Lightweight Cellular Concrete Fill to Mitigate Railroad Bridge approach Settlement

Nathan Johnson, PhD, PE, Kleinfelder, San Diego, CA

Moises Arzamendi, RCE, GE, Kleinfelder, San Diego, CA

KLEINFELDER
Bright People. Right Solutions.

Outline

- Project Background
- Project Challenges
- Background of LCCF
- Design Approach
- Stakeholder Involvement
- Lessons Learned

KLEINFELDER
Bright People. Right Solutions.

Project Purpose

- Construct 0.9-mile segment of second main track to connect existing double track segments at each end of the project limits
- Results in a continuous 7-mile stretch of double track within LOSSAN Corridor to downtown San Diego

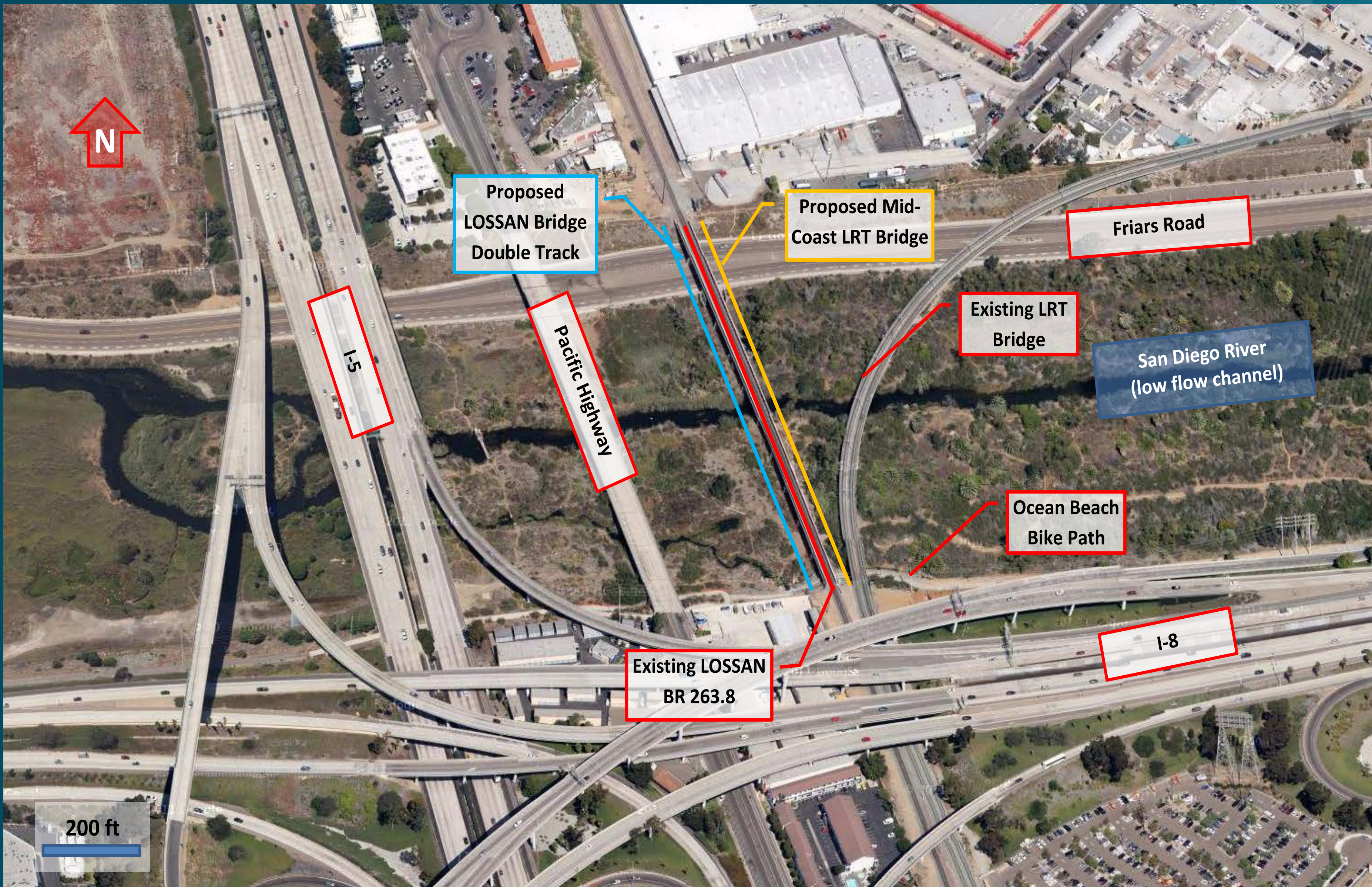
KLEINFELDER
Bright People. Right Solutions.

Major Project Components

- Replacement of existing single track bridge over San Diego River with a 900-foot-long double track bridge
- Runs parallel to proposed Mid-Coast LRT
- Design Components:
  - Bridge
  - Track Alignment
  - Railroad Systems & Signals
  - Collision & Retaining Walls
  - Drainage
  - Lowering of Ocean Beach Bike Path
  - Utilities
  - ROW
- Construction late 2015

KLEINFELDER
Bright People. Right Solutions.

San Diego River Bridge



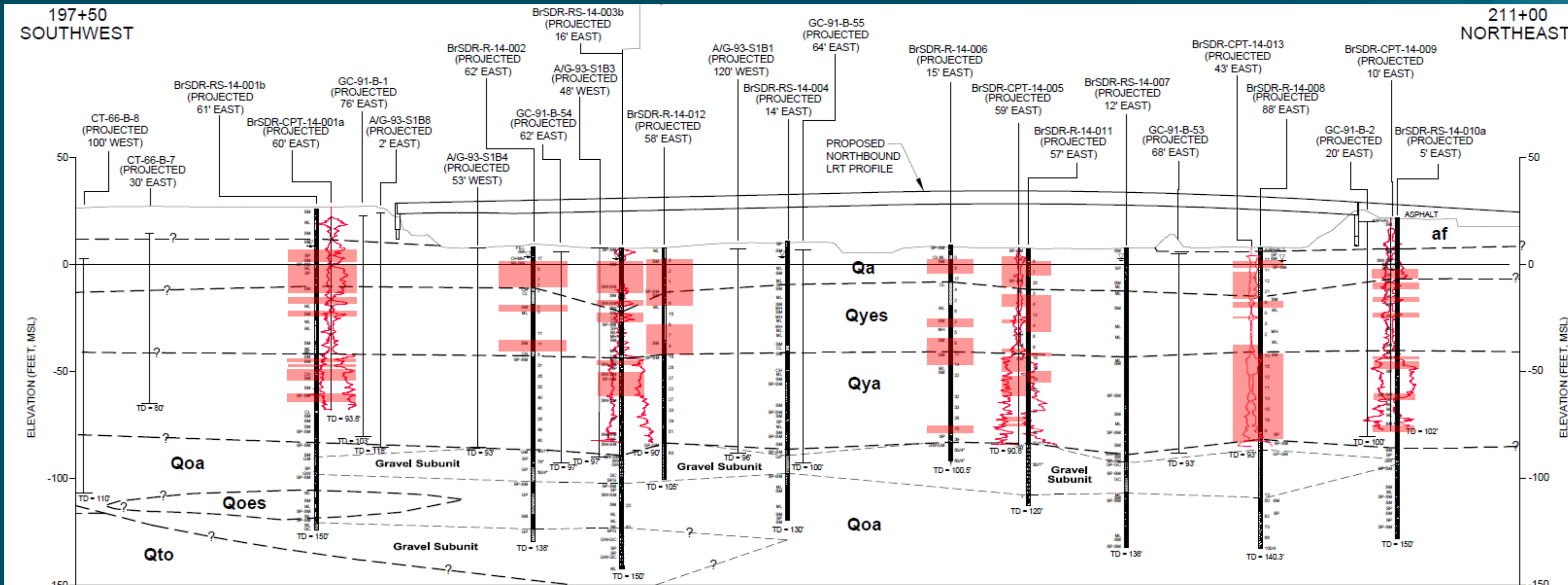
Major Stakeholders

- SANDAG – Project Delivery
- NCTD – Rail Operator and Maintainer
- MTS – Right-of-Way owner

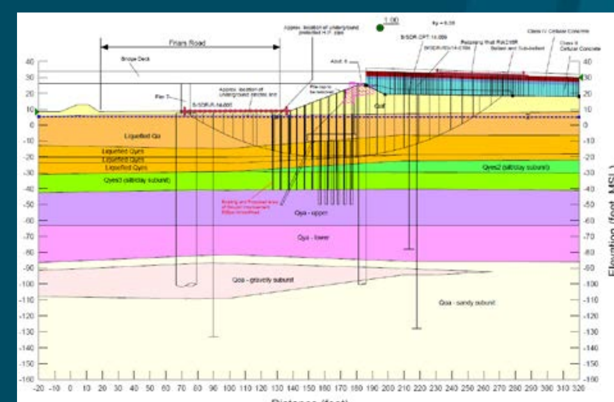
- Adjacent Mid-Coast Corridor LRT Project

- Contractor (Skanska / Stacey& Witbeck / Herzog)

River Soil Conditions During Earthquake

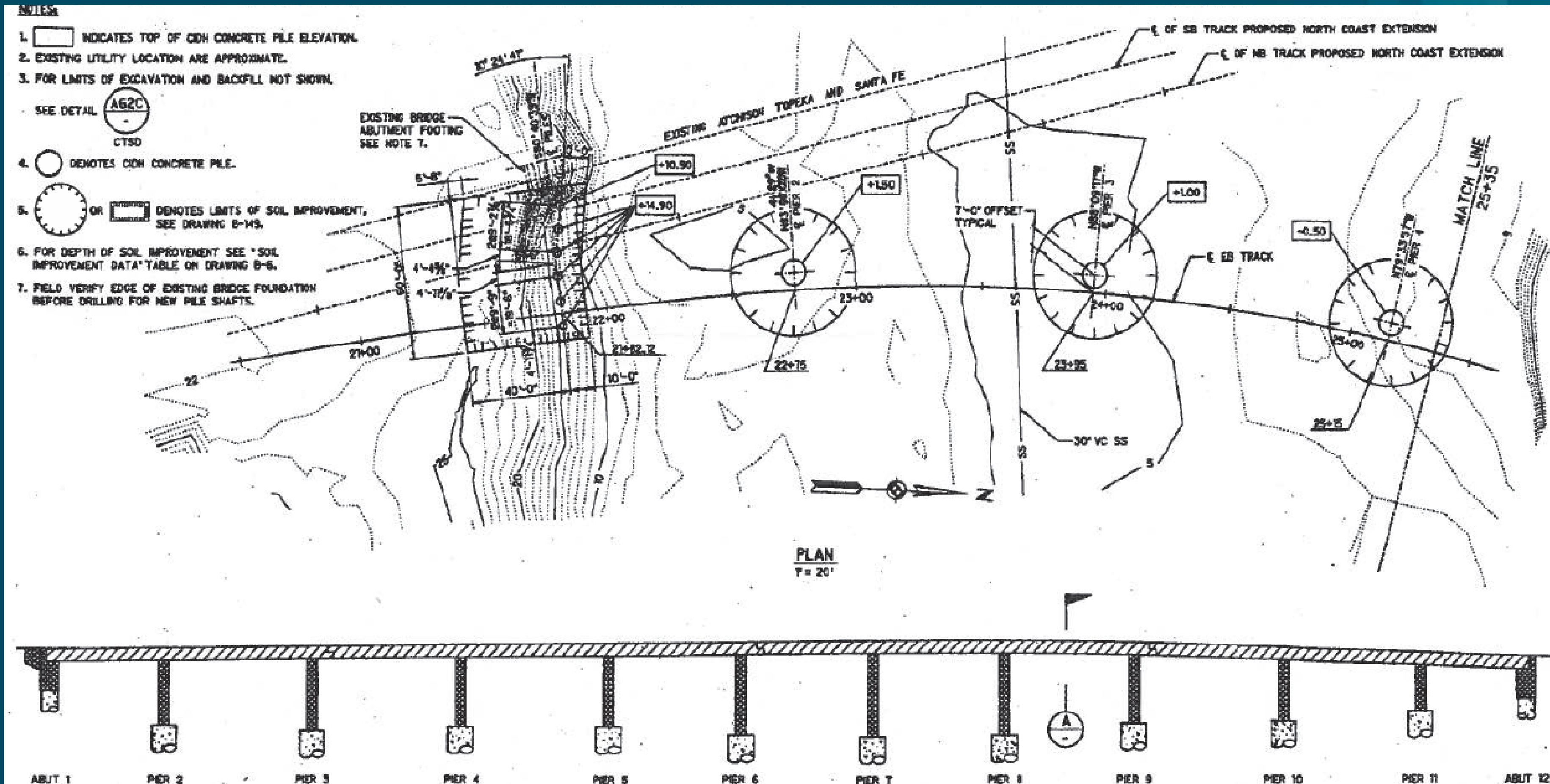


- Survivability Event – Approximately 80 feet deep
- Scour is up to 20 feet
- Slope Stability and Lateral Spreading



KLEINFELDER
Bright People. Right Solutions.

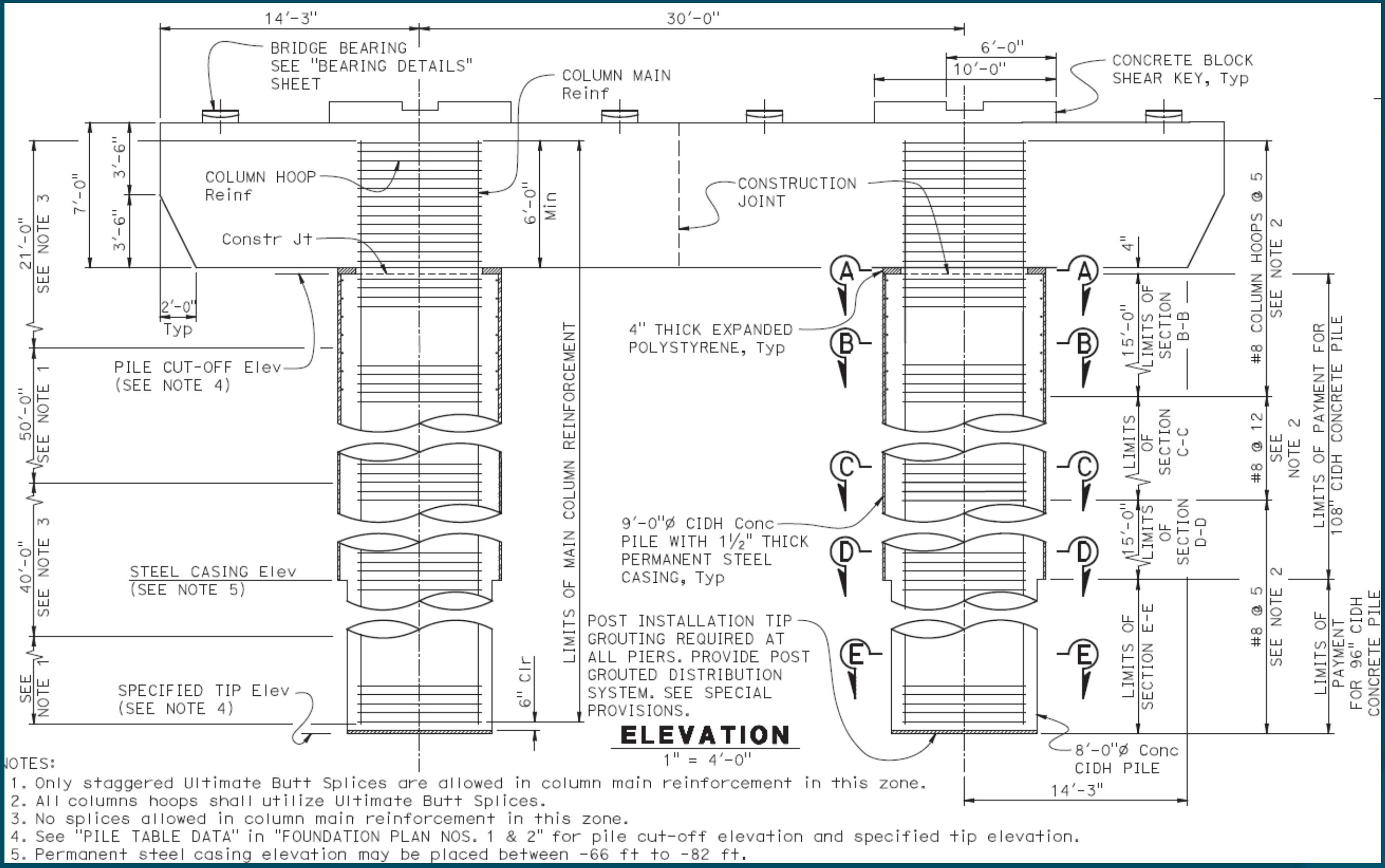
Mission Valley West

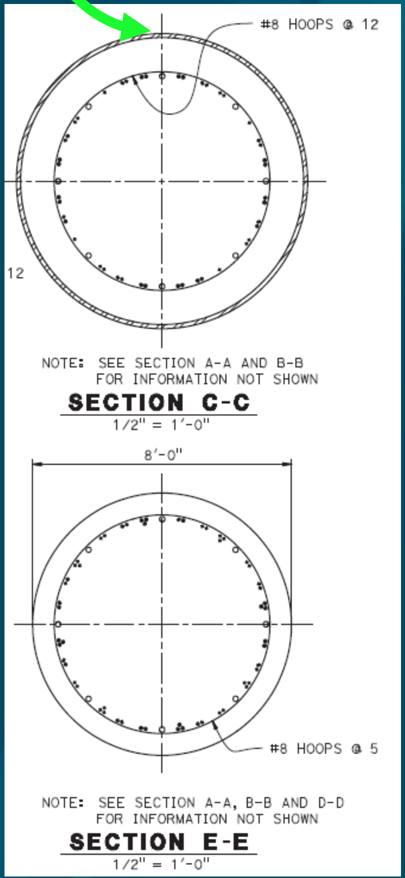


KLEINFELDER
Bright People. Right Solutions.

San Diego River

- Permanent Casings 65 feet deep
- Used for Strength and Stiffness
- Approx. $4M Cost Savings

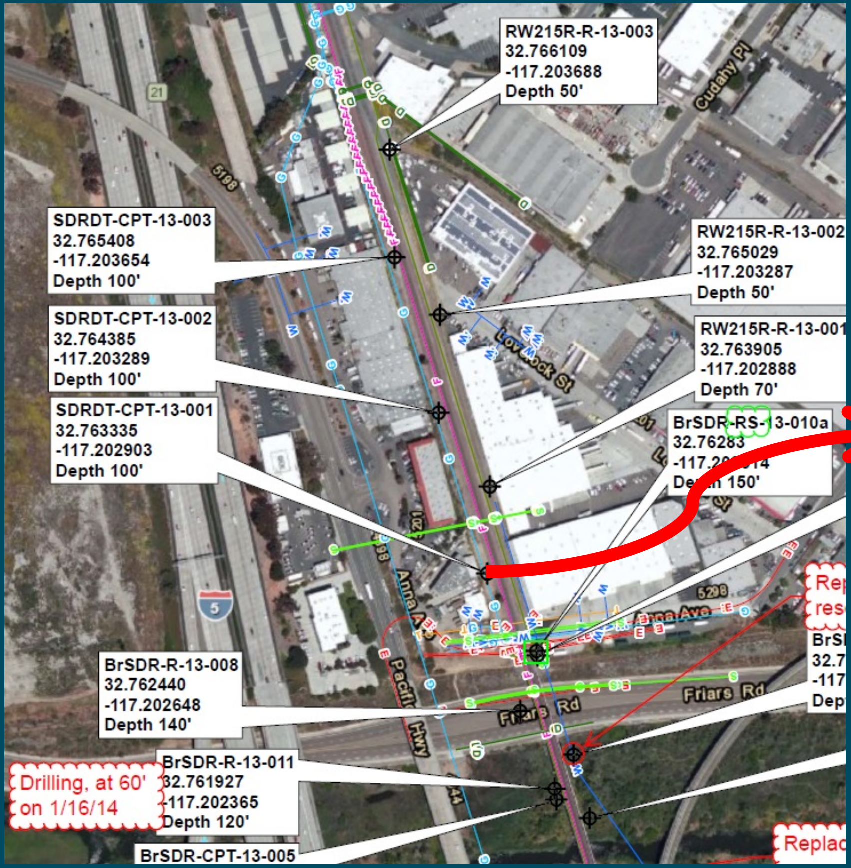


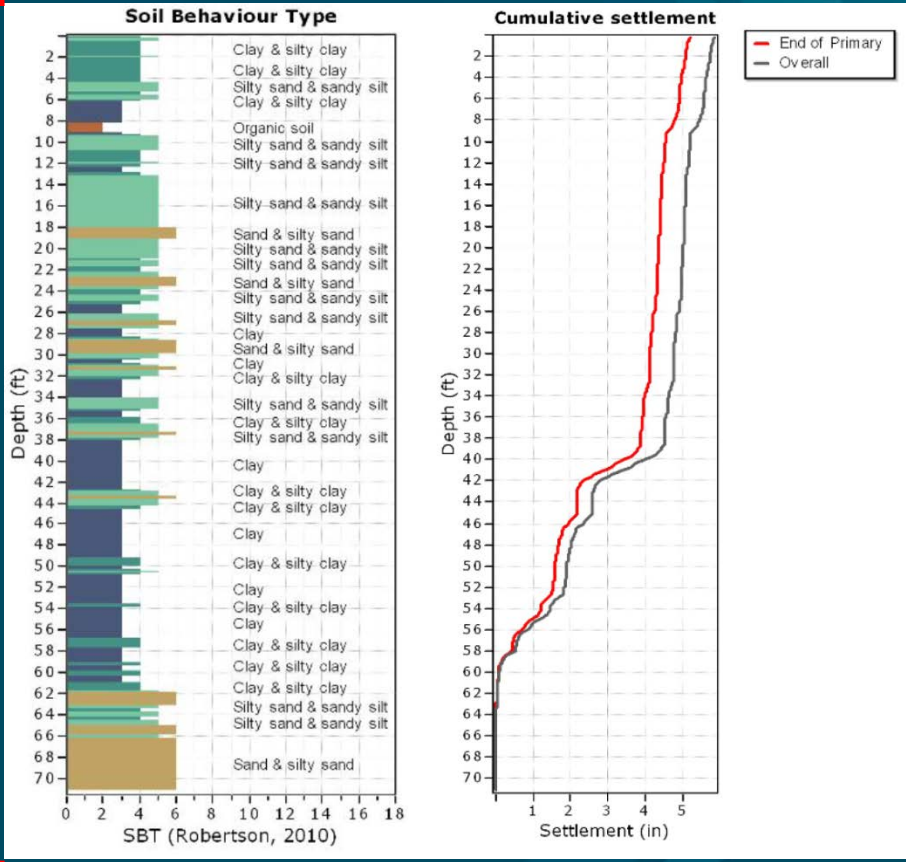


KLEINFELDER
Bright People. Right Solutions.

Traditional Wall (Preliminary Design)

Compressible Soils





CPT 001 – Directly under fill

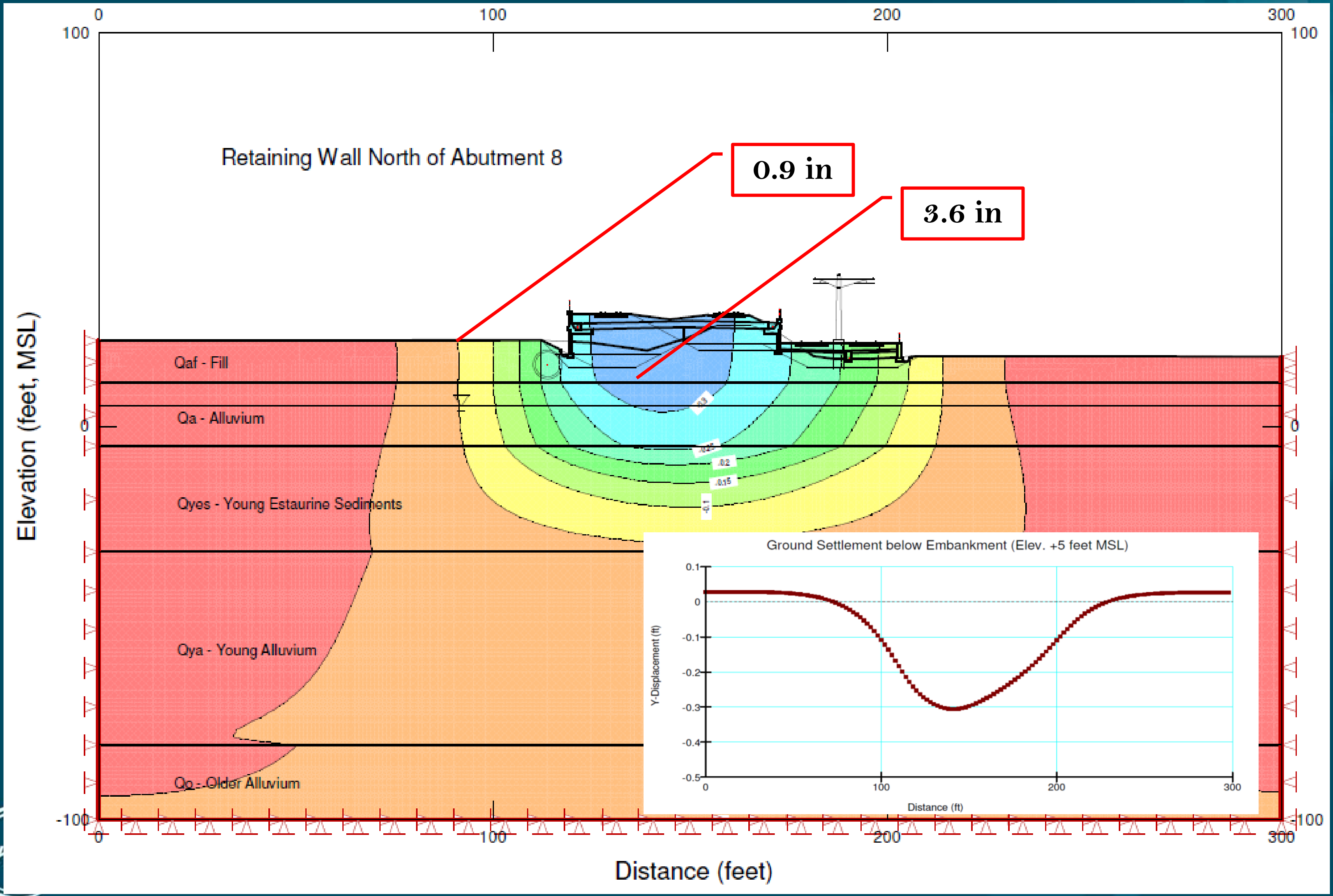
KLEINFELDER
Bright People. Right Solutions.

Estimated Building Settlements

- Typically Desire < 0.25 in

KLEINFELDER
Bright People. Right Solutions.

Sample Traditional Fill



Issues and Solutions

- Potential Issues
  - Building Settlements
  - Track Settlements order of 5 inch
  - Utility Settlements (similar to track)

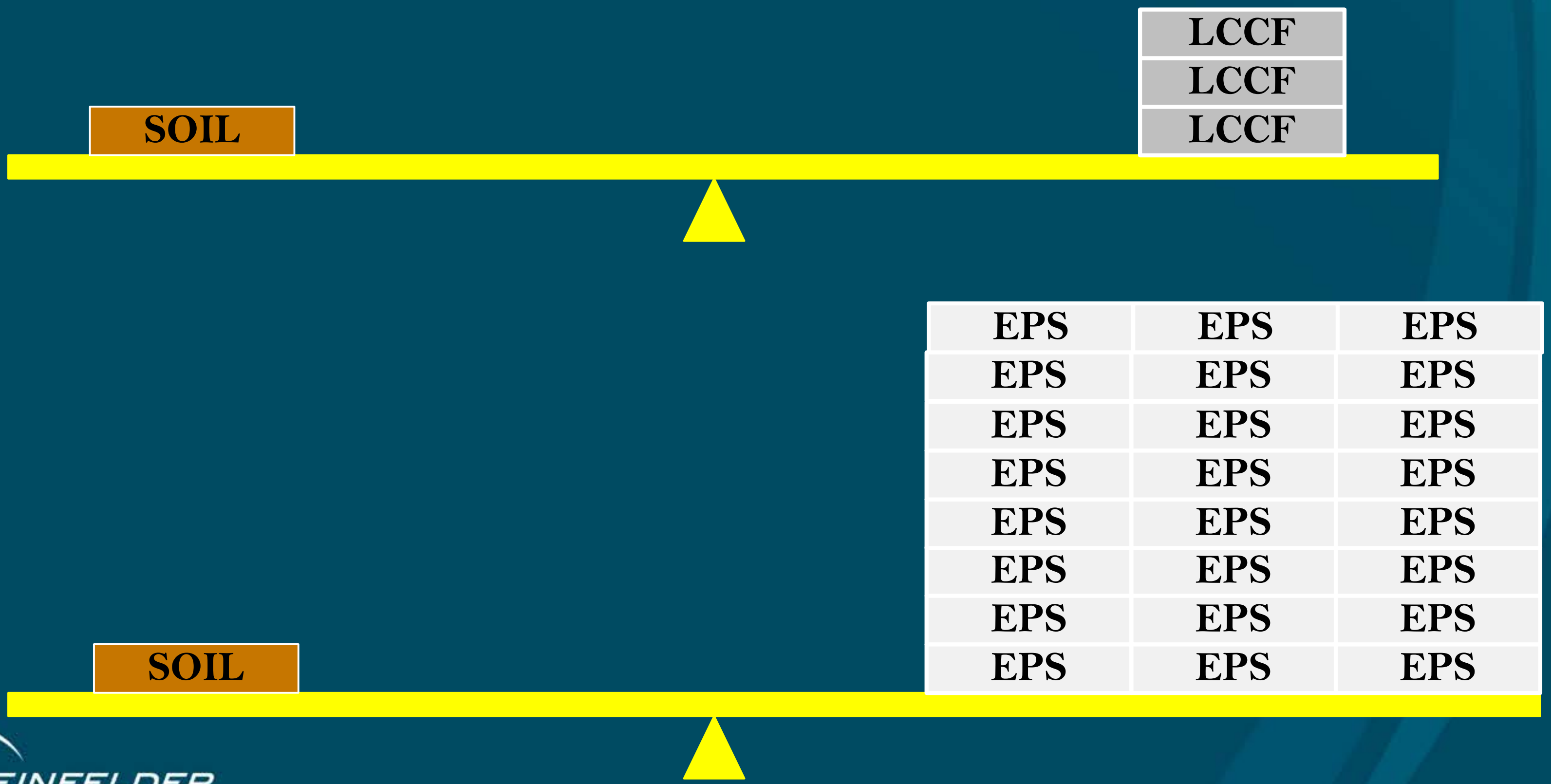
- Solutions
  - Sheet Pile Wall → utilities, building risk, cost, track settlement
  - Lower Profile → cannot lower profile enough
  - Ground Improvement Only → expensive, building and utility risks
  - Surcharge → building and utility risks
  - Bridge Structure → expensive and maintenance

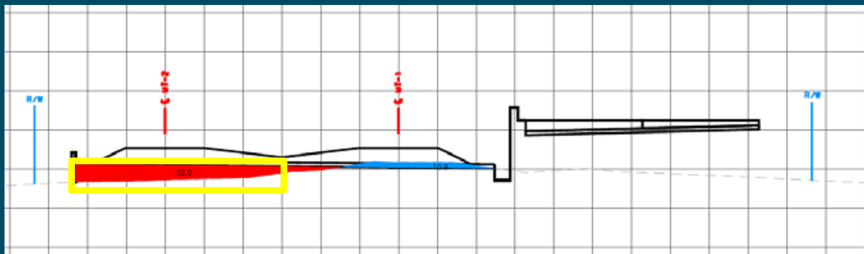
  → Lightweight Fill with Ground Improvement

KLEINFELDER
Bright People. Right Solutions.

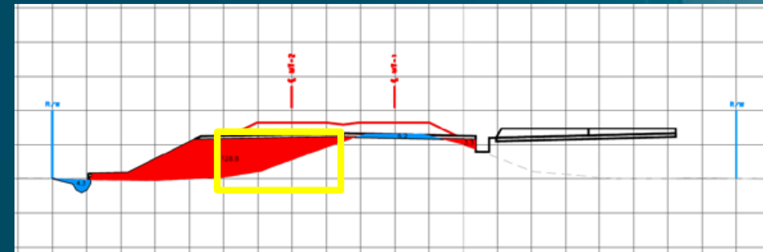
Preferred Solution

- Lightweight Fill
- Use light material and over-excavate to balance load





209+60

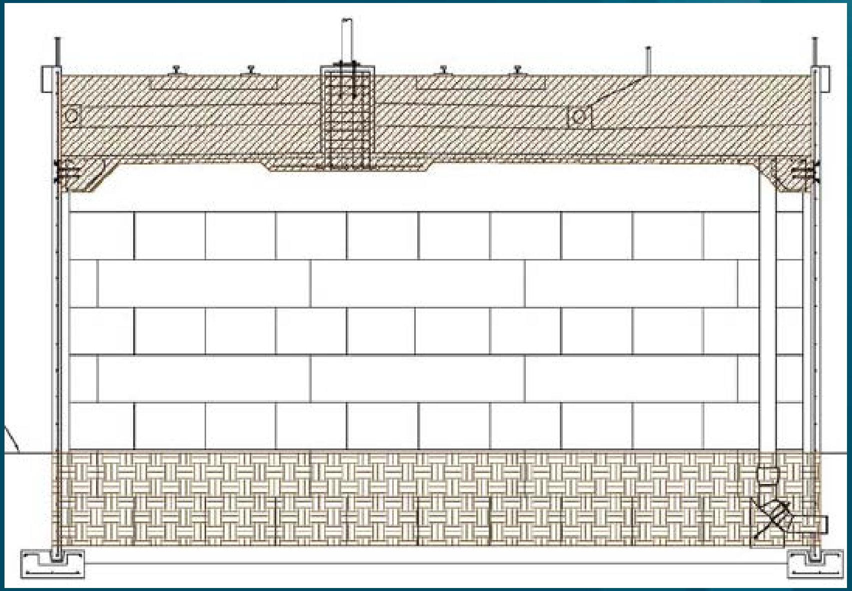


217+60

KLEINFELDER
Bright People. Right Solutions.

Geo-foam Considerations

- Benefits over proposed
  - Lighter weight
  - EPS first used for roadway embankments in 1972
- Drawbacks
  - Less "heavy rail" precedent
  - Must be sealed from solvents, etc.
  - Can be susceptible to rodents, fire, insects
  - Not monolithic or pourable
  - Connectivity to facing
  - Agency approval



KLEINFELDER
Bright People. Right Solutions.

Bridge Considerations

- Benefits over proposed
  - More familiar for the corridor
  - Drainage

- Drawbacks
  - Capital Cost (estimate $18M vs. $2.5M)
  - Maintenance (assume concrete - regular inspections)
  - Constructability (pile construction, slow orders, slope stability)

KLEINFELDER
Bright People. Right Solutions.

Lightweight Cellular Concrete Fill

- Site mixed with foaming agent
- 2-3 foot lifts
- Approx. $40-50/cuyd (typical)
- Demonstrated past use
- Special Provisions and TransLab tests

Cellular Concrete Class	Cast Density Pcf	Minimum Compressive Strength at 28 days* psi
I	24-29	10
II	30-35	40
III	36-41	80
IV	42-49	120
V	50-79	160
VI	80-90	300

KLEINFELDER
Bright People. Right Solutions.

Lightweight Fill Considerations

- Agency Approval
- Proof of Use
- Constructability
- Durability
- Maintenance
- Drainage
- Global Stability
- Seismic Displacements
- Seismic Stability
- Settlements
- Vibration
- Flotation

KLEINFELDER
Bright People. Right Solutions.

LCCF Projects with MSE Facing

Project	City	Completion Date	Volume (CY)	Agency
Cypress Replacement	Oakland	1997	110,000	Caltrans
12th Street Lake Merrit	Oakland	2011	75,000	Oakland / FHWA
SW Moody Avenue Reconstruction	Portland	2011	39,000	Portland
San Bruno Railroad Grade Separation	San Bruno	2012	200,000	CalTrain
UPRR Flyover Project (Colton Crossing)	Colton	2013	220,000	UP/BNSF
Exposition Light Rail - Phase II	Los Angeles	2014	43,000	LA Metro
405/22 Separation Caltrans Contract 12-071624	Garden Grove	In Progress	66,000	Caltrans/ OCTA

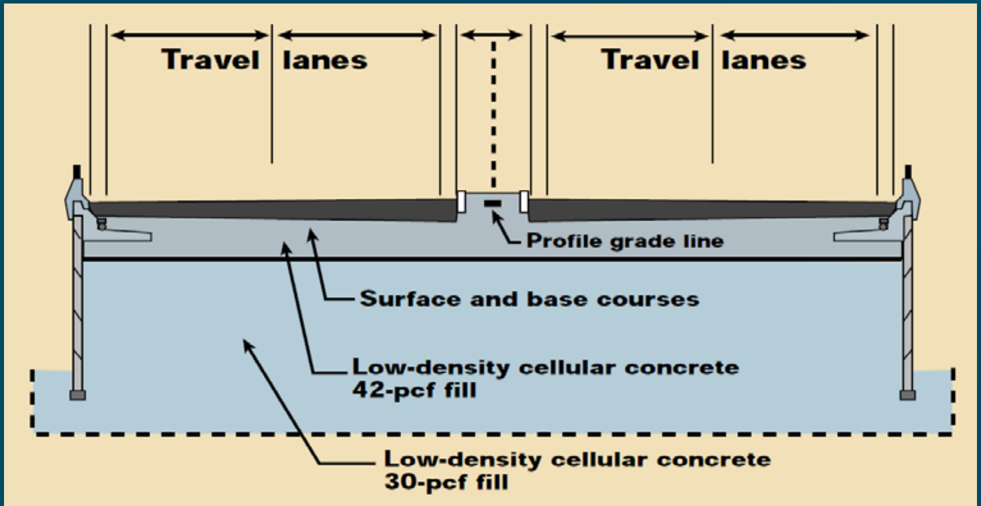
KLEINFELDER
Bright People. Right Solutions.

Cypress Viaduct

- 1989 collapse 42 deaths
- 3.5 mile freeway reconstruction
- Used beneath roadway
  - Poor underlying bay mud with low strength
  - Compressible and liquefiable

KLEINFELDER
Bright People. Right Solutions.

Maintenance Record



- AADT = 121000 vehicles
- MacArthur Maze estimated cost of $6M/day closure
- 17-year Maintenance Record from District 4 Chief of Maintenance
  - Cypress lightweight fill section is holding up well
  - No rehab project in this section, nor any significant maintenance repair work involving the structural section

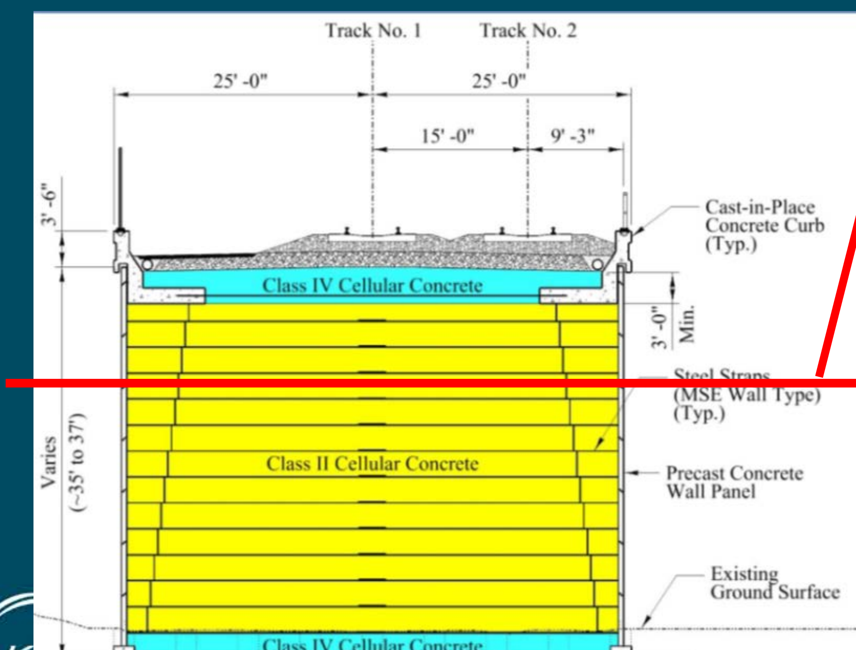
KLEINFELDER
Bright People. Right Solutions.

Example: San Bruno Grade Separation

- Caltrain Heavy Commuter Rail
- Directly over Bart tunnel to SFO
- Net zero requirement for project
- Cellular Concrete Fill 40 ft high
- 10 ft additional load balance

Colton Crossing

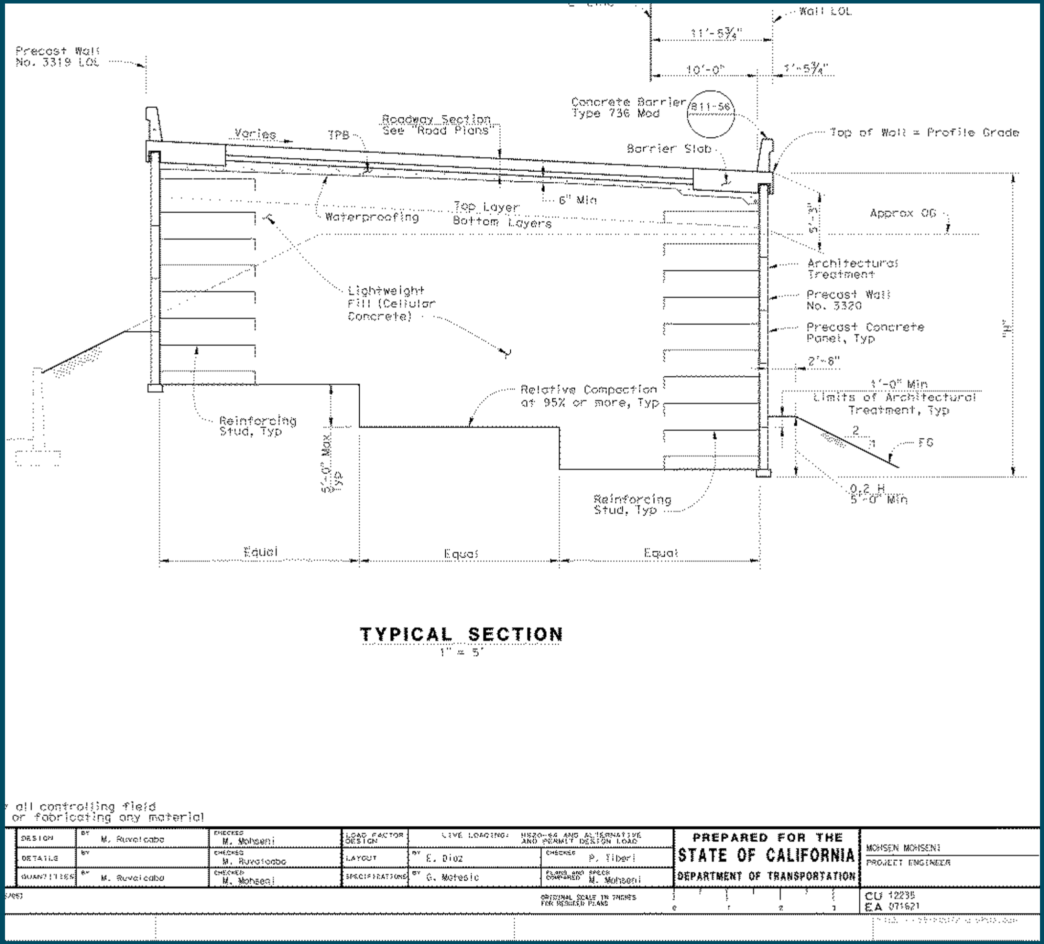
- BNSF MSE Style overpass up to 40 ft high
- Fill to reduce settlement concerns
- >100 Trains/Day (BNSF, UP,Metrolink, Amtrak)



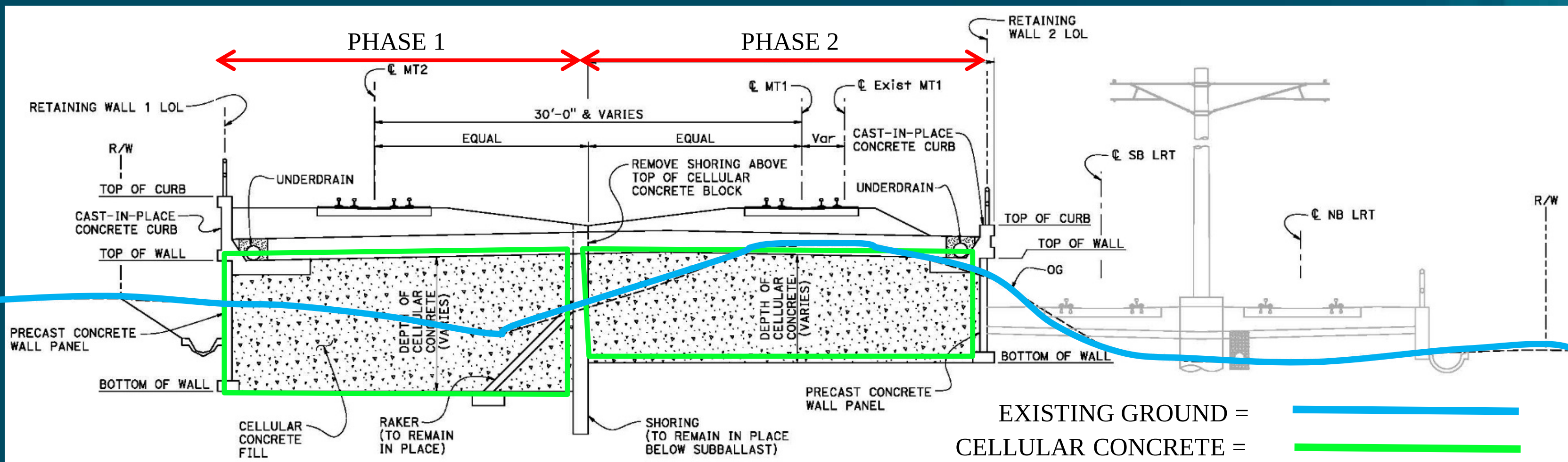
Bright People. Right Solutions.

I-405/SR22 Grade Separation

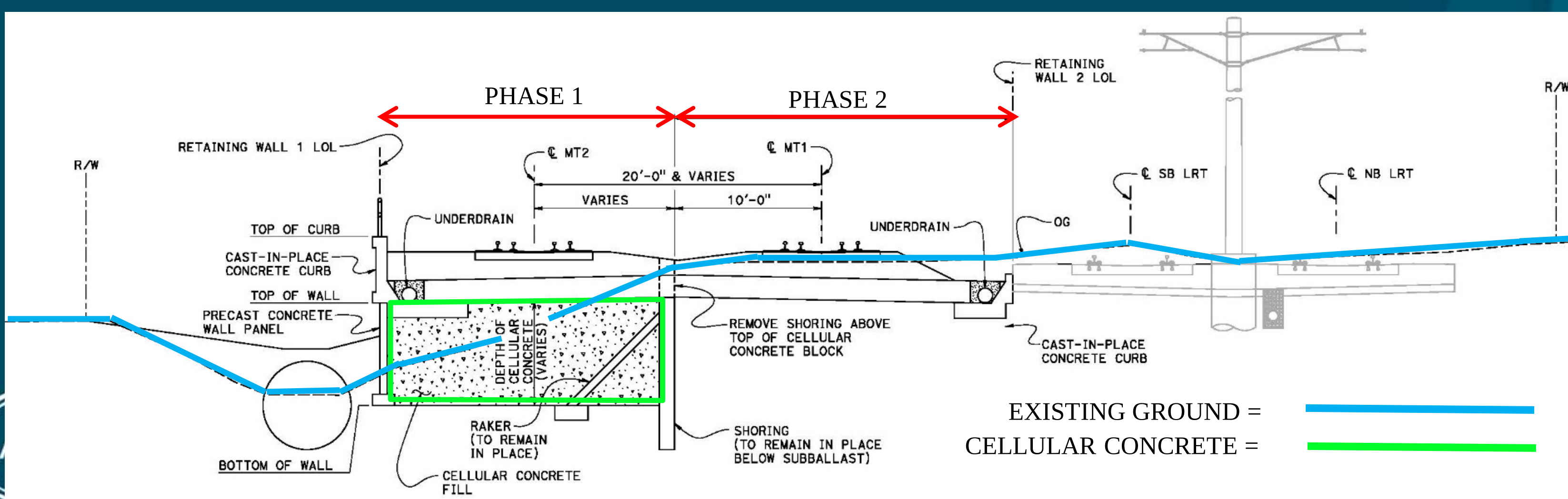
- Caltrans/OCTA highway embankment
- Load balancing (similar quantity to SDRDT)



Concept Section at 30% Design



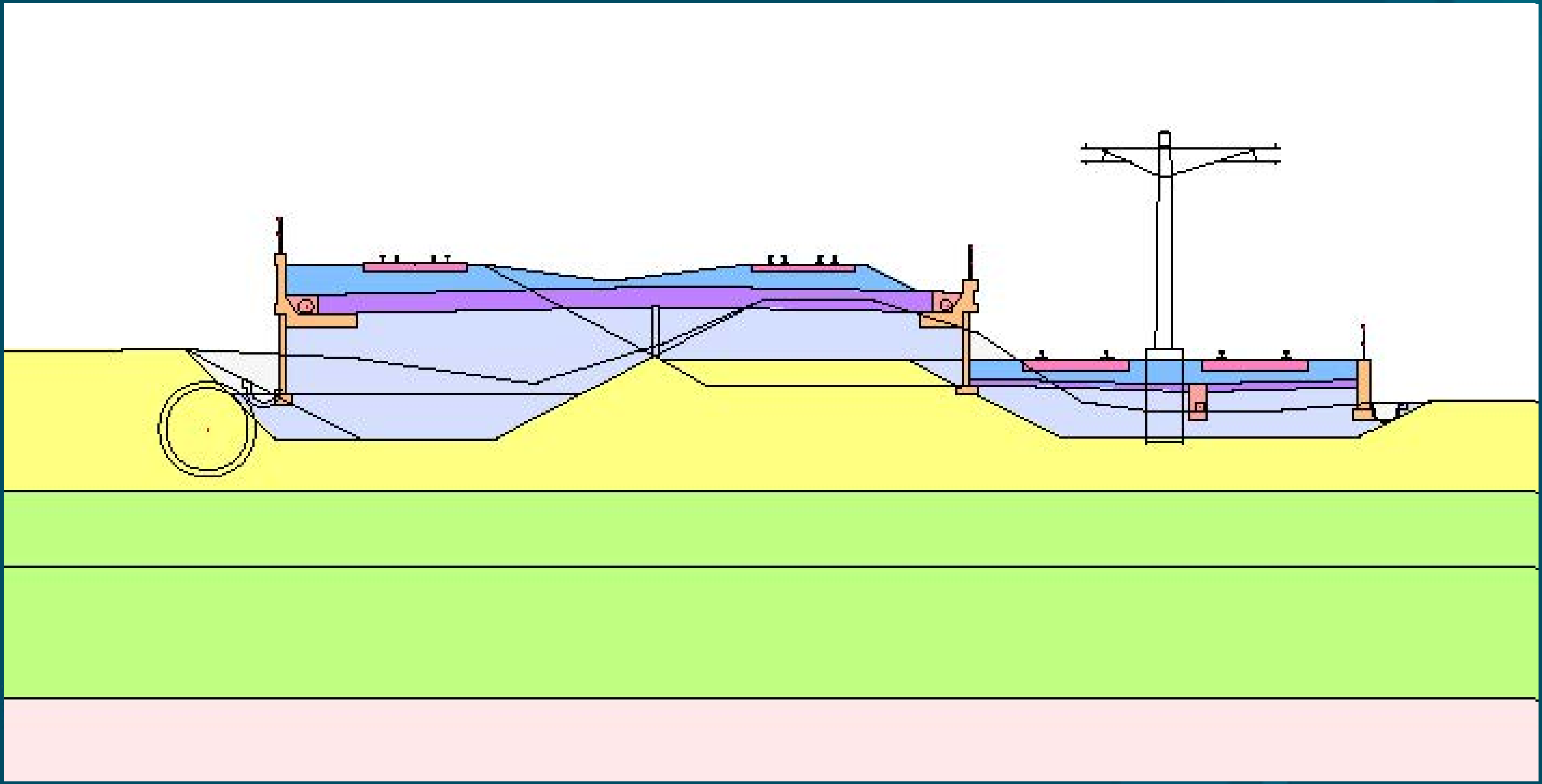
Cross Section of Lightweight Fill below MT1 and MT2 at South End of Wall



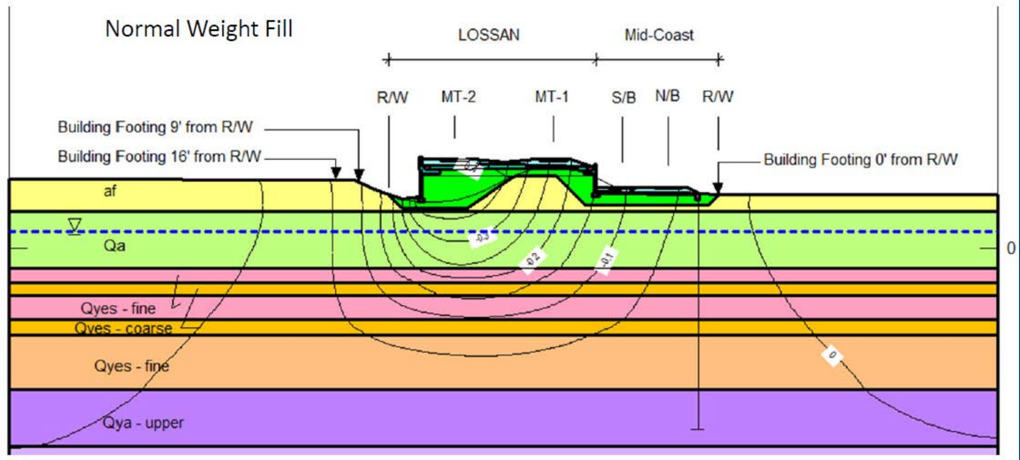
Cross Section of Lightweight Fill below MT1 and MT2 at North End of Wall

60% Design LCCF Configuration

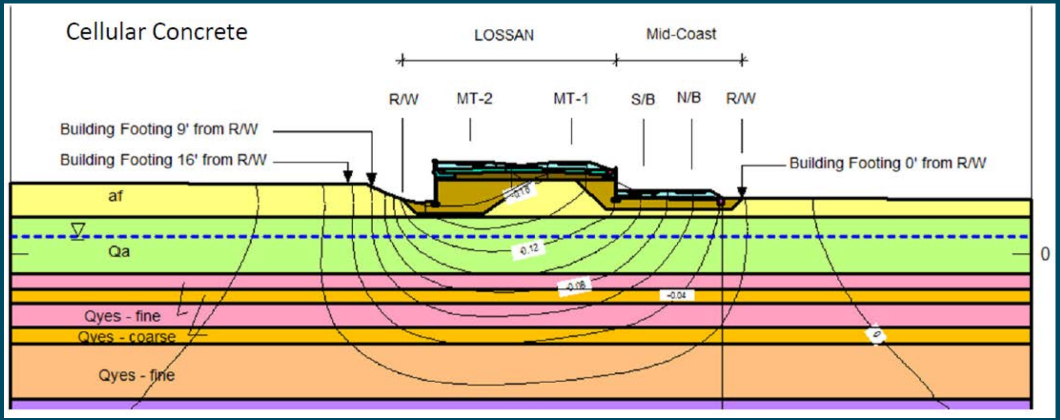
- Reduce Shoring
- Sample Analysis of Staged Construction



Normal Fill vs. LCCF



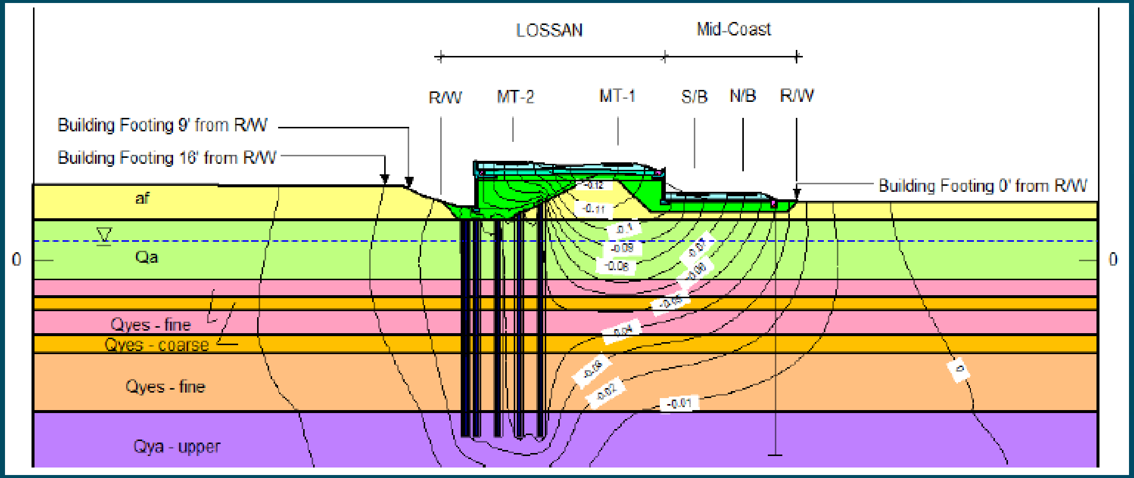
- Max Settlement = 4.8"; ROW = 1.2"



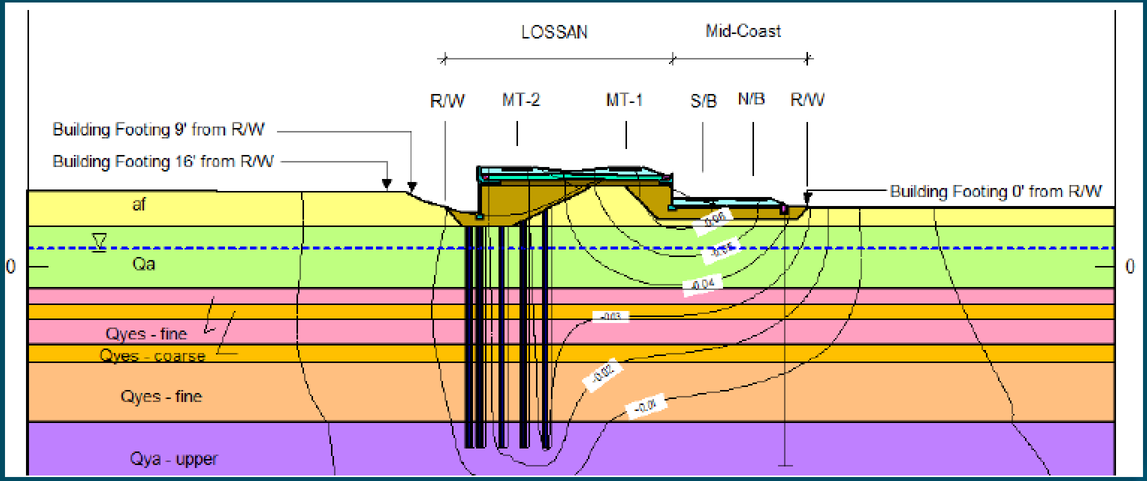
- Max Settlement = 1.9"; ROW = 0.7"

KLEINFELDER
Bright People. Right Solutions.

Compaction Grouting



- Max Settlement = 1.4”; ROW = 0.25”

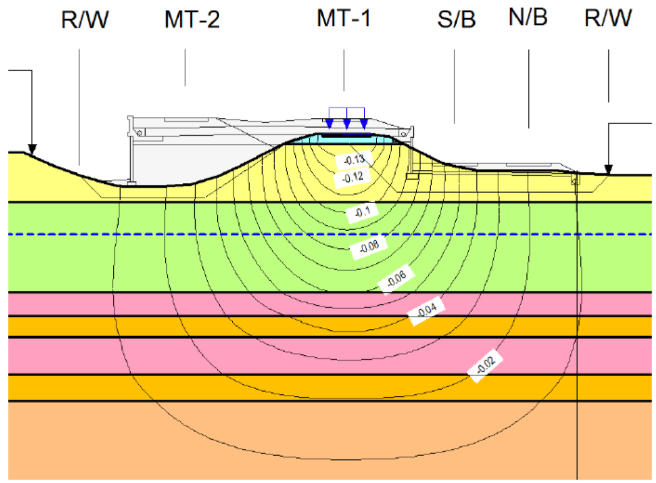


- Max Settlement = 0.5”; ROW = 0.12”

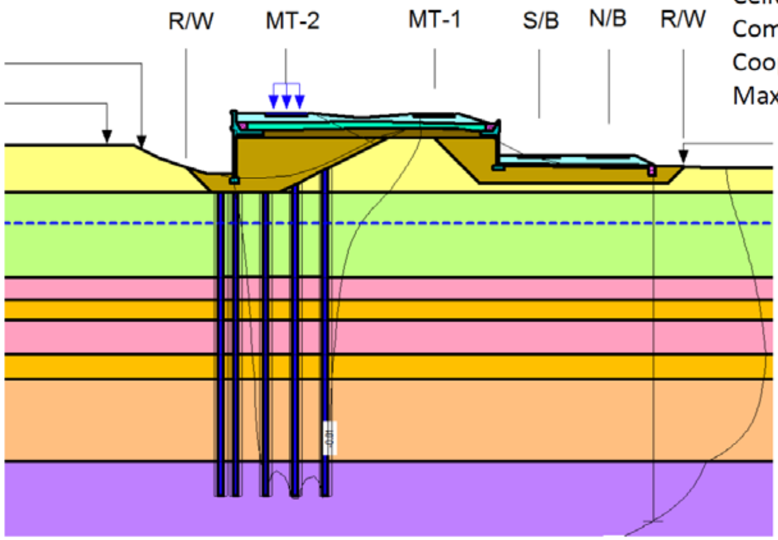
KLEINFELDER
Bright People. Right Solutions.

Live Loading

- Existing Condition = 0.13 ft
- SDRDT Design = 0.01 ft



Existing Condition
Cooper E80 Loading = 1300 psf
Maximum settlement = 0.13’ (1.6”)

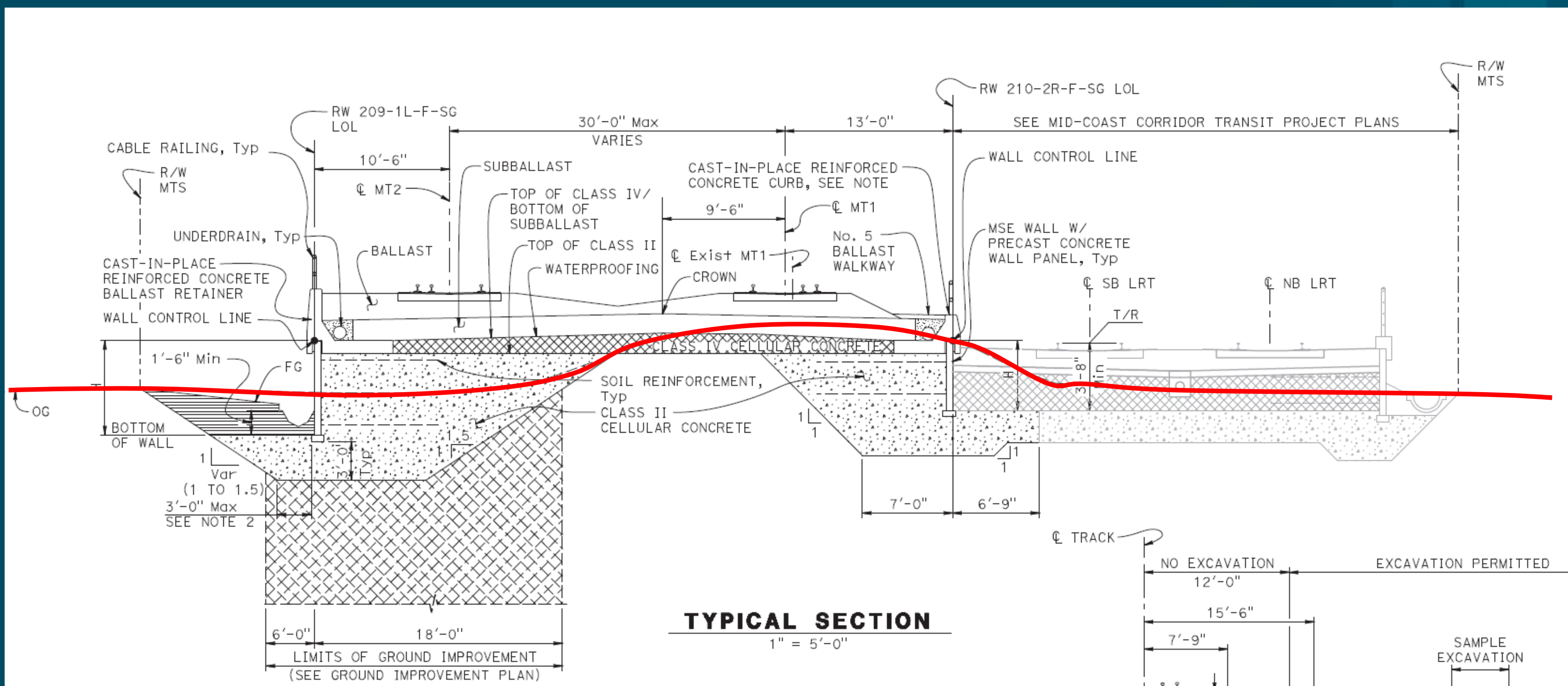


Cellular Concrete w/
Compaction Grouting (D = 2’, S = 6’, AR = 9%)
Cooper E80 Loading = 1300 psf
Maximum settlement = 0.01’ (0.1”)

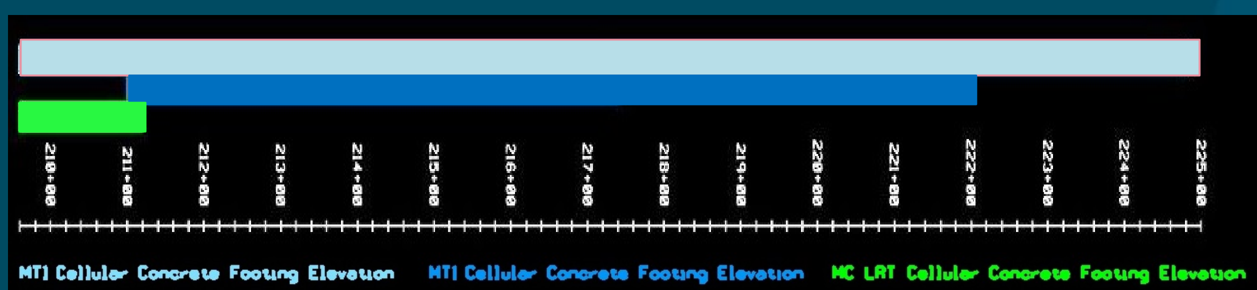
KLEINFELDER
Bright People. Right Solutions.

Final Solution

- 2-Phase Construction
- Targeted Ground Improvement
- Less Surcharge + More Resistance
- Approx. $8M Cost Savings Compared to bridge



Lightweight Fill Transitions



KLEINFELDER
Bright People. Right Solutions.

Stakeholder Involvement – Operator

- Major Concerns – Maintenance and Safety
  - Began communicating 4/2014
  - 90% design 5/2015
  - Approved 8/2015

- Several meetings and documents
- Capital costs not a concern

- Justification of Use
- Service Life Analysis
- Maintenance Life Cycle Costs

- Case Approval Based on Necessity

SAN DIEGO RIVER BRIDGE DOUBLE TRACK
(CP TECOLOTE TO CP FRIAR)

SANDAG

90% DESIGN ADDENDUM SUBMITTAL
Lightweight Cellular Concrete Fill
Service Life Memorandum

Prepared by: Kelly Burnell — 7/30/15 Date

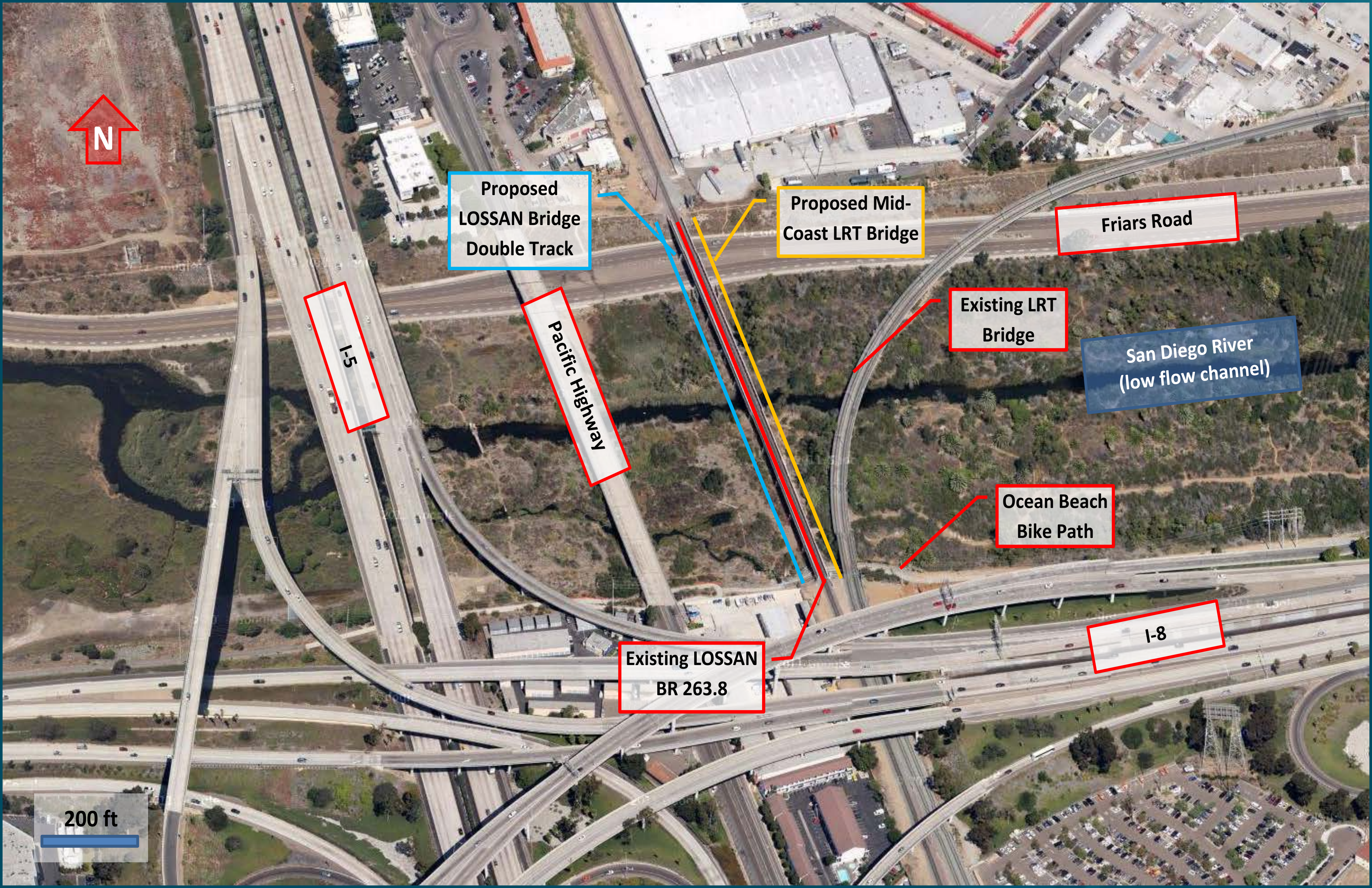
Supervised by: Kelly Burnell — 7/30/15 Date

Quality Control by: Nathan Johnson — 7/30/15 Date

Approved by: Nathan Johnson — 7/30/15 Date

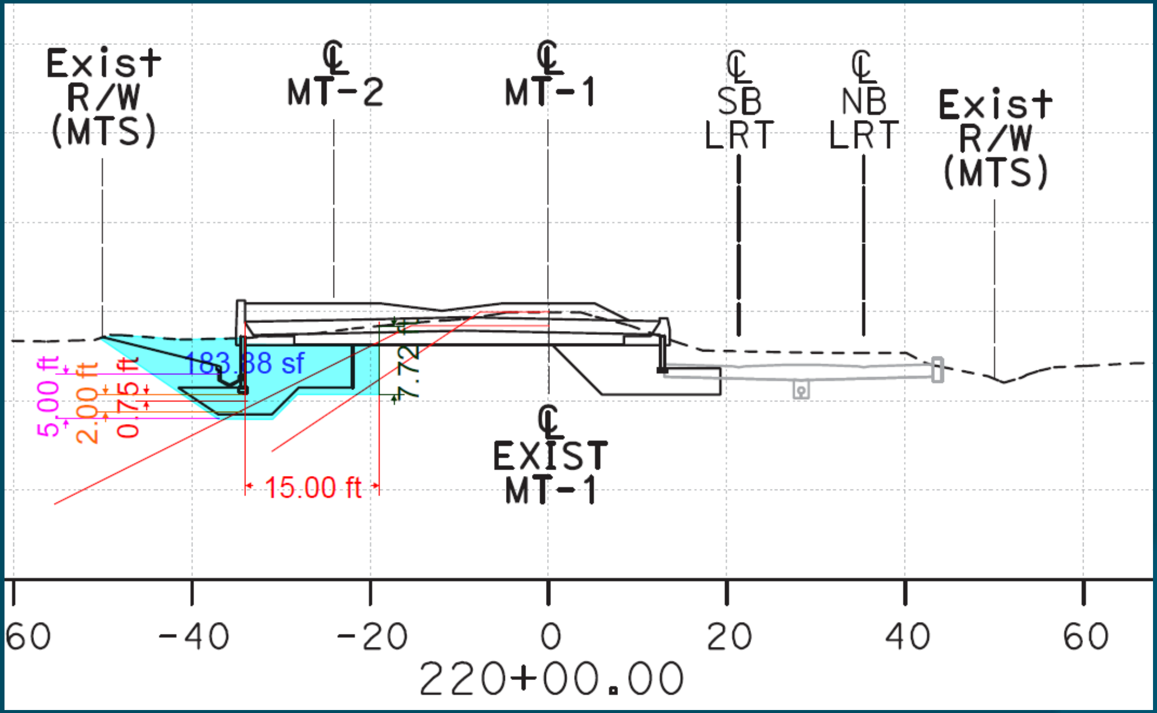
Revision	Date	Description
Rev 0	9/19/2014	LCCF Service Life Memorandum
Rev 1	11/6/2014	LCCF Service Life Memorandum Update
Rev 2	7/31/2015	90% Addendum LCCF Service Life Memorandum

Stakeholder Involvement – Adjacent Project



Stakeholder Involvement – CMGC

- 60% Design – Reduce Need for Shoring
- GMP (bid process)
  - Excessively long straps for CMGC subs



KLEINFELDER
Bright People. Right Solutions.

Lessons Learned

- Lightweight fill is useful and proven solution for transportation
- Innovative materials can take significant effort to approve
- Persistency is important
- Delivering agency needs to be on board

- CMGC
  - Early involvement is helpful, but subs may not be on-board
  - Engineer involvement during ICE process is very valuable

- Practical Innovative Solutions

KLEINFELDER
Bright People. Right Solutions.