Structural Design of Main Post Cut & Cover Tunnels Presidio Parkway Project

Western Bridge Engineers Seminar

September 8, 2017

Portland, OR

By: Allen Rejaie, PhD, PE

GOLDEN LINK CONCESSIONAIRE

HNTB

Presidio Parkway

- Project Overview
  - History and Phases
  - Site Complexity
  - Architecture
  - Environmental Issues
- Main Design Elements
  - Ground Improvements
  - MPT Structural Design Criteria
  - Fire Analysis
  - Halleck St. & Ret Walls
  - Moveable Form
  - Landscaping /Backfill
- Closing
  - Lessons Learned
  - Conclusions

GOLDEN LINK CONCESSIONAIRE

HNTB

History & Phases

PROJECT GOALS

- Providing a dedicated & safe evacuation route for emergency
- Replacing seismically and structurally deficient structures
- Congestion relief for daily commuters
- Providing direct and safe access to the waterfront for pedestrians
- Beautification of a landmark and historic area
- Restoring greenbelt on Hwy 1 and local streets
- Freeway noise reduction

GOLDEN LINK CONCESSIONAIRE

HNTB

History & Phases (Cont.)

- Scheduled in 4 phases, about $1.3 billion const. for all phases combined
- Contract 4 awarded to Flatiron-Kiewit-HNTB JV around March 2011
- High profile project for the local community
- Multiple stakeholder on the first P3 contract in California
- In the works for about 12 yrs.

FHWA

San Francisco County Transportation Authority

Caltrans

The Presidio Trust

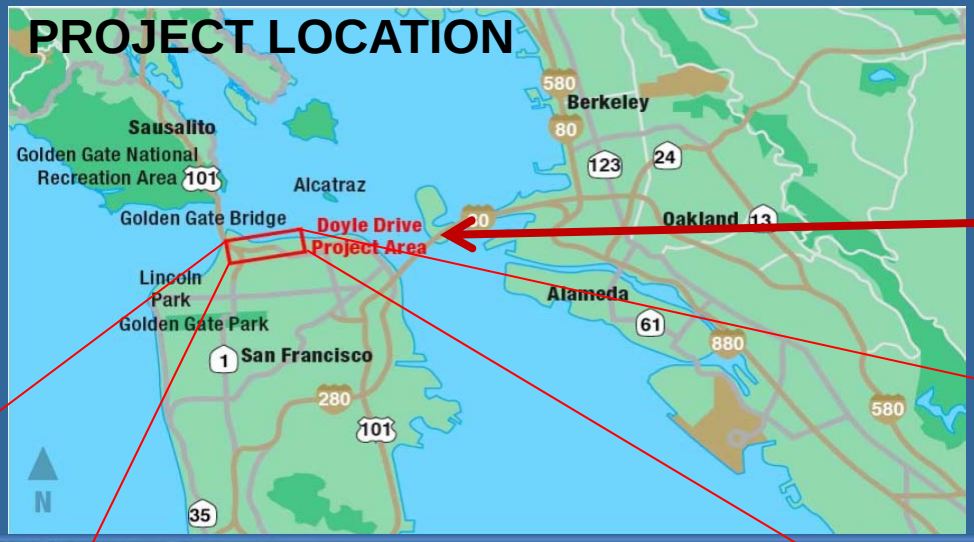
National Park Service

Golden Gate Bridge

GOLDEN LINK CONCESSIONAIRE

HNTB

History & Phases (Cont.)



South Approach to Golden Gate – About 1.6 miles long

GOLDEN LINK CONCESSIONAIRE

HNTB

Site Complexity

- Aggressive schedule for a large D/B contract
- Substantial completion scheduled for September 23, 2015
- Difficult site (liquefaction, high W.T., Caltrans ROW, PT owned)
- Limited access (required multiple detours & closures)
- Stringent design criteria (1000 yrs. return period)
- Prescribed profile grade and layout (no modification was allowed)
- Required substantial design completion to identify structural footprint for the necessary ground improvement
- Drainage, water-treatment and structural waterproofing

GOLDEN LINK CONCESSIONAIRE

HNTB

Site Complexity (Cont.)

Demolition & staging were major efforts.

Photo: curtesy of Caltrans

GOLDEN LINK CONCESSIONAIRE

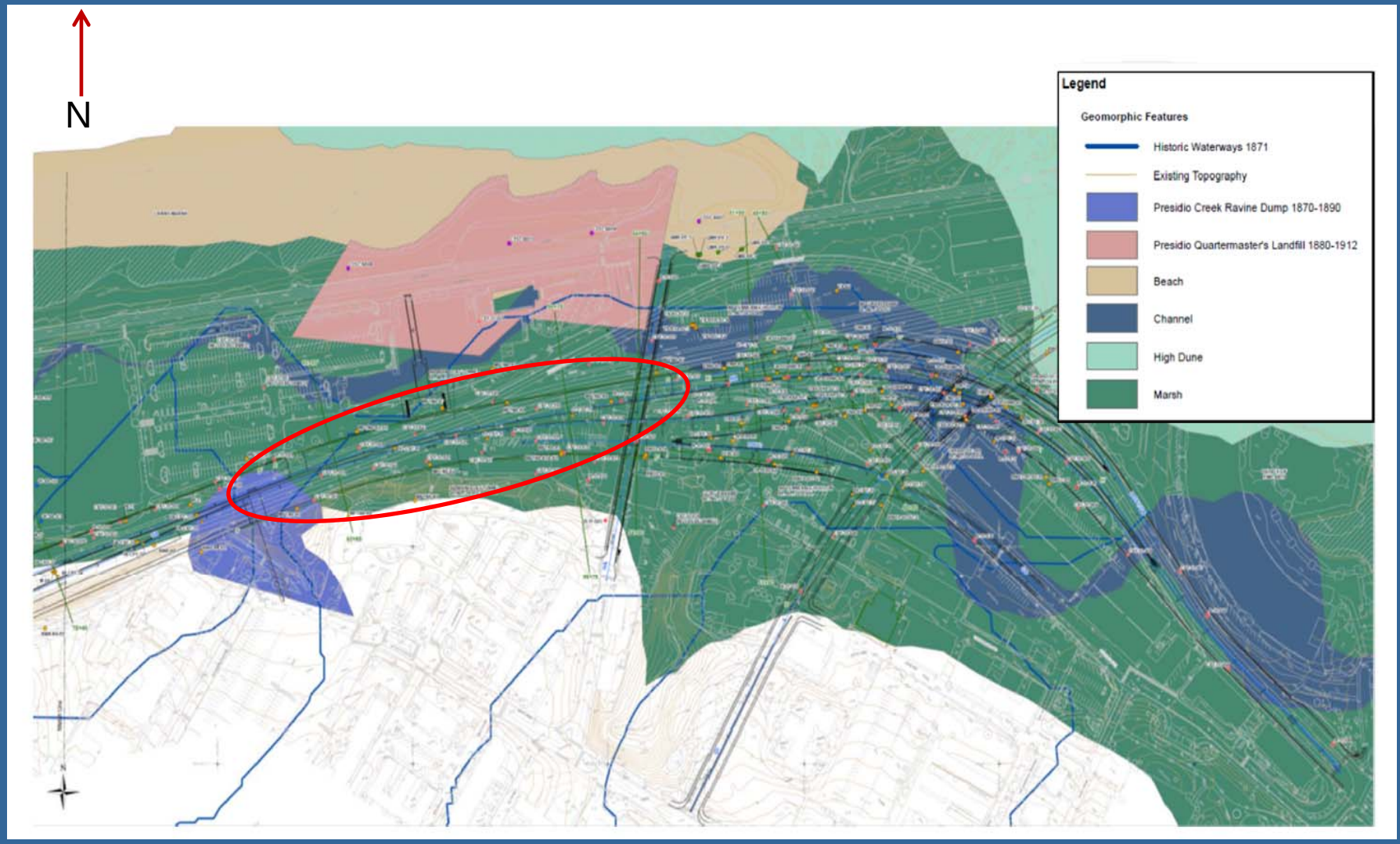
HNTB

Site Complexity (Cont.)

GOLDEN LINK CONCESSIONAIRE

HNTB

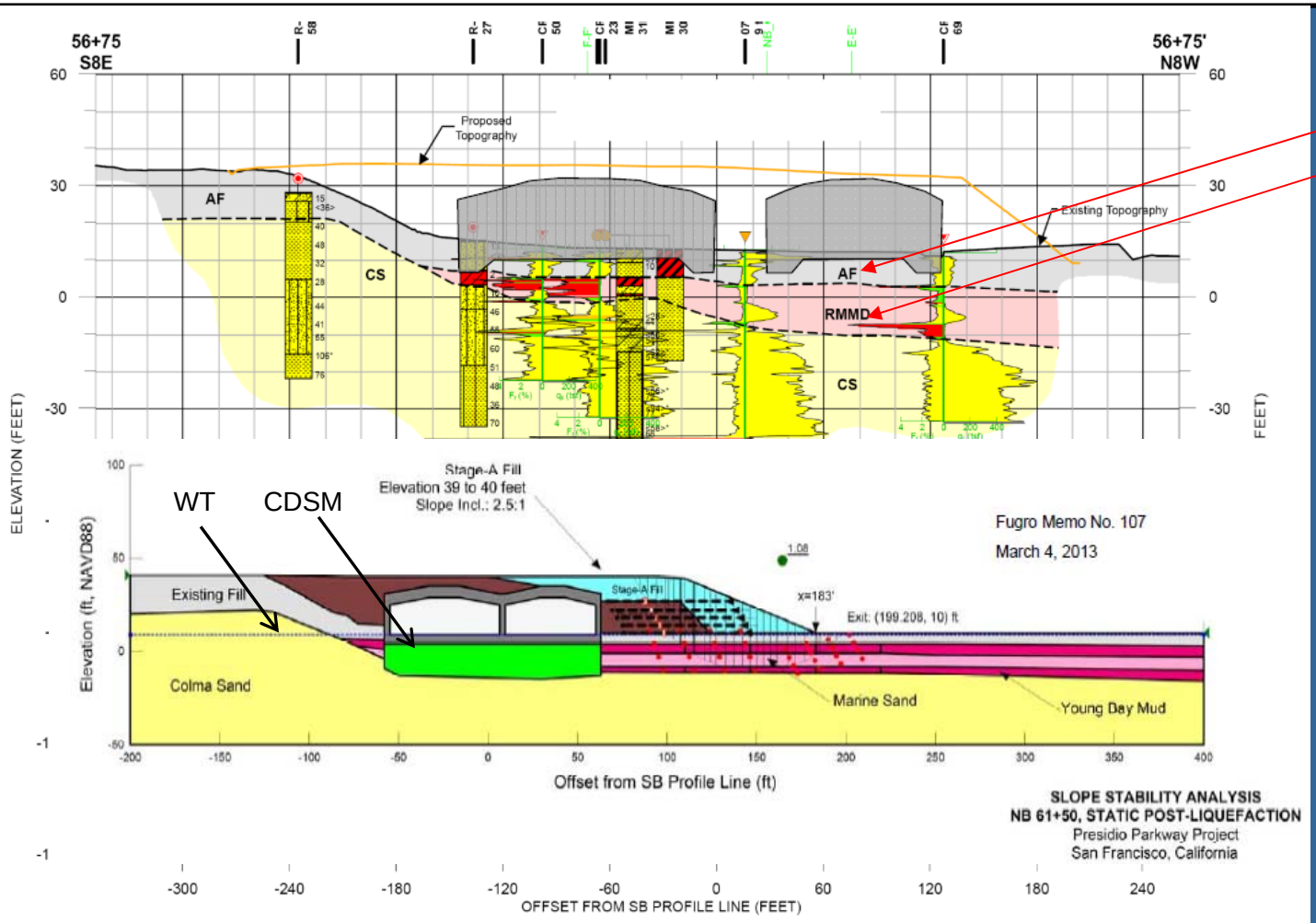
Site Complexity (Cont.)



GOLDEN LINK CONCESSIONAIRE

HNTB

Site Complexity (Cont'd)



LIQUEFACTION

- AF: Artificial Fill
- MD: Marsh Deposit
- Both of these layers are susceptible to liquefaction.

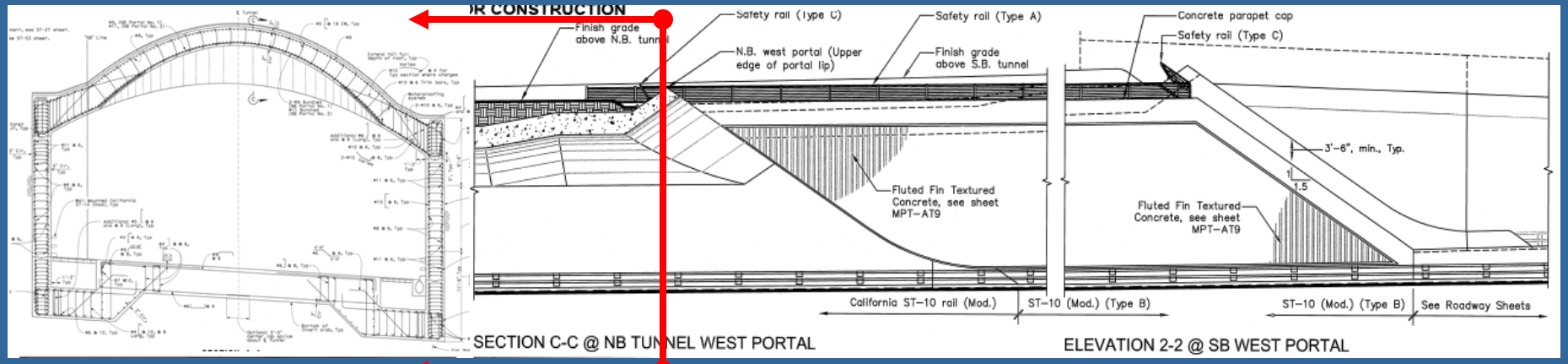
- CDSM Design was a close cooperation between structures & Geotechnical teams.
- The intent was to transfer load to CS

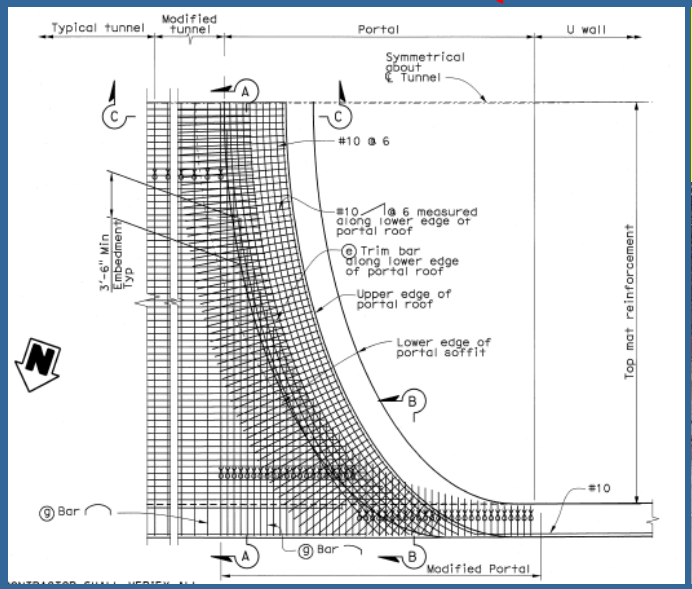
CS: Colma Sand

GOLDEN LINK CONCESSIONAIRE

HNTB

Architecture





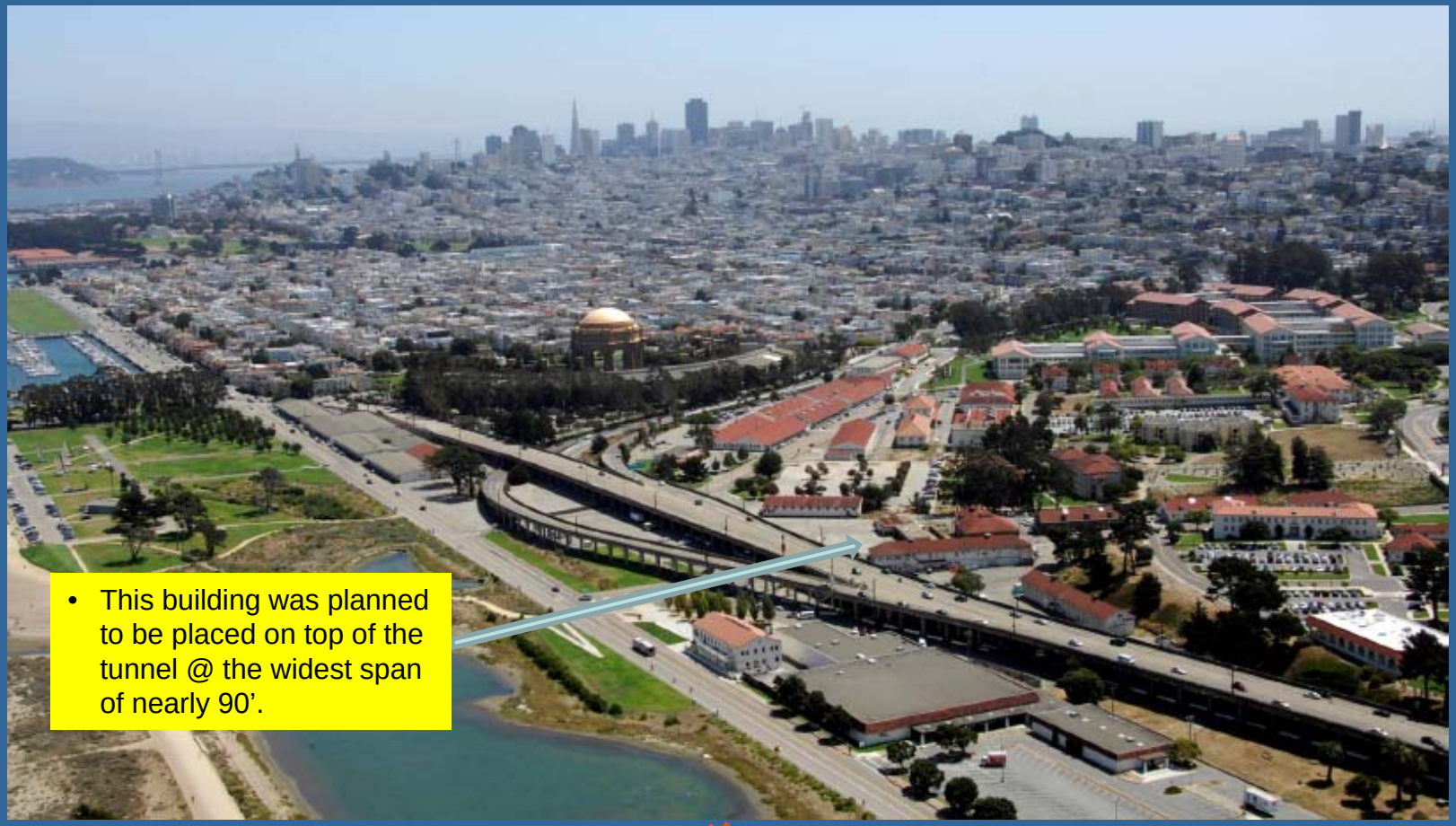
- 3D Models for the portal/tiara geometry, FEM, and reinforcement
- Finishes to be consistent with GGB finishes (paint + galvan.)
- Customized light-poles for the entire project
- Non-matching tunnel lengths

GOLDEN LINK CONCESSIONAIRE

HNTB

Architecture (Cont'd)

- Historic Preservation of Existing Bldgs.
- Some of bldgs. will be placed back (settlement monitor. in progress)



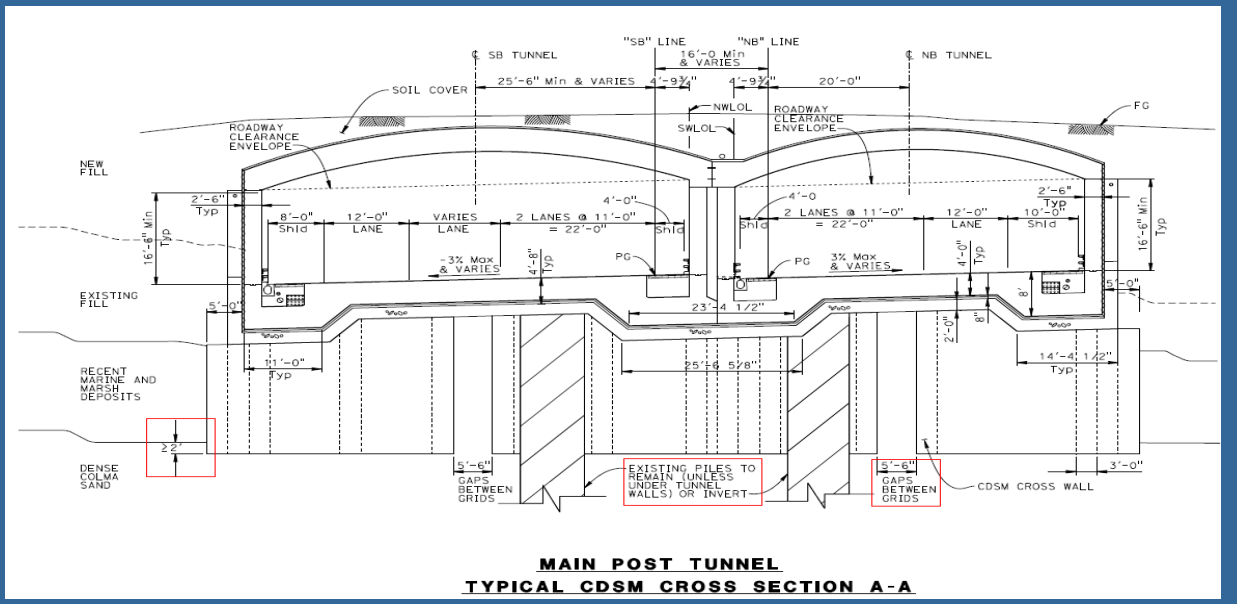
GOLDEN LINK CONCESSIONAIRE

HNTB

Environmental Issues

- Close to a major body of water, high water table, natural GW flow, opening ins CDMS
- Sensitive environment (native plants, migratory birds)
- Sensitive Natural aquifers that could not be punctured
- Pet cemetery
- Hazardous material (serpentine rock near/at surface, containing natural asbestos)
- In the heart of Presidio National Park and National Cemetery

Photo: curtesy of Caltrans



MAIN POST TUNNEL
TYPICAL CDSM CROSS SECTION A-A

GOLDEN LINK CONCESSIONAIRE

HNTB

Presidio Parkway

- Project Overview
  - History and Phases
  - Site Complexity
  - Architecture
  - Environmental Issues
- Main Design Elements
  - Ground Improvements
  - MPT Structural Design Criteria
  - Fire Analysis
  - Halleck St. & Ret Walls
  - Moveable Form
  - Landscaping /Backfill
- Closing
  - Lessons Learned
  - Conclusions

GOLDEN LINK CONCESSIONAIRE

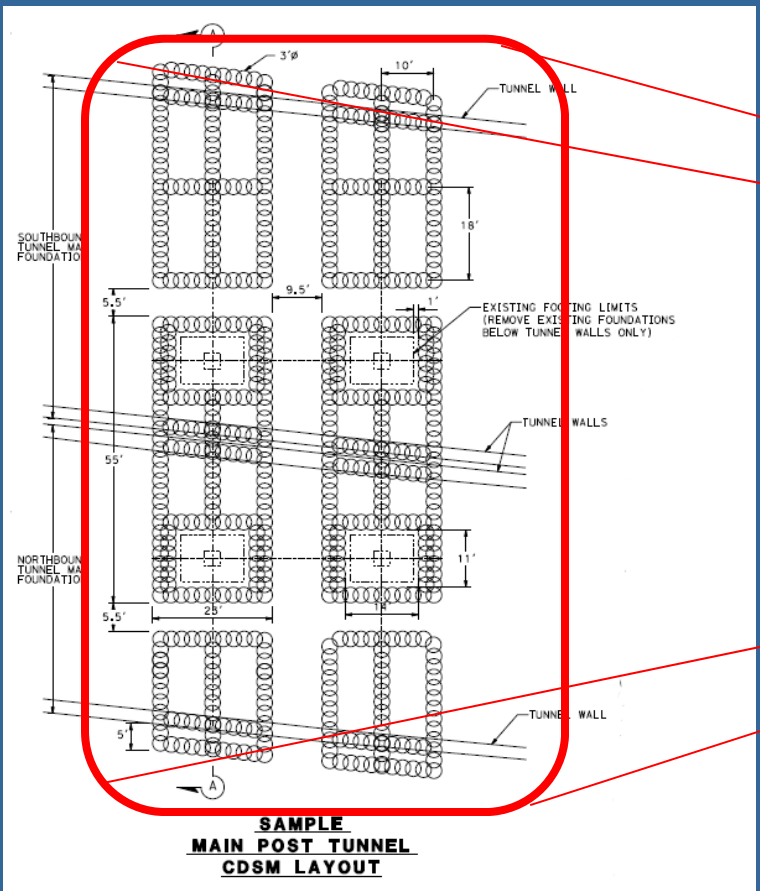
HNTB

Ground Improvements

CDSM

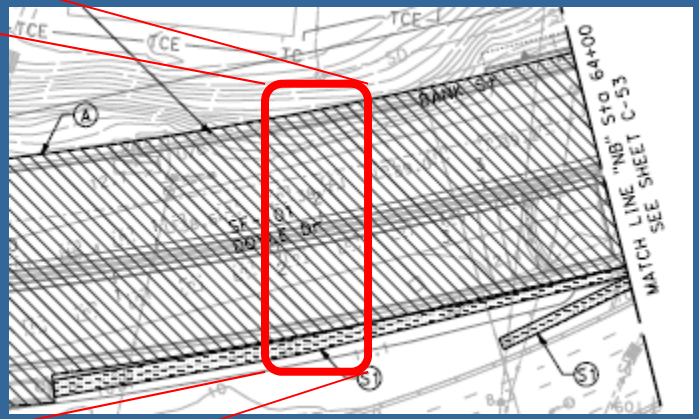
CEMENT DEEP SOIL MIXING (CDSM) TABLE

SYMBOL	LOCATION (ZONE TO BE IMPROVED)	BRIDGE/WALL NUMBER	PURPOSE OF CDSM	HORIZONTAL EXTENT	VERTICAL EXTENT	MIN AVERAGE REPLACEMENT RATIO (%)
	(A) MAIN POST TUNNEL NB AND SB, AND DRAINAGE CULVERT	34-0163R&L	STATIC SETTLEMENT MITIGATION, SEISMIC SETTLEMENT AND LATERAL SPREADING MITIGATION.	EXTENDS ≥5' BEYOND EDGES OF MAT FOUNDATION (3) EXCEPT AT MAIN POST SUBSTATION AND RW T04.) CDSM CONFIGURED IN GRIDS WITH ~5' TO 10' GAPS BETWEEN TO ALLOW GROUNDWATER TO CONTINUE TO FLOW. MAXIMUM CLEAR SPACE BETWEEN TRANSVERSE CDSM WALLS (RUNNING APPROXIMATELY NORTH-SOUTH) WITHIN GRIDS IS 8' EXCEPT AT EXISTING FOUNDATIONS TO	TOP: UNDER FOOTPRINT FROM BASE OF DRAINAGE COURSE AND AROUND PERIMETER FROM BASE OF ADJACENT DRAINAGE LAYER. BOTTOM: 2' INTO DENSE COLMA SANDS (~Elev 3' TO -14').	33.6 (INCLUDING GAPS BETWEEN GRIDS)



SAMPLE
MAIN POST TUNNEL
CDSM LAYOUT

Every element in CDSM had a unique label for proper construction coordination to assure proper support is provide for the structure.



GOLDEN LINK CONCESSIONAIRE

HNTB

Ground Improvements (Cont.)

Dry season was helpful to get the CDSM installation completed on an expedited schedule.

Completion of CDSM for the MPT was on critical path.

GOLDEN LINK CONCESSIONAIRE

HNTB

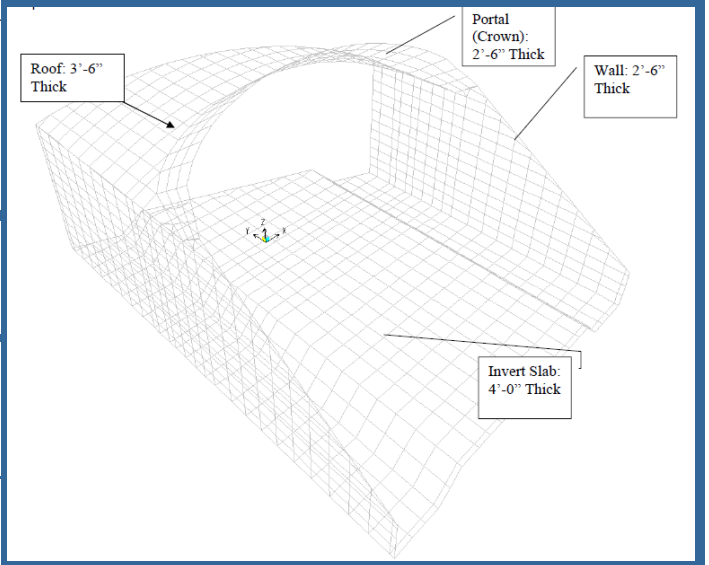
MPT Design Criteria

SEISMIC DESIGN:

PROJECT SPECIFIC SEISMIC DESIGN CRITERIA

PERFORMANCE MEASURES

Design Earthquake	Performance Level
Functionality Evaluation Earthquake (FEE)	Minimal damage Immediate service
Safety Evaluation Earthquake (SEE)	Repairable damage/No-collapse Limited service



Safety Evaluation Earthquake (SEE)

Envelope of the median (50th percentile) deterministic Maximum Credible Earthquake (MCE) ARS and a probabilistic hazard ARS for an event with a mean return period of 1,000 years (i.e., 7.5% probability of exceedance in 75 years).

Functionality Evaluation on Earthquake (FEE)

A probabilistic hazard ARS for an event with a mean return of 108 years (i.e., 50 % probability of exceedance in 75 years).

Displacement Capacity:

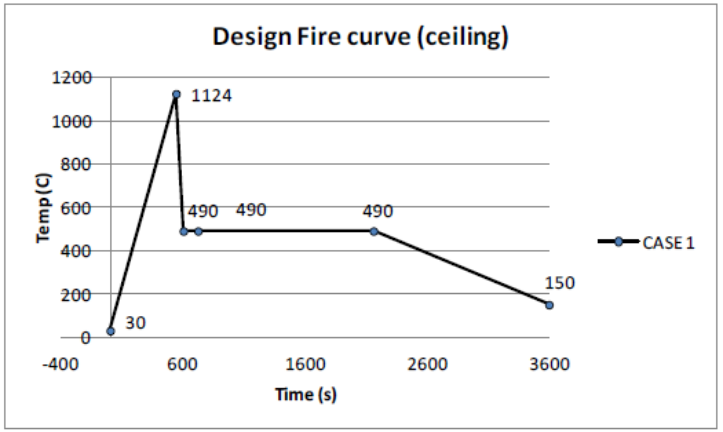
Pushover analysis with concrete strain limits: FEE-e_c=0.0033
(Concrete Strain Limits Control Section Displacement Capacity) SEE-e_c=0.005

Displacement Demands:

Dynamic non-linear time history analysis.

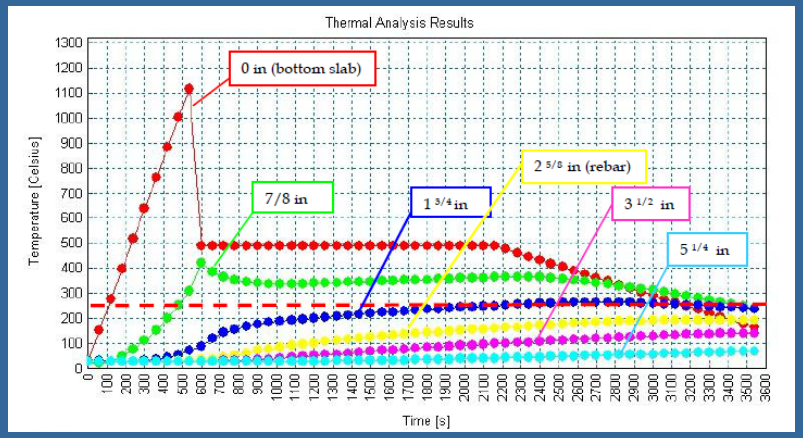
MAXIMUM FIRE LOAD CRITERIA

PROJECT SPECIFIC FIRE LOAD TUNNEL VENTILATION, FIRE PROTECTION, DRAINAGE AND STRUCTURE SYSTEMS ARE DESIGNED FOR MAXIMUM FIRE LOAD OF 100 MW.



Component	Component Performance Criteria			
	Functional Evaluation Earthquake (FEE)		Safety Evaluation Earthquake (SEE)	
	Ductile [1]	Capacity-Protected [2]	Ductile [1]	Capacity-Protected [2]
Tunnel Roof Slab		X		X
Tunnel Invert Slab		X		X
Tunnel Walls	X		X	
Retaining Walls	X		X	
Footings		X	X	
Piles		X	X	
Columns	X		X	
Bulkheads		X	X	

Fire Analysis



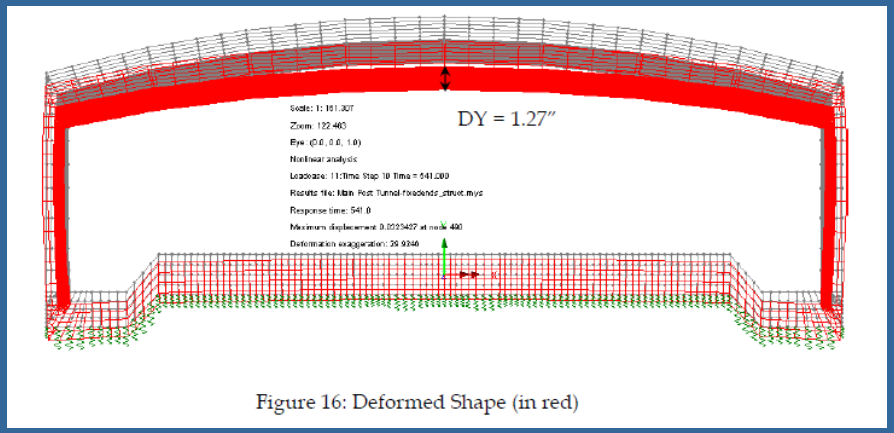


Figure 16: Deformed Shape (in red)

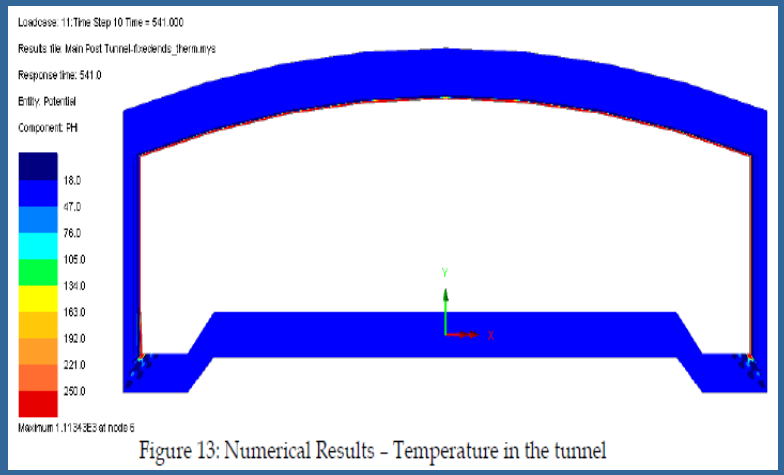


Figure 13: Numerical Results – Temperature in the tunnel

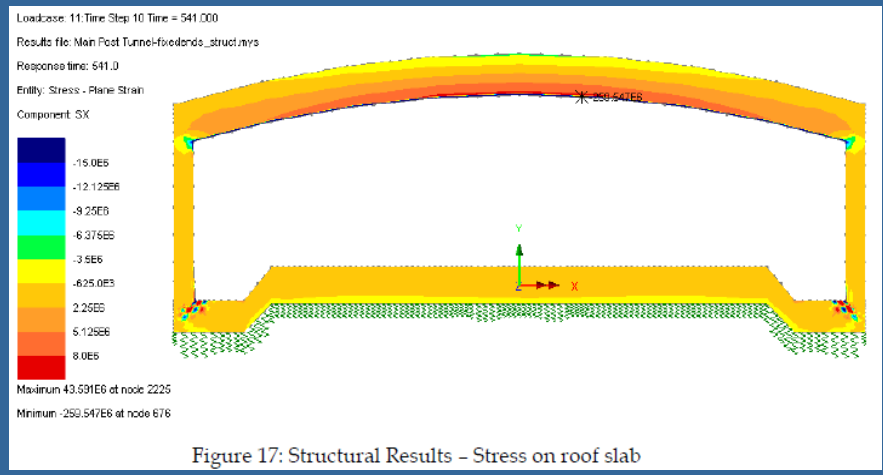


Figure 17: Structural Results – Stress on roof slab

GOLDEN LINK CONCESSIONAIRE

HNTB

Fire Analysis (Cont.)

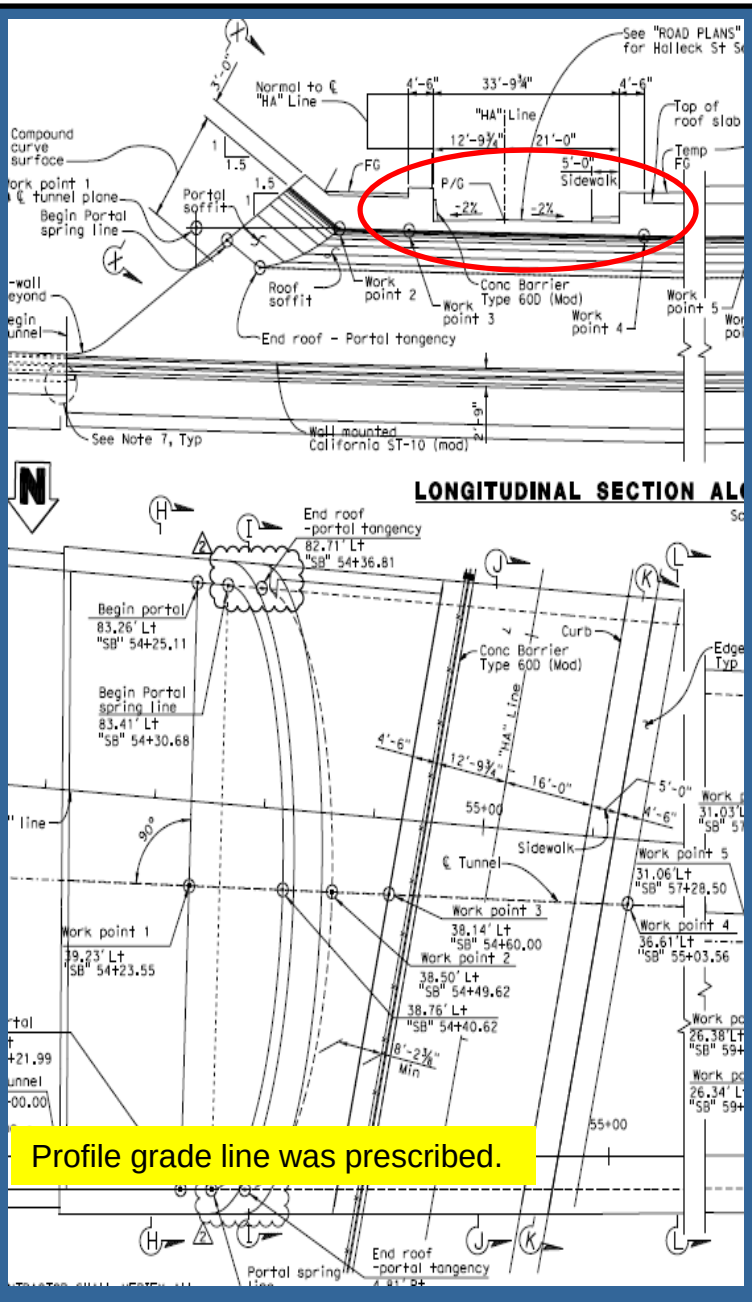
Raised r

modate jet fans.

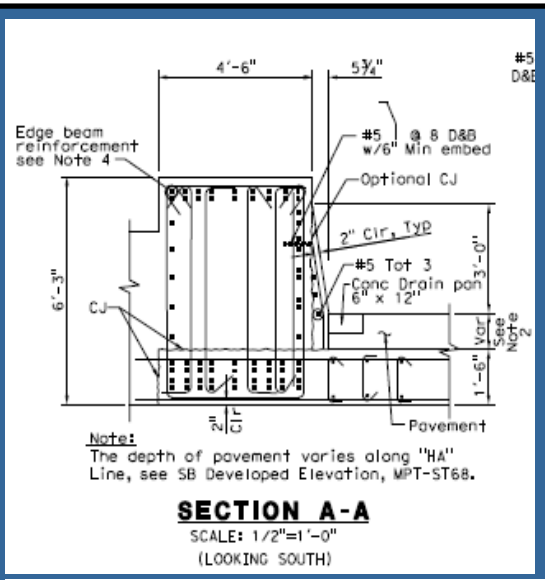
GOLDEN LINK CONCESSIONAIRE

HNTB

Halleck St.



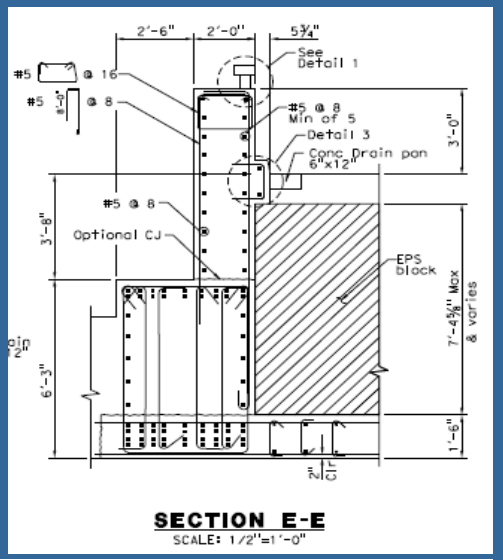
Profile grade line was prescribed.



SECTION A-A

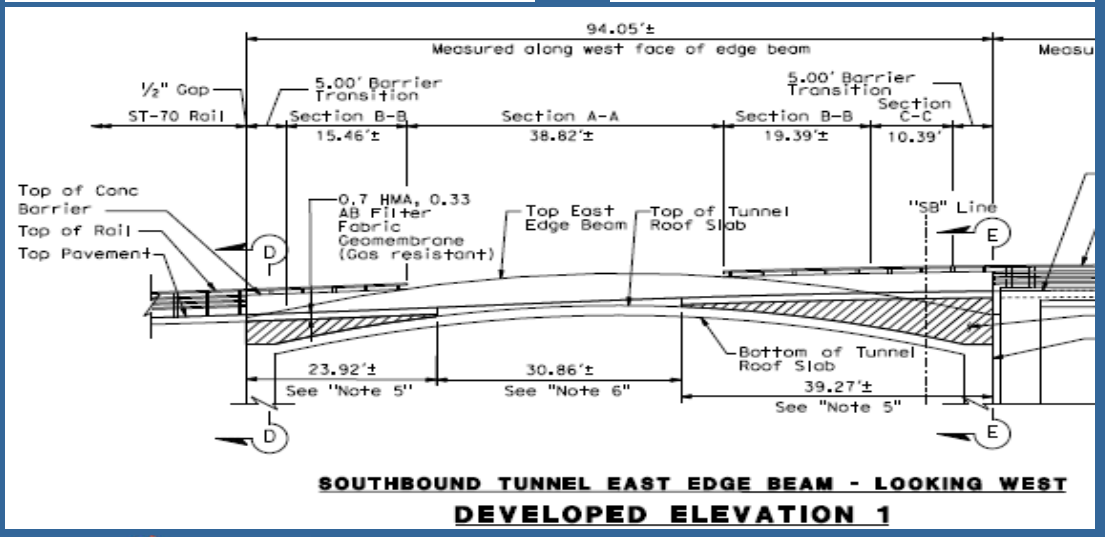
SCALE: 1/2"=1'-0"

(LOOKING SOUTH)



SECTION E-E

SCALE: 1/2"=1'-0"



SOUTHBOUND TUNNEL EAST EDGE BEAM - LOOKING WEST

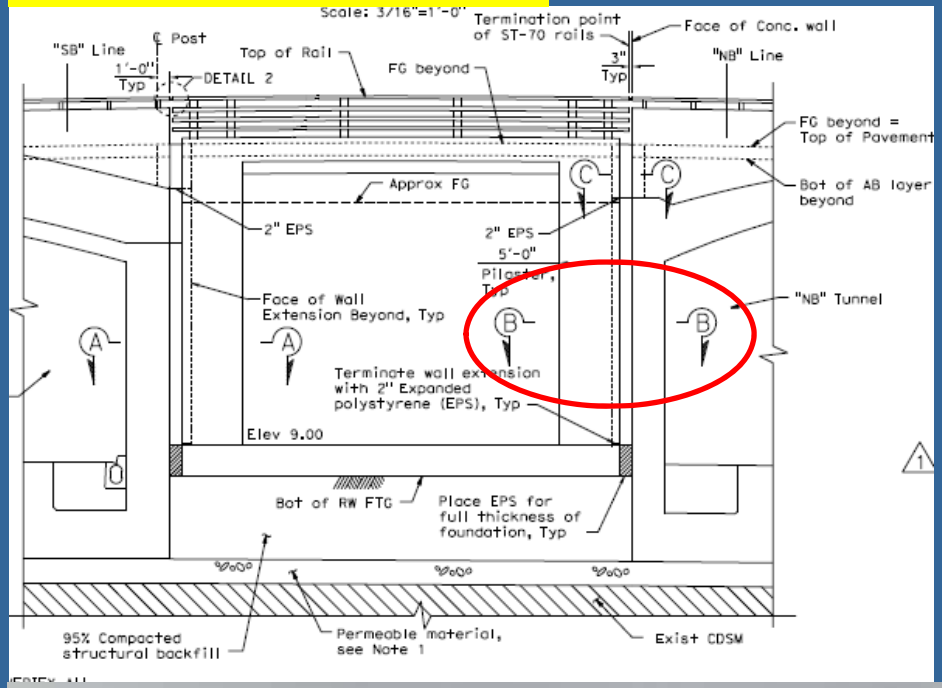
DEVELOPED ELEVATION 1

GOLDEN LINK CONCESSIONAIRE

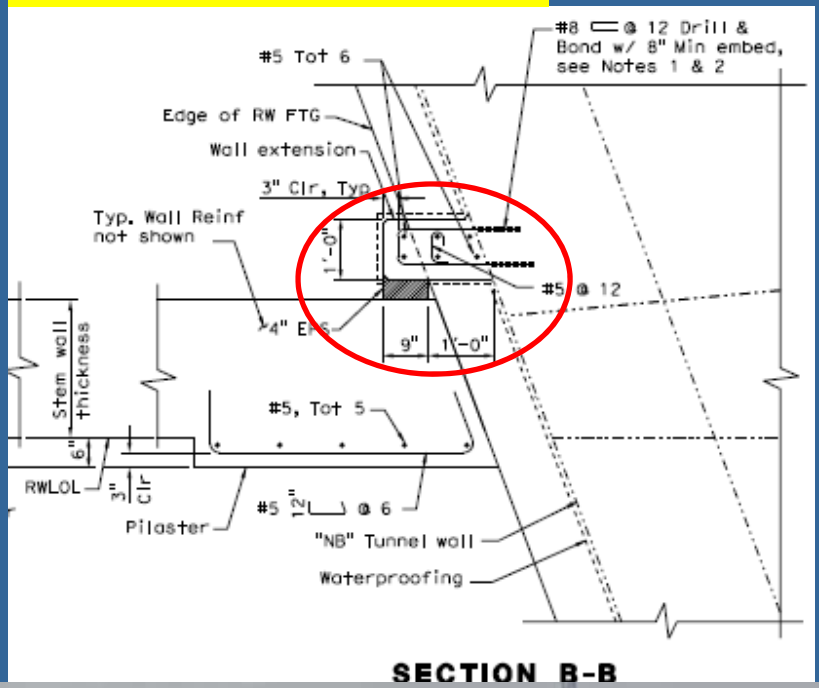
HNTB

Halleck St. (Cont.)

RW119 was detail to accommodate independent movement.



Footing lowered to avoid concentrated load on tunnel walls.



Google

Moveable Form

- High strength concrete with F'c = 6.0 ksi was used to expedite MPT NB roof slab pour and ability to move the form within one day.
- Surveys were performed to check the vertical displacement of roof after removal of the form.
- JV was able to pour about 60 ft. length of tunnel roof in one day.

GOLDEN LINK CONCESSIONAIRE

HNTB

Landscaping / Backfill

- Stone column are placed to improve existing ground.
- Geogrids will be placed prior to backfill the area on the north side of the tunnels.

Substation Building

GOLDEN LINK CONCESSIONAIRE

HNTB

Presidio Parkway

- Project Overview
  - History and Phases
  - Site Complexity
  - Architecture
  - Environmental Issues
- Main Design Elements
  - Ground Improvements
  - MPT Structural Design Criteria
  - Fire Analysis
  - Halleck St. & Ret Walls
  - Moveable Form
  - Landscaping /Backfill
- Closing
  - Lessons Learned
  - Conclusions

GOLDEN LINK CONCESSIONAIRE

HNTB

Lessons Learned

- For complex site conditions having the local knowledge and technically strong GEOR is extremely valuable.
- Detailed review of the technical design criteria is a must.
- For any ambiguous item in the design criteria, ask for clarification prior to submitting the proposal.
- PMs and Task Leads: Know the contract very well and use it during the design phase as frequently as possible
- Proper documentation is extremely important. (Develop meeting minutes for important decisions)
- Communication across the disciplines is a must. Learn other disciplines at least the basics to be able to make better decisions.

Allen Rejaie, PhD, PE

GOLDEN LINK CONCESSIONAIRE

HNTB

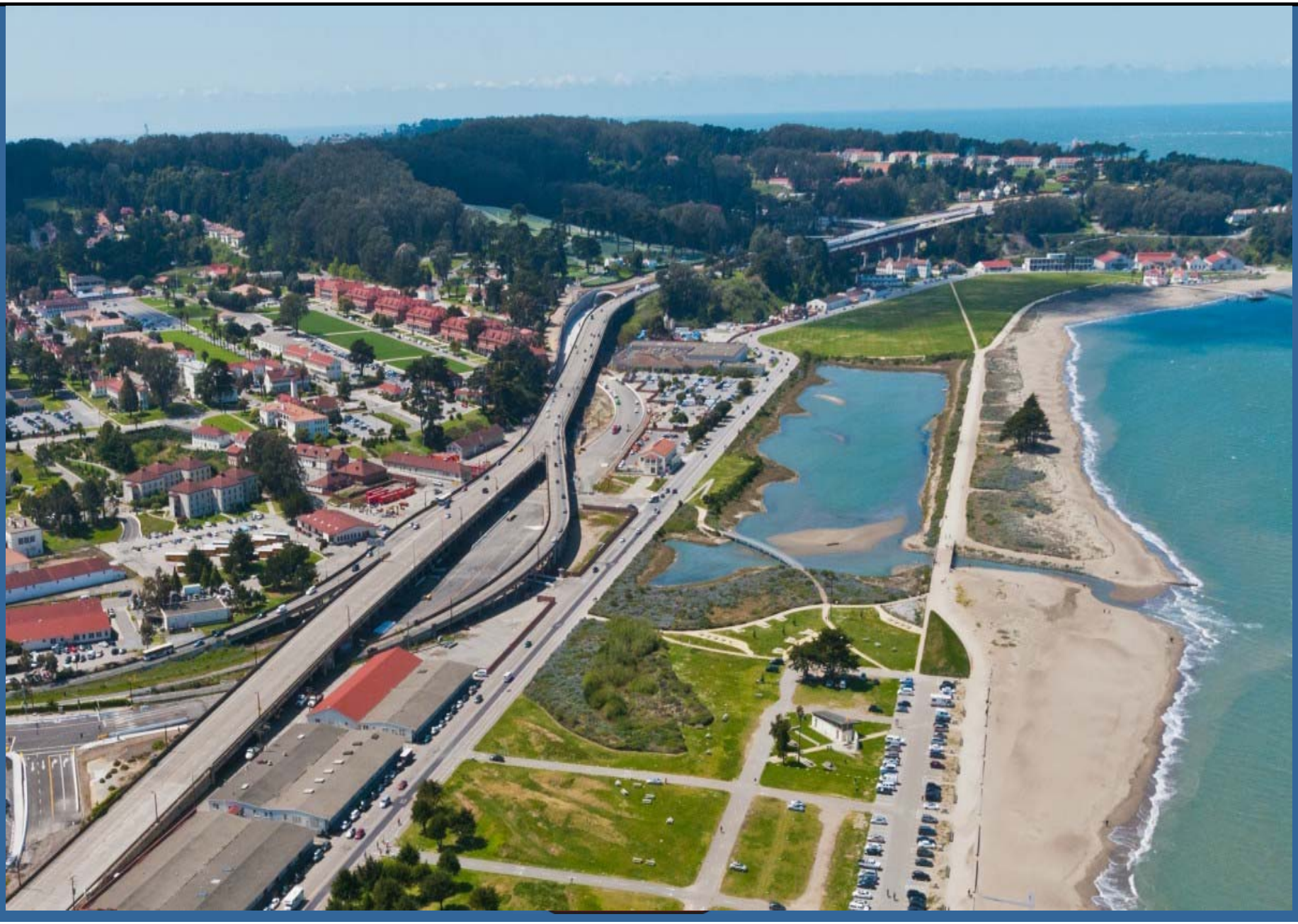
Conclusions

- Presidio was managed very well from day one. (Strong PM with in depth knowledge in scope and contract)
- Proper documentation was extremely important. Cooperative sub-consultant are also crucial.
- Communication across the disciplines is a must. Learn other disciplines at least the basics to be able to make better decisions.
- Presidio was a very successful project.
- Six offices supported the design work (including mechanical, electrical design, and CADD):
  - Oakland / San Jose / San Francisco
  - Roseville (Sacramento)
  - Irvine
  - Portland
  - Bellevue
  - Kansas City

GOLDEN LINK CONCESSIONAIRE

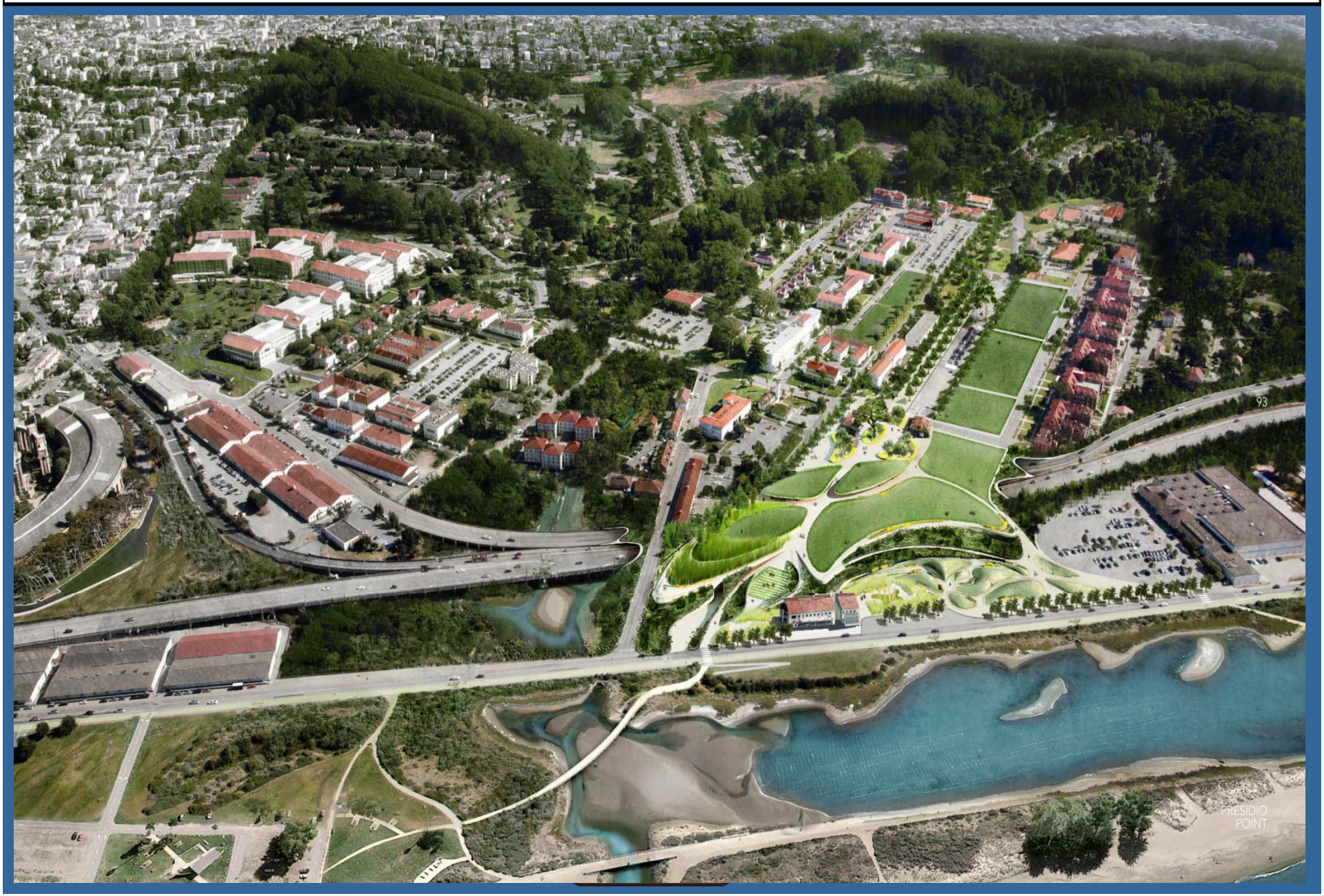
HNTB

Before



After (almost)

Landscaping of MPT (Option 1)



Landscaping of MPT (Option 2)

Questions?

GOLDEN LINK
CONCESSIONAIRE

HNTB