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Ensuring Stability and Safety in Texas Retaining Walls Through Small Scale Repairs (*if possible*)

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TxDOT Bridge Division

Field Ops / Geotechnical Branch

47 | **SOUTHWEST GEOTECHNICAL**
TH | **ENGINEERING CONFERENCE**

TxDOT Bridge Geotech Branch

- Standards, Specifications, Contracts, Review, Recommendations, etc.
- Bridge Foundation Design
- Retaining Wall Design
- Slopes and Embankments
- Culverts and Scour
- Preliminary design, construction, monitoring, maintenance, and repair



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BACKGROUND

Texas Geology

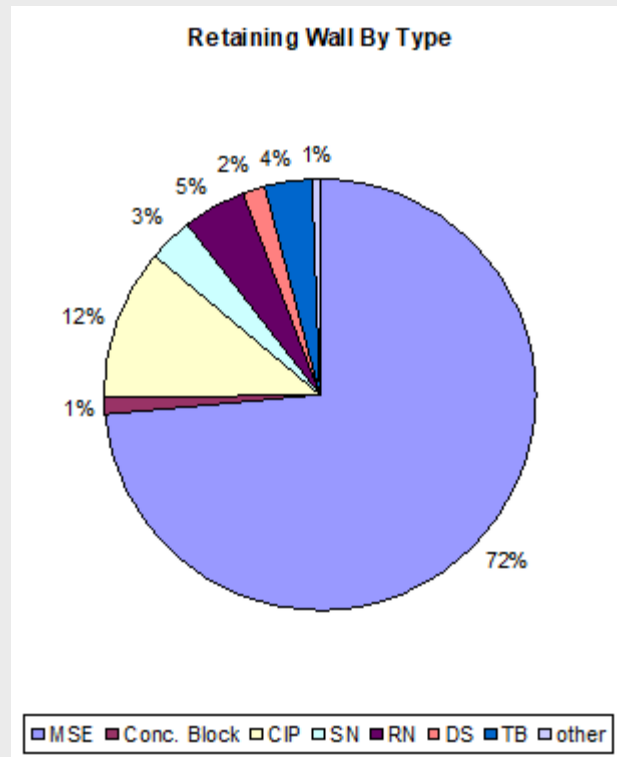
Foundations placed on earth, walls retaining earth

- State is very diverse
- Soils: Clays, Sands, Gravel, Muck, Fill, etc.
- Bedrock: Everything
 - Sedimentary (limestone/shale)
 - Igneous (granite/basalt)
 - Metamorphic (schist/gneiss)
- 254 Counties within 25 TxDOT Districts



Texas DOT Retaining Walls

- By ft² of Exposed Wall..
- MSE (panel type) most dominant
- Pending formal inventory
- Temp. Special Shoring (mostly)
 - TEW
 - Soil Nail
 - Sheet Pile
 - Solider Pile w/ Lagging



MSEW and CB Walls Design Responsibilities

- External Stability Check by TXDOT or Consultant
 - Sliding
 - Limiting Eccentricity
 - Bearing Capacity
 - Global Stability
 - Settlement
- Internal Stability Check by Vendor
 - Tensile Resistance
 - Pullout Resistance
 - Face Element
 - Face Element Connection
- MSEW reinforcement and wall type is NOT specified at project bidding stage



FAILURE

Failure

- Definition: Inability of a component or structure to perform its intended function
- Note: Failure does not necessarily involve collapse or rupture

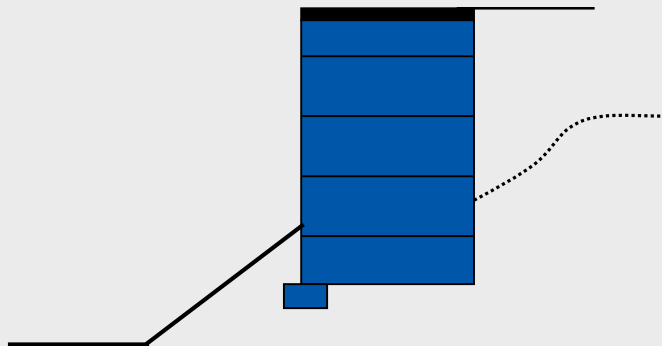


Causes of Failures

1. Design deficiencies
2. Material defects
3. Construction/Inspection deficiencies
4. Maintenance deficiencies



1. Design Deficiencies (*e.g.*, MSE Wall Placed on a Slope)



- Retaining walls are sometimes placed on slopes to minimize retaining wall square footage



MSE Wall Placed on a Slope - Wall Failure



2. Material Defects (*e.g.*, Fills)

- Gradation affects the performance of embankments & walls
- Backfill should not break down (compaction or water)
- Backfills with significant fine material:
 - have lower drained shear strength
 - retains water and allows pore pressures to build up
 - can undergo large settlements



Embankment and RW Fills – Item 132 : Embankment

Type:	Definition	Compaction: Ordinary or Density Controlled
A	Granular material free from veg. meeting LL < 45, and PI < 15	as determined by plans
B	Rock, loam, clay, or other approved	as determined by plans
C	Specifications shown on plans	as determined by plans
D	From required excavation areas show on the plans	as determined by plans
CSAB	Cement-Stabilized Backfill	Density but default, unless indicated in plans
Flowable Fill	Non-excavatable or Excavatable	Fill in all air void areas

2024 Specifications

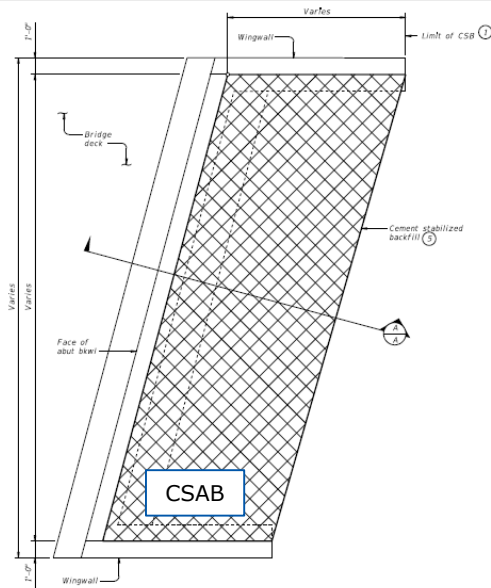
400

3.3.4.

Cement-Stabilized Backfill. Backfill the excavation to the elevations shown with cement-stabilized backfill when shown on the plans. Use cement-stabilized backfill that contains aggregate conforming to the gradation limits shown in Table 1, water, and at least 7% hydraulic cement based on the dry weight of the aggregate, in accordance with [Tex-120-E](#).

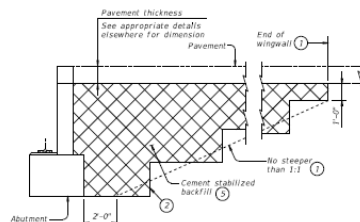
Place cement-stabilized backfill equally along the sides of structures to prevent strain on or displacement of the structure. Fill voids when placing cement-stabilized backfill. Use hand-operated tampers, if necessary, to fill voids. Compact the mixture using density control unless otherwise shown on the plans. Place and compact the backfill within 2 hr. of mixing.

CSAB in Approach

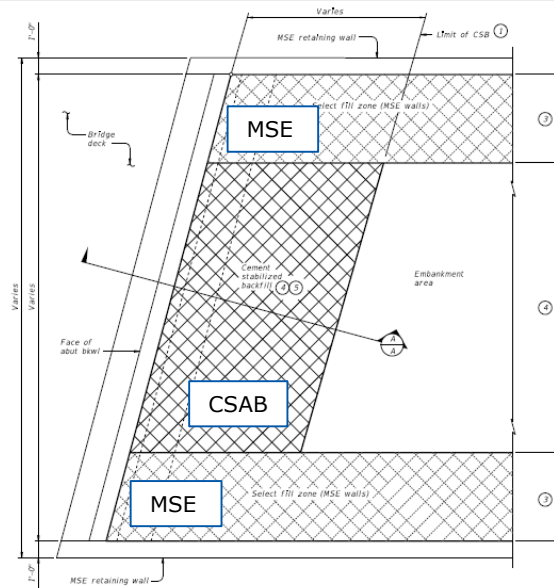


OPTION 1 ~ PLAN WITH WINGWALLS

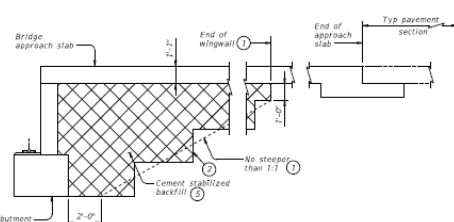
Cast-in-place retaining walls similar.



WITHOUT APPROACH SLAB



OPTION 1 ~ PLAN WITH MSE RETAINING WALLS



WITH APPROACH SLAB
(Showing BAS-C, BAS-A similar.)

SECTION A-A

- ① Usual limit of Cement Stabilized Backfill is at end of wingwall. Extend CSB limits as required to maintain a slope no steeper than 1:1 at bottom of backfill.
- ② Bench backfill as shown with 12" (approximate) bench depths.
- ③ Where MSE retaining walls are present, adjust CSB limits to accommodate the select fill zone. See retaining wall details for additional information.
- ④ When distance between select fill zones is less than 5'-0", MSE select fill may be substituted for cement stabilized backfill with approval from the Engineer.
- ⑤ If shown in the plans, flowable backfill can be used as a substitute for cement stabilized backfill with the following constraints:
 - a. If flowable backfill is to be placed over MSE backfill, then a filter fabric will be placed over the MSE backfill prior to placement of the flowable (Ft), and
 - b. Place flowable fill in lifts not exceeding 2 feet in height. Place each successive lift when the previous lift has set/firmed/hardened (i.e. has lost its flowability).

GENERAL NOTES:


See the Bridge Layout for selected Option. Option 1 is intended for construction only requiring plasticity index (PI) controlled embankment fill or excavation in competent soils/rocks in order to construct the abutment. Option 2 is intended for new construction requiring high plasticity embankment fill with a PI greater than 30 or pavement built in poor native soil. Poor soils are defined as high plasticity clays or expansive clays.

Construct abutment backfill in accordance with Item 400, "Excavation and Backfill for Structures". Provide Cement Stabilized Backfill (CSB) meeting the requirements of Item 400, "Excavation and Backfill for Structures", to the limits shown at bridge abutments.

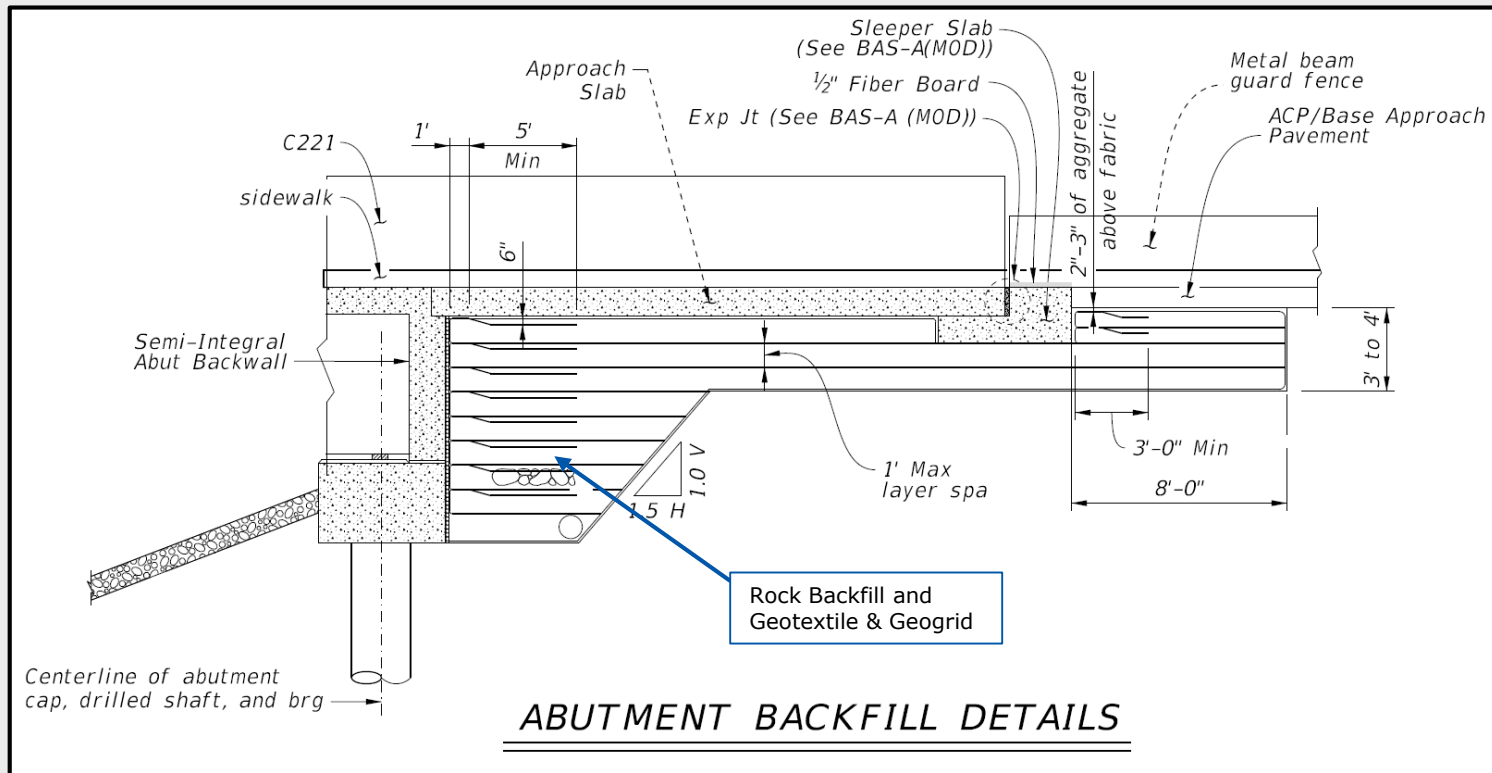
If required elsewhere in the plans, provide Flowable Backfill meeting the requirements of Item 401, "Flowable Backfill", to the limits shown at bridge abutments.

Details are drawn showing left forward skew. See Bridge Layout for actual skew direction. These details do not apply when Concrete Block retaining walls are used in lieu of wingwalls.

SHEET 1 OF 2

 Texas Department of Transportation		Bridge Division Standard	
CEMENT STABILIZED ABUTMENT BACKFILL BRIDGE ABUTMENT			
CSAB			
Rev	By	Date	Notes
1	WOT	April 2019	Initial
REVISED			
Checked: [Signature] Date: [Date]			

Semi-Integral Abutments (*test bridges*)



Embankment and RW Fills – Item 423 : Retaining Wall

Type:	Definition	Compaction: Ordinary or Density Controlled
AS	Best Gradation	Density but default, unless indicated in plans
BS	Good Gradation, used for Permanent Walls	Density but default, unless indicated in plans
CS	Highest range of approved gradations, used for Temp Walls	Density but default, unless indicated in plans
DS	Gradation for better drainage, wall areas subject to inundation	Density Controlled

Select Backfill Gradation Limits

Type	Sieve Size	Percent Retained
AS	3"	0
	1/2"	50–100
	#4	See Note
	#40	85–100
	#200	95–100
BS	3"	0
	#4	See Note
	#40	40–100
	#200	85–100
CS	3"	0
	#4	See Note
	#200	75–100
DS	3"	0
	3/8"	85–100
	#200	95–100

Note—Use No. 4 sieve for determination of rock backfill in accordance with Section 2.4., "Backfill."

Houston District
Primarily Uses CSAB
in the MSE

3. Construction/Inspection Deficiencies (e.g., misc.)



Obstruction Treatment?



Missing Reinforcement, Procedure?



Compaction?

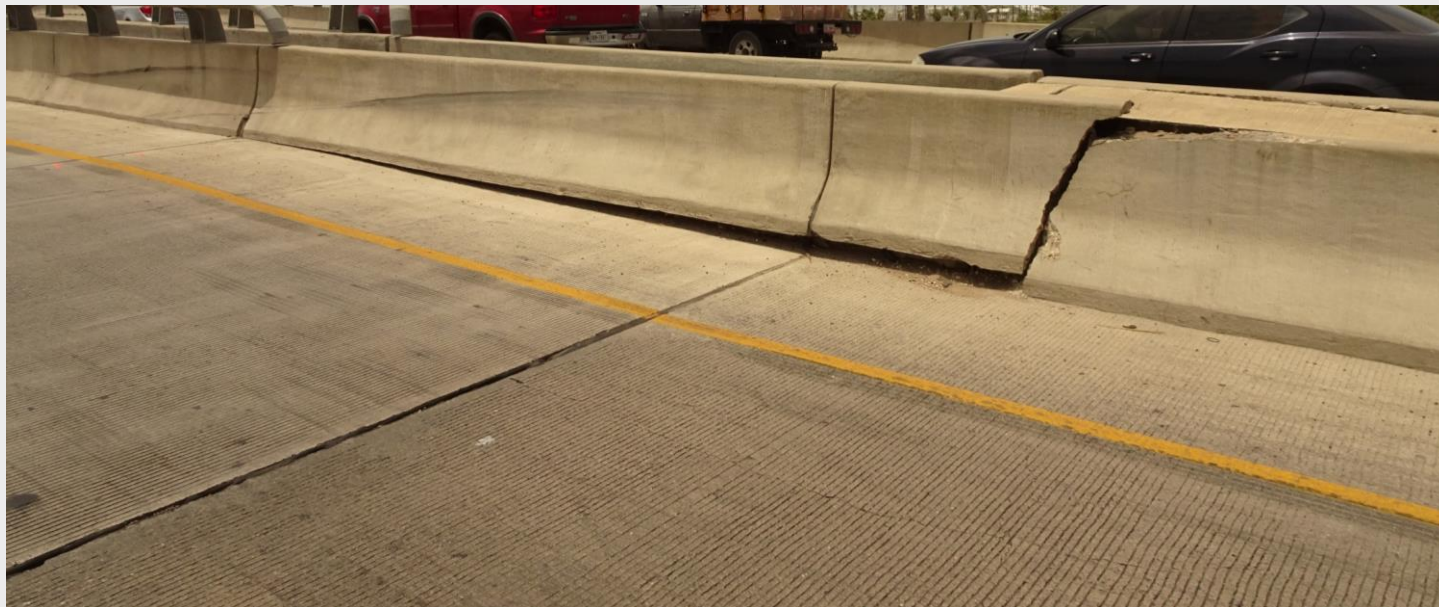
Long Term Performance

- Inspectors need to follow and enforce the specifications.
- The behavior of the wall is highly dependent upon the construction process



RESPONSE AND INVESTIGATION

Bridge Approach Slab – Settlement and Undermining



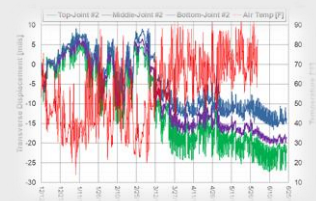
Backfill Washout – Migration/Erosion (loss of material)



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Visits, Monitoring, and Instrumentation

- Records (past inspections)
- Crack Gauge Documentation
- Photos
- GPR and Concrete Coring
- Boreholes, Inclinometers, Piezometers
- FWD, DCP, LiDAR
- Other Geophysical Tools (ERI/resistivity, MASW/FWI/seismic)



SMALL SCALE REPAIRS

Approach Slab

- Crushed Rock (1" – 3")
- Cement Stabilized Sand
- Lean Concrete
- Grout
- Flowable Backfill
- Expansive (*URETEK*) Foam – Feasible option with long term durability concerns, only to be performed in localized applications and verify qualifications of contractor to ensure more problems are not stemming from the pressurized injections



Figure 5.18 URETEK Slab Jacking Process

Drainage and Erosion

- Sealing Joints (and flashing)
- Curbs, Gutters, and Flumes
- Adding more Riprap

Limitation: Slope < 2:1 (Rule of Thumb)



NOT SOO SMALL SCALE REPAIRS

RW Repair Options

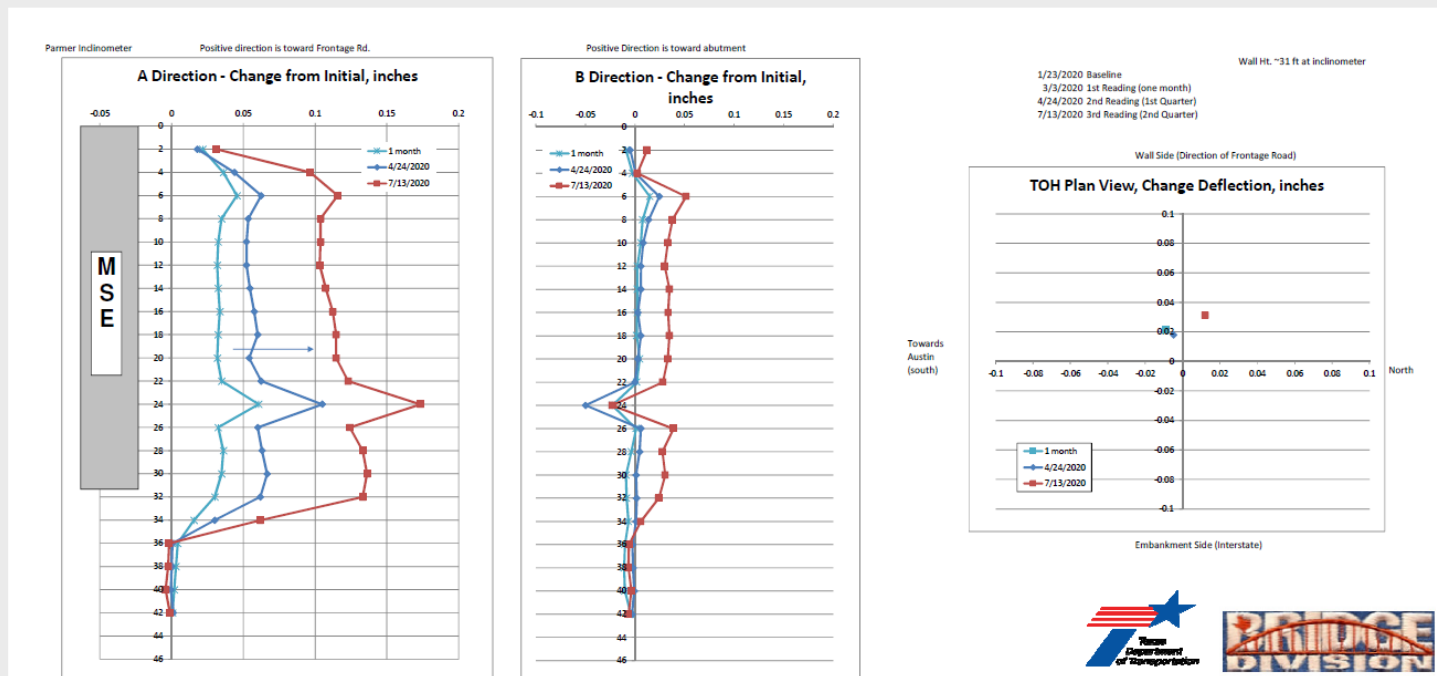
- Monitor
- Remove and Replace (Partial or Complete)
- Structural Support
- Bury, Entomb, Buttress
- Other

Lp1 SB exit ramp MSE Wall @ Parmer Ln



Lp1 SB exit ramp MSE Wall @ Parmer Ln - Inclinometer

- 'A' Direction (perp. to traffic) $\sim 0.1''$ sliding deflection over 6months



MSE Wall @ Parmer – Immediate Buttrressing

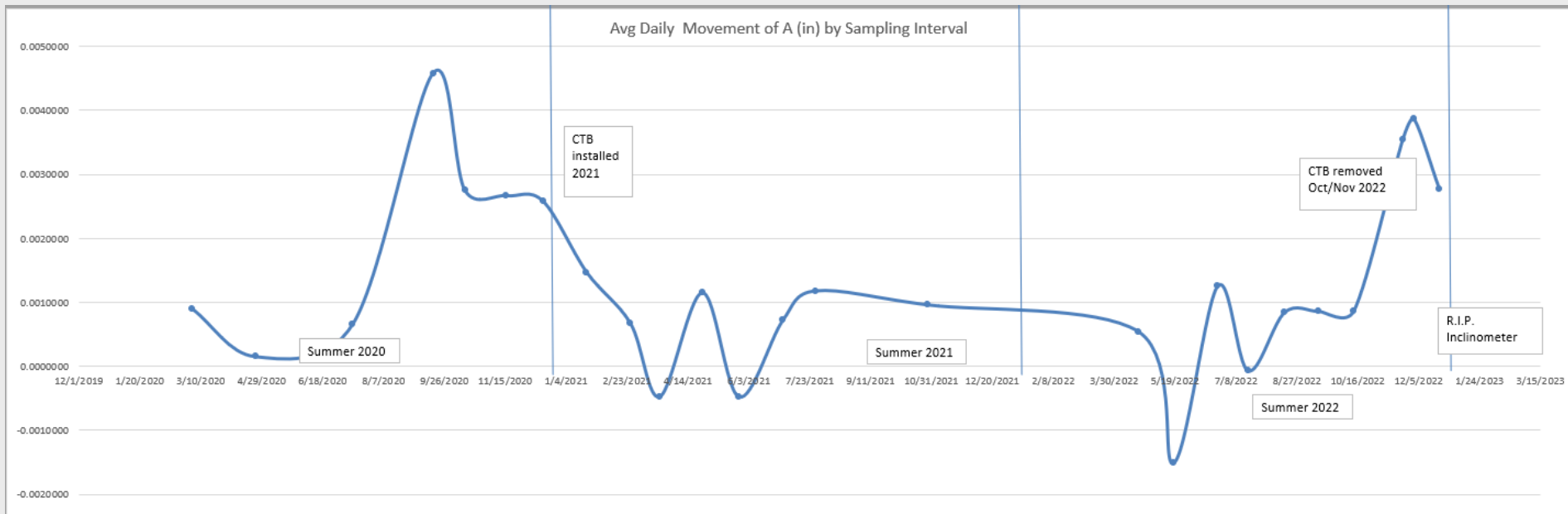


Temporary Stabilization



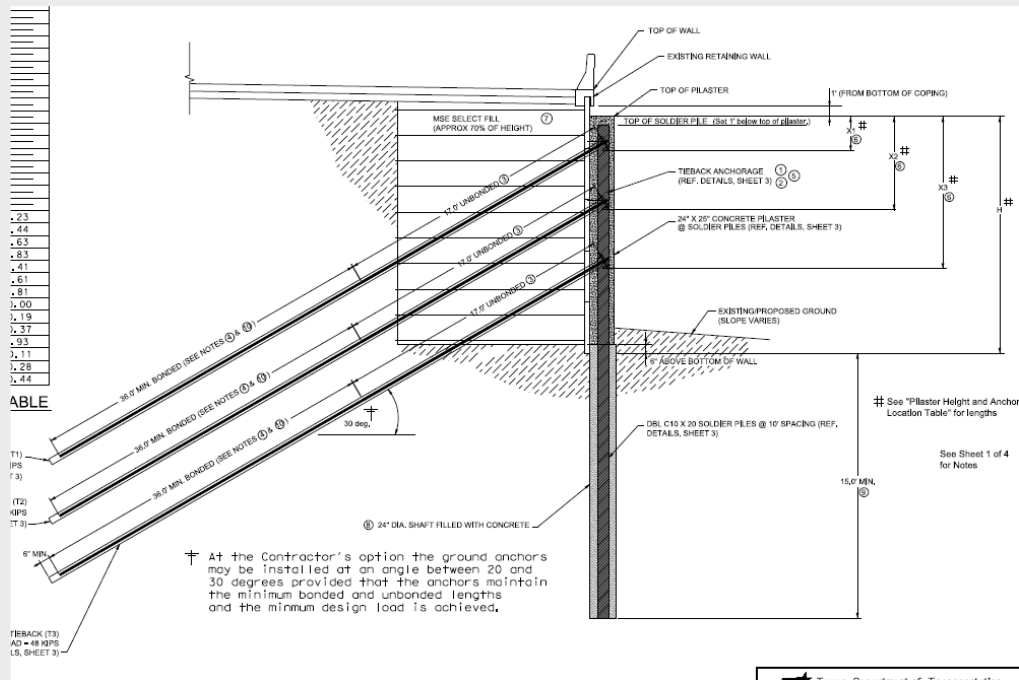
LPCTBs

MSE Wall @ Parmer – Buttressing Effect



MSE Wall @ Parmer – Long Term Support

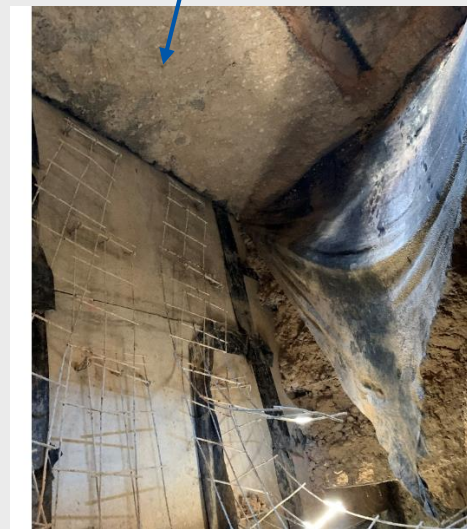
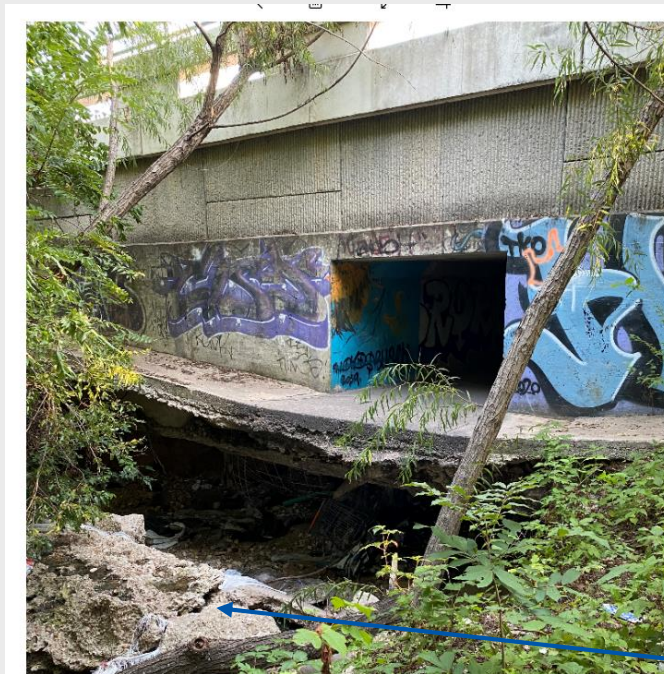
- Solider Piles (& Tie-back anchors) Installed every 10ft between panels of existing wall



MSE Wall @ Parmer - Now



SH 71 @ Burleson



Debris

SH 71 @ Burleson – Immediate Response

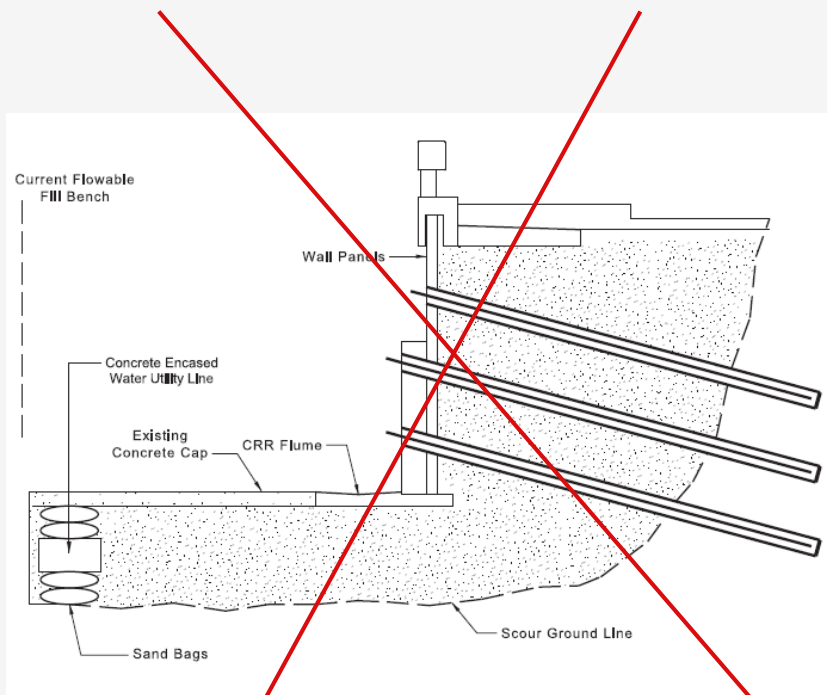


Concrete Encased Water Line

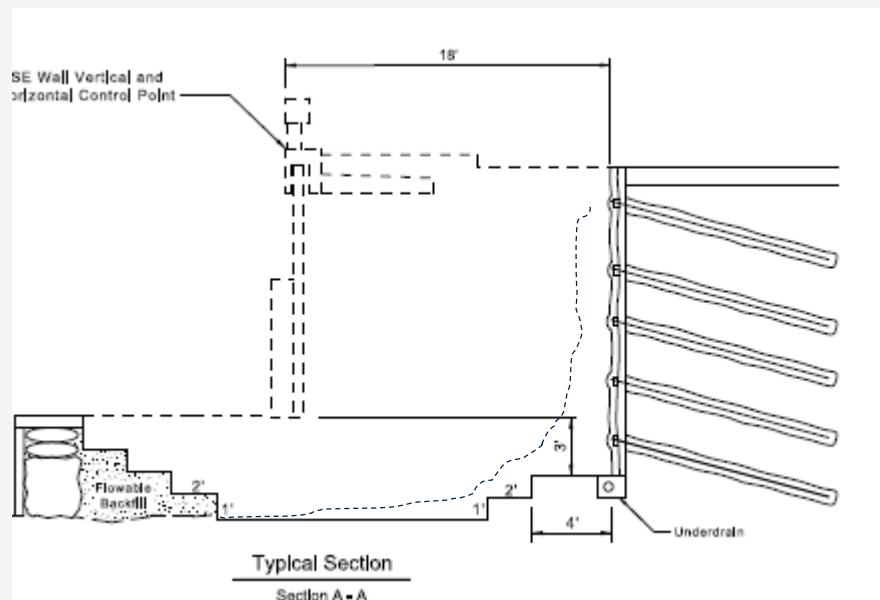


Flowable Fill Bench

SH 71 @ Burleson – Long Term Support

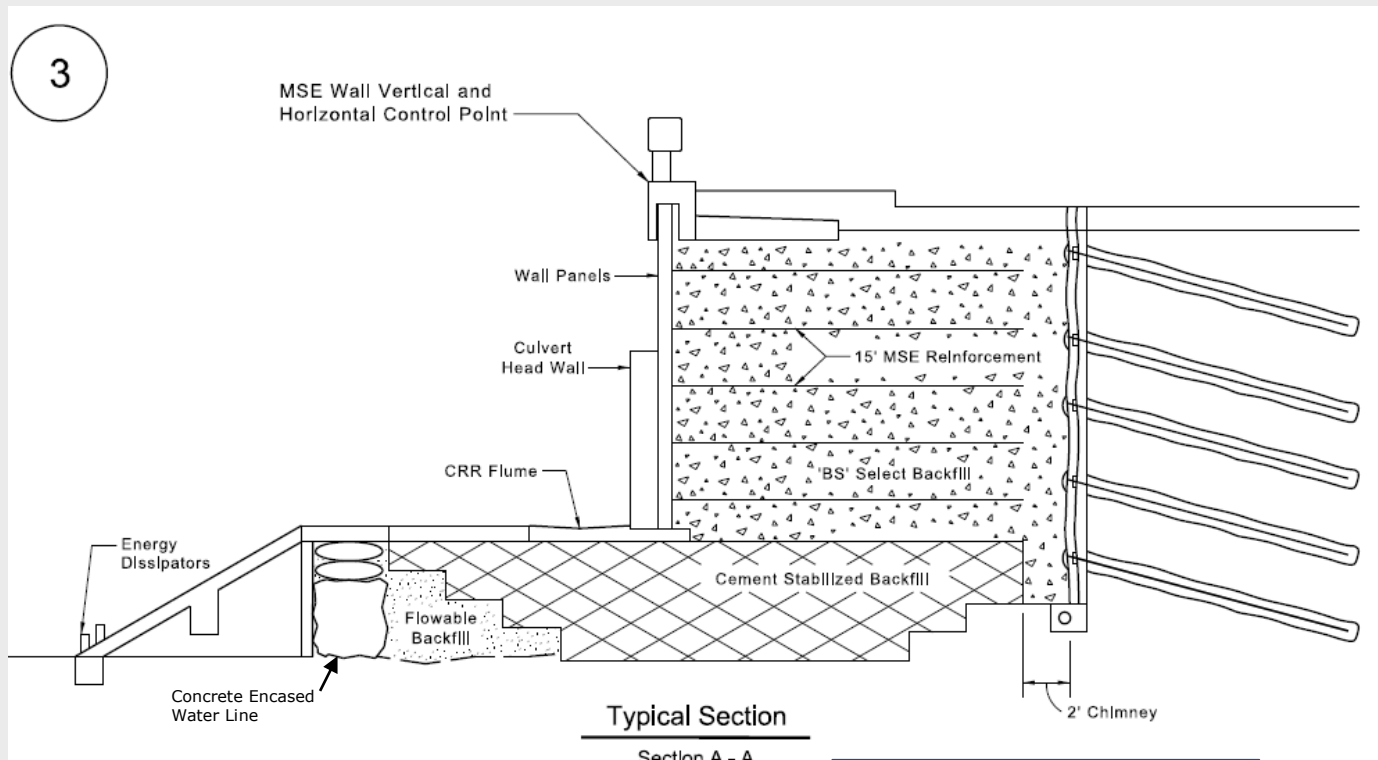


1st Design



Redesign

SH 71 @ Burleson – Long Term Fix



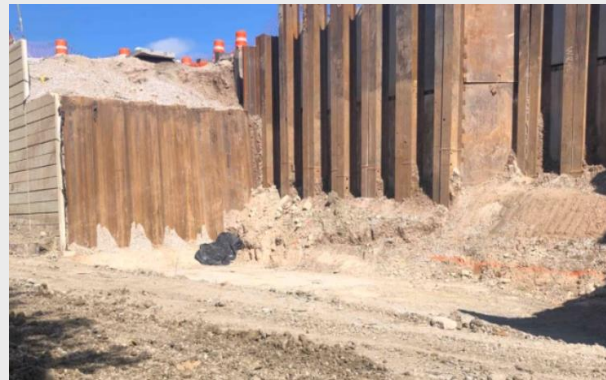
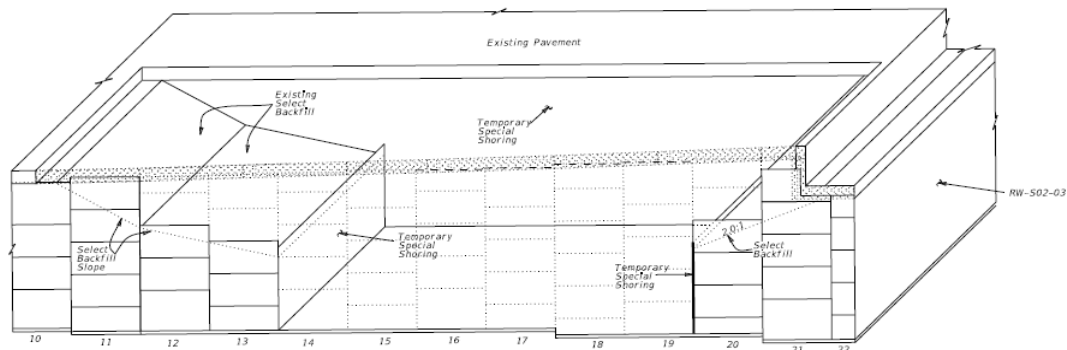
Redesign, pending construction

US 290 @ Walnut Creek

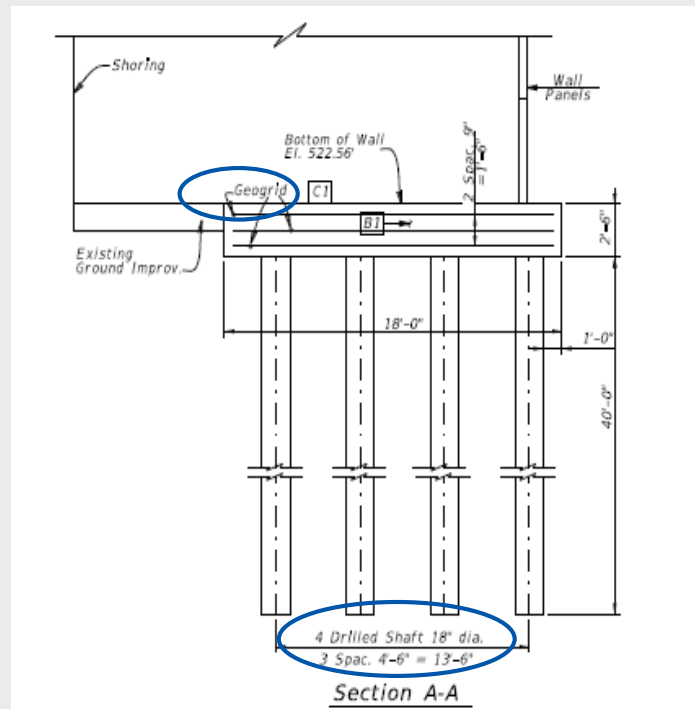
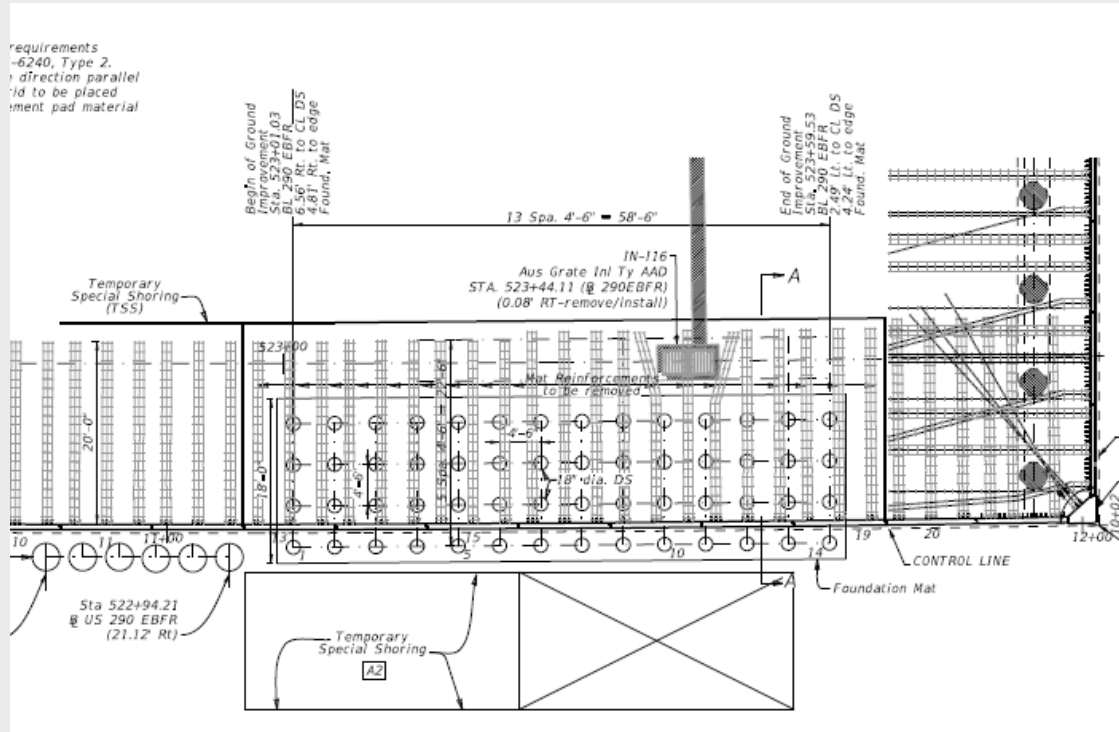


- Void Extended 16' behind wall face
- Need to remove trench box and recompact material in front of wall
- **Ground Improvement** Needed at Toe and Wall Foundation

US 290 @ Walnut Creek - Plan



US 290 @ Walnut Creek – Foundation Improvement



US 290 @ Walnut Creek - Final



Conclusion



- Proactive design and diligent **construction inspection** make solid retaining walls
- Problems rarely happen, but..
- Quick action and monitoring will lead to severity
- Follow up action can be as intense as we deem
- Geotechnical efforts are appreciated by all levels within the DOTs

THANK YOU

QUESTIONS

Please CONTACT:

Edward Galbavy, P.E.
Ryan Eaves, P.E.

Or any of the great engineers w/in:

***TxDOT Bridge Division -
Geotechnical Branch***



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