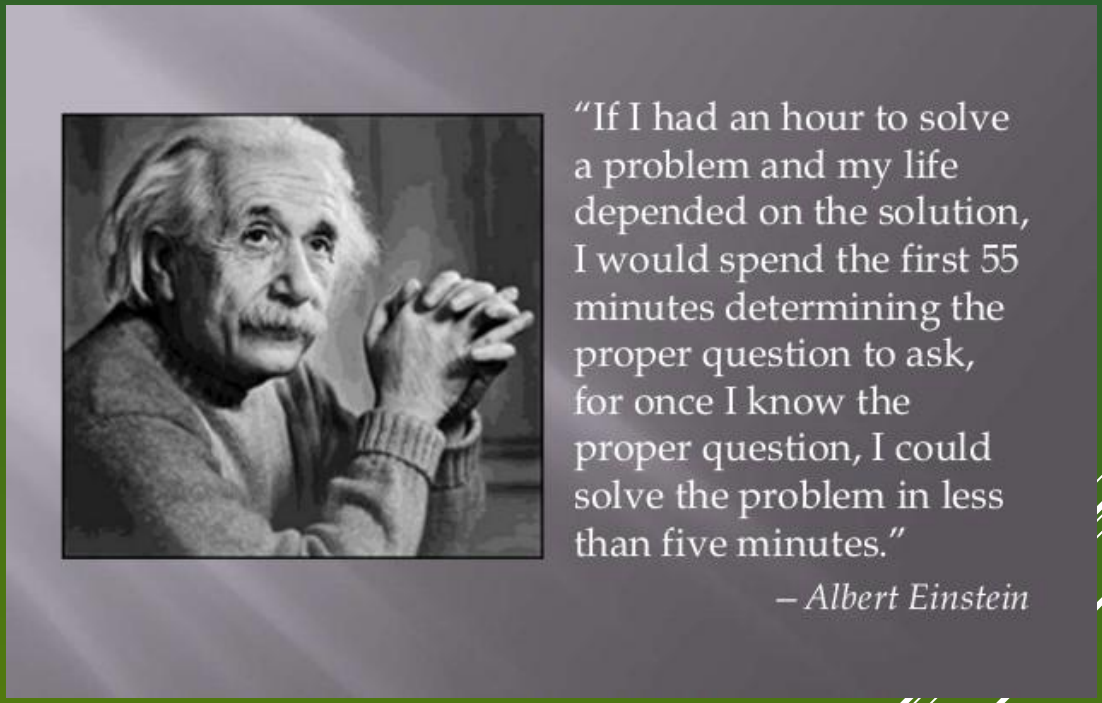
GEOFOAM APPLICATIONS PRESENT AND FUTURE

Steven F. Bartlett, Ph.D., P.E.

https://www.sfb-engineering.com/

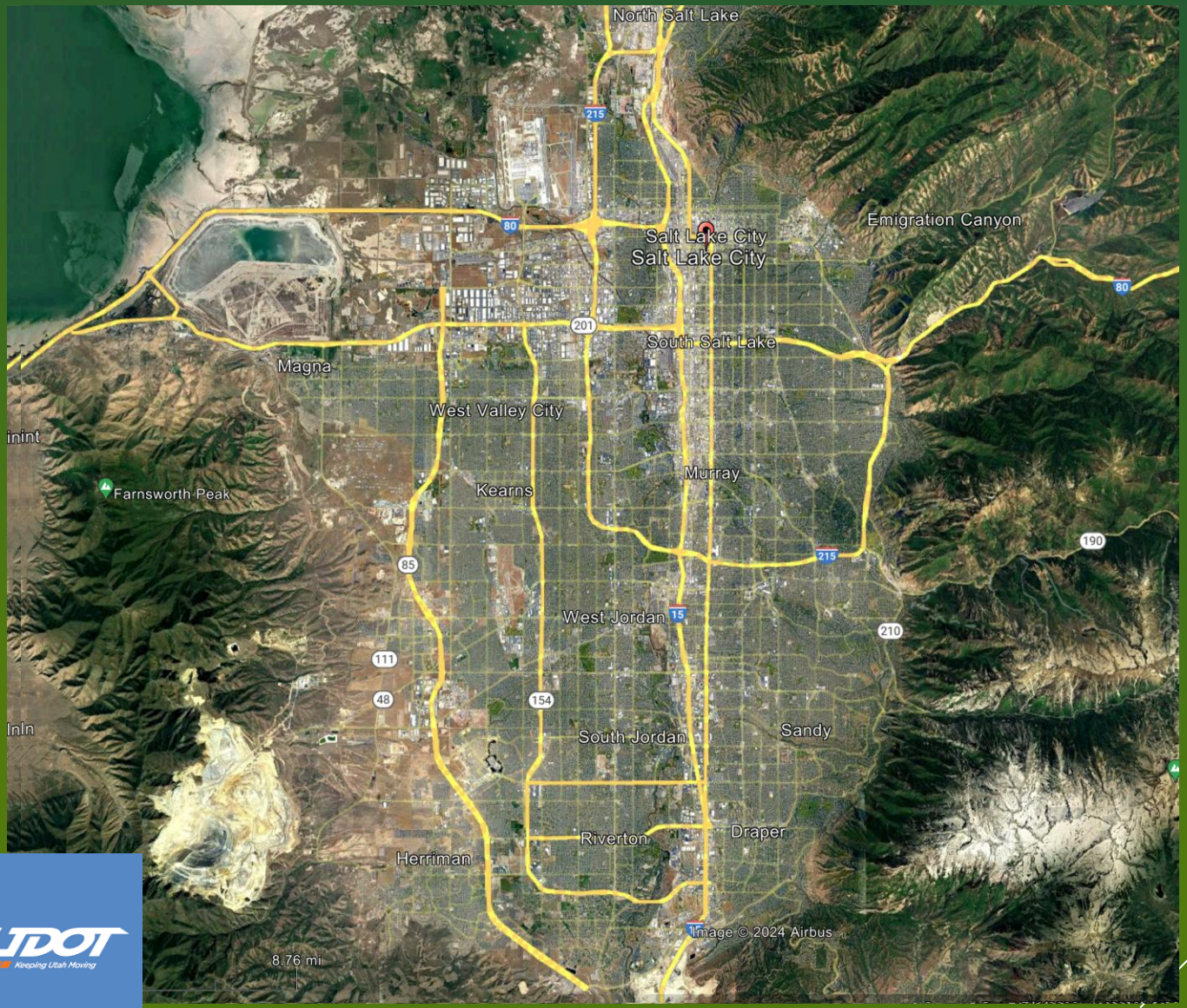
IMAGINE THE UNIVERSITY OF UTAH

Imaginative, Critical Thought



EXPRESSWAYS ON STYROFOAM?

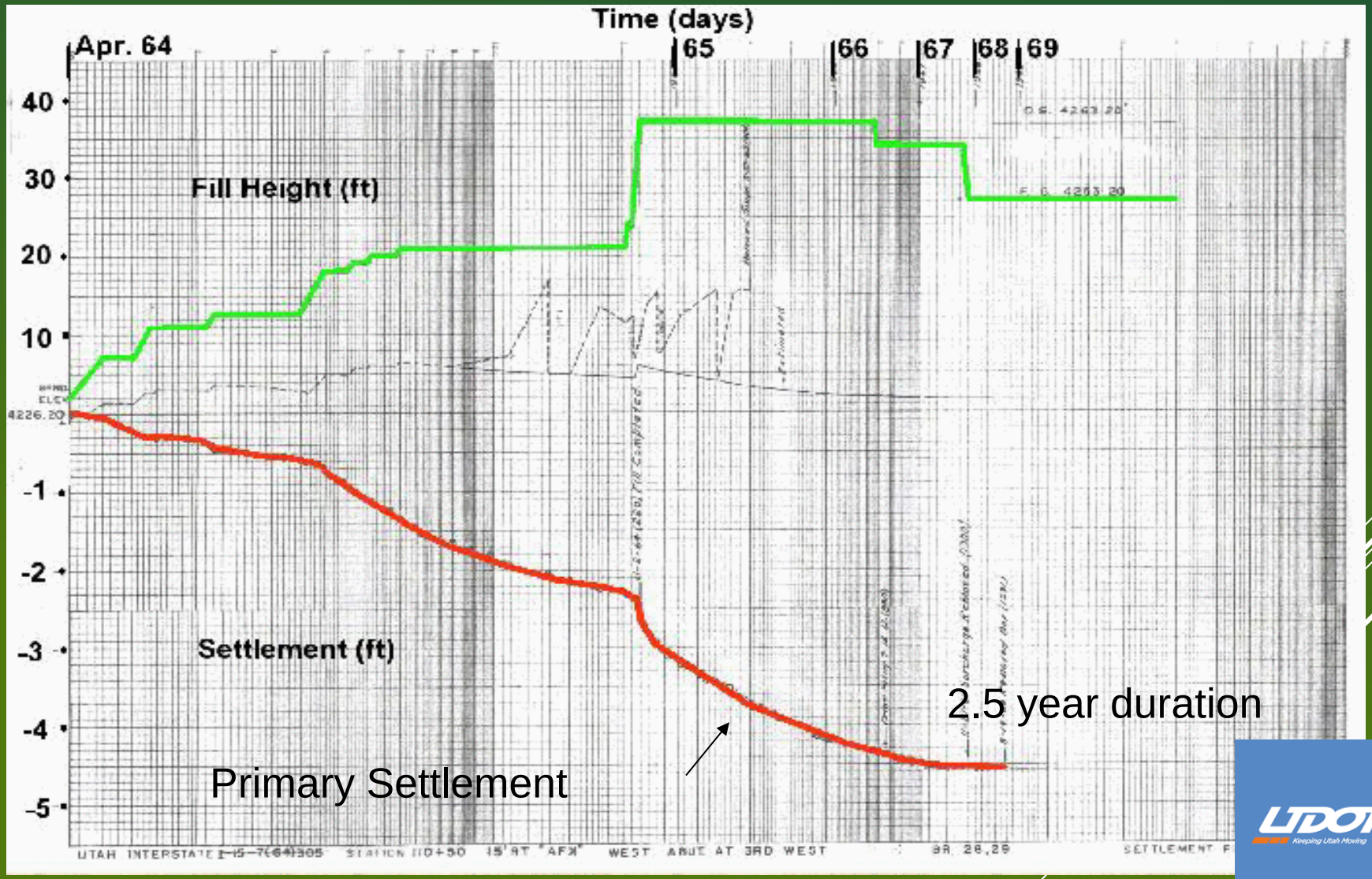
I-15 PROJECT – SALT VALLEY



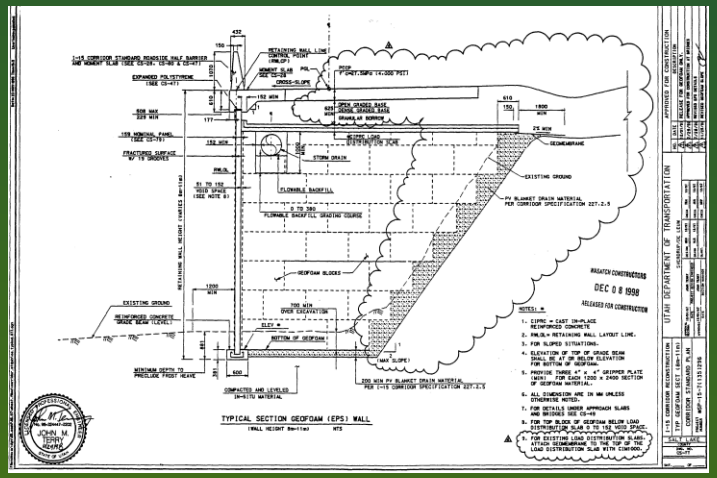
SALT LAKE 2002

UDOT Keeping Utah Moving

I-15 PROJECT – SETTLEMENT RECORD 1960s



I-15 RECONSTRUCTION GEOFOAM TASK FORCE TEAM



ADVANTAGES OF LIGHT-WEIGHT MATERIALS

Properties

- Light-weight to ultra light-weight
- High strength to mass ratio
- Good damping characteristics
- Thermal Insulators
- High Buoyancy

Important Functions

- Reduces soil settlement
- Improves bearing capacity of roadways
- Improves foundation, wall and slope stability
- Decreases horizontal and vertical loads
- Rapid construction
- Can save construction time and money

ASTM D6817

ASTM D6817 Physical Property Requirements of EPS Geofoam

Type	EPS12	EPS15	EPS19	EPS22	EPS29	EPS39	EPS46
Density, min., kg/m^3(lb/ft^3)	11.2 (0.70)	14.4 (0.90)	18.4 (1.15)	21.6 (1.35)	28.8 (1.80)	38.4 (2.40)	45.7 (2.85)
Compressive Resistance, min., kPa (psi) at 1 %	15 (2.2)	25 (3.6)	40 (5.8)	50 (7.3)	75 (10.9)	103 (15.0)	128 (18.6)
Compressive Resistance, min., kPa (psi) at 5 %	35 (5.1)	55 (8.0)	90 (13.1)	115 (16.7)	170 (24.7)	241 (35.0)	300 (43.5)
Compressive Resistance, min., kPa (psi) at 10 % [A]	40 (5.8)	70 (10.2)	110 (16.0)	135 (19.6)	200 (29.0)	276 (40.0)	345 (50.0)
Flexural Strength, min., kPa (psi)	69 (10.0)	172 (25.0)	207 (30.0)	240 (35.0)	345 (50.0)	414 (60.0)	517 (75.0)
Oxygen index, min., volume %	24.0	24.0	24.0	24.0	24.0	24.0	24.0

The typical design load limit for EPS Geofoam is the compressive resistance at 1%. Please refer to section 4.2 for additional information.

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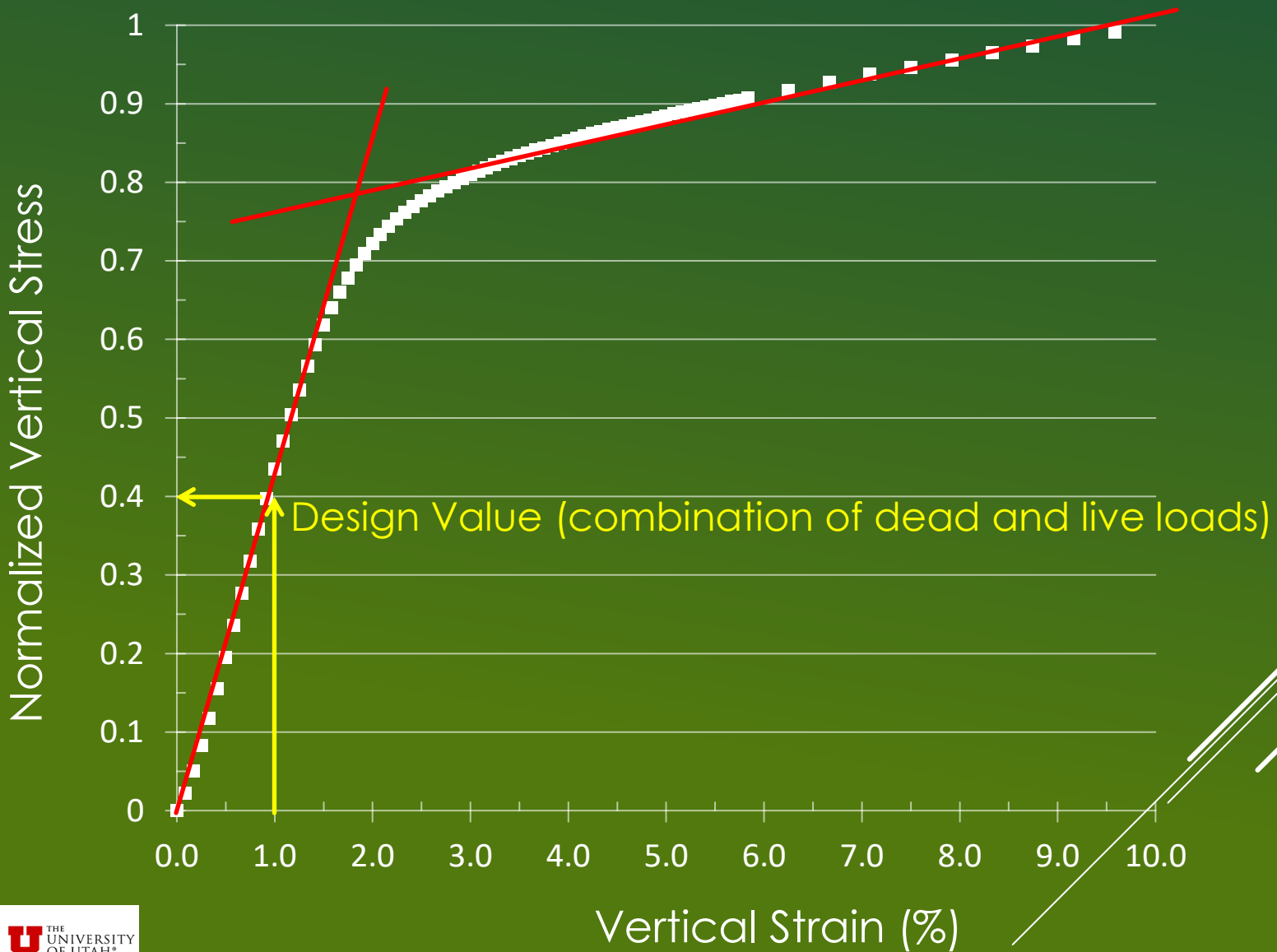
STRENGTH AND COMPRESSIVE RESISTANCE



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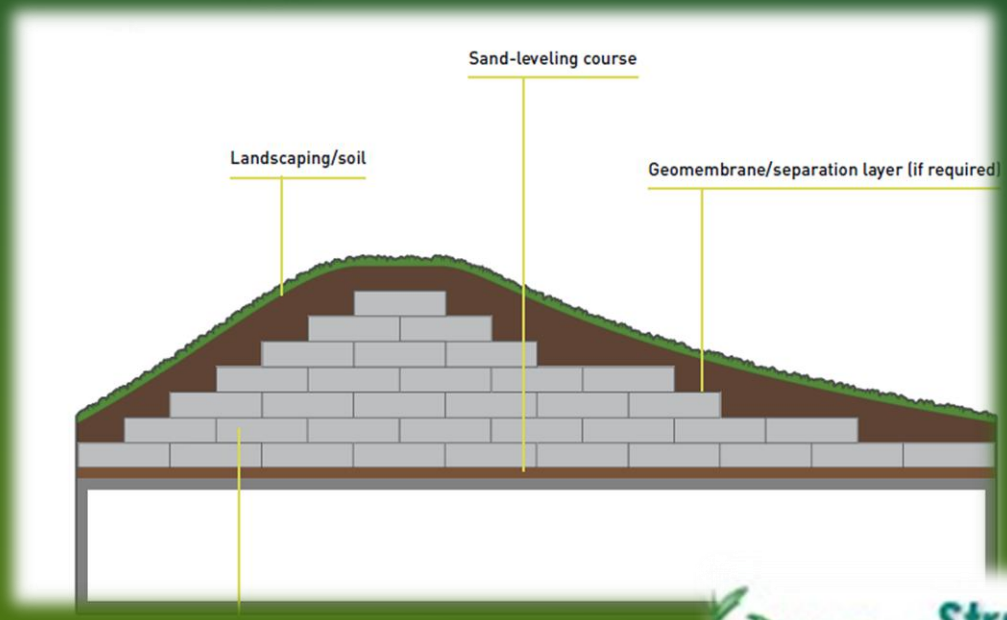
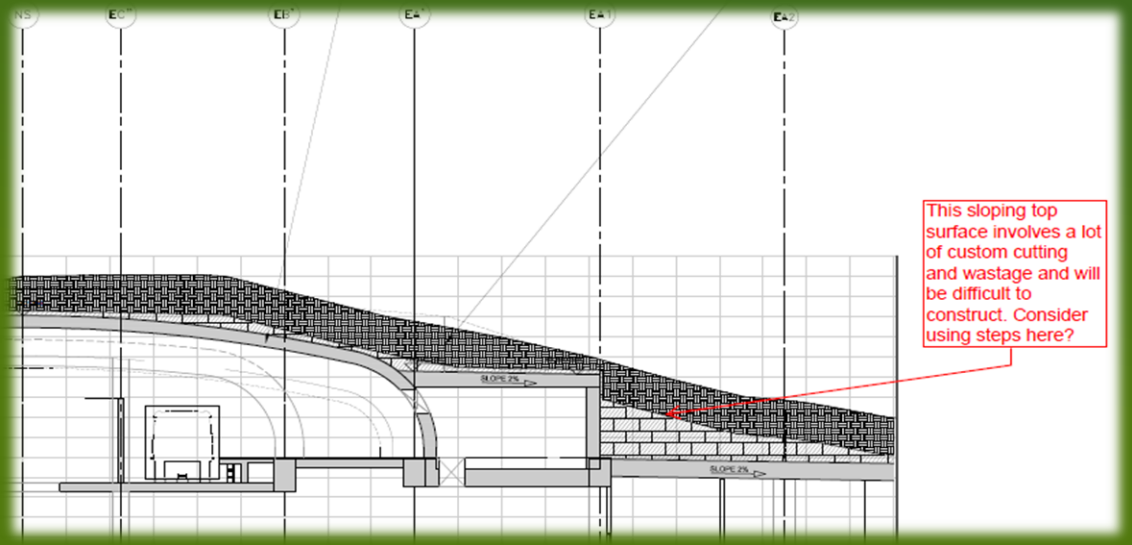
PRIMARY APPLICATIONS OF EPS GEOFOAM

- Landscaping and green roofs
- Lightweight fill for retaining and buried walls
- Culverts, pipelines, utilities
- Stadium and theater seating
- Airport runway and taxiways
- Roadway construction
- Rail embankment
- Bridge abutments
- Bridge underfill
- Accelerated bridge construction
- Compensating foundations
- Slope stabilization
- Retaining and buried wall backfill
- Raising of Leeves and Dikes
- Foundation for lightweight structures

LANDSCAPIING AND GREEN ROOFS



LANDSCAPING AND GREEN ROOFS



Lessons

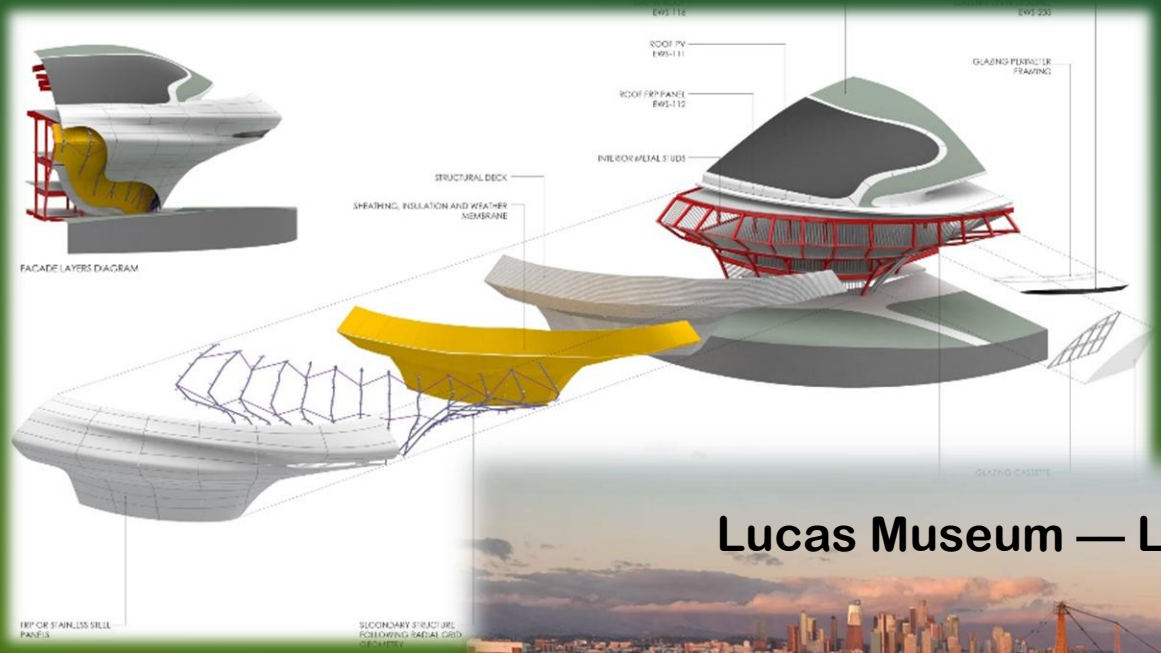
- Combine green roof with EPS insulation to achieve better energy performance
- Angular concrete surfaces and hardscape can be sculpted to create better aesthetics.

DESIGN CONSULTANT:
ATKINS

Airport Terminal – Jeddah

SPACESHIPS THAT NEVER FLY?

LANDSCAPING AND GREEN ROOFS



Lucas Museum of Narrative Art

CITY OF LOS ANGELES FOUNDED 1781

Lucas Museum — Los Angeles

LERA 1923 2023 100

Stantec

Hover to to Play

LANDSCAPING AND GREEN ROOFS

South Park

Lessons

- Complex project can require further testing and design revisions to satisfy permitting agencies
- Design of green roofs can be complex in high seismic regions.

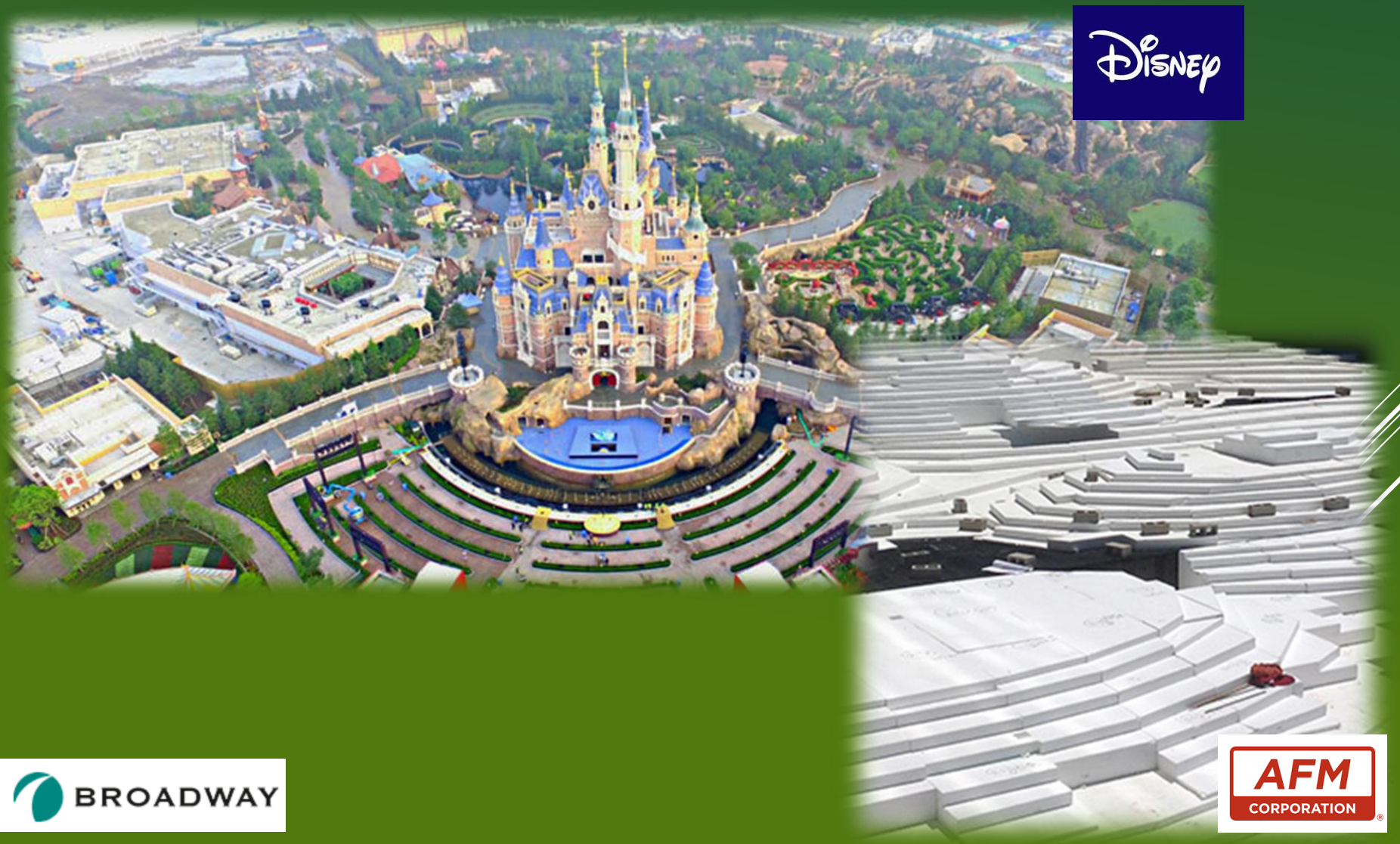
South Park – Mirror Water Feature

Los Angeles Dept. of City Planning

ICE CREAM CASTLES IN THE SKY?

LANDSCAPING AND GREEN ROOFS

Mission Rock Development, San Francisco, CA

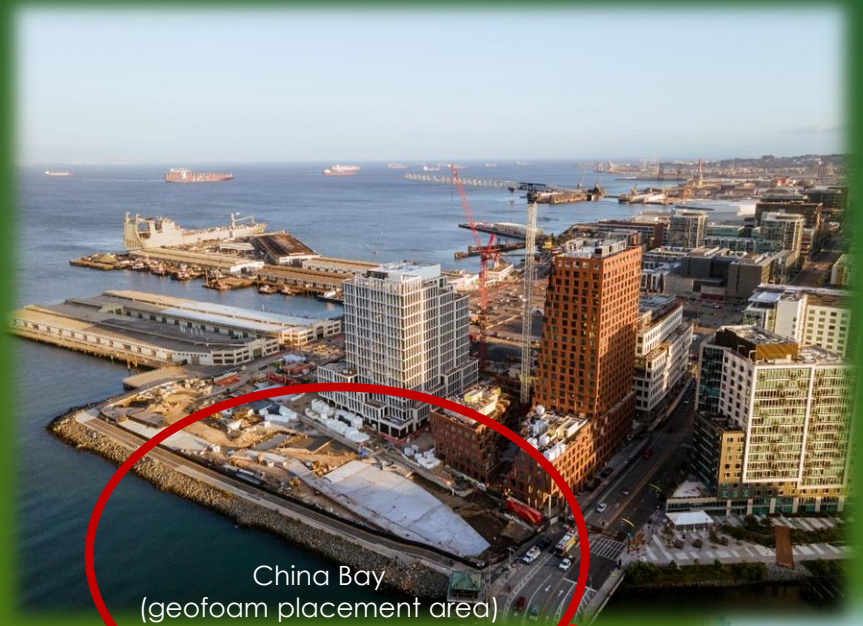


BROADWAY

AFM CORPORATION

COASTAL ENGINEERING & GROUND RECLAMATION

Mission Rock Development, San Francisco, CA



TISHMAN SPEYER
Where Matters

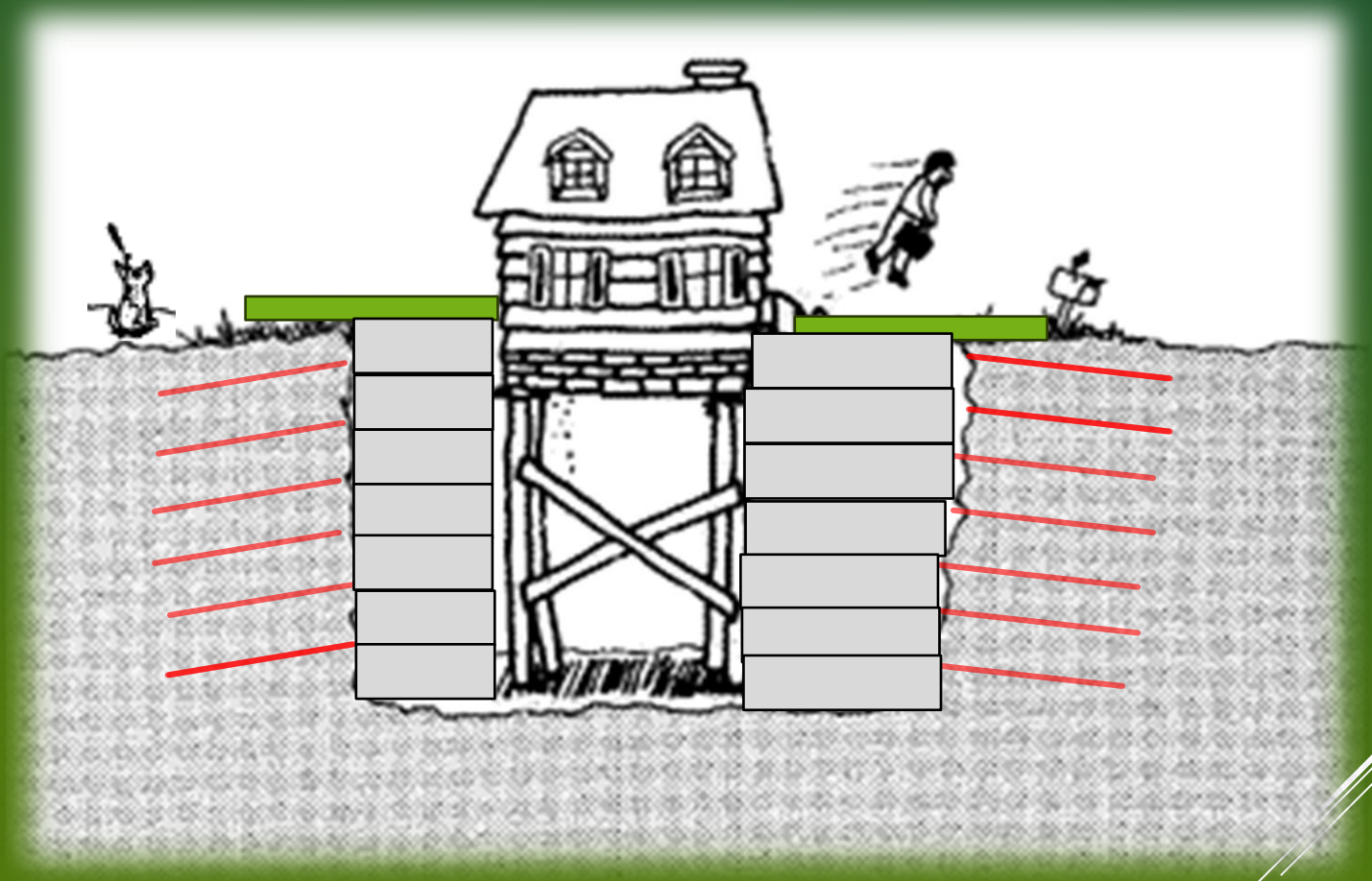
PORT OF SAN FRANCISCO

MISSION ROCK RESIDENTIAL

LANGAN

SGA

HOUSES WITH FLYING MEN?



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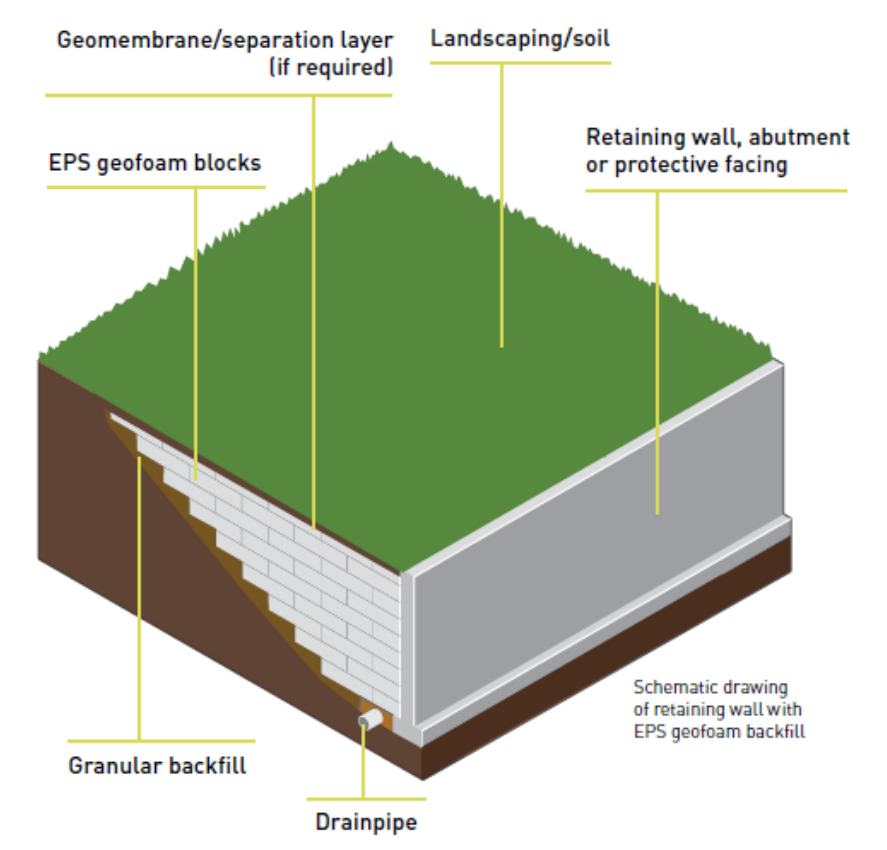
RETAINING & WALL BACKFILL

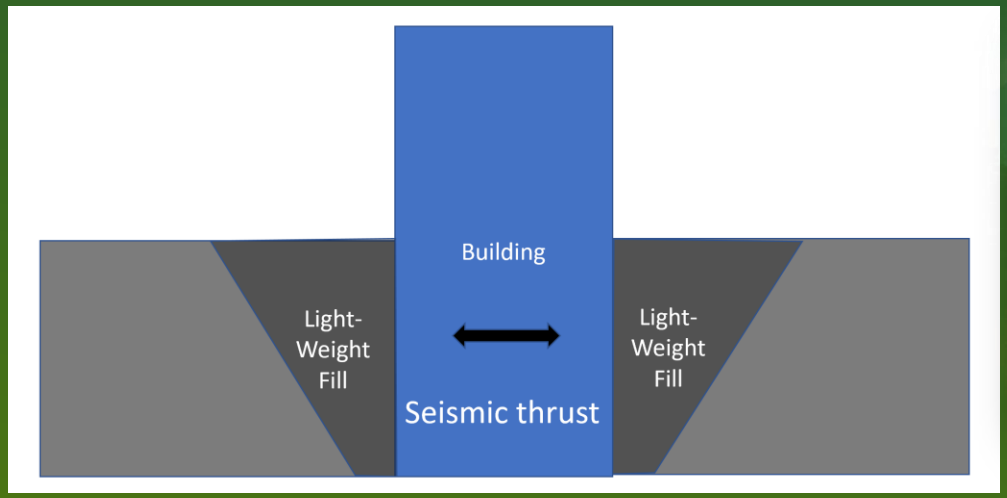
Reduction of Earth Pressures Against Structures



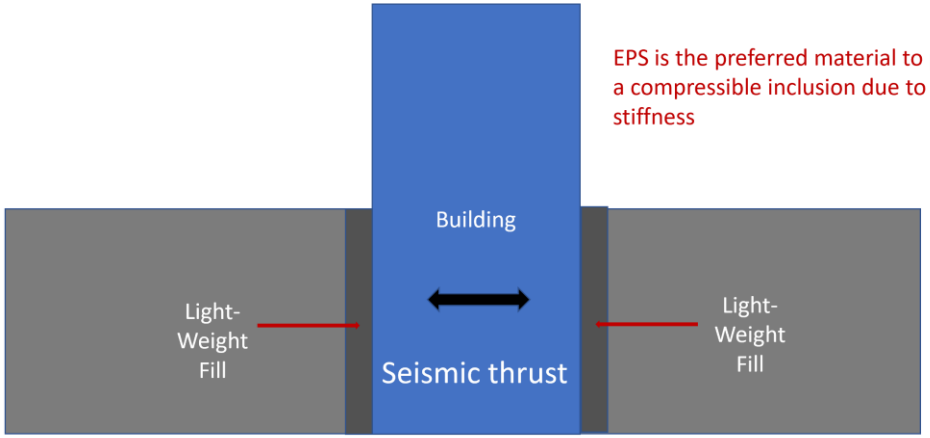
(EPS Geofoam Applications & Technical Data by EPSIA, 2012)

RETAINING & WALL BACKFILL

Reduction of Earth Pressures Against Structures



EPS is the preferred material to produce a compressible inclusion due to its low stiffness



Seismic thrust greatly reduced due to low unit weight and compressibility of light-weight materials

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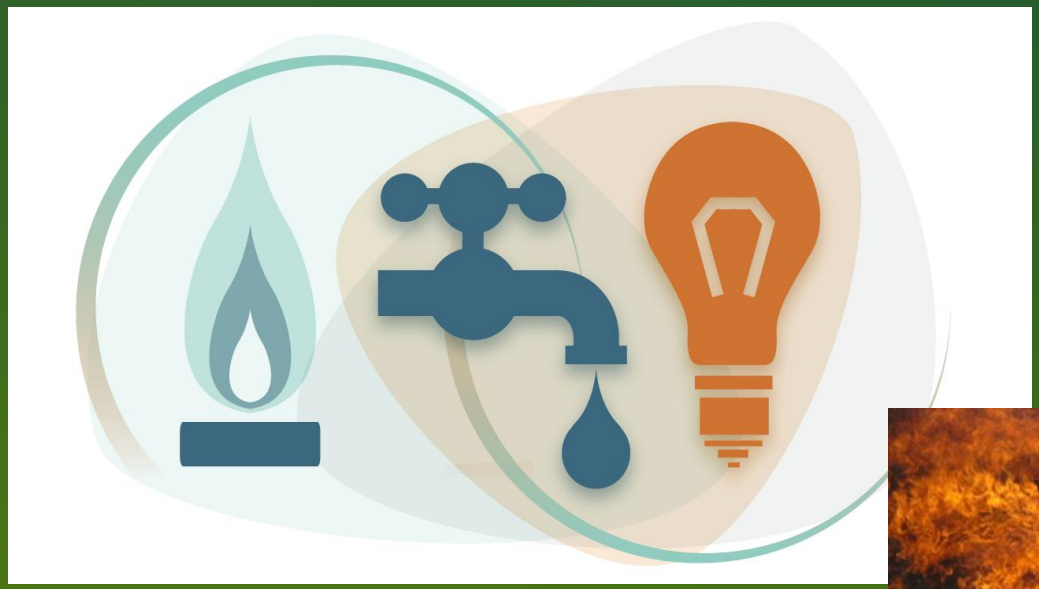
UTILITIES THAT NEVER BREAK?



Dominion Energy®

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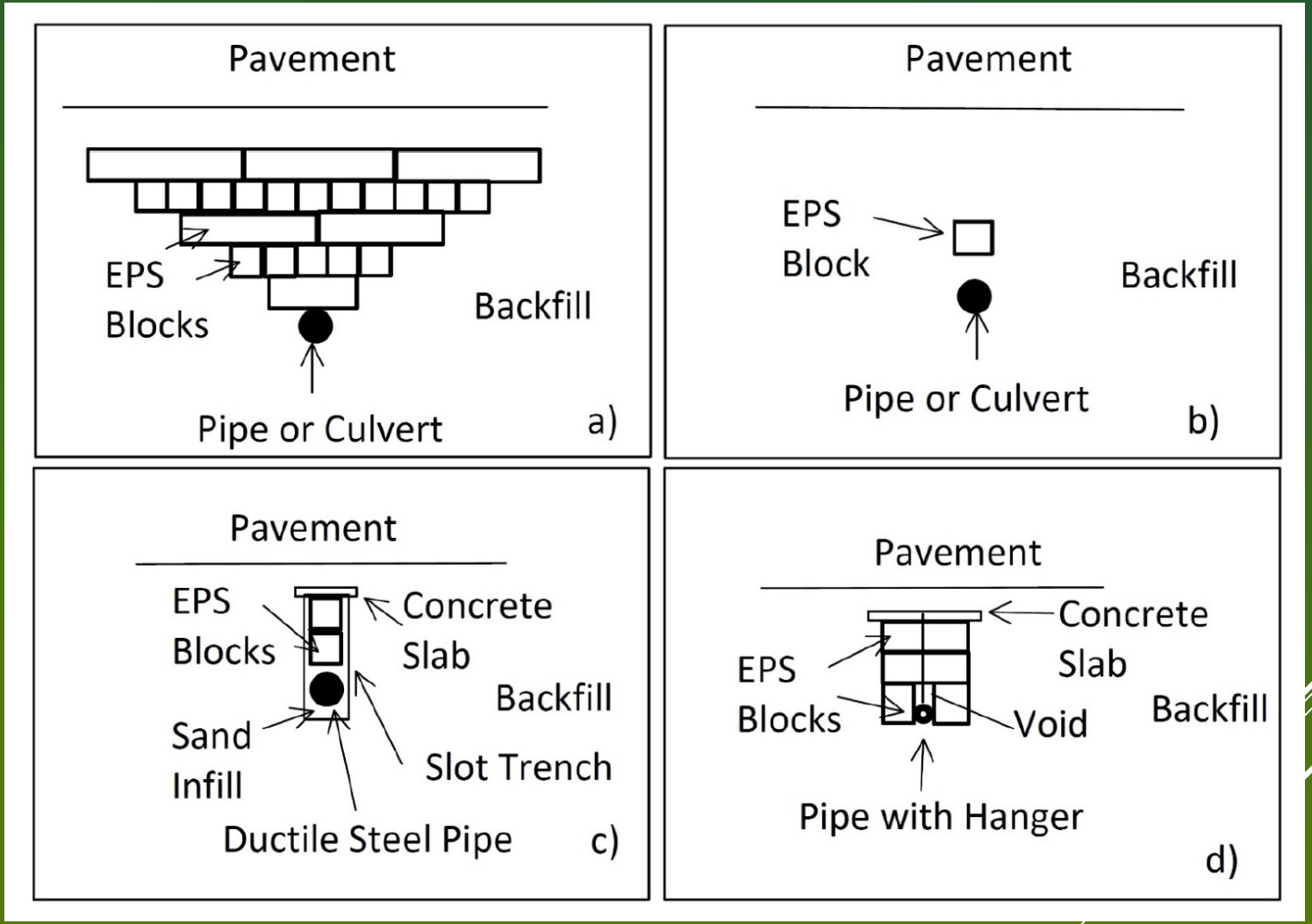
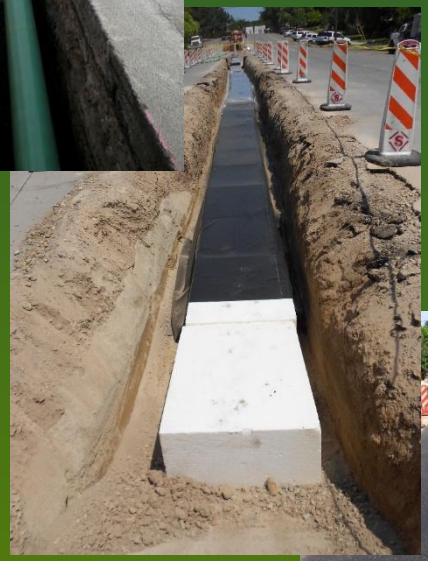
REDUCTION OF LOAD ON UTILITIES AND PIPELINES



REDUCTION OF LOAD ON UTILITIES AND PIPELINES



UTA

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Dominion Energy

BRIDGES APPEARING IN THE NIGHT?

Statens vegvesen

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BRIDGE APPROACH FILL

UTA Light and Commuter Rail – Salt Lake Valley, Ut

ACCELERATED BRIDGE CONSTRUCTION

Lokkeberg Bridge,
Norway

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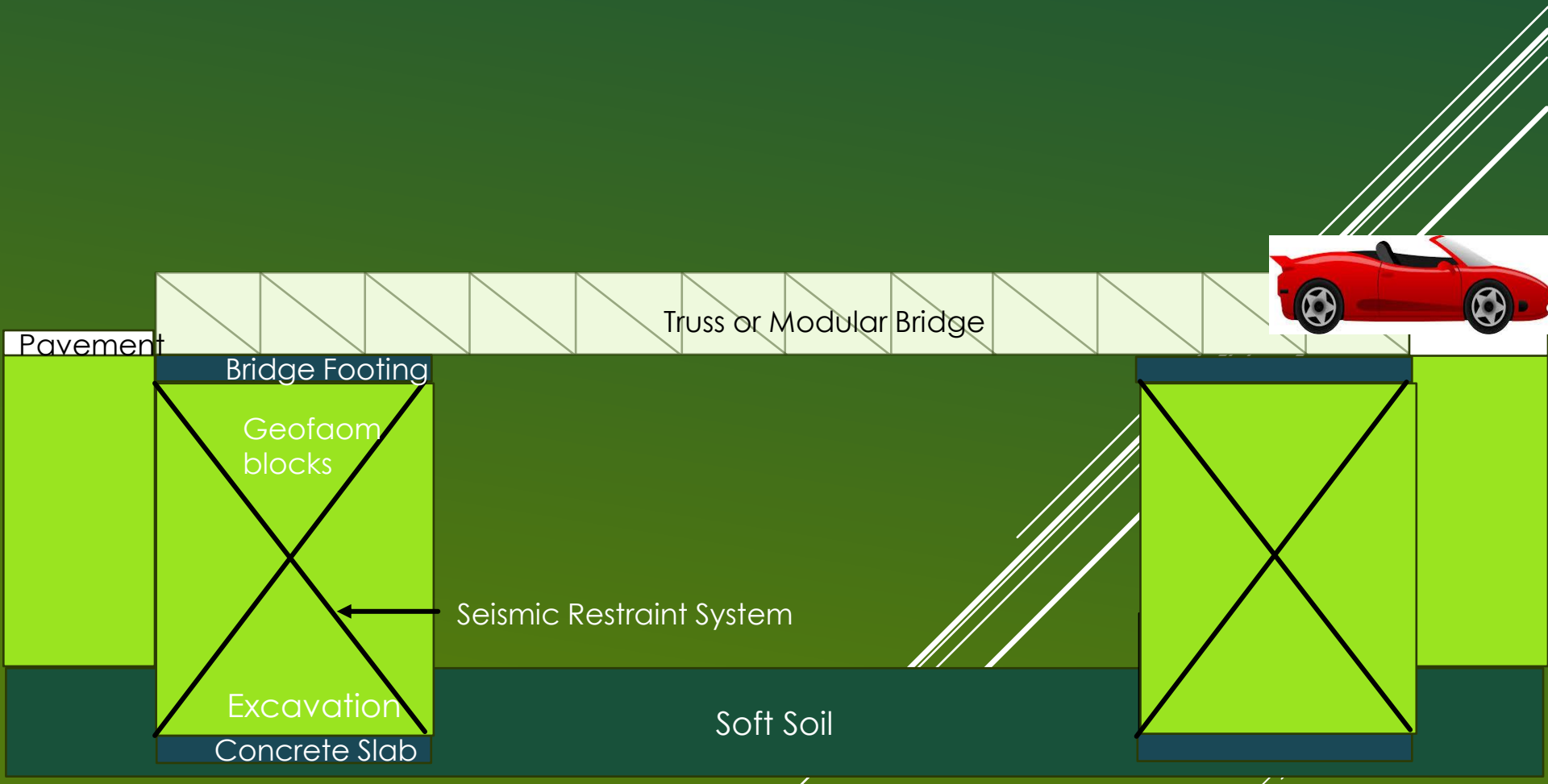
ACCELERATION BRIDGE CONSTRUCTION



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ATLANTIS REBORN?

FLOATING CITIES

Oxagon, Neom, Saudi Arabia

Oceanix City, Busan, S. Korea

FLOATING PLATFORMS AND BUILDINGS

Structural insulated panel
With polystyrene core

SIPs can be up to 70 percent more energy efficient than conventional buildings

SIP Construction

CONSTRUCTION OF FLOATING PLATFORMS

http://amphibioushomes.weebly.com/floating-foundations--bases.html

MATERIAL AND CONSTRUCTION CONSIDERATIONS

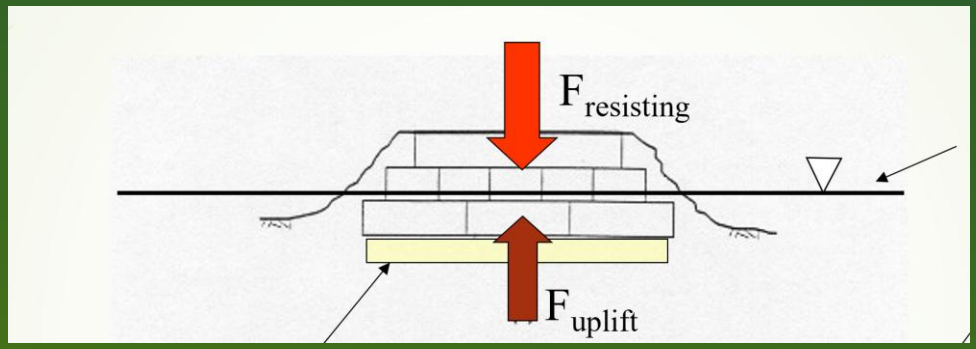
- Buoyancy can be minimized by installing geofoam above the water table and ensuring suitable drainage. In addition, it can be counteracted by placing overlaying soils, pavements, sidewalks to sufficiently offset uplift forces resulting from buoyancy.

- Chemical resistance - EPS geofoam does not decompose nor is affected by road salts. Petroleum products and other chemicals can damage EPS, so incorporation of protective layers or barriers is used (e.g., soil cover, concrete slabs, geo-membranes, etc.).

- Flammability - EPS is combustible when exposed to an oxygen source, so it is important to cover with non-flammable materials (i.e., soil, etc.) and include a flame retardant. Geofoam is usually isolated by membranes, soils, or pavement in the finished application.

BUOYANCY CONSIDERATIONS

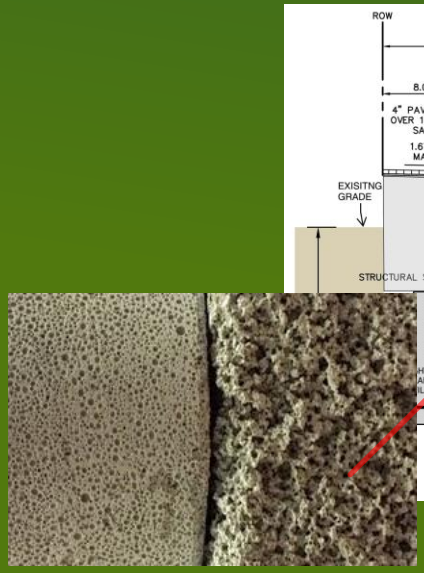
Option 1 - Use weight of EPS cover

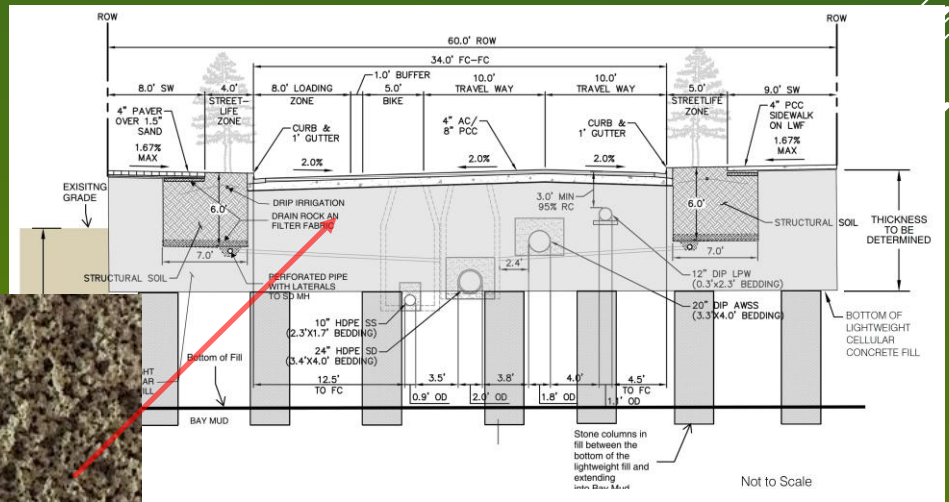


Maximum groundwater level

F resting > 1.2 F uplift

Option 2 - Use permeable cellular concrete or granular material below the water table





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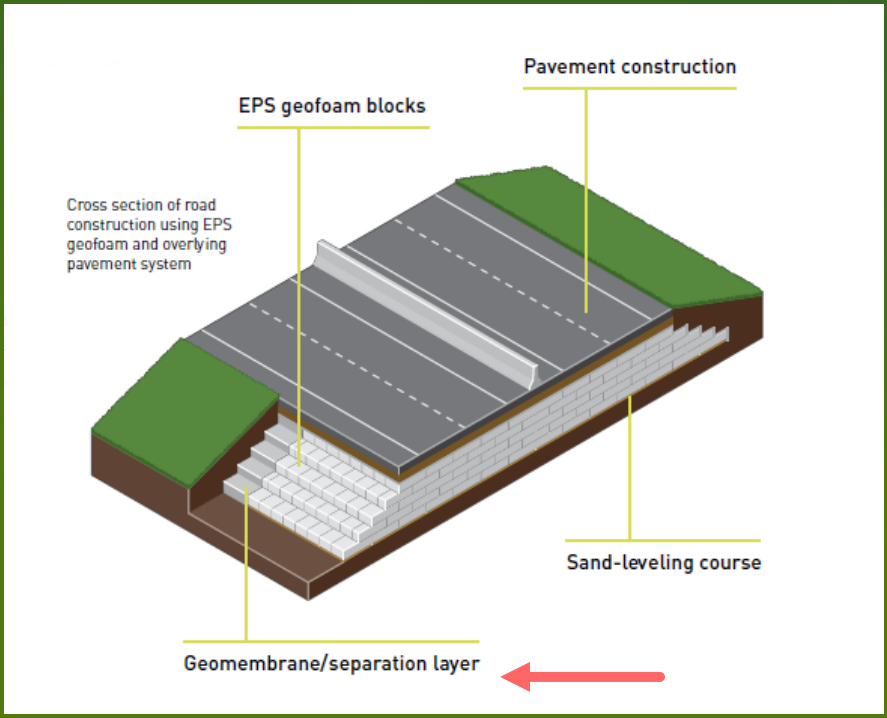
CHEMICAL RESISTANCE CONSIDERATIONS

(1) The possibility of petroleum spill is less because heavy truck and vehicle traffic is not present.

(2) The consequences of potential damage to the EPS are less because landscaping applications are less critical than roadway applications.



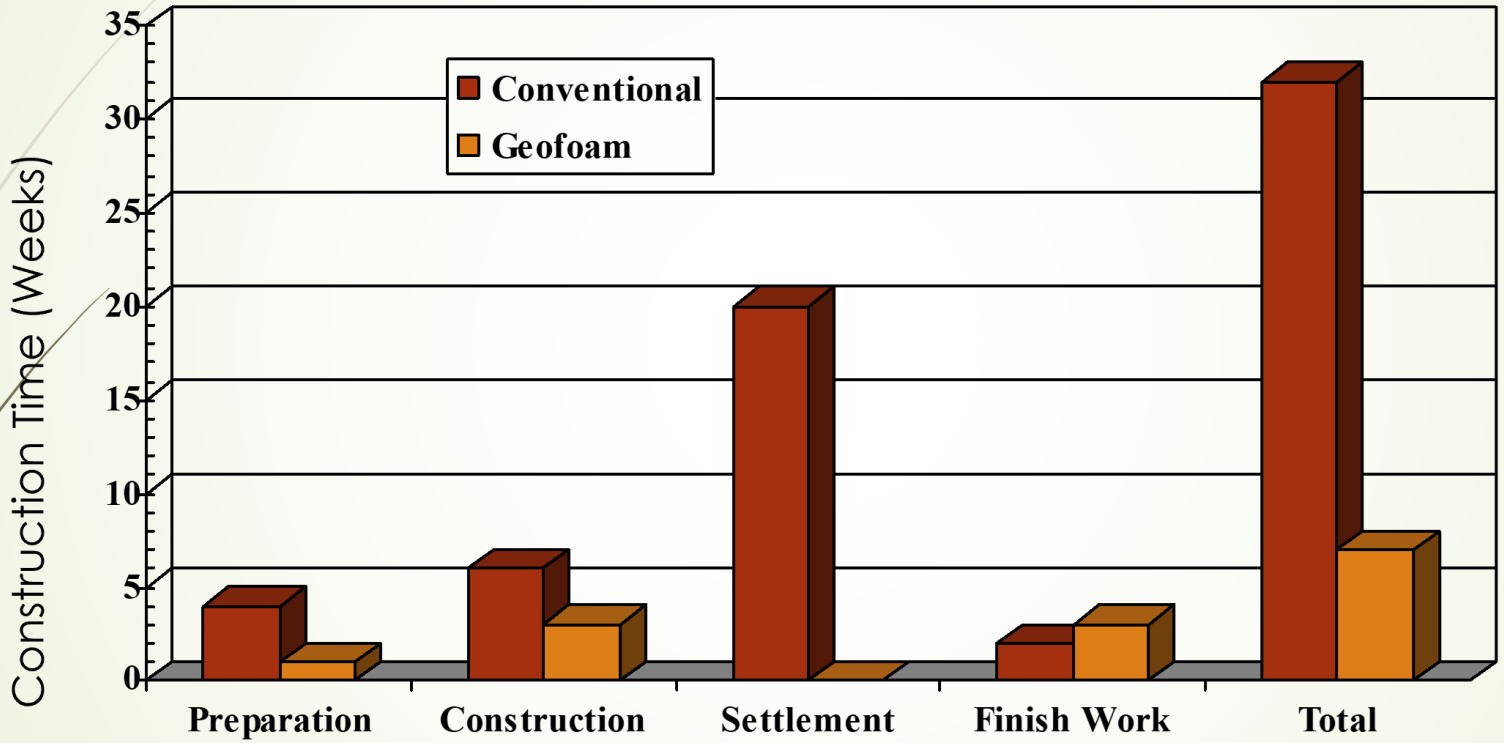
Method 1 – Sloped Embankment With Geomembrane Separation Layer

Method 2 – Vertical Embankment with concrete Load Slab and Precast ConcretePanels

Note Federal Highways Administration will accept either method

I-15 Reconstruction Geofoam Task Force Team

SCHEDULE COMPARISON



Typical Construction Time from I-15 Project

COST COMPARISON

Geotechnology	Various construction activities (*With typical unit cost*)	Associated costs (Year 2000)
Lime cement columns	Existing embankment removal ($6/m^3)	$9,500
	Lime cement column installation (0.8 m *column*—$17.5/m, 0.6 m *column*—$16/m)	$97,000
	One-stage MSE wall/embankment construction ($200/m^2 *wall face*)	$43,500
	One-stage embankment construction, surcharging, settlement, and removal (*placement*—$9/m^3, *removal* $6/m^3)	$10,000
	Total=	**$160,000**
Geofoam	Existing embankment removal ($6/m^3)	$1,500
	Bedding sand ($7/ton, *with 1 crew 1* week)	$5,500
	Geofoam embankment ($45/m^3)	$65,000
	Tilt-up panel wall ($200/m^2 *wall face*)	$20,000
	Load distribution slab ($60/m^2 *surface area*)	$23,000
	Embankment above geofoam ($9/m^3)	$5,000
	Total=	**$120,000**
Two-stage MSE wall	Existing embankment removal ($6/m^3)	$9,500
	Bedding sand ($7/ton, *1 crew 2* days)	$2,500
	PV drain installation (1.5 m triangular spacing) ($1.5/m *without predrilling*, $3/m *with predrilling*)	$14,000
	Wall/embankment construction and settlement time ($300/m^2 *wall face*, $9/m^3 *embankment*)	$54,000
	Three-stage embankment construction, surcharging, settlement time, and removal (*placement*—$9/m^3, *removal* $6/m^3)	$20,000
	Total=	**$100,000**

The above costs do not include utility relocation costs.
If utilities are present then geofoam is the low cost alternative

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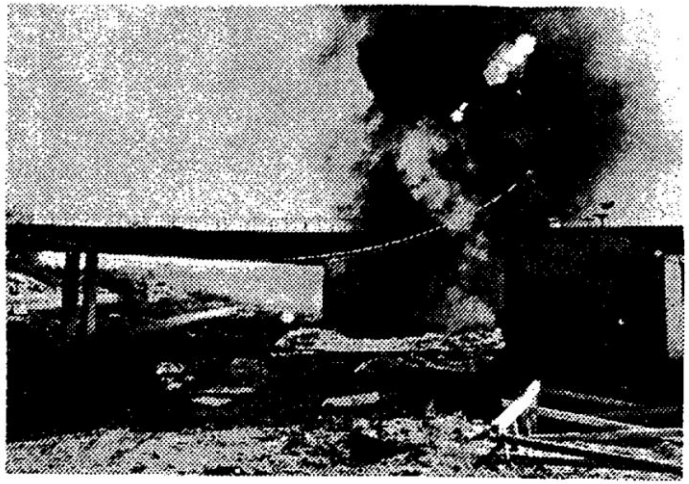
FLAMMABILITY CONSIDERATIONS



a) EPS embankment on fire. Knatten bridge, Norway.

Ordinary Expanded Polystyrene is a combustible material and will bum when set on fire. For this reason some precautions should be taken when constructing EPS fills using the normal quality material. Such precautions may include fencing in any stockpiles on site and provide round the clock guards, or place the blocks directly inn the fill as they arrive on site, working round the clock shifts if necessary.

Alternatively a self-extinguishing quality of EPS may be used at approximately 5 % increase in productions costs. Once the EPS is covered by the pavement material on top and soil on the side slopes, however, there will not be sufficient oxygen available to sustain a fire.

Two failures due to fires have occurred in Norway and were caused by welding activities on bridge abutments adjacent to EPS fills during the construction phase. . . . So the fire potential should not be overlooked and in some counties in Norway the local highway offices are using self-extinguishing material at the somewhat higher cost in order to exclude fire hazards. A third fire incident is reported from Japan. (Proceedings of EPS 1996 – Japan)

FLAMMABILITY CONSIDERATIONS

Step 1 – Use Flame Retardant Additive

EPS Fire Resistance

The primary flame retardant currently used in EPS foam insulation is HBCD. Hexabromocyclododecane (HBCD) is an additive flame retardant that promotes increased fire resistance in EPS building and construction applications. This allows EPS foam insulation to meet the stringent fire safety requirements governed by the International Code Council and National Building Code of Canada, providing increased protection to buildings and building occupants. HBCD has also been used as a flame retardant in solid plastics such as high impact polystyrene and in carpets, upholstery and other textiles.

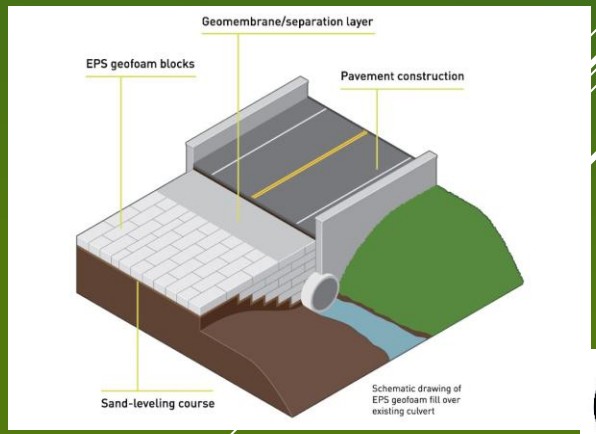
SIPA Structural Insulated Panel Association

Step 2 - Construction Precautions

- Prohibit smoking or any other ignition sources near the EPS block storage and staging area at the job site.
- Keep all sources of ignition away from the installed geofoam area, such as:
  - Welding
  - Open flames
  - Cutting torches
  - Cutting or grinding tools
  - Sources of static or electrical discharge

EPS Industry Alliance

Step 3 – Cover/Incapsulate Block



SCA

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

PARTNERS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Oracle Group
Aerix Industries
Advanced Engineered Foam Solutions
Throop Lightweight Fill
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الهيئة العامة للطيران المدني
مشروع تطوير مطار الملك عبد العزيز الدولي


Design Consultant:
ATKINS


ATLAS


Mission Rock
Residential


LERA
1923
2023
100


NEOM


Lucas Museum of Narrative Art


ISO Moulders SA


ARM Group
Engineers and Scientists


OSP
برنامج استدامة الطلب على البترول
Oil Sustainability Program


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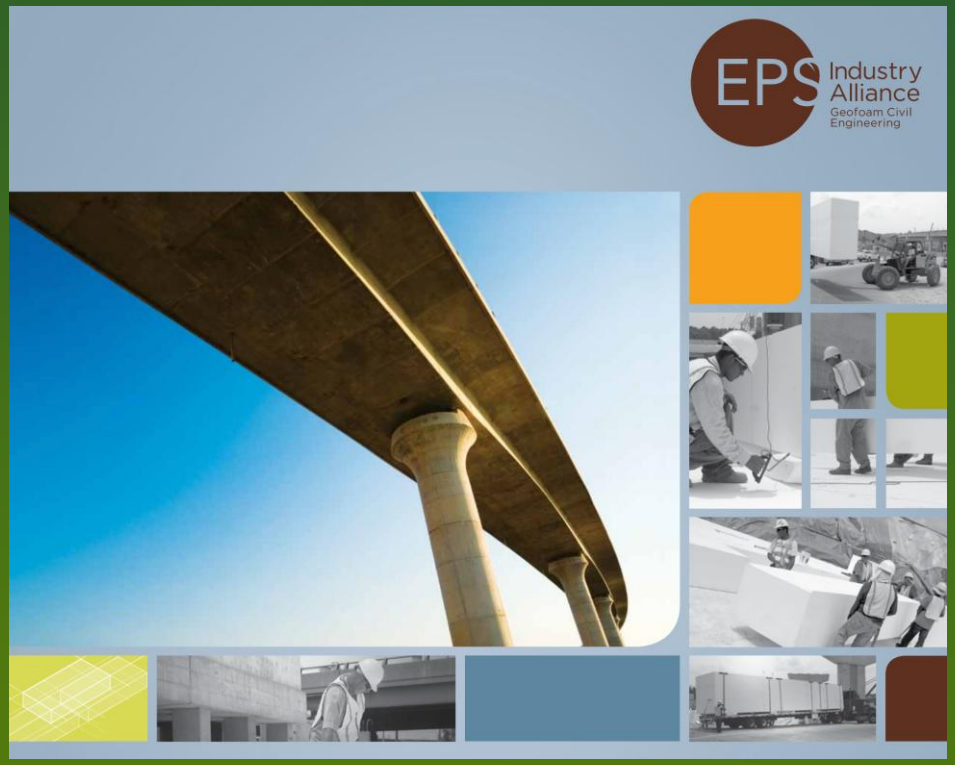
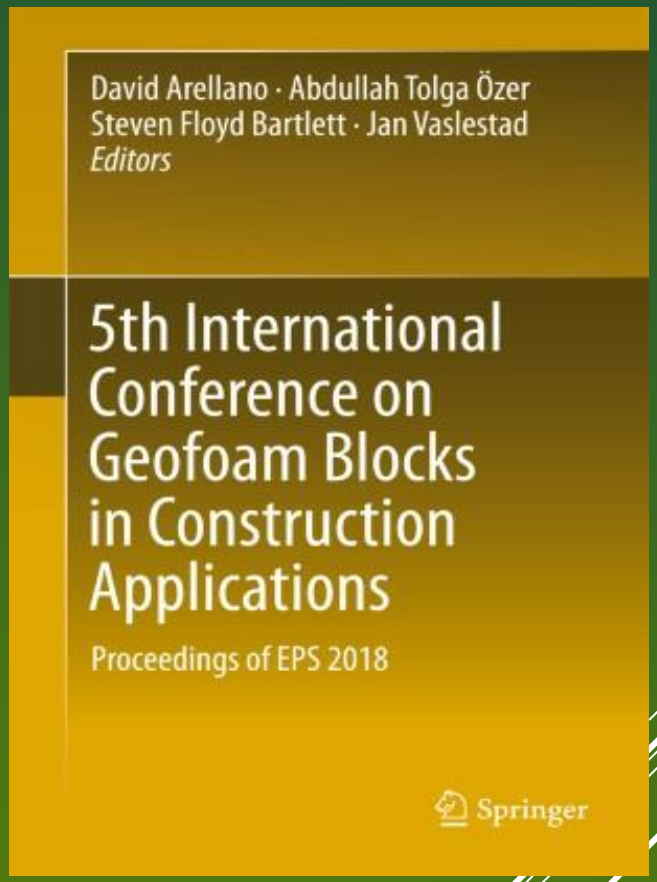
Cell-Crete
Kiewit
Polioles
EPS Industry Alliance
EPSDER
EPS Sanayi Derneği
Turkish EPS Industry Association
EUMEPS
Stacy and Witbeck

RESOURCES



https://www.geofoam.com/?pdf=EPS-Geofoam-Applications-Technical-Data.pdf&id=968

Authors: Stark, Bartlett and Arellano, 2012



https://www.springerprofessional.de/en/5th-international-conference-on-geofoam-blocks-in-construction-a/15790828?tocPage=1