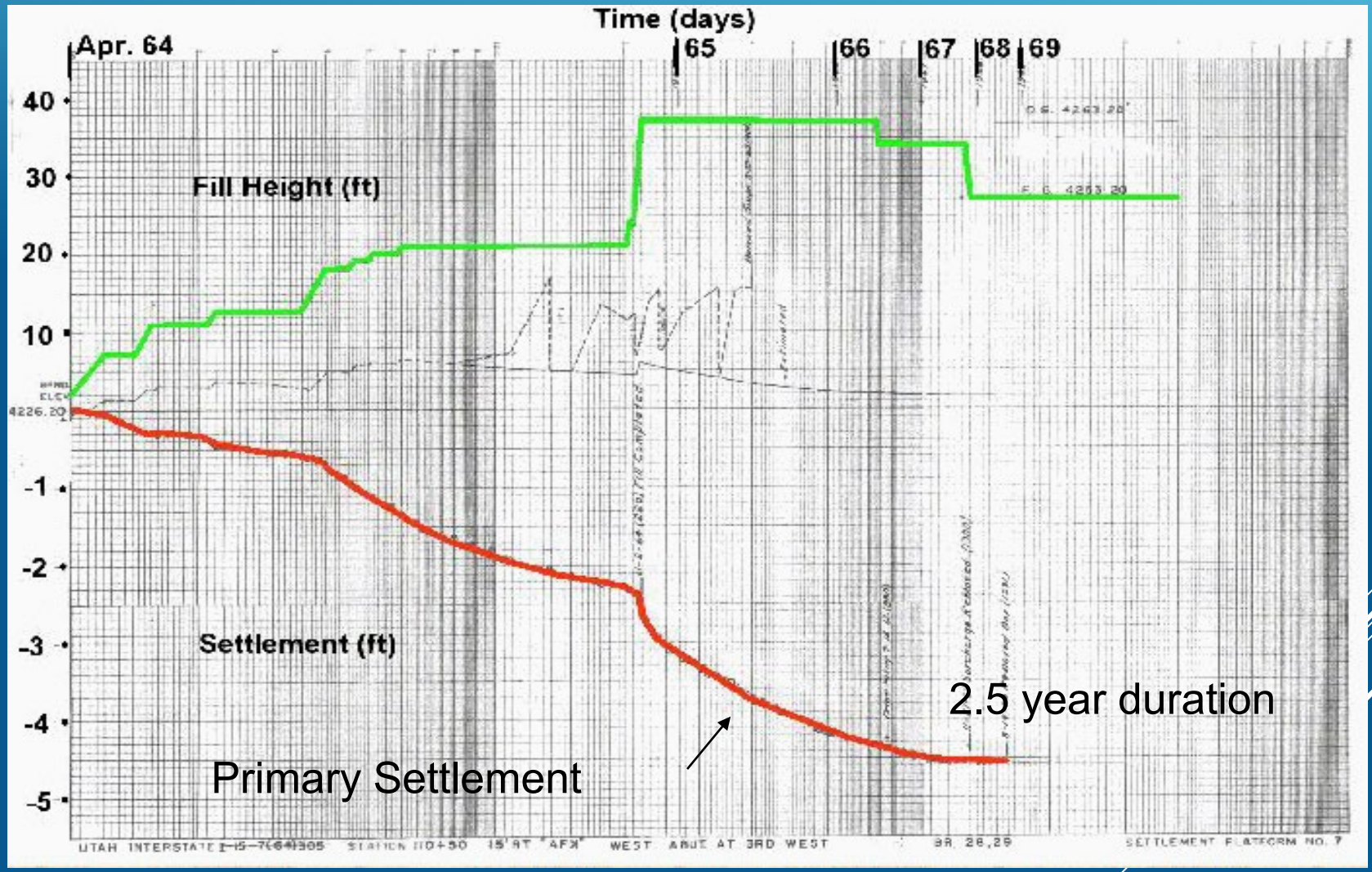
I-15 RECONSTRUCTION PROJECT



Subsurface Profile in Salt Lake Valley

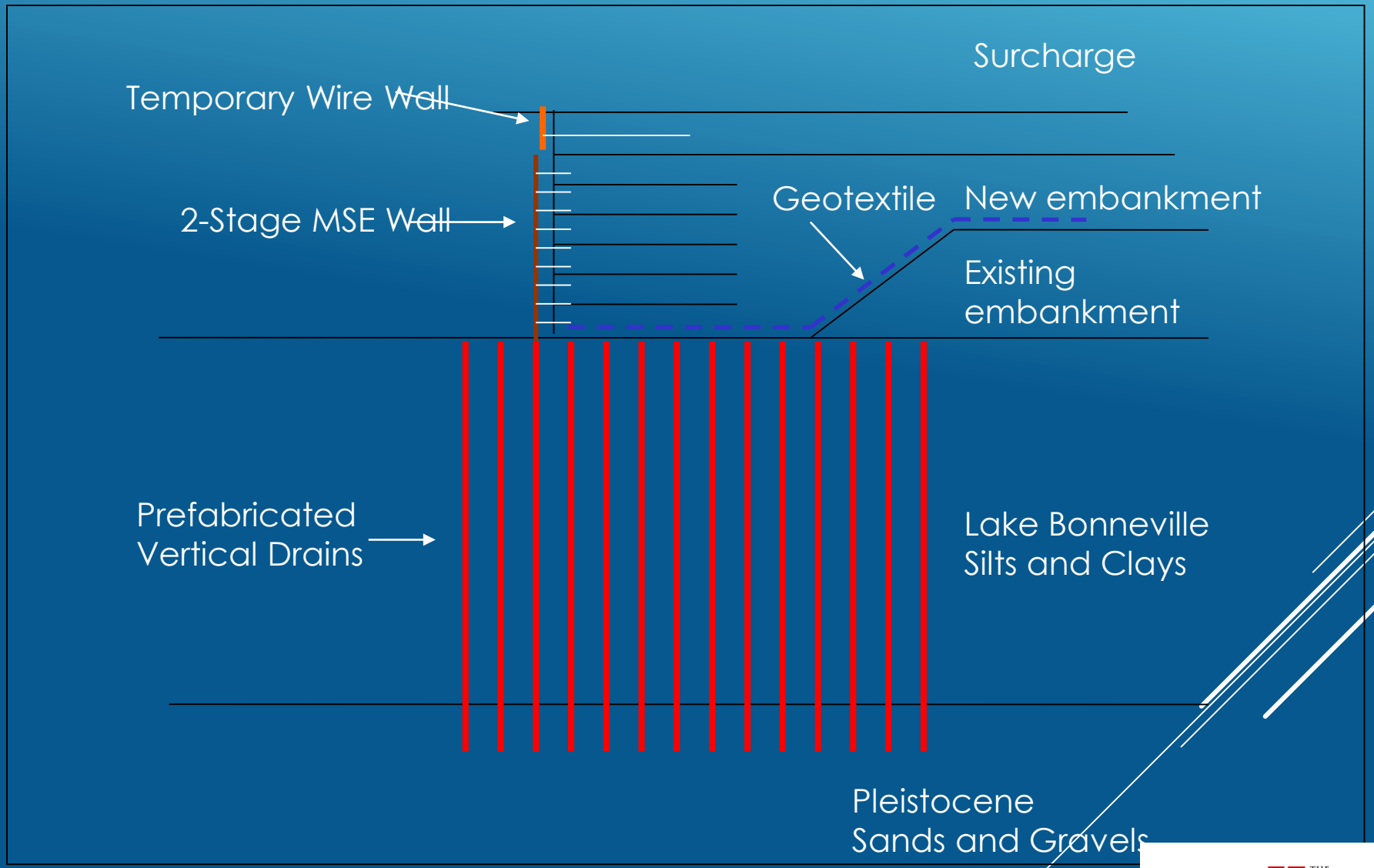
IMAGINE THE UNIVERSITY OF UTAH

I-15 PROJECT – SETTLEMENT RECORD 1960s



IMAGINE THE UNIVERSITY OF UTAH

TYPICAL I-15 EMBANKMENT CONSTRUCTION



CONVENTIONAL I-15 EMBANKMENT CONSTRUCTION

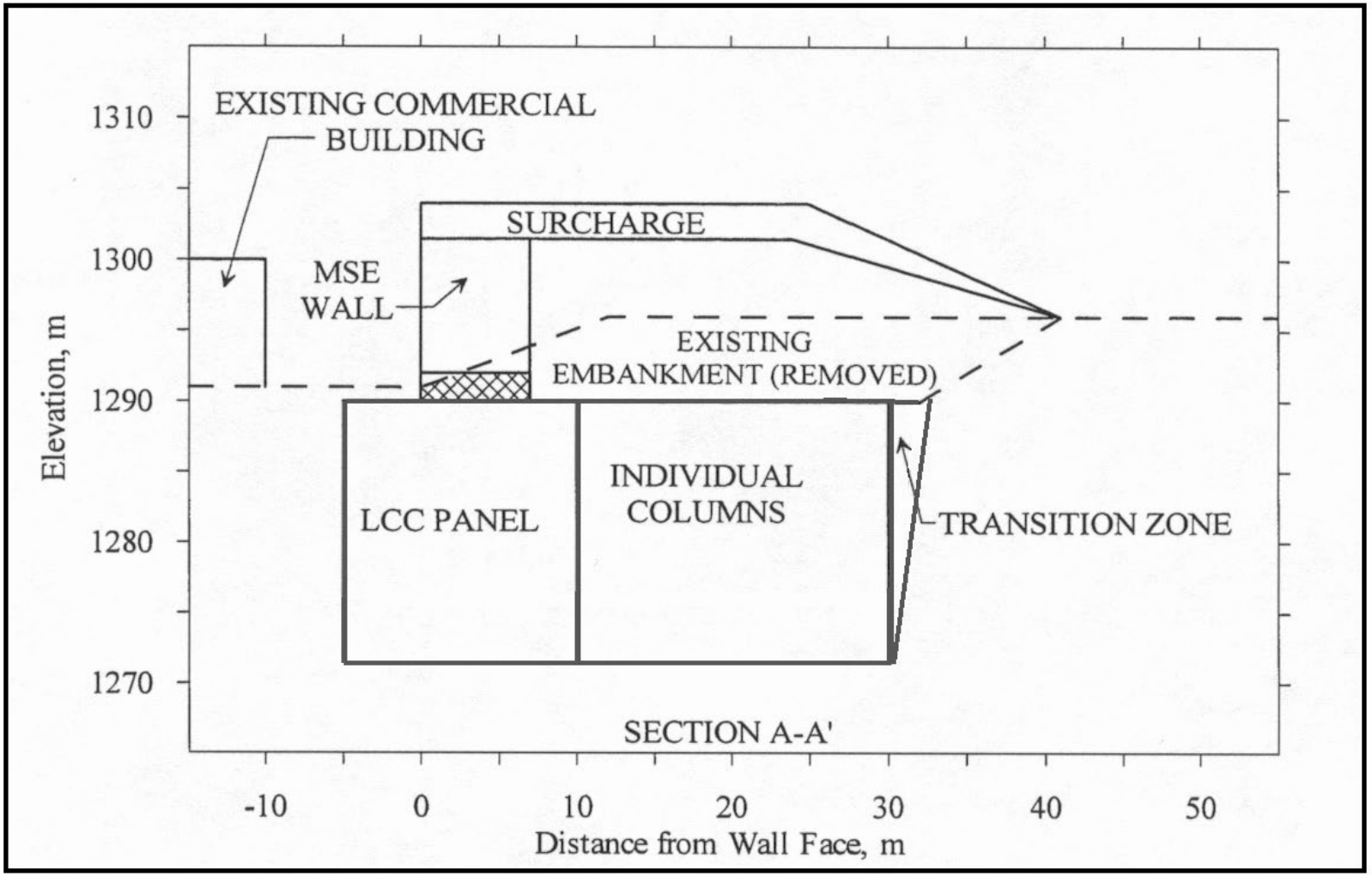
PV or Wick Drains

Surcharging

Geotextile Reinforced Slopes

IMAGINE THE UNIVERSITY OF UTAH

LIME CEMENT COLUMNS



LCC = Lime Cement Columns

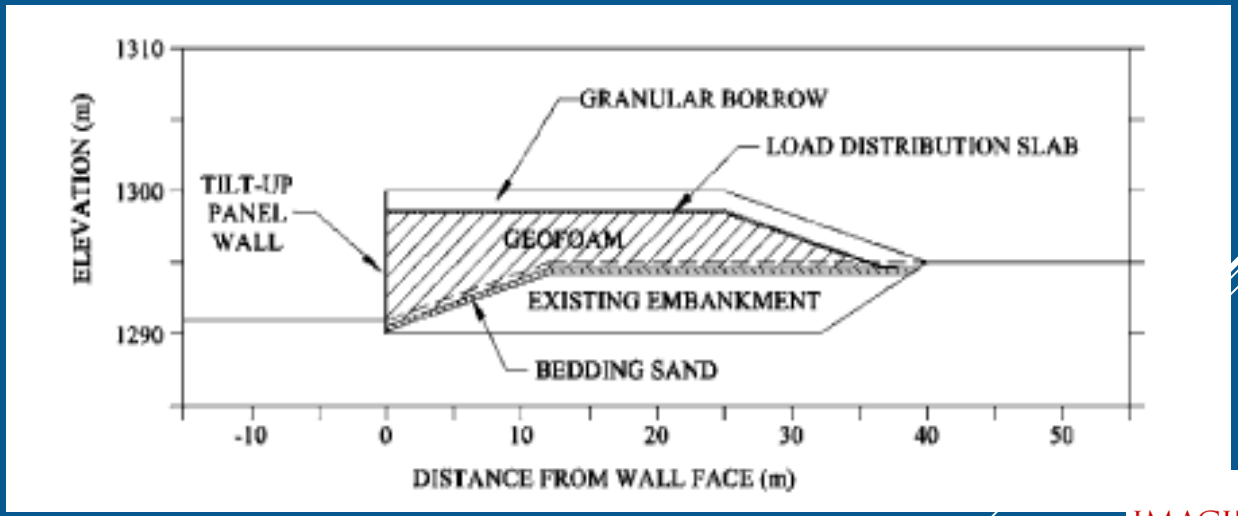
LIME CEMENT COLUMNS (CONT.)

Lime Cement Columns

One stage MSE atop columns

I-15 RECONSTRUCTION PROJECT – TYPICAL GEOFOAM FILL

I-15 Reconstruction Project
Salt Lake City, Utah



I-15 RECONSTRUCTION PROJECT – GEOFOAM FILL AERIAL VIEW

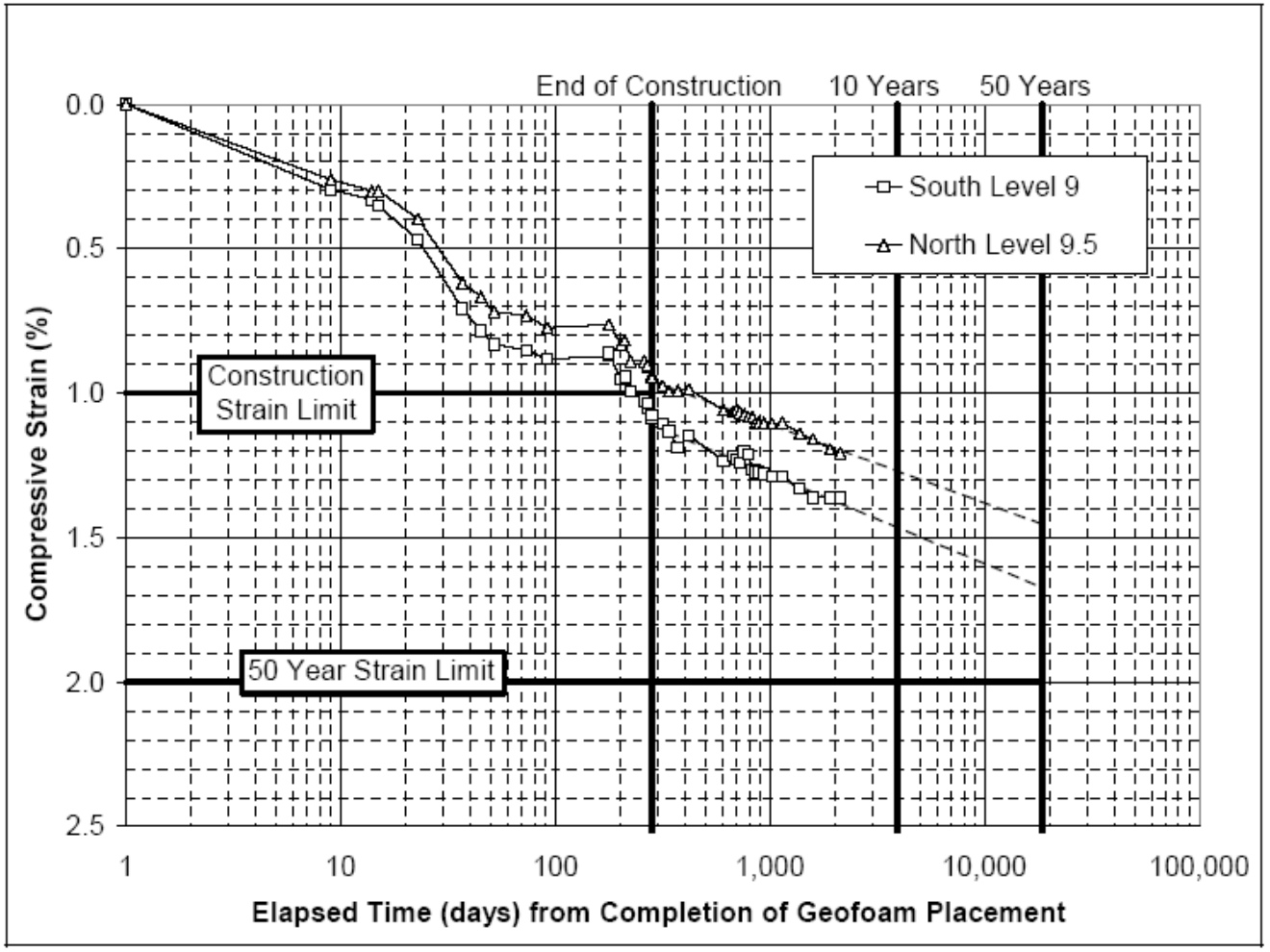
I-15 Reconstruction Project, Salt Lake City, Utah

I-15 RECONSTRUCTION PROJECT

Reinforced Concrete
Load Distribution Slab

Completed Load Distribution Slab

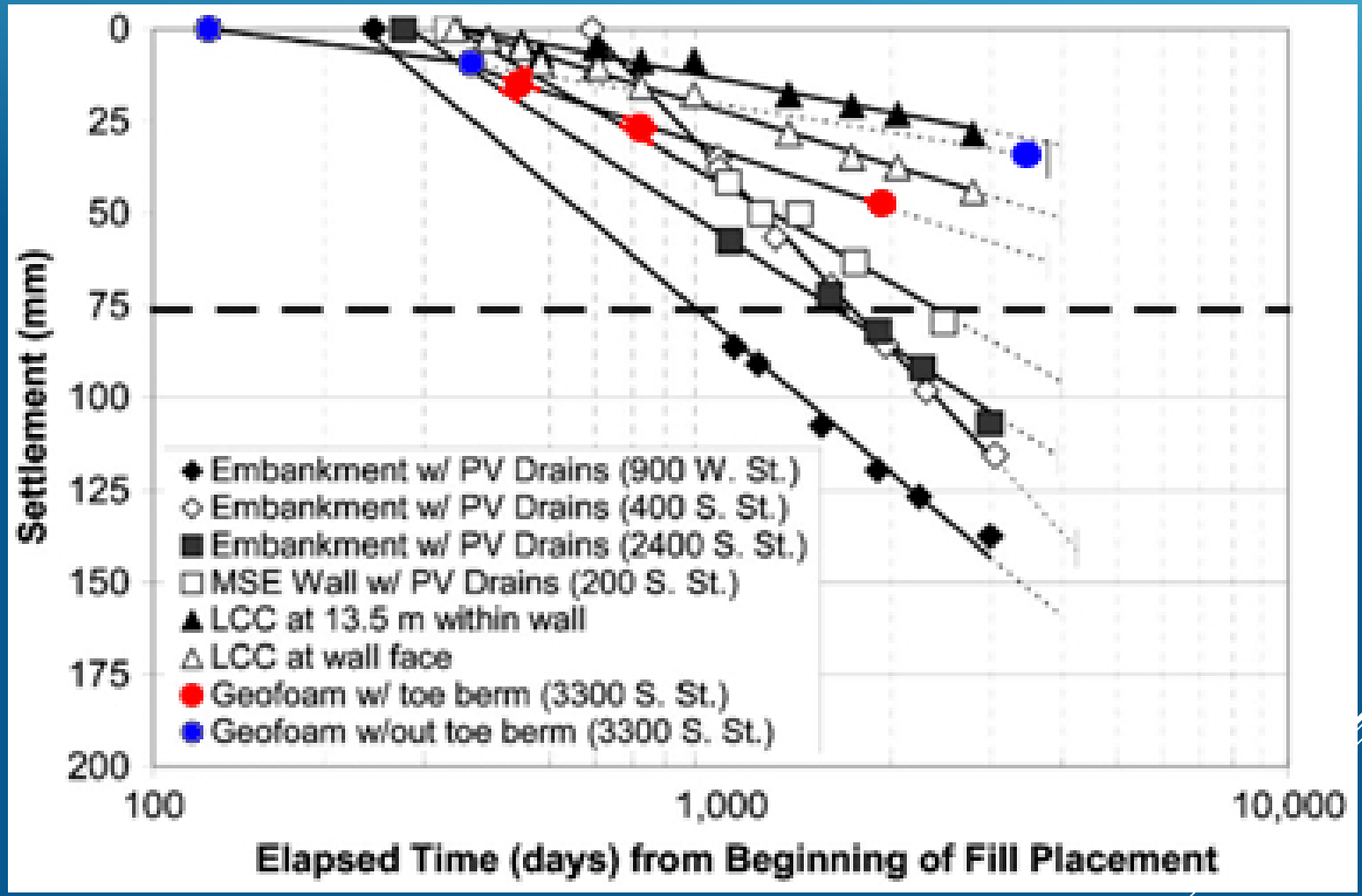
SETTLEMENT MONITORING 100 SOUTH STREET GEOFOAM EMBANKMENT



1% elastic construction strain

IMAGINE THE UNIVERSITY OF UTAH®

GEOTECHNOLOGY SETTLEMENT PERFORMANCE
I-15 RECONSTRUCTION



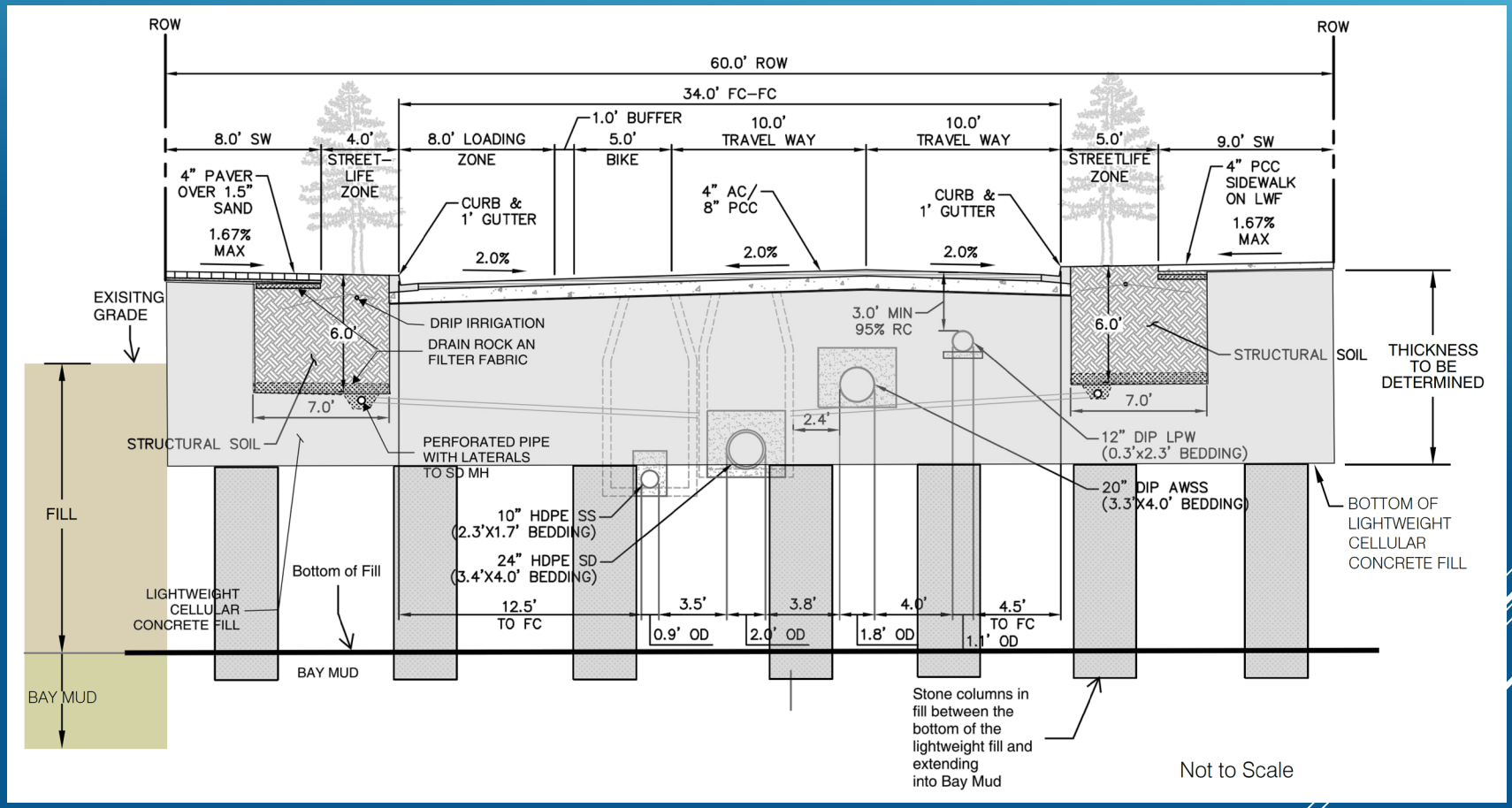
I-15 GEOFOAM CONCLUSIONS

1. Geofoam fills performed as expected with no major issues.
2. Approximately 1 percent vertical strain occurred during construction.
   a. Strain due to seating and compression of geofoam.
3. Approximately 0.3 to 0.5 percent creep strain (15 mm) has occurred in a 10-year post construction period.
4. The vertical stress distribution that develops in a geofoam wedge fill is complex, but generally diminishes with depth.
5. Pressure cell measurements suggest that approximately 45 kPa of vertical stress has developed in the center of the geofoam mass. This is approximately 50 percent of the compressive strength of the geofoam.

CONSTRUCTION OVER RECLAIMED LAND

Reclaimed Land – Mission Rock Project, Port of San Francisco

ROADWAY X-SECTION MISSION ROCK



Mission Rock Development, San Francisco, CA.

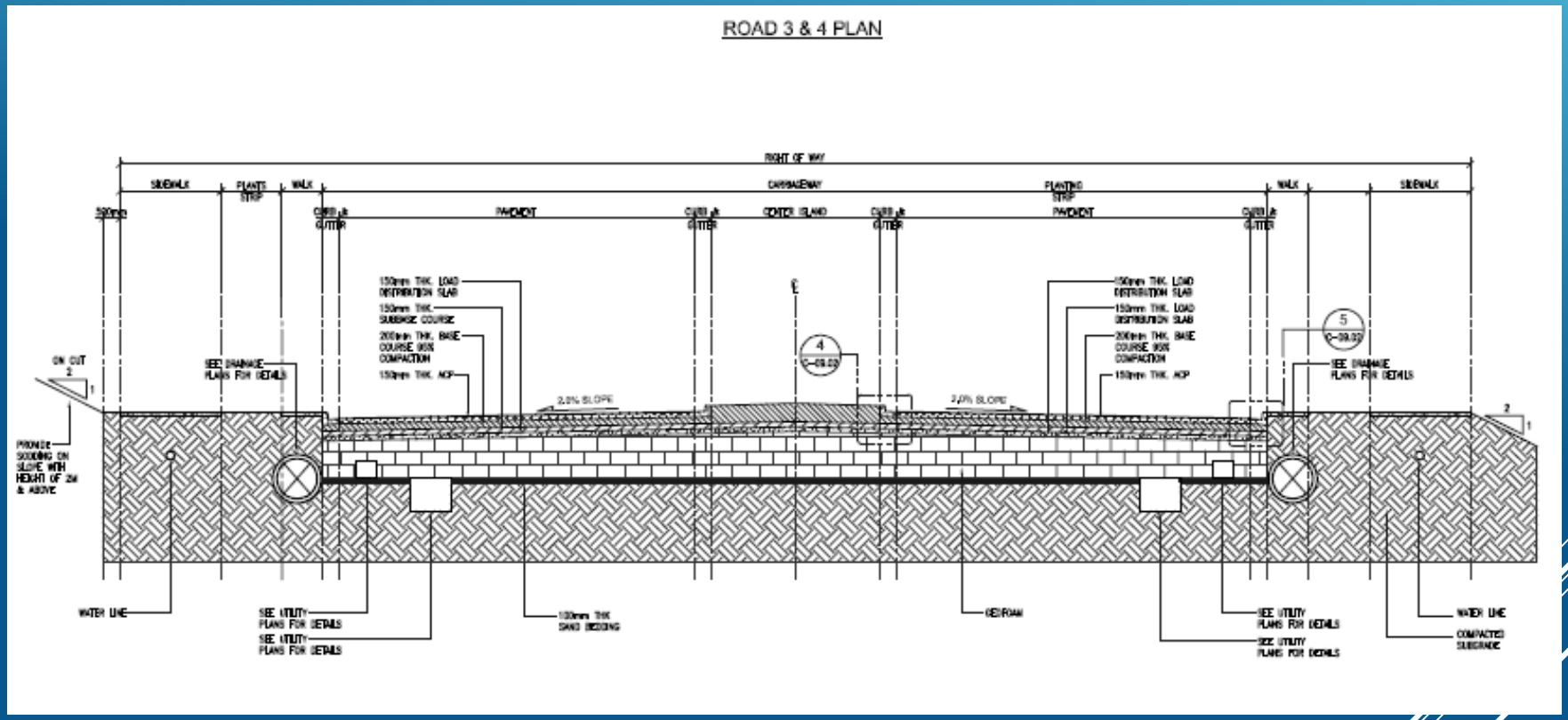
ROADWAY CONSTRUCTION OVER RECLAIMED LAND

St. Rosa Road

Private Road
Constructed Over
Rice Fields

St. Rosa, Philippines

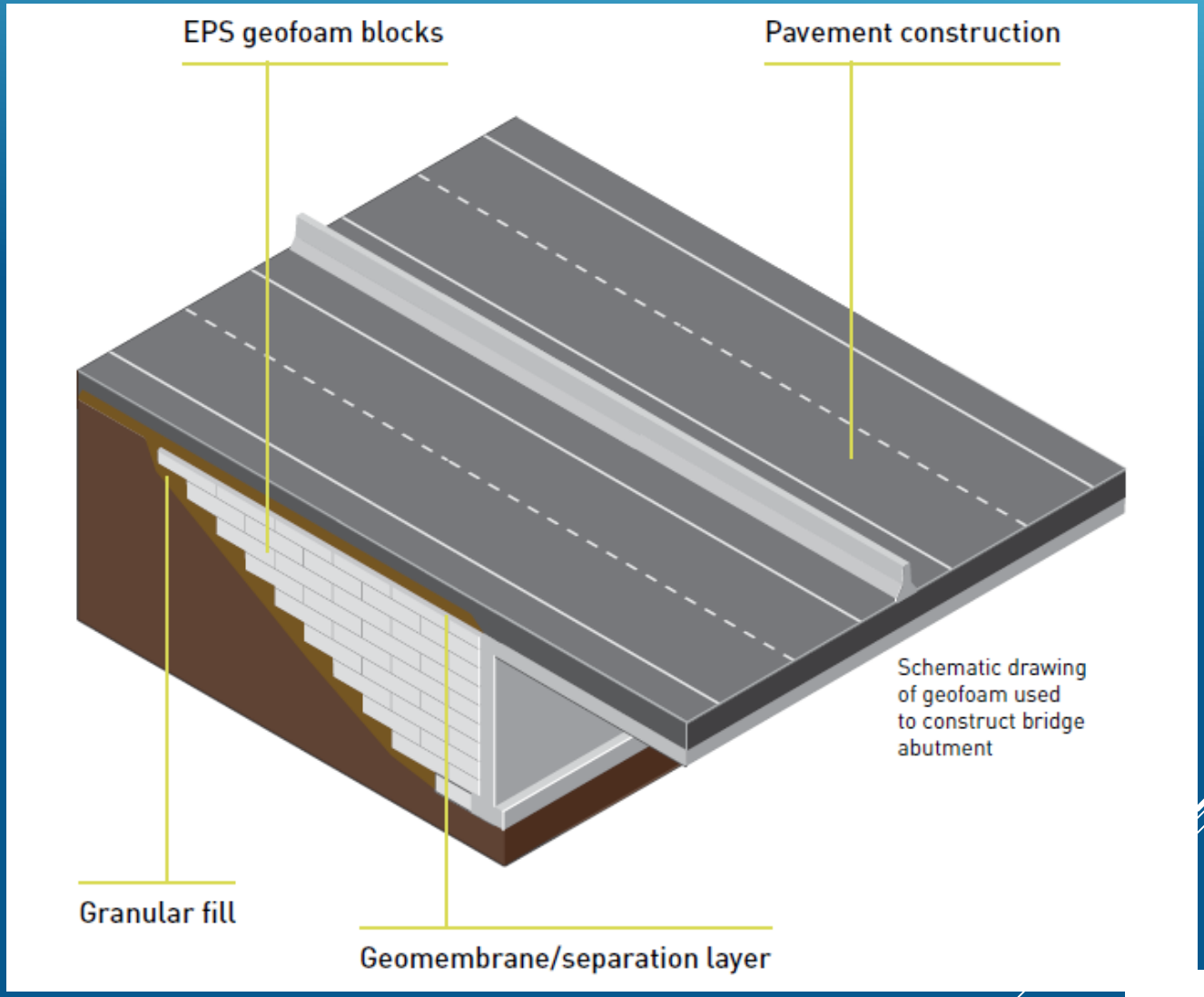
ROAD CONSTRUCTION OVER SOFT SOILS / RECLAIMED LAND



Reclaimed Land – Manila Philippines

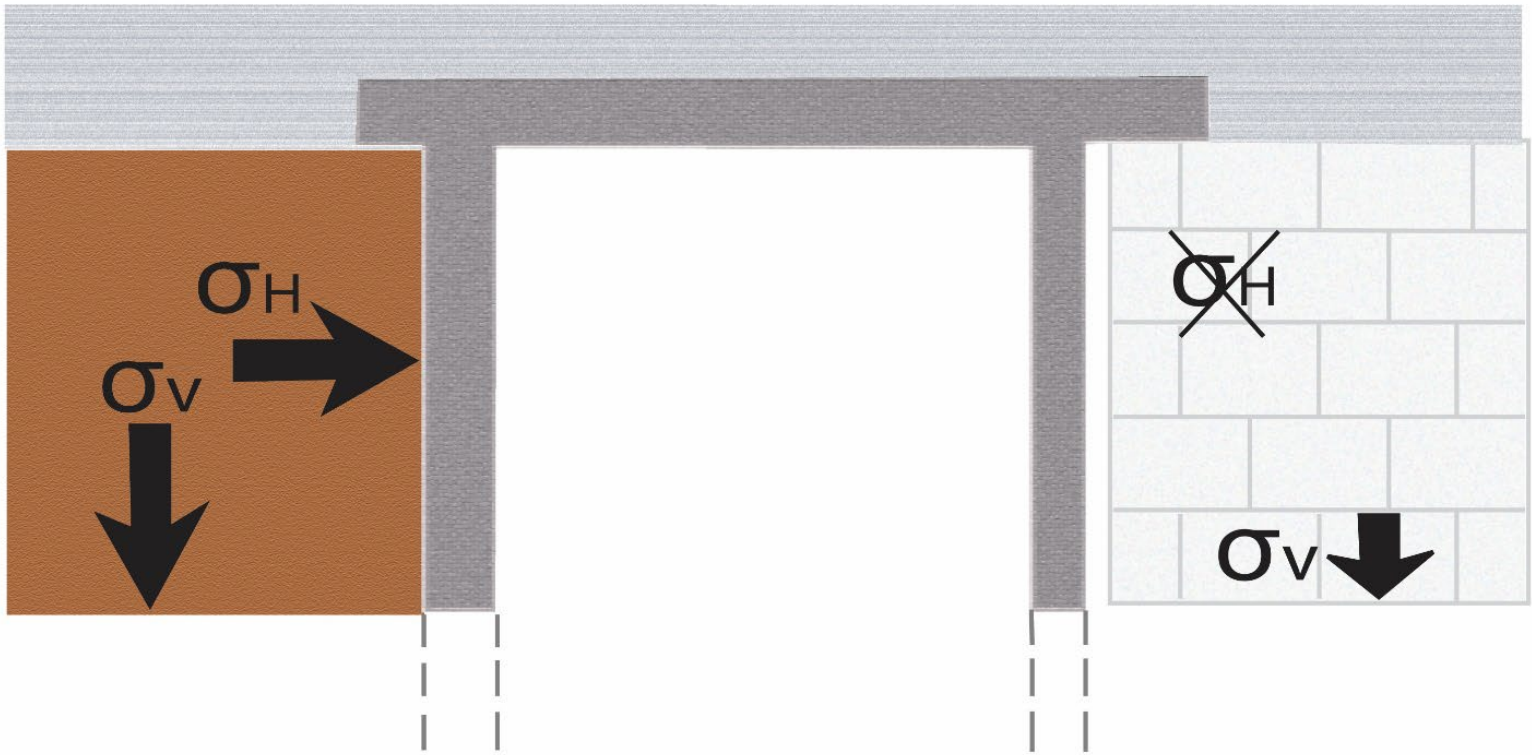
IMAGINE THE UNIVERSITY OF UTAH®

BRIDGE ABUTMENTS AND UNDER FILL

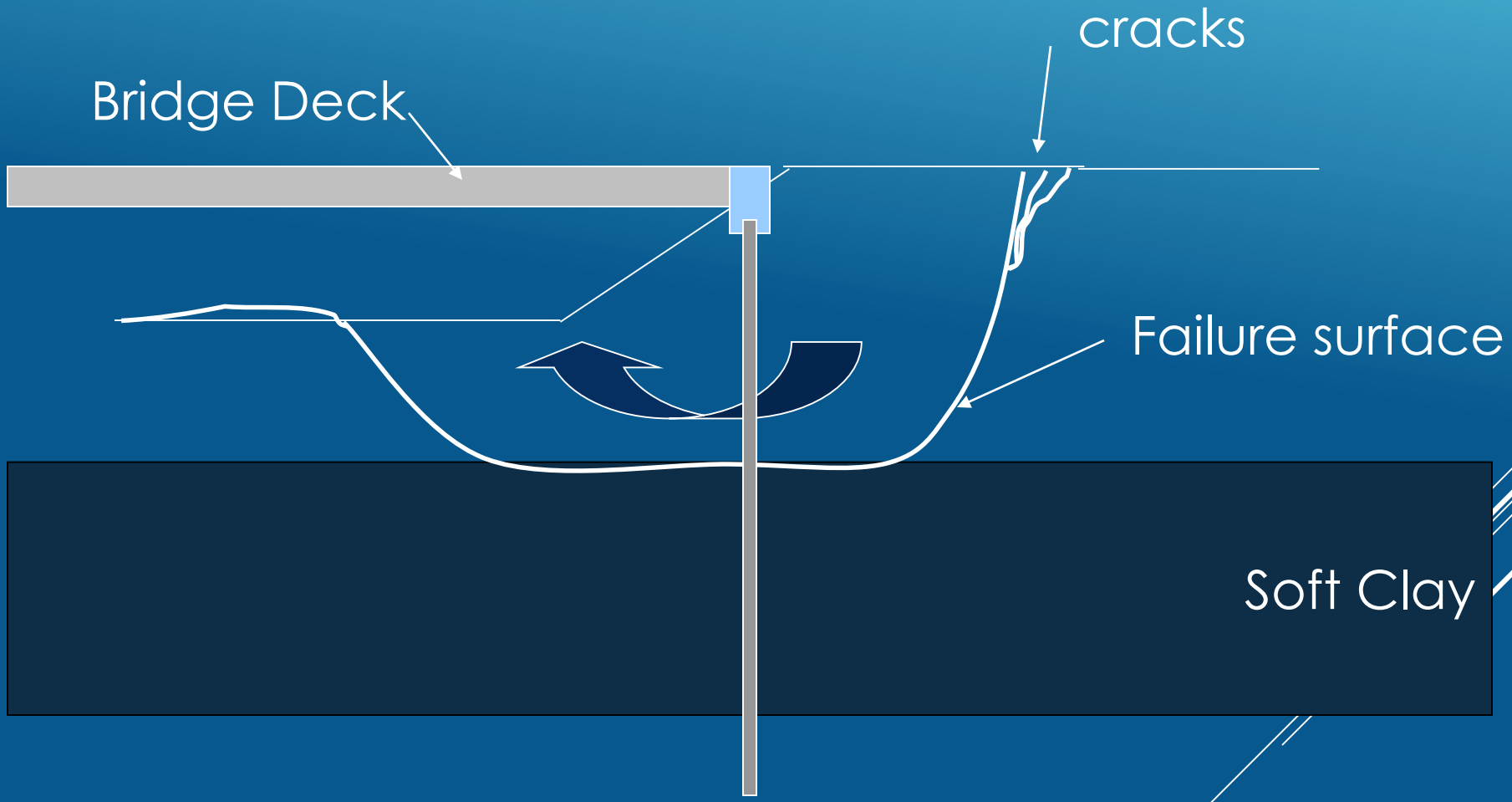


Schematic drawing of geofoam used to construct bridge abutment

BRIDGE ABUTMENTS AND UNDER FILL

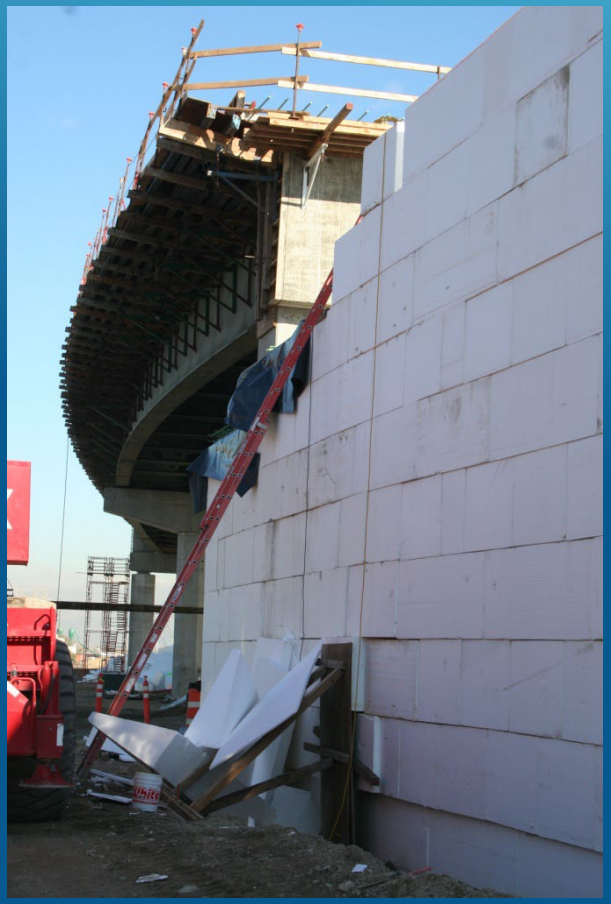


BRIDGE ABUTMENTS AND UNDER FILL IMPROVE EMBANKMENT STABILITY



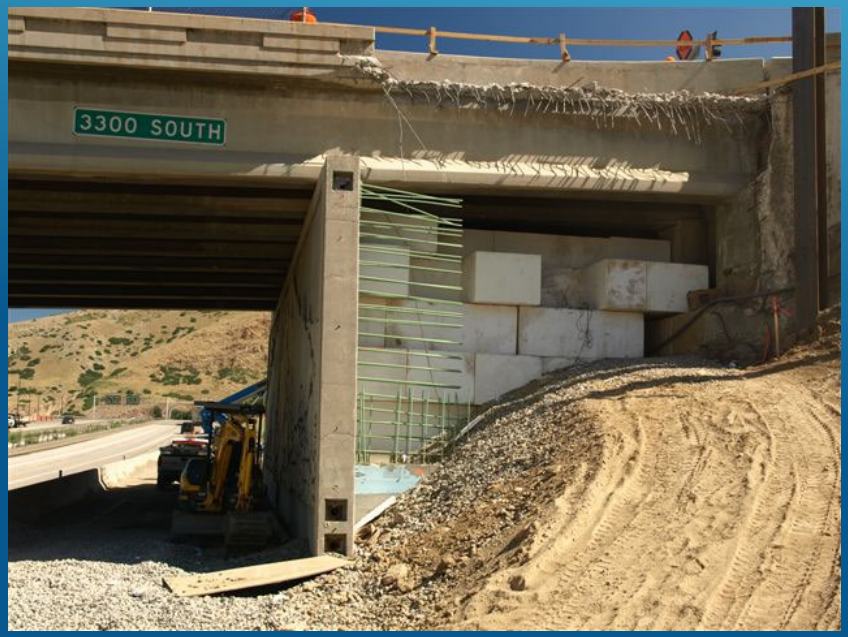
BRIDGE ABUTMENTS AND UNDER FILL

I-15 Reconstruction,
Salt Lake City, Utah



Overpass, 5300 S. over
UTA TRAX
Salt Lake City, Utah

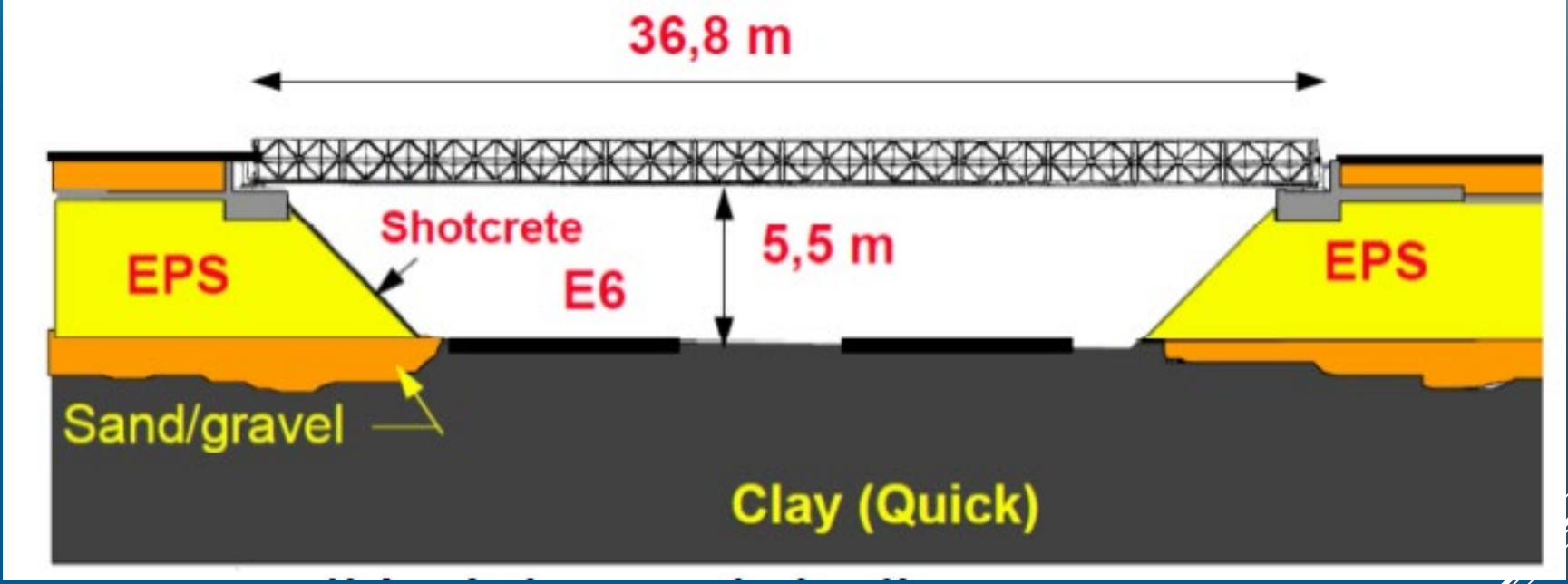
BRIDGE ABUTMENTS AND UNDER FILL



I-215 at 3300 South,
Salt Lake City, Utah

Tunnel Infill, Tucker Blvd.,
St. Louis, Missouri

ACCELERATED BRIDGE CONSTRUCTION (ABC)

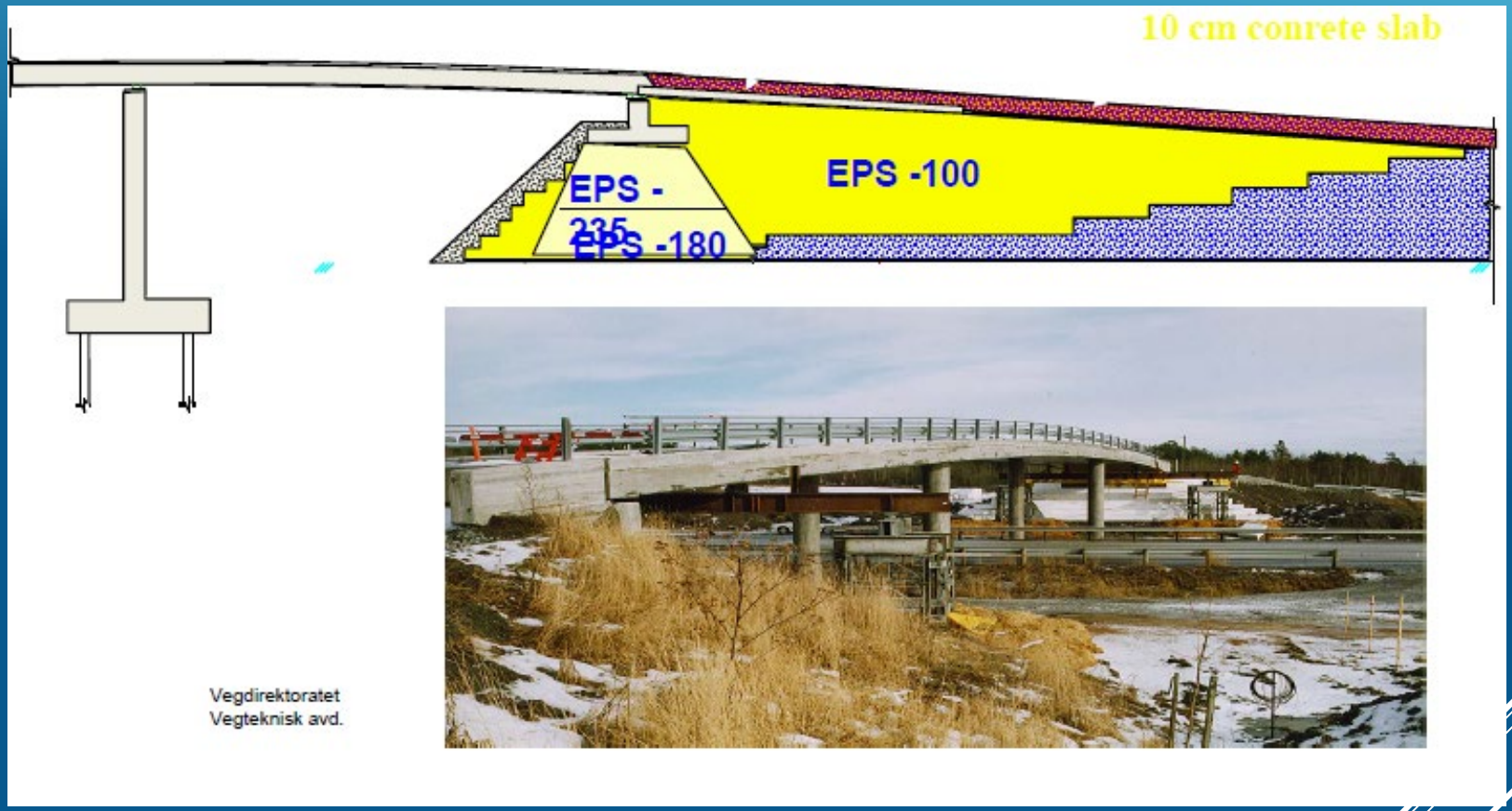


Lokkeberg Bridge, Norway

ACCELERATED BRIDGE CONSTRUCTION

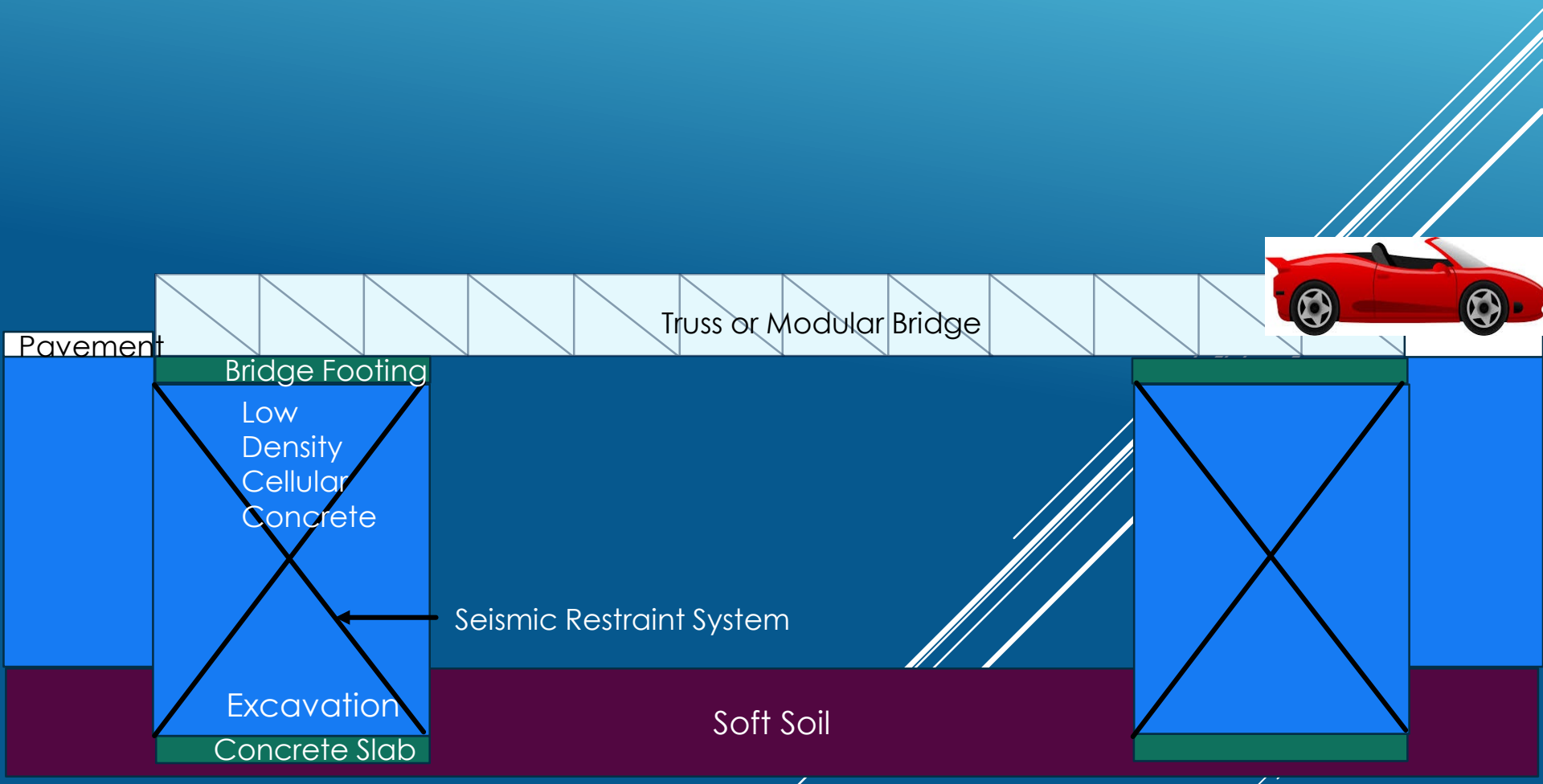
Lokkeberg Bridge,
Norway

ACCELERATED BRIDGE REPAIR



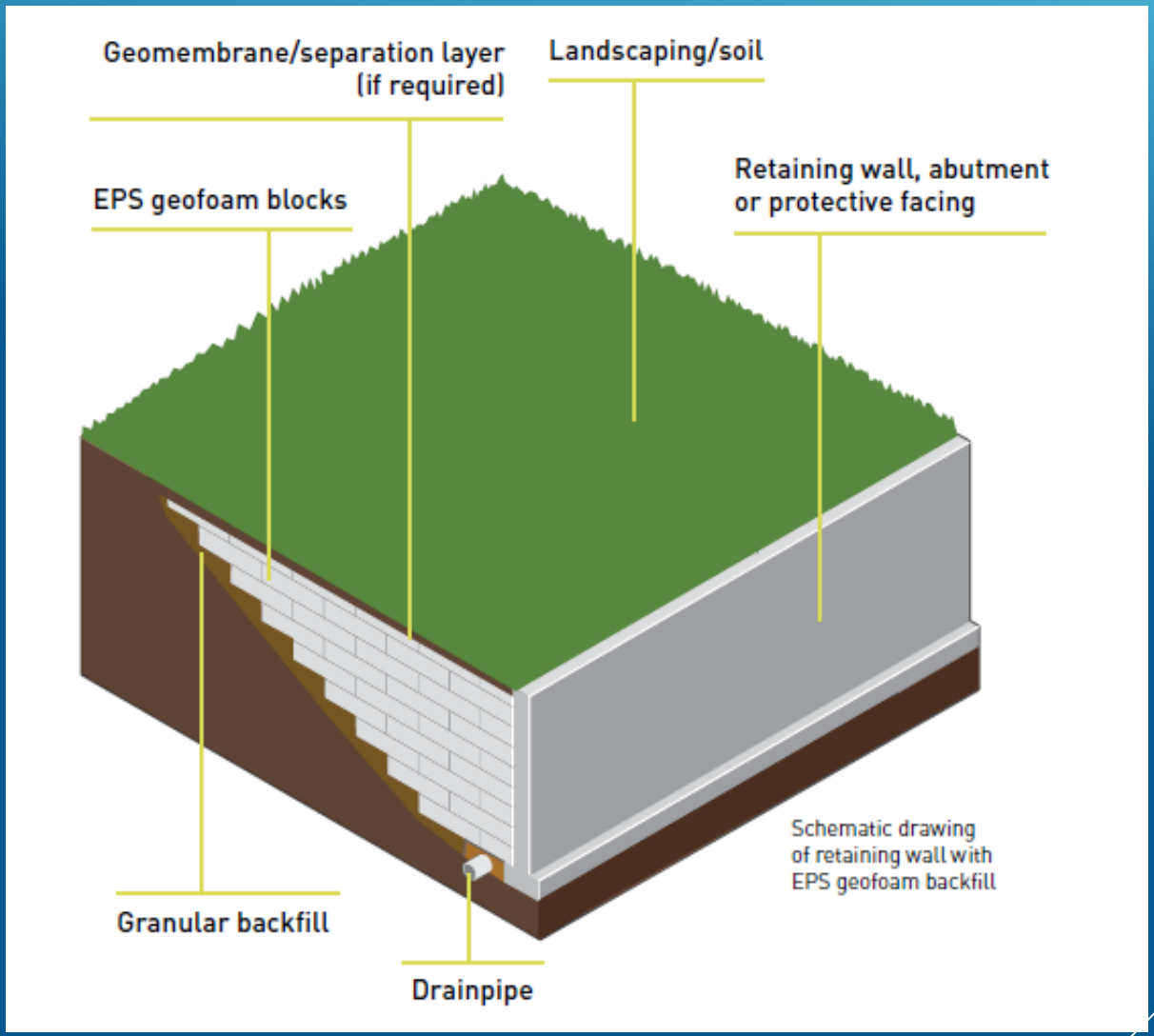
Hjelmungen Bridge, Norway

ACCELERATION BRIDGE CONSTRUCTION WITH LOW DENSITY CELLULAR CONCRETE



IMAGINE THE UNIVERSITY OF UTAH

RETAINING AND BURIED WALL BACKFILL



RETAINING AND BURIED WALL BACKFILL

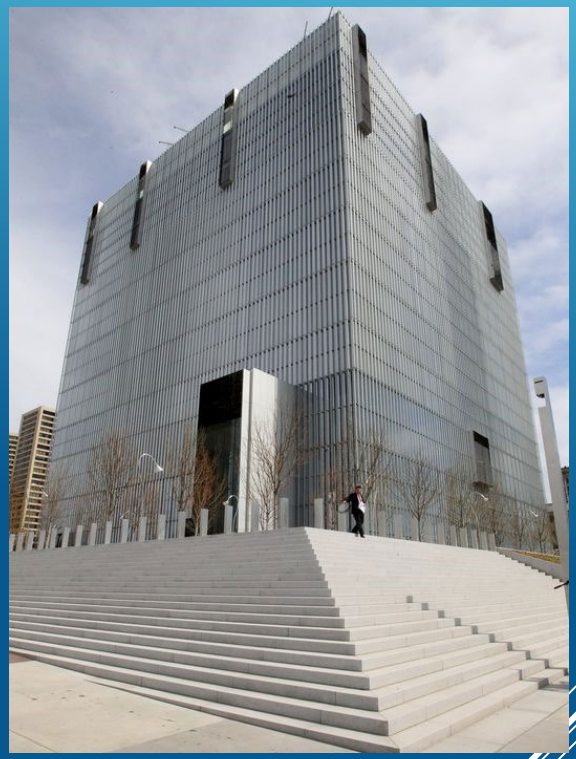
Federal Courthouse – Salt Lake City

IHC Hospital – Murray, Ut

Casino/Hotel – Reidoso, NM

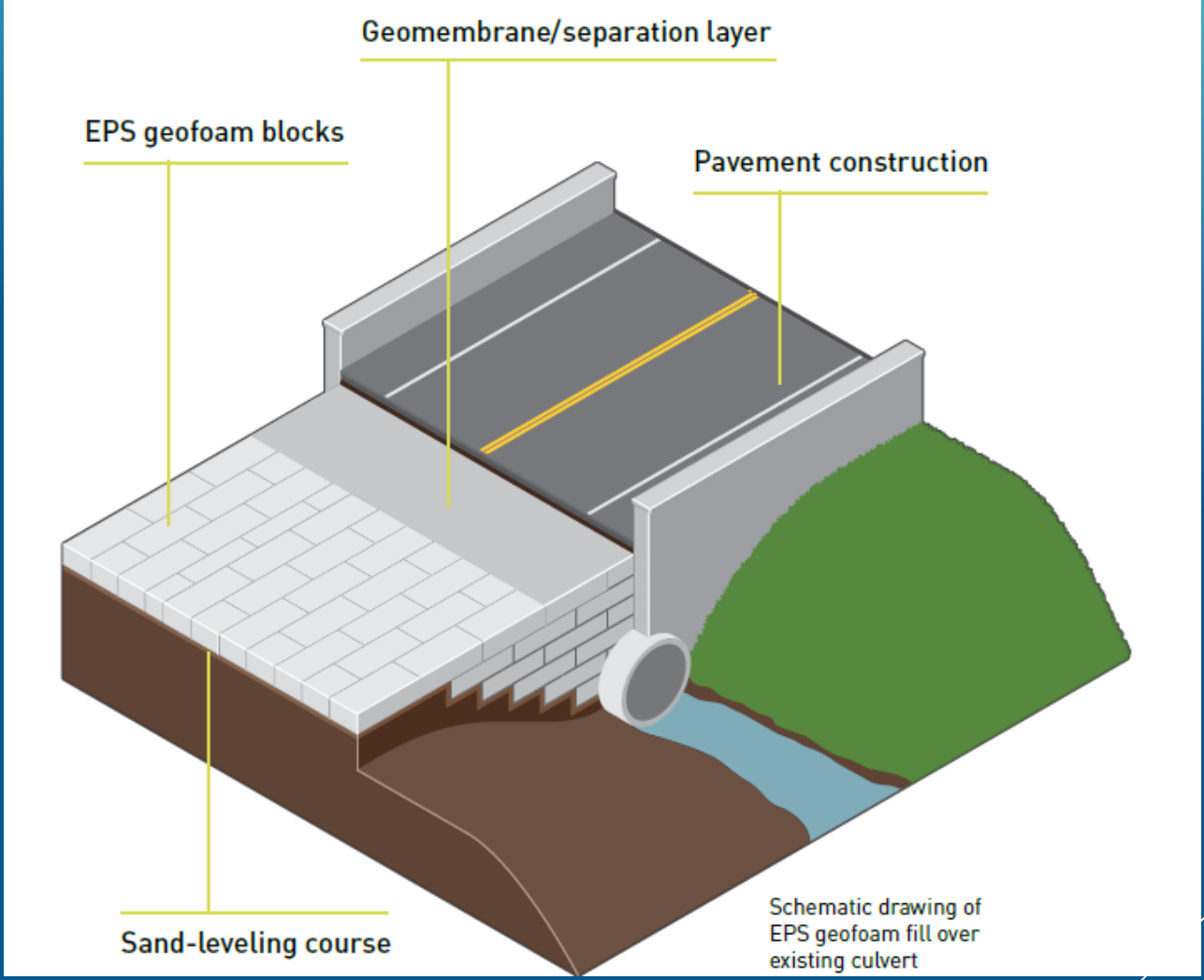
IMAGINE THE UNIVERSITY OF UTAH

U.S. FEDERAL COURTHOUSE, SALT LAKE CITY, UTAH



http://www.asce.org/magazine/20140527-courthouse-takes-form-of-contemporary-cube/

CULVERTS, PIPELINES AND BURIED STRUCTURES

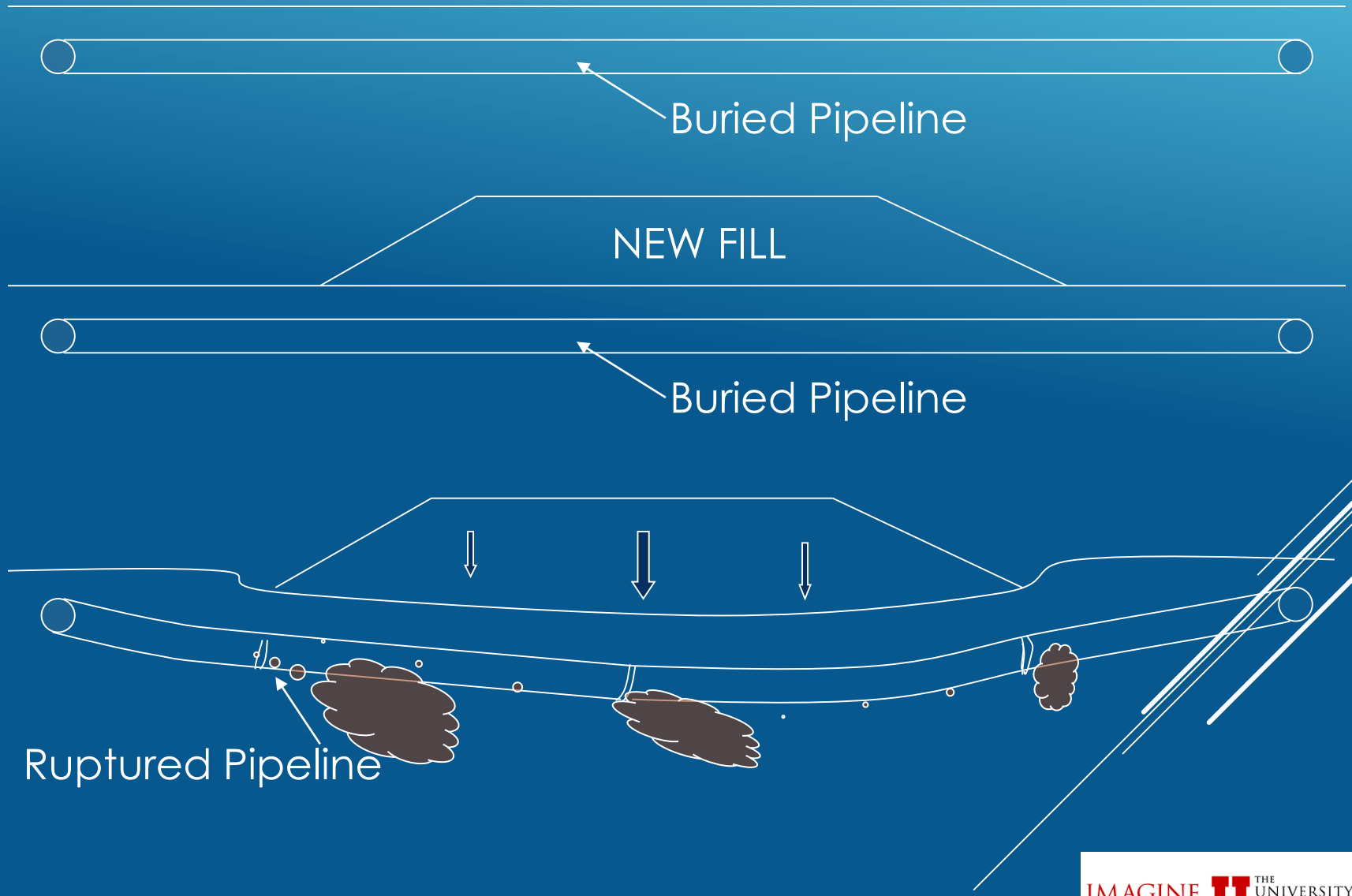


CULVERTS, PIPELINES AND BURIED STRUCTURES

UTA Commuter Rail Widening Over Existing Culvert, Corner Canyon, Draper, Utah

Unknown location

CULVERTS, PIPELINES AND BURIED STRUCTURES



WASATCH FAULT AT LITTLE COTTONWOOD CANYON

NORMAL FAULT OFFSET – TYPICAL EXAMPLES

CULVERTS, PIPELINES AND BURIED STRUCTURES

Fire from rupture of high pressure gas line, North Ridge California Earthquake

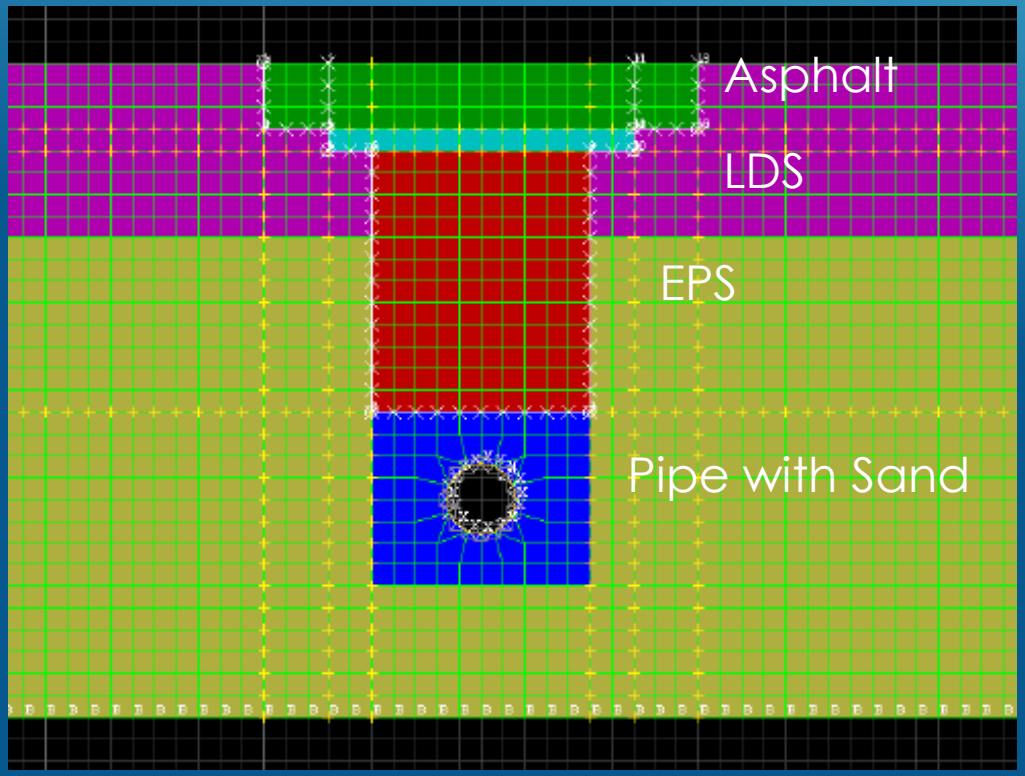
Culverts, pipelines and buried structures

Alaskan Pipeline – Strike Slip Fault

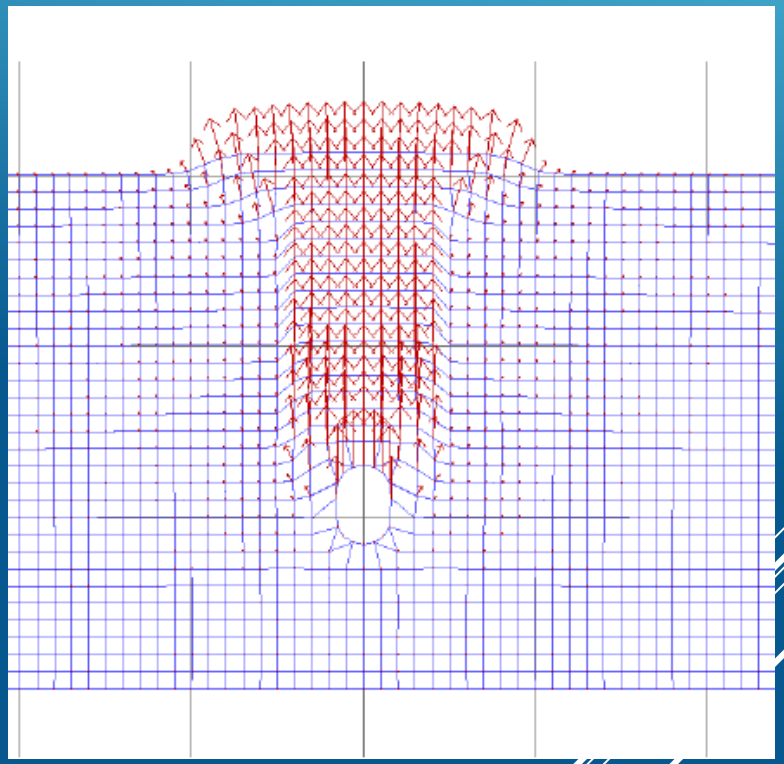
Alaskan Pipeline – Normal Fault

PIPELINES (LIGHT-WEIGHT COVER OVER FAULTS)

CULVERTS, PIPELINES AND BURIED STRUCTURES
PIPELINES (LIGHT-WEIGHT COVER OVER FAULTS)

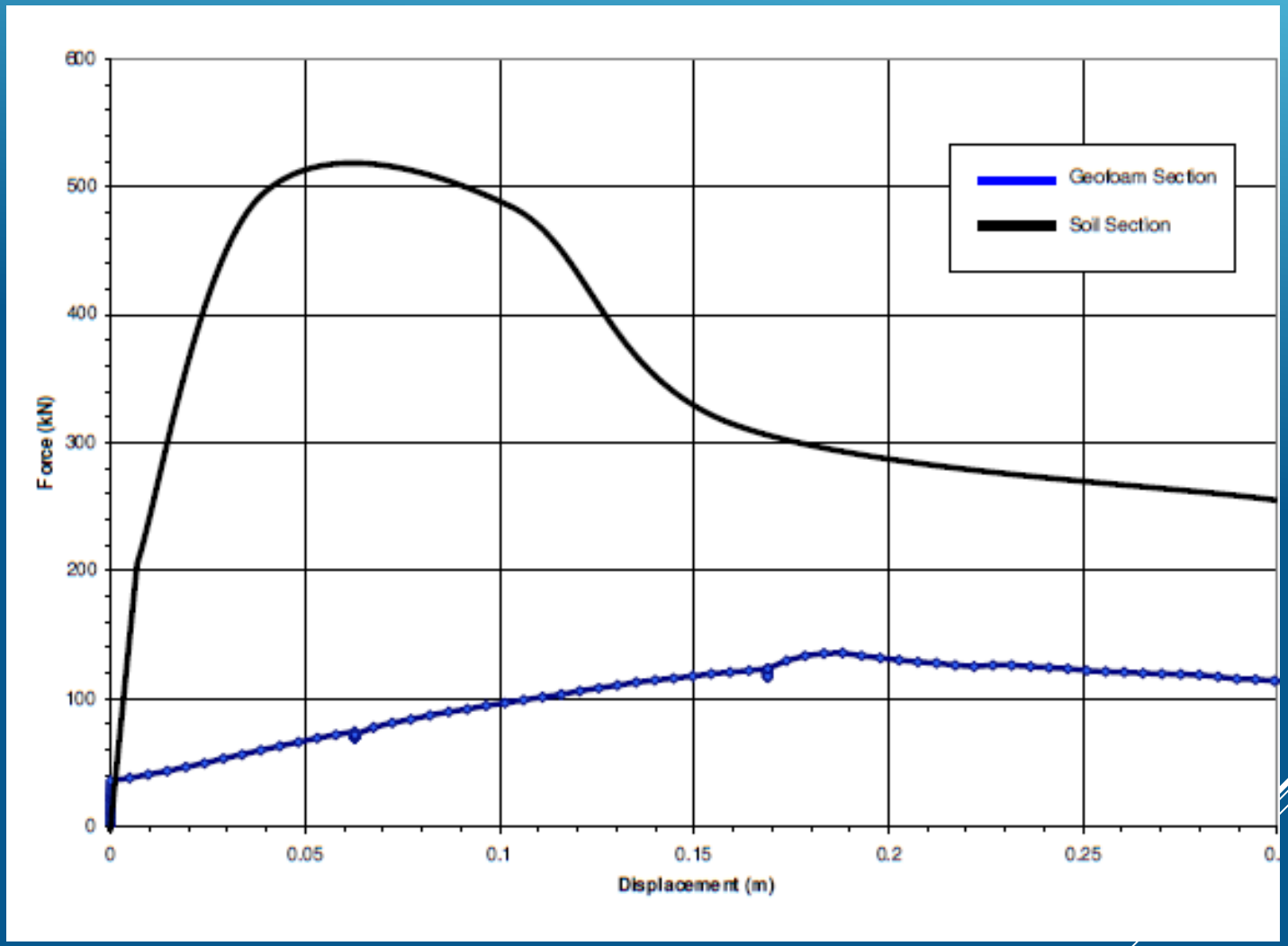


Lightweight-Cover System



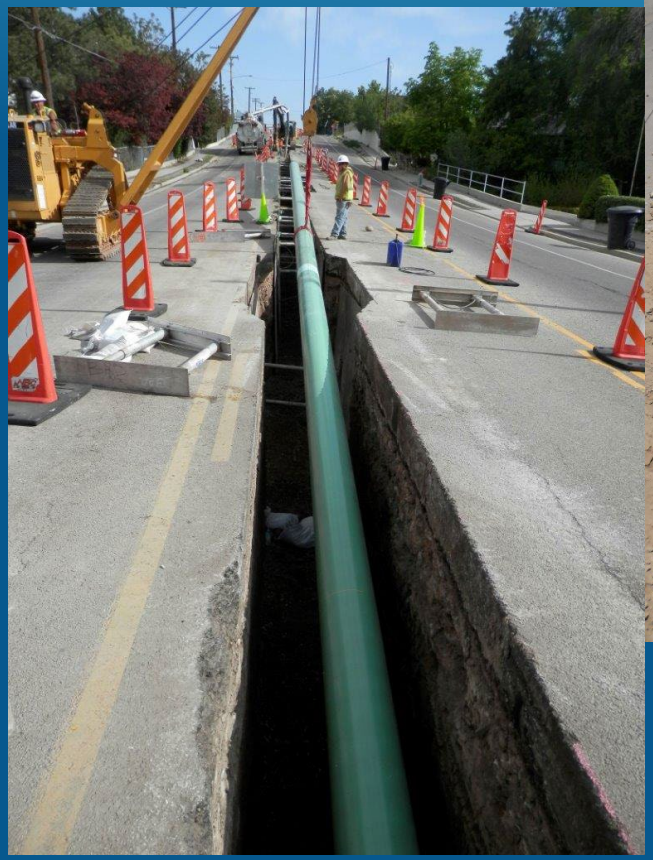
Predicted Displacement Vectors During Failure

CULVERTS, PIPELINES AND BURIED STRUCTURES



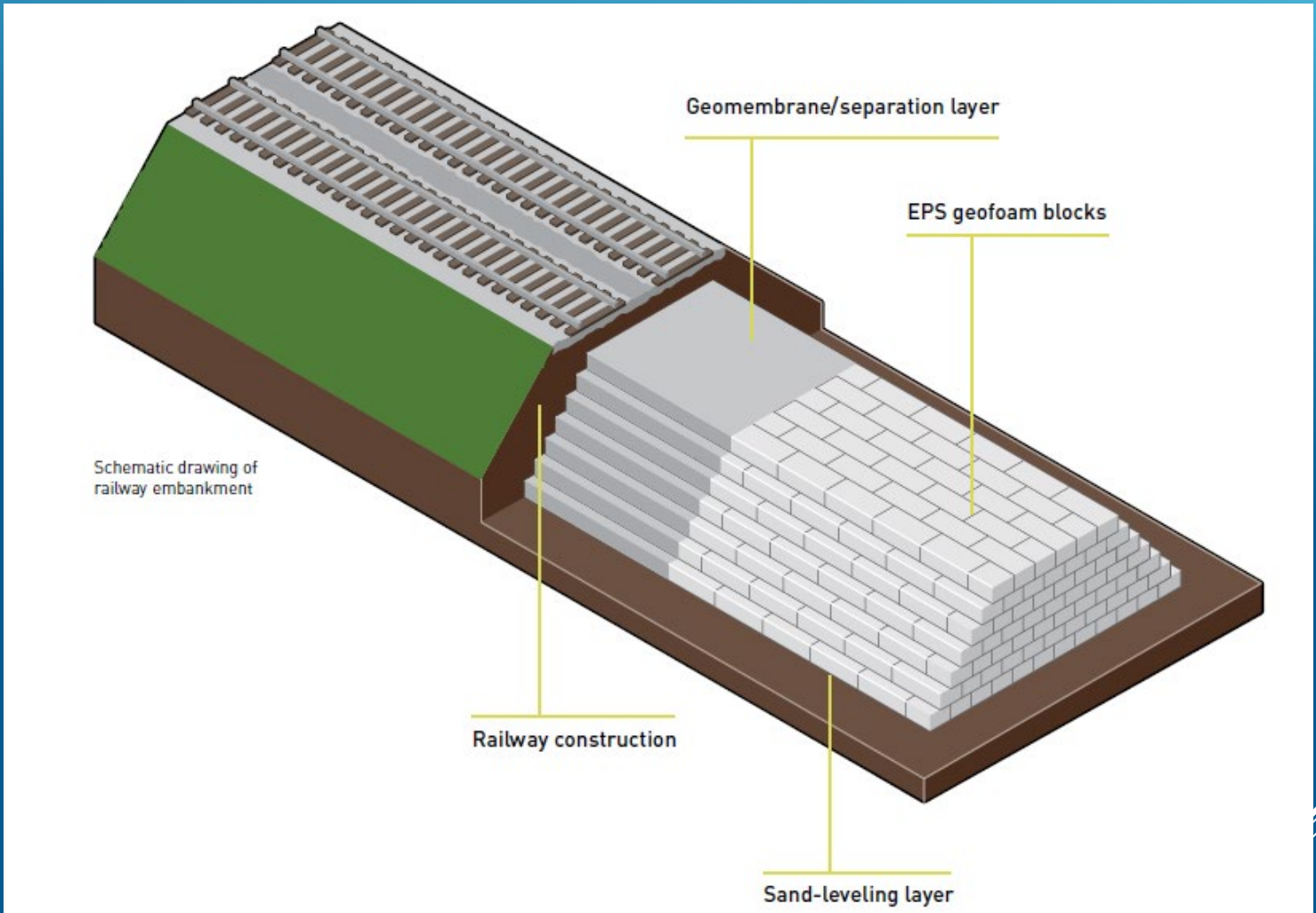
Force – Displacement Relation

CULVERTS, PIPELINES AND BURIED STRUCTURES

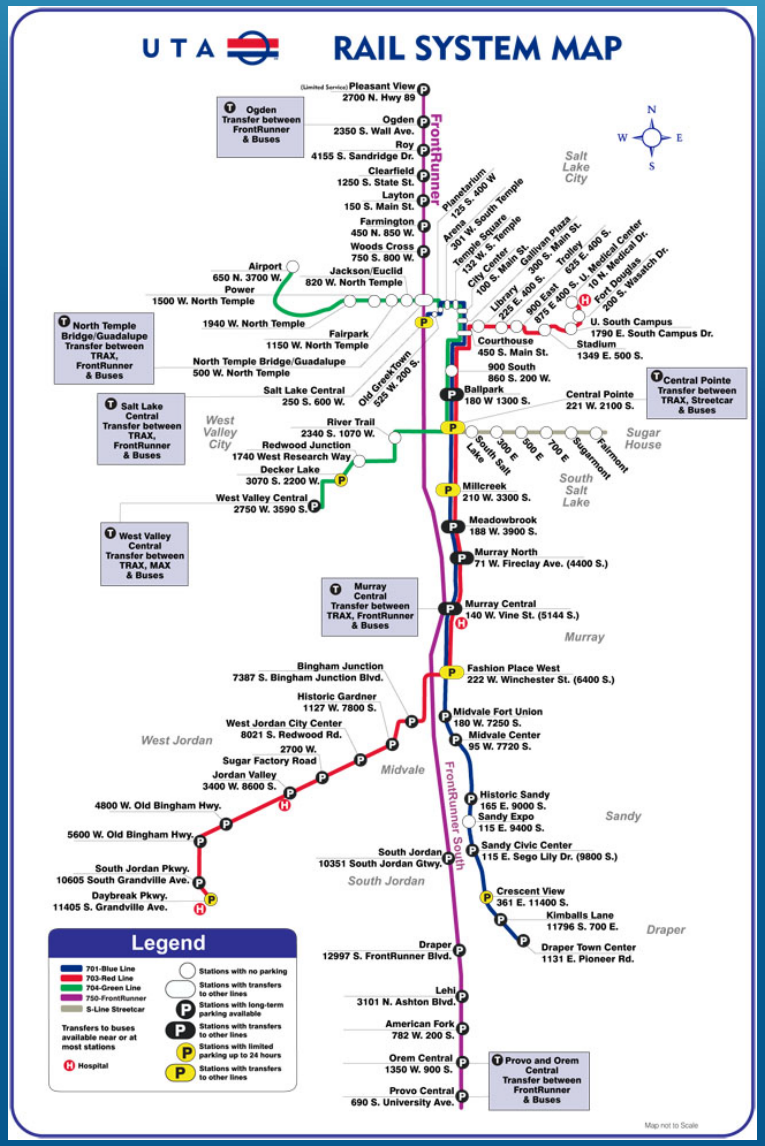


Questar Gas – Salt Lake City

RAIL EMBANKMENTS



UTAH TRANSIT AUTHORITY SYSTEM



Light rail system - TRAX

Commuter Rail system
- Frontrunner

IMAGINE THE UNIVERSITY OF UTAH®

LIGHT RAIL EMBANKMENTS

UTA –Light Rail – Salt Lake City, Utah

IMAGINE THE UNIVERSITY OF UTAH®

LIGHT RAIL EMBANKMENTS

UTA –Light Rail – Salt Lake City, Utah

LIGHT RAIL EMBANKMENTS

UTA –Light Rail – Salt Lake City, Utah

COMMUTER RAIL EMBANKMENTS

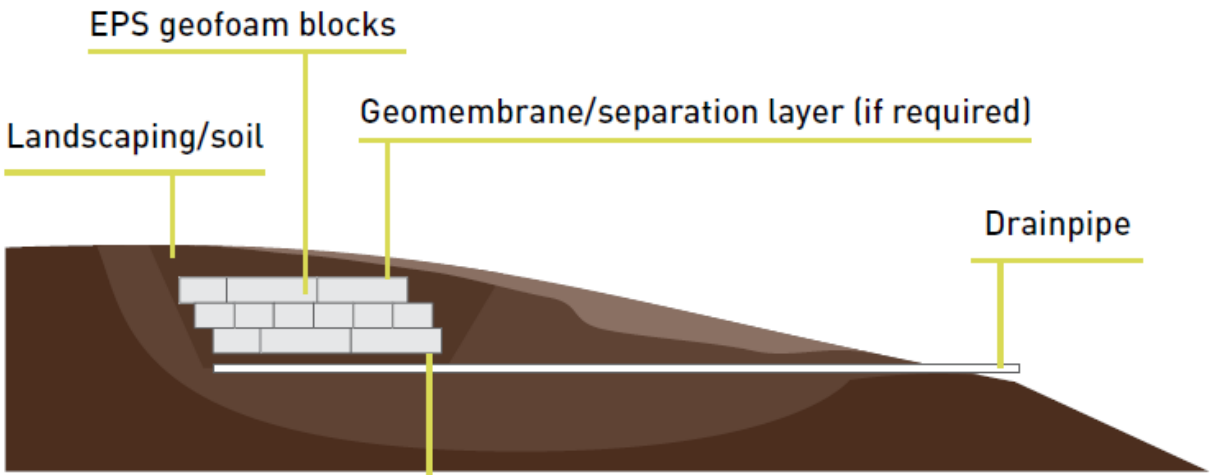
Front Runner – UTA – Corner Canyon – Draper Utah

IMAGINE THE UNIVERSITY OF UTAH®

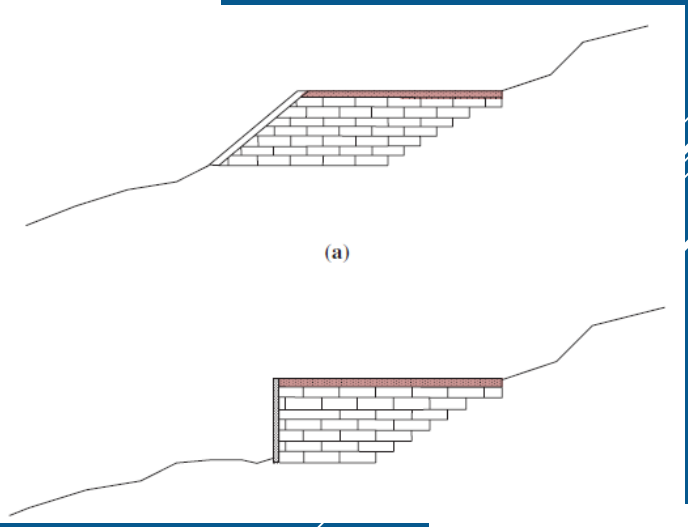
Field Testing and Monitoring

Deflection Monitoring for Rail Systems

SLOPE STABILIZATION



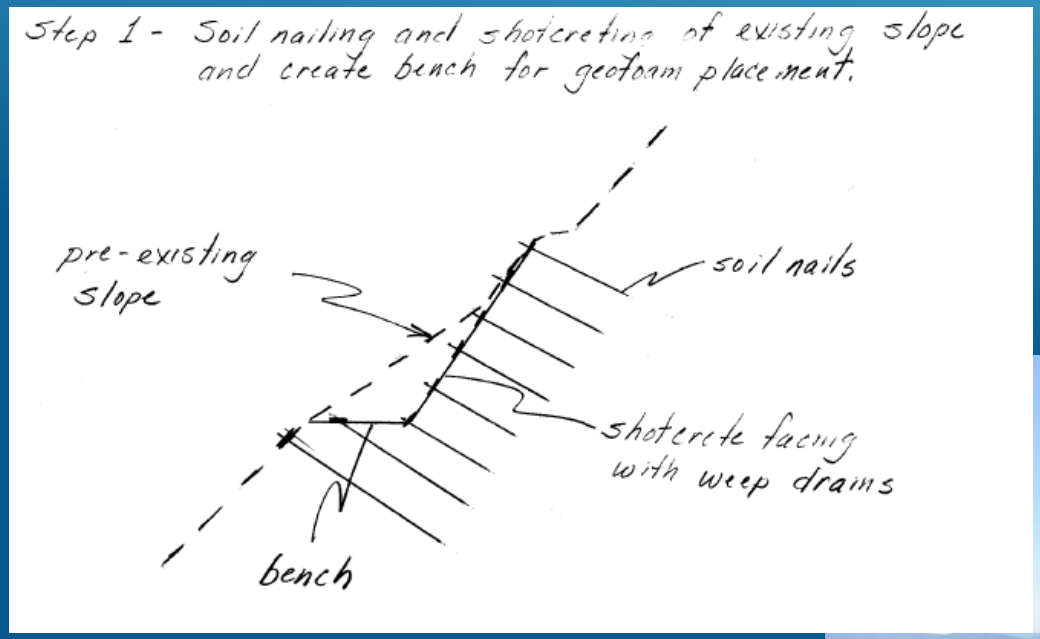
Schematic drawing of EPS geofoam placement in a slide area



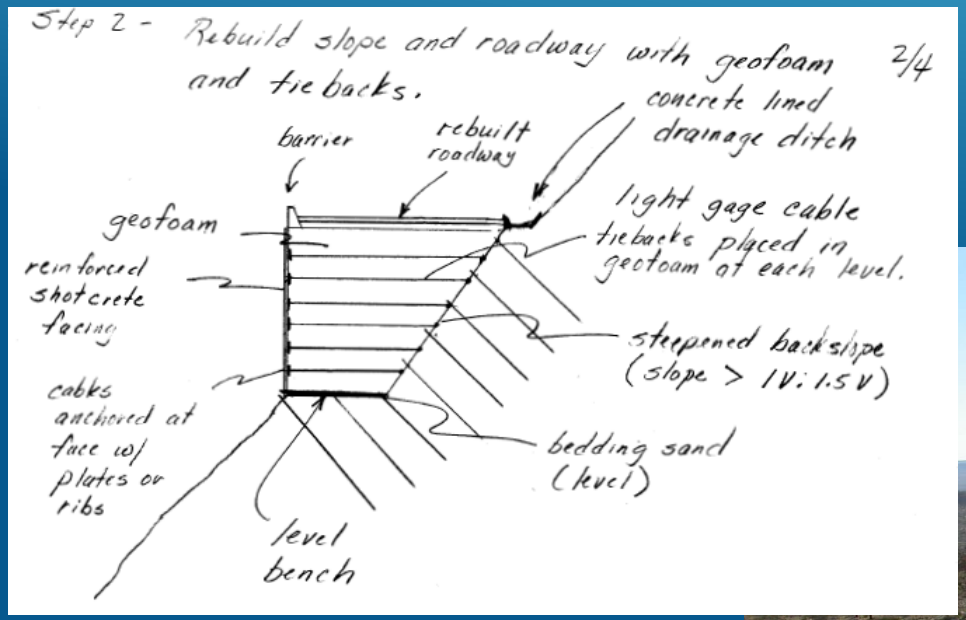
SLOPE REMEDIATION AND ROADWAY WIDENING – 2ND MESA ARIZONA

IMAGINE THE UNIVERSITY OF UTAH®

SOIL NAIL STABILIZATION OF SLOPE

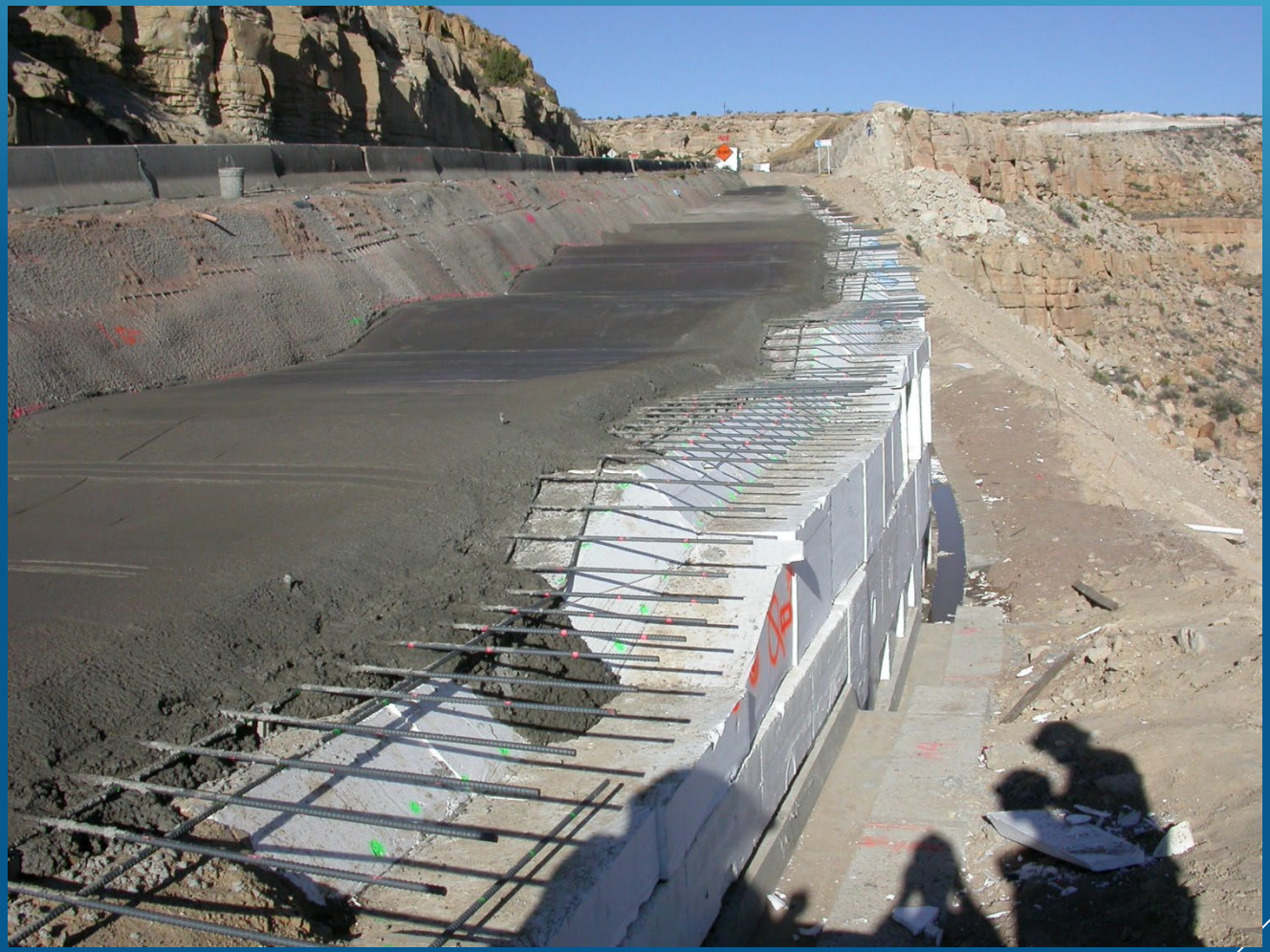


PLACEMENT OF EPS



IMAGINE THE UNIVERSITY OF UTAH®

CONSTRUCTION OF LOAD DISTRIBUTION SLAB



FINISHED ROADWAY

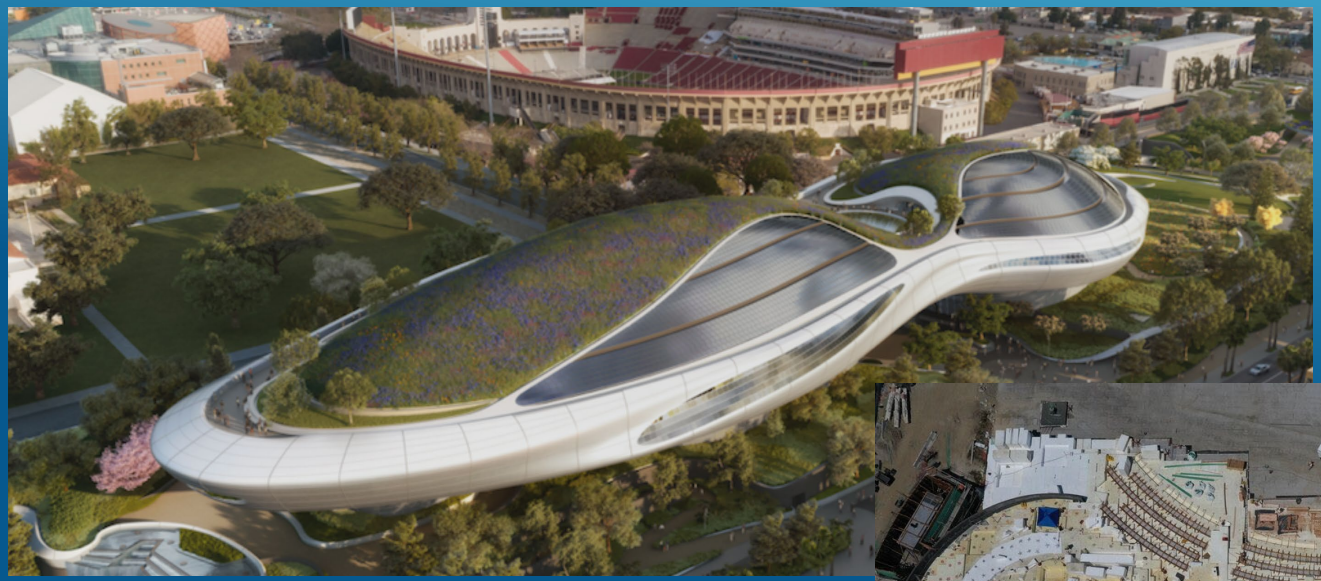
LANDSCAPING AND GREEN ROOFS

Disney Shanghai

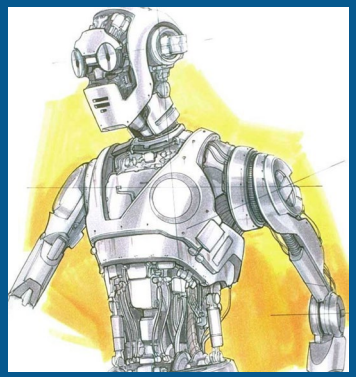
Example terraces (Not from Disney Project)

IMAGINE THE UNIVERSITY OF UTAH

LANDSCAPING AND GREEN ROOFS



Conceptual View of
Lucas Museum, UCLA, California



Green Roof Example,
Not from Lucas Museum

AWARDS

ASCE 2002 Outstanding Civil Engineering Achievement (OPAL) Award, Wasatch Constructors I-15 Reconstruction Design-Build Team, Salt Lake City, Utah

ACEC Arizona 2006 Grand Award, Rockfall Containment and Safety, SR 264 at 2nd Mesa, Arizona

ASCE 2010 Local Outstanding Civil Engineering Achievement Awards, Geotechnical Category – Outstanding Award SR 519 / I-90 to SR 99, Intermodal Access I/C Improvements Phase 2 Design Build Project Seattle, Washington

Rebuilding America's Infrastructure Magazine 2012,
Best of America's Infrastructure – Cost Saving Approaches,
Geofoam Embankments, UTA TRAX line, Salt Lake, City, Utah