TIRE DERIVED AGGREGATE BACKFILL FOR RETAINING WALLS

Christopher L. Helstrom
Haley and Aldrich, Inc.

James L. Foster Jr., P.E.
Quincy Engineering, Inc.

Western Bridge Engineers' Seminar
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Acknowledgements

Stacey Patenaude

California Integrated Waste Management Board

Acknowledgements

Why use TDA for retaining wall backfill?

- Low unit weight (0.8 Mg/m^3)
- Free draining ($k > 1$ cm/s)
- Good thermal insulation (8 x better than soil)
- 100 tires per m^3!

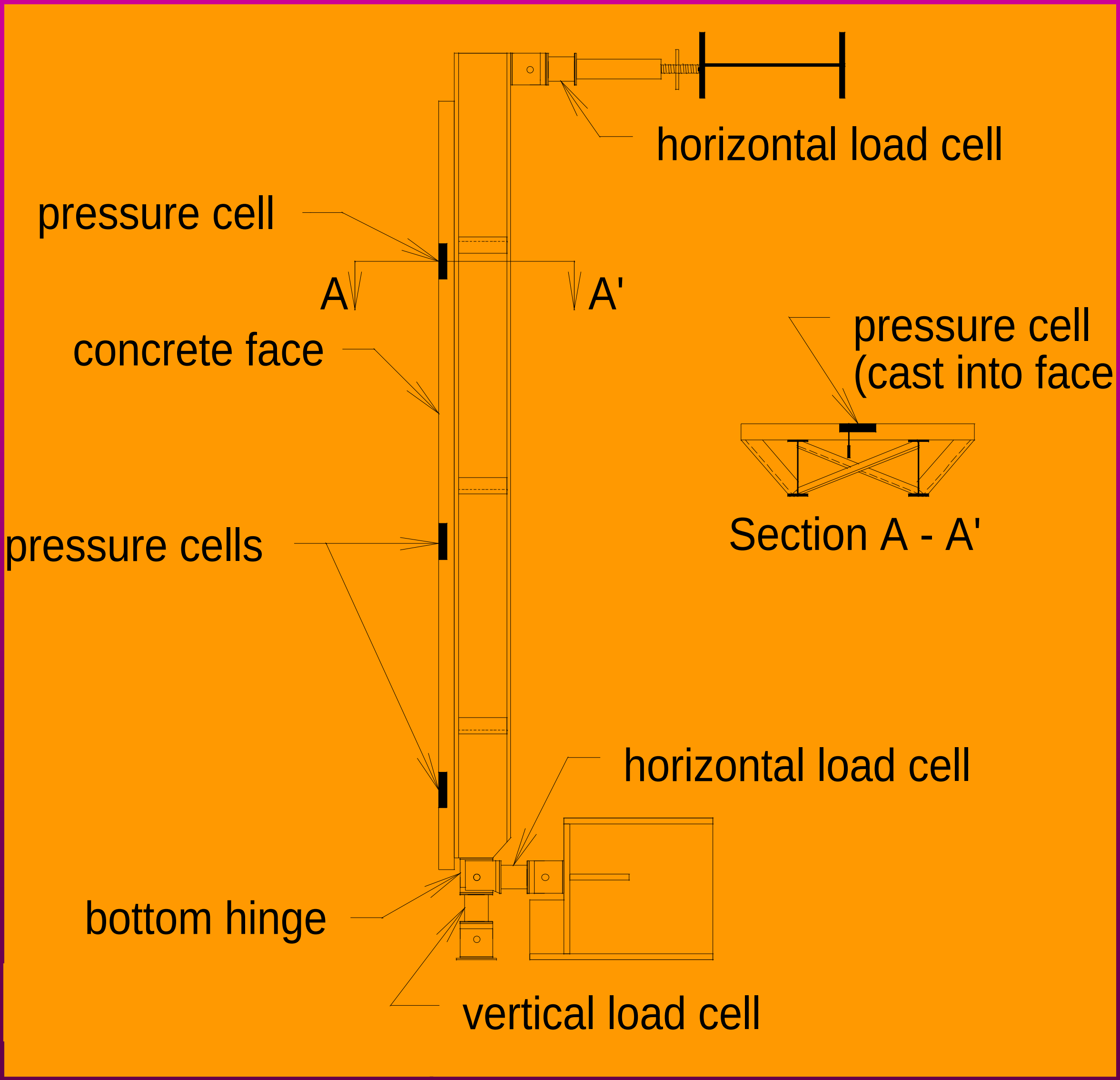
Five full-scale instrumented Walls

- UMaine Test Wall (three trials)
- North abutment Merrymeeting Bridge (Topsham, ME)
- Limestone Run Bridge (Tarrtown, PA)
- Wall 119 (Riverside, CA)
- Wall 207 (Riverside, CA)

Interior of UMaine Test Wall facility

Orono, ME

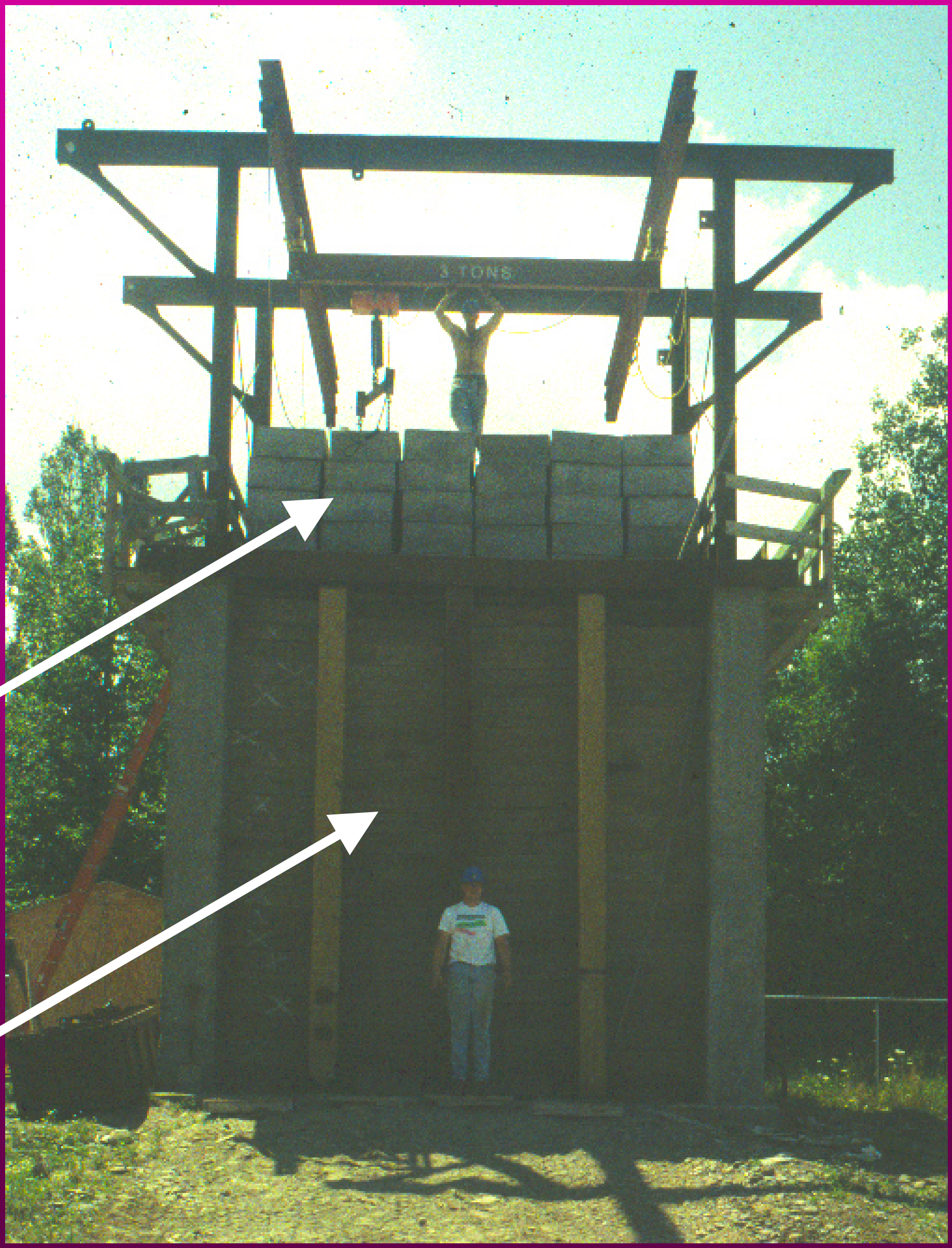
UMaine instrumented front wall



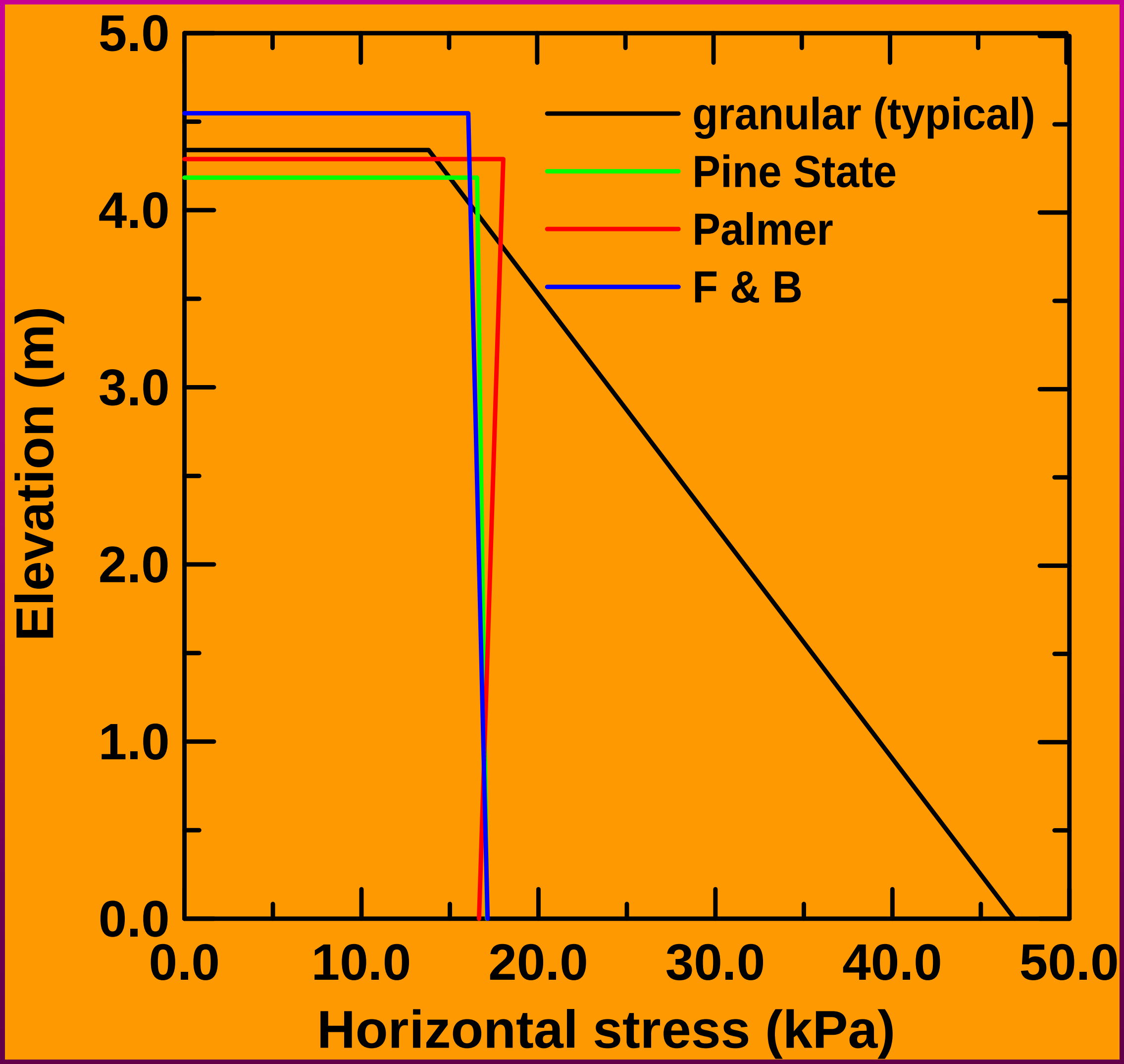
Test facility fully loaded

Surcharge blocks

Removable backwall



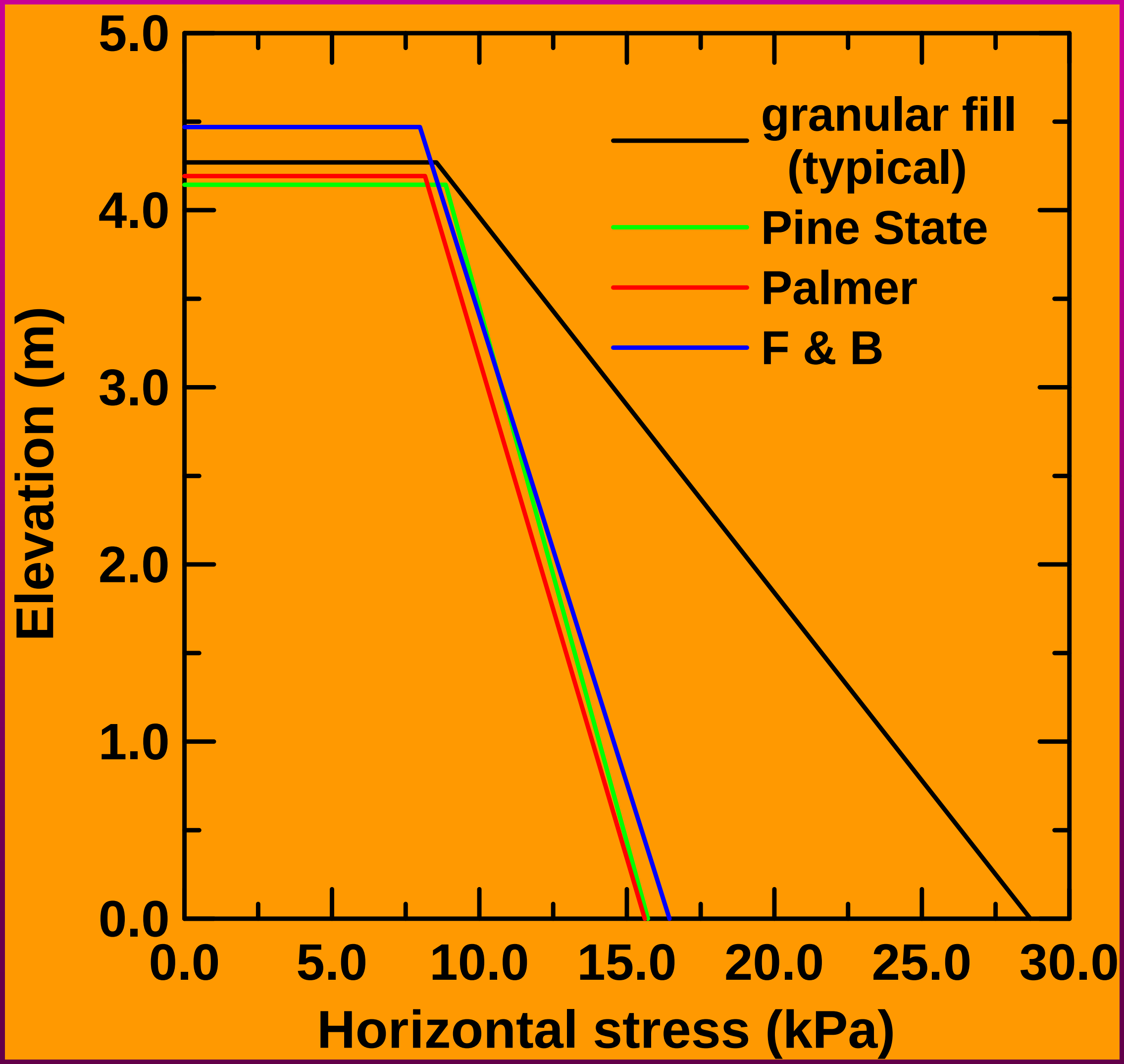
At-rest stress distribution at 35.9 kPa surcharge



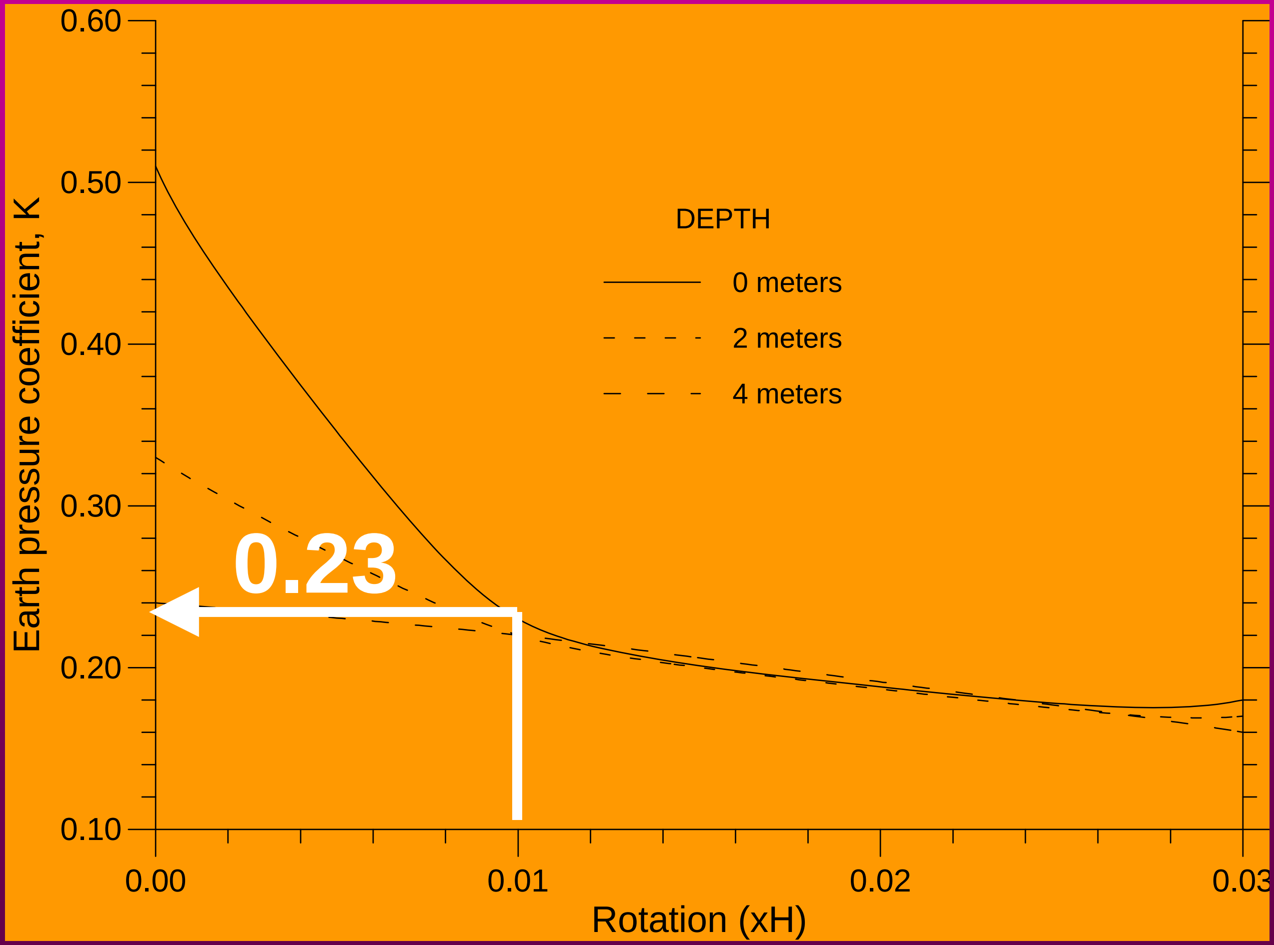
Rotating wall away from backfill

Screw Jacks

Stress at 35.9 kPa surcharge and 0.01H rotation



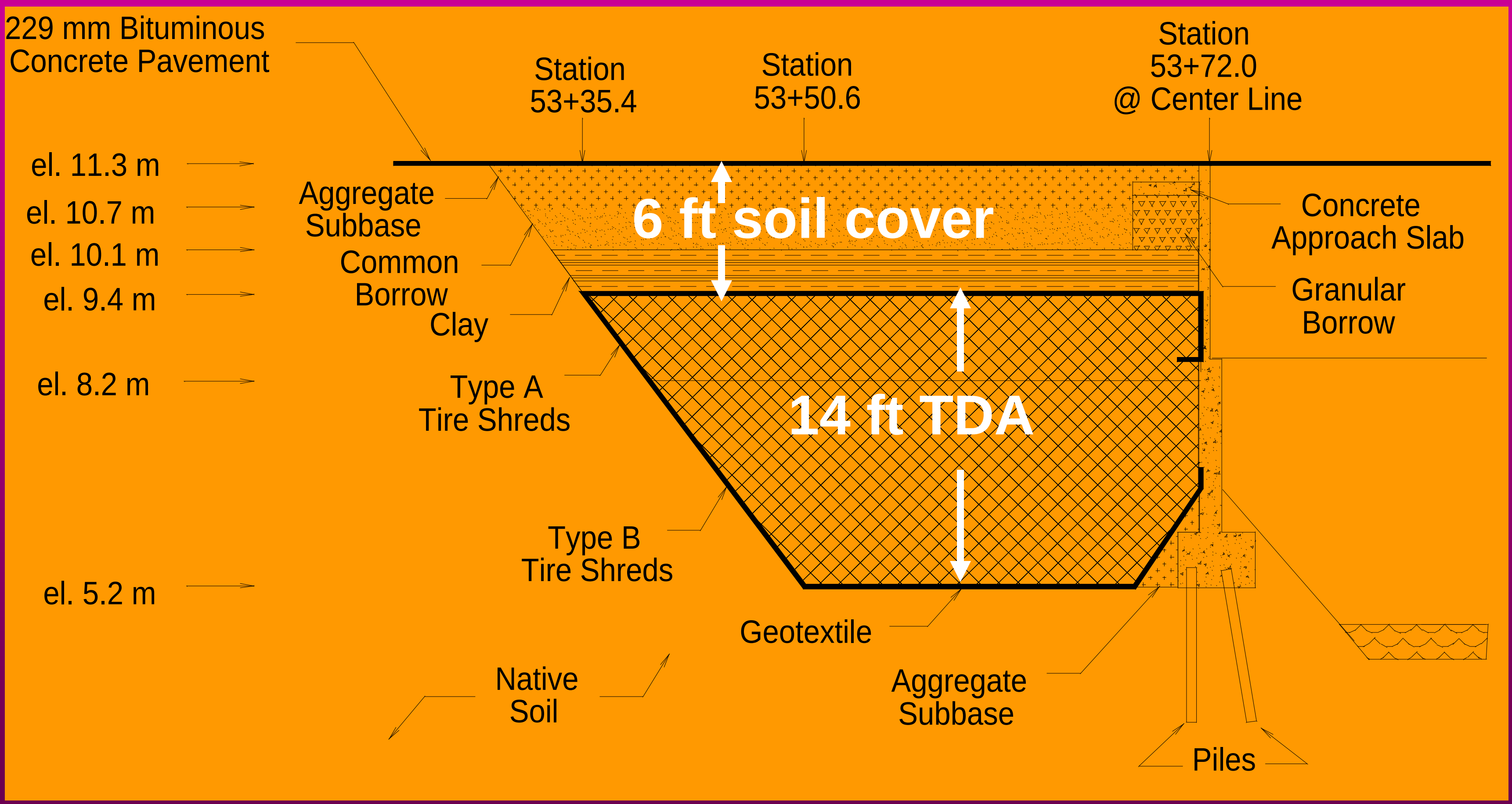
Effect of rotation on earth pressure coefficient



North Abutment of Merrymeeting Bridge Topsham, ME

- Bridge approach underlain by weak clay
- Existing factor of safety = 1.1
- Excavate upper portion of existing slope
- 14 ft of TDA fill covered by 6 ft of soil
- Used 400,000 tires

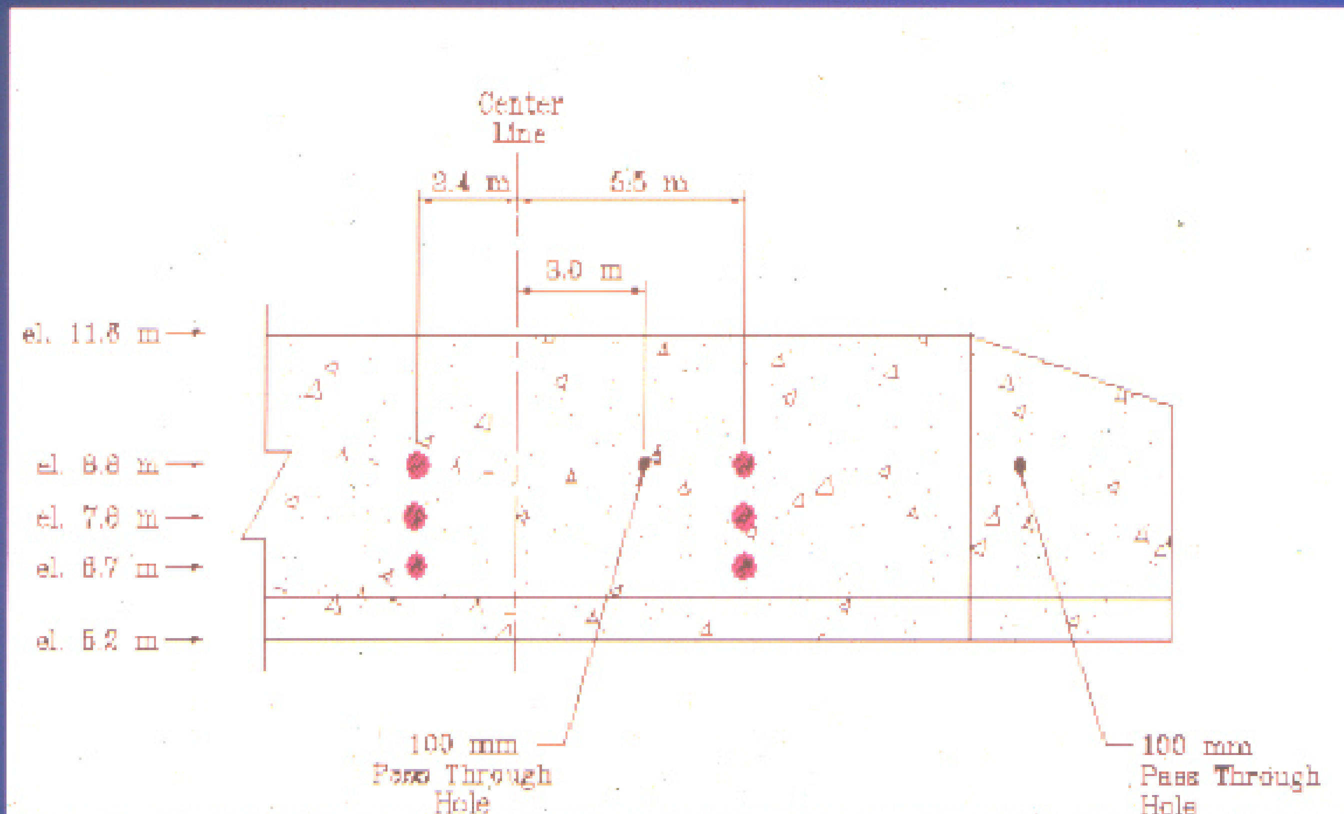
Cross section of north abutment



Placement with Dump Truck

Compaction with 10-ton Roller

Pressure Cell Locations
North Abutment



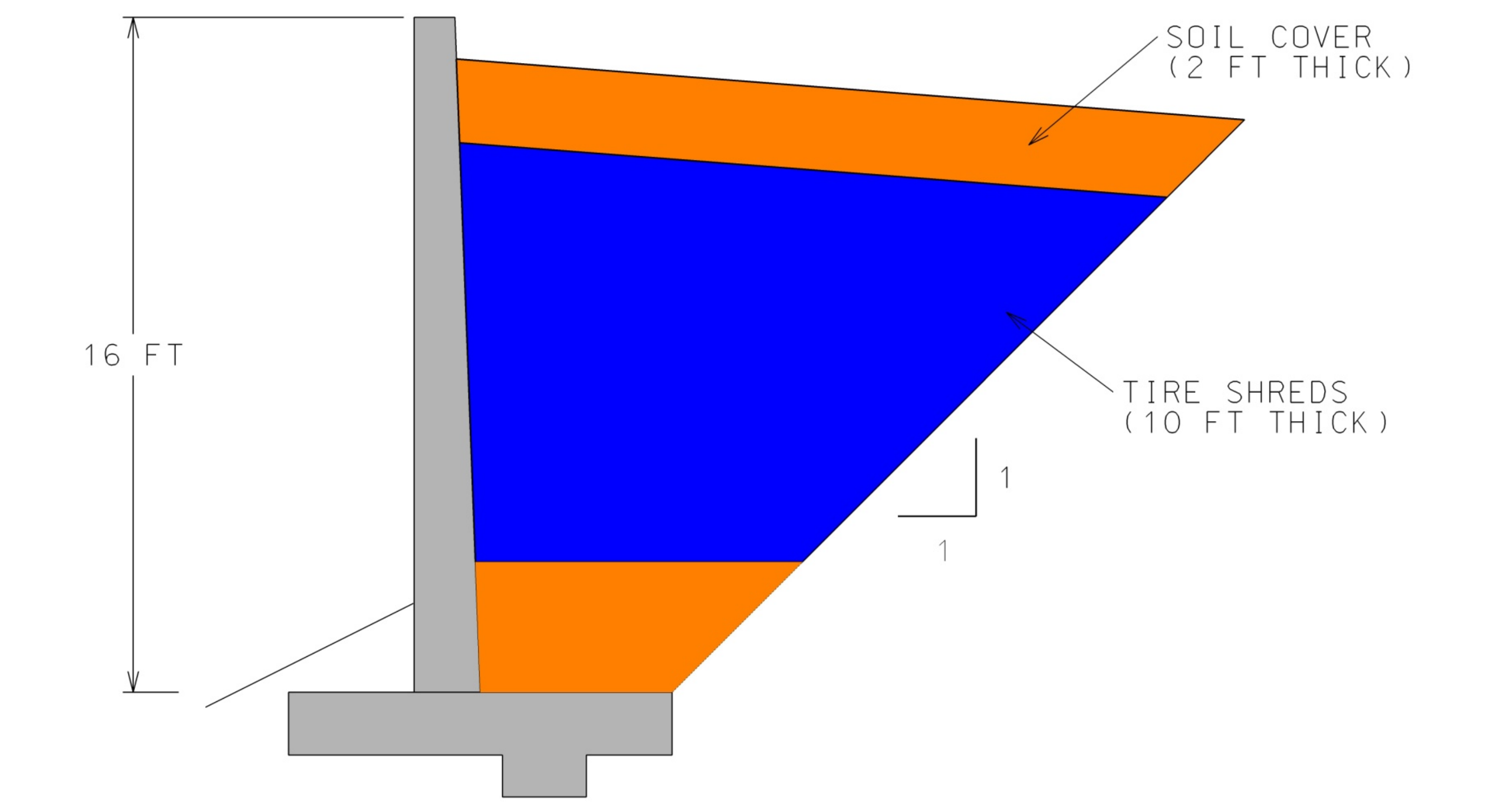
Limestone Run Bridge
Tarrtown, PA

- Two massive pile supported bridge abutments
- Abutment 1 had a single 10-ft thick layer of TDA overlain by 4.5 ft soil
- Abutment 2 had 10-ft thick TDA layer overlain by 3-ft soil, then second TDA layer with 3-ft thickness at the abutment overlain by 4.5 ft soil

Wall 119 in Riverside, CA

- Freeway widening
- Three sections with TDA and one with soil
- Length: 79 m
- Tires used: 75,000 PTE

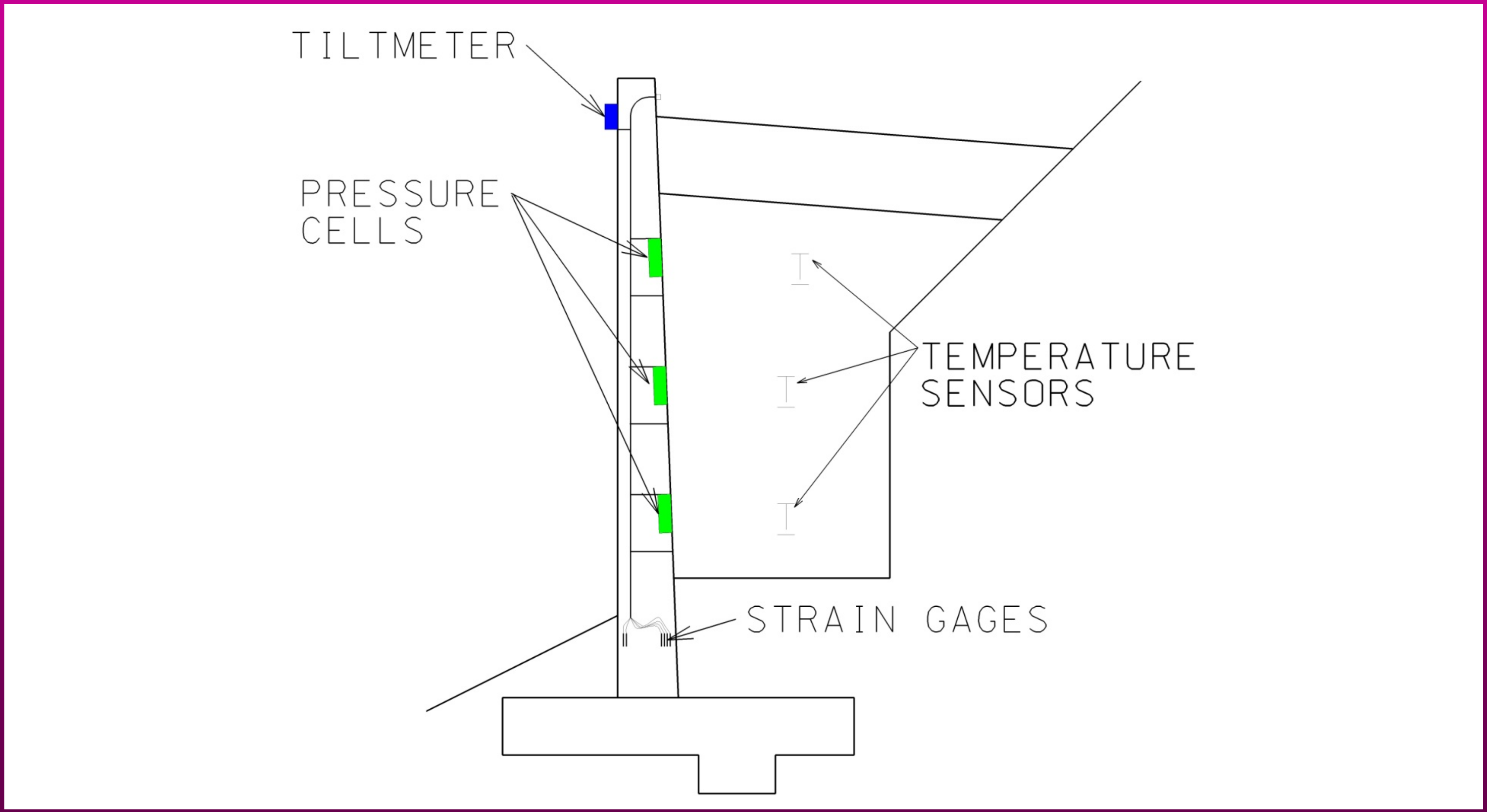
Wall 119 cross section



Compacting TDA

Placing soil cover

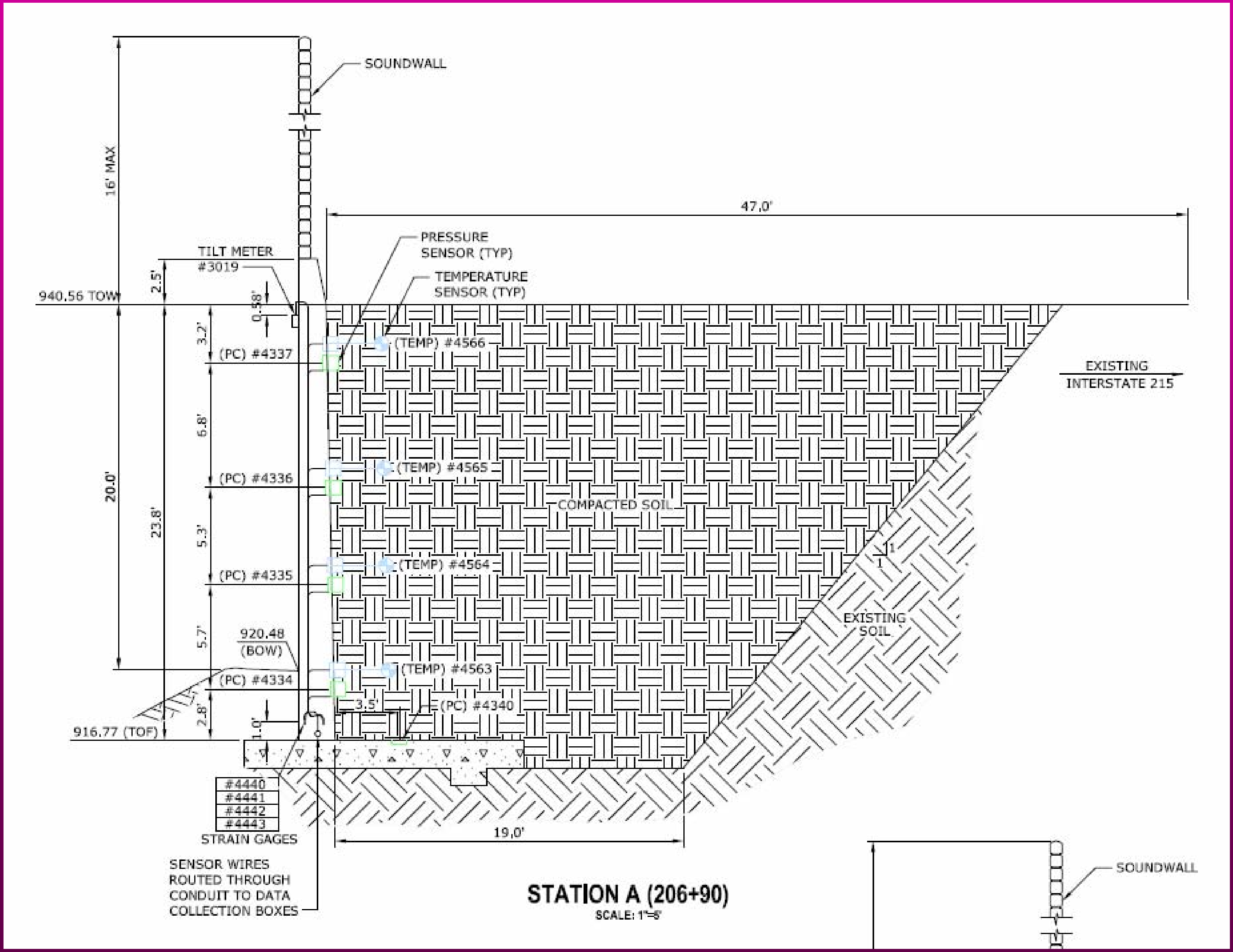
Wall 119 instrumentation



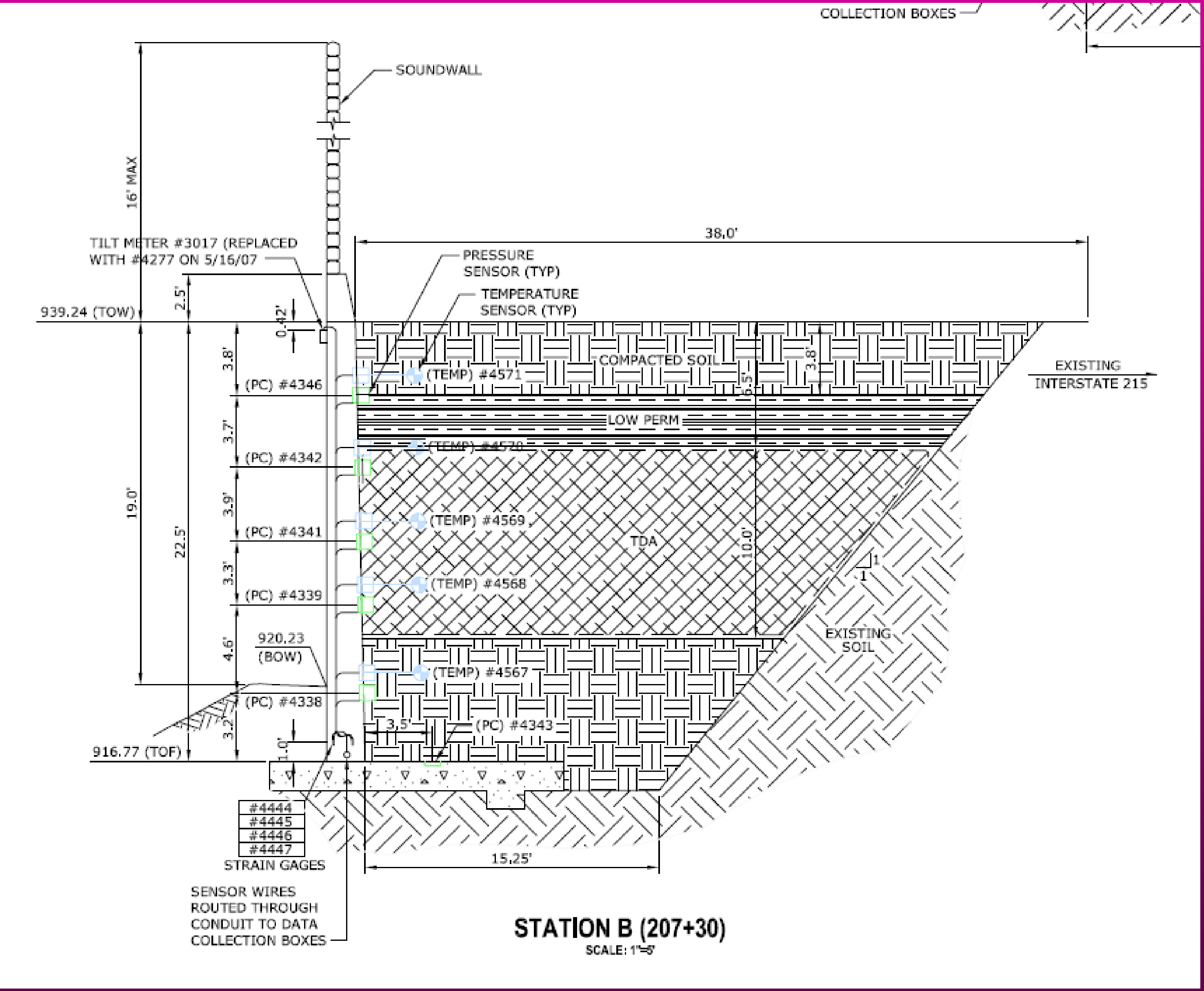
Wall 207 in Riverside, CA

- Two sections with soil backfill
- Two sections with TDA backfill

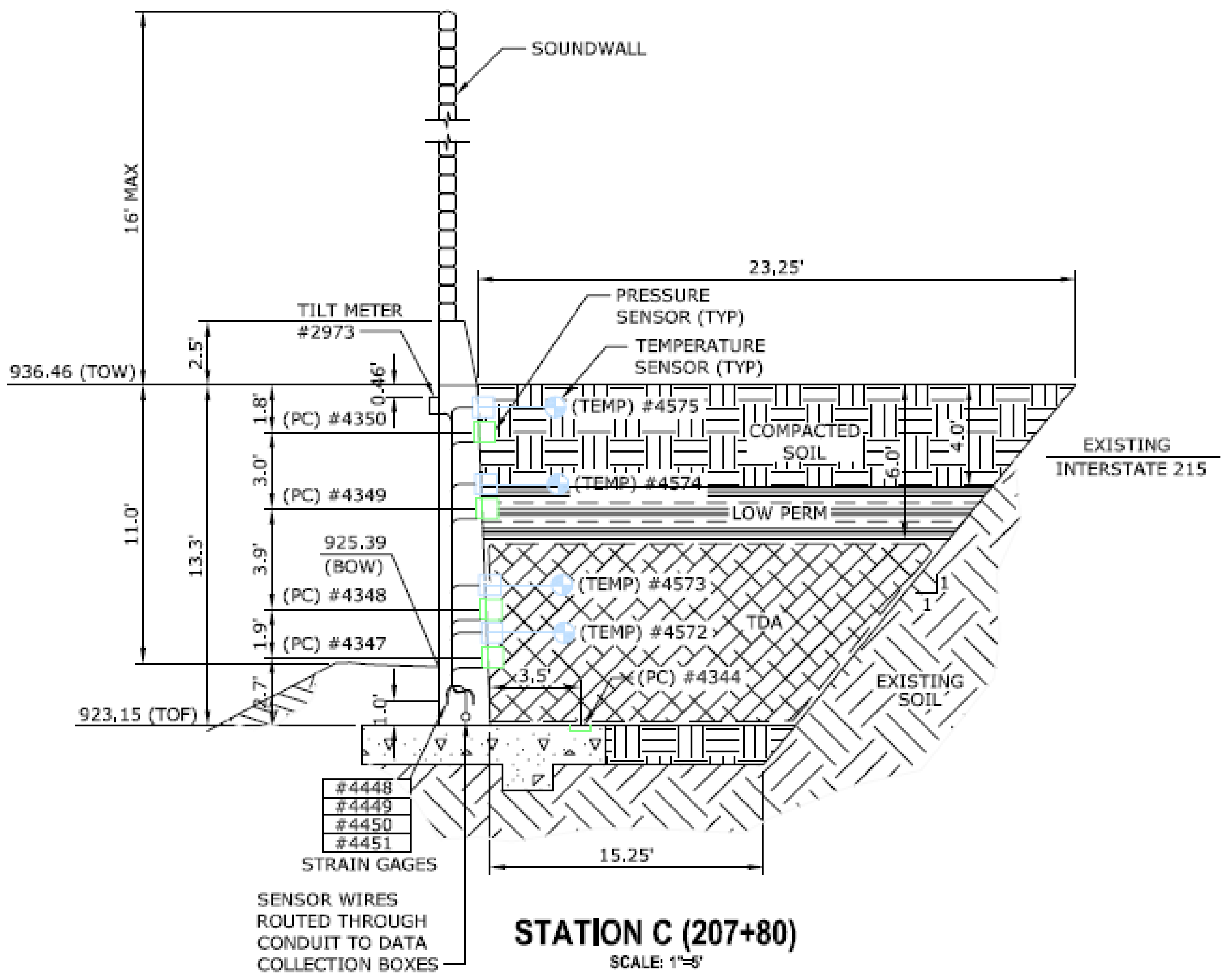
Wall 207 Station A



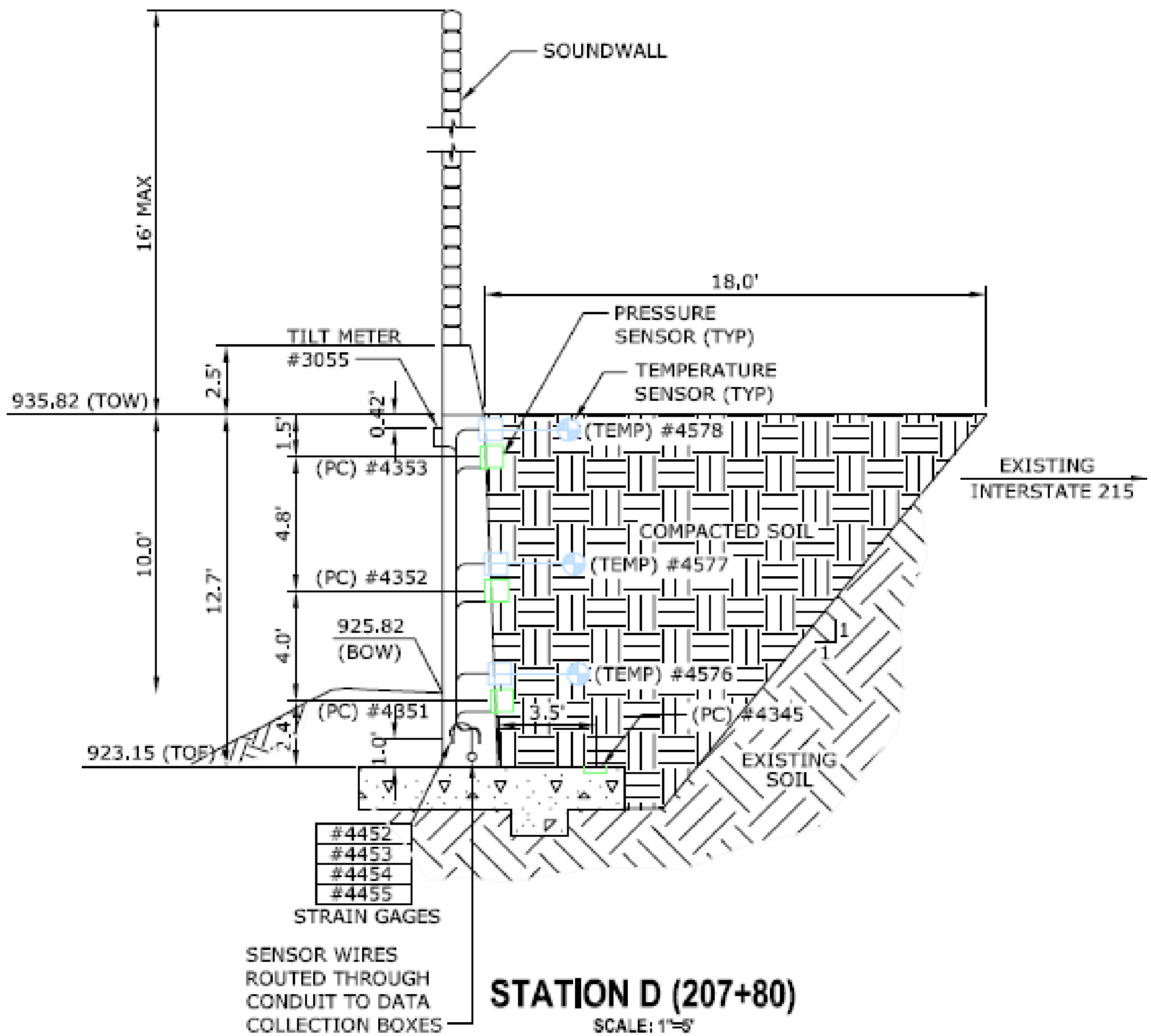
Wall 207 Station B



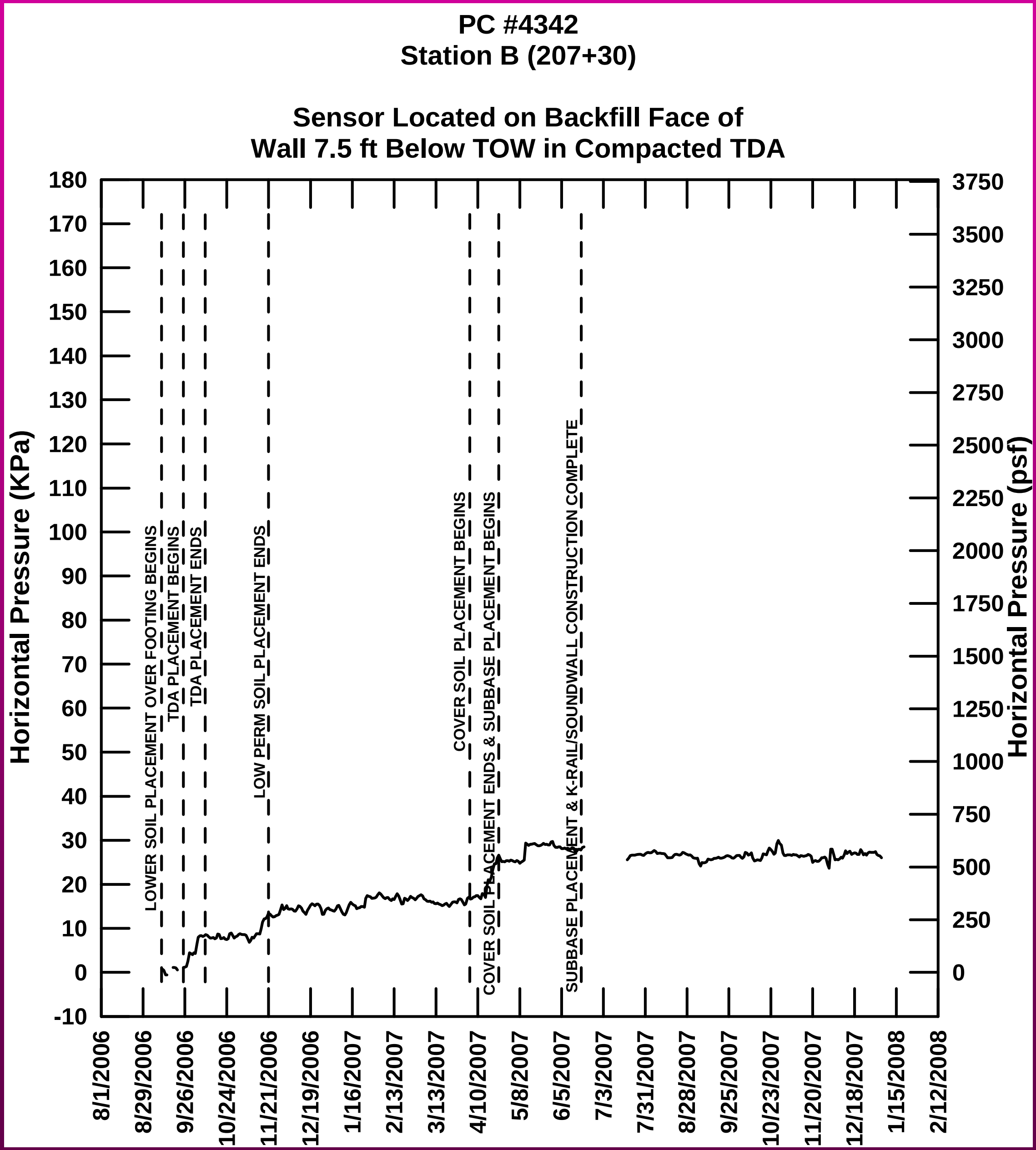
Wall 207 Station C



Wall 207 Station D



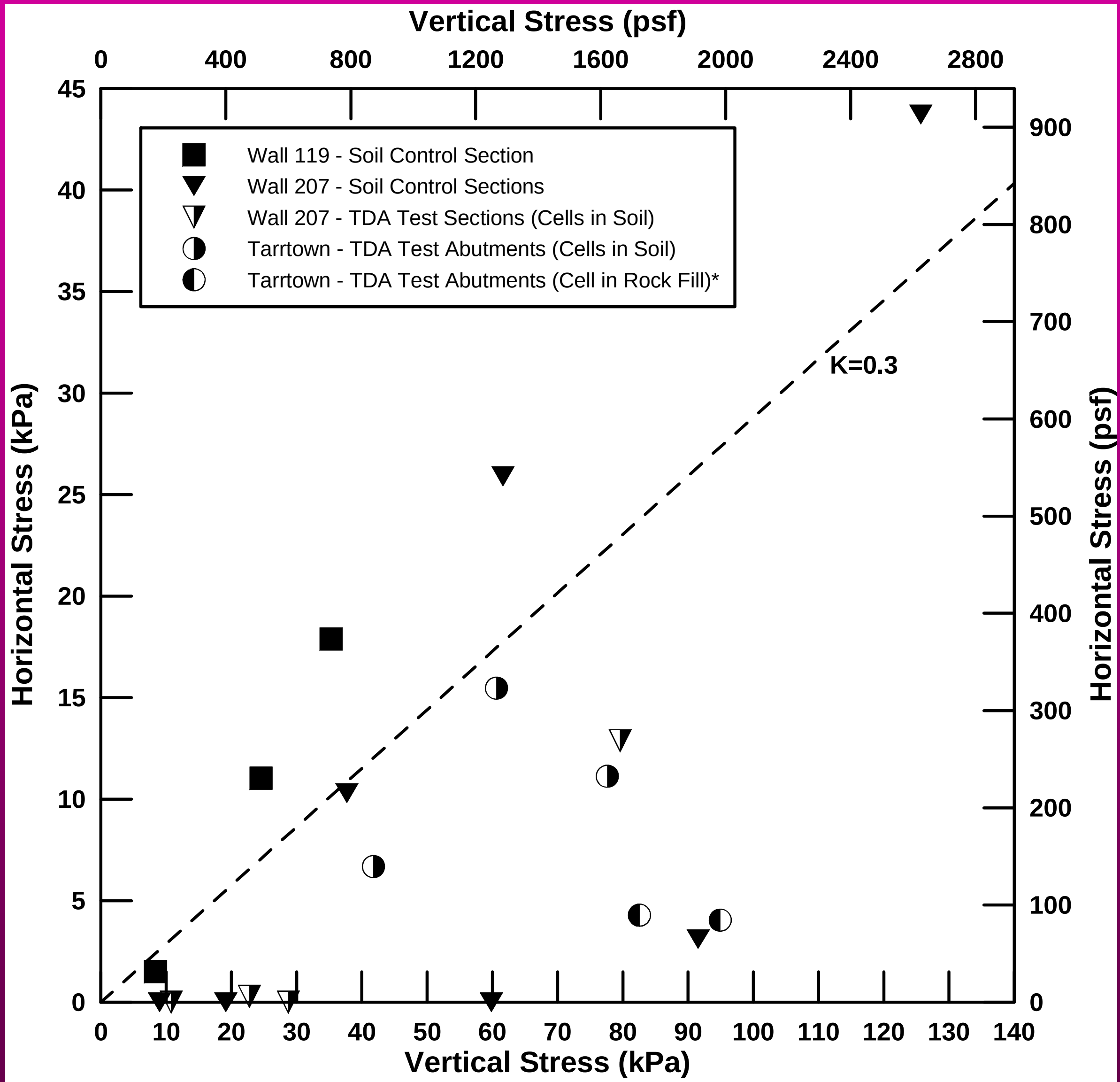
Example of Horizontal Pressure vs. Time



Summary of horizontal stress vs. vertical stress

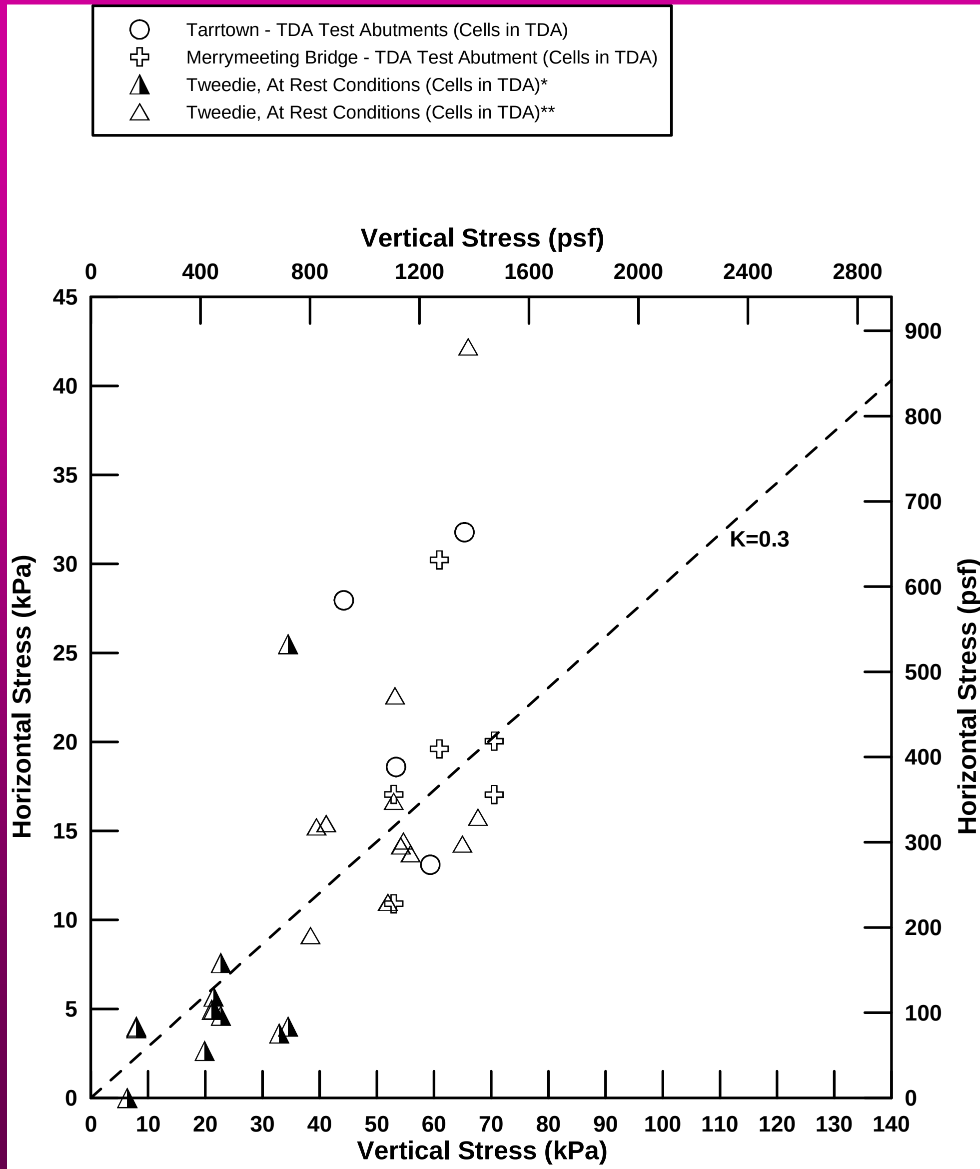
- Five projects had pressure cells in TDA
- Three projects had pressure cells in soil
- Three projects had negligible wall movement (at rest conditions)
- Three projects expected to have some wall movement away from backfill (potential for active conditions)

Horizontal vs. Vertical Stress (Cells in Soil)



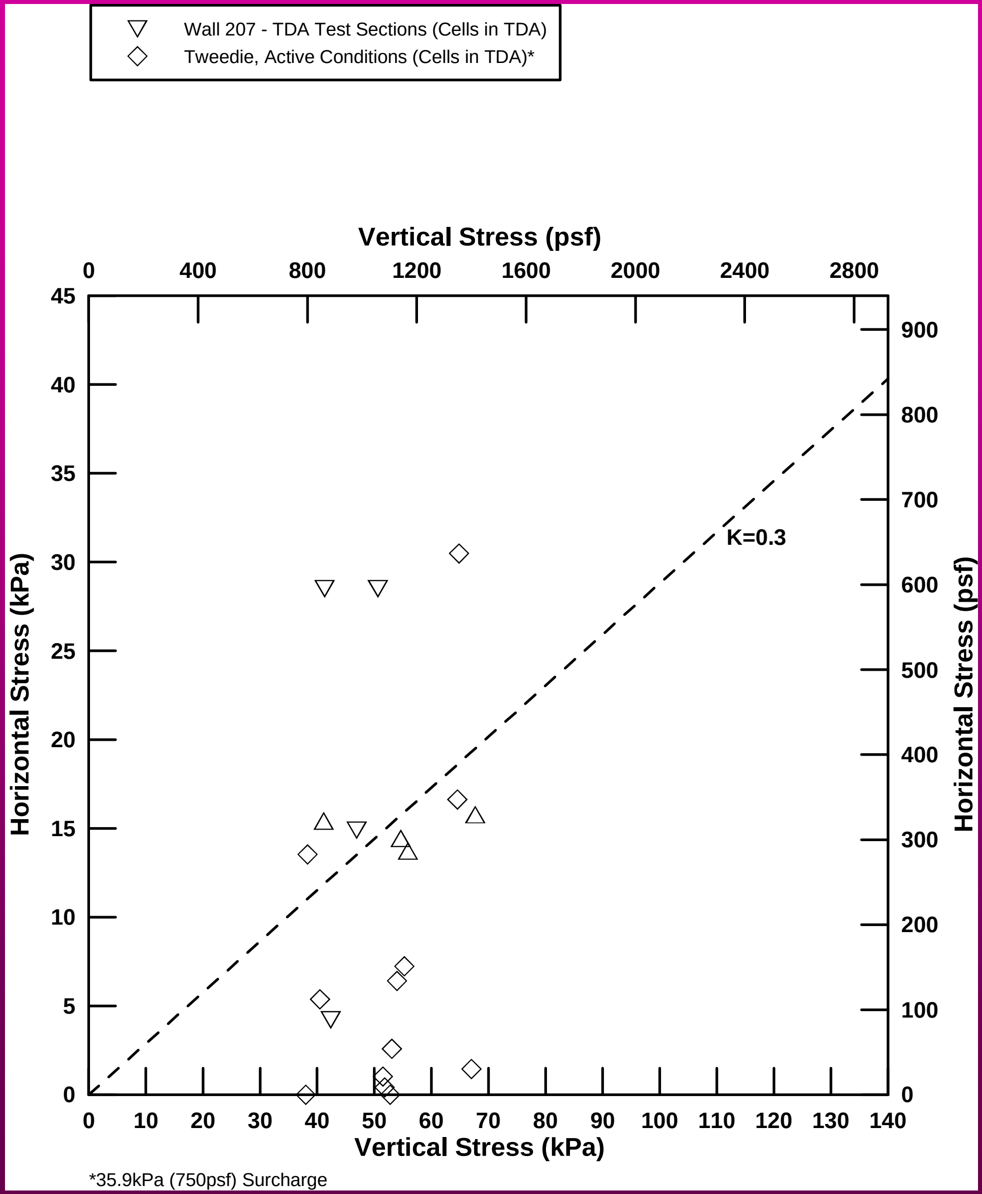
*Rock Fill consists of ± 6-in. ripped angular bedrock fragments

Horizontal vs. Vertical Stress (Cells in TDA, At Rest Sections)

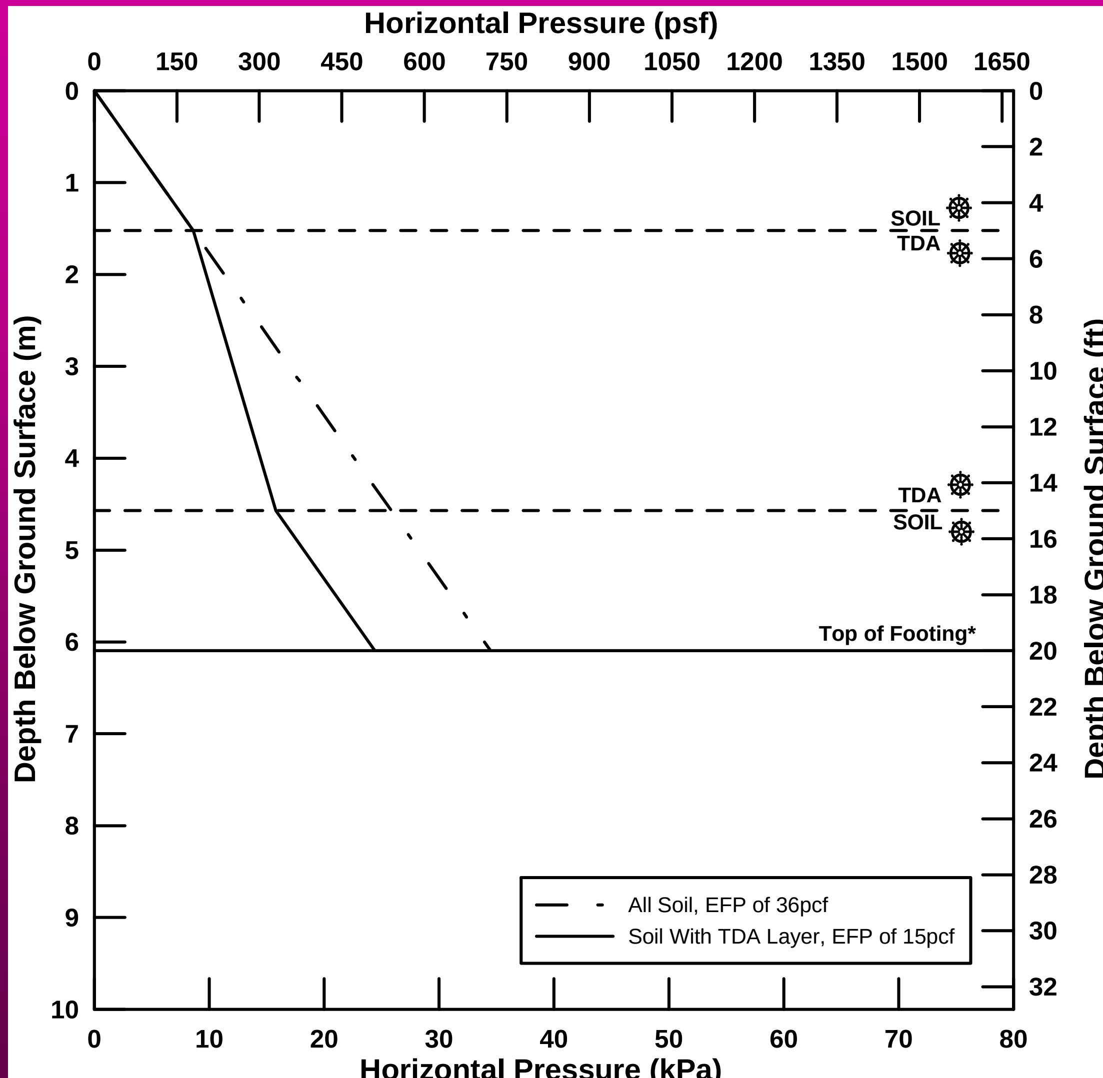


*No Surcharge
**35.9kPa (750psf) Surcharge

Horizontal vs. Vertical Stress (Cells in TDA, Active Sections)



Example of Potential Benefits



Summary of Research Findings

- Current CALTRANS earth pressure coefficient (K = 0.3) applicable to both soil and TDA backfill
- Use equivalent fluid pressure for soil backfill equal to 36 pcf
- Use equivalent fluid pressure for TDA backfill equal to 15 pcf

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ANALYSIS OF TIRE DERIVED AGGREGATE (TDA) AS BACKFILL FOR CALTRANS TYPE 1 RETAINING WALLS

Presented by:
James L. Foster, P.E

Quincy Engineering, Inc.

In cooperation with

California Integrated Waste Management Board

Dana N. Humphrey, PH.D., P.E.

Haley and Aldrich, Inc.

Caltrans

Objective

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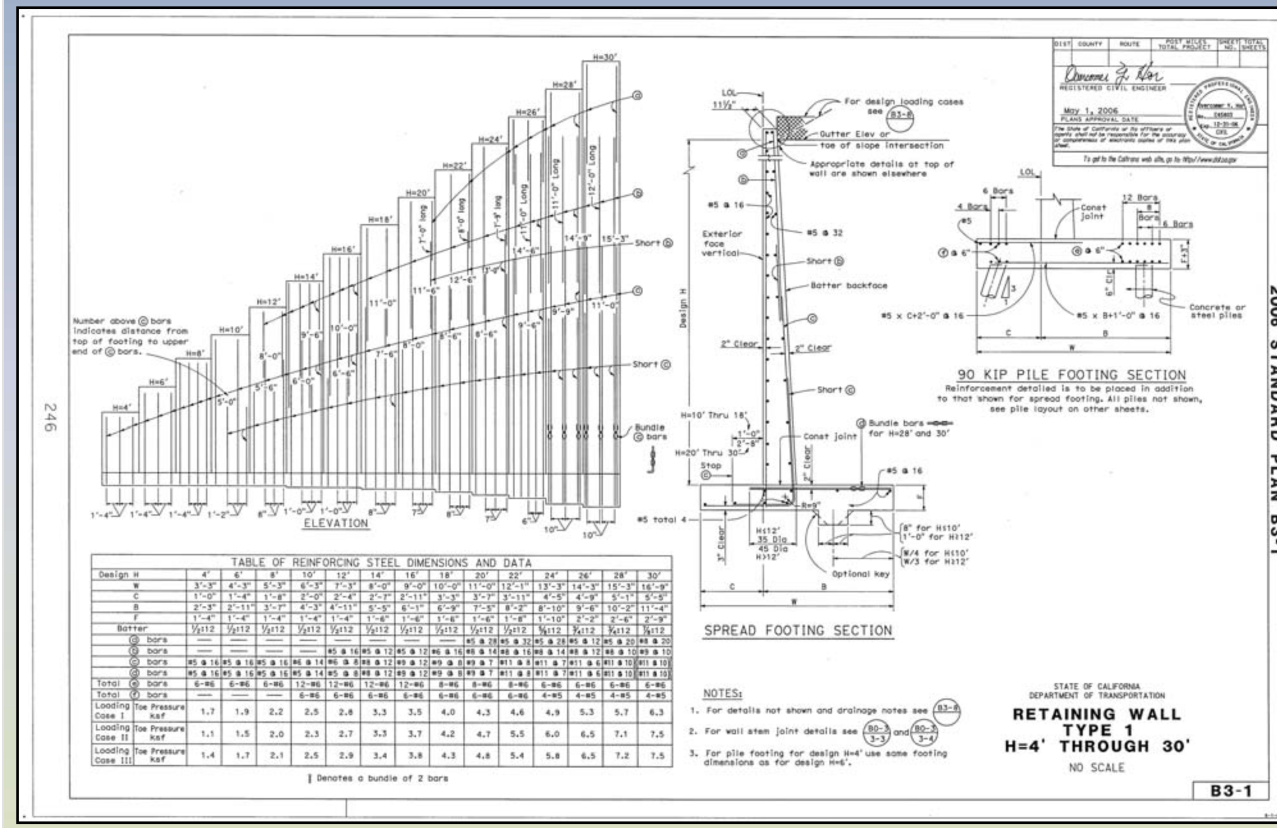
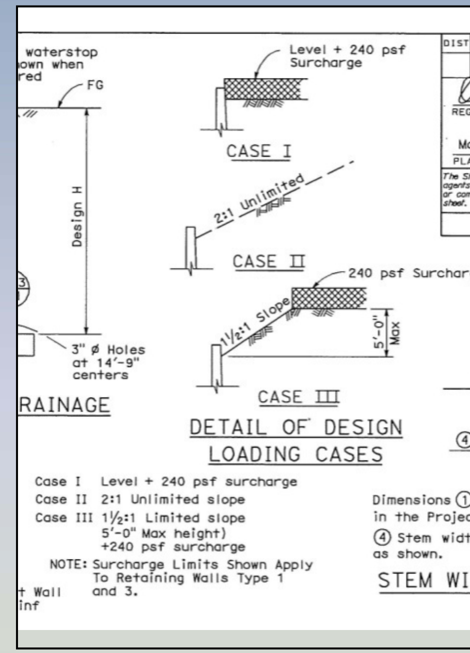
Compare Caltrans Type 1 Concrete Retaining Wall using soil backfill versus tire derived aggregate (TDA) backfill

Determine if additional effort to develop standard plans and specifications for TDA backfilled walls is warranted.

Load Case



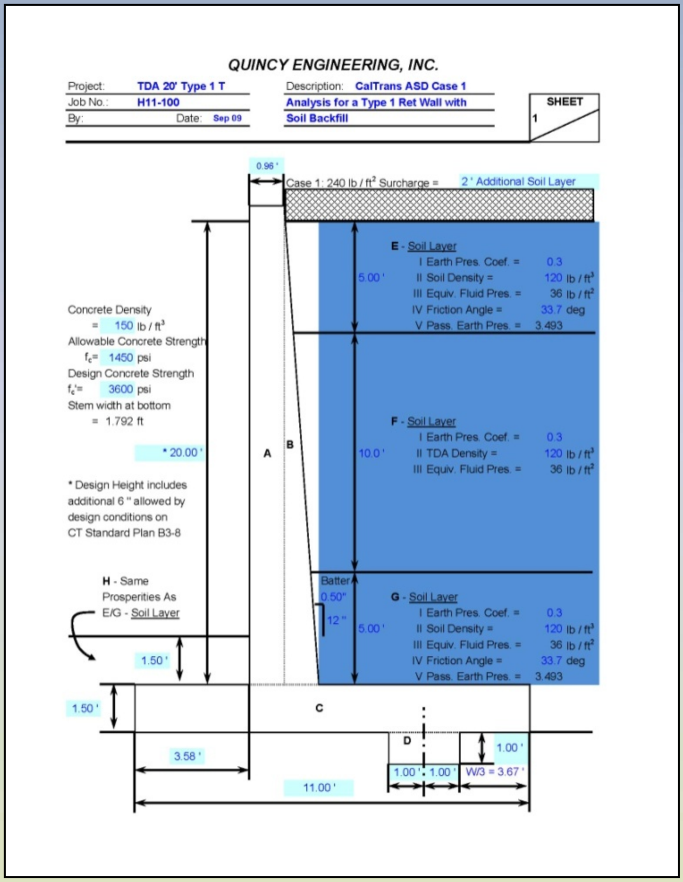
Type 1 Wall – Standard Plan B3-1



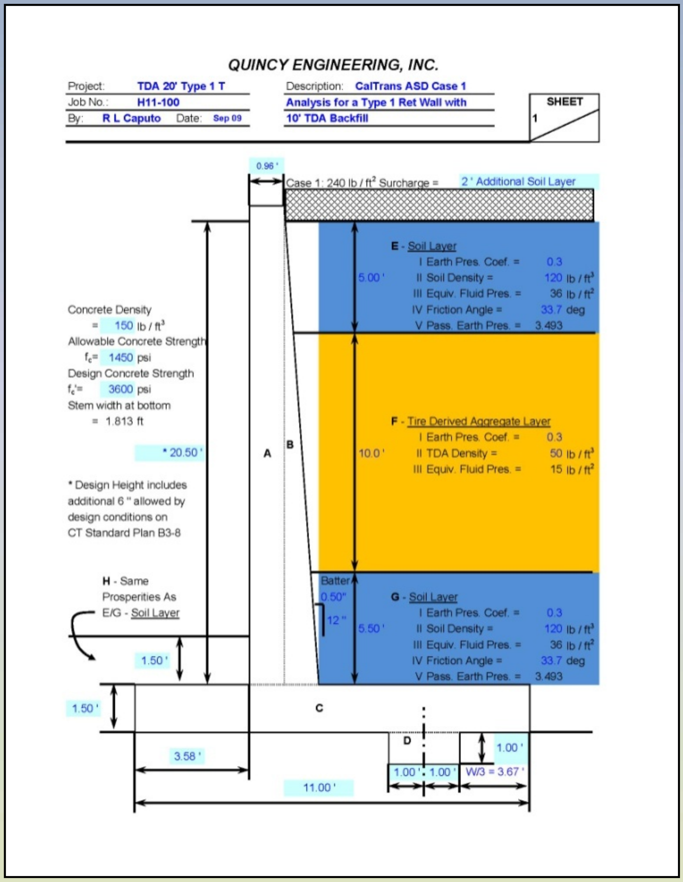
Load Cases – Standard Plan B3-8

Only Load Case 1 was evaluated at this time.

Load Case

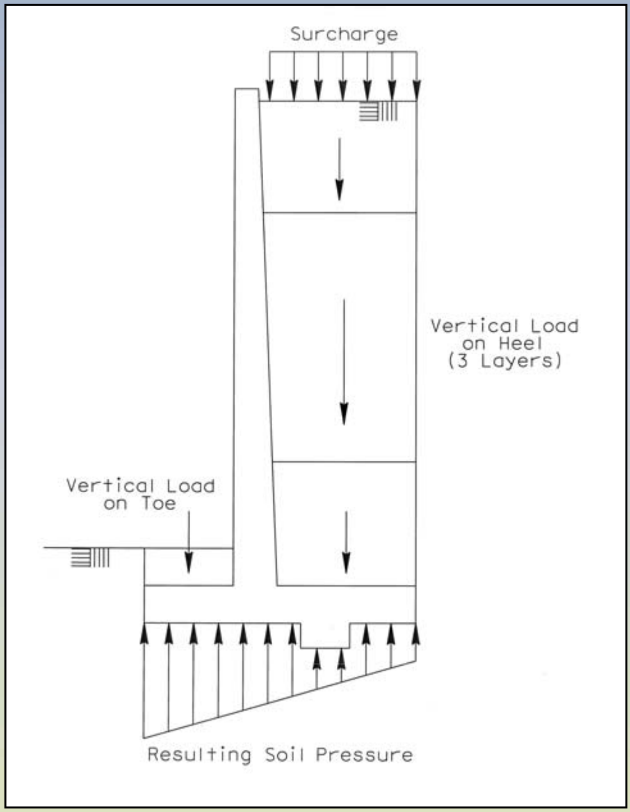


Soil Backfill Diagram

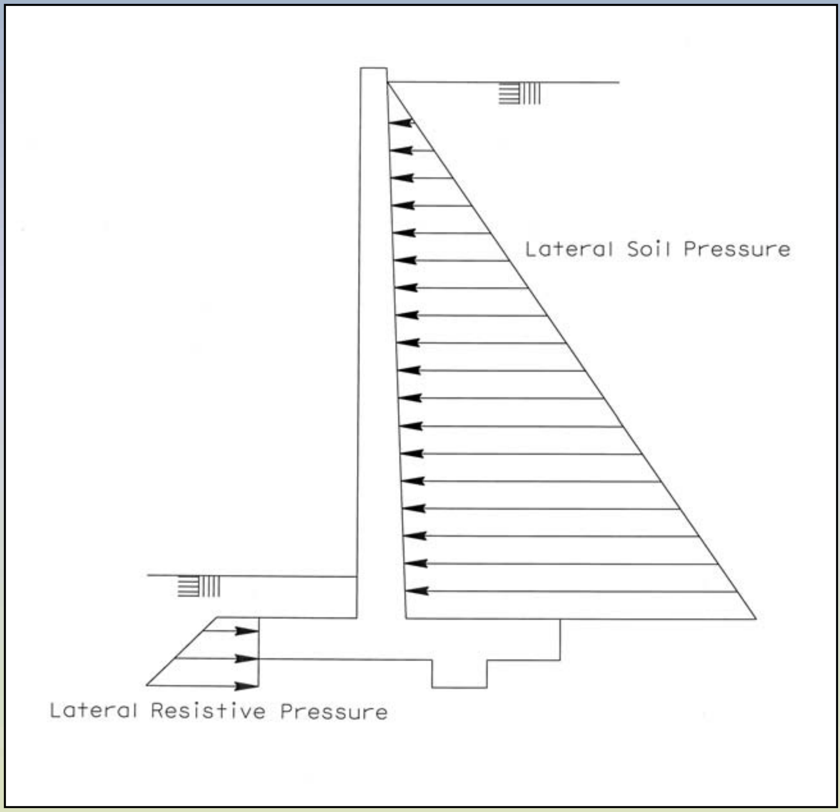


TDA Backfill Diagram

Calculate Loads

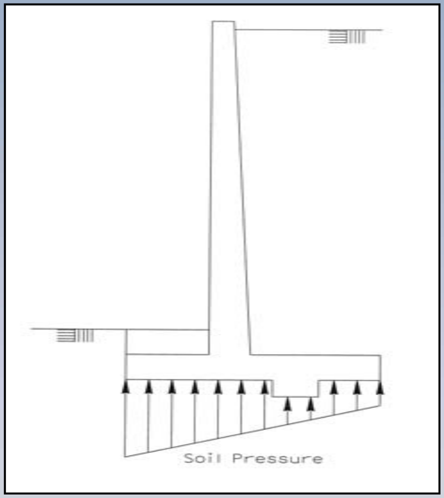


Vertical Loads

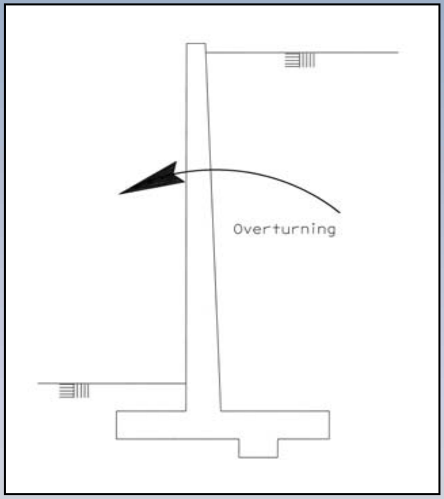


Lateral Loads

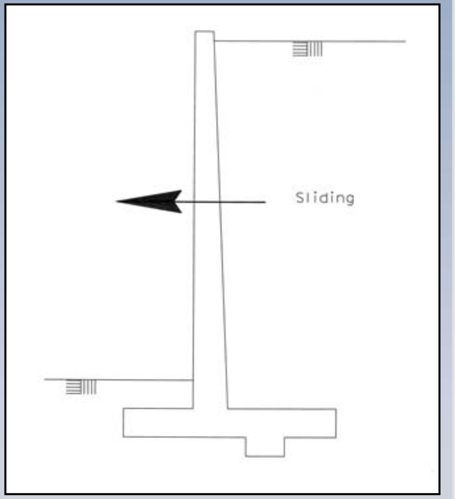
Check



Footing Pressures

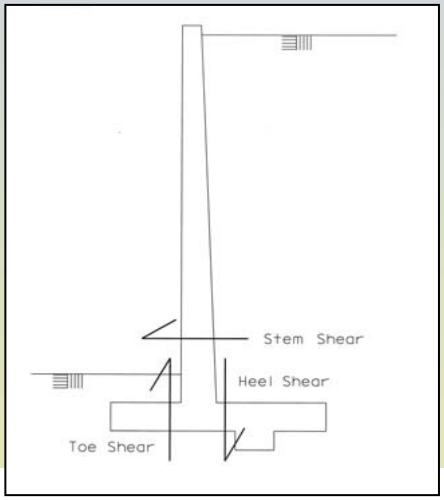


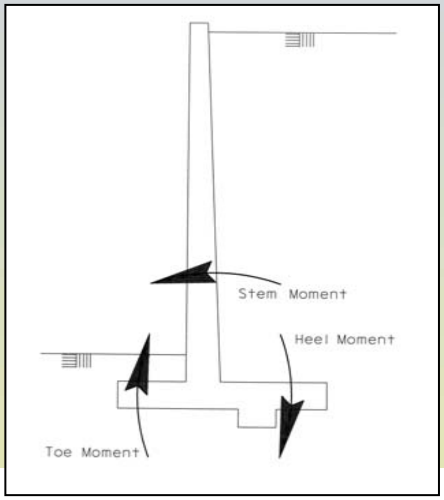
Overturning



Sliding

Shears





Moments

Results – Soil Backfill

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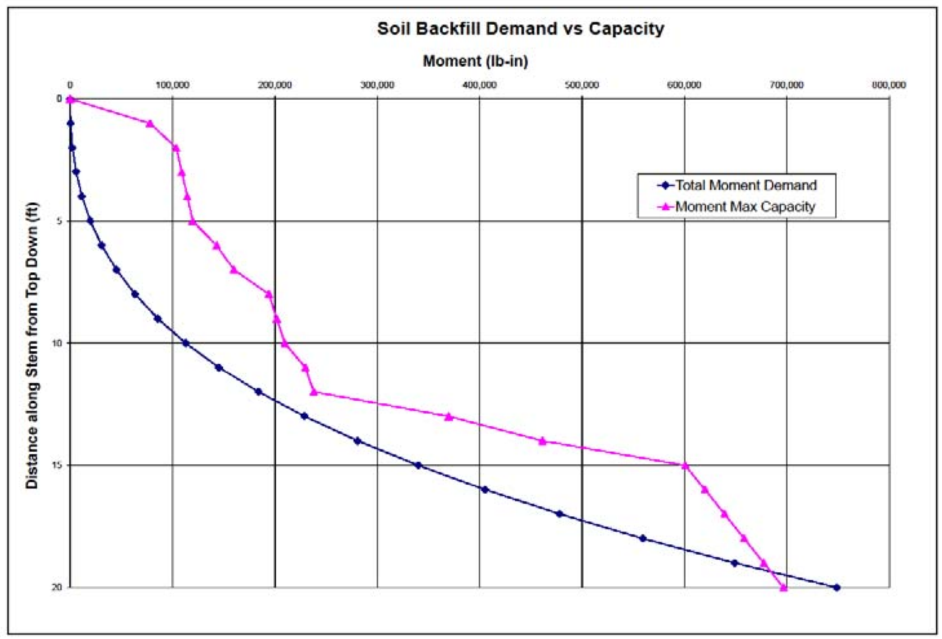
Load	Demand	Allowable per Std Plan B3-1
Toe Pressure	4.3 ksf	4.3 ksf

Load	Demand	Capacity	Demand to Capacity Ratio
Shear			
Stem (at base)	9.87 k	13.34 k	1.4
Toe	8.93 k	11.99 k	1.3
Heel	11.40 k	11.61 k	1.0
Moment			
Stem	See Chart		
Toe	24.6 k-ft	40.7 k-ft	1.7
Heel	44.6 k-ft	44.0 k-ft	1.0

Load	Demand	Capacity	Demand to Capacity Ratio	Minimum D/C (Safety Factor)
Overturning	76.3 k-ft	161.3 k-ft	2.1	2.0
Sliding	9.87 k	17.05 k	1.7	1.5



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Results – TDA Backfill

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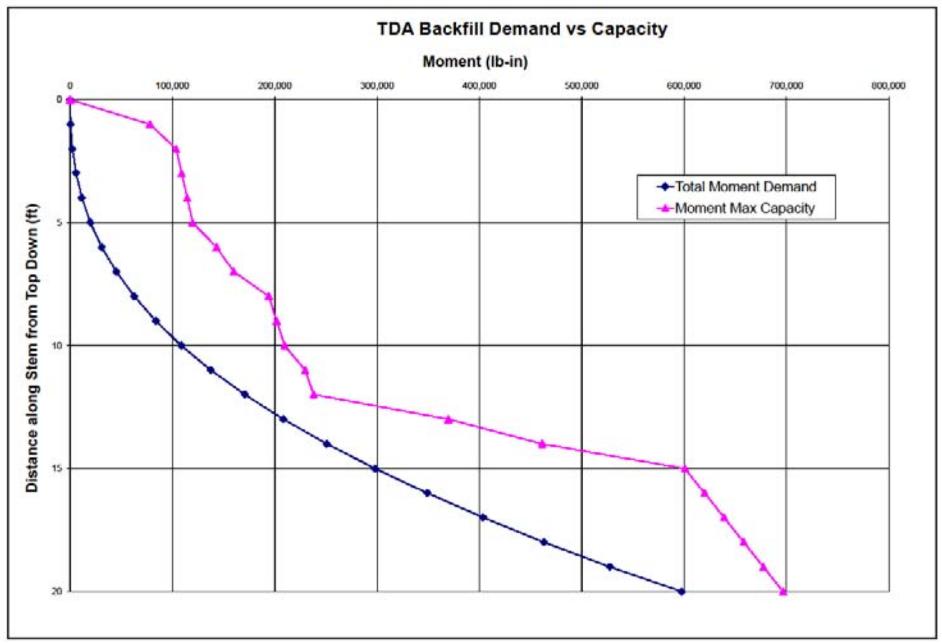
Load	Demand	Allowable per Std Plan B3-1
Toe Pressure	3.7 ksf	4.3 ksf

Load	Demand	Capacity	Demand to Capacity Ratio
Shear			
Stem (at base)	7.45 k	13.34 k	1.8
Toe	7.64 k	11.99 k	1.6
Heel	8.76 k	11.55 k	1.3
Moment			
Stem	See Chart		
Toe	21.3 k-ft	40.7 k-ft	1.9
Heel	32.7 k-ft	44.0 k-ft	1.3

Load	Demand	Capacity	Demand to Capacity Ratio	Minimum D/C (Safety Factor)
Overturning	61.51 k-ft	127.61 k-ft	2.1	2.0
Sliding	7.45 k	14.23 k	1.9	1.5



Comparison – Soil vs. TDA Backfill

Load	Soil Demand	TDA Demand	Δ (%)
Toe Pressure	4.3	3.7	-16
Overturning	76.3 k-ft	61.5 k-ft	-19
Sliding	9.87 k	7.45 k	-25
Shear			
Stem (at base)	9.87 k	7.45 k	-25
Toe	8.93 k	7.64 k	-14
Heel	11.40 k	8.76 k	-23
Moment			
Stem (at base)	62.4 k-ft	49.8 k-ft	-20
Toe	24.6 k-ft	21.3 k-ft	-13
Heel	44.6 k-ft	32.7 k-ft	-27

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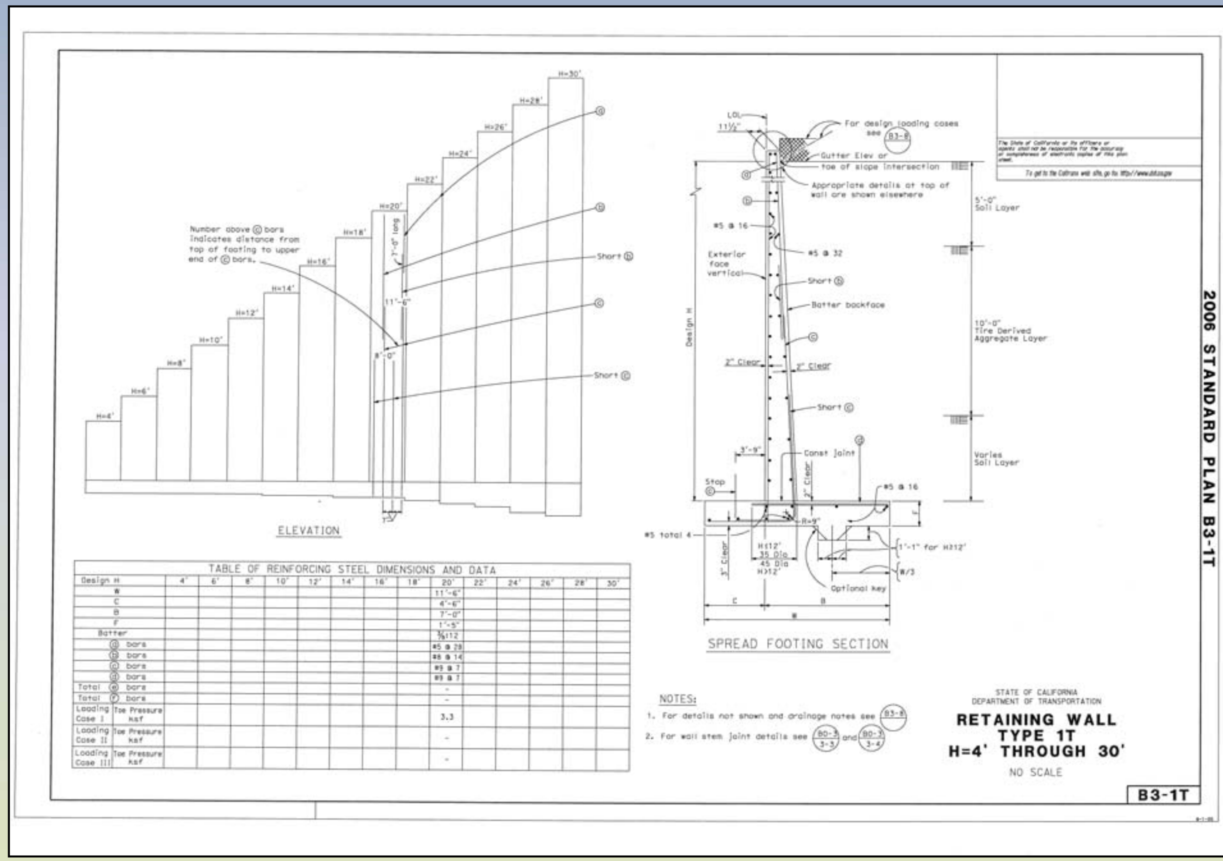
Optimization

Lower Construction Costs

- Reduced Concrete
- Reduced Rebar
- Reduced Excavation
- Reduced Backfill



Optimization

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Use at Marginal Soil Sites

- Lower Toe Pressure
- May Eliminates Need for Pile Footing

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Conclusions

Effective use for previously considered "waste" tire material.

Reduced construction costs through use of less materials and labor.

Spread footings usable at sites where previously not feasible due to unfavorable soil conditions.

Next Steps

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Develop design and standardized plans for Reinforced Concrete Type 1T retaining walls with TDA backfill using the LRFD Specifications

Identify and conduct additional studies and tests to further validate the TDA properties and behavior.

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QUESTIONS

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