Use of EPS Geofoam in Transportation Systems

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Geofoam Research Consortium

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Resources

Expanded Polystyrene (EPS)
Geofoam Applications
& Technical Data

The EPS Industry Alliance
1298 Cronson Boulevard
Suite 201
Crofton, MD 21114
800.607.3772
info@epscentral.org
www.epsmolders.org

Authors: Stark, Bartlett and Arellano, 2012

www.civil.utah.edu\~bartlett\geofoam

Topics

- EPS Properties
- Design and Construction Considerations
- Applications for Transportation Projects
- Performance Monitoring

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EPS Manufacturing

raw styrene beads

steam expanded (1st steam heating)

block molding (2nd steam heating)

block placement

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Summary of EPS Geofoam Properties

Physical Properties of Foam-Control EPS Geofoam[1,2]								
TYPE - ASTM D6817		EPS12	EPS15	EPS19	EPS22	EPS29	EPS39	EPS46
Density, min.	lb/ft^3 (kg/m^3)	0.70 (11.2)	0.90 (14.4)	1.15 (18.4)	1.35 (21.6)	1.80 (28.8)	2.40 (38.4)	2.85 (45.7)
Compressive resistance @ 1% deformation, min.	psi psf (kPa)	2.2 320 (15)	3.6 520 (25)	5.8 840 (40)	7.3 1050 (50)	10.9 1570 (75)	15.0 2160 (103)	18.6 2680 (128)
Elastic Modulus	psi (kPa)	220 (1500)	360 (2500)	580 (4000)	730 (5000)	1090 (7500)	1500 (10300)	1860 (12800)
Flexural Strength min.	psi (kPa)	10.0 (69)	25.0 (172)	30.0 (207)	35.0 (240)	50.0 (345)	60.0 (414)	75.0 (517)
Water Absorption by total immersion, max.,	volume %	4.0	4.0	3.0	3.0	2.0	2.0	2.0
Oxygen Index, min.,	volume %	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Buoyancy Force	lb/ft^3 (kg/m^3)	61.7 (990)	61.5 (980)	61.3 (980)	61.1 (980)	60.6 (970)	60.0 (960)	59.5 (950)

Source: ASTM D6817

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Expanded-Polystyrene Block Geofoam

- Typical Block dimensions
  - 0.6 x 1.2 x 2.4 m
  - 0.8 x 1.2 x 4.9 m
- Density/unit weight
  16 to 45.7 kg/m^3

(Legacy Highway Project, Utah Dept. of Transportation)

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Topics

- EPS Properties
- Design and Construction Considerations
- Applications for Transportation Projects
- Performance Monitoring

Material, Design and Construction Considerations

- Material
  - Density
  - Compressive Resistance (Modulus)
  - Insect Control Additive
  - Flame Resistance Additive
  - Moisture Absorption
- Design
  - Concentrated Loads
  - Seismic Loads
  - Drainage / Buoyancy
  - Protection Against Chemical Degradation
  - Settlement
  - Creep
  - Internal and External Stability
  - Bearing Capacity
  - Pavement Design
- Construction
  - Bedding Material
  - Compaction
  - Handling
  - Block Dimensions
  - Block Layout & Placement
  - Cover and UV protection
- Quality Assurance/Control
  - Specifications / Provisions
  - Testing and Sampling
  - Inspection
  - Corrective Action

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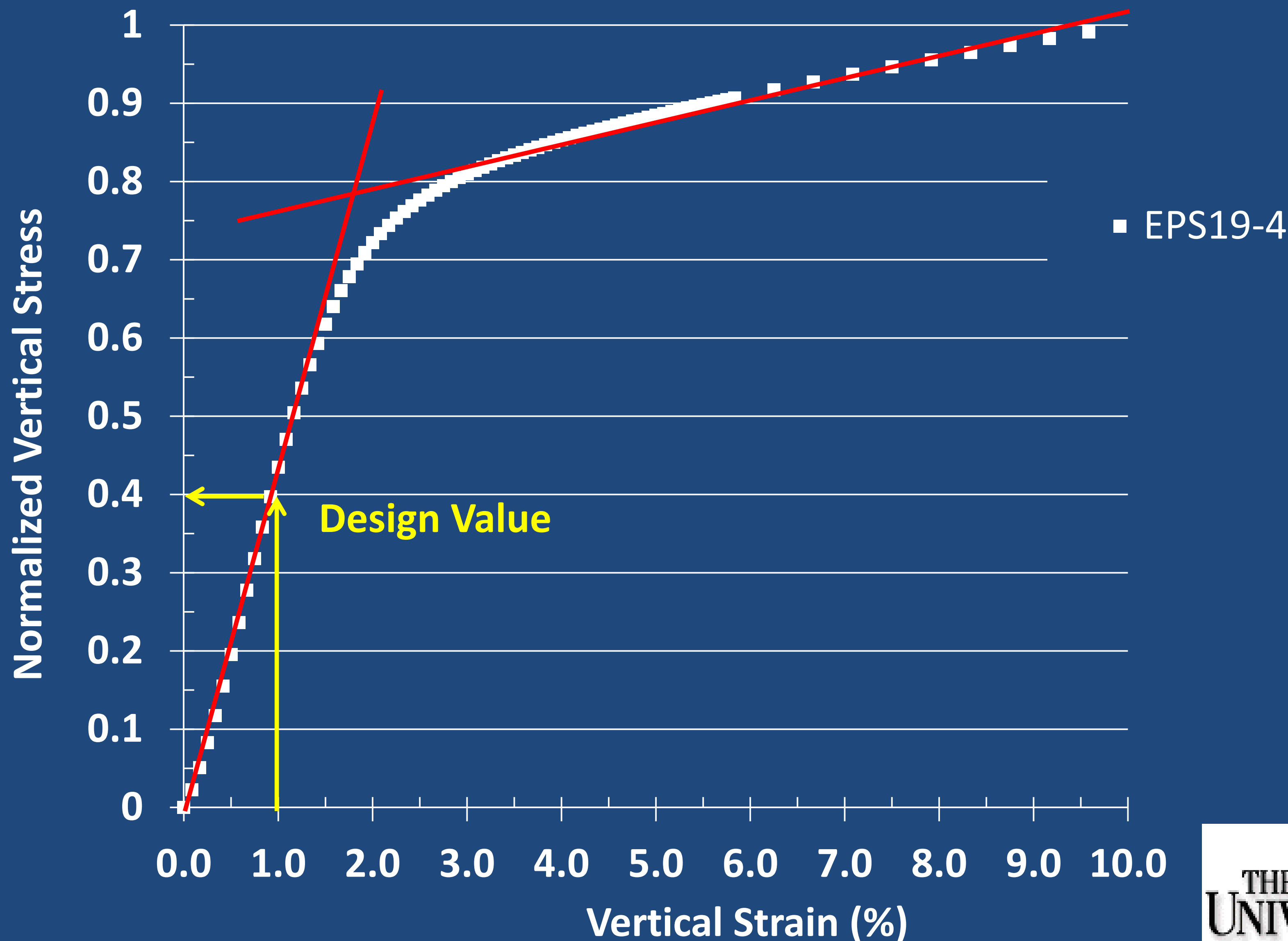
Compressive Resistance



Design Guidance for Transportation Projects

- Current Design Methods / Guidance
  - Norwegian Public Roads Administration (1987, 1992)
  - Japanese – EDO (1996, 2001)
  - Draft European Design Code (1998)
    - I-15 Reconstruction Project (1998-2001)
  - NCHRP 529 and Web Document 65 (2004)
  - European EPS White Book (2011)
  - NCHRP Project 24-11(02) Phase I Study (slopes) (2011)
  - Various Research Reports
  - Technical Papers

Available from: www.civil.utah.edu\~bartlett\geofoam

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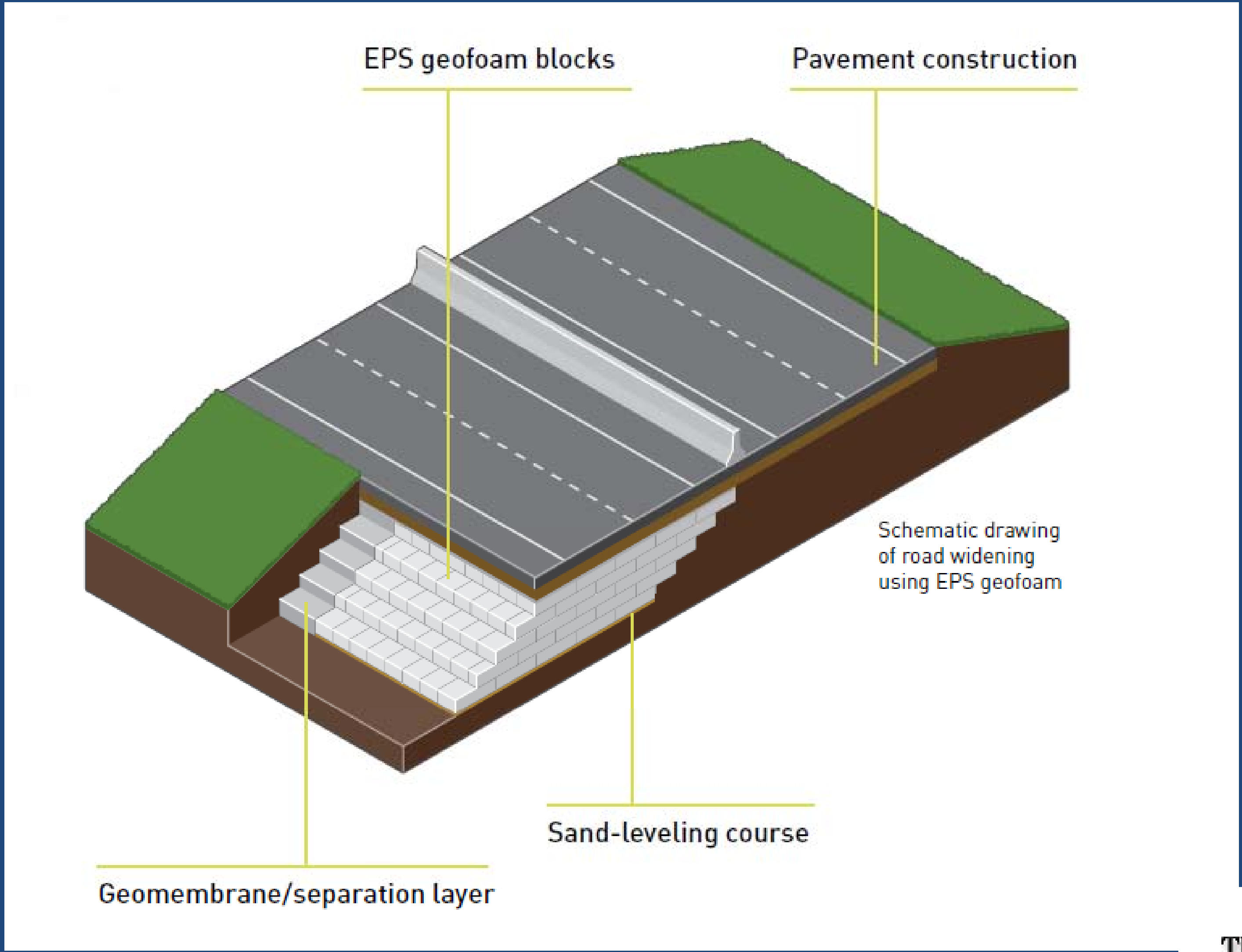
Topics

- EPS Properties
- Design and Construction Considerations
- Applications for Transportation Projects
- Performance Monitoring

Primary Uses For Transportation Projects

- Roadway widening
- Road construction over poor soils
- Bridge abutments
- Bridge underfill
- Culverts, pipelines and buried structures
- Railway embankment
- Light-weight backfill
- Slope stabilization

Roadway Widening



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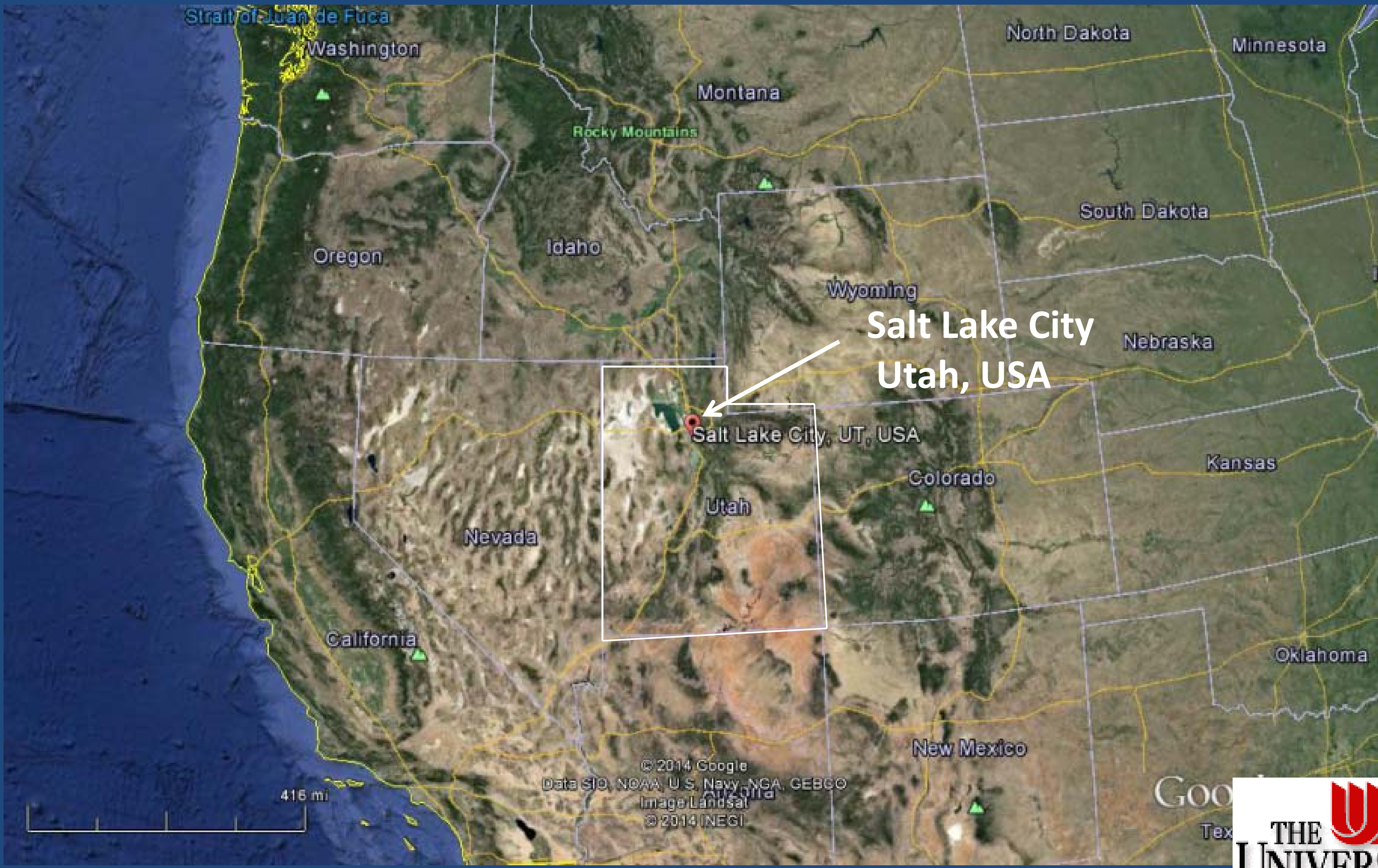
Roadway Widening (I-15 Project)



Roadway Widening (I-15 Project)

Largest geofoam project worldwide
100,000 cubic meters of geofoam

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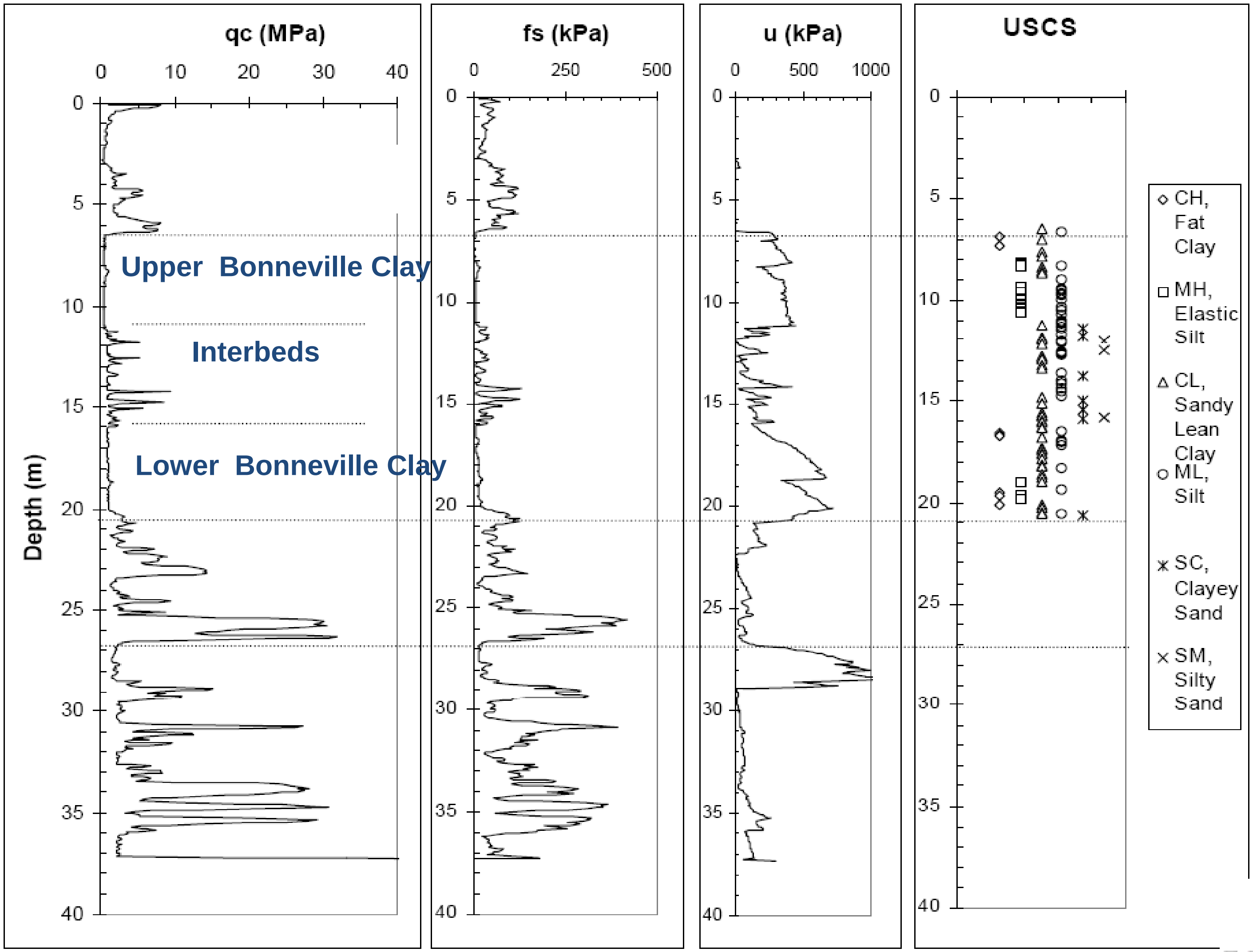
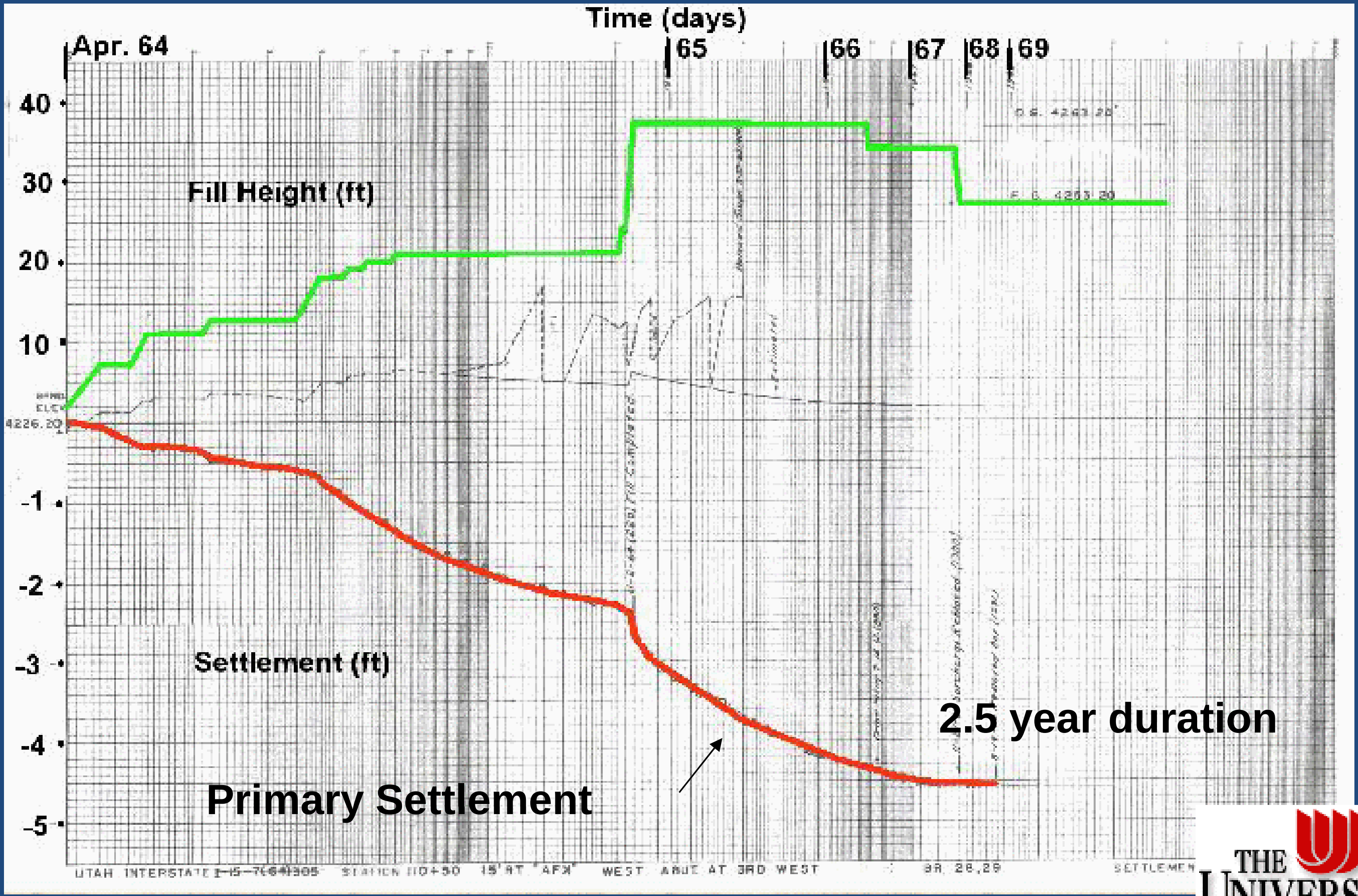
Road Widening (I-15 Project)



Subsurface Profile in Salt Lake Valley

Road Widening (I-15 Project – Settlement Record)



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Roadway Widening (I-15 Project)

Geofoam Embankment, Salt Lake City, Utah

Roadway Widening (I-15 Project)

I-15 Reconstruction Project Salt Lake City, Utah

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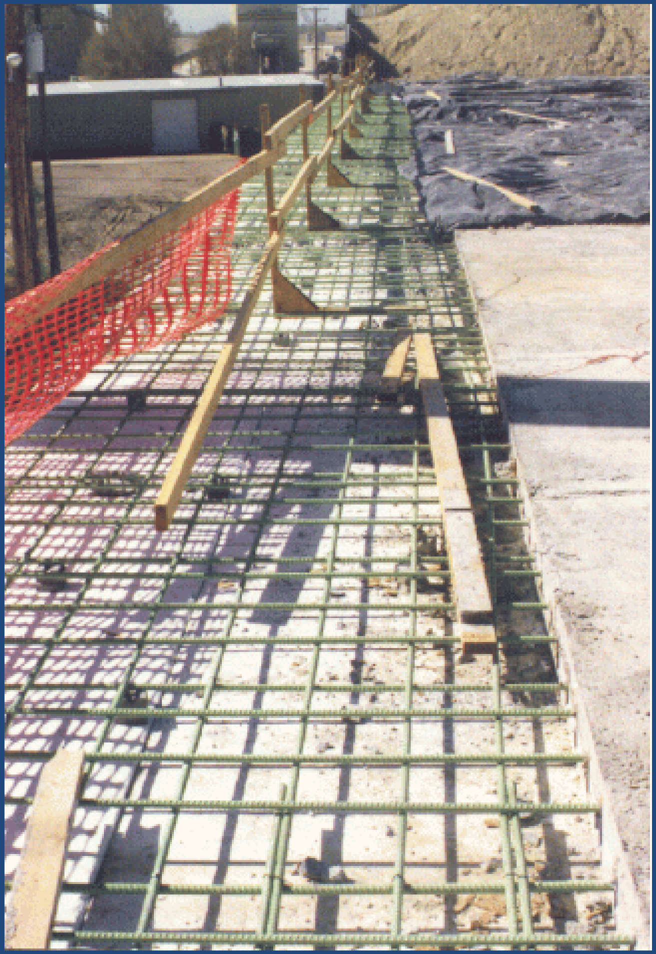
Roadway Widening (I-15 Project)



Completed Load Distribution Slab

Reinforced Concrete
Load Distribution Slab

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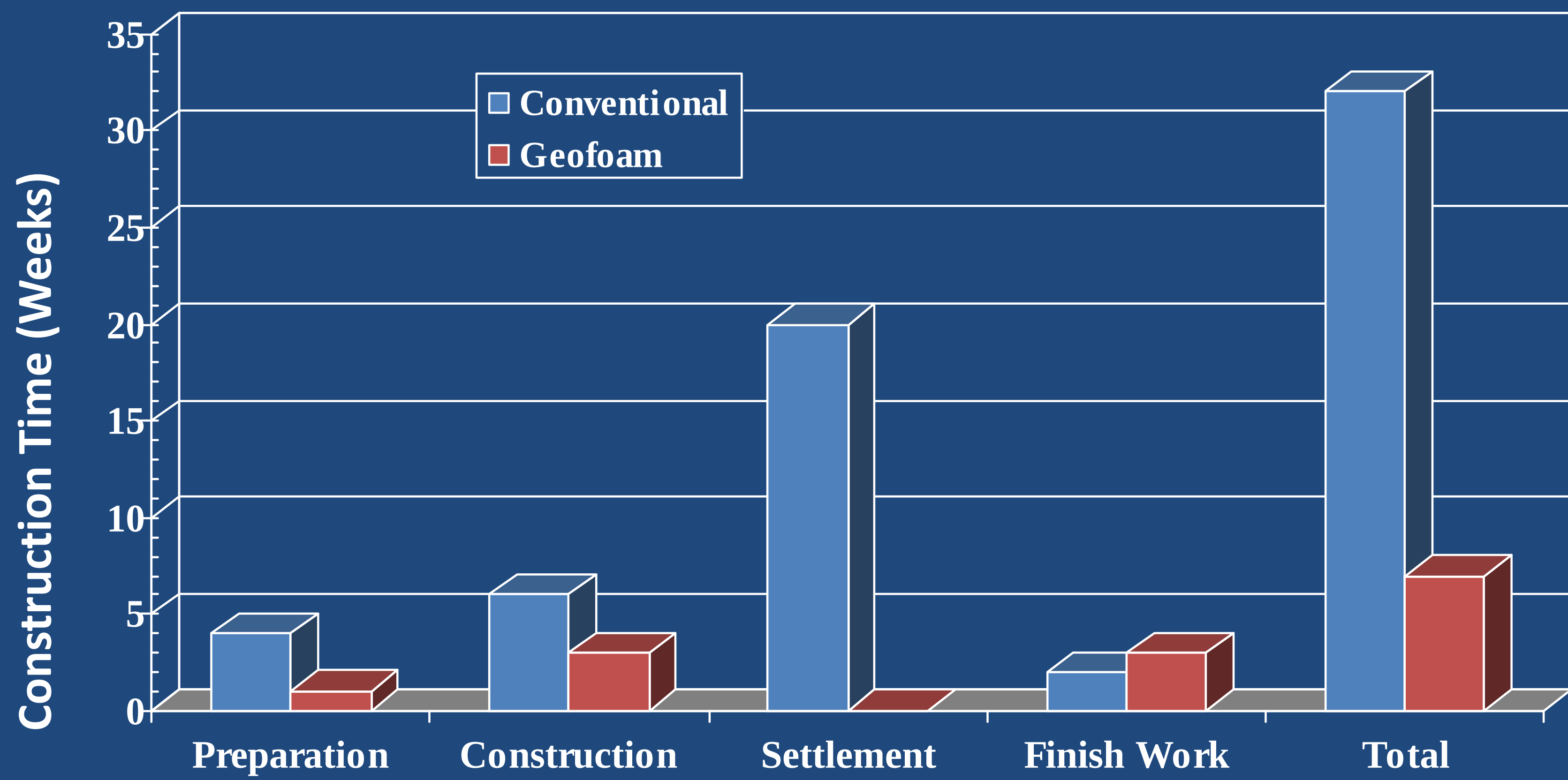
Geofoam for Rapid Construction
Comparison of Construction Times



Typical Construction Time from I-15 Project

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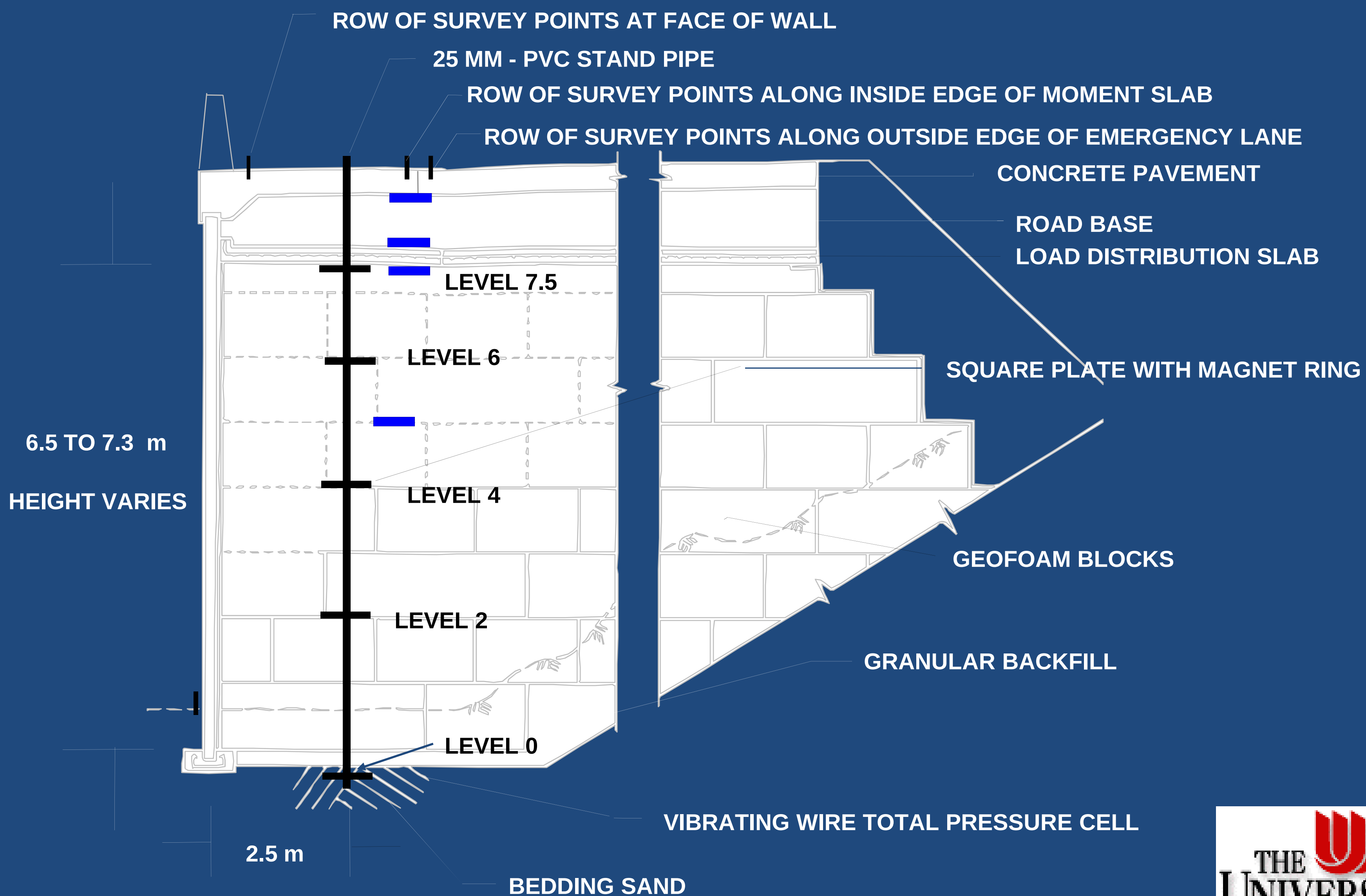
Field Testing and Monitoring



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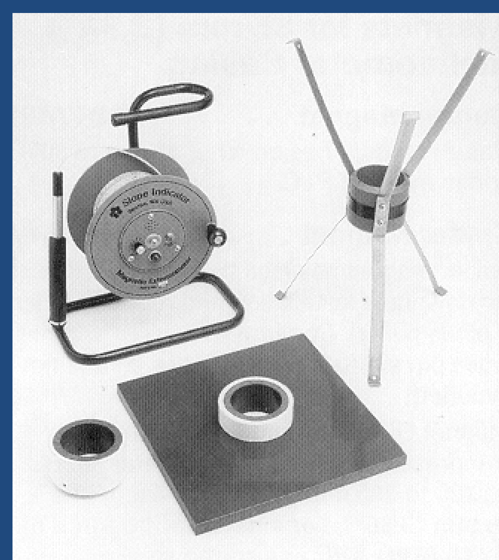
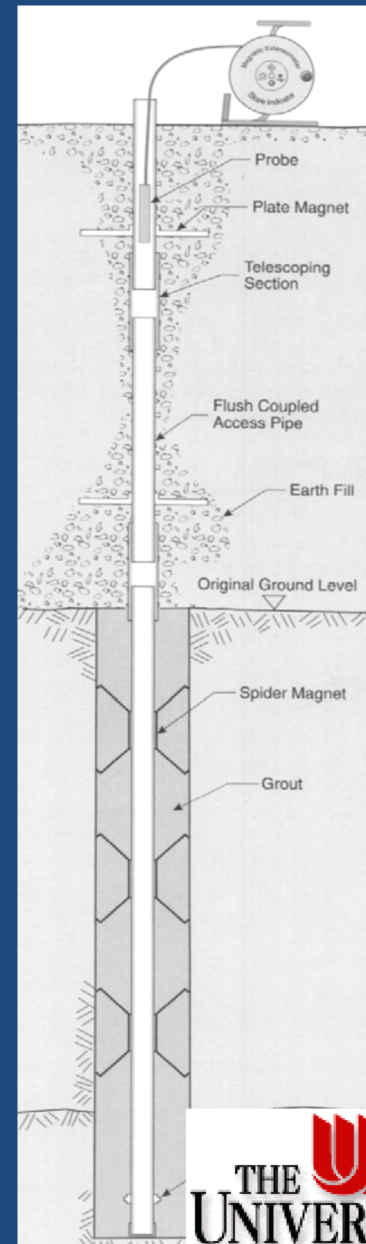
Field Testing and Monitoring

Magnet Extensometer Installation





Field Testing and Monitoring

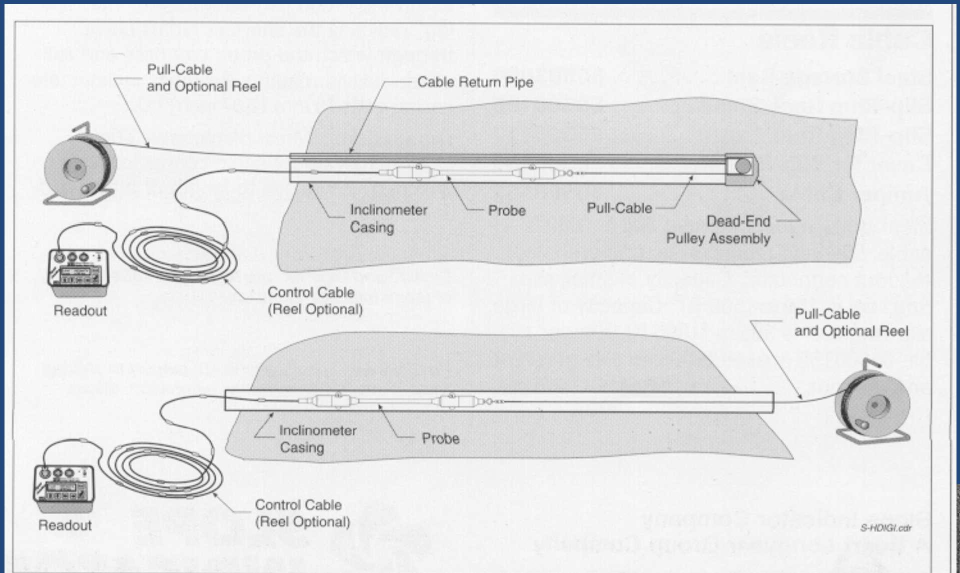
Vibrating Wire Total Pressure Cells

Hotwire Cut Slot for Pressure Cell

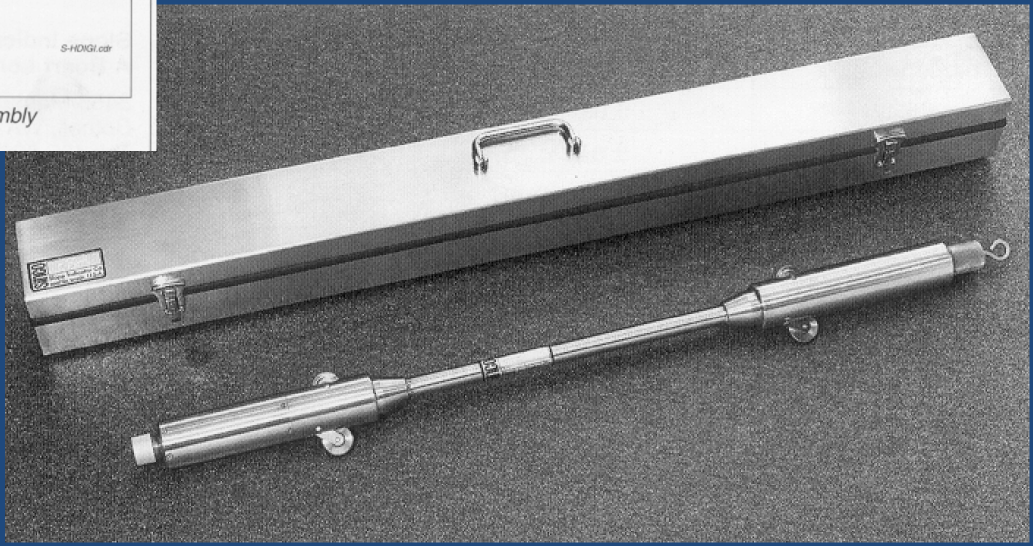
Pressure Cell Cast in Bridge Abutment

Pressure Cell in Base Sa

Field Testing and Monitoring



Horizontal Inclinometer Systems, with and without dead-end pulley assembly



Horizontal Inclinometer

UDOT GOING THE EXTRA MILE

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Ground and Pavement Surveys

UDOT GOING THE EXTRA MILE

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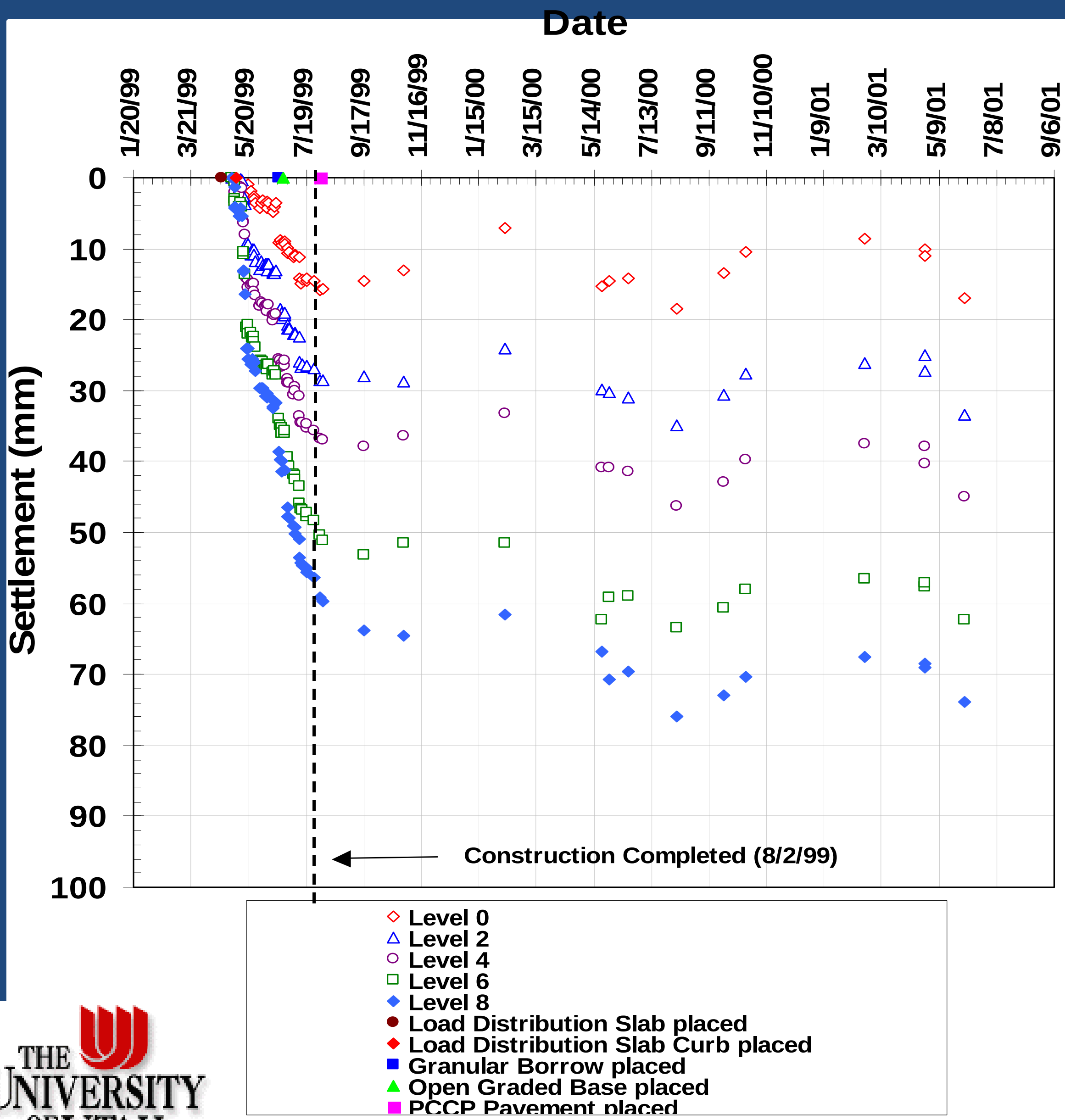
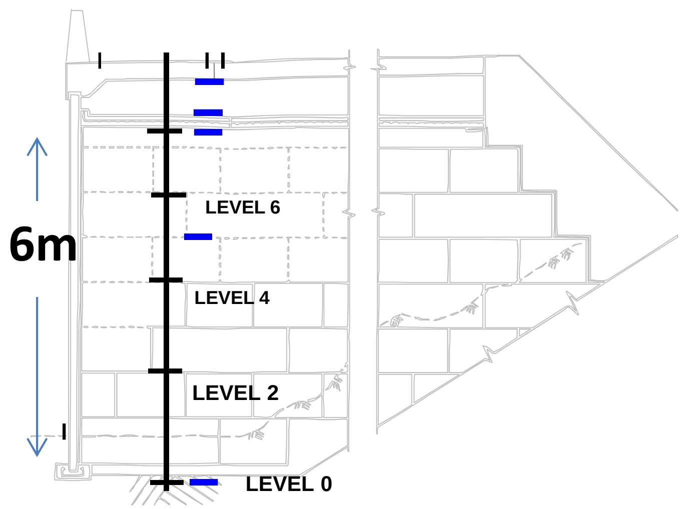
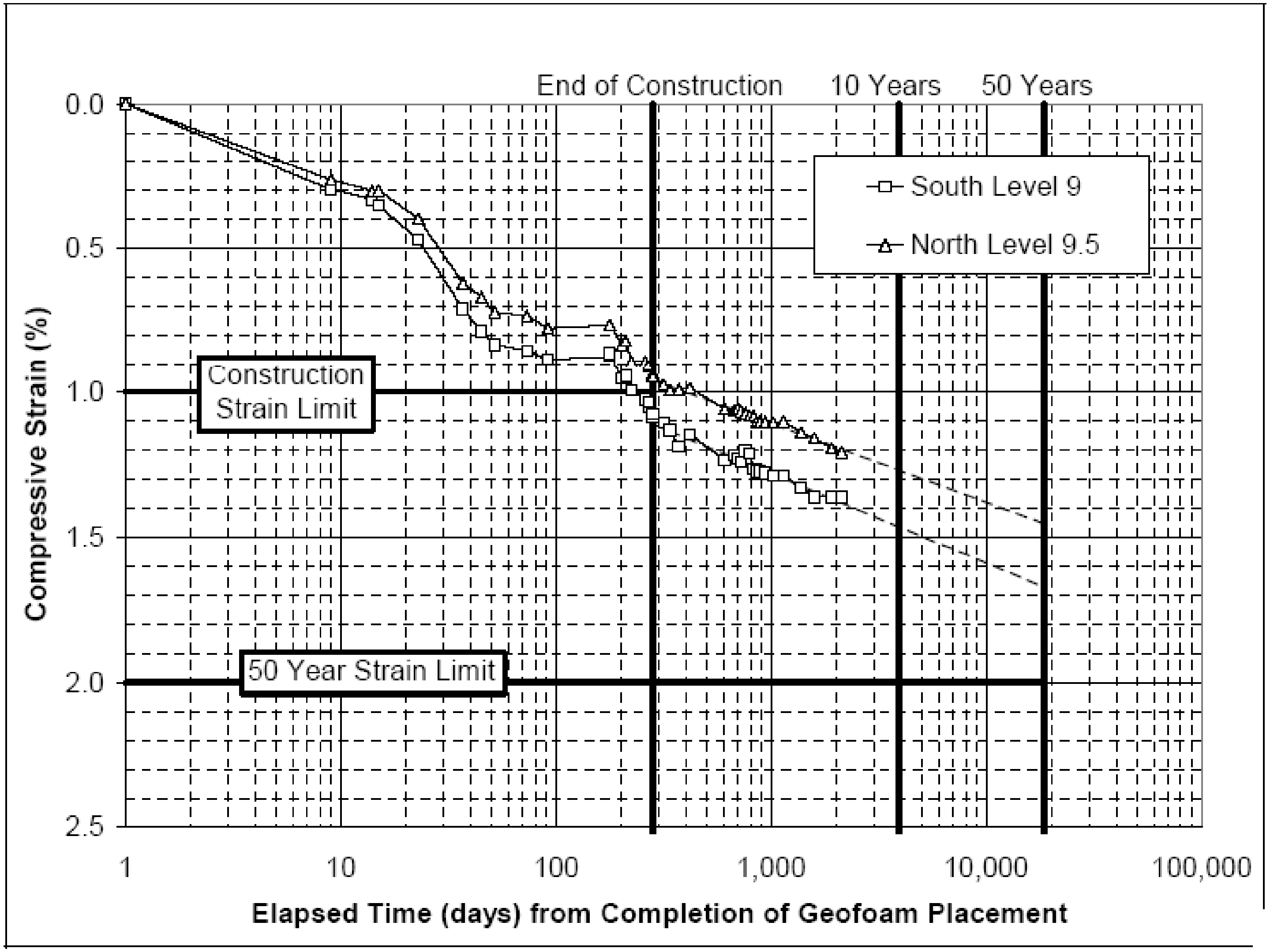
3300 South Compression of EPS

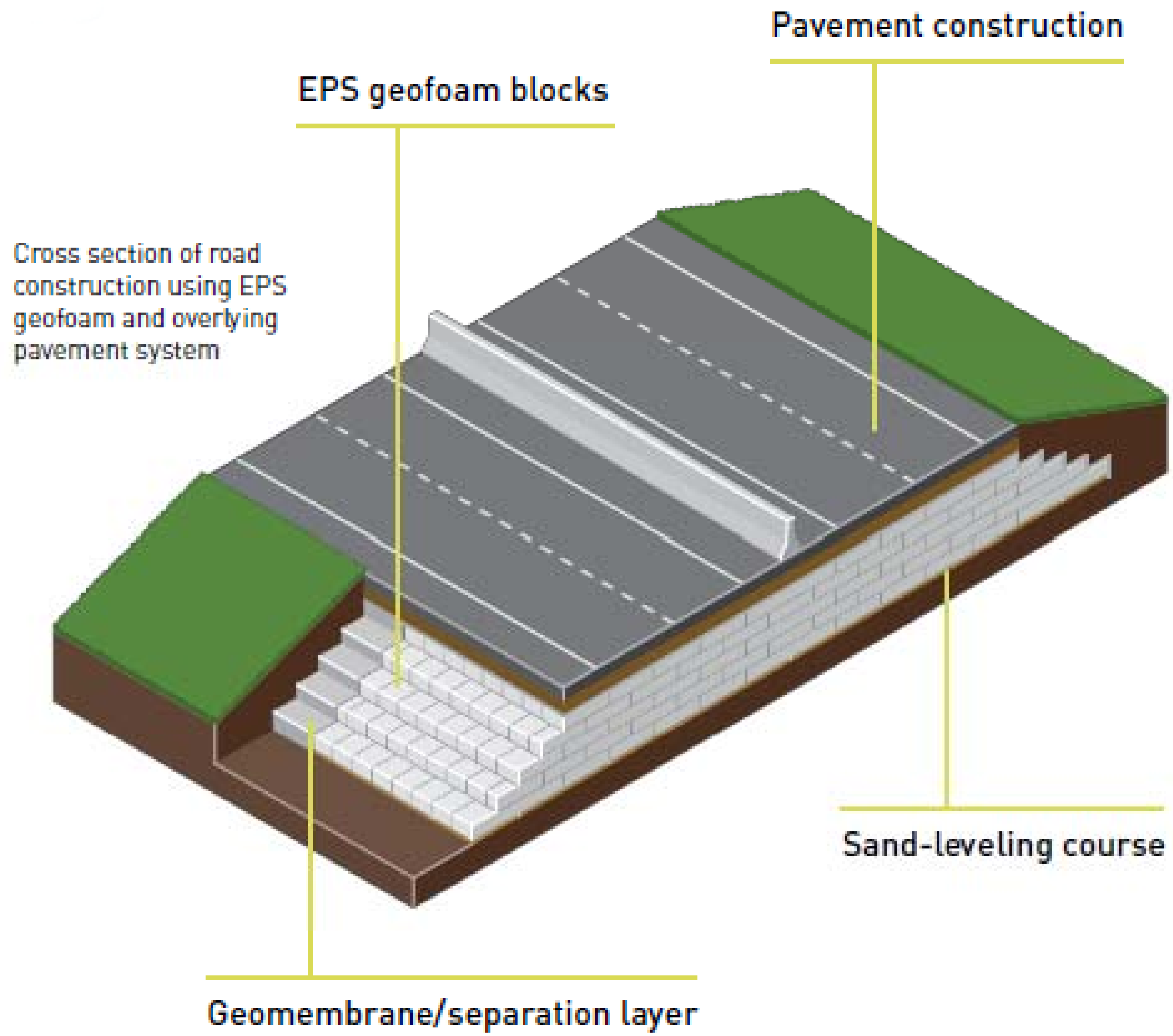




Field Testing and Monitoring



Road Construction Over Poor Soils



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Road Construction Over Poor Soils

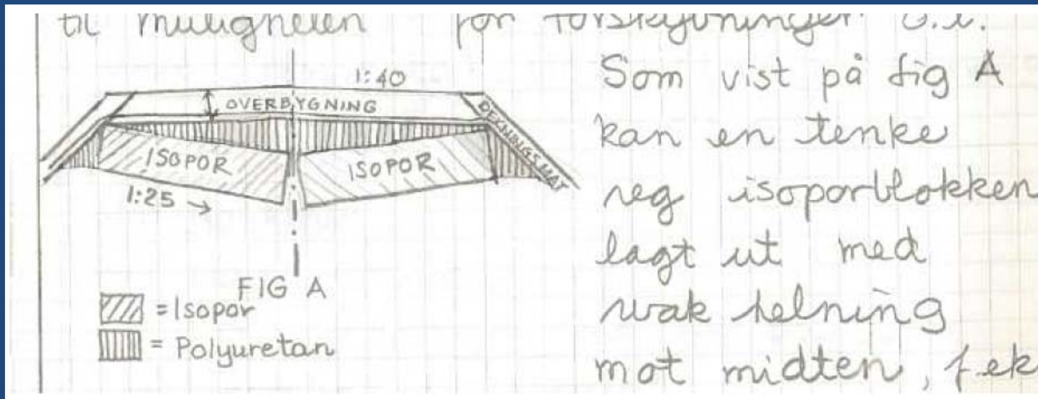

Figure 3. Excavation of the first EPS embankment at Flom bridge (EPS and polyurethane as protective layer).

Flom Bridge – 1972 – Lillestrom, Norway

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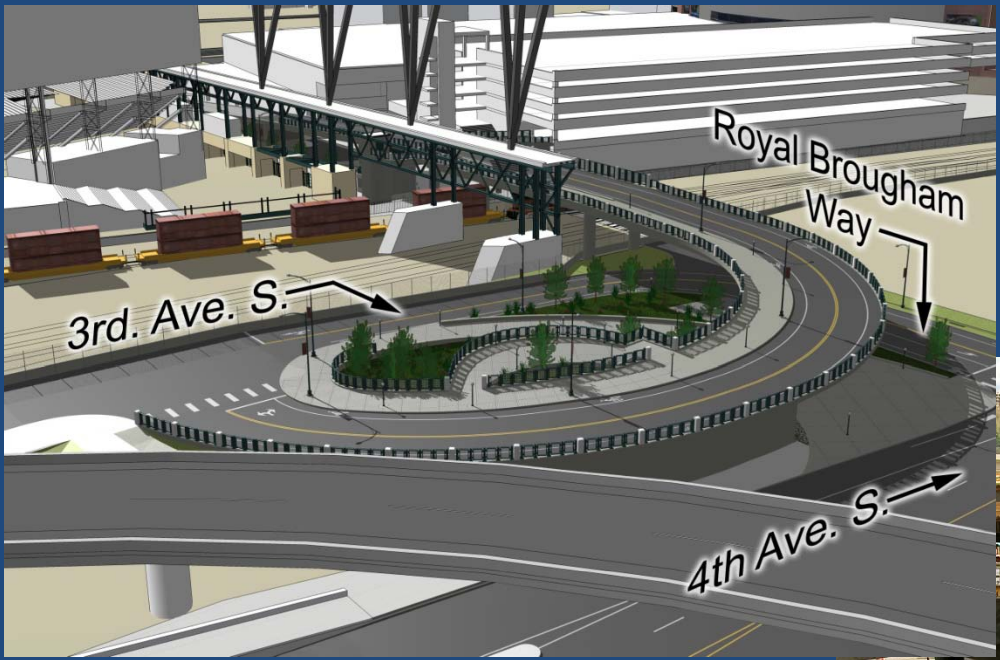
Norwegian Public Roads Administration

Road Construction Over Poor Soils



SR-519 Interchange
Seattle, Washington

Road Construction Over Poor Soils

St. Rosa Road

Private Road Constructed Over Rice Fields

St. Rosa, Philippines

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Road Construction Over Poor Soils

Reclaimed Land – Casino Project – Manila Philippines

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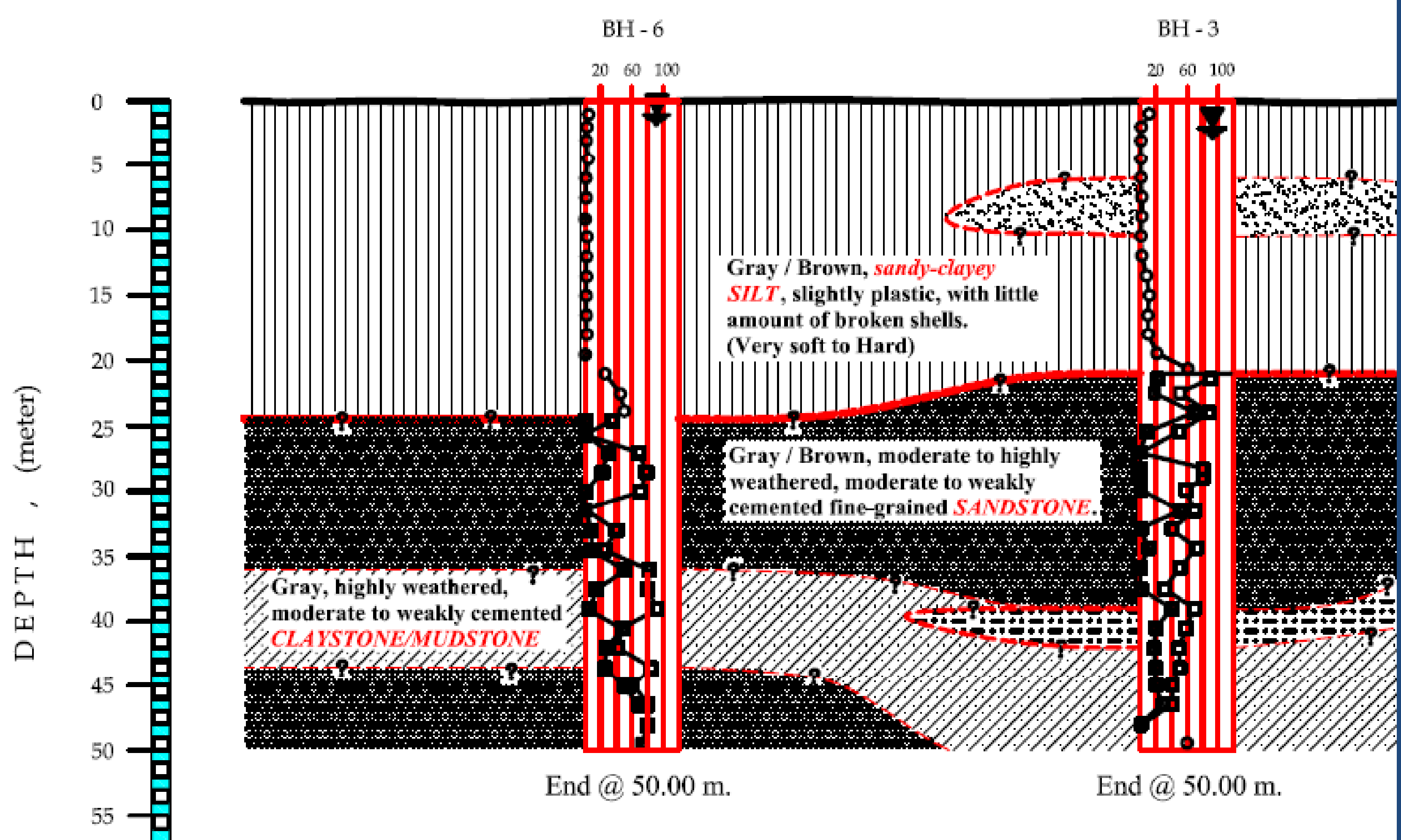
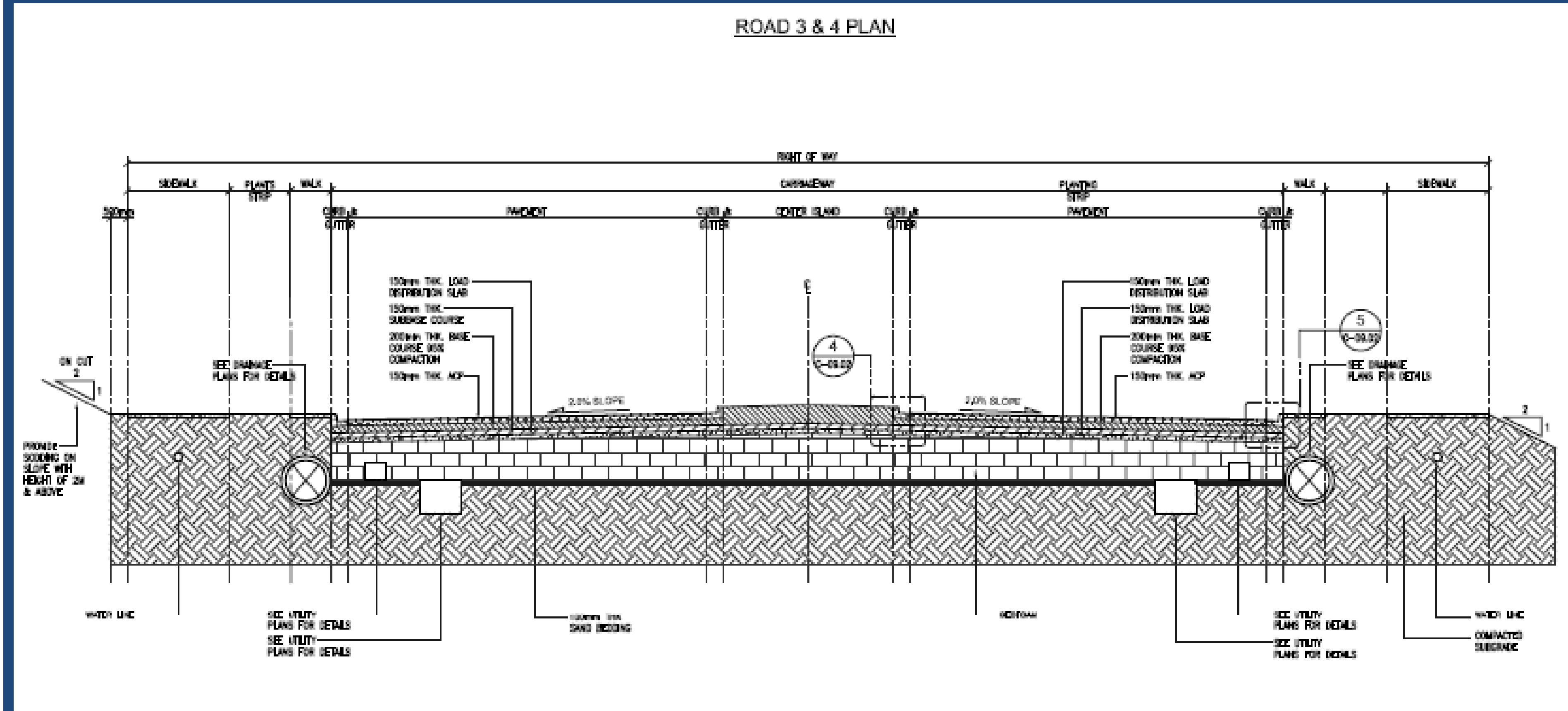
Road Construction Over Poor Soils



Reclaimed Land – Aruze Project – Manila Philippines

Road Construction Over Poor Soils



Reclaimed Land – Casino Project – Manila Philippines

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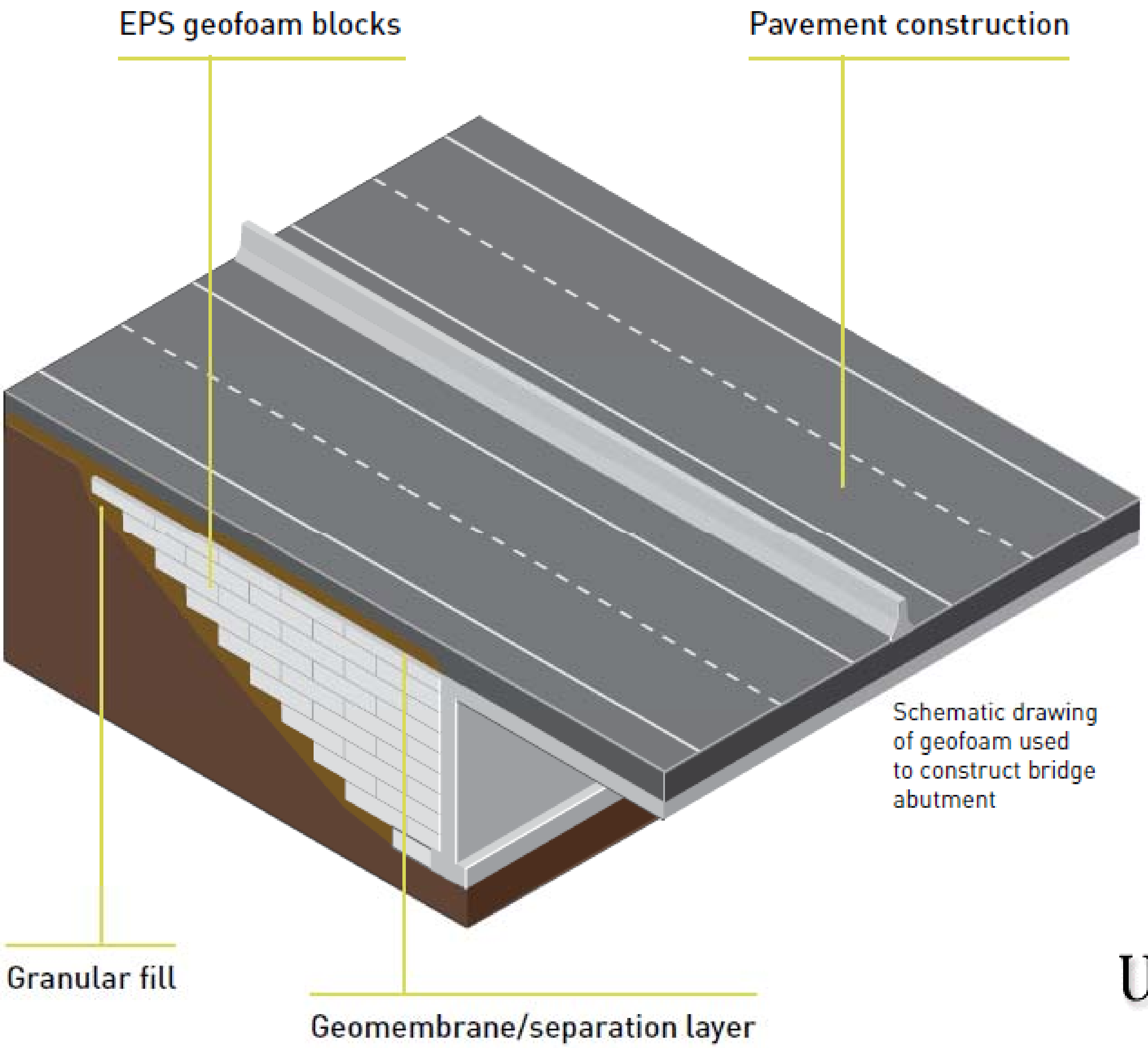
Bridge Abutments



Schematic drawing of geofoam used to construct bridge abutment

Bridge Approaches

North Temple Viaduct – Salt Lake City, Utah

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Bridge Abutment

I-15 Reconstruction,
Salt Lake City, Utah

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

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Temporary Bridge Supported on EPS

Grimsoyveien
Norway

Statens vegvesen

Norwegian Public Roads Administration

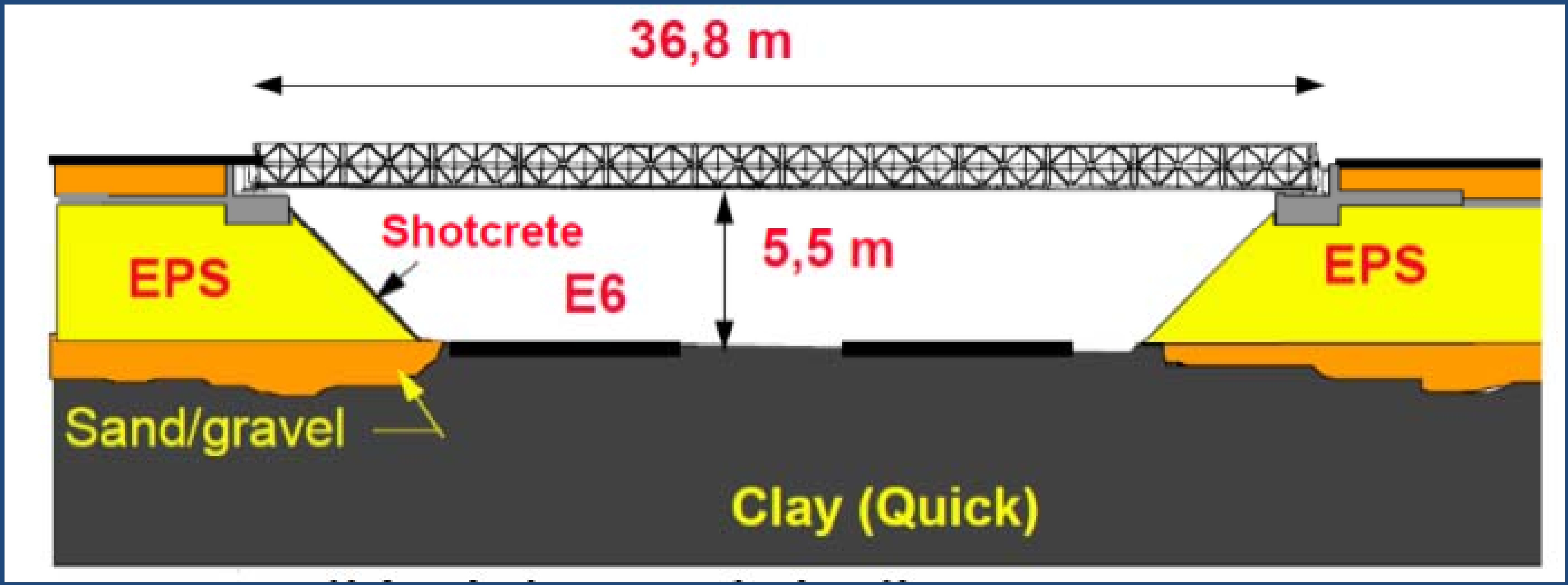
Temporary Bridge Supported on EPS

Lokkeberg Bridge, Norway

Statens vegvesen

Norwegian Public Roads Administration

Temporary Bridge Supported on EPS



Lokkeberg Bridge, Norway

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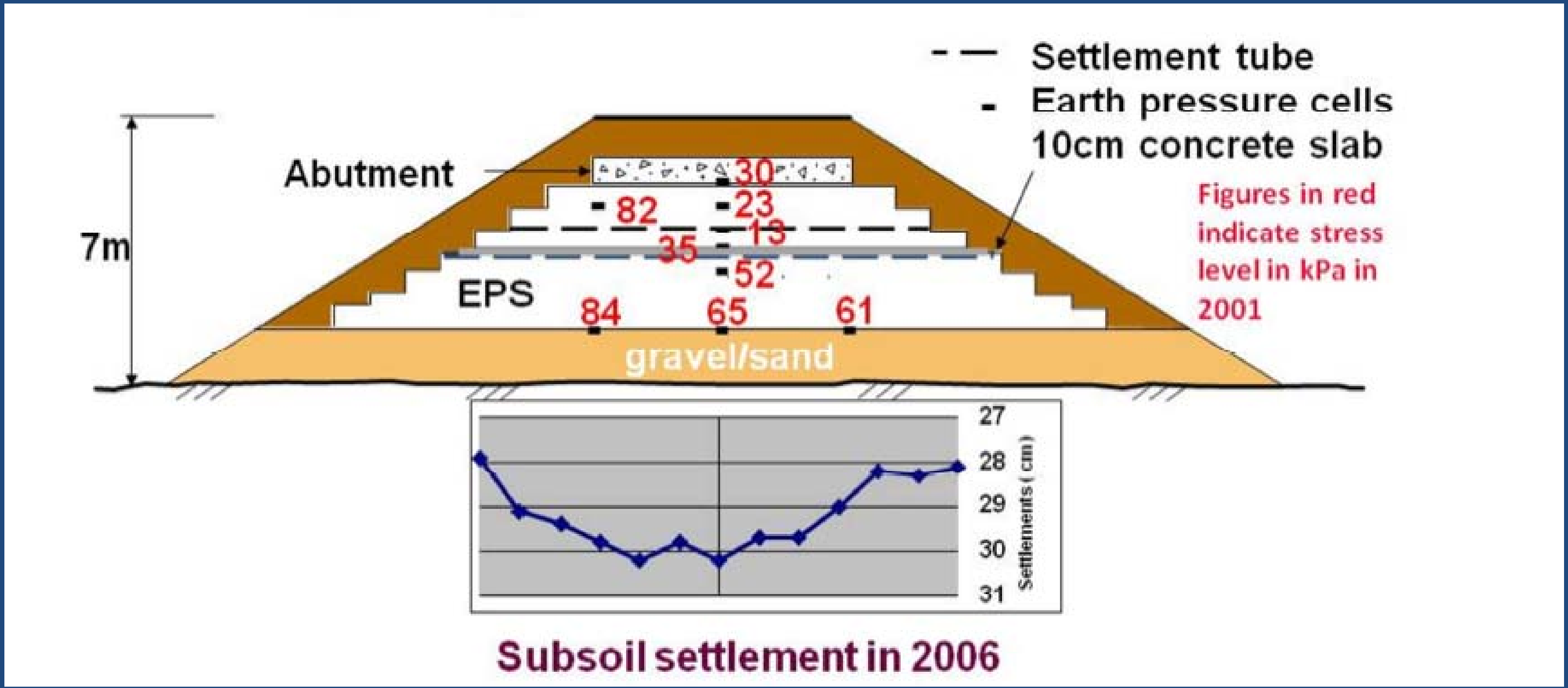
Norwegian Public Roads Administration

Temporary Bridge Supported on EPS



Lokkeberg Bridge, Norway

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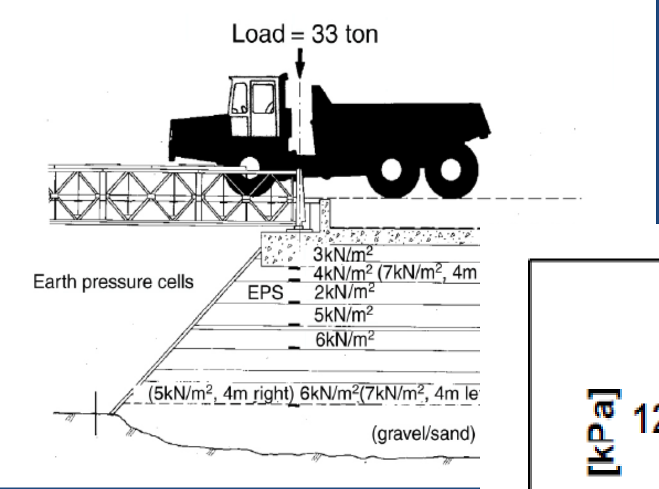
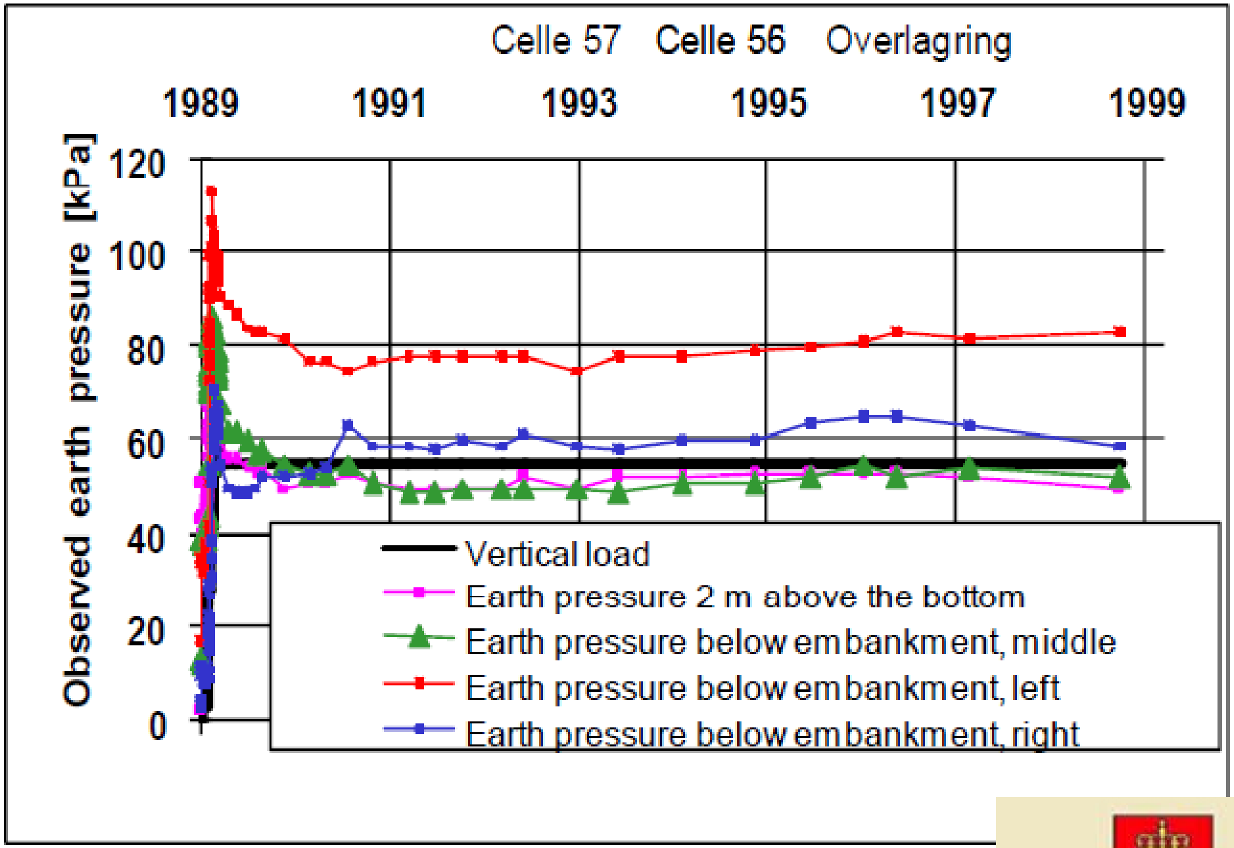
Norwegian Public Roads Administration

Temporary Bridge Supported on EPS





Løkkeberg bridge

Lokkeberg Bridge, Norway

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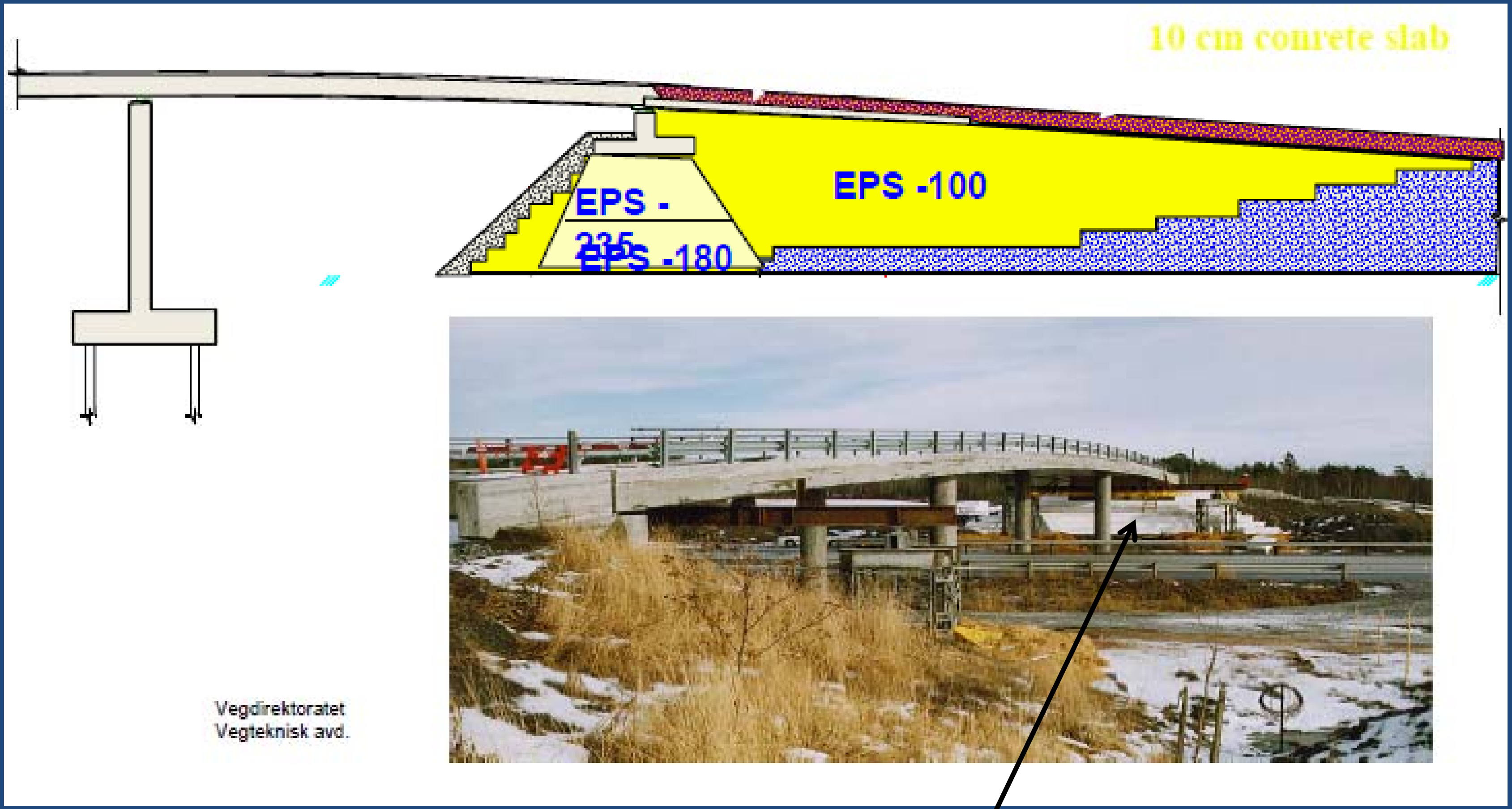
Permanent Bridge Supported on EPS



Hjelmungen bru, Norway

EPS block

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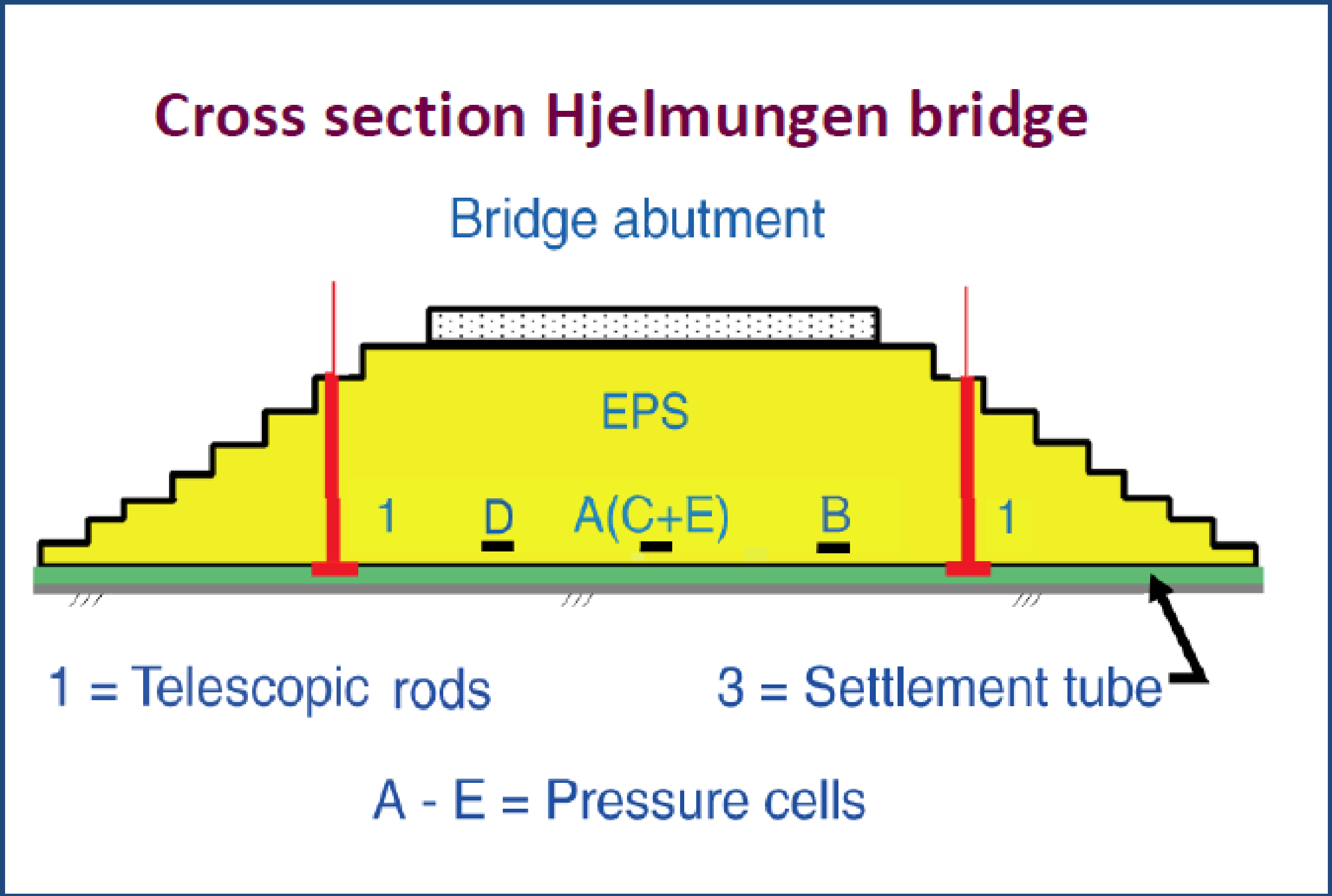
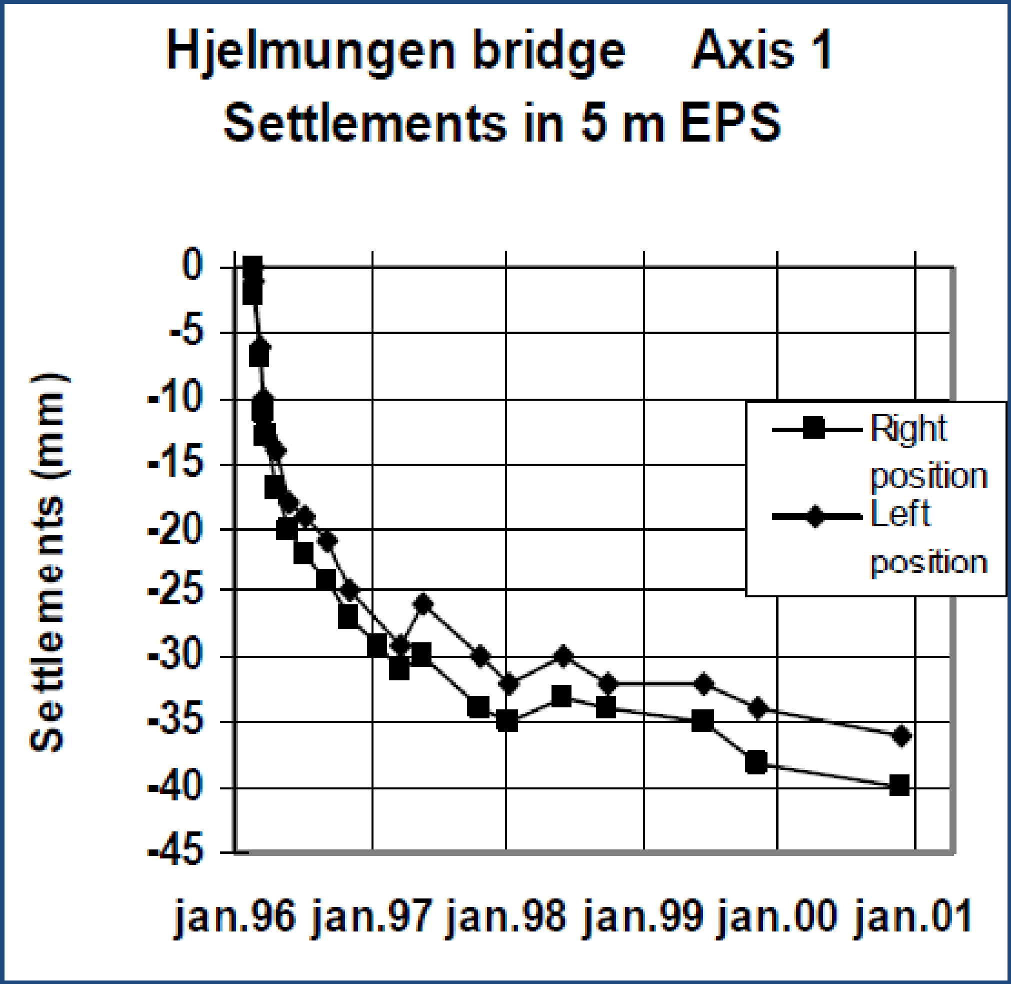
Permanent Bridge Supported on EPS



Hjelmungen bru, Norway

Permanent Bridge Supported on EPS



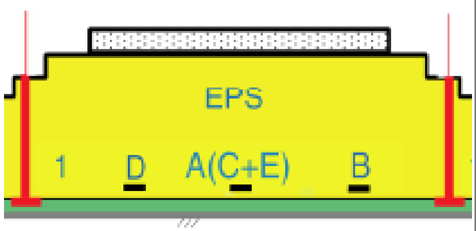
Hjelmungen bru, Norway

Permanent Bridge Supported on EPS

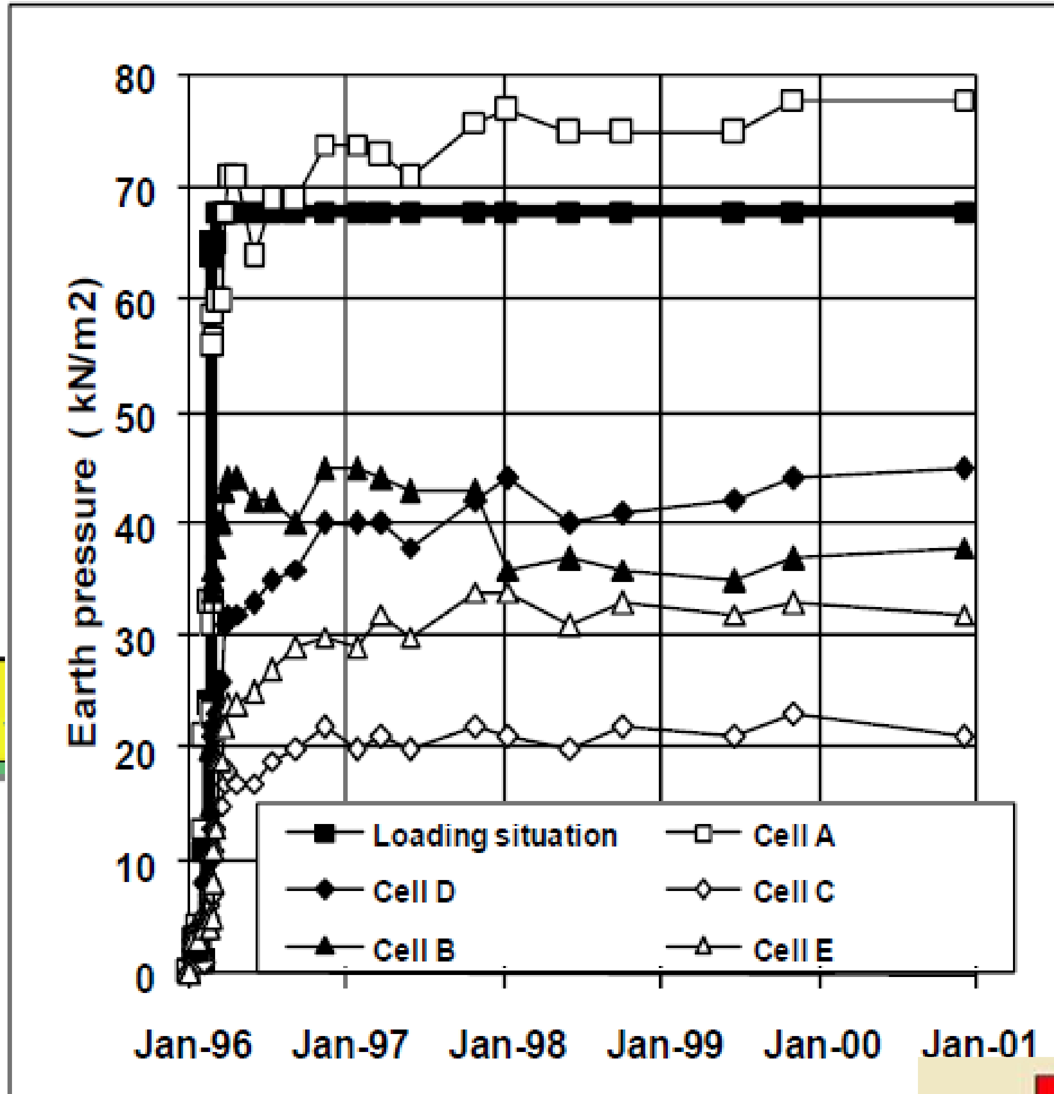
Hjelmungen bridge

Earth pressure below EPS layer

Bridge abutment



Vegdirektoratet
Vegteknisk avd.



Hjelmungen bru, Norway

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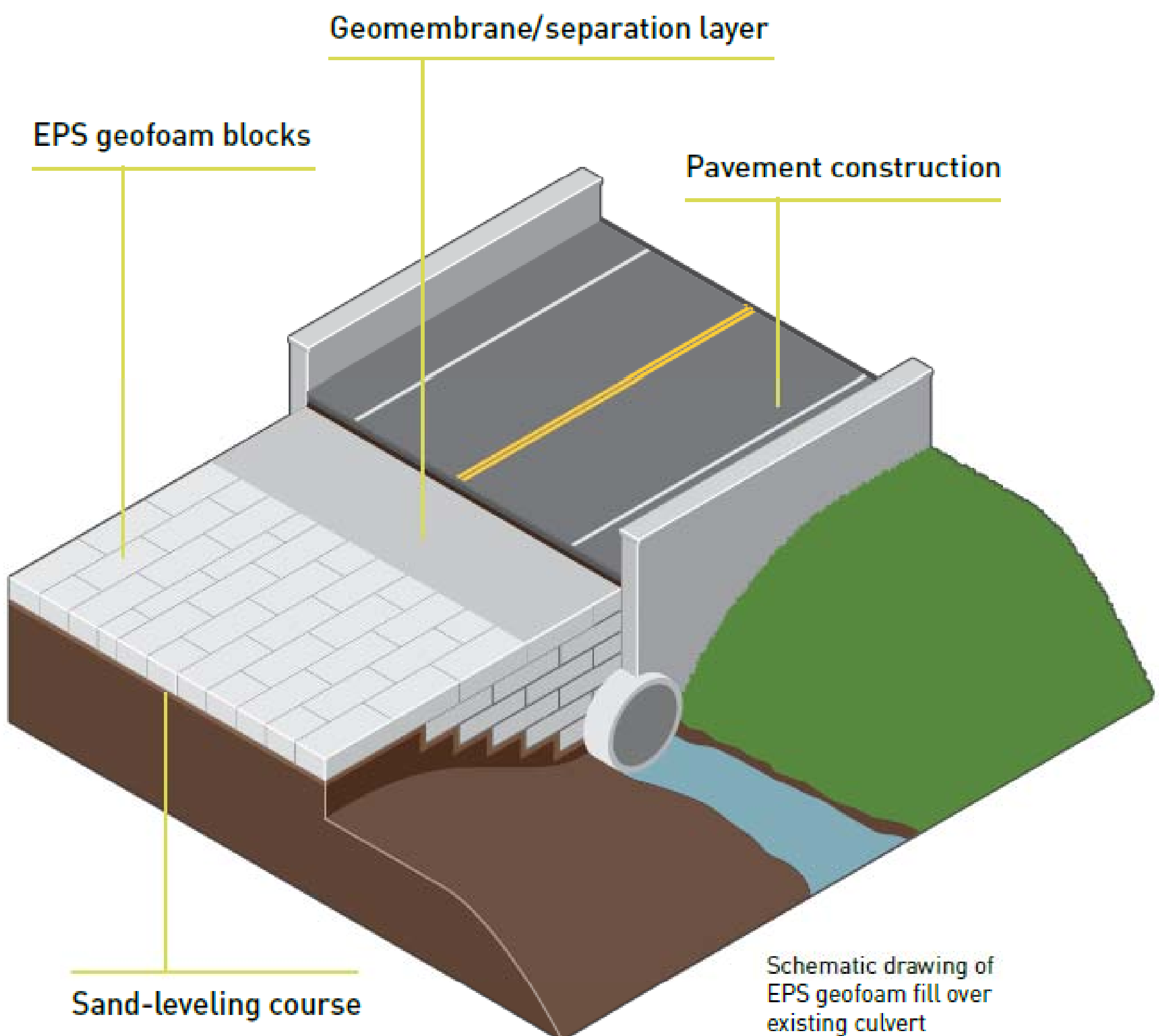
Norwegian Public Roads Administration

Bridge / Tunnel Underfill

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

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

Culverts (Light-Weight Fill)



Schematic drawing of EPS geofoam fill over existing culvert

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Culverts (Light-Weight Fill)

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

Unknown location

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Pipeline Protection

Wasatch Fault at Little Cottonwood Canyon

Pipeline Protection

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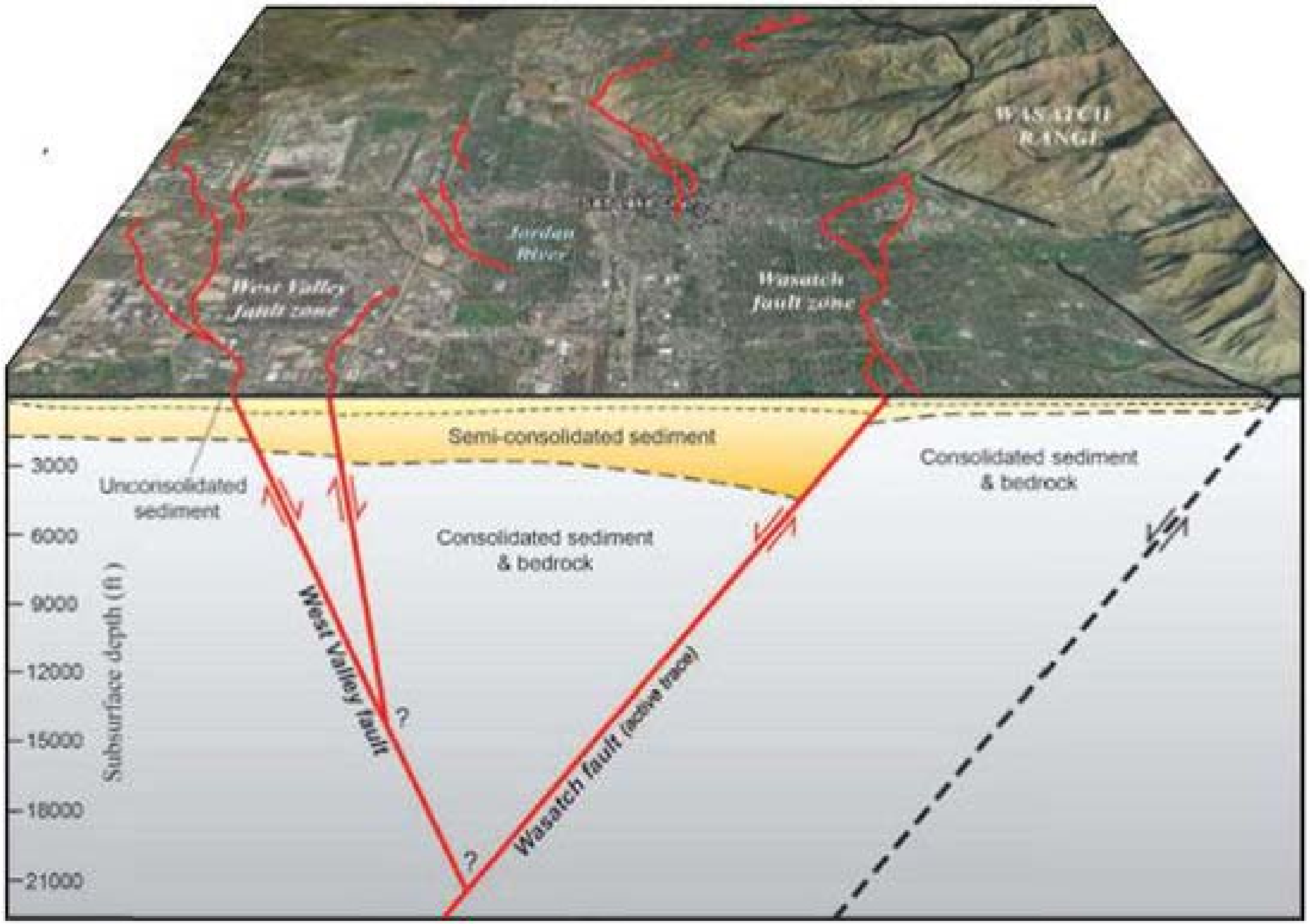
Pipeline Protection



Wasatch Fault – Salt Lake City Segment

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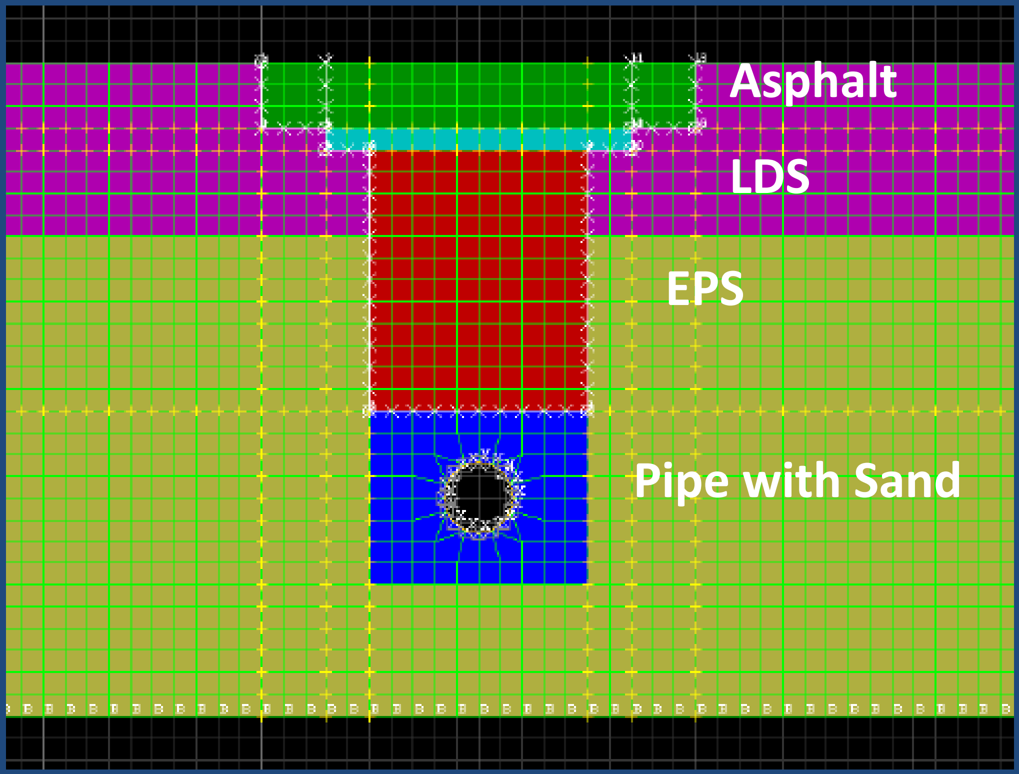
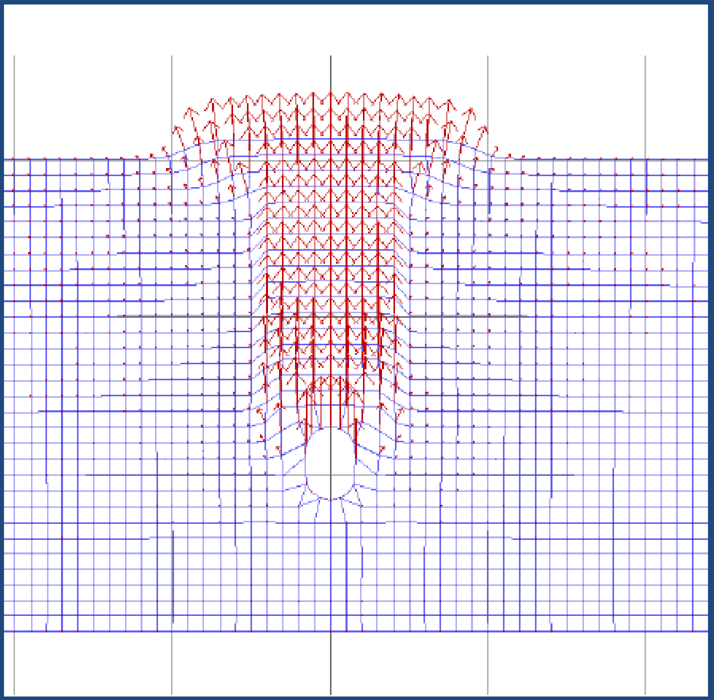
Pipelines (Light-weight Cover Over Faults)

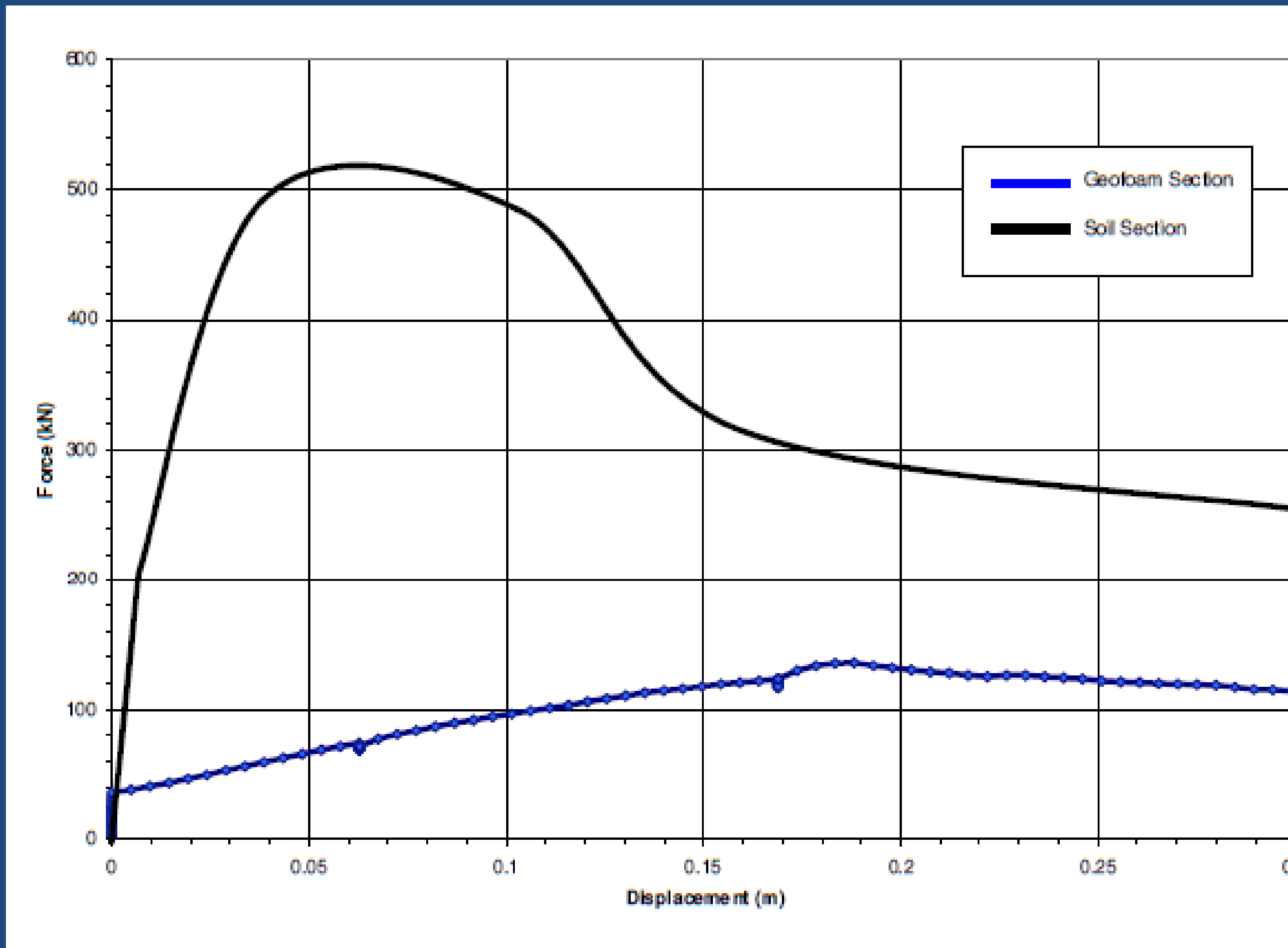


Lightweight-Cover System



Displacement Vectors During Failure

Pipelines (Light-weight Cover Over Faults)



Force – Displacement Relation

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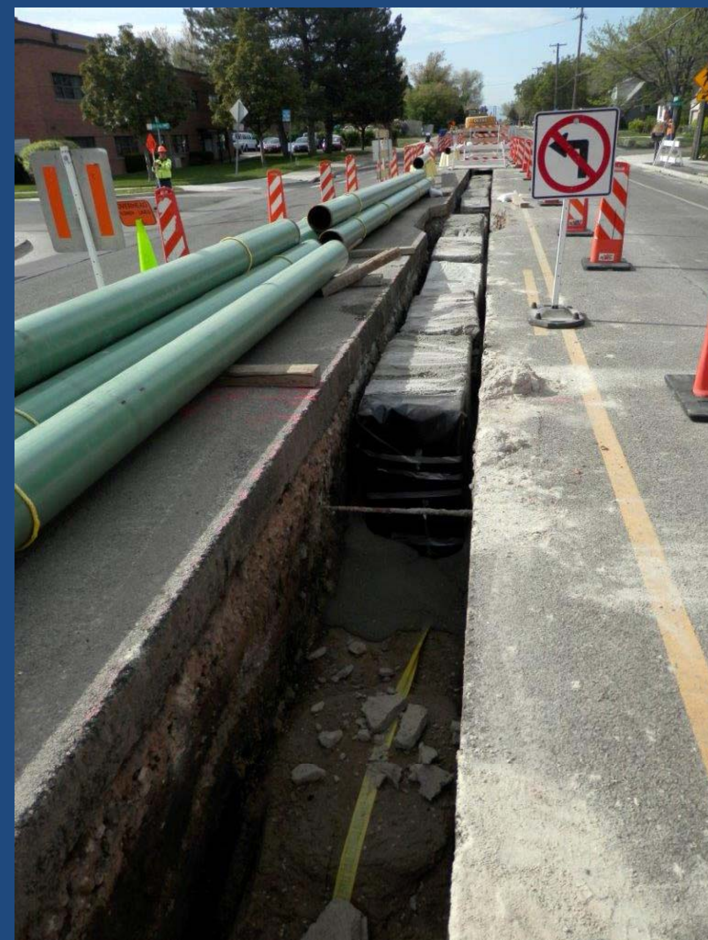
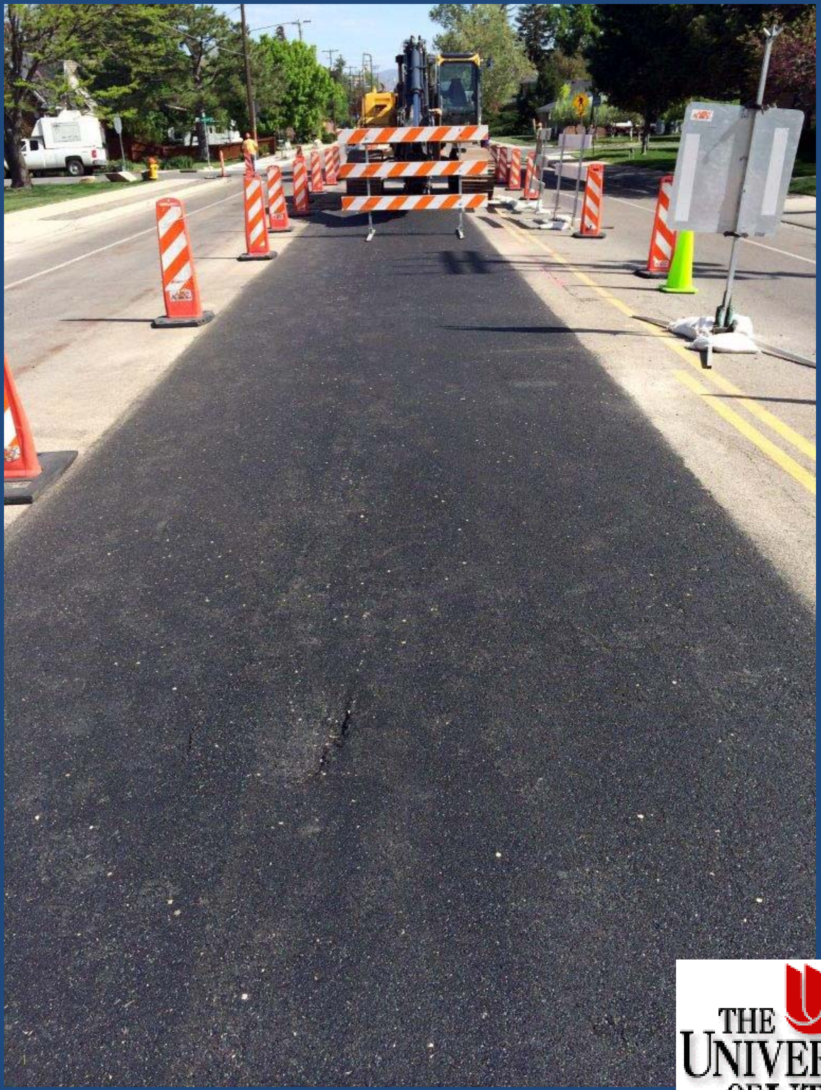
Pipelines (Light-weight Cover Over Faults)

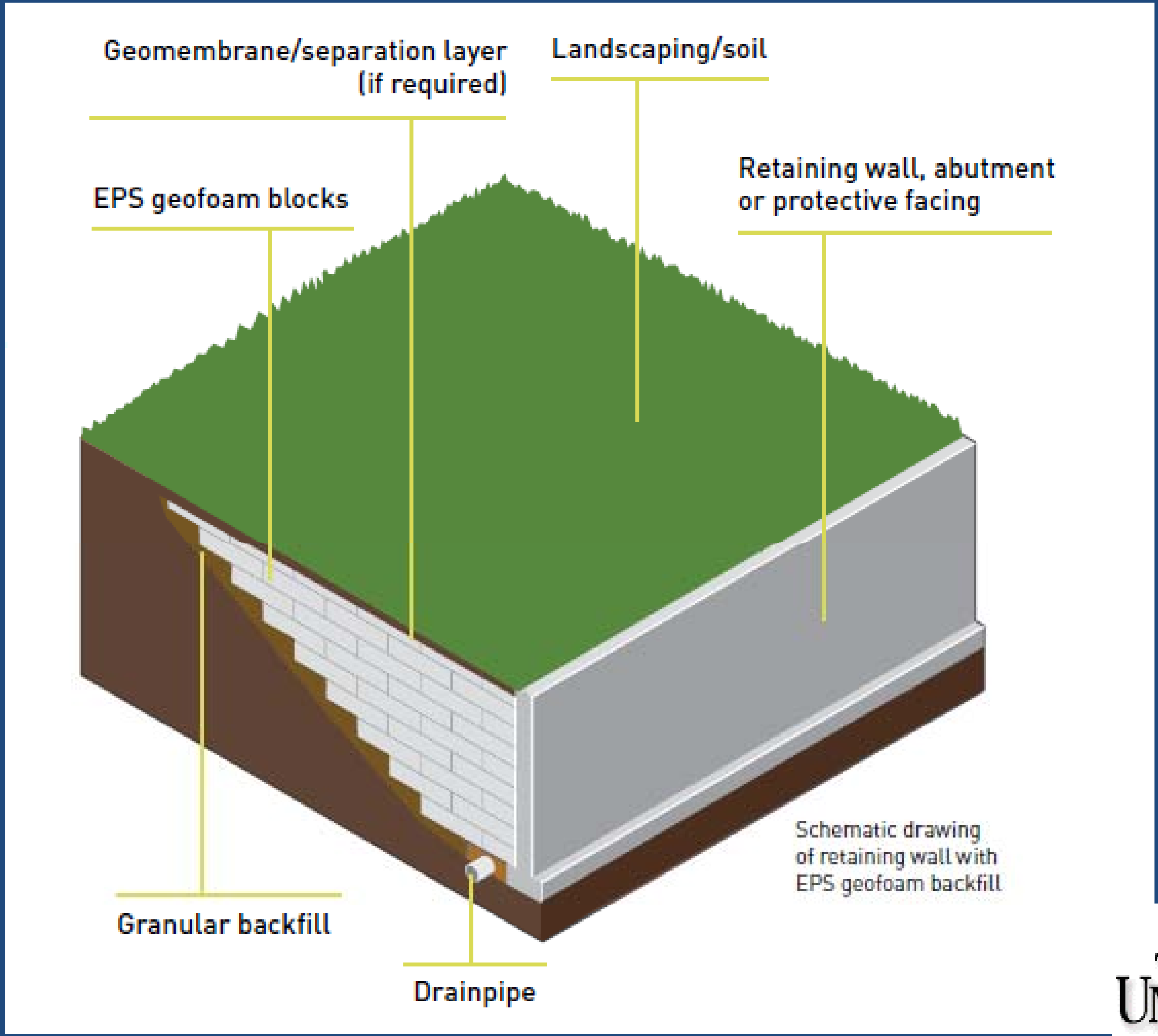


Pipeline Crossing, Salt Lake City, Utah

Pipelines (Light-weight Cover Over Faults



Light-Weight Backfill



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Buried Structures and Walls (Light-Weight Backfill)

Federal Courthouse – Salt Lake City

IHC Hospital – Murray, Ut

Casino/Hotel – Reidoso, NM

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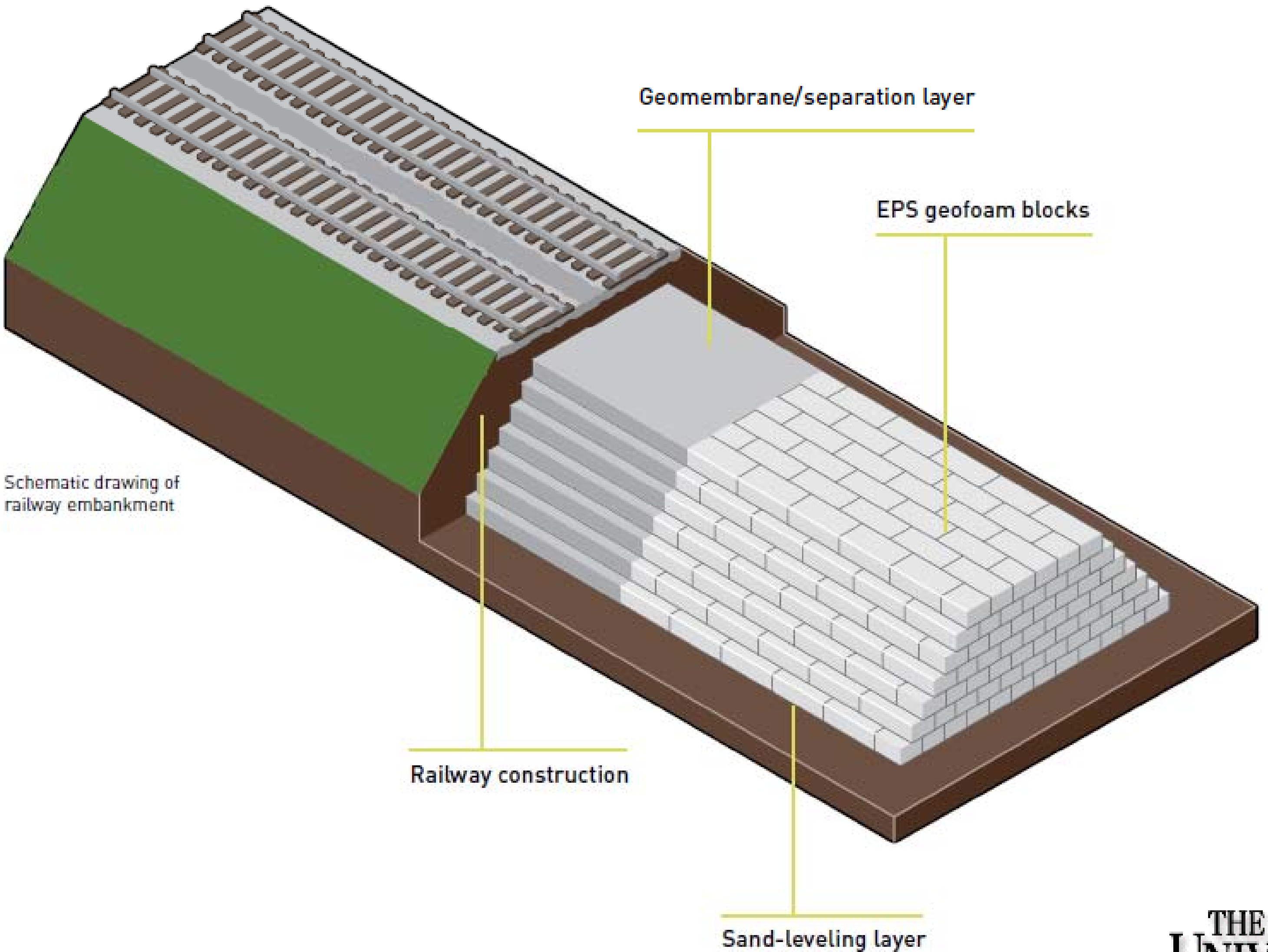
Rail Embankments



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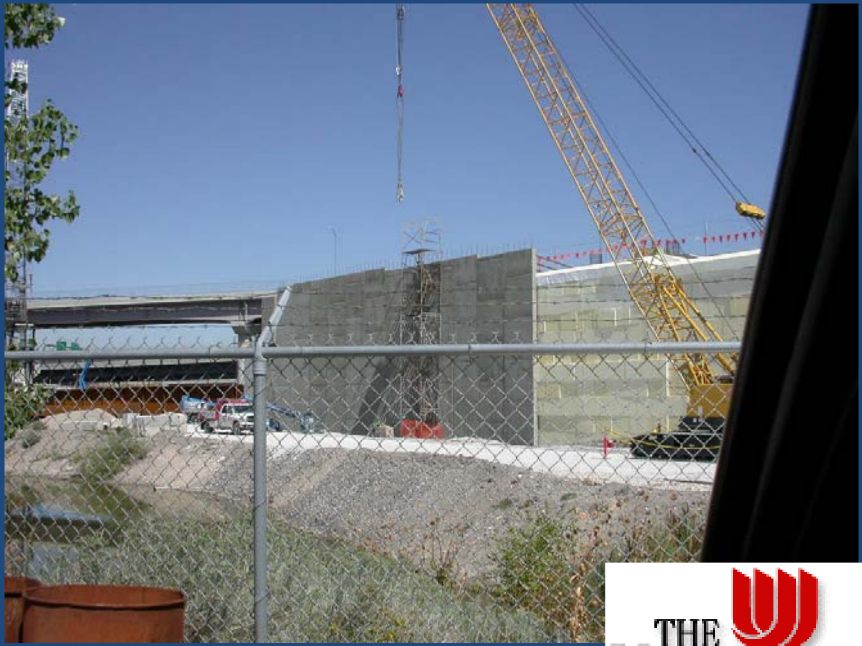
Light Rail Embankments

UTA –Light Rail – Salt Lake City, Utah

Light Rail Embankments



UTA –Light Rail – Salt Lake City, Utah

Light Rail Embankments

UTA –Light Rail – Salt Lake City, Utah

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Commuter Rail Embankments

Front Runner – UTA – Corner Canyon – Draper Utah

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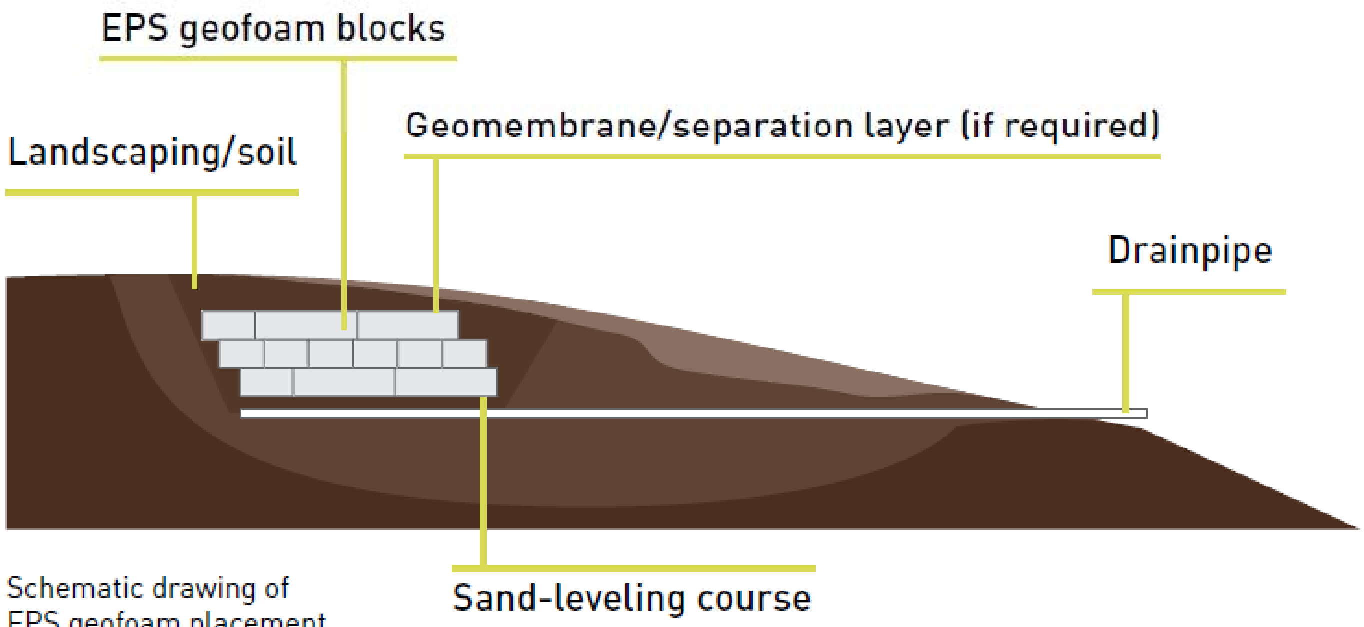
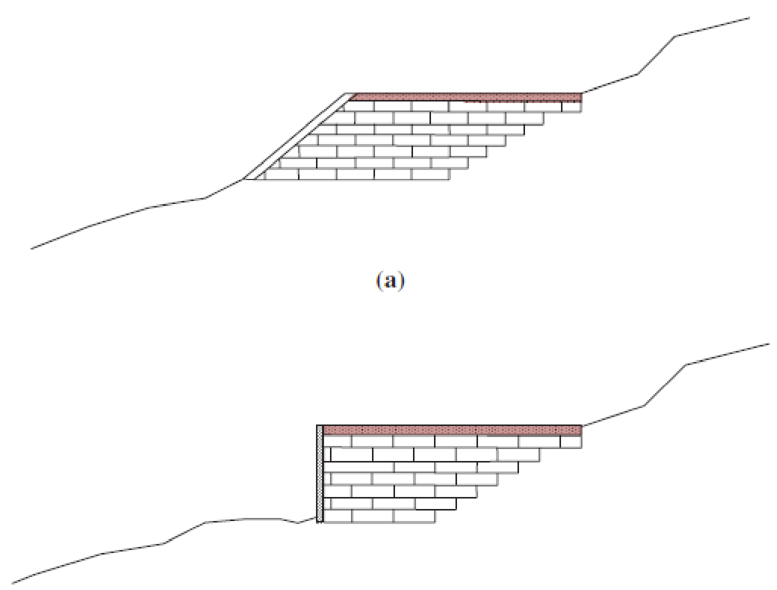
Slope Stabilization



Schematic drawing of
EPS geofoam placement
in a slide area



Slope Stabilization

Pavement Cracking

Scarp

Alabama DOT

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Slope Stabilization

Overview of EPS Block Placement Configuration

Alabama DOT

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Slope Stabilization

Backfill Placement Behind EPS

Completed Road

Alabama DOT

Slope Stabilization

SR264 at 2nd Mesa, Arizona

Topics

- EPS Properties
- Design and Construction Considerations
- Applications for Transportation Projects
- Performance Monitoring

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

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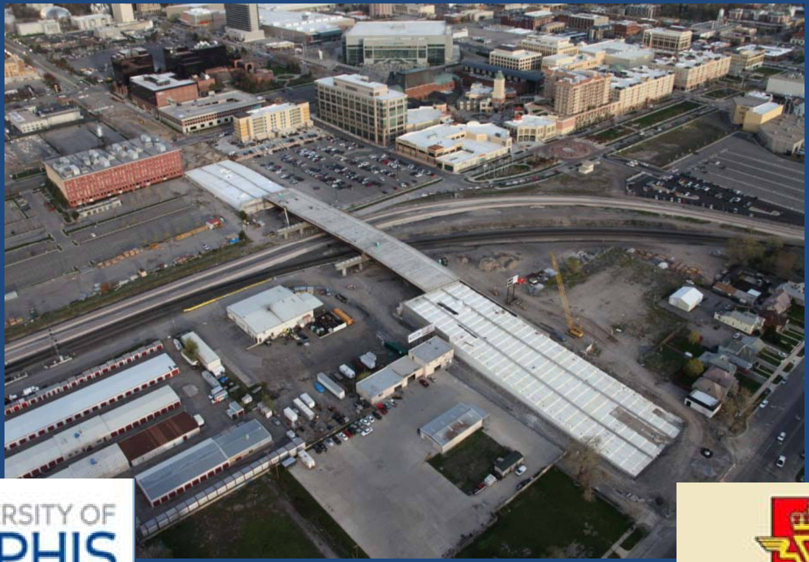
Questions



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