CRENSHAW/LAX DESIGN -BUILD
MANCHESTER BRIDGE EMBANKMENT

Western Bridge Engineer's Seminar 2017
Portland, Oregon

Aamir Aleem Durrani - HNTB Corporation
Murali Hariharan - HNTB Corporation

PROJECT OVERVIEW

- Preliminary Planning Study – 1994
- Bid – $2.058 Billion
- Bid Announcement – Jun. 7, 2013
- Notice To Proceed (NTP) – Sep 2013
- Official Ground-Breaking Ceremony – Jan. 21, 2014
- Expected Opening – 2019

PROJECT OVERVIEW

- Total Length of Project - 8.5 mile (13.7 km)
- 7 Aerial Guideway Structures
- 4 Underground Guideway Structures – 3 Cut-and-Cover Tunnels; a Dual TBM Tunnel
- 8 Stations – 3 Underground; 4 At-Grade; 1 Elevated on Aerial Guideway
- Miscellaneous Earth Retaining Walls and Other Structures

CRENSHAW/LAX MANCHESTER EMBANKMENT

- **MANCHESTER BRIDGE EMBANKMENT**

- **CENTRAL ELEMENT OF THE EMBANKMENT PROJECT**

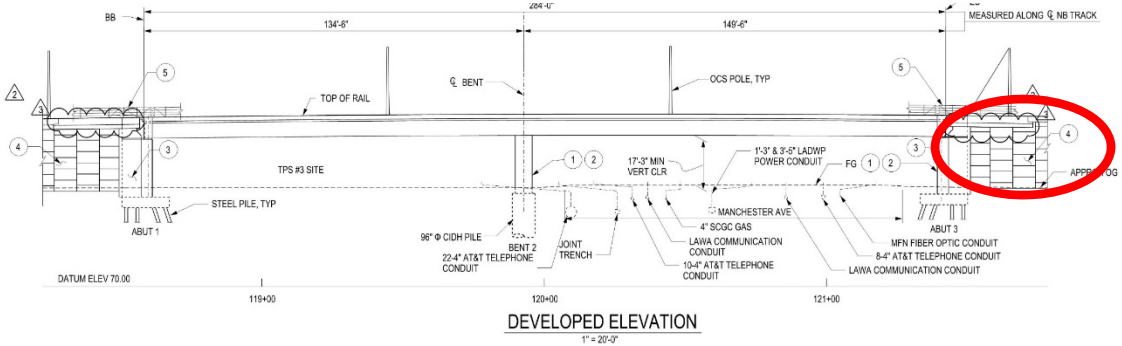
WALSH SHEA CORRIDOR CONSTRUCTORS

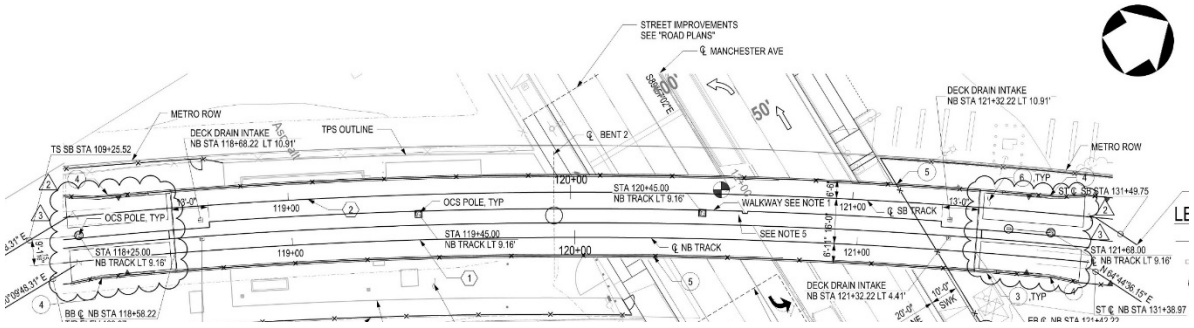
HNTB

CRENSHAW/LAX MANCHESTER EMBANKMENT

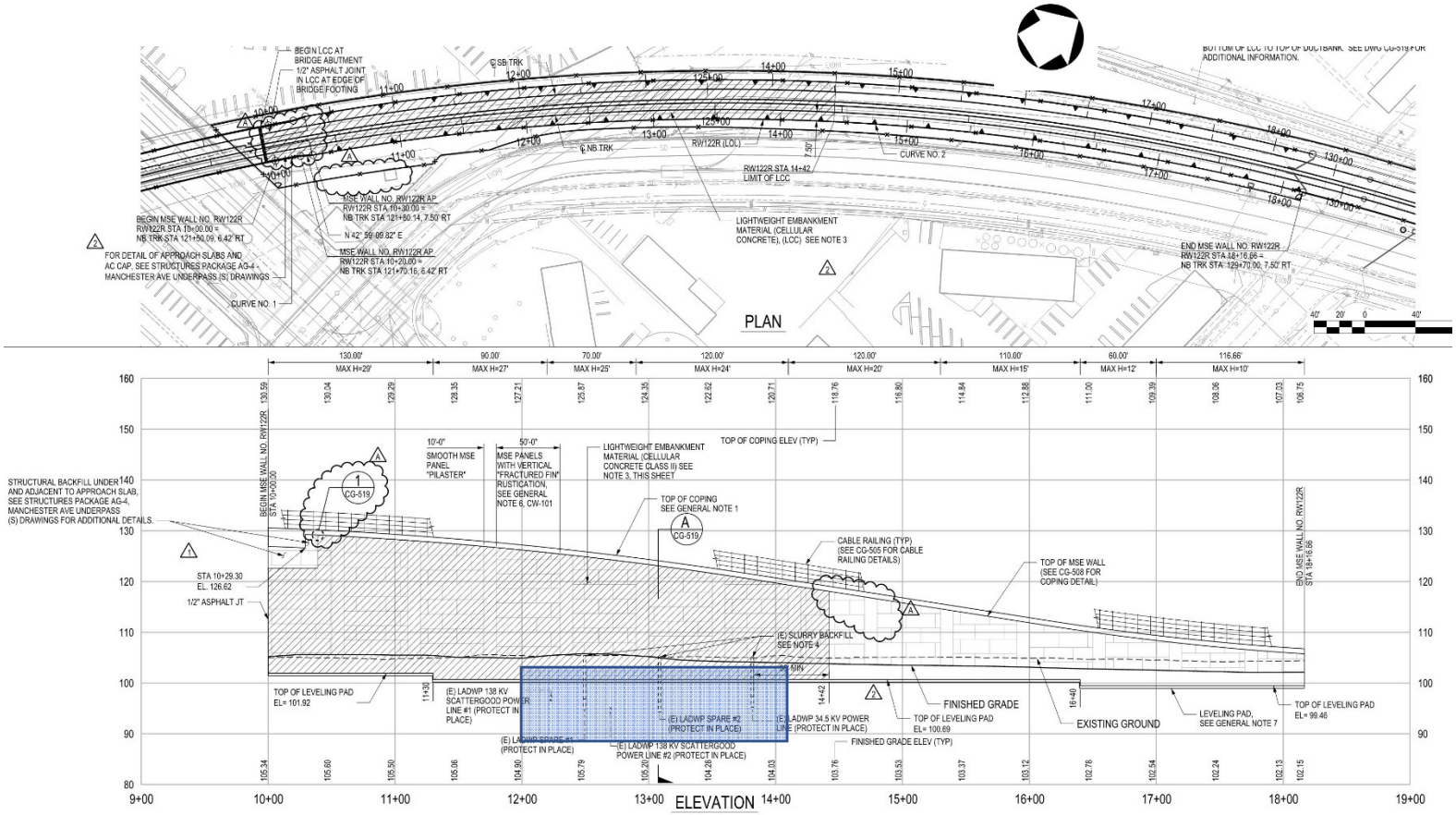
- **MANCHESTER BRIDGE LOCATION**

- **BRIDGE AND EMBANKMENT**

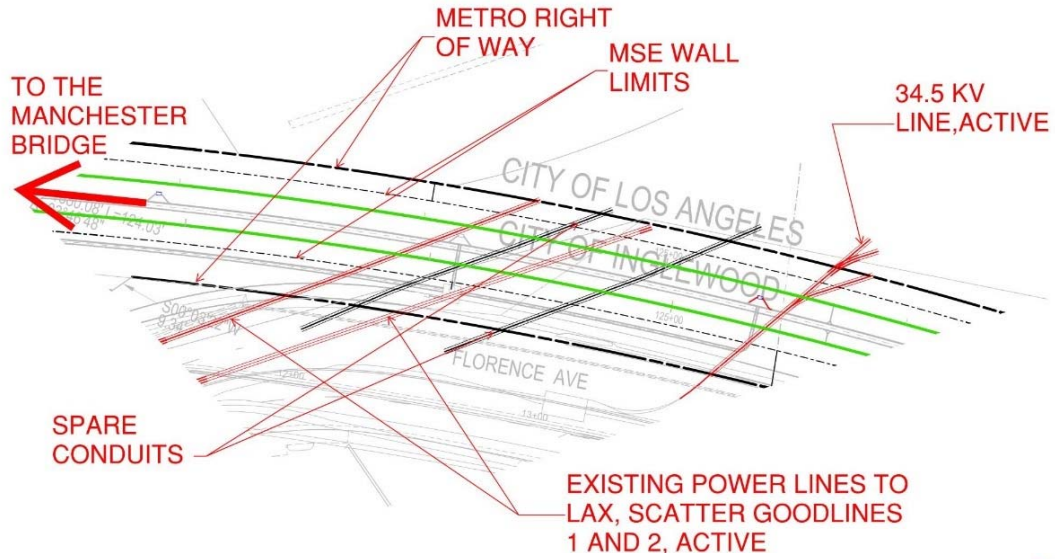




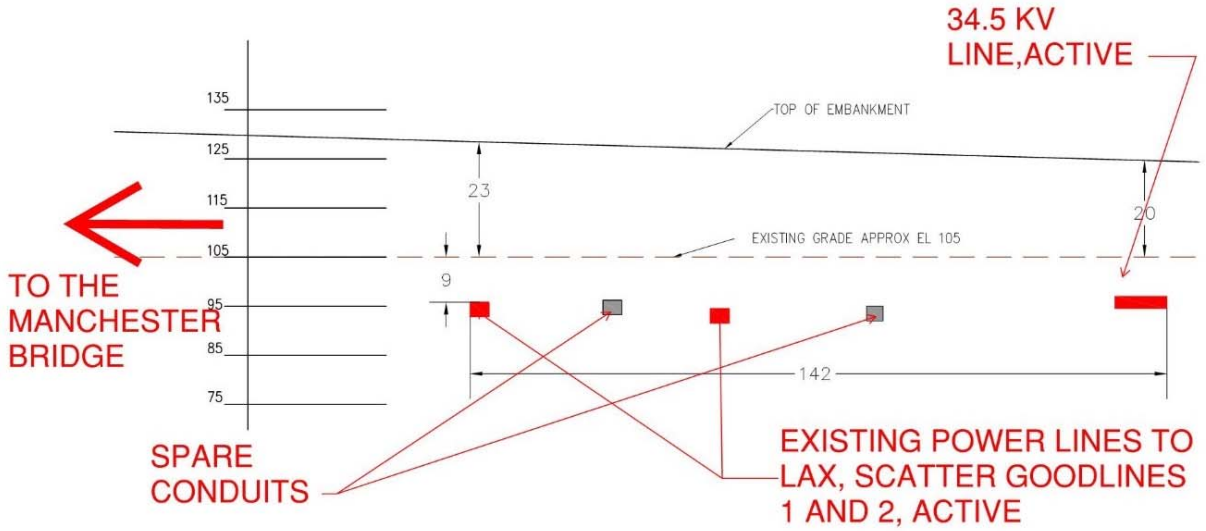
CRENSHAW/LAX MANCHESTER EMBANKMENT



CRENSHAW/LAX MANCHESTER EMBANKMENT

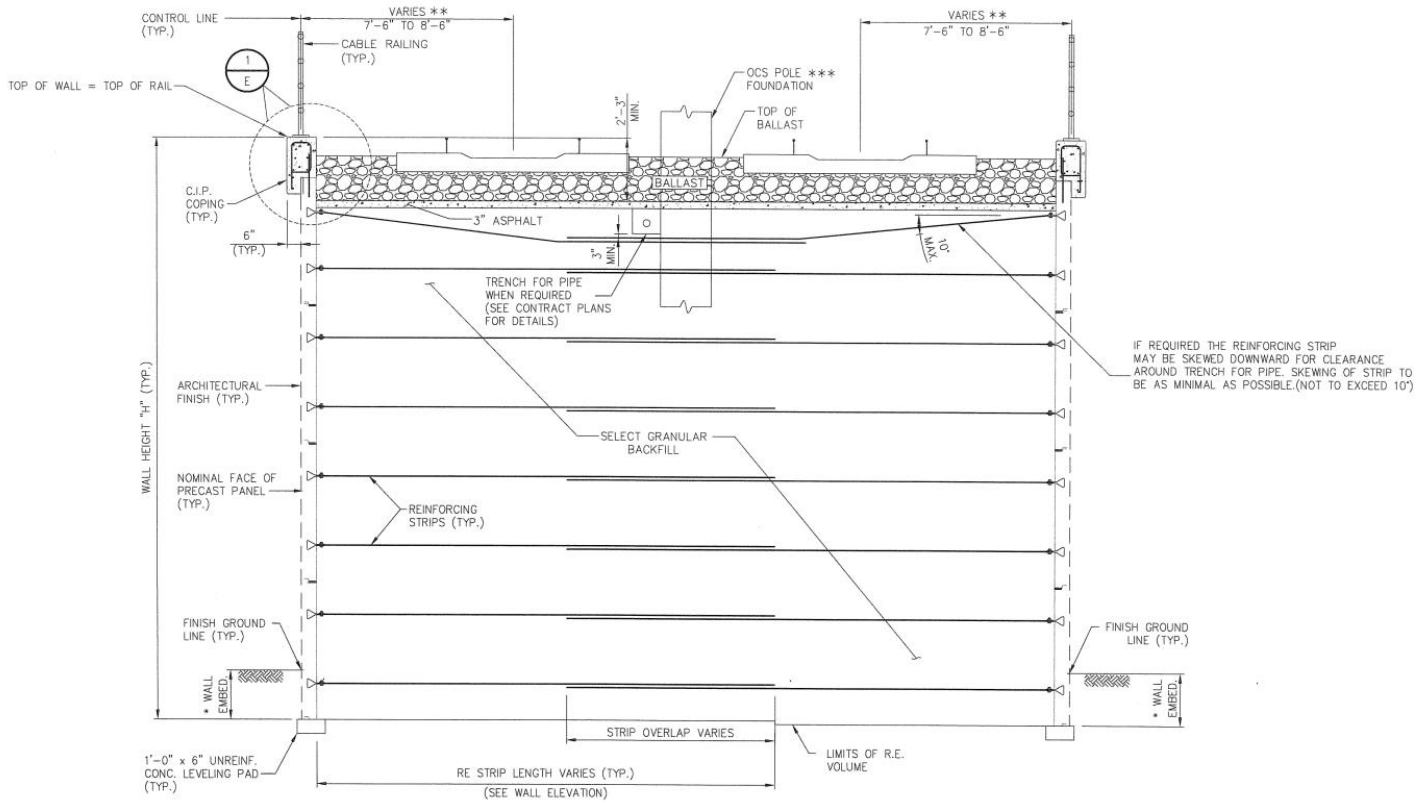


Scattergood Lines are the power lines to LAX



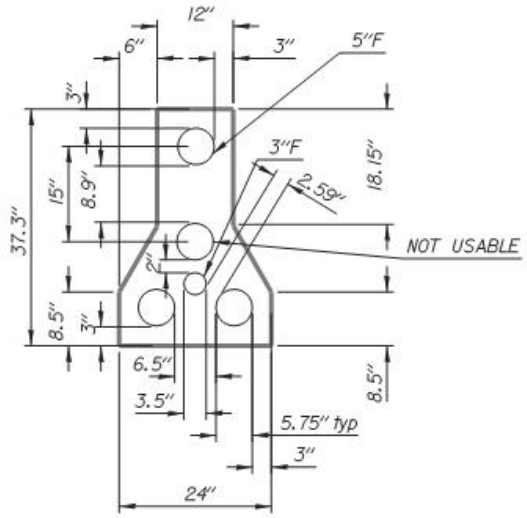
CRENSHAW/LAX MANCHESTER EMBANKMENT

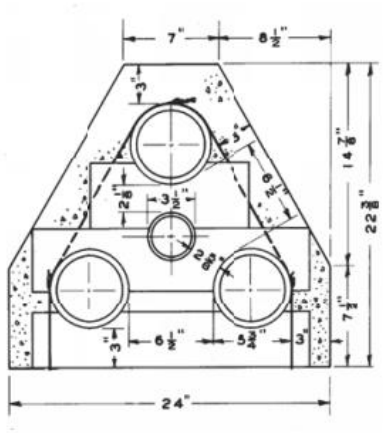
TYPICAL MSE EMBANKMENT SECTION - ~30’ WIDE

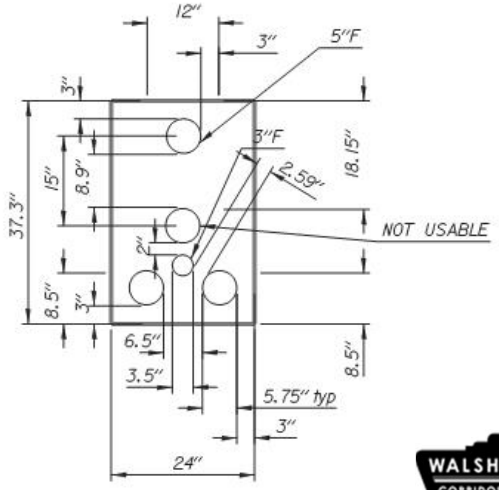


POWER LINE DETAILS – Scattergood Lines

- Owned by the Los Angeles Department of Water and Power
- Scattergood Lines Built circa 1965
- Tar Impregnated Wood conduits encased in Slurry approx. 1700 psi strength

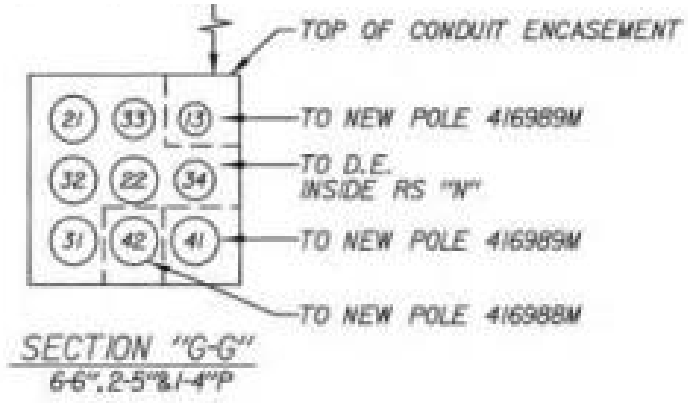






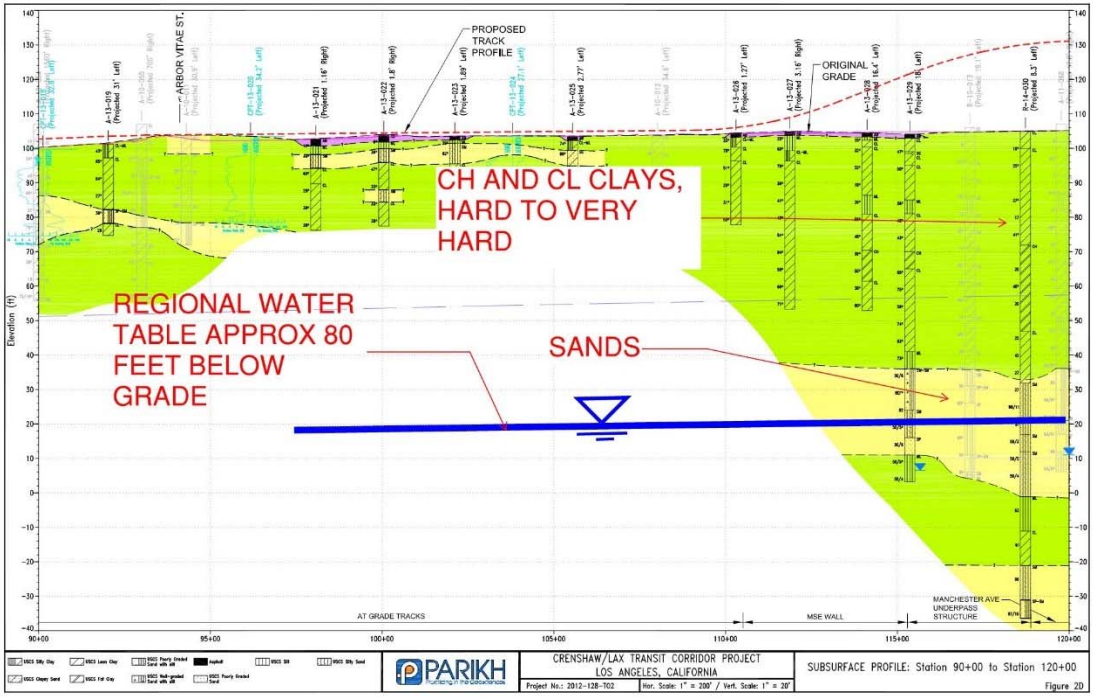
POWER LINE DETAILS – 34.5 kV Line

- Owned by the Los Angeles Department of Water and Power
- Built Just before the Crenshaw Project commenced
- PVC Conduits encased in 3000 psi concrete
- Scattergood lines more critical for design



CRENSHAW/LAX MANCHESTER EMBANKMENT

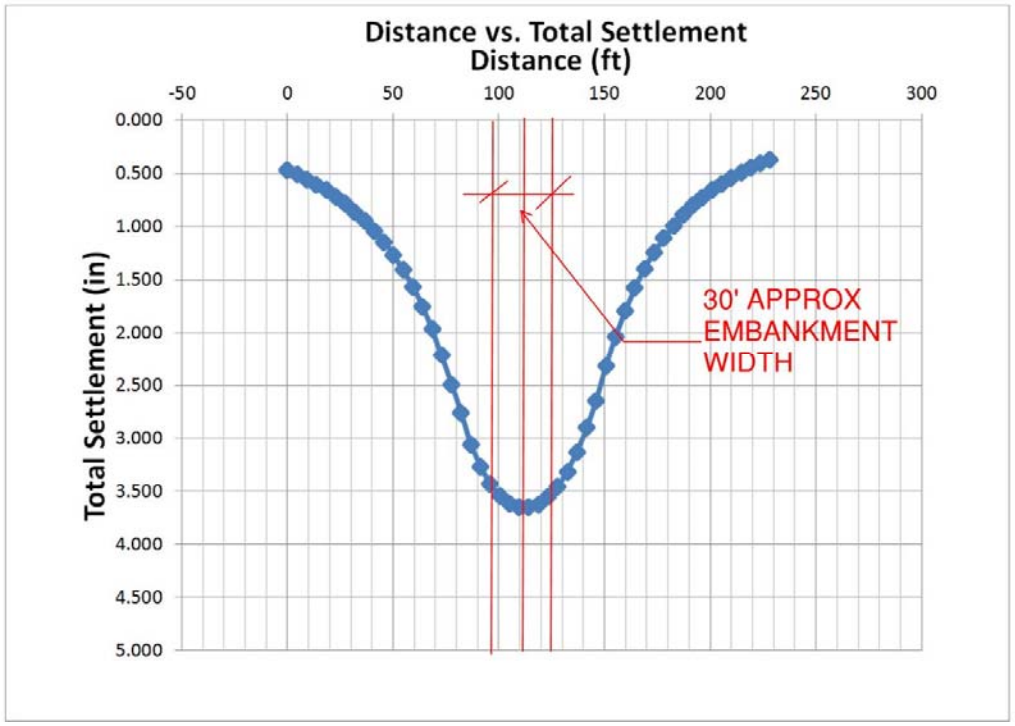
EFFECT OF AN EMBANKMENT- SETTLEMENT



- Soil under the embankment composed of Clays – though dry
- Elastic Settlements of Concern, consolidation settlements expected to be minimal

EFFECT OF AN EMBANKMENT- SETTLEMENT

- Parikh, Inc Geotechnical Engineer, Estimated Settlements
- Elastic Settlement under Embankment on the order of ~4” for a soil embankment

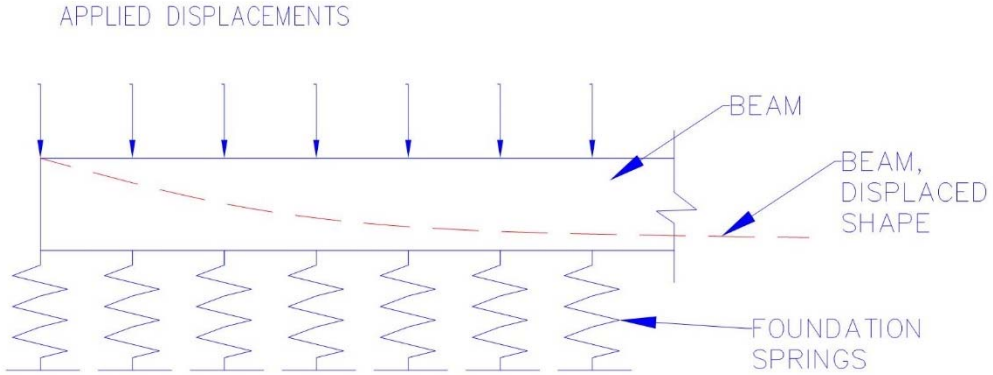


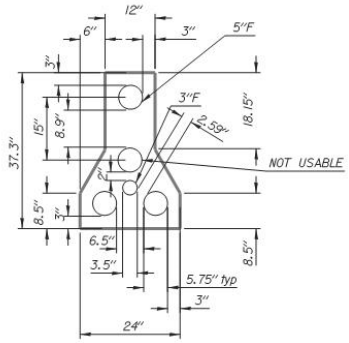
$$S = I_0 I_1 \frac{qB}{E}\left(1 - \nu^2\right)$$

I_0, I_1 = Factors that depend on Embankment Geometry and Embedment of the load
q= Applied Load
B= Footing Width
E = Foundation Soil Modulus
v=Poisson’s Ratio of foundation Soil

EFFECT OF AN EMBANKMENT- SETTLEMENT

- Structural Analysis of the effect of settlement used a beam on elastic foundation with forced displacements. STAAD used to model the beam





BEAM SECTION

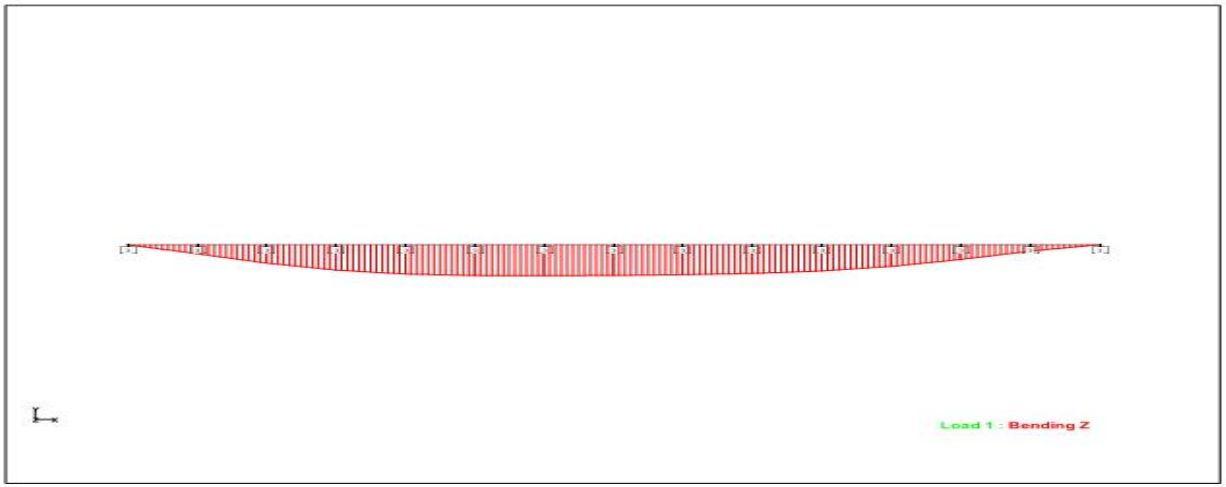
$$K = \frac{E}{B\left(1-\nu^2\right)}$$

SOIL SPRING

EFFECT OF AN EMBANKMENT- SETTLEMENT

- Bending stresses in the Beam ~ 360 psi, indicating cracking of the ductbank.

The bending moment diagram is as shown:



The maximum bending moment is 85 k-ft.

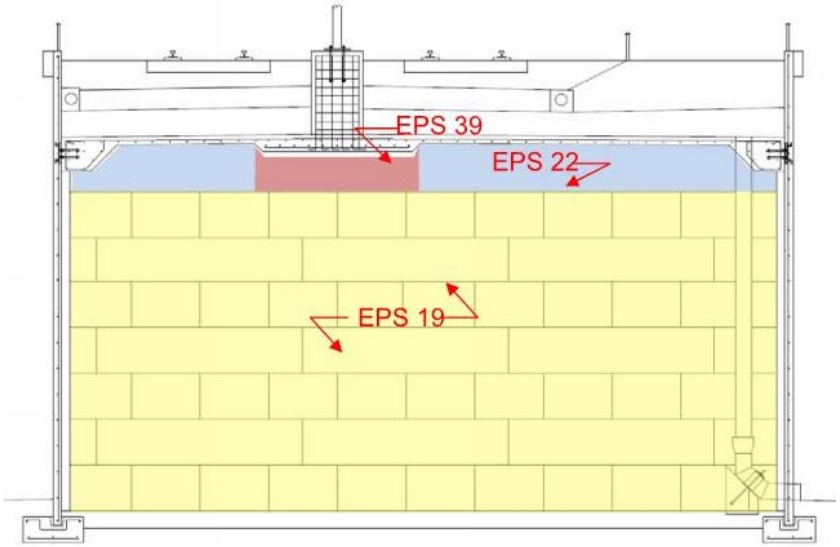
The corresponding bending stress is: $\frac{M}{S} = \frac{(85)(12000)}{2856.6}$ = 360 psi

Tensile strength of 1700 psi concrete per ACI 318-11, for structural plain concrete is:
$5\phi\sqrt{f_c'}$ = 5 x 0.6 x 1700^0.5 = 123 psi

CRENSHAW/LAX MANCHESTER EMBANKMENT

SETTLEMENT MITIGATION – GEOFOAM AND LIGHT WEIGHT CELLULAR CONCRETE (LCC) EMBANKMENTS

- Both are proven technologies for reducing or eliminating settlement
- A Geofoam embankment consists of Geofoam Blocks installed between a containment structure. Geofoam weight only 2 to 3 lbs/cub ft and is essentially a zero new load solution



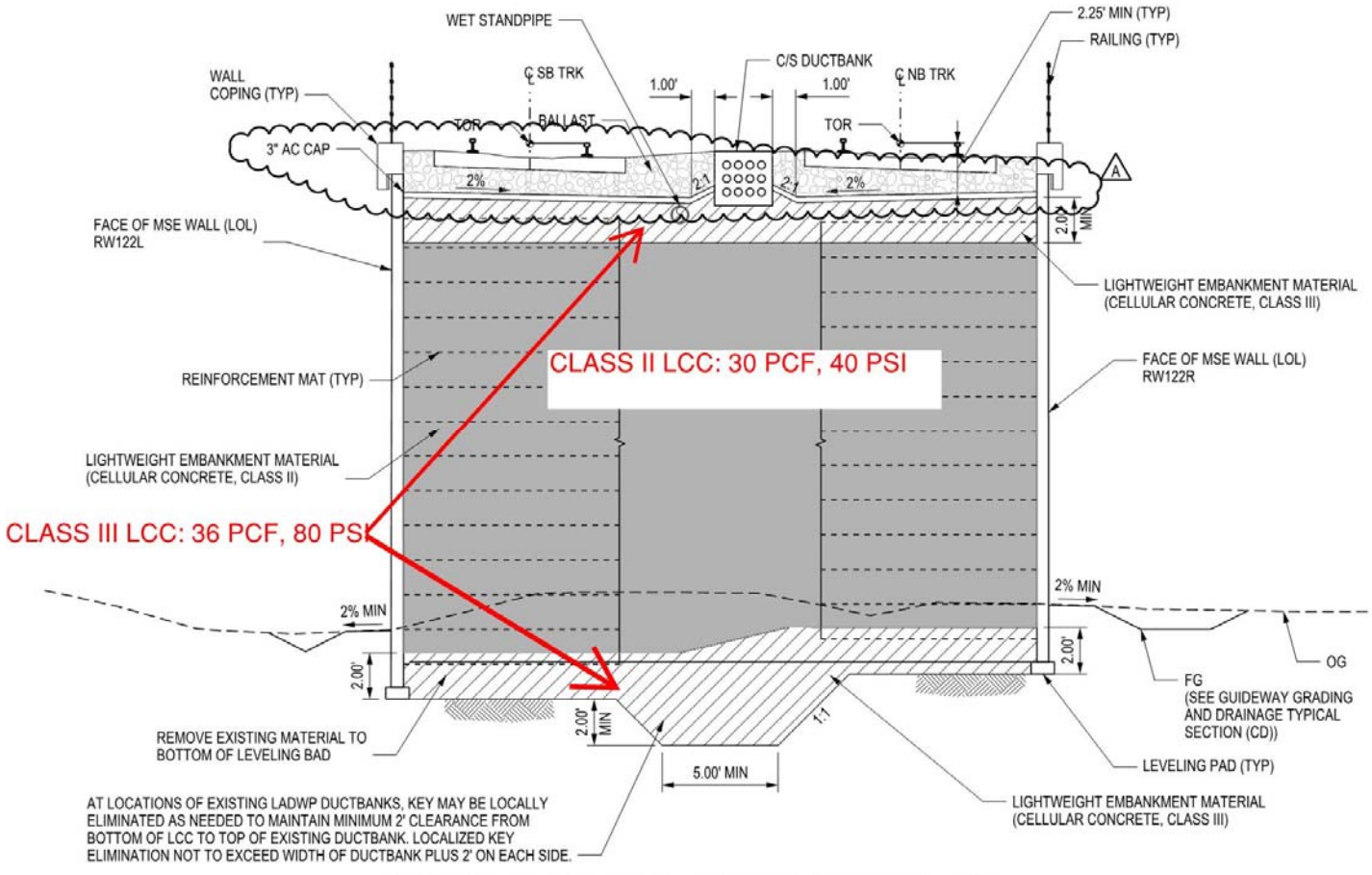
CRENSHAW/LAX MANCHESTER EMBANKMENT

SETTLEMENT MITIGATION – GEOFOAM AND LIGHT WEIGHT CELLULAR CONCRETE (LCC) EMBANKMENTS

- LCC Embankments are constructed in the same manner as soil embankments and are most compatible with a MSE type facing
- Instead of soil fill, the LCC fill is used
- LCC is a light weight foam concrete and weighs around 30 lbs/cub ft. It is also very effective in reducing settlements, e.g. Colton Project in UTAH, embankment carrying 3 freight rail tracks
- Due to Owner preference and compatibility with the MSE construction, LCC was chosen as the Lightweight Fill Material. The Geofoam alternate was not explored further

CRENSHAW/LAX MANCHESTER EMBANKMENT

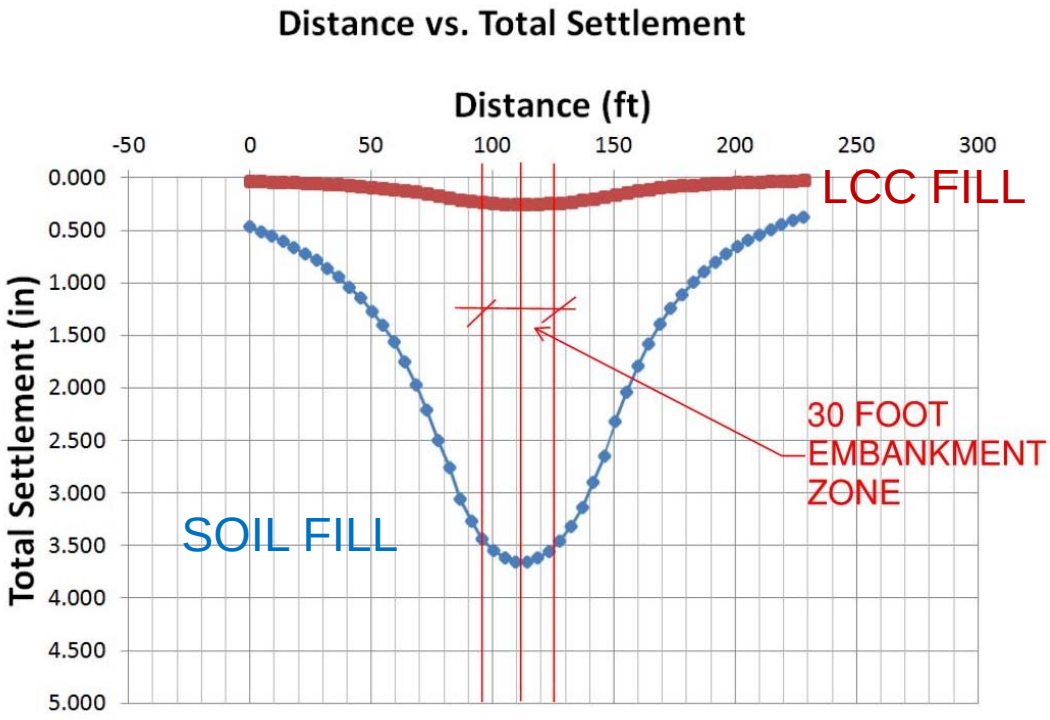
SETTLEMENT MITIGATION – LCC EMBANKMENT



CRENSHAW/LAX MANCHESTER EMBANKMENT

SETTLEMENT MITIGATION –LCC

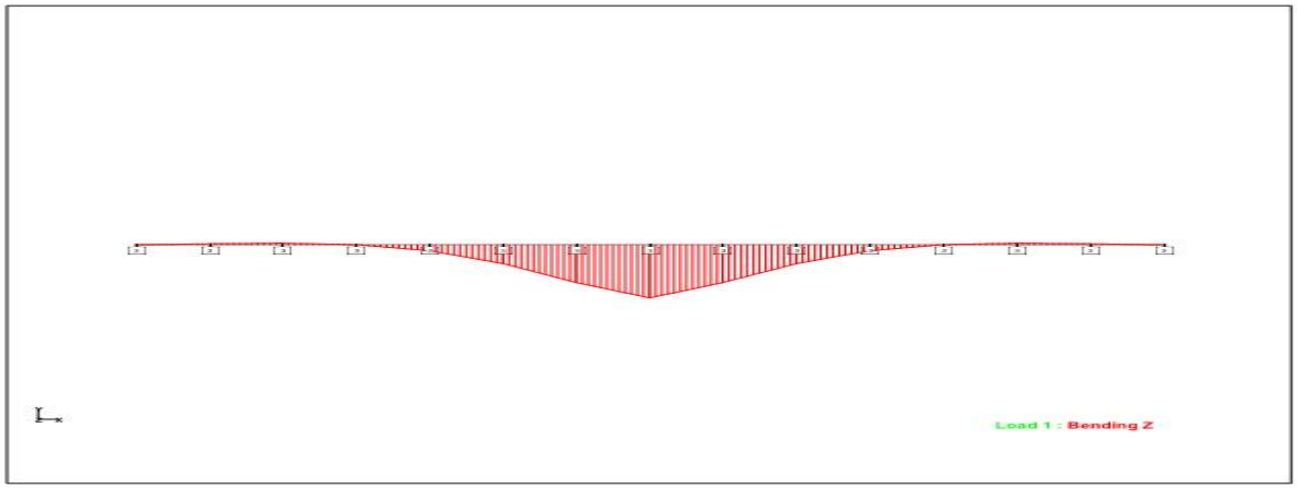
- Settlement with the LCC approx. 0.25” max.
- A partial load balancing was used. Some existing soil was removed and replaced with LCC further lightening the load on the ground



CRENSHAW/LAX MANCHESTER EMBANKMENT

SETTLEMENT MITIGATION

The bending moment diagram is as shown:



The maximum bending moment is 16.5 k-ft.

The corresponding bending stress is: $\frac{M}{S} = \frac{(16.5)(12000)}{2856.6} = 69.32$ psi

Tensile strength of 1700 psi concrete per ACI 318-11, for structural plain concrete is:
$5\phi\sqrt{f_c'}$ = 5 x 0.6 x 1700^0.5 = 123 psi

CRENSHAW/LAX MANCHESTER EMBANKMENT

LCC DESIGN AND CONSTRUCTION

- Seismic Design was based on a wall that can undergo large displacements on the order of approx. 4 inches and a foundation deformation of approx. 2 inches, i.e., k_h = 0.347g for a PGA of 0.65g, roughly 50% PGA.
- CELL-CRETE Constructed the LCC embankment, ReCO (Reinforced Earth Company) designed the MSE wall. WSCC monitored the wall for settlement.

CRENSHAW/LAX MANCHESTER EMBANKMENT

LCC DESIGN AND CONSTRUCTION

- Mix Design by Cell Crete is below
- Foam is the main ingredient that limits the density. Lift height of the LCC was limited to 5 feet in order to prevent collapse of the foam bubbles and maintain the low density.

CRENSHAW/LAX MANCHESTER EMBANKMENT

LCC DESIGN AND CONSTRUCTION

CLASS II LCC, 30 PCF DENSITY, 40 PSI STRENGTH

PURPOSE Backfill

Mix Component	lb/CY	Specific Gravity	Density, lbs/ft3	Absolute Vol. (ft^3)
Potable Water	232.45	1.00	62.40	3.73
Portland Cement (ASTM C150)	422.64	3.15	196.50	2.15
Foam (ASTM 796-97, 869)	73.91	0.05	3.50	21.12
Total =	729.00		27.00	27.00

LABORATORY TEST DATA

LAB ID	TestAge	TestDate	Diameter	Height	Area	Max. Comp	Compr. PSI	BreakType
114854	7	1/22/2014	2.94	5.85	6.79	670	100	Cone
114855	7	1/22/2014	2.93	5.82	6.74	590	90	Cone
114856	28	2/12/2014	2.96	5.82	6.88	740	110	Cone
114857	28	2/12/2014	2.93	5.86	6.74	750	110	Cone

Result Specimens tested satisfy Design (PSI) strength requirement.

28-Day Avg = 110 (PSI)

LCC DESIGN AND CONSTRUCTION

CLASS III LCC, 36 PCF DENSITY, 80 PSI STRENGTH

PURPOSE Backfill

Mix Component	lb/CY	Specific Gravity	Density, lbs/ft3	Absolute Vol. (ft^3)
Potable Water	291.46	1.00	62.40	4.67
Portland Cement (ASTM C150)	448.40	3.15	196.50	2.28
Foam (ASTM 796-97, 869)	70.15	0.05	3.50	20.04
Total =	810.00		30.00	27.00

REPORT OF TEST

Mix Design: CCC30-65 *Design (PSI):* N/A *Time:* 1:15 PM

Sample No.	Date of Test	Height (In.)	Area (Sq. In.)	Load (Lbs.)	Load (PSI)	Diameter (In.)	Dimension (In.)	Age Days
1	4/27/12	5.85	6.79	1,110	160	2.94	3 x 6	7
2	5/4/12	5.87	6.88	1,300	190	2.96	3 x 6	14
3	5/18/12	5.96	6.88	1,410	200	2.96	3 x 6	28
4	5/18/12	5.87	6.88	1,440	210	2.96	3 x 6	28

LCC DESIGN AND CONSTRUCTION – FOAM USED IN THE MIX

TECHNICAL DATA SHEET

Aerix Industries™
Advanced Engineered Foam Solutions

Features:

- Fluid, Easy Installation
- Lightweight / Insulating
- Controlled Densities & Strengths

Applications:
Recommended for use in:

- Annular Grouting
- Tunnel Backfill
- Void Fill
- Load-Reducing Backfill
- Unstable Soil Replacement
- Utility/Trench Backfill
- Retaining Wall Backfill
- Roadway Subbase
- Bridge Approach Backfill
- Pipe Bedding
- Slipliner Grouting
- Pipeline/Tank Abandonment
- Abandoned Mine Fill

AERLITE™ FAMILY

Foam Liquid Concentrate

Description:
The AERLITE™ family of foam liquid concentrates is used in combination with specialty foam generating equipment for the production of high quality, low density cellular concrete (LDCC). The AERLITE™ family includes AERLITE™ a protein/synthetic hybrid formula and AERLITE-iX™ a fully synthetic product. The AERLITE™ family of foam liquid concentrates produces the most stable preformed foam in the industry, producing cellular concretes that comply with the standard specifications outlined in ASTM C 869 when tested in accordance with ASTM C 796.

Performace Characteristics:

Air Pressure System	*lb/yd³*	*kg/m³*
Cement Factor	328-878	149-398
Water	164-439	75-199
w/c	0.50	
	lb/ft³	*kg/m³*
Target Density	20-50	320-801
	psi	*Mpa*
Compressive Strength @ 28 Days	50-640	0.34-4.41

Note: The compressive strength, weight and densities illustrated above are approximate. As with traditional concrete, the strength at any given density and mix proportion will also vary with the type of cement and the final water content of the mix.

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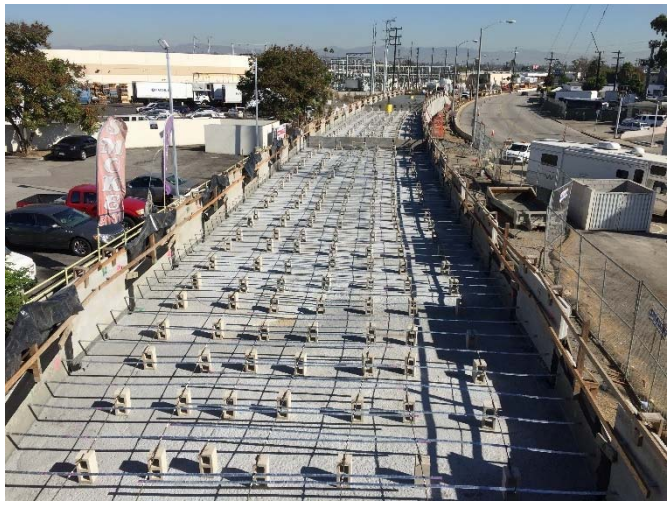
SYNTHETIC HYBRID FOAM

WALSH SHEA CORRIDOR CONSTRUCTORS

HNTB

CRENSHAW/LAX MANCHESTER EMBANKMENT

LCC DESIGN AND CONSTRUCTION

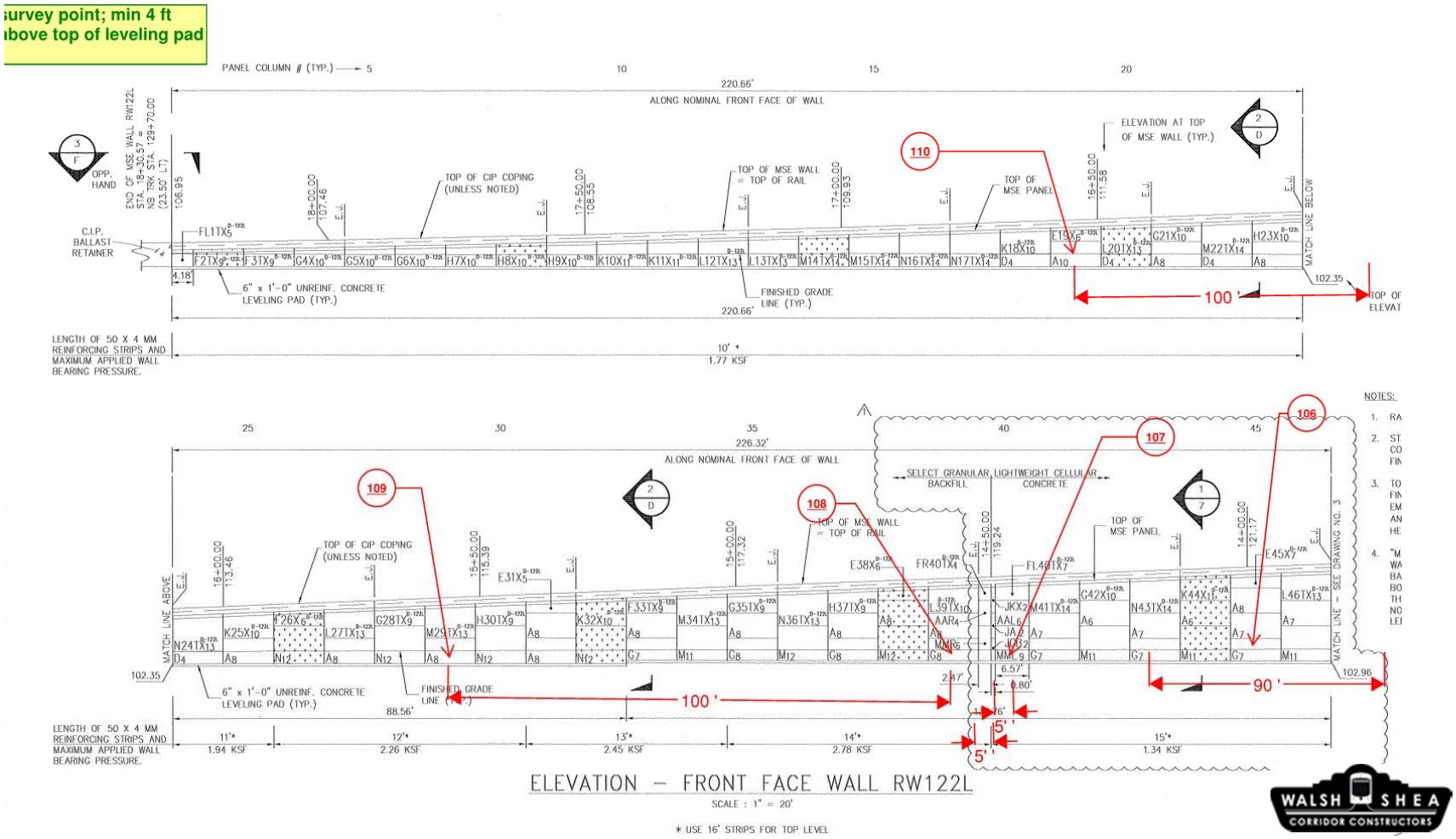


LCC has consistency of shaving foam when placed.

When cured a piece of LCC is similar to a lightweight stone fragment.

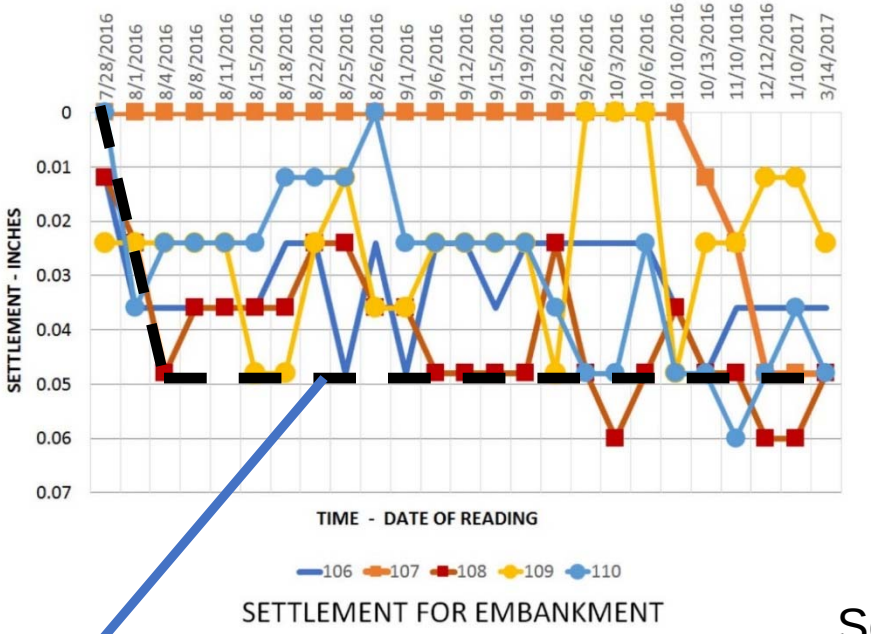
CRENSHAW/LAX MANCHESTER EMBANKMENT

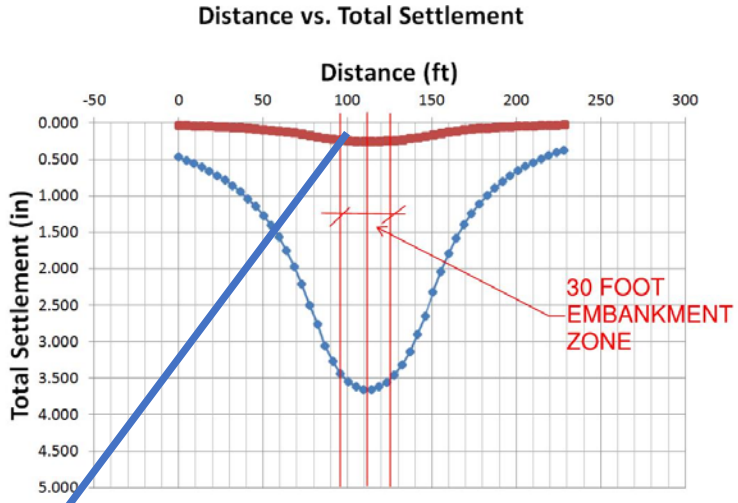
LCC EMBANKMENT- SETTLEMENT POINTS



CRENSHAW/LAX MANCHESTER EMBANKMENT

LCC EMBANKMENT- RECORDED SETTLEMENT





Settlement at face of MSE Wall = Interpreted to be stabilized at approx. 0.05”, no noticeable movement changes after approx. August/September 2016

Settlement at face of MSE Wall = 0.18” for a center settlement of 0.25”

CRENSHAW/LAX MANCHESTER EMBANKMENT

QUESTIONS?