

TRI - REGIONAL JETS 2025





USACE Caribbean District - Rio Puerto Nuevo Project: Design and Construction Considerations



U.S. ARMY



US Army Corps
of Engineers®





USACE Caribbean District - Rio Puerto Nuevo Project: Design and Construction Considerations

Moderator:

Kevin Golinghorst, PE, Benham Design

Speakers:

- Luan M. Esteban, MECE, PE, Chief - Technical Support Branch
- Jorge A. Rivera-Cruz, PhD, PE, Structural Engineer
- Edgardo E. Bermúdez Rodríguez, MSCE, PE, Geotechnical Engineer



MODERATOR

Kevin Golvinghorst, PE

Benham Design

Director of Business Development – Federal
Design



- **Sports Teams:** Army West Point, St. Louis Battlehawks, Pittsburgh Steelers
- **Vacation Spots:** Hawaii (thanks to SAME IPRS)
- **Did You Know:** I married a USNA “squid”
- **Hobbies:** Military History / Attending Reunion(s)
- **Cooler Project(s):** Road Construction near Ketchikan, Alaska (1998)
Arecibo, Guanajibo, & Nigua on Puerto Rico (2022)



SPEAKER

Luan M. Esteban, MECE, PE

USACE SAA, Chief - Technical Support Branch



- **Sports Teams:** No favorite sports teams, unless pro tennis counts or my daughter's team is playing
- **Vacation Spots:** Vieques and Isabela, PR
- **Did You Know:** I've gone full circle, literally around the world
- **Hobbies:** Pickleball, Travel planning and Travel
- **Cooler Project(s):** Rio Puerto Nuevo, Islandwide Reservoirs Feasibility



SPEAKER

Jorge Rivera^{PhD, PE}
USACE SAA, Structural Engineer



- **Sports Teams:** New York Yankees
- **Vacation Spots:** West coast of Puerto Rico (Rincon beaches)
- **Did You Know:** I played little league baseball (Second baseman)
- **Hobbies:** Play chess
- **Cooler Project(s):** Rio Puerto Nuevo, and Cano Martin Pena



SPEAKER

Edgardo Bermudez_{MSCE, PE}
USACE SAA, Geotechnical Engineer



- **Sports Teams: LAKERS – KB Fan!**
- **Vacation Spots: Western beaches of Puerto Rico**
- **Did You Know: I been working in construction with my father since I had 7 years old.**
- **Hobbies: Spend time with my kids and play basketball**
- **Cooler Project(s): Guajataca DAM, Rio de la Plata, and Rio Puerto Nuevo**



Learning Objectives

- Know the USACE Mission and Engagement in Puerto Rico
 - Completed Projects
 - Ongoing and Future Projects
- Understand USACE multidisciplinary design and construction considerations/requirements.
 - Rio Puerto Nuevo Project



Agenda

- Overview
- Hydraulic
- Geotechnical
- Structures
- Construction Considerations
- Summary
- Q&A



Have you heard about USACE Caribbean District Civil Works Program?

- a) Yes
- b) Kind of?
- c) No



Overview



USACE Caribbean District Established in 2024

Provides additional leadership bandwidth and focus on priority missions in USVI and Puerto Rico



Caribbean District Programs

Civil works, regulatory, Military,



USACE Completed Projects

Portugues
Dam



Guajataca
Dam



RPN Upper
Margarita
Channel and
Stilling Basin

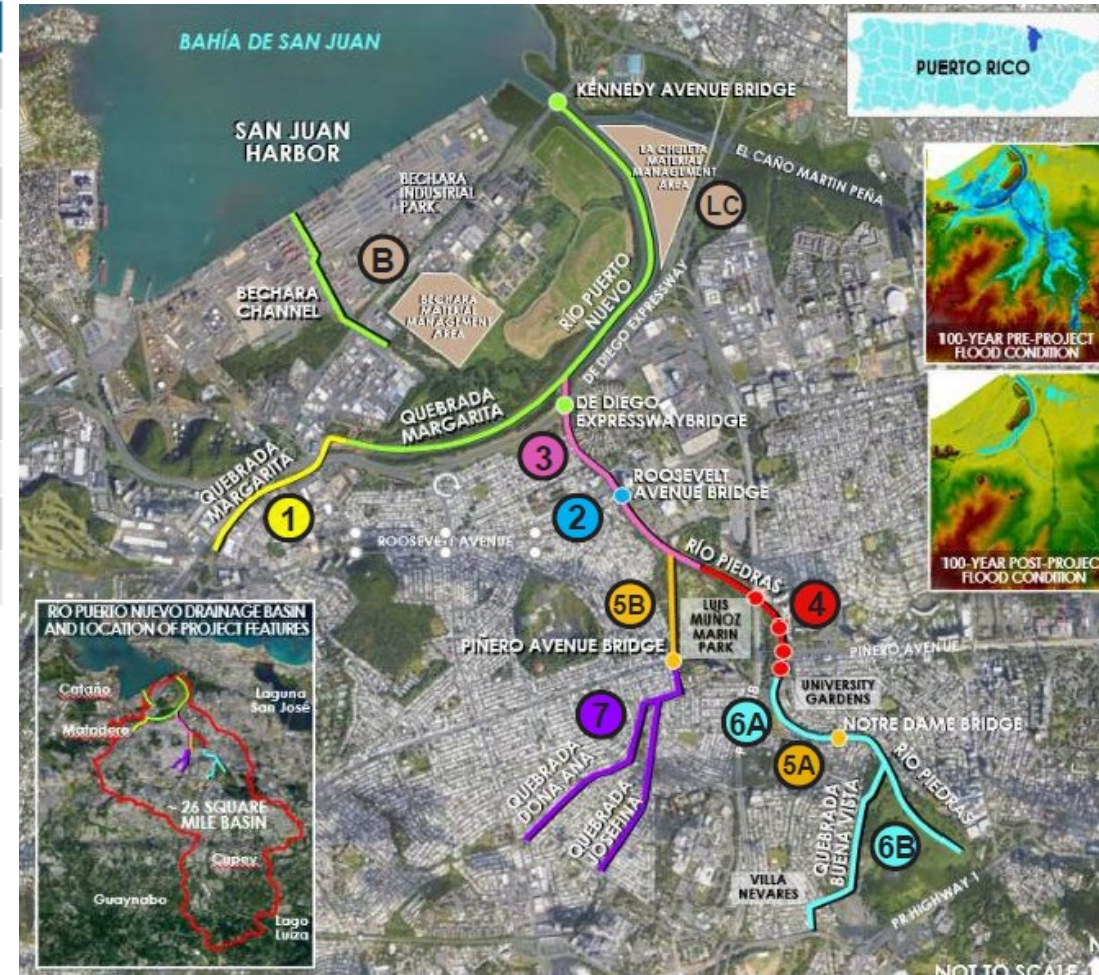


RPN 2D
Walls
Contract

Río Puerto Nuevo Flood Risk Management

Project overview

Supplemental Contract	Design	Construction
Contract 1: Upper Margarita Channel	Stanley Consultants	
Contract 2: Roosevelt Bridge	Arcadis	Ferrovial
Contract 3: Main Channel (Río Piedras)	Arcadis	Upcoming award
Contract 4: Las Americas Bridges	CDM Smith	
Contract 5a: Piñero Bridge and Josefina Channel	CDM Smith	
Contract 5b: Notre Dame Bridge	Philadelphia District	
Contract 6: Main Channel and Buena Vista	Huntington District	
Contract 7: Josefina and Doña Ana Channel	Pre-Award	
Contract: La Chuleta Material Management Area	Stanley-Stantec JV	
Contract: Bechara Material Management Area	Stanley-Stantec JV	



Hydraulics





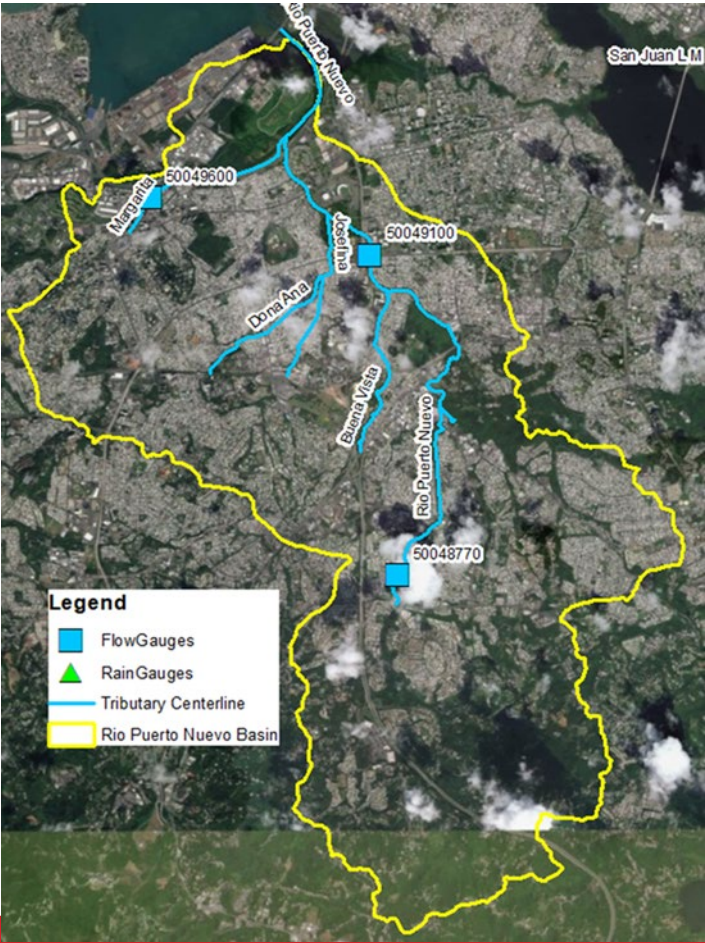
- **Design Considerations**

- ✓ Hydrologic updates
- ✓ Hydraulic studies
- ✓ HEC-RAS
- ✓ Channel sediment transport
- ✓ Bridge scour analysis
- ✓ Sedimentation analysis
- ✓ Physical model
- ✓ Computational fluid dynamics 3D hydraulic model

Hydrologic Updates

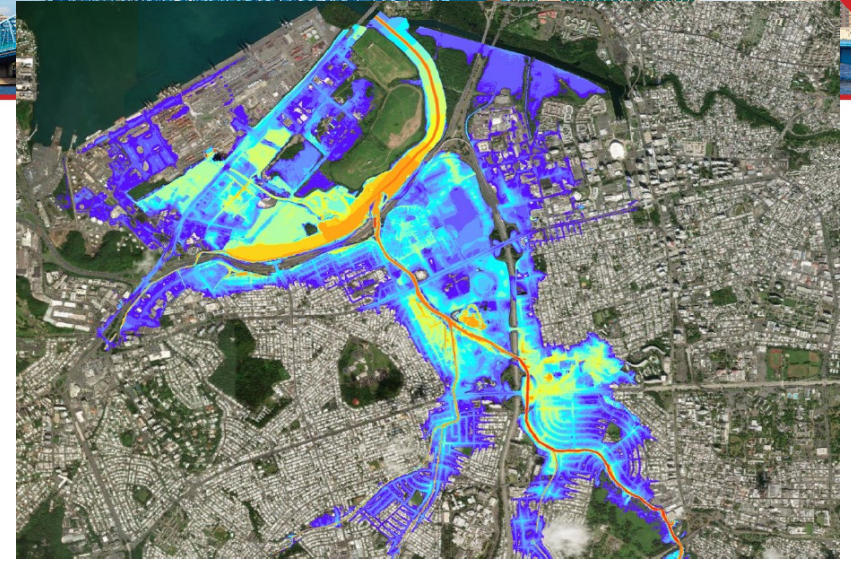
- General Design Memorandum (GDM)
 - TP-42 rainfall
 - 10.4 inches for 0.01 annual exceedance probability (AEP)
 - Curve Number methodology
 - SCS Type II distribution
 - 24-hour rainfall distributed into a 4-2-1-3 balanced storm six-hour distribution
 - HEC-1
- 2019 Supplemental Update
 - NOAA Atlas 14 rainfall
 - 13.3 inches basin average of approximately (11.9-14.7 in. spatially varying rainfall).
 - Curve Number methodology
 - NRCS Incremental Intensity Temporal Distribution
 - HEC-HMS

USGS Station	Location	0.01 AEP Design Storm Flow Comparison (cfs)			
		2019 HMS Model USACE	1986 Survey Report 1985 condition	1986 Survey Report 2035 condition	2009 FEMA
50049100	Rio Piedras at Hato Rey (at Pinero Bridge)	25,150	28,390	35,700	25,380
50048770	Rio Piedras at El Senorial	13,774	16,490	22,700	13,941

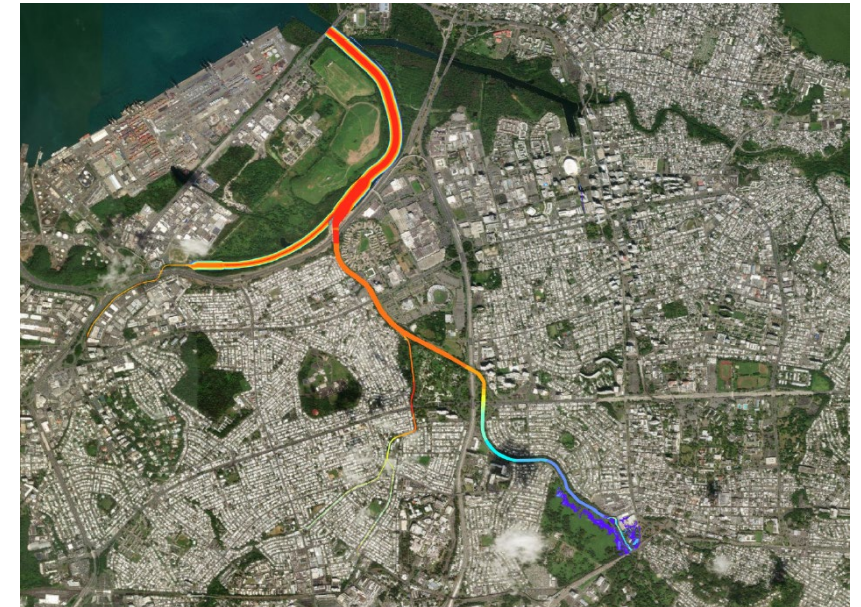


Hydraulic Studies

- HEC-RAS 1D/2D & full 2D
 - ✓ Existing condition model
 - ✓ Proposed conditions
 - ✓ Construction sequence
 - ✓ Diversion during construction
- Channel Sediment Transport
 - ✓ To evaluate the scour potential on the channel bottom
- Bridge scour analysis
 - ✓ To evaluate scour potential on bridge piers



100-yr existing condition inundation map



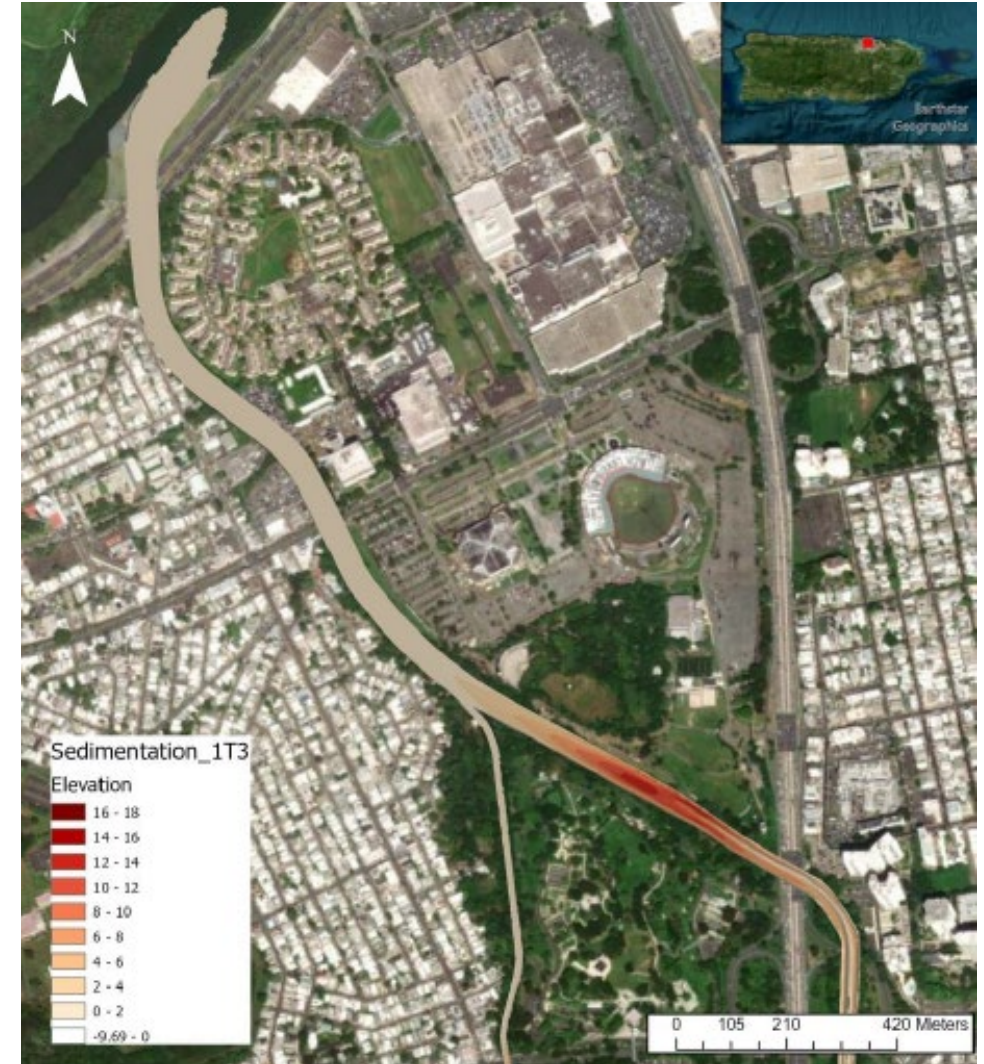
100-yr post project inundation map

Hydraulic Studies

Sedimentation Analysis

- ✓ Adaptive Hydraulics 2d (Adh)
- ✓ To evaluate the channel performance due to sediment deposition and to develop an O&M procedure.
- ✓ Designed channel capacity to convey storm events after several years of sediment deposition without maintenance.

Sedimentation Condition	Frequency Storm				
	2yr	5yr	10yr	25yr	100yr
1 year	Yes	Yes	Yes	Yes	Yes
2 years	Yes	Yes	Yes	Yes	Yes
3 years	Yes	Yes	Yes	Yes	Yes
4 years	Yes	Yes	Yes	Yes	Yes
5 years	Yes	Yes	Yes	Yes	Yes
6 years	Yes	Yes	Yes	Yes	No



Hydraulic Studies

Physical Model

- ✓ Roughness flume
 - ✓ To determine the roughness of the drilled shaft walls and the composite roughness of drilled shaft walls and articulated concrete blocks channel bottom (ACB).
 - ✓ Determine ACB type needed for different project reaches.
- ✓ Project reach hydraulics flume
 - ✓ To analyze the channel hydraulics performance due to sharp channel bends and effect of drilled shafts for the design of the channel scour protection.
 - ✓ Verify the effect of standing waves, flow separation.



Hydraulic Studies

Roughness Flume



Project Reach Flume



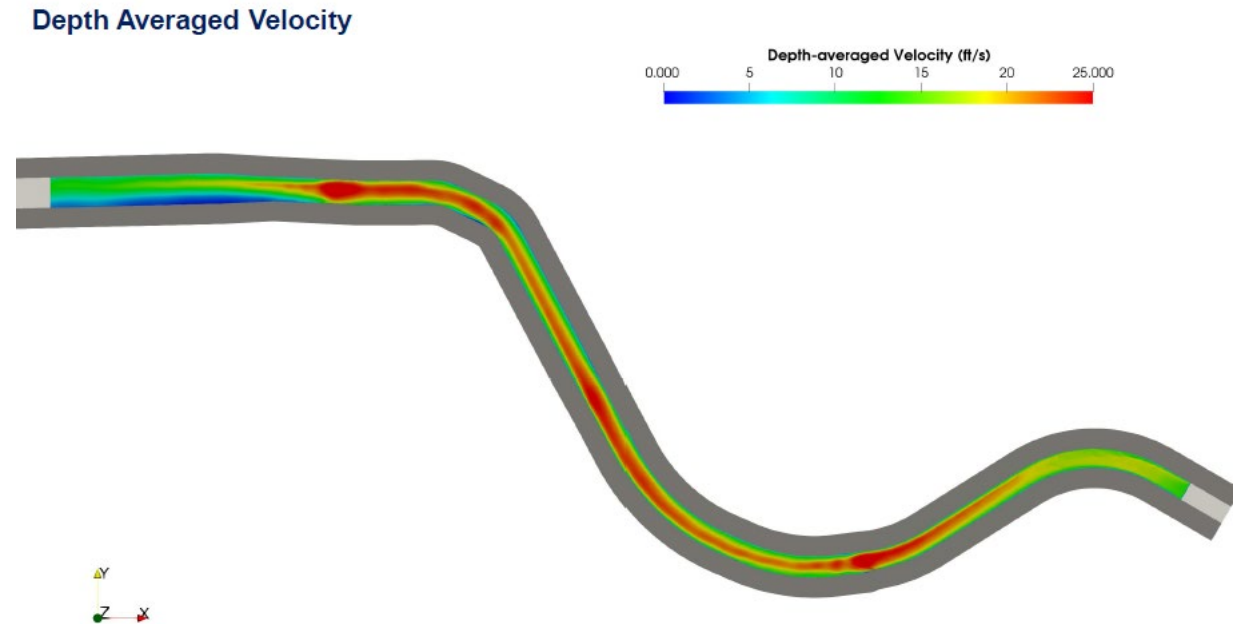
Hydraulic Studies



Hydraulic Studies

Computational Fluid Dynamics 3D Hydraulic Model (CFD)

- Validated numerical model calibrated to the physical model that can be used to test alternatives for the channel scour protection:
 - ✓ Articulated Concrete Blocks (ACB)
 - ✓ Concrete Armor Units (CAU)
- Provide detail hydraulic results visualization
- Channel hydraulics controlled by the tangent walls with flow concentrating to the middle of the channel.



Geotechnical



Geotechnical

- DESIGN CONSIDERATIONS
 - ✓ Design Standards
 - ✓ Geotechnical Subsurface Investigations
 - ✓ Seismic Considerations
 - ✓ Seismic Site Classification and Peak Ground Acceleration Estimate
 - ✓ Geotechnical Seismic Explorations
 - ✓ Seismic Site-Specific Study
 - ✓ Probabilistic Seismic Hazard Analysis (PSHA) and Deterministic Seismic Hazard Analysis (DSHA)
 - ✓ Site Response
 - ✓ Soil Parameters
 - ✓ Liquefaction Screening and Cyclic Softening in Clays and Plastic Silts Assessment
 - ✓ Linear and Non-linear Model
 - ✓ Global Stability Analysis
 - ✓ Soil Remediation



Design Standards

- **Geotechnical design must follow Engineering Manuals, Regulations and Design Codes.**
 - EM 1110-1-1804 Geotechnical Investigations
 - EM 1110-2-1906 Laboratory Soils Testing
 - ER 1110-2-1806 (2024) Earthquake Analysis, Evaluation, and Design for Civil Works Projects
 - EC 1110-2-6000 Selection of Design Earthquakes and Associated Ground Motions
 - EM 1110-2-6053 Earthquake Design and Evaluation of Concrete Hydraulic Structures
 - ETL 1110-2-580 Guidelines for Seismic Evaluation of Levees
 - EM 1110-1-1905 Bearing Capacity of Soils
 - EM 1110-2-2502 Floodwalls and other Hydraulic Retaining Walls
 - ITL-92-11 The Seismic Design of Waterfront Retaining Structures
 - EM 1110-2-1902 Slope Stability
 - ASCE 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures
 - NCEER - Liquefaction Resistance of Soils
 - FHWA-NHI-16-027 Ground Modification Methods Reference Manual
 - FHWA-HRT-13-046 Deep Mixing for embankment and Foundation Support
 - FHWA-NHI-18-024 Drilled Shafts: Construction Procedures and Design Methods



US Army Corps
Of Engineers



ASTM INTERNATIONAL

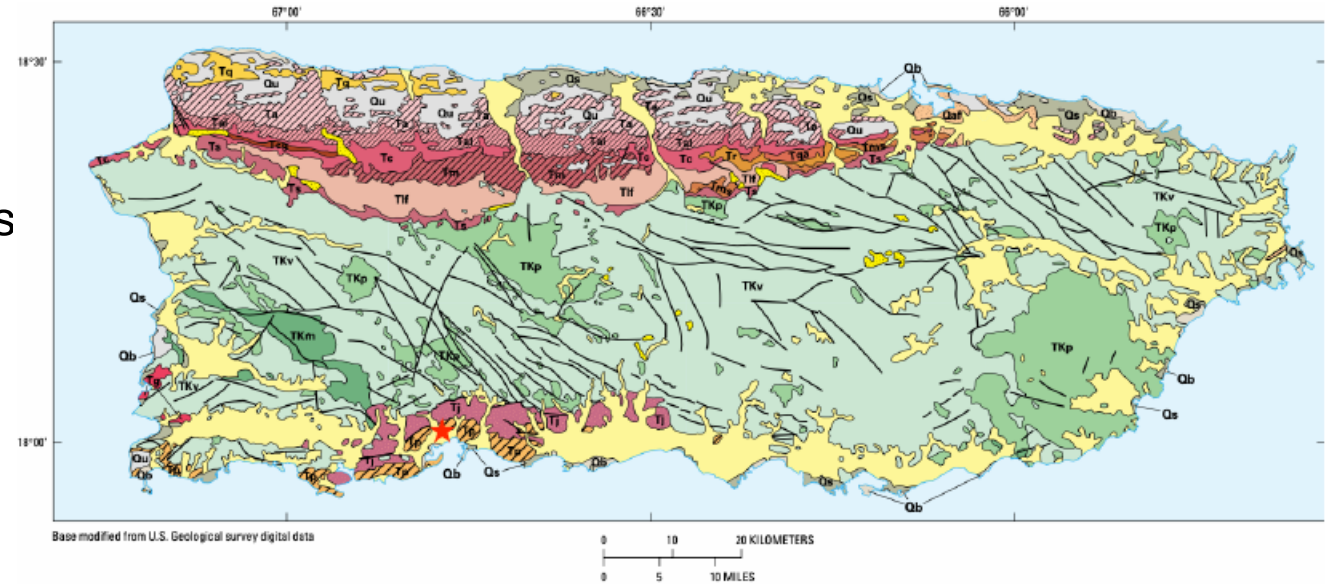
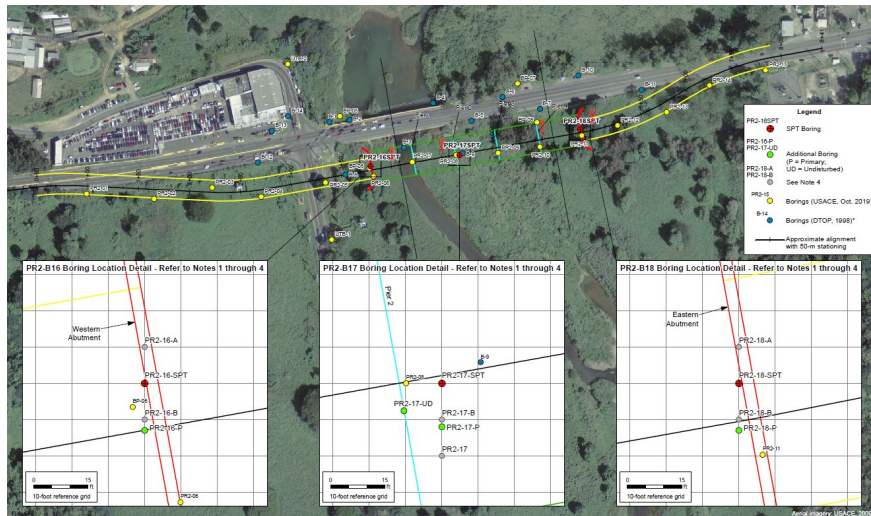


U.S. Department of Transportation
Federal Highway Administration



GEOTECHNICAL SUBSURFACE INVESTIGATIONS

- Following:
 - ✓ EM-1110-1-1804
- Common Subsurface Investigation Methods
 - ✓ Standard Penetration Testing, SPT
 - ✓ Cone Penetration Testing, CPT
 - ✓ Vane Shear Test



Base modified from U.S. Geological Survey digital data

EXPLANATION

Quaternary deposits

Qa	Alluvium
Ql	Landslide deposits
Qb	Beach deposits
Qs	Swamp, marsh deposits
Qaf	Artificial fill
Qu	Undifferentiated surficial deposits

Pliocene and Miocene rocks

Tq	Quebradillas Limestone
	Ponce Limestone

Miocene rocks

Ts	Ayamón Limestone
Tal	Aguada (Los Puertos) Limestone
Tg	Guanajibo Formation
Tc	Cibao Formation
Tm	Montebello Limestone Member
Tka	Quebrada Arenas Limestone Member—Includes Miranda Sand Member
Tr	Rio Indio Limestone Member—Includes Almirante Sur Lintil
Tcg	Guajataca Member

Miocene and Oligocene rocks

Tns	Mucarabones Sand
Tj	Juana Díaz Formation
Th	Lares Formation
Ts	San Sebastián Formation

Eocene, Paleocene, and Cretaceous rocks

TKv	Volcanic and sedimentary rocks
TKp	Plutonic rocks—Mostly quartz diorite and granodiorite
TKm	Metamorphic (serpentine), sedimentary, and igneous rocks

— Fault

Seismic Considerations

- ER 1110-2-1806
 - ✓ Site specific Study - Response Spectrum Analysis – Time-History Analysis

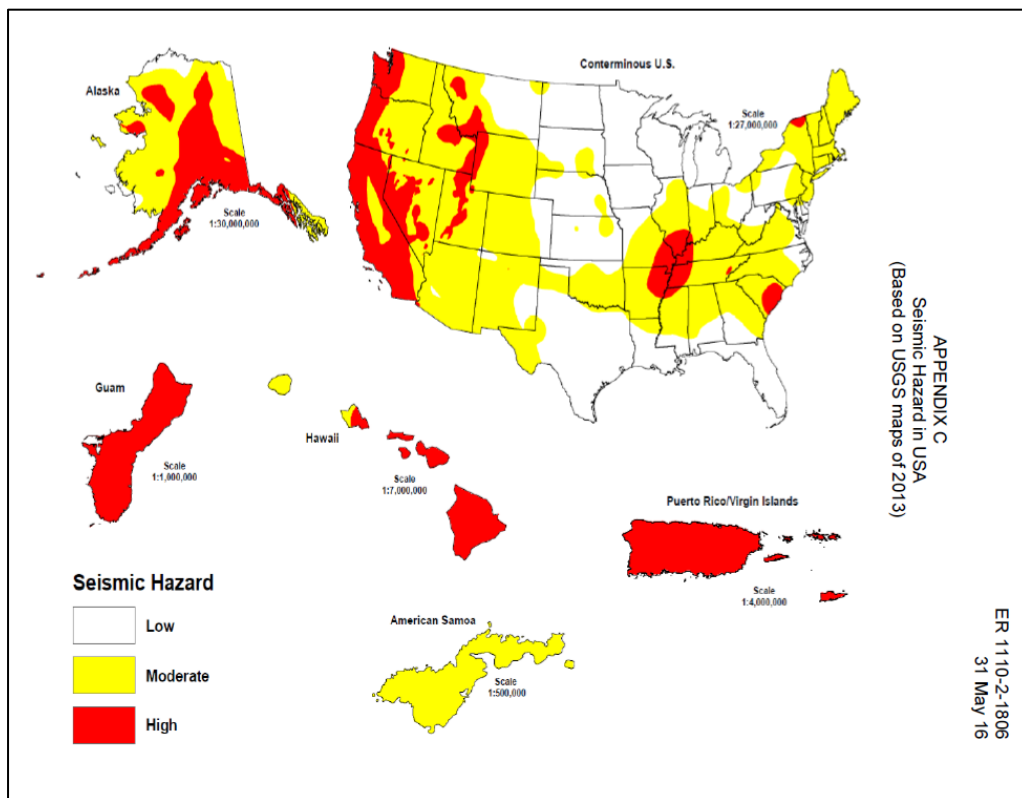


Table 1

Consequence-based project feature classification

Project Feature Type ¹	Direct Loss of Life ²	Disruption or Loss of Project Feature Service or Functionality; Loss of Service or Access for Lifeline Facilities ³	Property Losses ⁴	Adverse Environmental Impacts ⁵
Non-Critical	None expected	None or damages are cosmetic or rapidly repairable	Minimal	Minimal damage
Critical	None expected to probable or likely (one or more)	Probable or likely	Major to extensive	Major to extensive damage ⁶

Table 2

Criteria for seismic design ground motions

Project Feature Type	Minimum Earthquake Return Period for OBE-GM ¹	Earthquake Return Period for MDE-GM
Non-Critical	145-year return period ²	975-year return period
Critical	475-year return period ³	Greater ⁴ of the following: 1) 2,475-year return period ^{5,6} 2) MCE-GM (84th percentile values from ground motion models for source slip rate, $SR \geq 0.9$ mm/year, median or 50th percentile values for $SR \leq 0.3$ mm/year, and interpolation for SR values between 0.3 mm/year and 0.9 mm/year (see paragraph 9c(4))



Seismic site Classification and Peak ground acceleration estimate

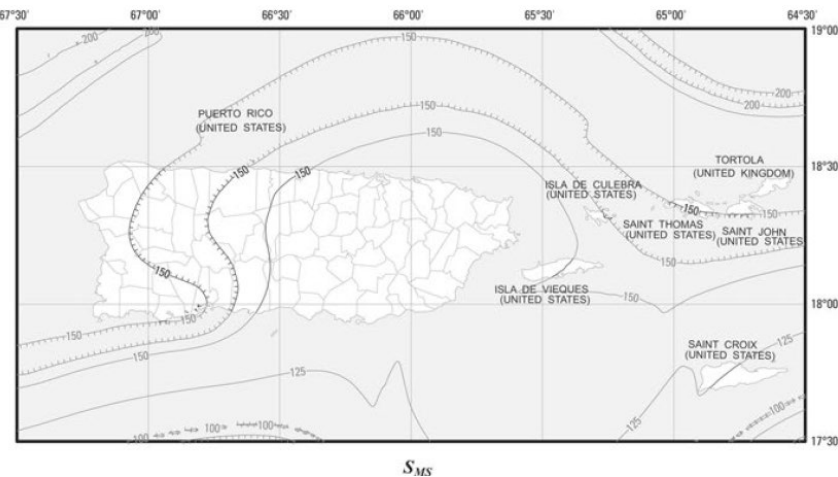
- EM-1110-2-6053 – Development of Standard Horizontal Response Spectrum
- Seismic Coefficient method

$$\bar{S}_S = F_a S_a \quad S_A = b(T_R)^m$$

$$\bar{S}_1 = F_v S_1 \quad m = \frac{\log(S_A^{T_R=2475}) - \log(S_A^{T_R=475})}{0.7169}$$

$$\log(b) = 4.7338 \log(S_A^{T_R=475}) - 3.7338 \log(S_A^{T_R=2475})$$

- Spectral 0.2 and 1-second period responses
- United States Geological Survey (USGS) - Seismic Hazard Maps, ASCE 7-22



- 2% probability of exceedance in 50 years (2,475-year return period)
- 10% probability of exceedance in 50 years (475-year return period)

Table B-3. Site correction coefficient F_a

Site Class	Coefficient F_a				
	$S_s \leq 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9

Table B-4. Site correction coefficient F_v

Site Class	Coefficient F_v				
	$S_s \leq 0.10$	$S_s = 0.20$	$S_s = 0.30$	$S_s = 0.40$	$S_s \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4

ASCE 7-22 Seismic Site Classification

Table 20.2-1. Site Classification.

Site Class	V_s Calculated Using Measured or Estimated Shear Wave Velocity Profile (ft/s)
A. Hard rock	$>5,000$
B. Medium hard rock	$>3,000$ to $5,000$
BC. Soft rock	$>2,100$ to $3,000$
C. Very dense sand or hard clay	$>1,450$ to $2,100$
CD. Dense sand or very stiff clay	$>1,000$ to $1,450$
D. Medium dense sand or stiff clay	>700 to $1,000$
DE. Loose sand or medium stiff clay	>500 to 700
E. Very loose sand or soft clay	≥ 500
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.2.1

Note: For SI: 1 ft = 0.3048 m; 1 ft/s = 0.3048 m/s.

- Effective Peak Ground Acceleration
- ITL-92-11 - Seismic coefficient (kh)
 - ✓ Typically, $kh = \frac{1}{2}$ to $\frac{2}{3}$ PGA
 - ✓ Seismic coefficient equal to $\frac{2}{3}$ of the peak ground acceleration, where liquefiable soils are present.
 - ✓ $kh = \text{full PGA}$ if deflection is small or structure is anchored/braced.
- Design Earthquakes
 - ✓ Most Credible Earthquake (MCE-GM), Maximum Design Earthquake (MDE-GM), and Operating Basis Earthquake (OBE-GM)

Seismic site Classification and Peak ground acceleration estimate

- United States Geological Survey (USGS) HAZARD TOOL - 2025

USGS > Hazard > Dynamic Hazard Curves

Model *
NSHM Puerto Rico & U.S. Virgin Isla...

Latitude (°) *
18.4
[15, 21.2]

Longitude (°) *
-66.92
[-70.95, -61.7]

Select Site

Vs30 (m/s) *
760

Site Class Presets
BC (Vs30 760)

Plot Options

Return Period (yr) *
2475

Presets
2475 (2% in 50)

Source Type
Total

IMT

50 (40%)

100 (40%)

200 (40%)

225 (20%)

475 (10%)

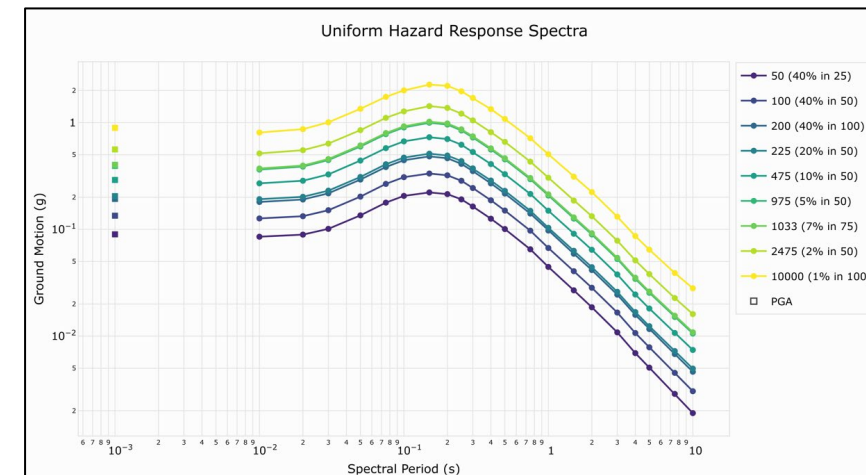
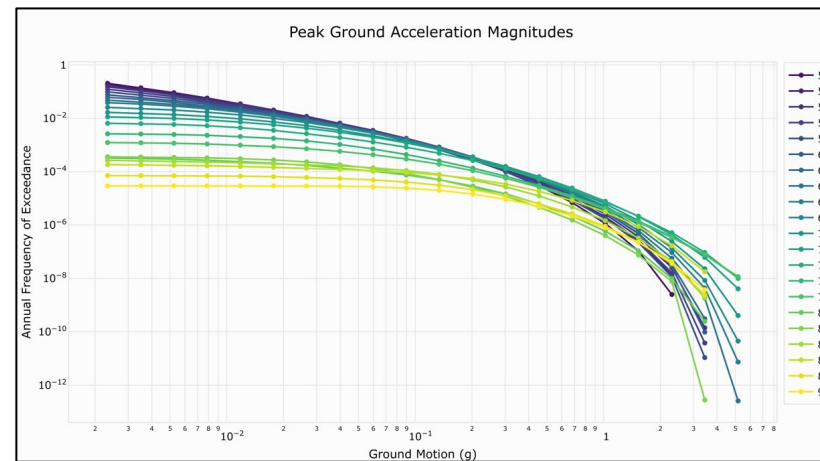
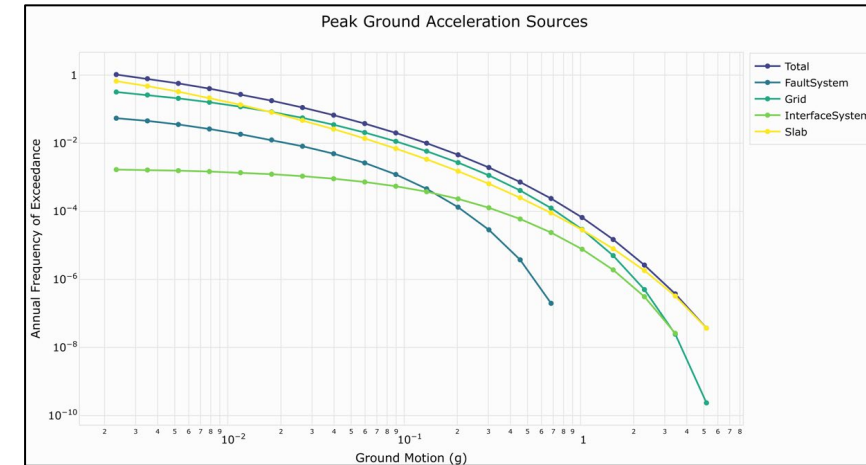
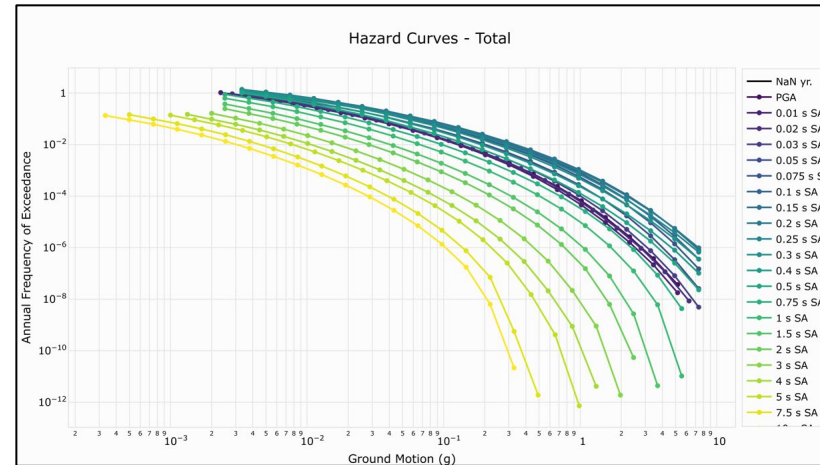
975 (5%)

1033 (7%)

2475 (2%)

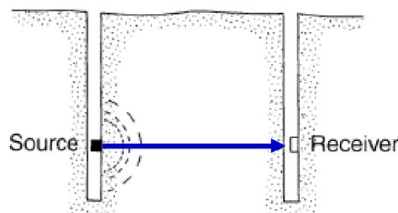
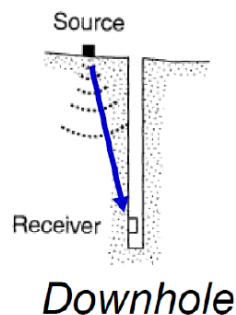
10000 (1%)

Plot Service Calls Reset

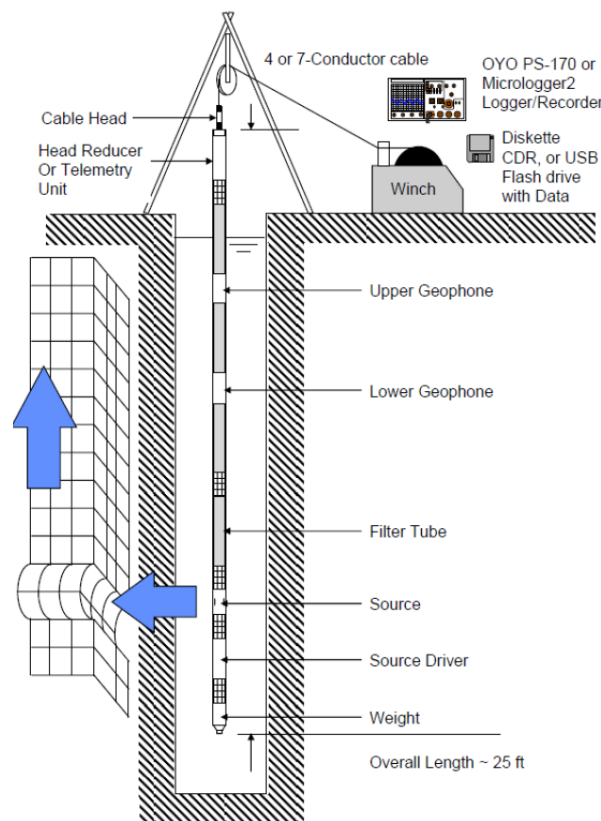


Geotechnical Seismic Explorations

- Following:
 - ✓ EM-1110-1-1804
 - ✓ ASTM D4428/4428M-14
- Geophysical Investigation Methods:
 - ✓ Downhole essay
 - ✓ Cross-hole essay
 - ✓ OYO-type P-S suspension logging

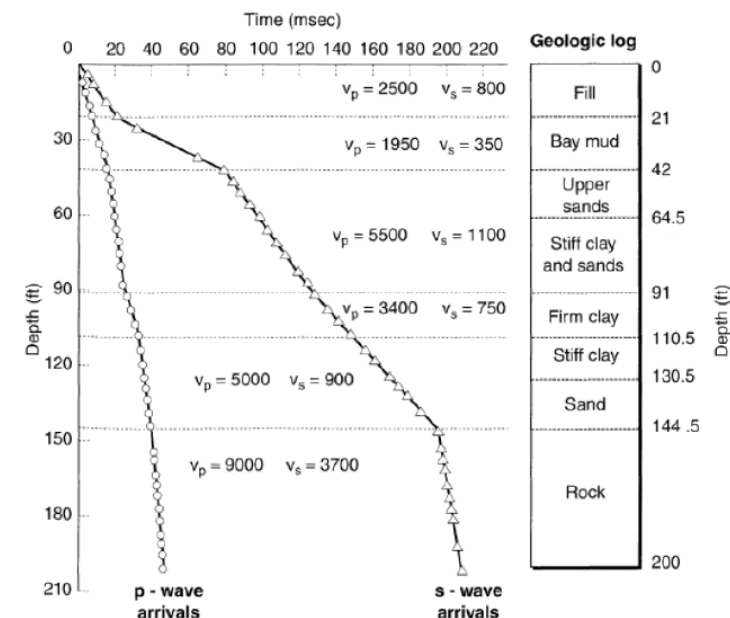


P-S suspension logging



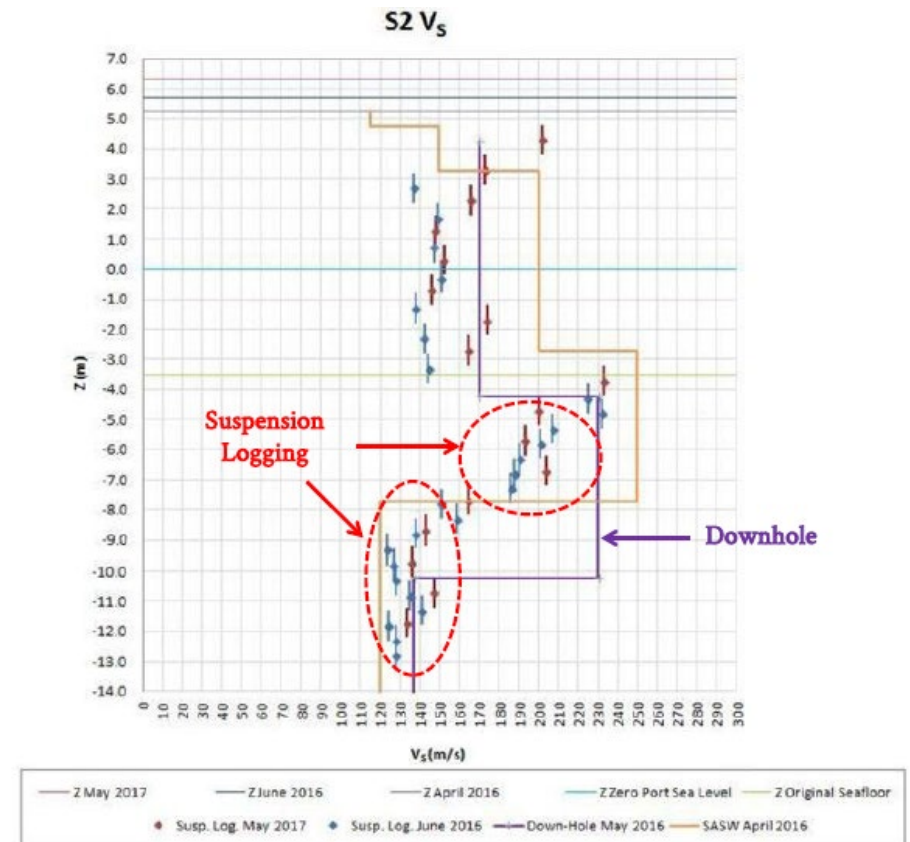
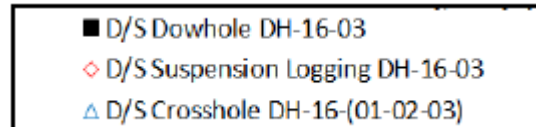
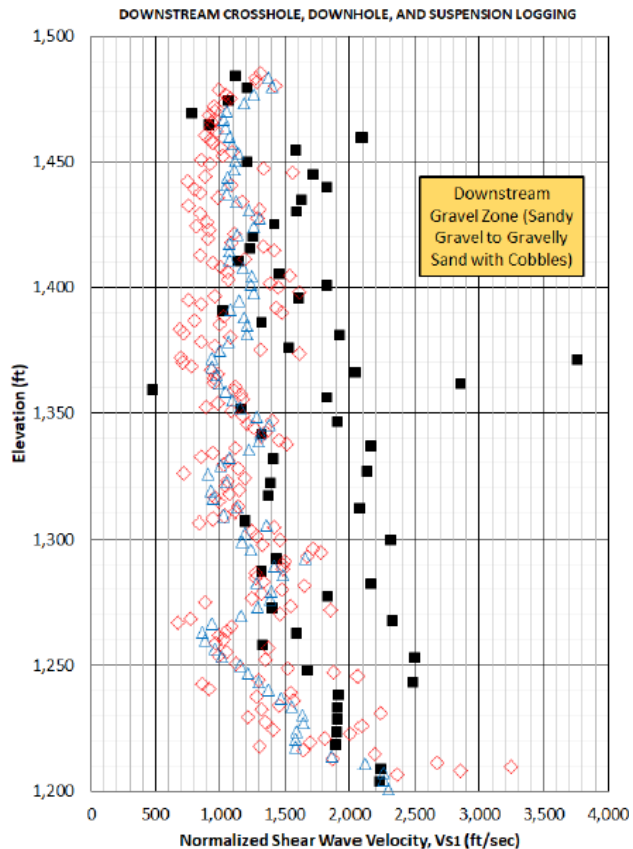
Measure S-Wave and P-Wave Velocities

$$V_S = \sqrt{\frac{G}{\rho}} \quad V_p = \sqrt{\frac{K + \frac{4}{3}G}{\rho}}$$

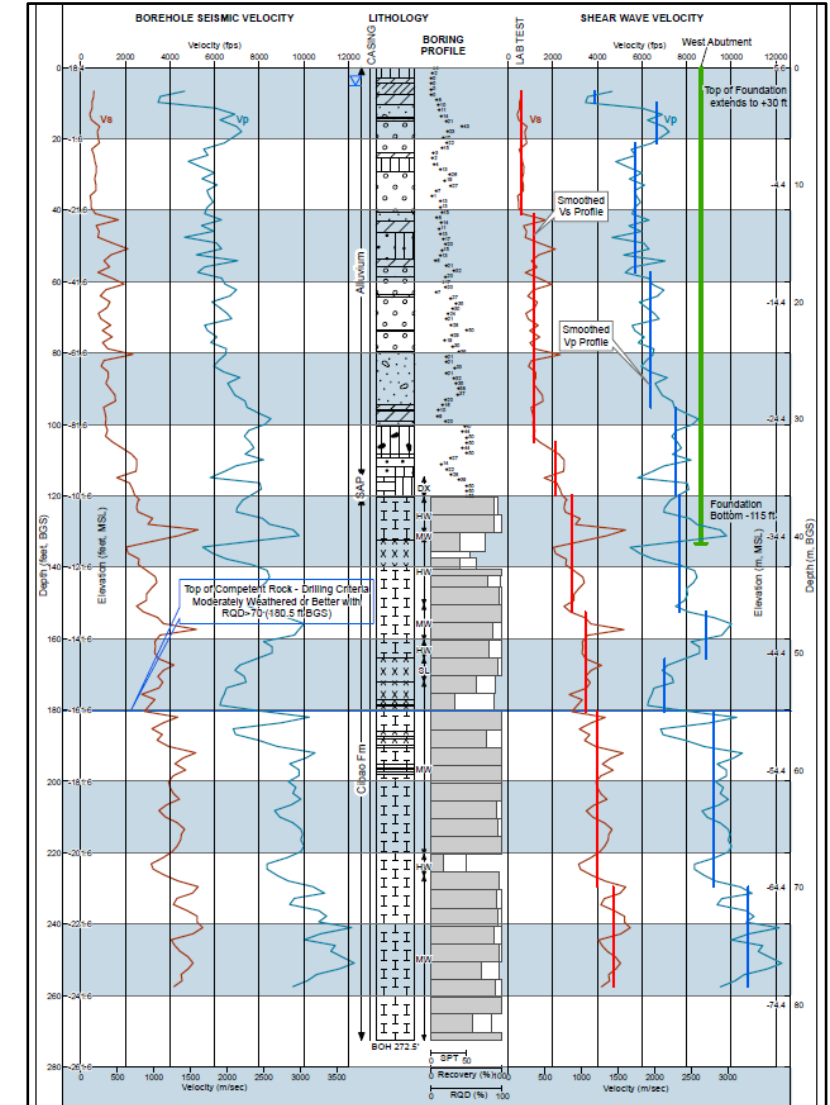
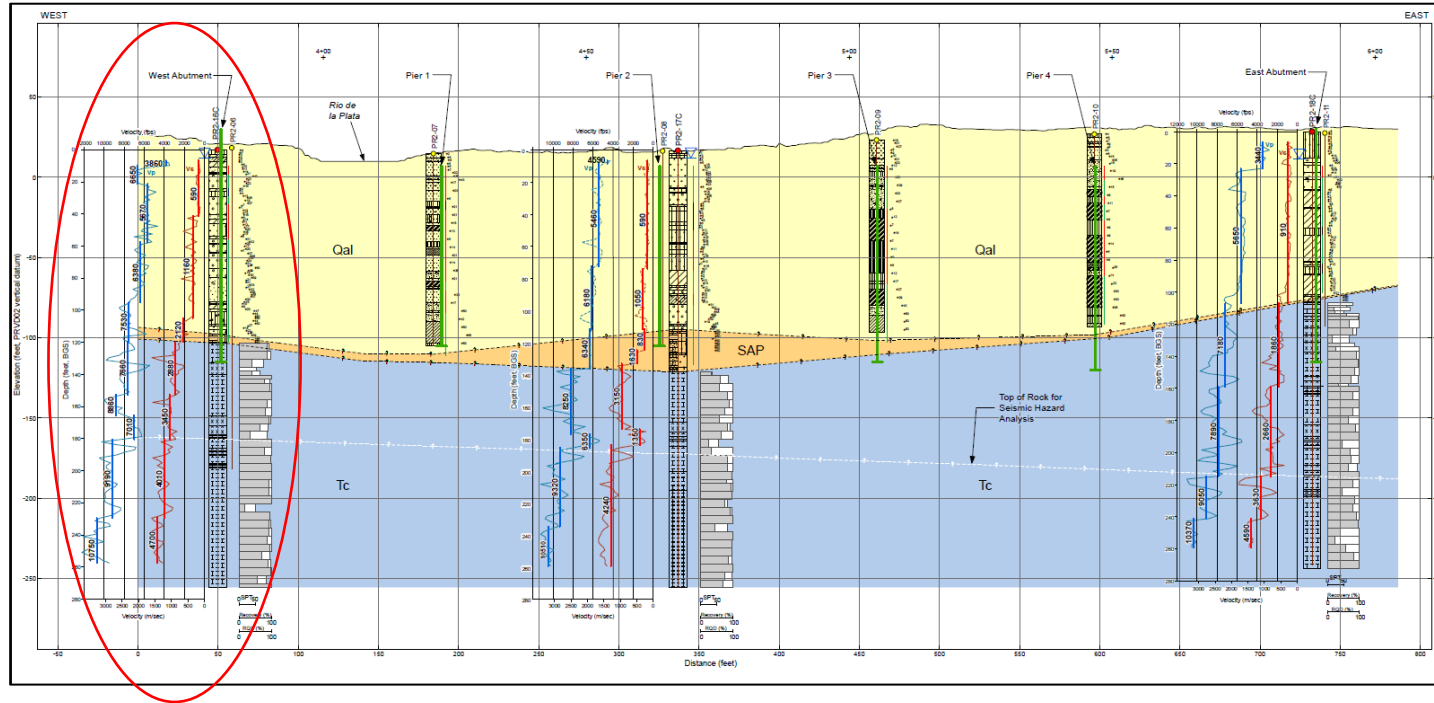


Geotechnical Seismic Explorations

- Following:
 - ✓ EM-1110-1-1804
 - ✓ ASTM D4428/4428M-14
- Comparison of Geophysical Investigation Methods:
 - ✓ Downhole essay
 - ✓ Cross-hole essay
 - ✓ OYO-type P-S suspension logging



Geotechnical Seismic Explorations

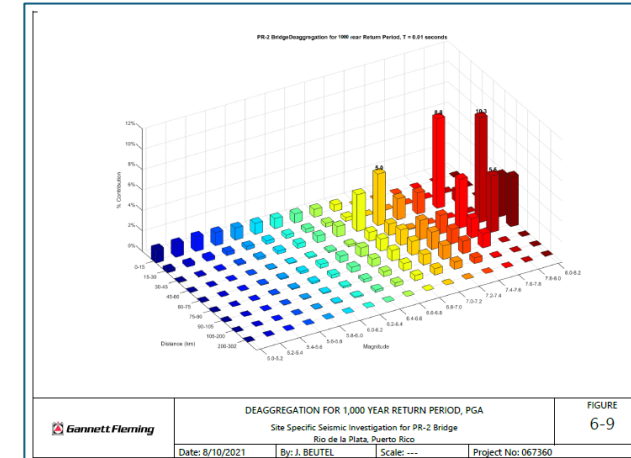
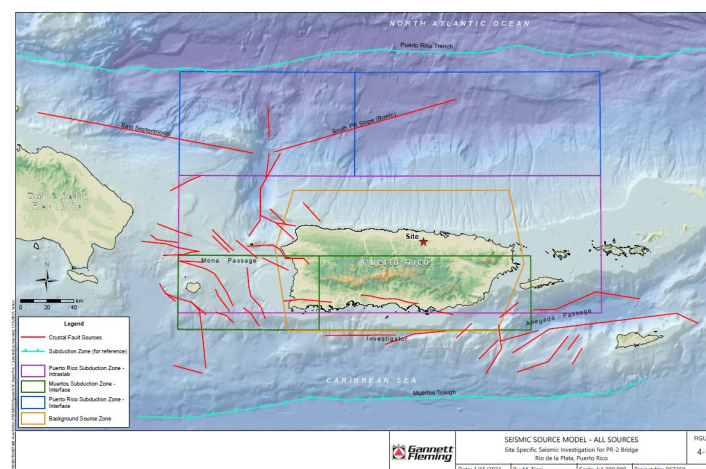
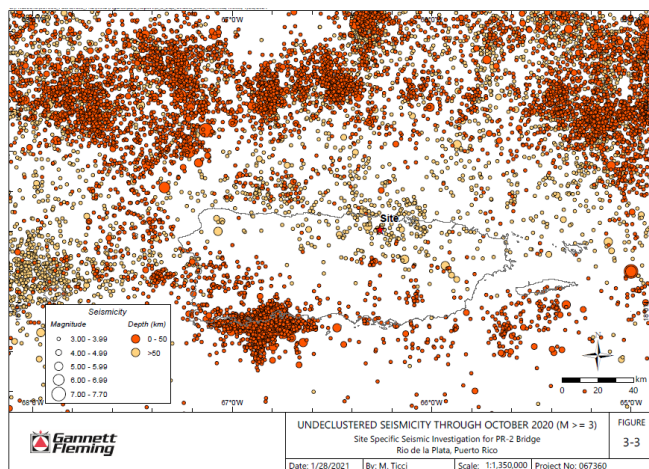


- Soil Profile Characterization
- Wave Velocity Propagation Profiles
- Identify top of bedrock and bedrock Vs30 condition.

Probabilistic Seismic Hazard Analysis (PSHA) AND Deterministic Seismic Hazard Analysis (DSHA)

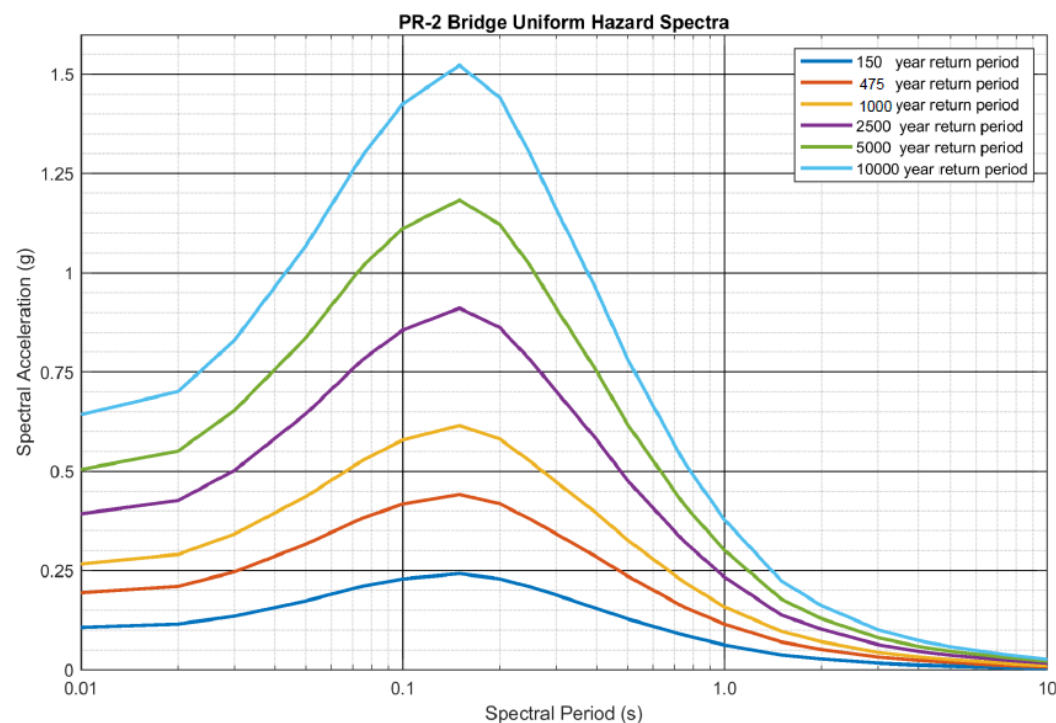
- Following:
 - ✓ ER-1110-2-1806
 - ✓ EC-1110-2-6000
 - ✓ AASHTO 2017
- Seismology Study
- Ground Motion Model (GMM)
 - ✓ Seismic source characterization
 - ✓ Historical seismicity ($M \geq 3$) of Puerto Rico
 - ✓ Historical seismicity catalog
 - ✓ Logic tree for subduction zones and crustal sources

Level	Method	Probability or Percentile
Most Credible Earthquake (MCE-GM)	DSHA	Median or 84 th percentile
Maximum Design Earthquake (MDE-GM)	PSHA and DSHA	2,475 year (2% probability of exceedance in 50 years) or Median and 84 th percentile
Operating Basis Earthquake (OBE-GM)	PSHA	475 year (10% probability of exceedance in 50 years)

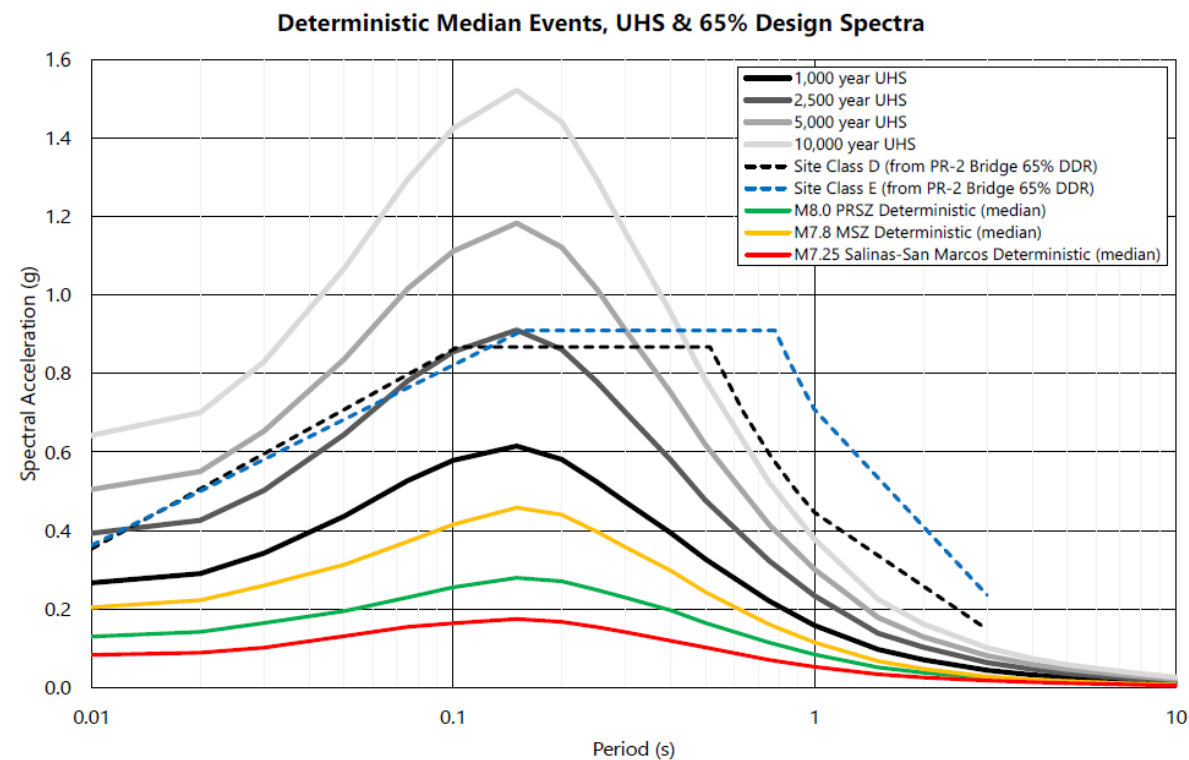


Probabilistic Seismic Hazard Analysis (PSHA) AND Deterministic Seismic Hazard Analysis (DSHA)

- Following:
 - ✓ ER-1110-2-1806
 - ✓ EC-1110-2-6000
 - ✓ Source characterization
 - ✓ Vs30
 - ✓ GMM



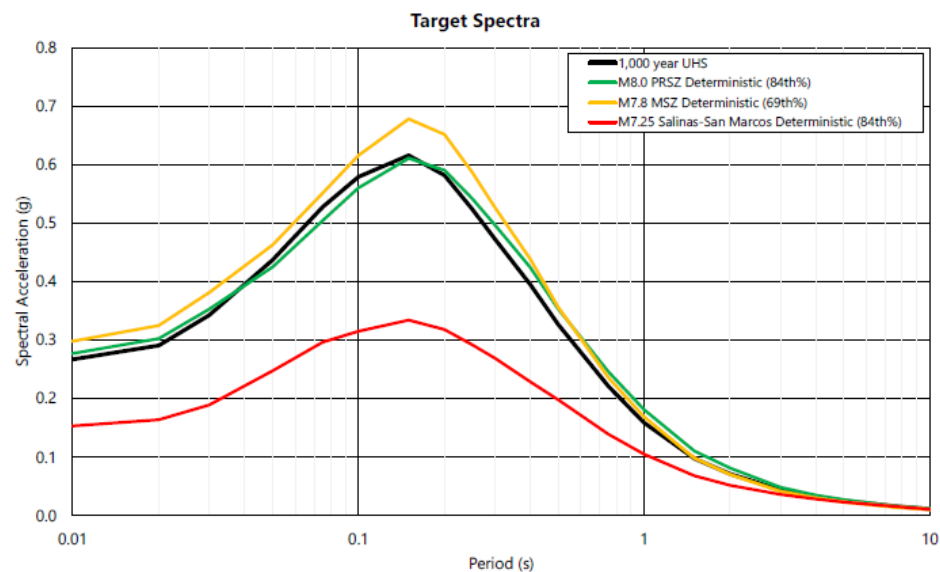
- Uniform Hazard Spectra



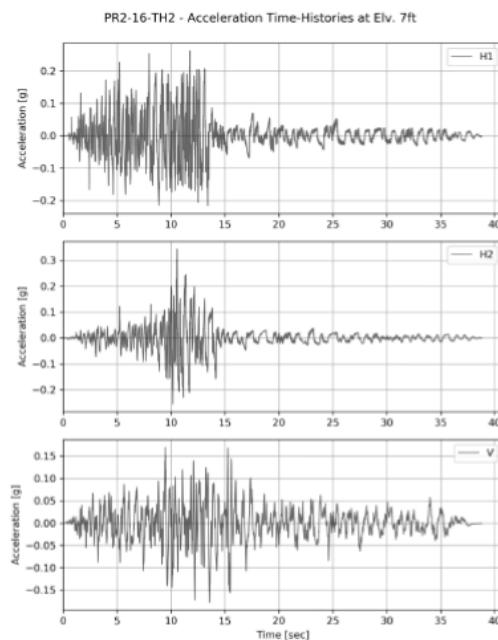
Probabilistic Seismic Hazard Analysis (PSHA) AND Deterministic Seismic Hazard Analysis (DSHA)

- Following:
 - ✓ ER-1110-2-1806
 - ✓ EC-1110-2-6000

Target Spectra

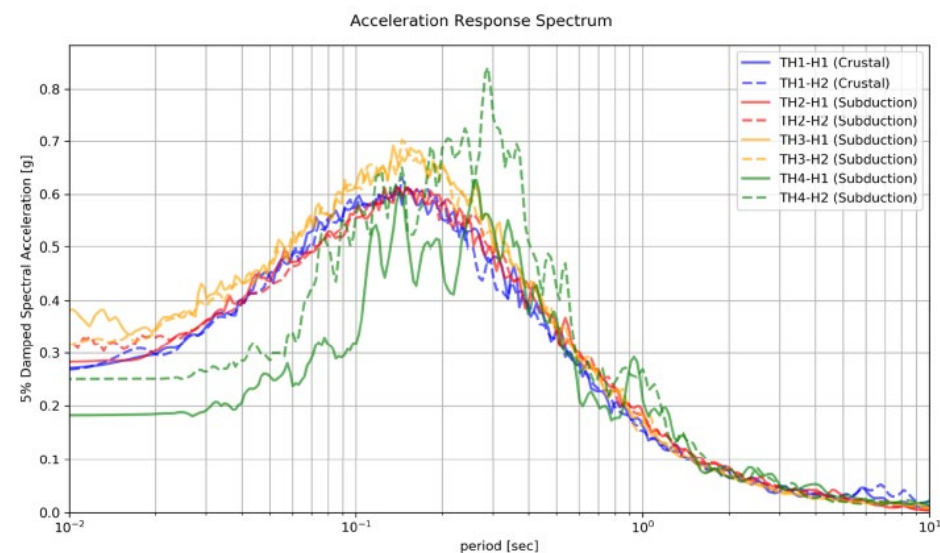


Historical Seismicity Catalog



Time History

Spectrally Matched



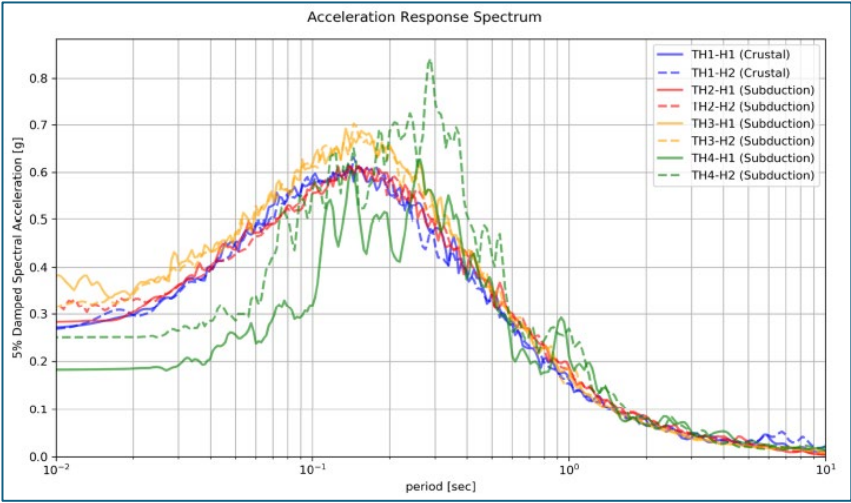
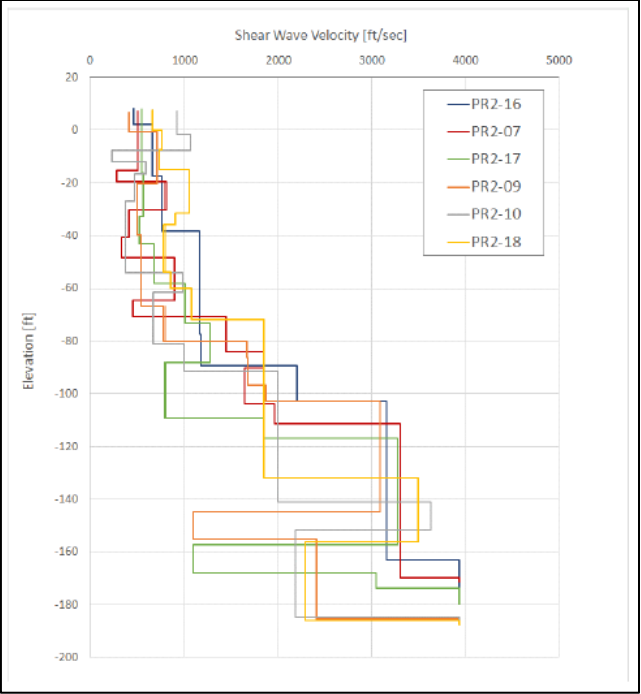
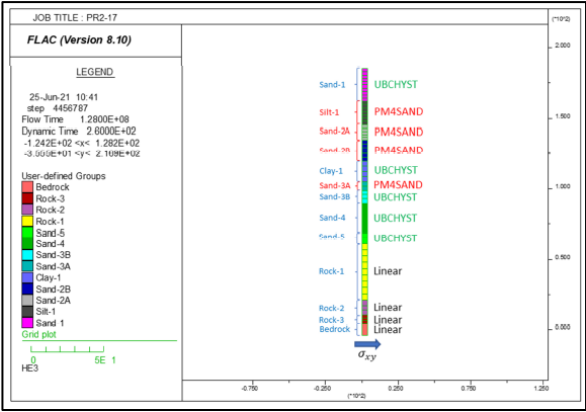
Bedrock Acceleration Response Spectra

Based on earthquake events that control seismic hazard

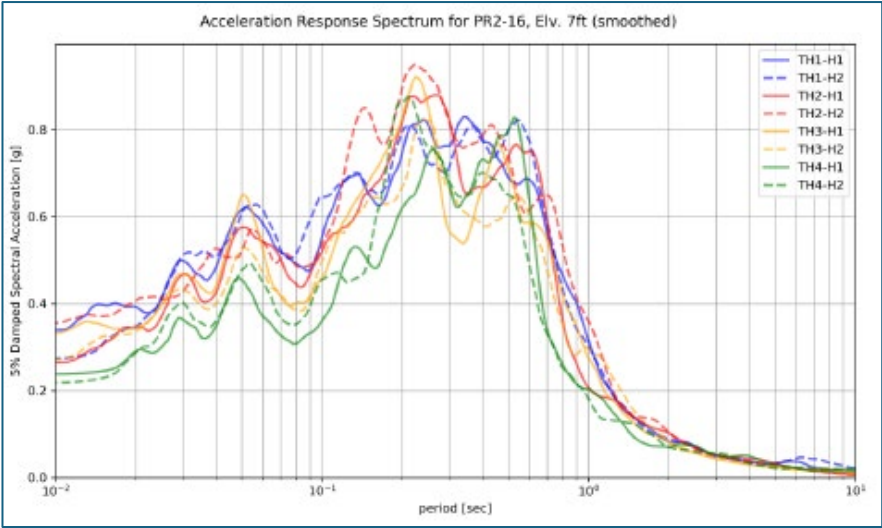


SITE RESPONSE

- Following:
 - ✓ EM-1110-2-6053
- DEEPSOIL
- FLAC Model



Bedrock Acceleration Response Spectra



Site Response Spectrum

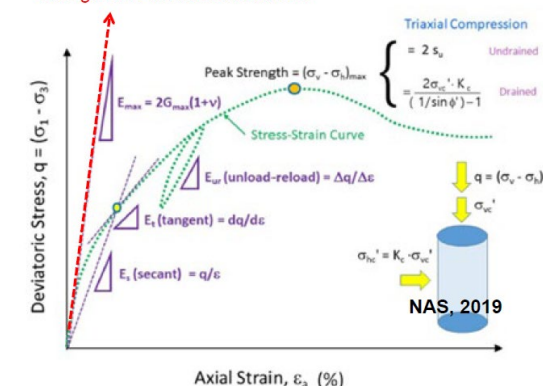
SOIL PARAMETERS

- Common Practice use of Correlations Based on N values (EM-1110-1-1905).
- Laboratory Test to Determine:
 - ✓ Soil classification
 - ✓ Strength parameters based on undisturbed samples
 - ✓ Settlement parameters based on consolidation tests
 - ✓ Stiffness parameters based on undisturbed samples and geophysical tests

$$s = c + \sigma \tan \phi$$

Design Condition	Shear strength state – Pore pressure	Obtained from Triaxial test
During Construction and End-of-Construction (Q-Case)	Undrained strength	Unconsolidated-Undrained (UU,Q) test
Long-term (S-Case)	Effective stress shear strength	Consolidated-drained (CD,S) test Consolidated-Undrained (CU,R) test
Rapid Drawdown (R-Case)	Undrained and Effective stress	Consolidated-Undrained (CU,R) test
Seismic (0.8R-Case) Post-Earthquake	Residual strength (Due to Seismic event soil shear strength is represented by undrained and drained conditions)	Consolidated-Undrained (CU,R) test

We get initial stiffness, G_{max} from V_s (if measured correctly). In-situ tests (BPT, SPT, etc.) and lab tests provide complete strength and stiffness behaviors.



From geophysical testing, we get initial G_{max} ($= \rho V_s^2$)

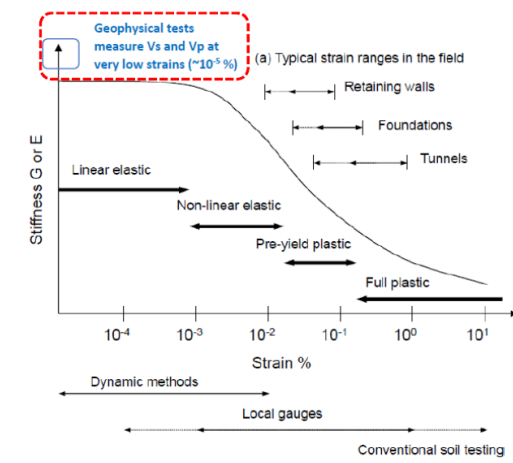
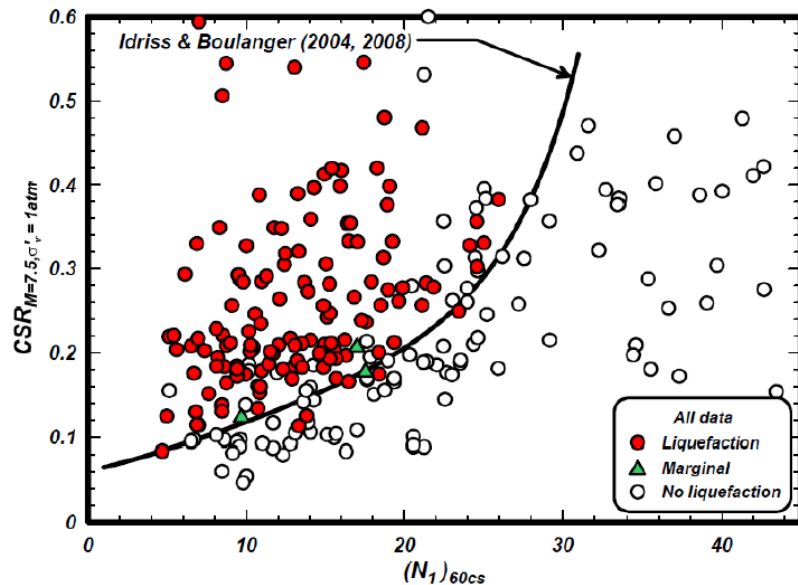


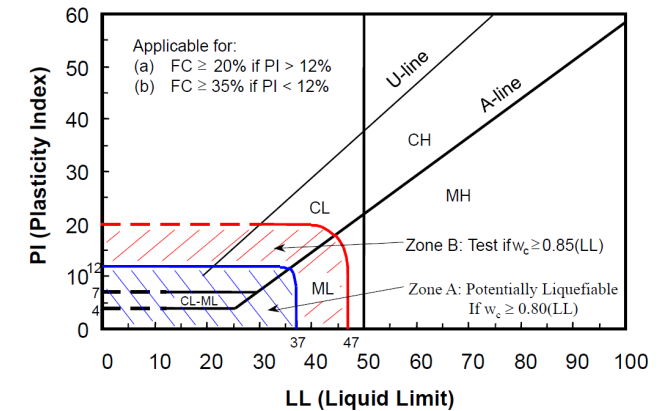
Figure 3. Stiffness vs. Strain based on different types of testing, soil behaviors, and types of applications [modified from Soga (2017) and Atkinson (2000)]

LIQUEFACTION SCREENING AND CYCLIC SOFTENING IN CLAYS AND PLASTIC SILTS ASSESSMENT

- Following:
 - ✓ ETL-1110-2-580
- Liquefaction Workshop, Youd, Idriss, et al. (2001)
 - ✓ Cyclic Stress Ratio, N corrected values, Cyclic Resistance Ratio
 - ✓ Sand Behavior



- Non-Liquefiable $FS \geq 1.4$
- Marginally Liquefiable $1 < FS < 1.4$



- Cyclic Softening - Idriss and Boulanger, 2007
 - ✓ Sand-Like Behavior or Clay-Like Behavior

Boulanger and Idriss (2007)

$$CRR_{M7.5, \alpha=0} = C_{2D} \left(\frac{\tau_{cyc}}{S_{u,ref}} \right)_{N=30} \frac{S_{u,ref}}{\sigma'_c}$$

C_{2D} is a correction for two-dimensional versus one dimensional cyclic loading [~ 0.96 by Boulanger and Idriss (2004)]

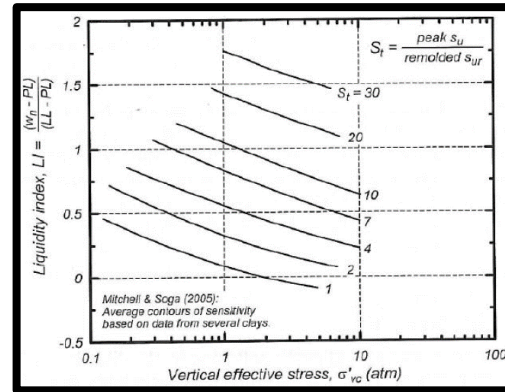
$\left(\frac{\tau_{cyc}}{S_{u,ref}} \right)_{N=30}$ is the ratio of cyclic stress to S_u for the number of equivalent uniform cycles representative of an $M_w=7.5$ earthquake

$\frac{S_{u,ref}}{\sigma'_c}$ SHANSEP stress normalized strength ratio

LIQUEFACTION SCREENING AND CYCLIC SOFTENING IN CLAYS AND PLASTIC SILTS ASSESSMENT

Sensitivity Estimated from

- ✓ S_t as a function of LI and Vertical Effective Stress (Mitchell and Soga, 2005)
- ✓ Vane Shear Tests
- ✓ CPT Tests



Designation: D2573/D2573M - 18

Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils¹

9.3 Sensitivity, S_T —Calculate the sensitivity of the soil as follows:

$$S_{TP} = (s_u)_p / (s_u)_r \quad (3)$$

where:

S_{TP} = sensitivity (dimensionless),
 $(s_u)_p$ = peak undrained shear strength, kPa [lbf/ft²], and
 $(s_u)_r$ = remolded undrained shear strength, kPa [lbf/ft²].

Table 7-14, Sensitivity of Cohesive Soils (Modified from Spangler and Handy (1982))

Sensitivity	Descriptive Term
< 1	Insensitive
1 - 2	Slightly Sensitive
3 - 4	Medium Sensitive
5 - 8	Sensitive
9 - 16	Very Sensitive
17 - 32	Slightly Quick
33 - 64	Medium Quick
>64	Quick

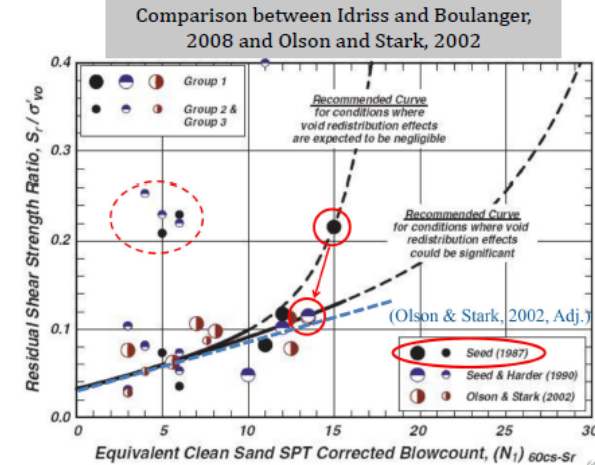
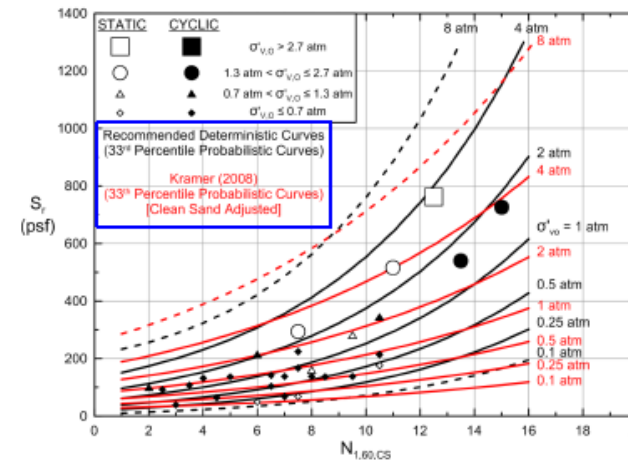
- Soil Parameter Adjustments due to Liquefaction and/or Cyclic Softening
 - ✓ 20% strength reduction for non-liquefiable soils (clay soils)

SCDOT Geotechnical Design Manual 2022

Table 7-15, Residual Shear Strength Loss Factor (λ_r)

Soil Type		Residual Shear Strength Loss Factor (λ_r)
USCS	Description	
Low Plasticity Clay	CL-ML	0.57
Medium to High Plasticity Clay	CL & CH	0.50

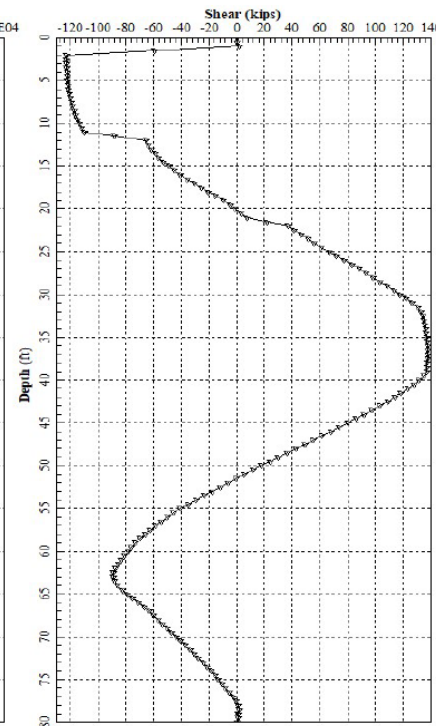
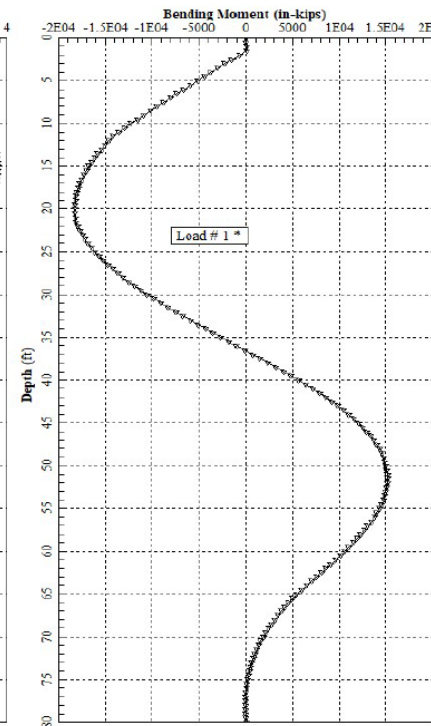
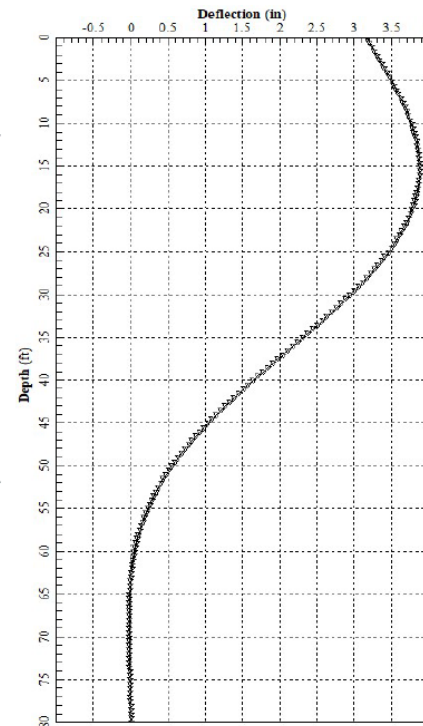
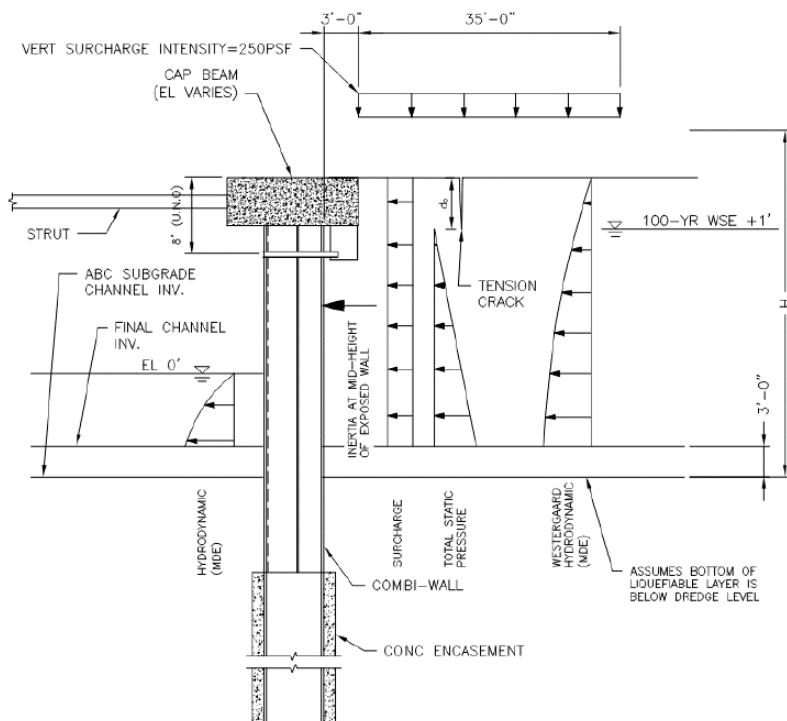
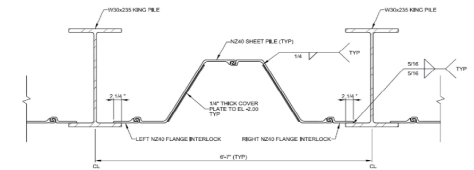
Liquefiable Soils





LINEAR AND NON-LINEAR MODEL

- Model Pressure Distribution using CWALSHT, or PYWall Software
 - ✓ Include seismic load as a horizontal pressure/force (Pseudo static Modeling)
 - ✓ P and Y multipliers must be included to account for the effect of pile spacing (group effect). Generally, P-multiplier is 0.5 for tangent piles and Y-multiplier is 4 under seismic loading (large deformations).
 - ✓ P and Y multipliers vary with soil type and loading condition (NCHRP 611/AASHTO)
 - ✓ More advanced modeling: PLAXIS and FLAC software.





Global stability Analysis

- GeoStudio Slope/W

- POINT LOAD 1 (EL. 11.9): 21,605 LBF (STRUT FORCE)
- POINT LOAD 2 (EL. -1.4): 360 LBF (PILE INERTIAL LOAD)
- POINT LOAD 3 (EL. 12): 1,120 LB (WALER/CAP BEAM LOAD)
- POINT LOAD 4 (EL. 11.9): 80 LBF (STRUT INERTIAL LOAD)
- PHREATIC SURFACE NOT APPLIED TO SUBSURFACE MATERIALS

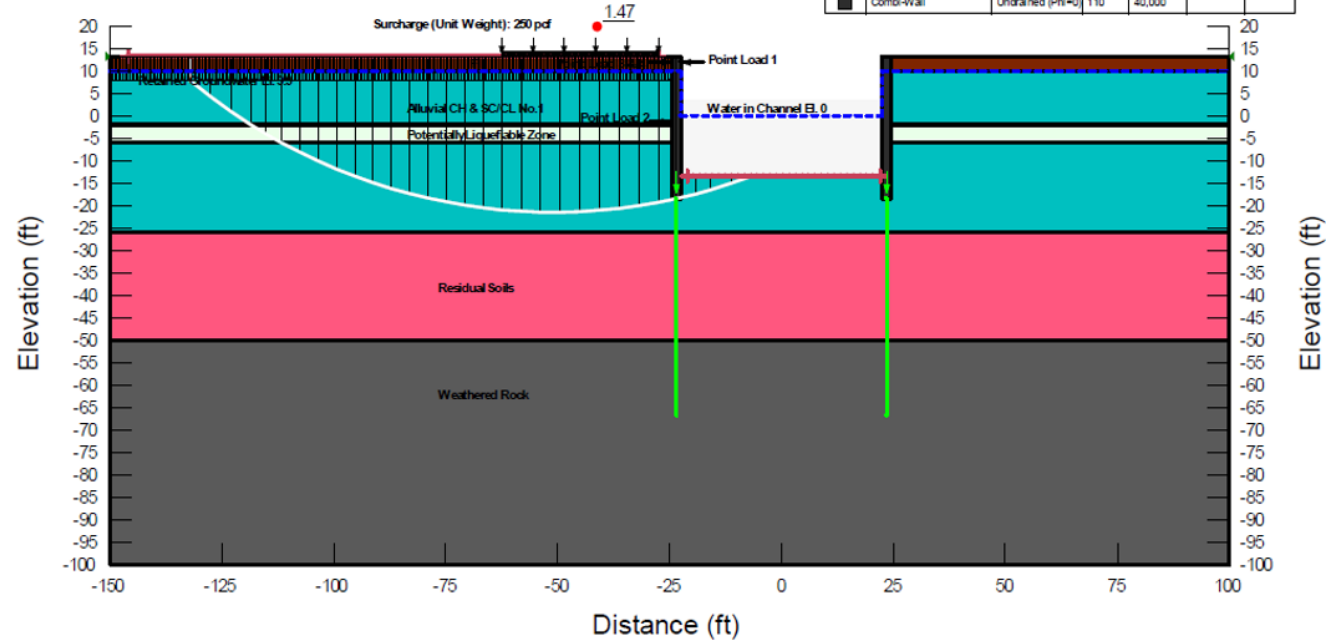
RIO PUERTO NUEVO CONTRACT 5B (RPN5B)
RESULTS OF SLOPE STABILITY ANALYSIS
CROSS SECTION AT DESIGN SECTION 1 – TYPICAL DOWNSTREAM
LT6 – NON-OPTIMIZED ENTRY EXIT

Color	Name	Type	Shear Force (lbf)	Apply Shear	Out-of-Plane Spacing (ft)
■	King Pile	Pile	520,000	Perp. to Reinf.	8.6

Rio Puerto Nuevo Contract 5B (RPN 5B)
Design Section 1 - Typical Downstream
LT6-Long-Term Static MDE 0.8R-Case
Horz Seismic Coef.: 0.23

Top of Grade El. 13.2
Pile Tip El. -66.8
Channel Bottom El. -13.5

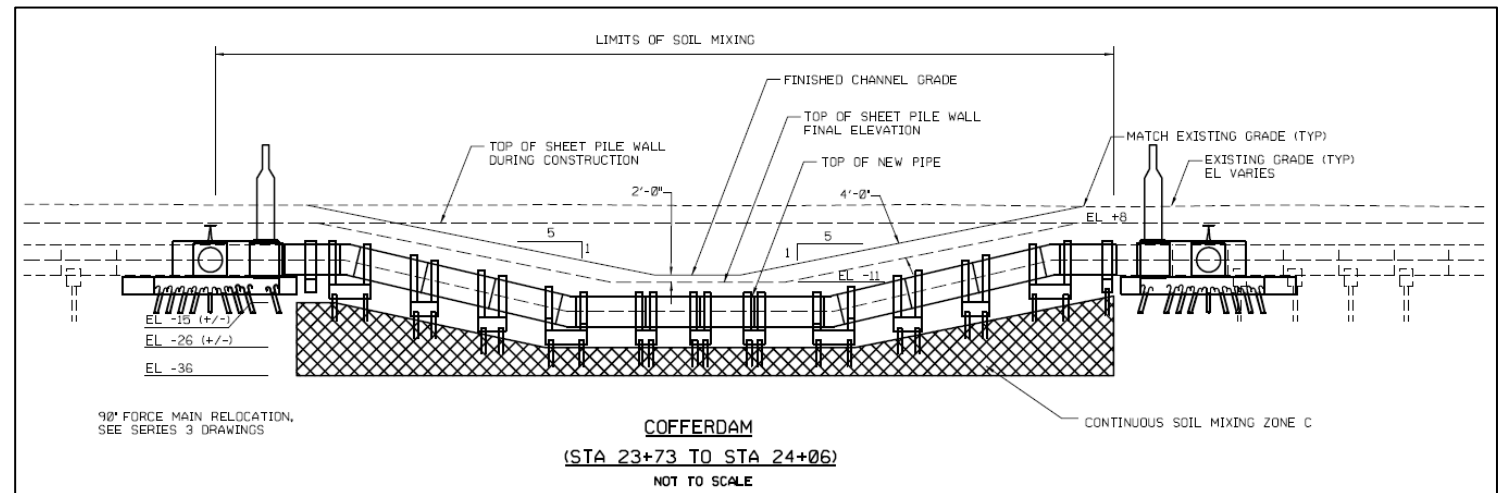
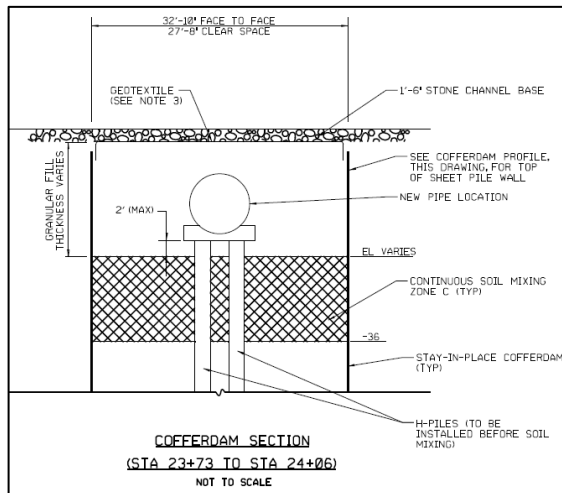
Color	Name	Slope stability Material Model	Unit Weight (pcf)	Total Cohesion (pcf)	Total Friction Angle (°)
■	1 - Fill - 0.8R-Case	Mohr-Coulomb	110	380	12
■	2 - Alluvial CH & SCCL No. 1 - 0.8R-Case	Mohr-Coulomb	110	220	12
□	2.1 - Potentially Liquefiable Zone	Mohr-Coulomb	114	220	0
■	3 - Residual Soils - R-Case	Mohr-Coulomb	134	2,000	21
■	4 - Weathered Rock - R-Case	Mohr-Coulomb	143	4,000	22
■	Comb-Wall	Undrained (Phi=0)	110	40,000	



SOIL REMEDIATION

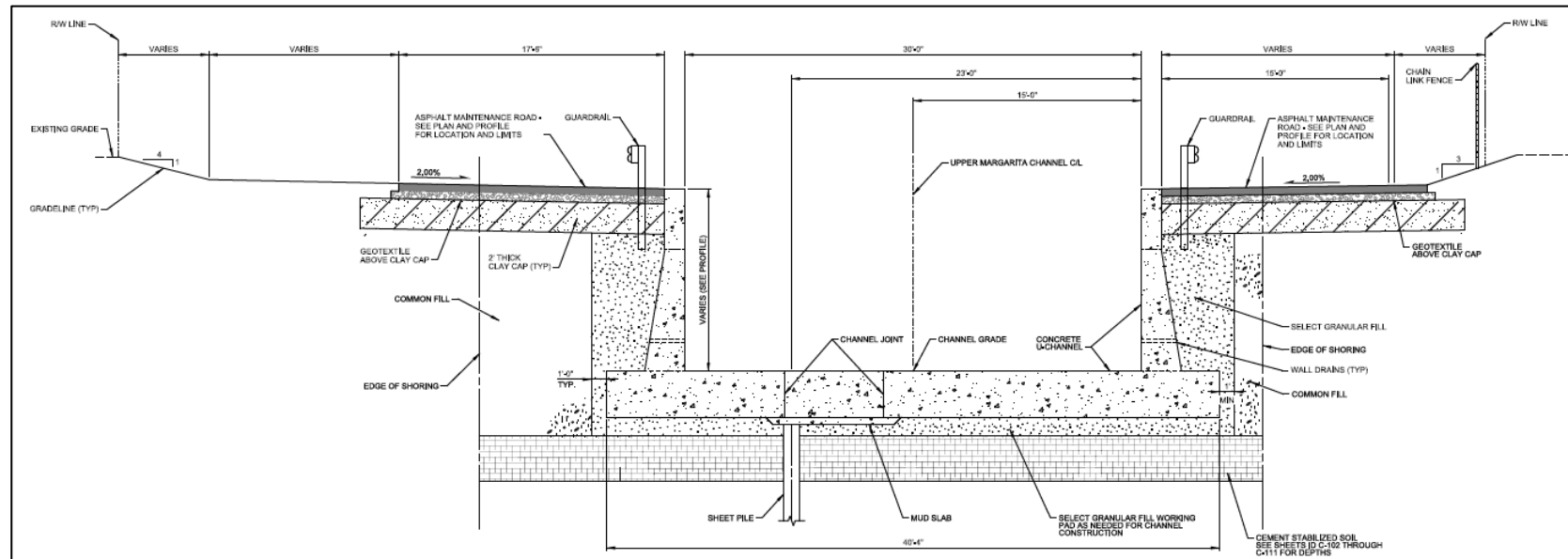
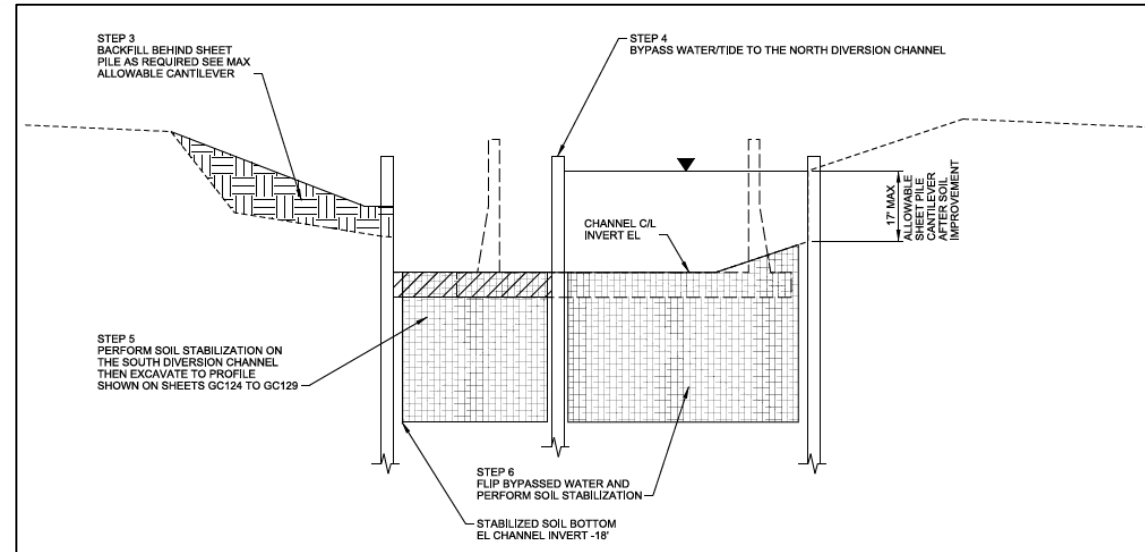
- Following:
 - ✓ FHWA Standards
 - ✓ USACE EM's
- Deep Soil Mixing

Bechara Industrial Area Sewer 90-in Line Relocation



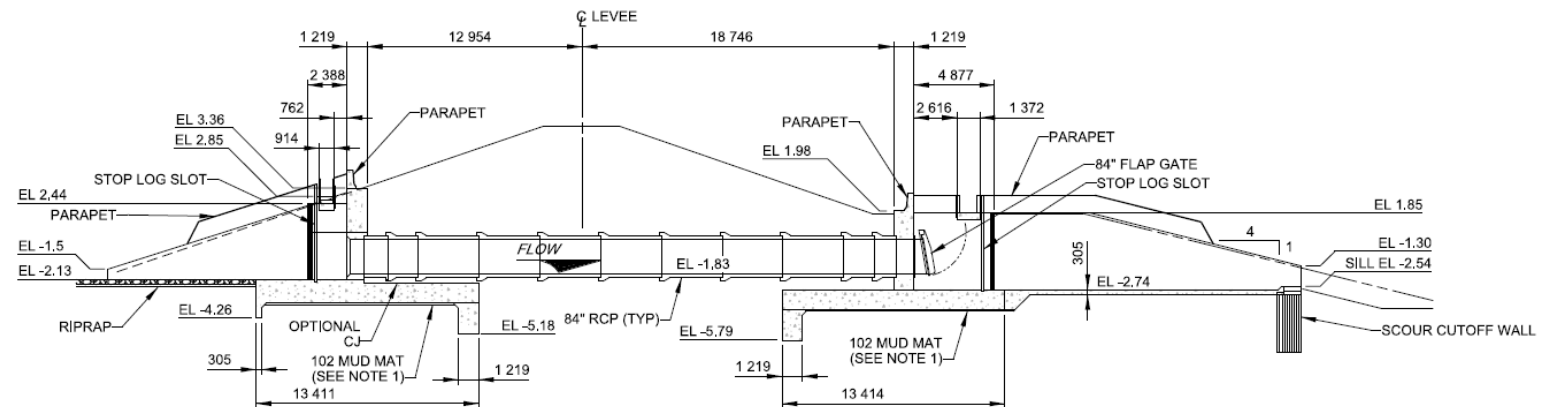
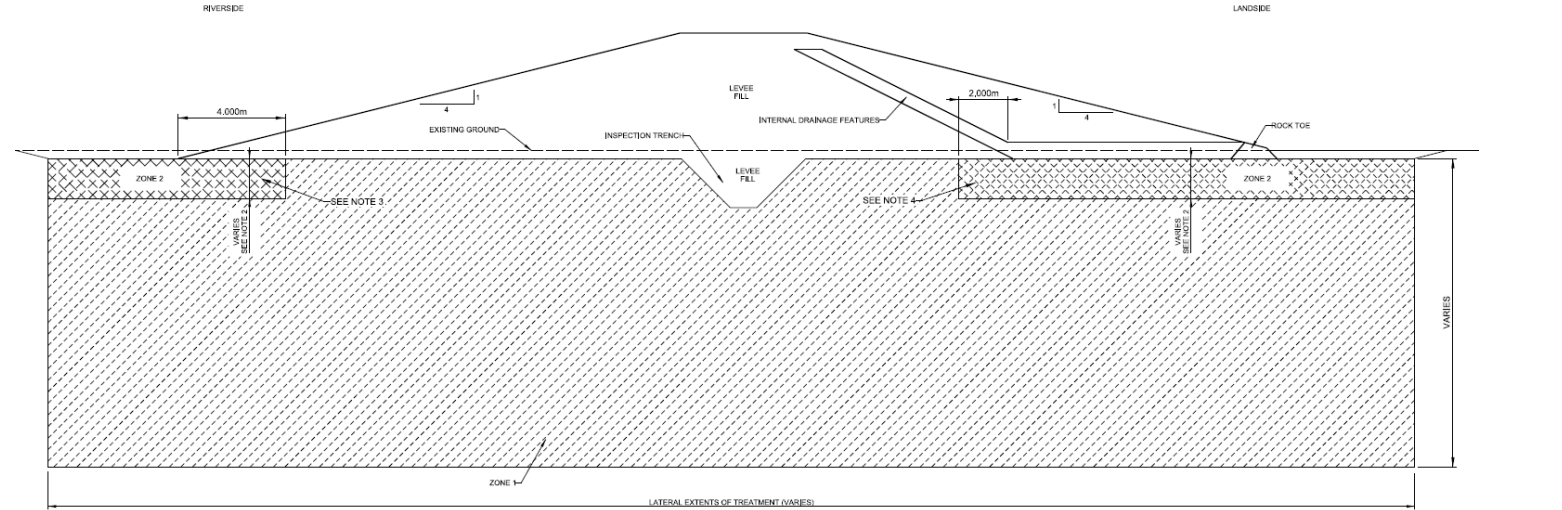
SOIL REMEDIATION

- Following:
 - ✓ FHWA Standards
 - ✓ USACE EM's
- Deep Soil Mixing



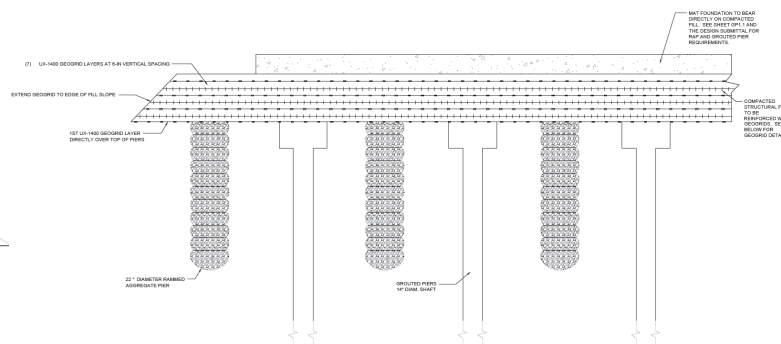
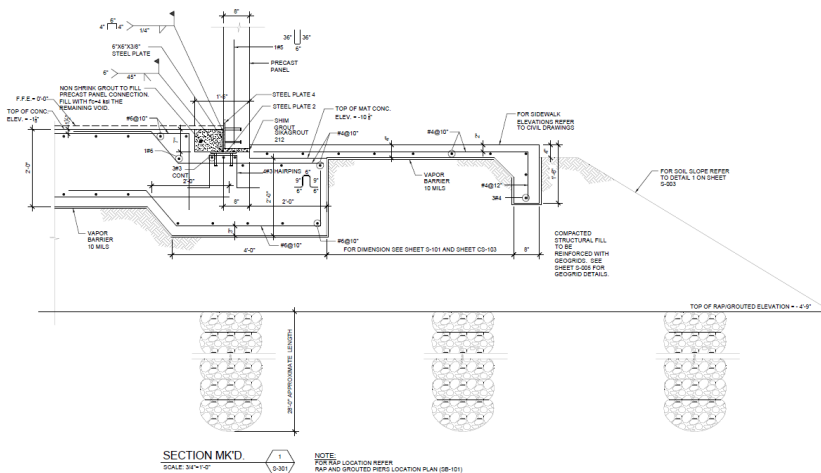
SOIL REMEDIATION

- Following:
 - ✓ FHWA Standards
 - ✓ USACE EM's
- Aggregate Columns
 - ✓ Rio de la Plata



SOIL REMEDIATION

- Following:
 - ✓ FHWA Standards
 - ✓ USACE EM's
- Aggregate Columns
- Auger Cast piles
- Structural Fill with Geogrids
- ✓ FDA Building



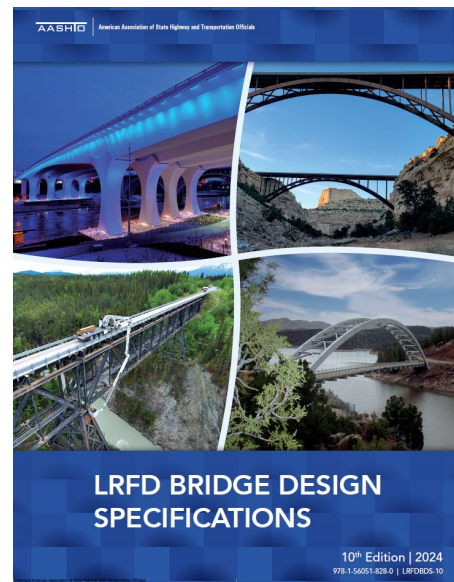
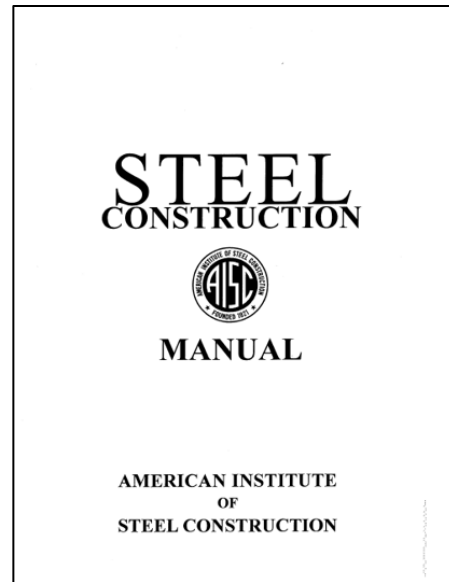
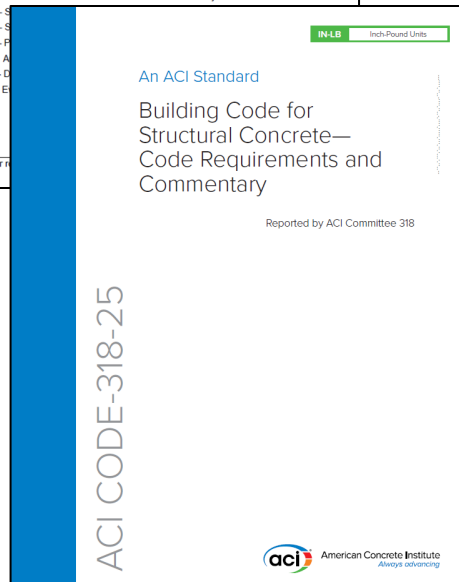
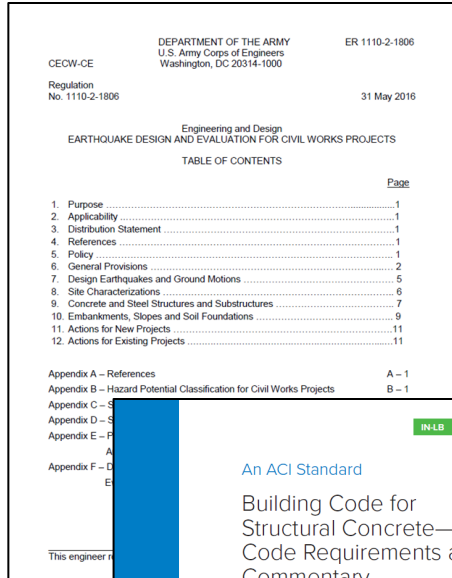
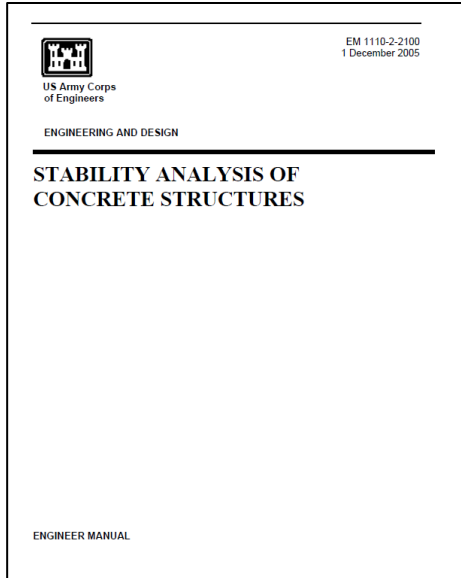
Structures



- **Design Considerations**

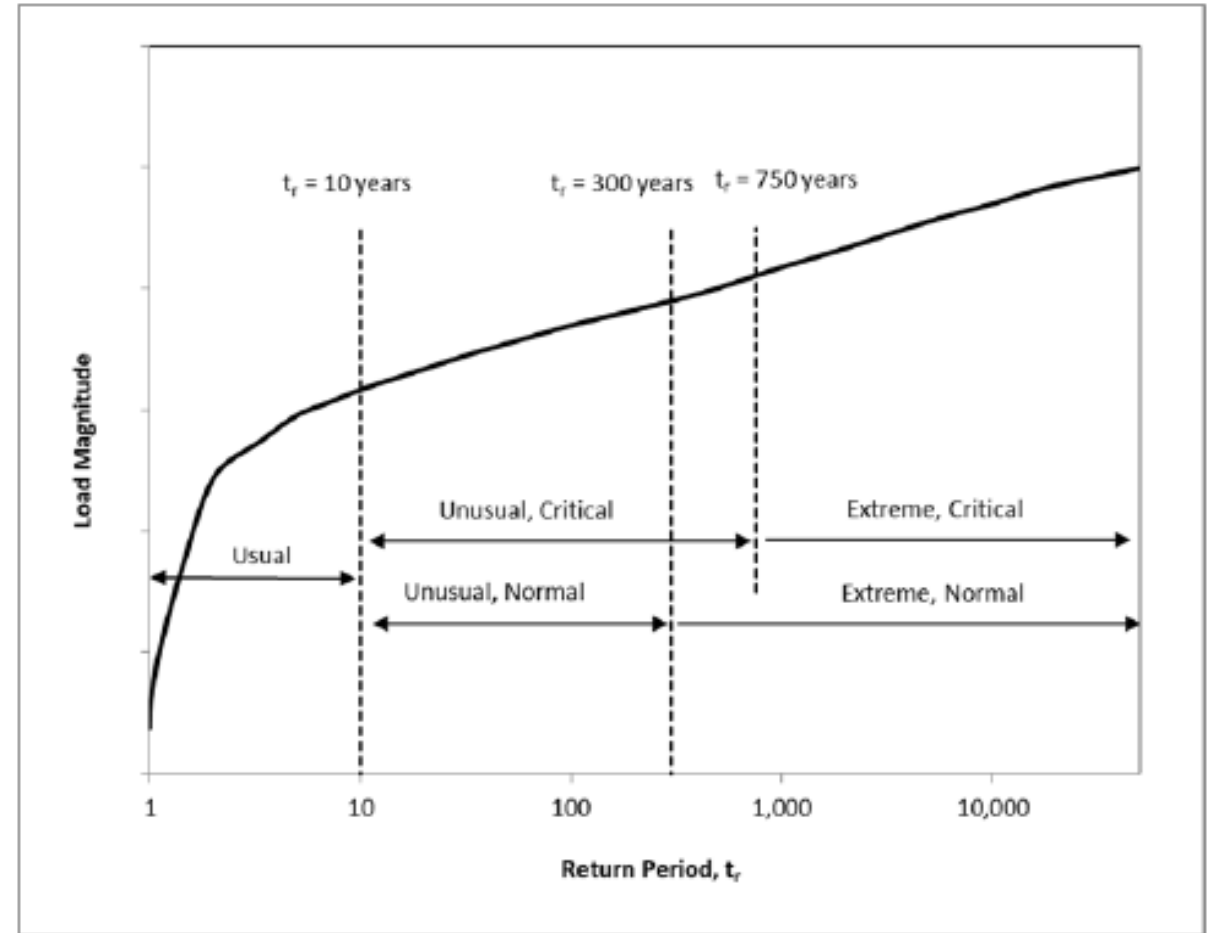
- ✓ Design Standards
- ✓ Design Limit States
- ✓ Service Life
- ✓ Load Conditions
 - ✓ Earthquake Loads
- ✓ Design Requirements
- ✓ Structural Systems

- Design Standards: Structural design must be in compliance with Engineering Manuals, Regulations and Design Codes.



Design considerations

- Serviceability Limit State
 - ✓ Usual ($t_r < 10$ years)
 - ✓ Unusual loads ($t_r < 300, 750$ years)
 - ✓ Limit cracking and provide durability
- Strength Limit State
 - ✓ Extreme loads ($t_r > 300, 750$ years)
 - ✓ Lower load factors
- Stability
 - ✓ Service loads (load factor = 1)
 - ✓ Sliding
 - ✓ Rotation
 - ✓ Bearing
 - ✓ Flotation
 - ✓ Global Stability



EM 1110-2-2104



Service Life

- Environmental Exposure
 - ✓ Traffic movement
 - ✓ Water, salt and other corrosive materials
 - ✓ Extreme temperatures
- Materials Quality
 - ✓ Construction specifications
 - ✓ ASTM standards
- Design and Construction
 - ✓ Concrete – limit cracking
 - ✓ Steel – Corrosion protection
- Operational
 - ✓ Operation of the structure following design considerations
 - ✓ Routine inspections and maintenance

Correct Concrete Curing – limit cracking



FIGURE 7.27 Curing concrete by wet covering. (Courtesy of FHWA)

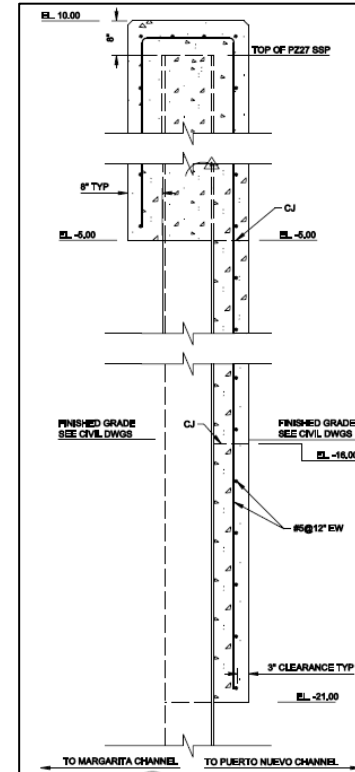


FIGURE 7.28 Curing concrete with impervious fabrics.

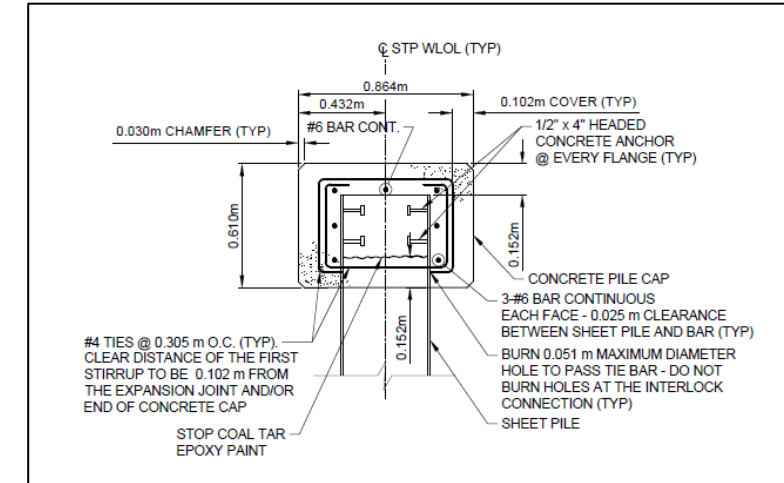
Reference: Materials for Civil and Construction Engineers,
4th Edition, by Michael S. Mamlouk and John P. Zaniwski

Steel Corrosion Protection

- Concrete Facing
- Coating



Margarita Channel

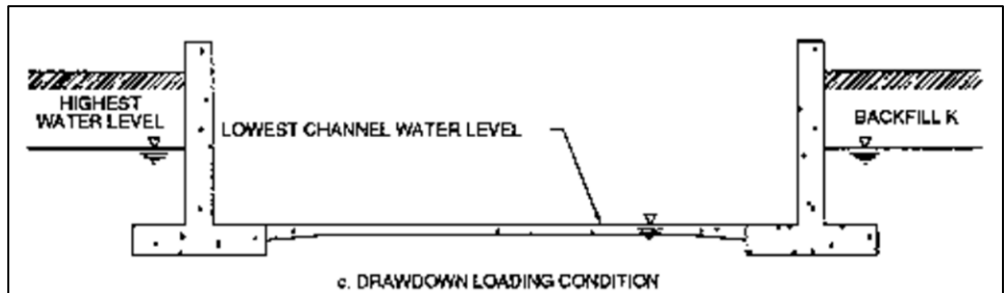
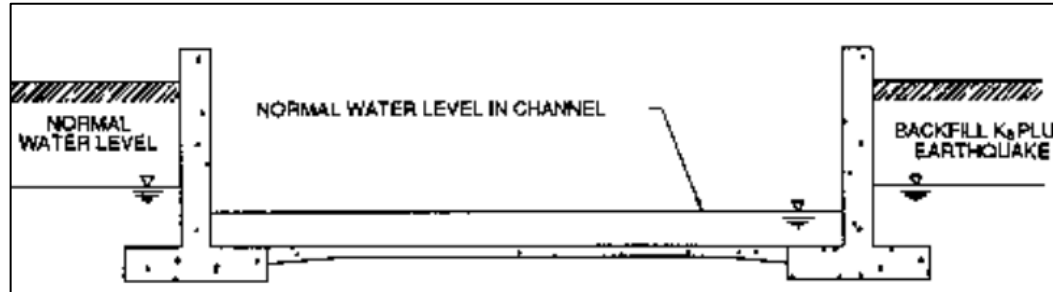
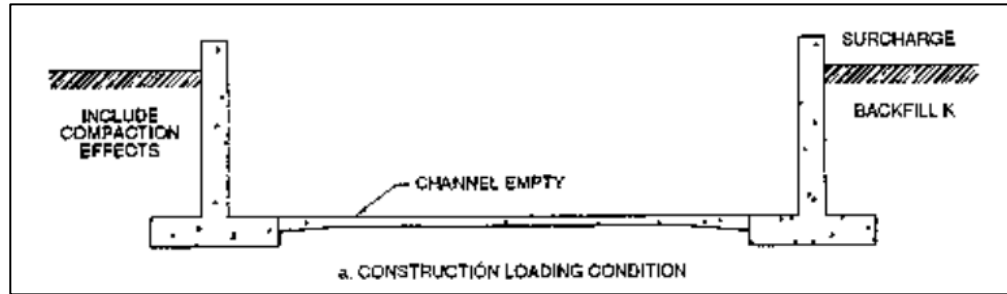


Cano Martin Pena

- Sacrificial Thickness

Load Conditions

- Construction (Unusual)
 - ✓ Temporary loading
 - ✓ Construction equipment, Temporary excavation
- Post-Construction (Usual)
 - ✓ Long term condition
- Drawdown (Usual - Unusual)
 - ✓ Post-flood condition with saturated soils
 - ✓ Water in channel to drawdown condition



Load Conditions

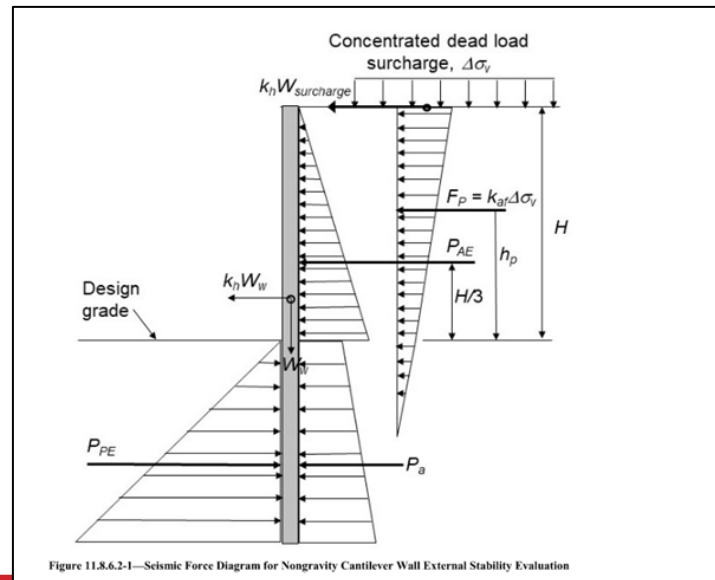
Maintenance (Unusual)

- ✓ Maintenance equipment, dewatering



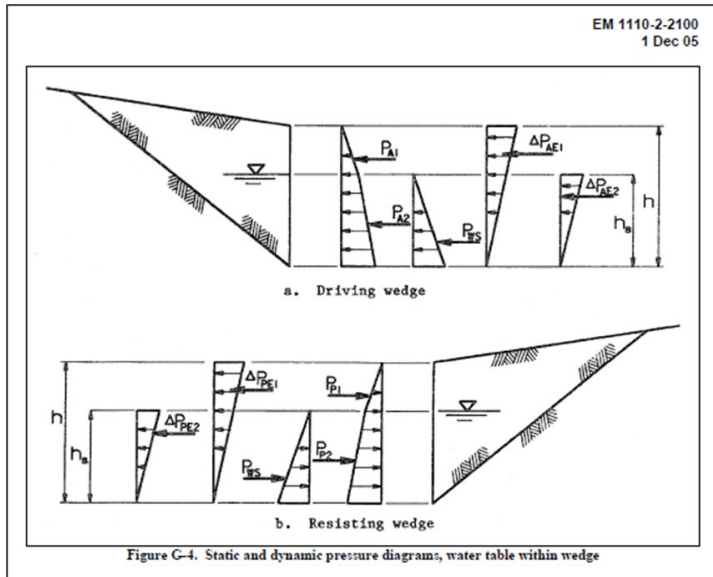
• Earthquake (Unusual - Extreme)

- ✓ Operational Basis Earthquake (OBE)
- ✓ Maximum Design Earthquake (MDE)
- ✓ Maximum Credible Earthquake (MCE)

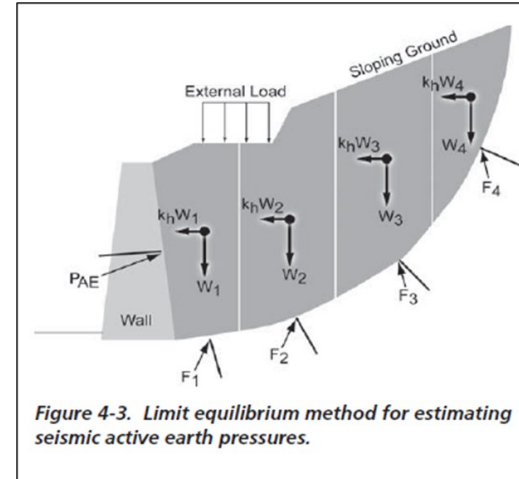


Earthquake Loads

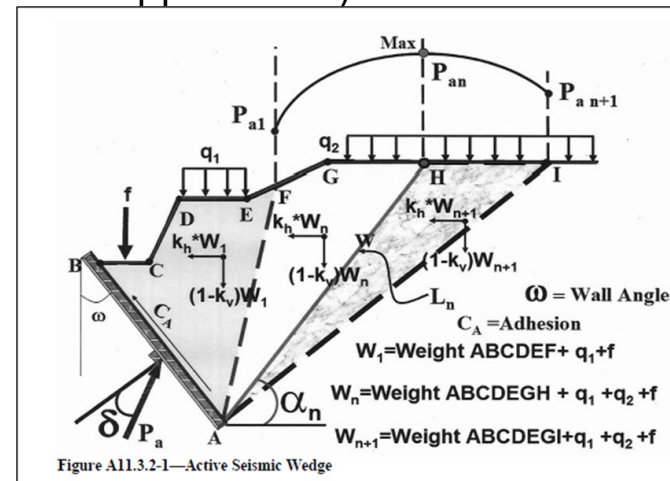
- General Wedge Earthquake Analysis (EM 1110-2-2100, 2502)



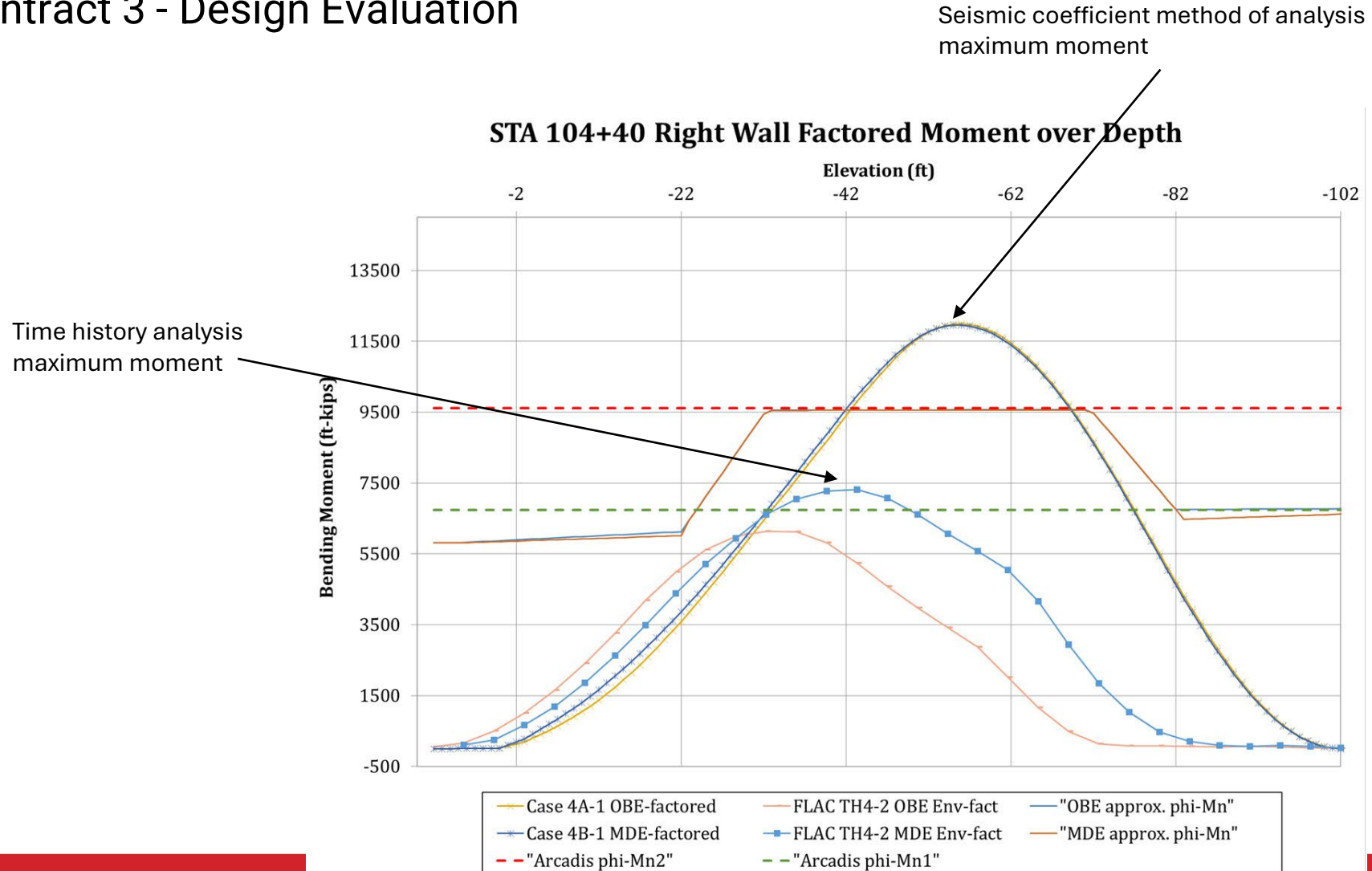
- Generalized Limit Equilibrium (GLE) Method (AASHTO LRFD 2021, NCHRP 611)



- Mononobe-Okabe Method Modification to Consider Cohesion (AASHTO LRFD-2011-Appedix A11)

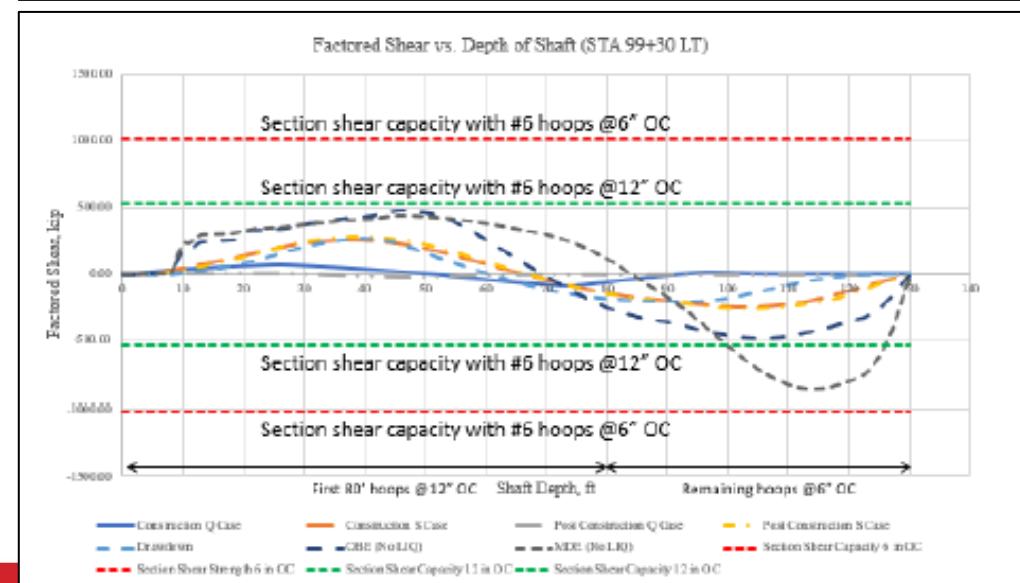
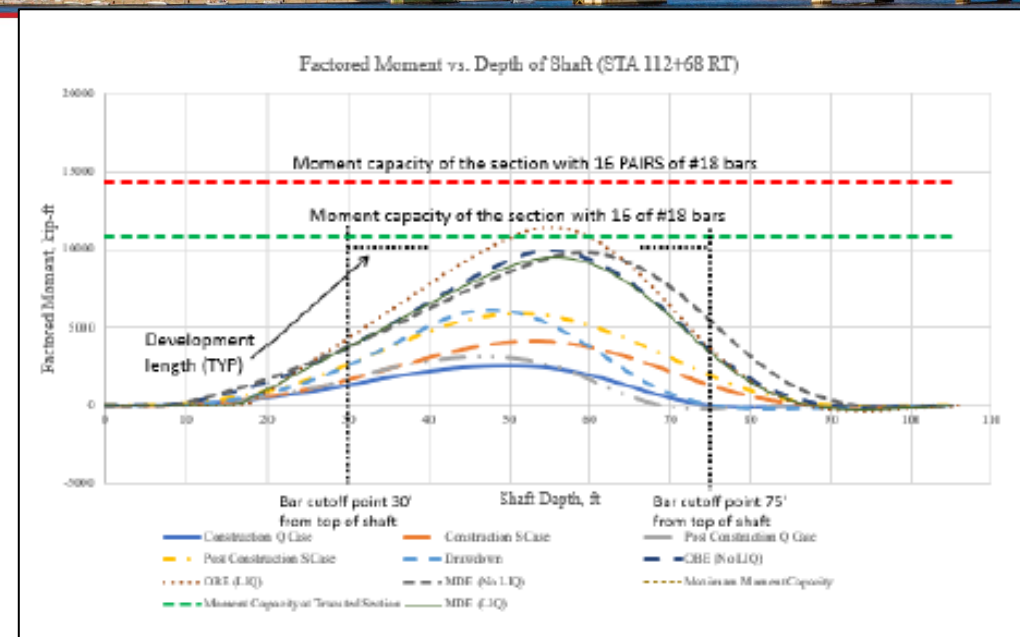
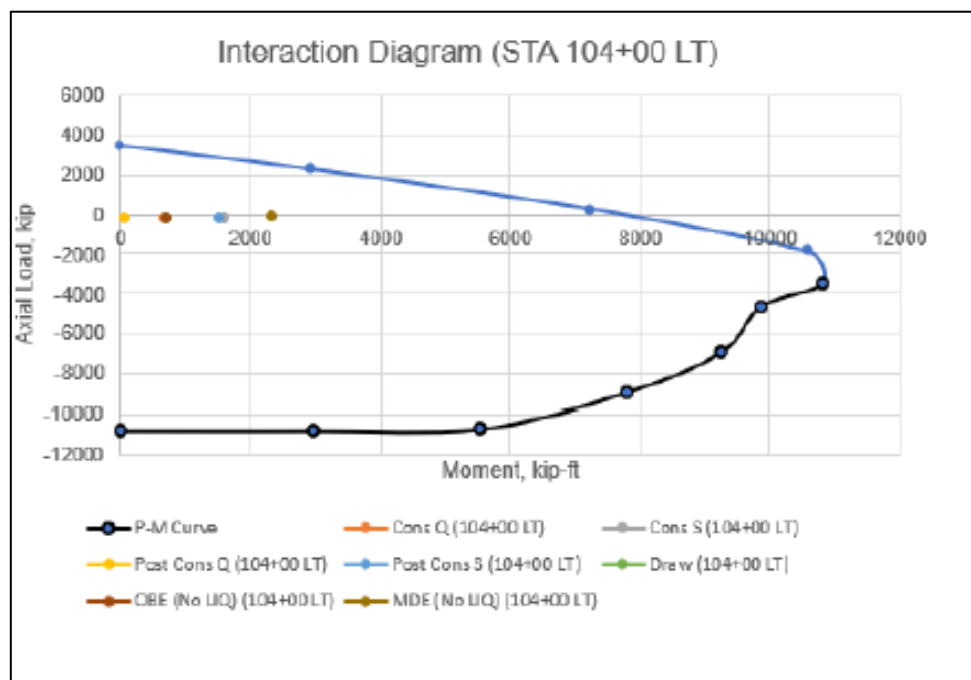


- Seismic coefficient and Nonlinear Time History Analyses Comparison
 - ✓ RPN Contract 3 - Design Evaluation



Design Requirements (Strength Design)

- RPN Contract 3 – Drilled Shaft Design



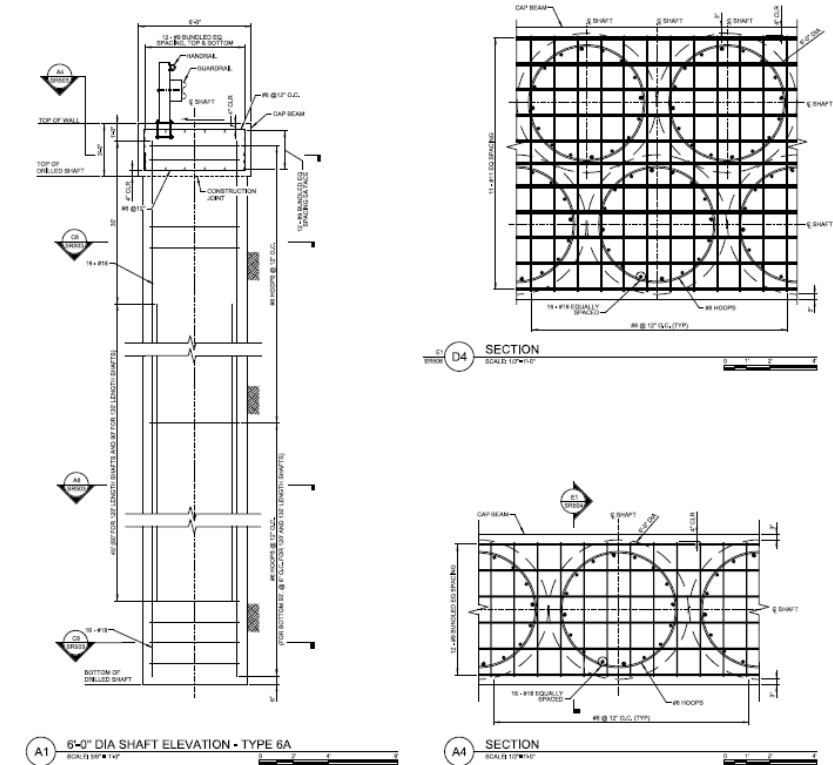
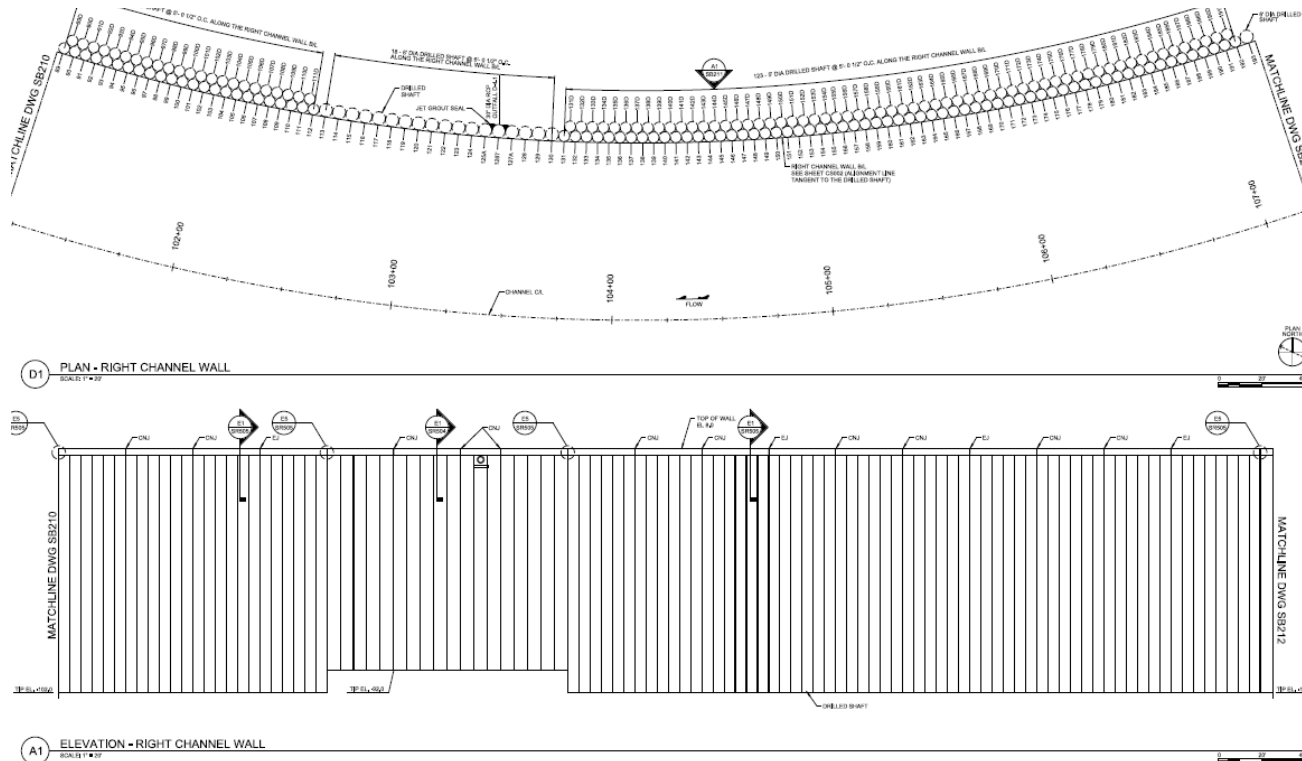
ELEVATION
SCALE: 1" = 20'

The elevation view shows the bridge structure with the following details:

- Overall Bridge Length:** 170'-6" (MEASURED ALONG C/R ROOSEVELT BLVD.)
- Spans:** SPAN 1 (85'-3") and SPAN 2 (85'-3").
- Piers:** C/R PIER 2, supported by a 5'-0" Ø DRILLED SHAFT (TYP.).
- Channel Walls:** FACE OF LEFT CHANNEL WALL and FACE OF RIGHT CHANNEL WALL, supported by 6'-0" Ø DRILLED SHAFT (TYP.).
- Channel Invert:** EL. -14.7.
- Ground Features:** EXIST. GRADE UPSTREAM, EXIST. GRADE DOWNSTREAM, EXIST. GRADE AT C/R ROOSEVELT AVE., and MIN. LOW MEMBER ELEV. 9.77.
- Structural Details:** 100 YR WSE 6.50, 36" FLORIDA I-BEAM, 42" F-SHAPE TRAFFIC RAILING (TYP.), and 1 1/2" JOINT.
- Stationing:** BFPR-BEGIN BRIDGE STA. 49+14.72 and BFPR-END BRIDGE STA. 50+85.22.

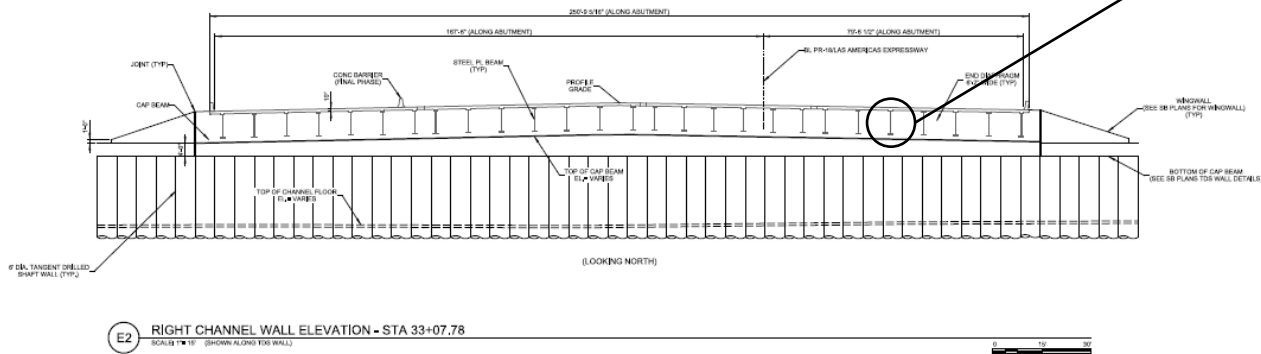
This technical drawing shows a cross-section of a bridge deck for Span 2 (East). The deck is supported by 15 No. 36 Florida I-beams, with a center-to-center spacing of 13'11 1/8" (101'-3 1/4" total). The deck width is 48'-7 1/2", divided into two 24'-3 7/8" halves by a central 36" single slope median barrier. The deck is 11" thick structural slab. On the left side, there is a 6'-0" sidewalk, a 1'-6" shoulder, and a 3'-5 7/8" light pole pedestal. The right side features a 6'-0" sidewalk, a 1'-6" shoulder, a 4'-8 1/2" utility shelf, and a 3'-5 7/8" pipe saddle. The bridge is divided into two phases: Phase I (left) and Phase II (right), each 24'-3 7/8" wide. The bridge has a 0.02 ft/ft slope. Key structural details include 4-8" conduits, 12-4" conduits, 10-4" conduits, 4-6" conduits, 4-6" PVC pipe scupper, 42" single slope traffic railing, and 32" O.D. duct iron pipe handrail. The drawing also shows the location of the Roosevelt Ave. 108'-9" crossing.

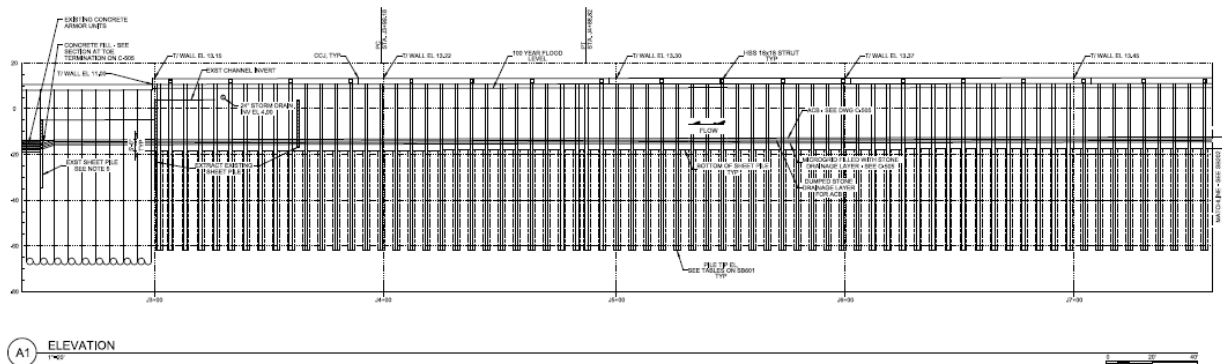
• Structural Systems: Rio Puerto Nuevo Contract 3 Channel Improvements



Double Rows of Shafts

Steel Plate Girder



[illegible]

CONSTRUCTION CONSIDERATIONS



Construction Requirements

- Specification documents outline construction requirements necessary for complete a project successfully as scope of work, materials to be used, installation methods, equipment, quality of the work, testing requirements and criteria for acceptance.
 - DoD - Unified Facilities Guide Specifications (UFGS) are published in an electronic format and are intended to be used with SpecsIntact's software.
- ✓ <https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs>



[LOGIN](#)
[CREATE ACCOUNT](#)
[SEARCH](#)

[DESIGN RECOMMENDATIONS](#)
[PROJECT MANAGEMENT - O & M](#)
[FEDERAL FACILITY CRITERIA](#)
[CONTINUING EDUCATION](#)
[ADDITIONAL RESOURCES](#)

DEPARTMENT OF DEFENSE / UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS)



Unified Facilities Guide Specifications (UFGS)

UFGS Master Updated February 9, 2023; Posted February 16, 2023

Unified Facilities Guide Specifications (UFGS) are a joint effort of the U.S. Army Corps of Engineers (USACE), the Naval Facilities Engineering Systems Command (NAVFAC), the Air Force Civil Engineer Center (HQ AFCEC) and the National Aeronautics and Space Administration (NASA). UFGS are for use in specifying construction for the military services.

The Unified Facilities Guide Specifications (UFGS) are published only in electronic format and are intended to be used with **SpecsIntact** software. The UFGS Master complies with UFC 1-300-02. SpecsIntact supports the UFGS format. SpecsIntact can still open Masters or Jobs created with older versions of the UFGS format.

Updated UFGS are posted quarterly in February, May, August, and November.

[Read More](#)

Questions, comments, suggestions and recommended changes for guide specifications are welcome and should be submitted as a Criteria Change Request (CCR). To submit a Criteria Change Request, click on the CCR link next to the document below. If a CCR does not fit cleanly into an existing section, submit a CCR to the section most closely related to the CCR. CCRs are not appropriate when they pertain to a specific project solicitation, request for proposal or after a project award. Questions or interpretations pertaining to these documents or situation should be referred to the Contracting Officer.

Click the 'Title' or 'Date' heading to sort by ascending or descending order. Narrow the list by selecting a 'Division' option from the drop-down or view archived documents by selecting from the 'Status' drop-down and clicking Apply.

These documents are available in the following formats: Adobe Acrobat (PDF) | SpecsIntact (SEC) in compressed ZIP

Indicates the UFGS has an attachment. Click the title to view the attachment under 'Related Materials'.

Status

Division

TITLE	DATE	VIEW	CCR
-------	------	------	-----



US Army Corps of Engineers

DIVISION 03 - CONCRETE

03 01 00	02/18	REHABILITATION OF CONCRETE
03 11 19.00	08/22	INSULATING CONCRETE FORMING
03 23 00	05/16, CHG 1: 08/18	STRESSED TENDON REINFORCING
03 30 00	02/19, CHG 4: 08/22	CAST-IN-PLACE CONCRETE
03 30 53	05/14	MISCELLANEOUS CAST-IN-PLACE CONCRETE
03 31 29	02/19	MARINE CONCRETE WITH SERVICE LIFE MODELING
03 31 30	02/19	MARINE CONCRETE
03 33 00	11/09	CAST-IN-PLACE ARCHITECTURAL CONCRETE
03 37 00	11/09	PREPLACED-AGGREGATE CONCRETE
03 37 13	02/18	SHOTCRETE
03 37 23	11/09	ROLLER-COMPACTED CONCRETE FOR MASS CONCRETE CONSTRUCTION
03 37 29	11/09	CONCRETE FOR CONCRETE CUTOFF WALLS
03 41 16.08	11/19	PRECAST CONCRETE ROOF SLABS (MAX. SPAN 8 FEET O.C.)
03 41 33	11/16, CHG 1: 11/18	PRECAST STRUCTURAL PRETENSIONED CONCRETE
03 42 13.00 10	05/16	PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION
03 44 00	02/13	REINFORCED AUTOCLAVE AERATED CONCRETE PANELS
03 45 00	05/16, CHG 2: 11/21	PRECAST ARCHITECTURAL CONCRETE
03 45 33	05/16, CHG 1: 11/21	PRECAST [PRESTRESSED] STRUCTURAL CONCRETE
03 47 13	08/16	TILT-UP CONCRETE
03 51 13	05/16	CEMENTITIOUS WOOD FIBER DECKS
03 52 00	08/11	LIGHTWEIGHT CONCRETE ROOF INSULATION
03 52 16	04/08	LIGHTWEIGHT INSULATING CONCRETE
03 52 16.19	08/11	LIGHTWEIGHT INSULATING CONCRETE OVERLAY
03 53 14	08/21	LIGHT REFLECTIVE NONFERROUS METALLIC AGGREGATE FLOOR SYSTEM
03 62 16	02/18	METALLIC NON-SHRINK GROUTING
03 70 00	02/10, CHG 2: 08/20	MASS CONCRETE

Ongoing Construction

- Rio Puerto Nuevo CNT2 Demonstration Wall



Shaft Excavation



Reinforcement Cage Installation



Concrete Placement

AFTER CONSTRUCTION

- Routine Inspections
 - ✓ Inspection of structures to verify any deficiencies or signs of distress.
- Operation and Maintenance
 - ✓ Operation of structure (control water EL of a dam or reservoir)
 - ✓ Maintenance of structure elements (gates, riprap, valve houses, bridges, concrete elements)
- Emergency Response
 - ✓ Inspection of structures after an extreme event
 - ✓ Hurricane Maria
 - ✓ Hurricane Fiona
 - ✓ 2022 Earthquake



Portugues Dam Inspection after Hurricane Fiona

SUMMARY

- USACE – SAA designs are up-to-date with current engineering manuals, regulations, and standards of practice:
- Hydraulic
 - ✓ Design Optimization: Hydrologic, hydraulic, sediment transport, sedimentation analysis, and physical modeling
- Geotechnical
 - ✓ Subsurface Investigations
 - ✓ Seismic Explorations
 - ✓ Site Specific Study
 - ✓ Soil Remediation
- Structures
 - ✓ Design in accordance with Current Design Standards
 - ✓ Design Optimization
 - ✓ Lesson Learned from previous designs, and construction projects
 - ✓ Value Engineering Studies

Q&A / Discussion



Contact Us

Caribbean District Intranet - Home

https://usace.dps.mil/sites/INTRA-SAA

SharePoint

SAA HUB Intranet Collaboration Site Index Publications Quick Links USACE HUB

Caribbean District Intranet

District Offices Training & Development Employee Resources Publications (Localize) Employee Portal Site Contents Training SAA Presentations Library

News

See all

Remembering María

OUR MISSION:

To safely deliver quality public infrastructure projects on time and within budget.

Quick Links

See all

Virgin Islands

Mostly sunny 87°F 87°/81° 10/08/2025 MSN Weather

San Juan, Puerto Rico

Light rain showers 89°F 90°/81° 10/08/2025 MSN Weather

Caribbean District Facebook Page

Caribbean District LinkedIn Page

Caribbean District Public Website

Commander's Corner

Suggestion Box

COL Charles L. Decker
Caribbean District
Commander

MAJ Ricardo Herrero
Caribbean District
Deputy Commander

Ms. Jackie Keiser
Caribbean District DPM

<https://usace.dps.mil/sites/INTRA-SAA>

TRI - REGIONAL JETS 2025

