May 23, 2024

Ensuring Stability and Safety in Texas Retaining Walls

Through Small Scale Repairs (*if possible*)

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Field Ops / Geotechnical Branch

47TH SOUTHWEST GEOTECHNICAL 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

Table of Contents

BACKGROUND

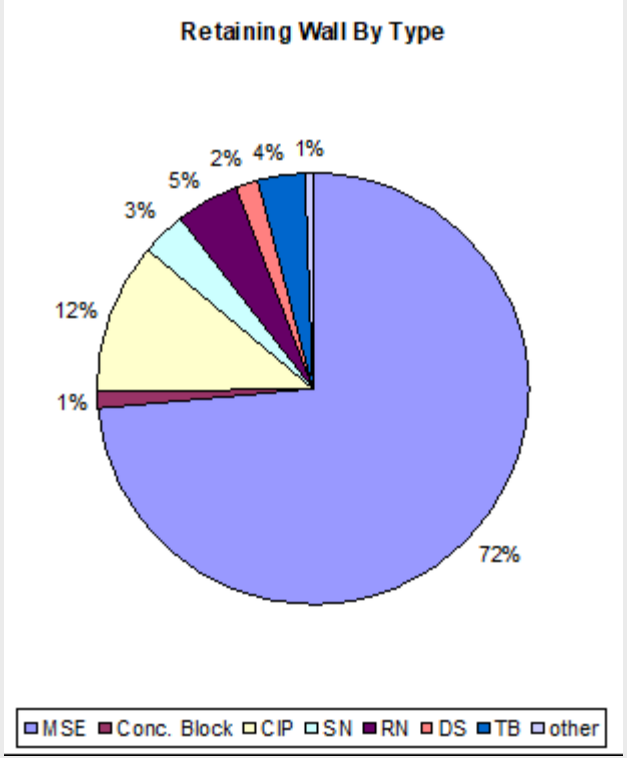
Texas Geology

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 ft^2 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

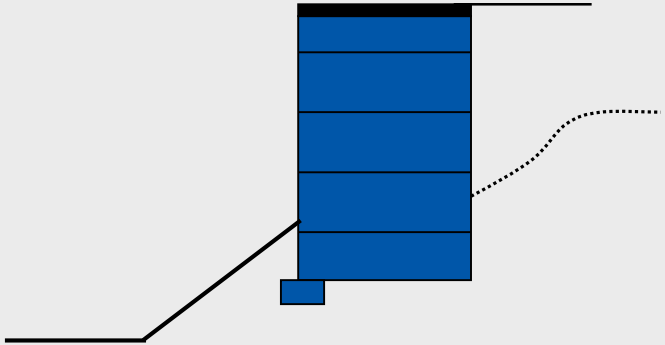
- Definition: Inability of a component or structure to perform its intended function
- Note: Failure does not necessarily involve collapse or rupture



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

11

MSE Wall Placed on a Slope - Wall Failure

2

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

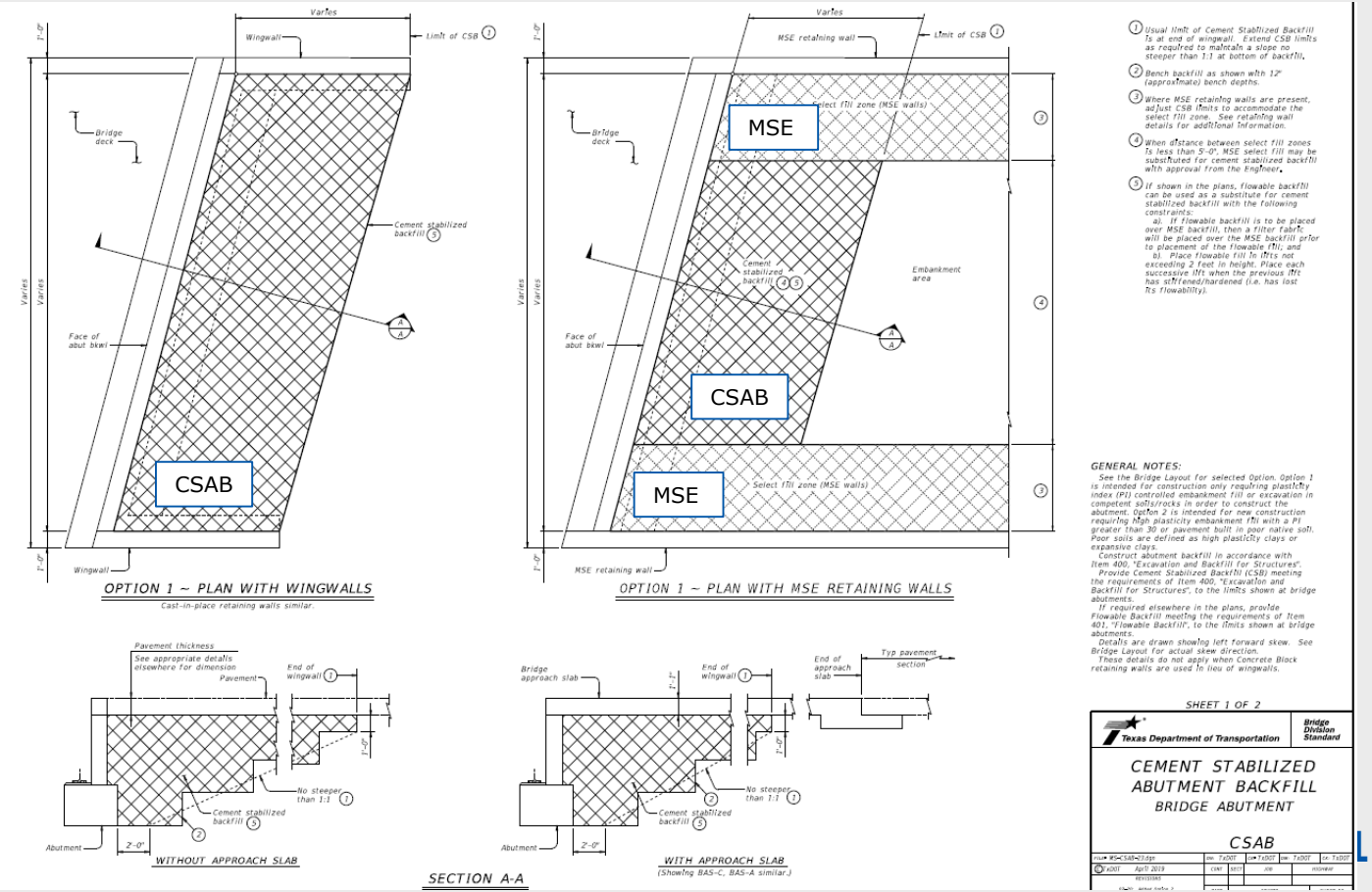
Type:	Definition	Compaction: Ordinary or Density Controlled
A	Granular material free from veg. meeting LL < 45, and PI < 15	as determined by plans
B	Rock, loam, clay, or other approved	as determined by plans
C	Specifications shown on plans	as determined by plans
D	From required excavation areas show 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**

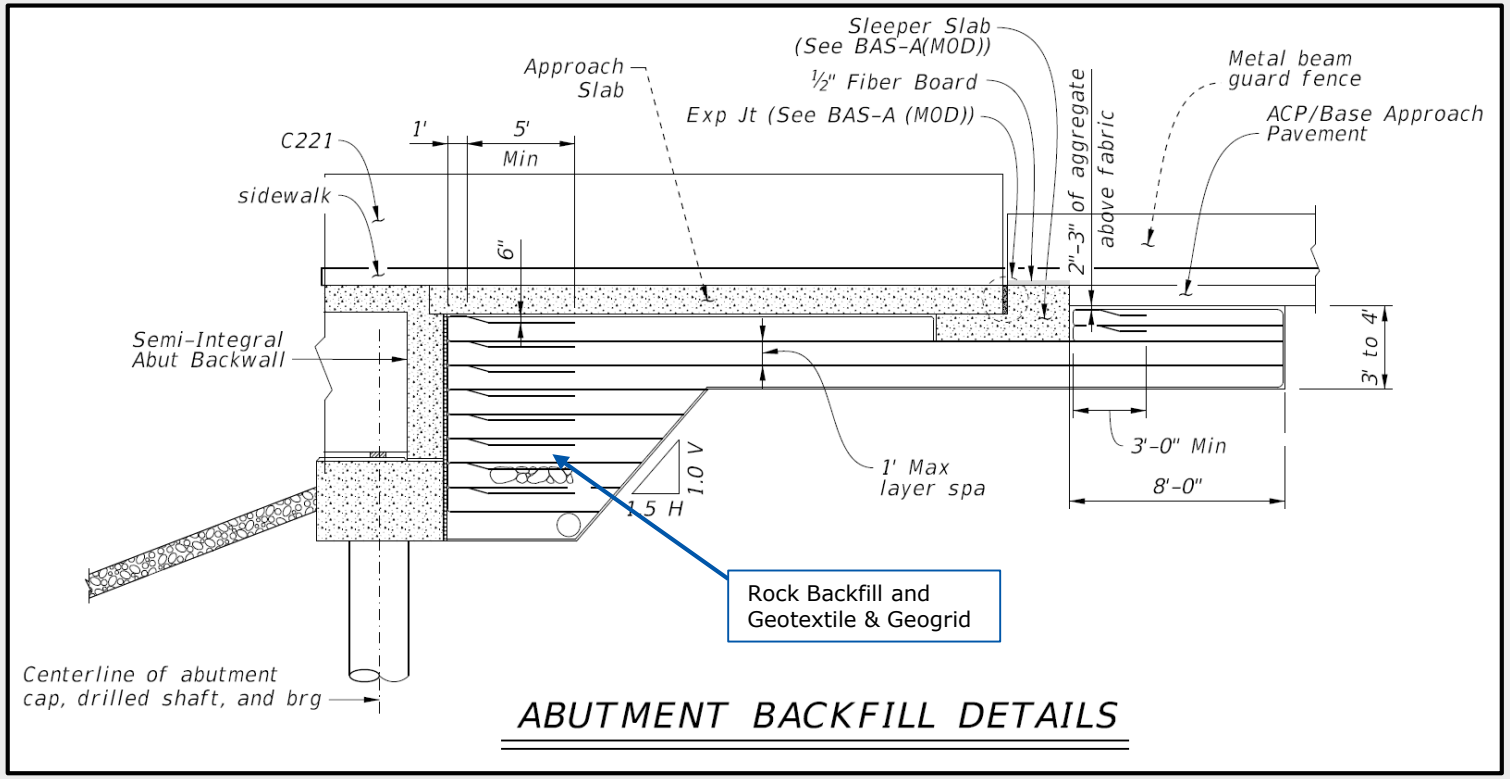
3.3.4. **Cement-Stabilized Backfill**. Backfill the excavation to the elevations shown with cement-stabilized backfill when shown on the plans. Use cement-stabilized backfill that contains aggregate conforming to the gradation limits shown in Table 1, water, and at least 7% hydraulic cement based on 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



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

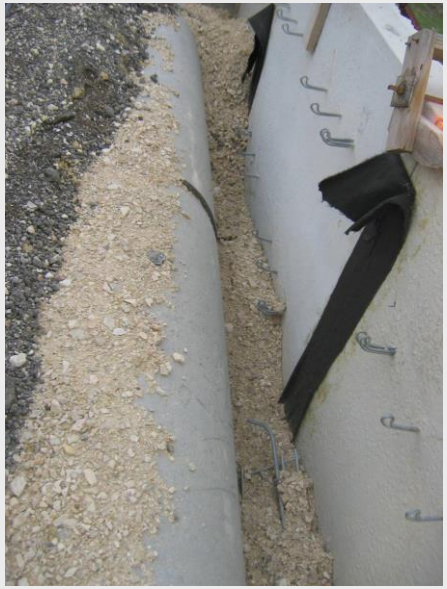
Select Backfill Gradation Limits

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?

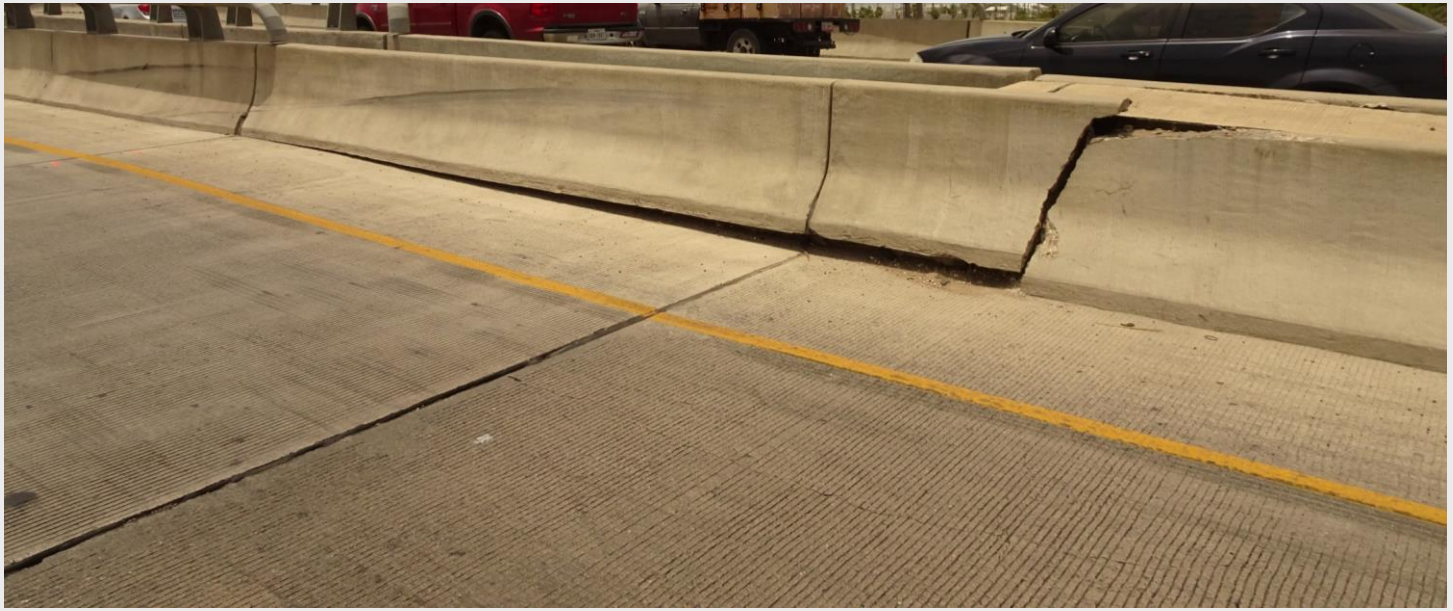
18

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

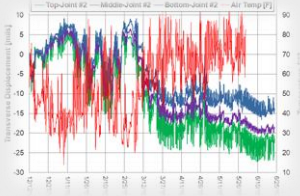
Bridge Approach Slab – Settlement and Undermining



Backfill Washout – Migration/Erosion (loss of material)

Visits, Monitoring, and Instrumentation

- Records (past inspections)
- Crack Gauge Documentation
- Photos
- GPR and Concrete Coring
- Boreholes, Inclinometers, Peizometers
- 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

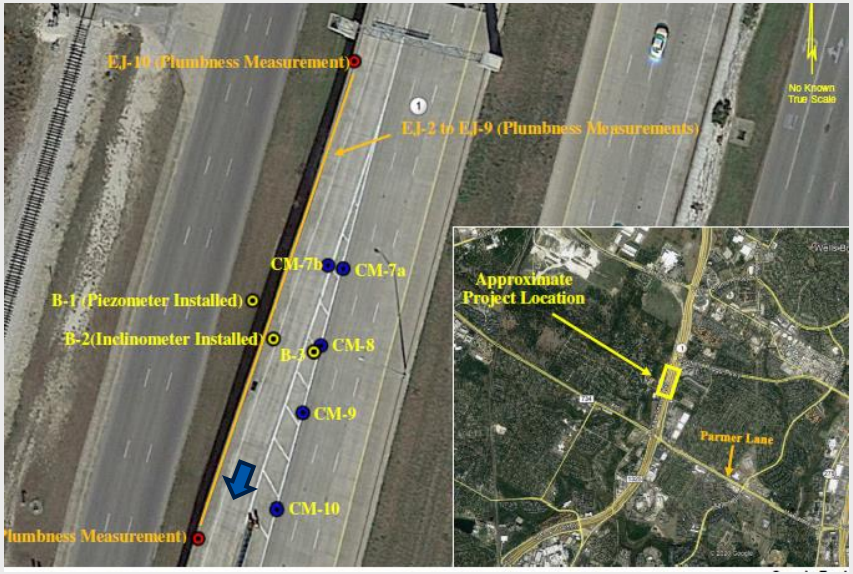
Limitation: Slope < 2:1 (Rule of Thumb)

NOT SOO SMALL SCALE REPAIRS

RW Repair Options

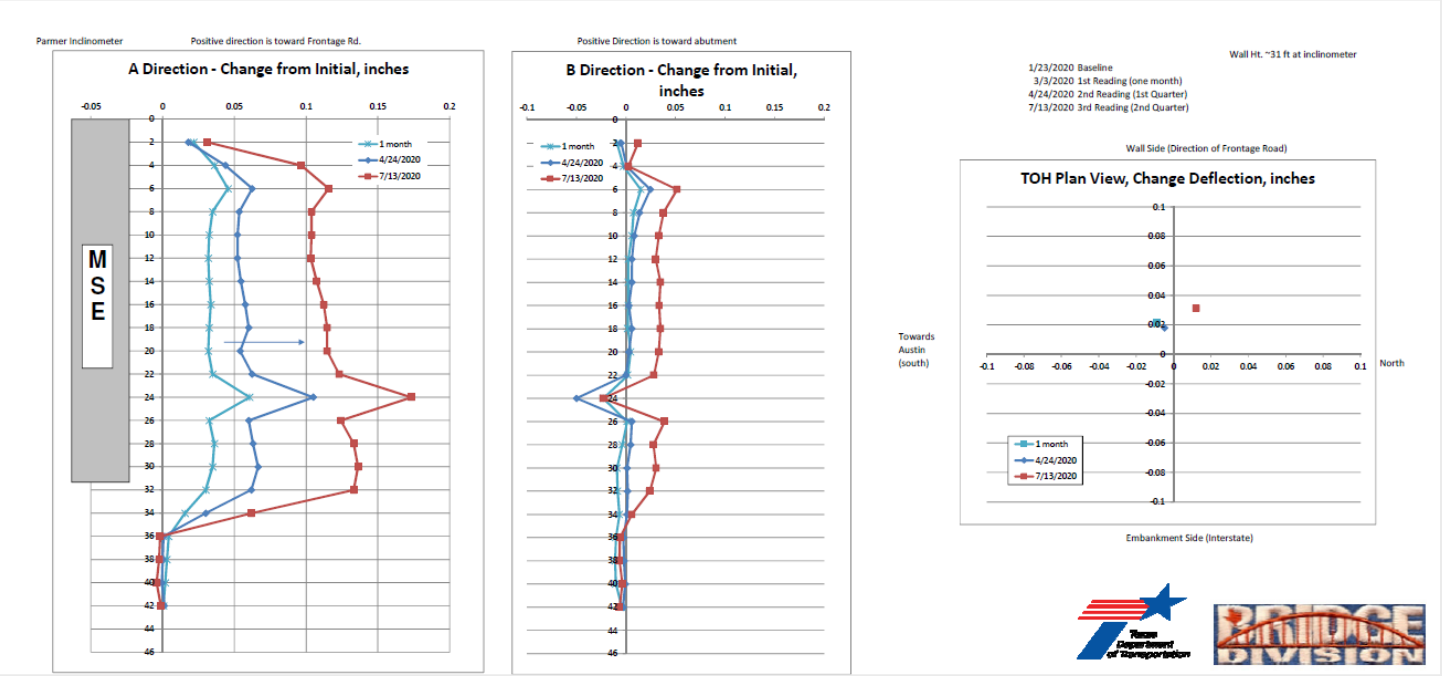
- Monitor
- Remove and Replace (Partial or Complete)
- Structural Support
- Bury, Entomb, Buttress
- Other

Lp1 SB exit ramp MSE Wall @ Parmer Ln



Lp1 SB exit ramp MSE Wall @ Parmer Ln - Inclinometer

- 'A' Direction (perp. to traffic) ~0.1" sliding deflection over 6months

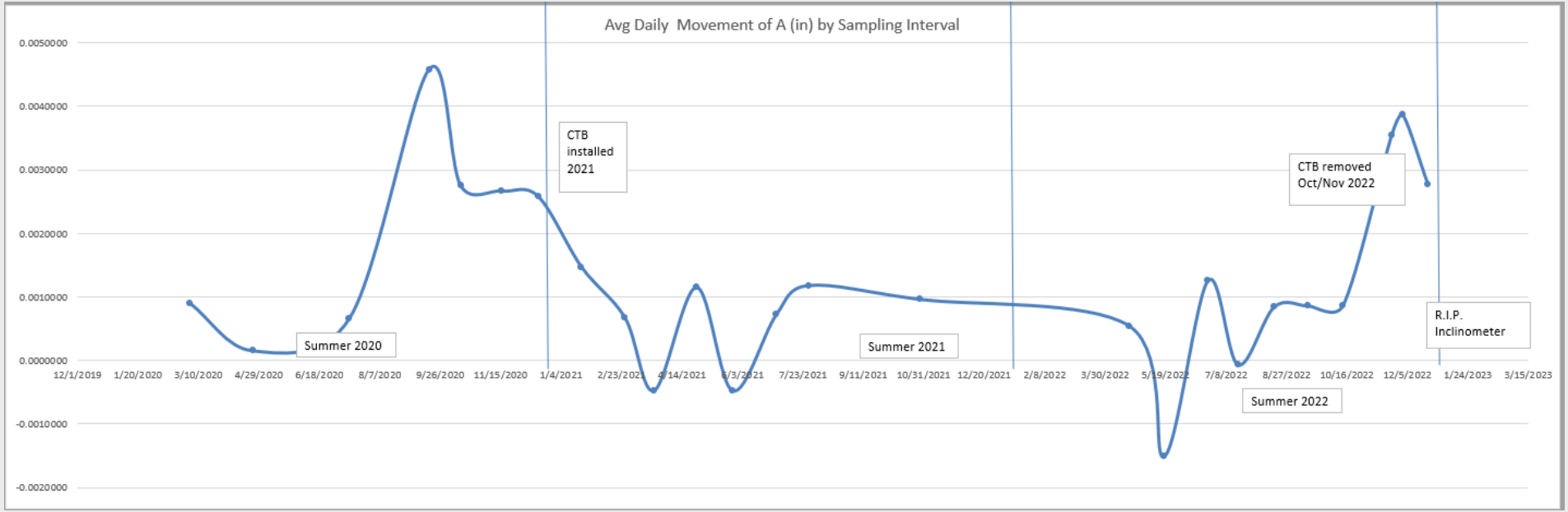


MSE Wall @ Parmer – Immediate Buttressing

Temporary Stabilization

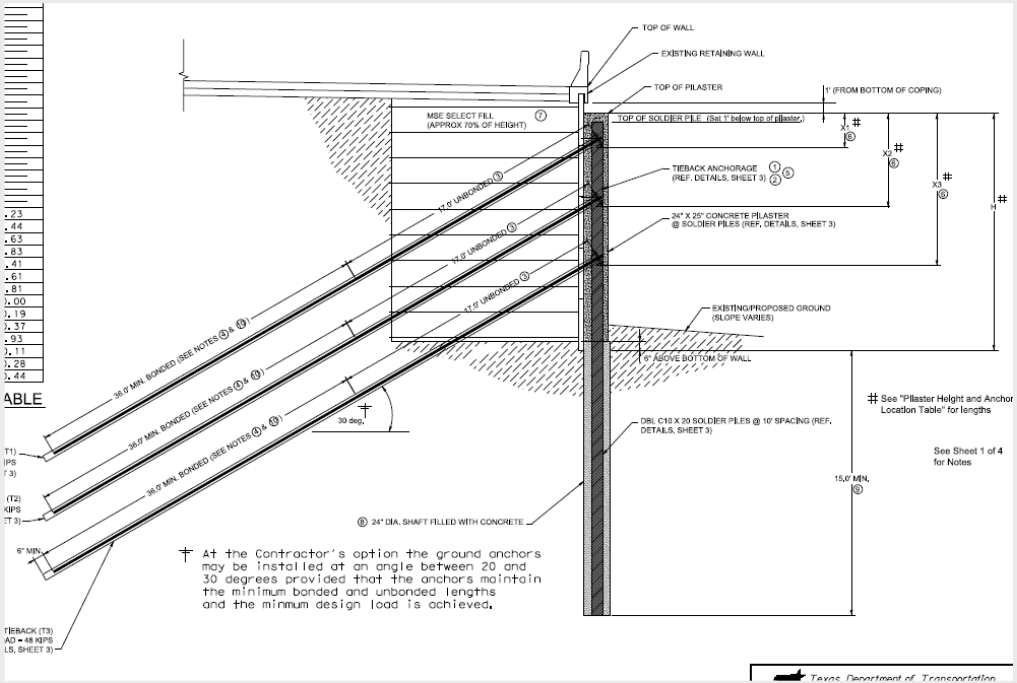
LPCTBs

MSE Wall @ Parmer – Buttressing Effect



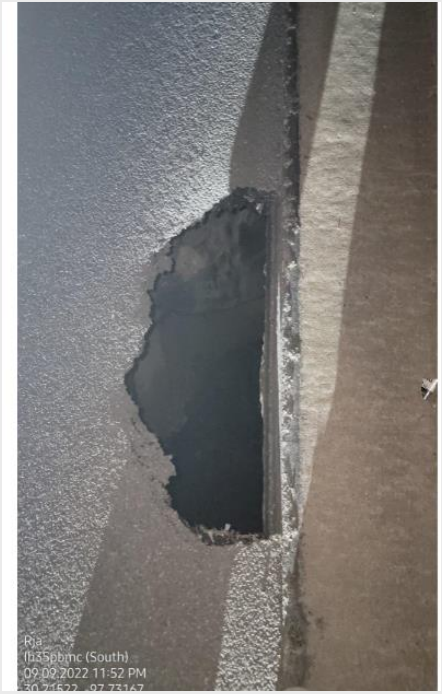
MSE Wall @ Parmer – Long Term Support

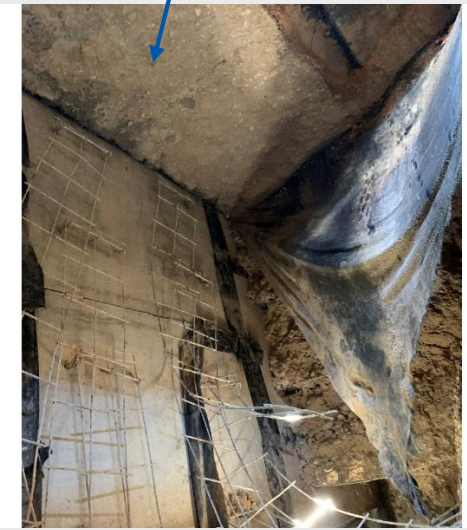
- Solider Piles (& Tie-back anchors) Installed every 10ft between panels of existing wall



MSE Wall @ Parmer - Now

SH 71 @ Burleson



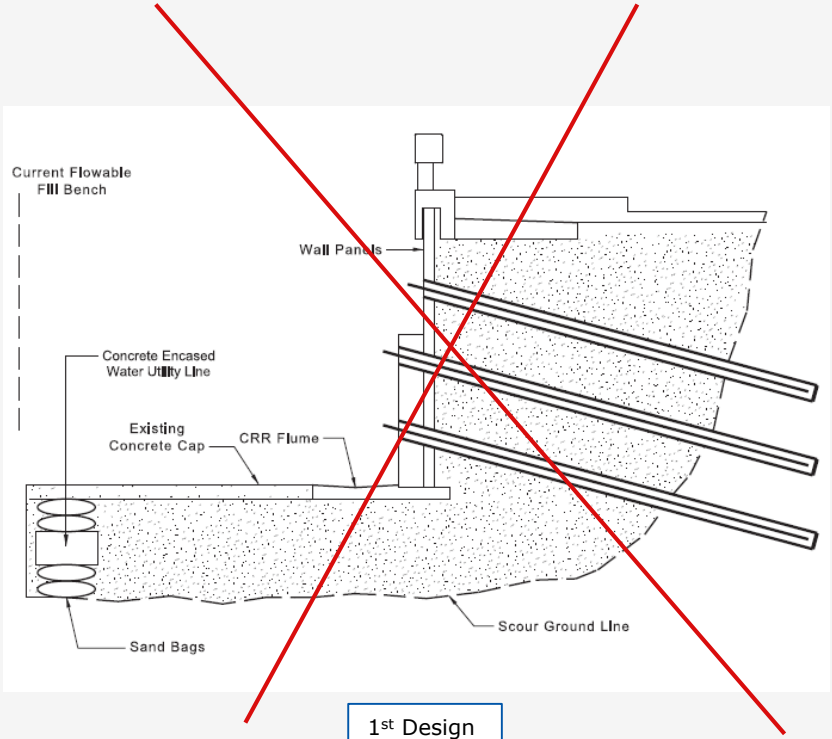


SH 71 @ Burleson – Immediate Response

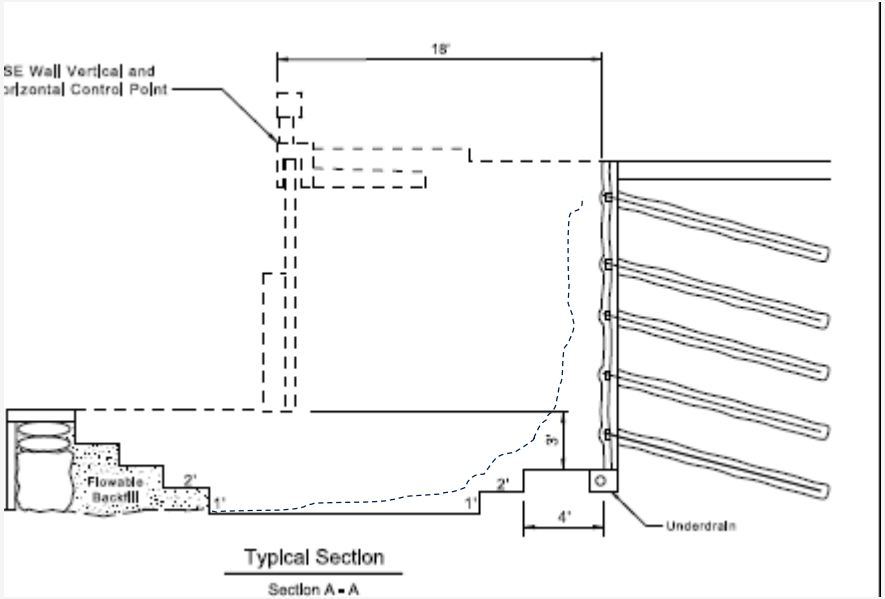
Concrete Encased Water Line

Flowable Fill Bench

SH 71 @ Burleson – Long Term Support

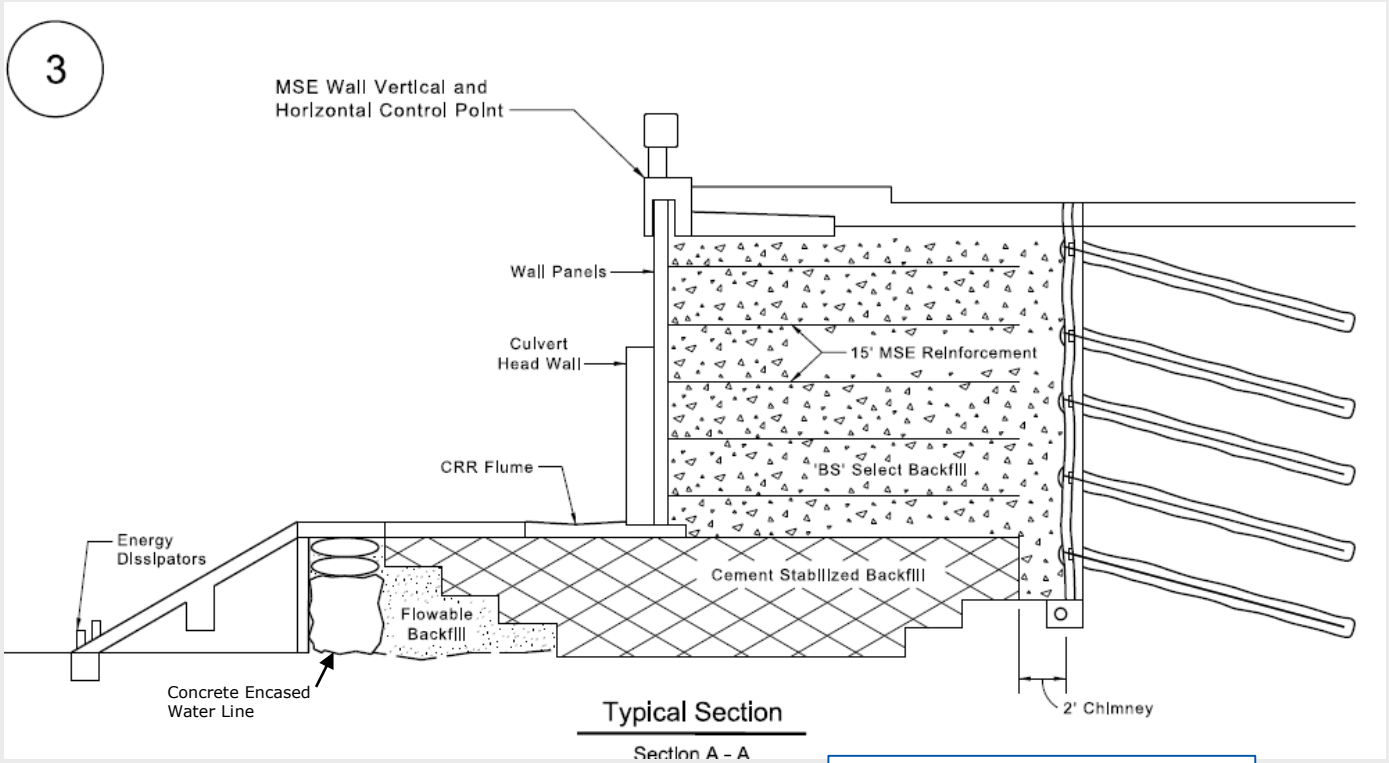


1st Design



Redesign

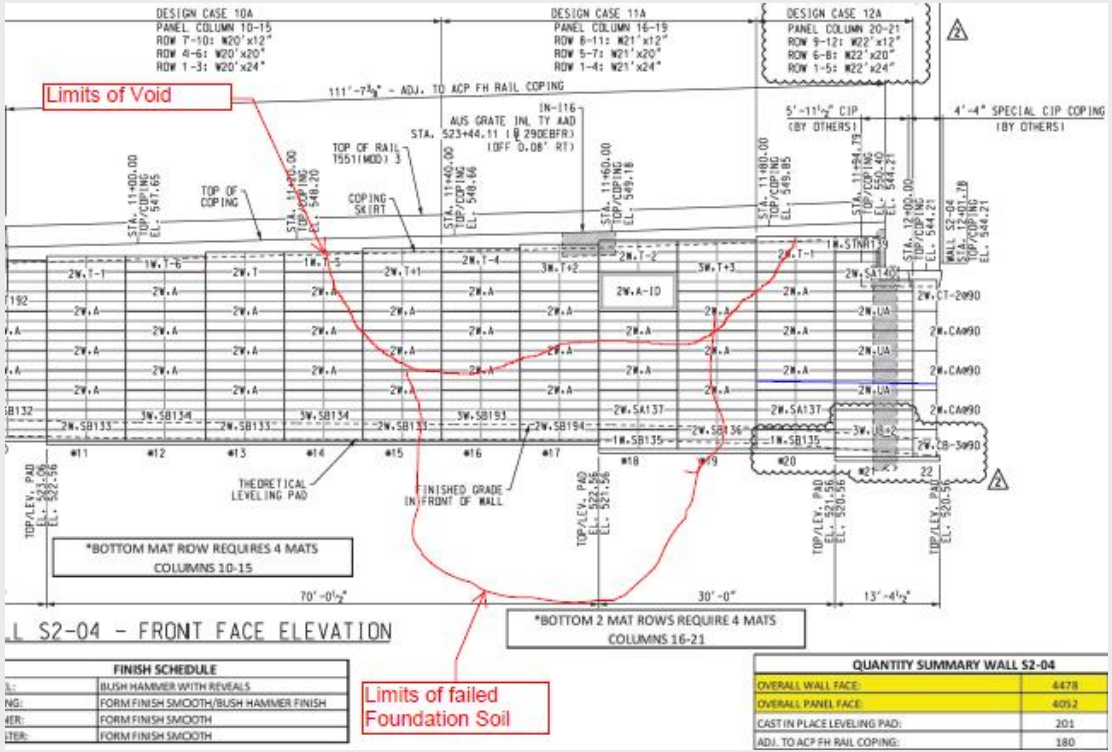
SH 71 @ Burleson – Long Term Fix



Redesign, *pending construction*

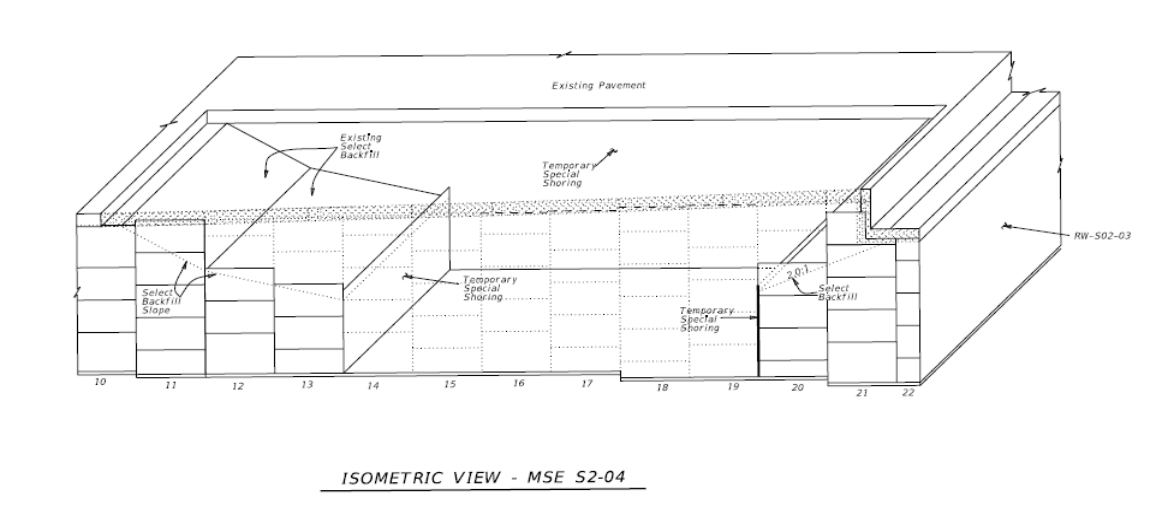
US 290 @ Walnut Creek

US 290 @ Walnut Creek – Limits

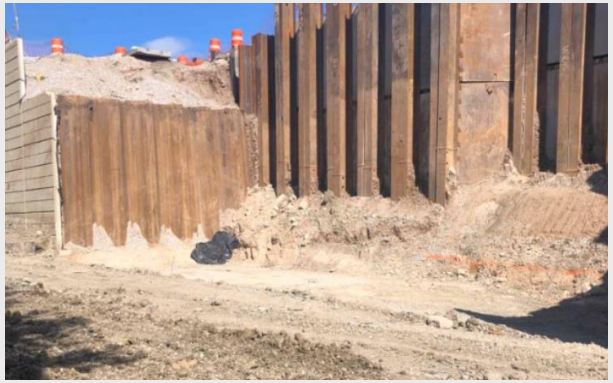


- Void Extended 16’ behind wall face
- Need to remove trench box and recompact material in front of wall
- **Ground Improvement** Needed at Toe and Wall Foundation

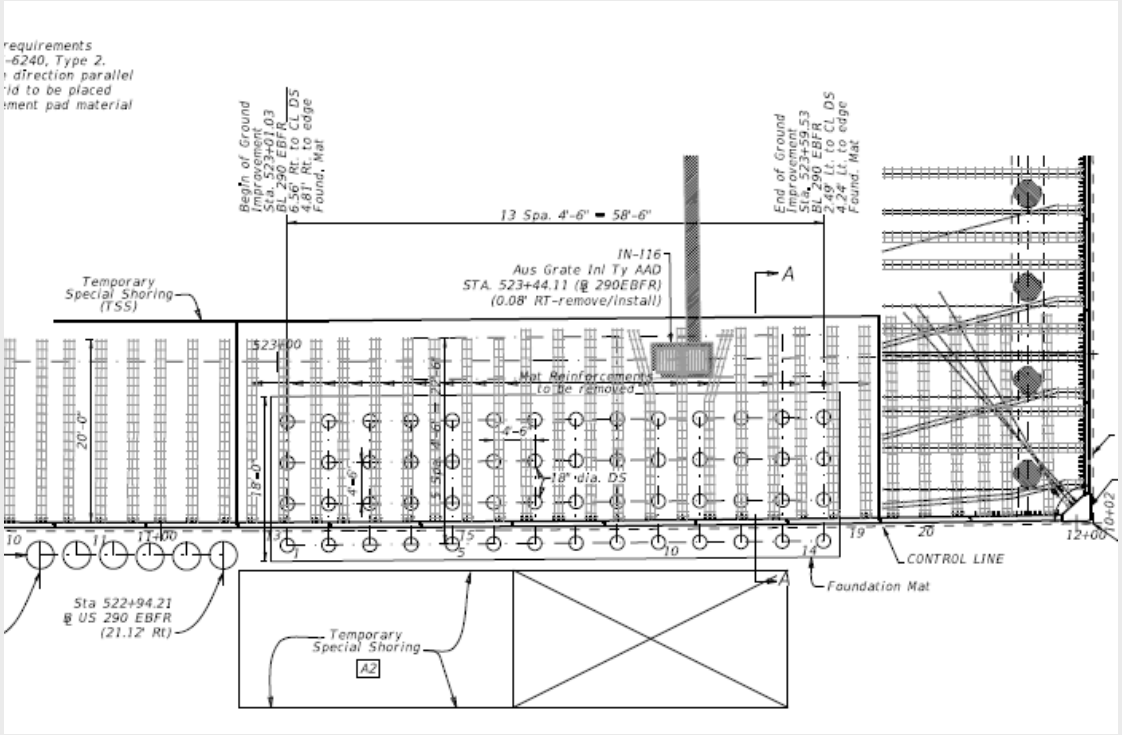
US 290 @ Walnut Creek - Plan

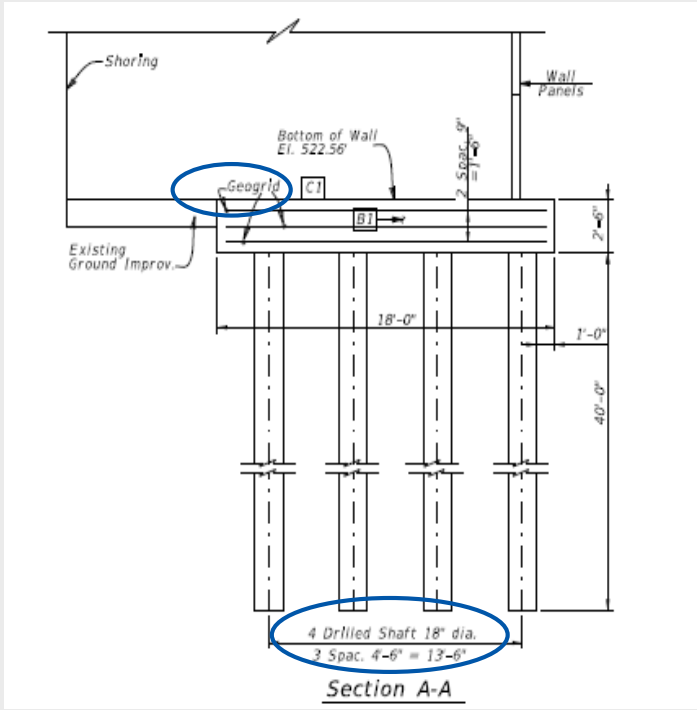


ISOMETRIC VIEW - MSE S2-04



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

QUESTONS
Please CONTACT:

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

Or any of the great engineers w/in:

TxDOT Bridge Division - Geotechnical Branch