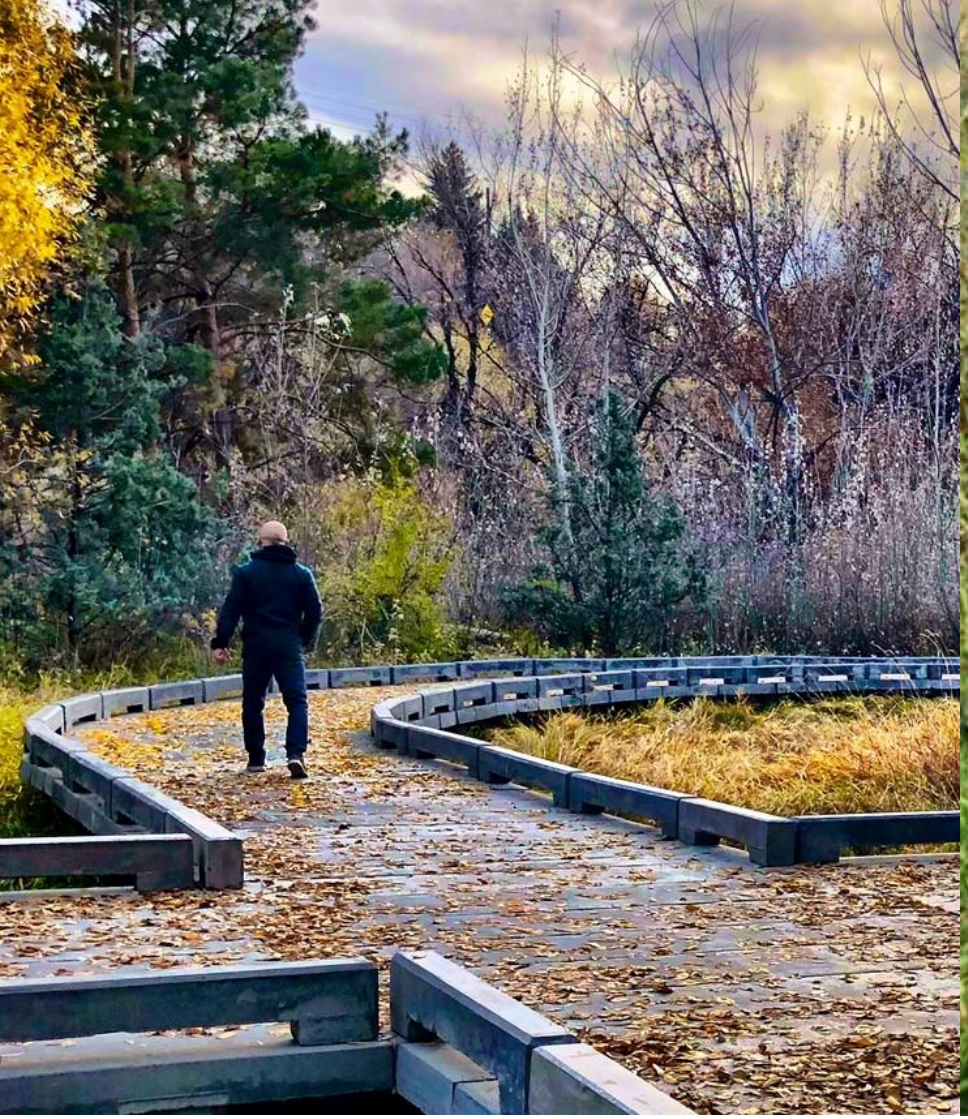


Basics of Boardwalk Design

Andrew Craig, PE
Permatrak Concrete Boardwalks
Director of Engineering

John Pyle, PE
PermaTrak Concrete Boardwalks
VP of Sales & Marketing

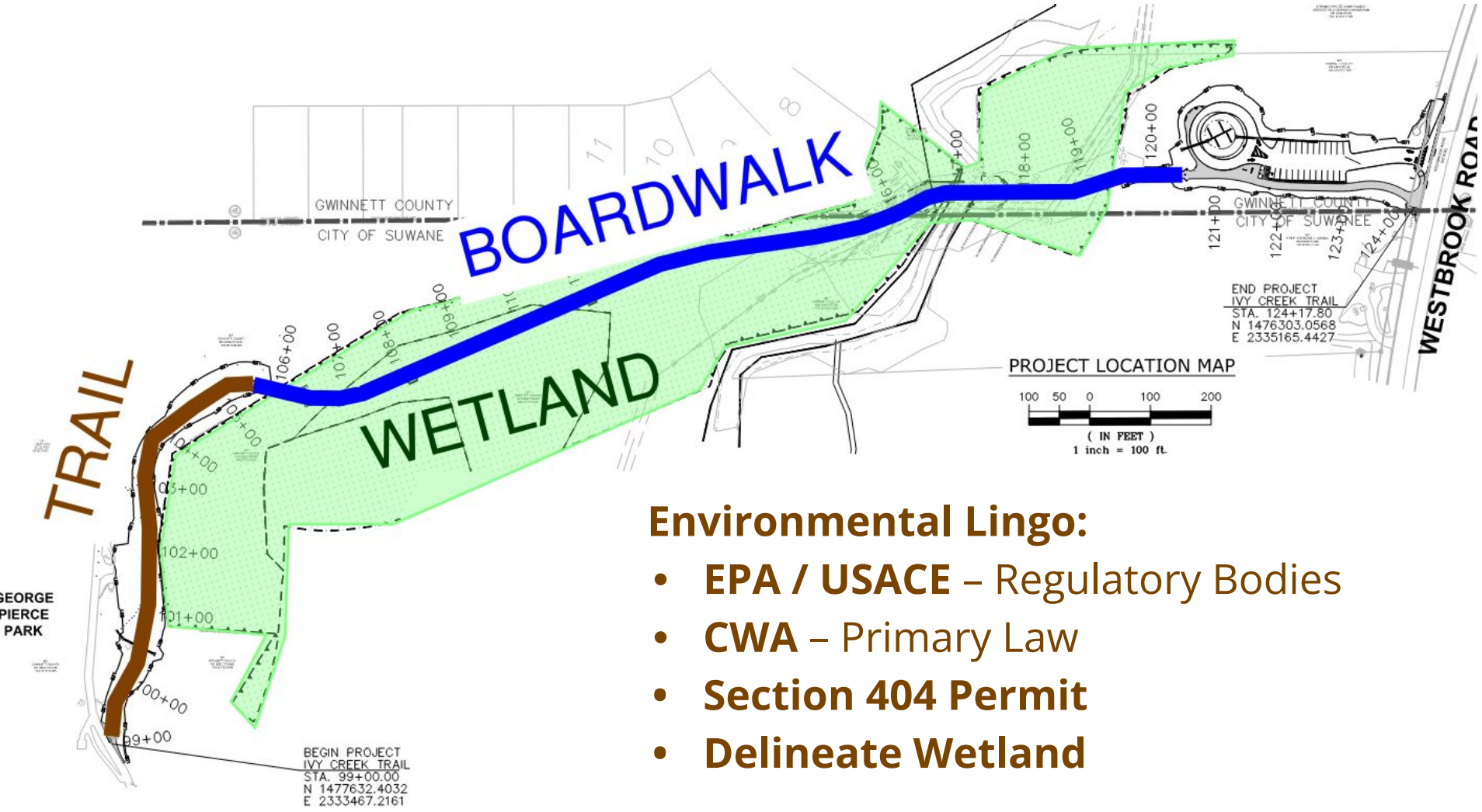
Carrie Parada, PE
PermaTrak Concrete Boardwalks
Project Consultant

Agenda

- Boardwalk Planning & Design
- Foundation Selection
- Material Selection
- Case Studies

Boardwalk Planning & Design

Define Boardwalk Location

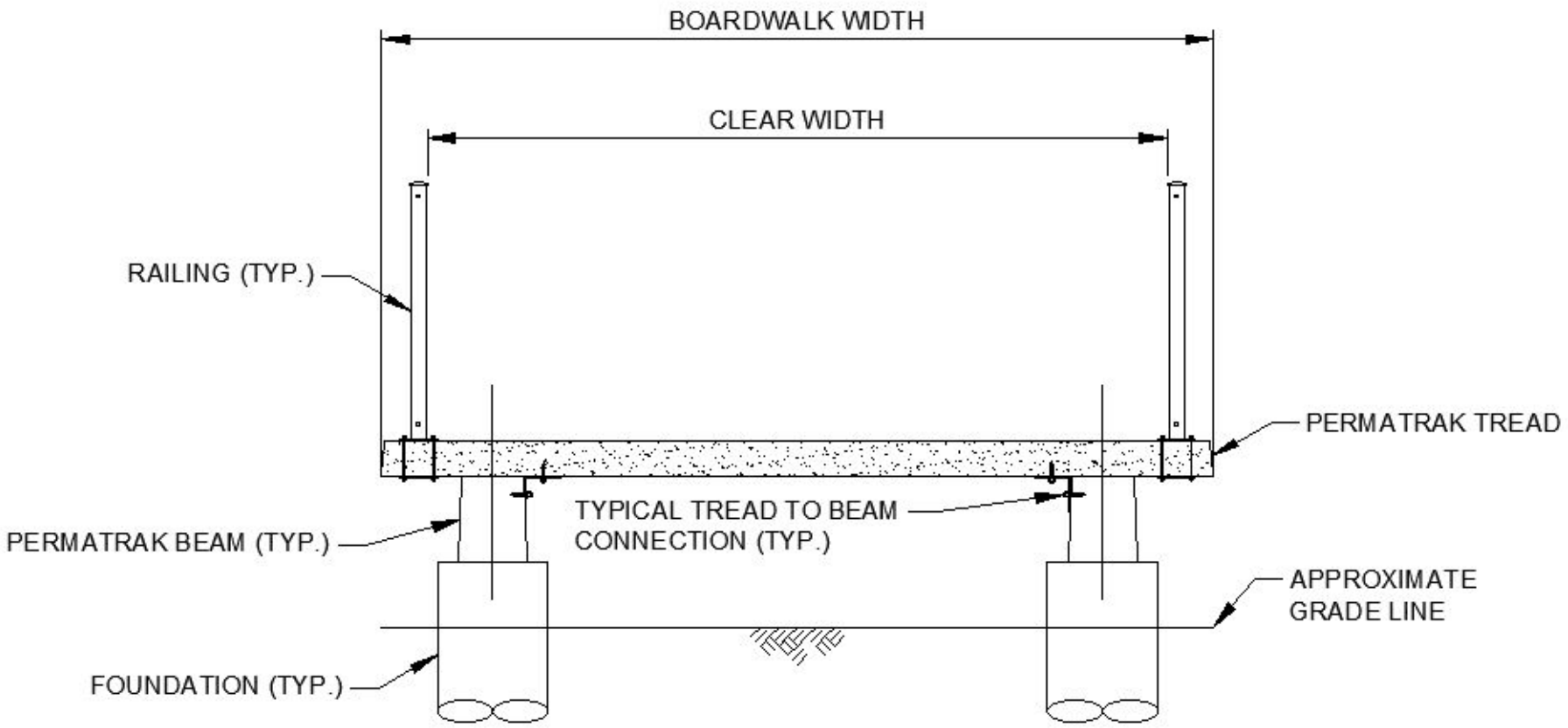


Environmental Lingo:

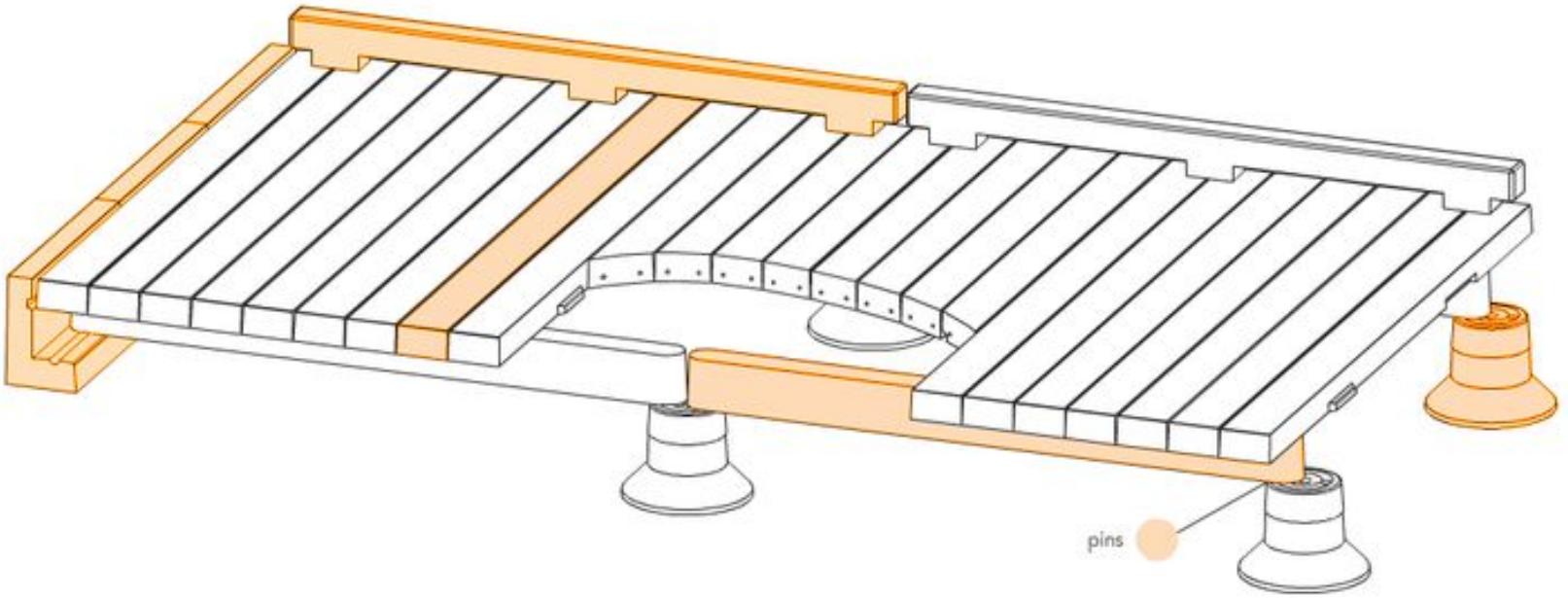
- **EPA / USACE** – Regulatory Bodies
- **CWA** – Primary Law
- **Section 404 Permit**
- **Delineate Wetland**

Define Typical Section

Typical Precast Concrete Section

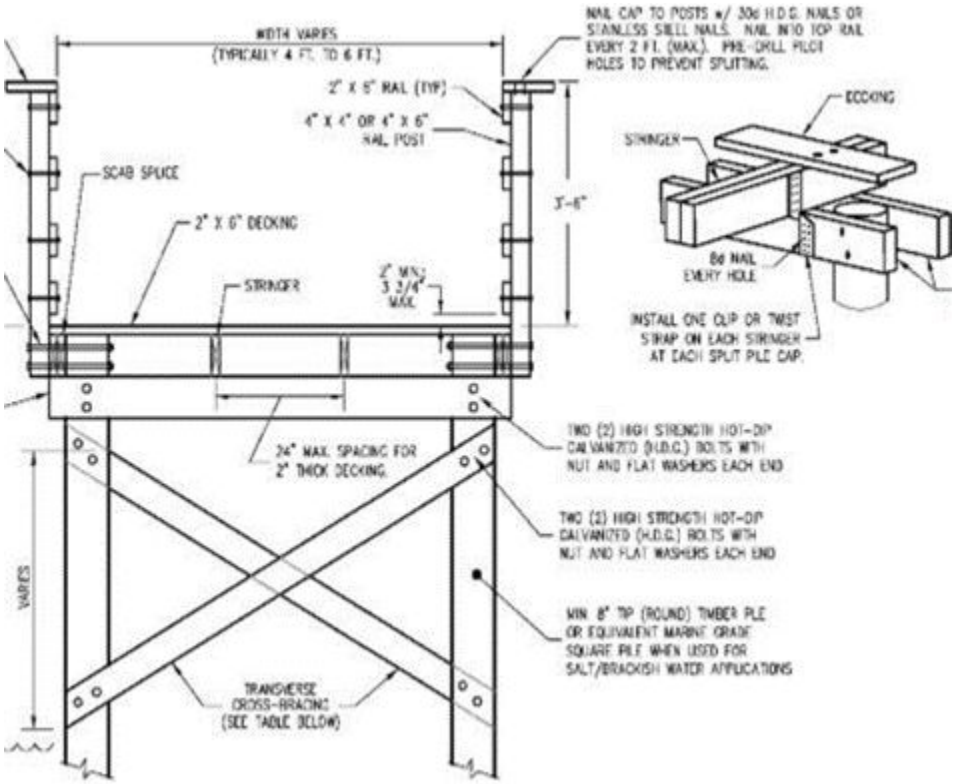


Typical Precast Concrete Section

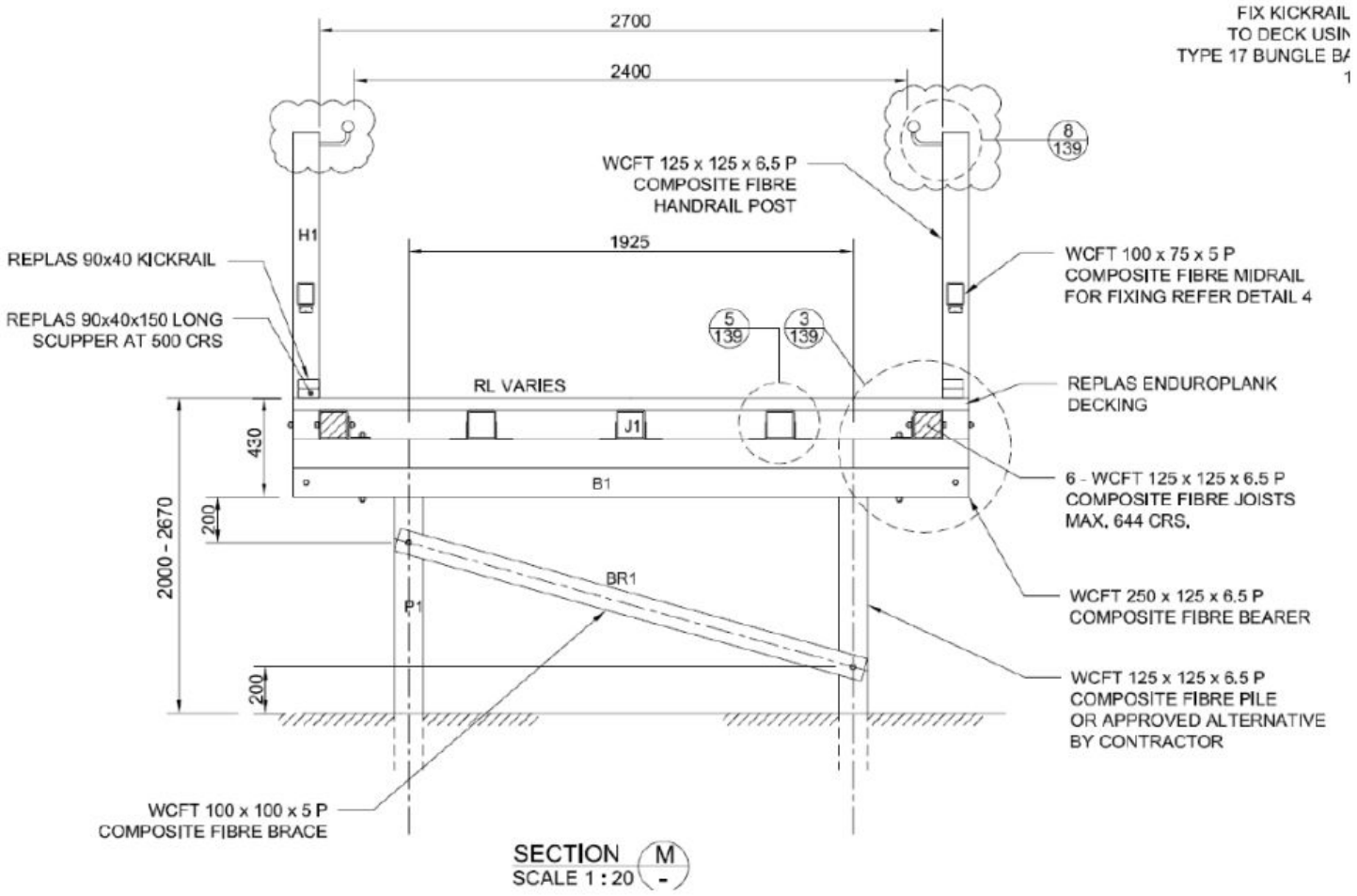


- Abutment
- Curb
- Piers
- Beams
- Treads

Typical Timber Section

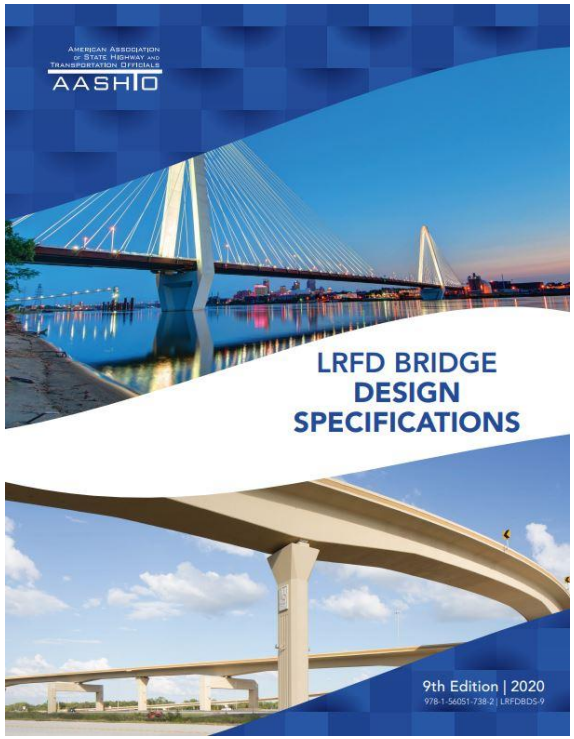


Typical Composite Section

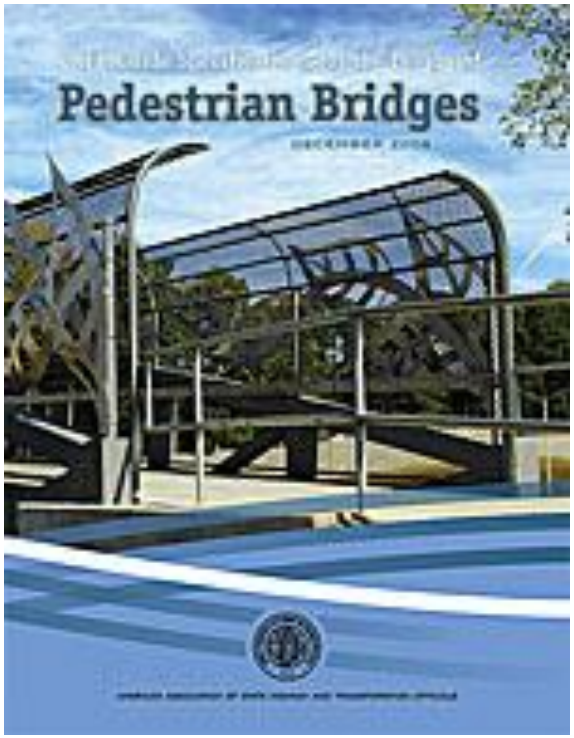


Define Clear Width

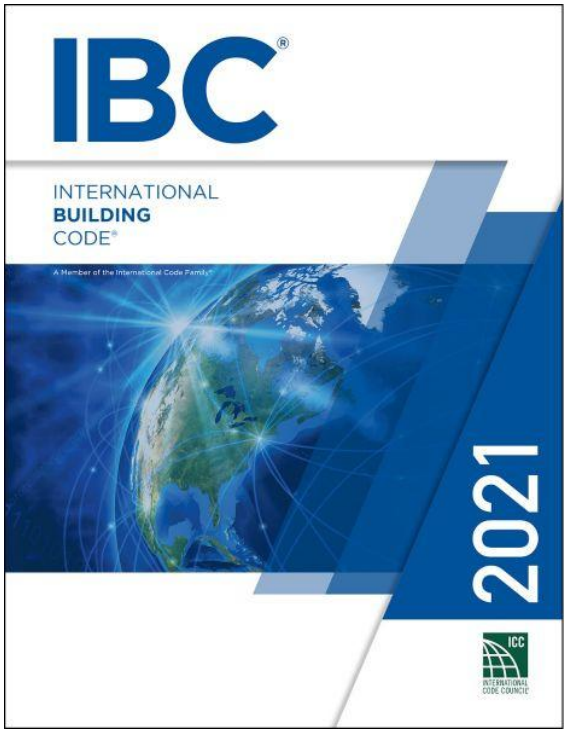
Determine Design Code



AASHTO LRFD Bridge Design Specifications



AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, 2nd Edition, with 2015 Interim Revisions



IBC
(Refers to ASCE for Loads)

Vertical Loads

AASHTO:

- Uniform = 90 PSF
- Vehicle
  - 5,000 LB>
  - H5 (10,000 LB.)
  - H10 (20,000 LB.)

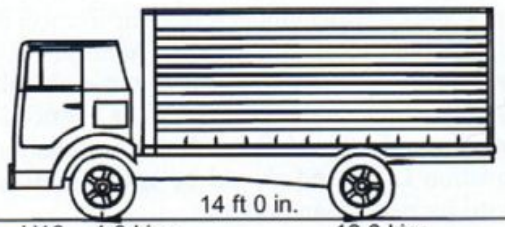
IBC:

- 60 to 100 PSF

A single truck shall be placed to produce the maximum load effects and shall not be placed in combinations with the pedestrian load. The dynamic load allowance need not be considered for this loading.

Table 3.2-1—Design Vehicle

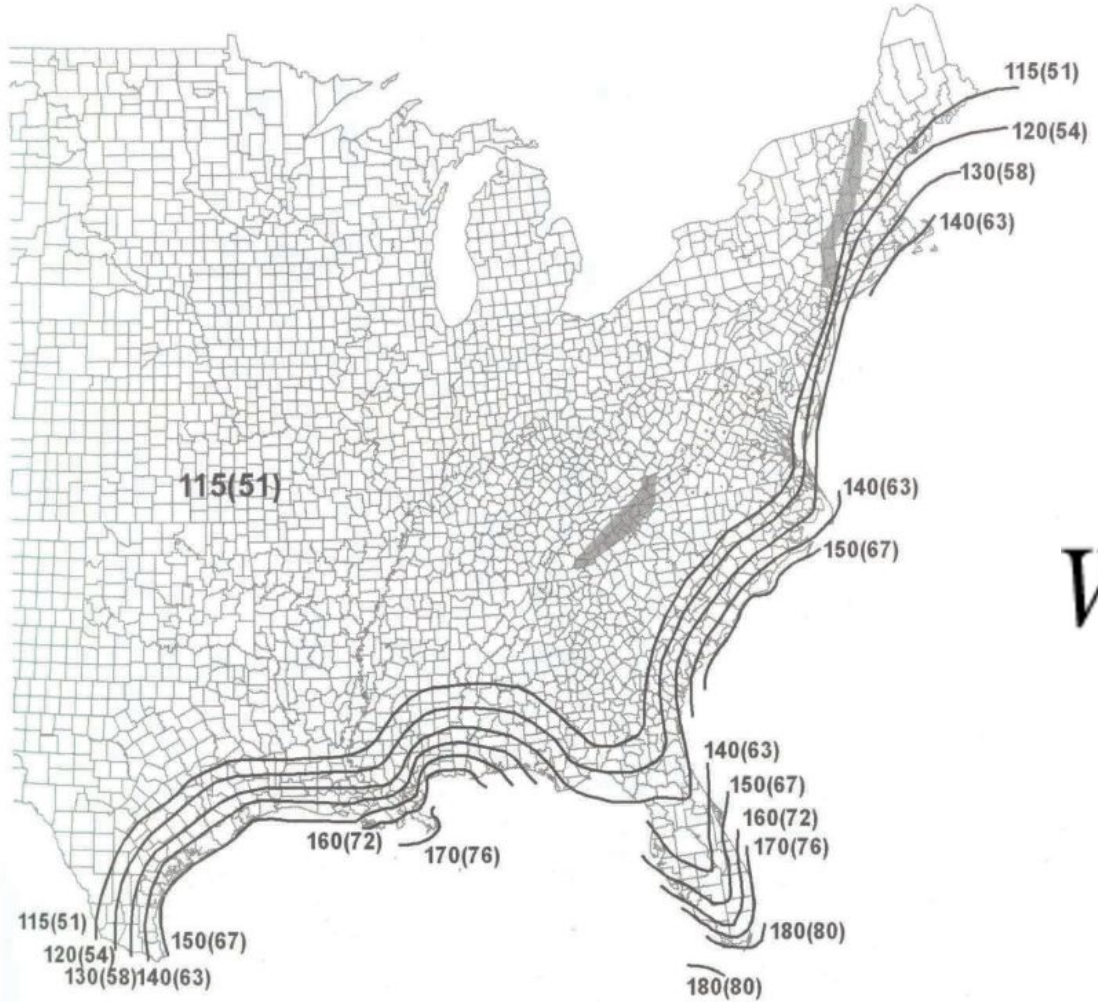
Clear Deck Width	Design Vehicle
7 to 10 ft	H5
Over 10 ft	H10



H10	4.0 kips	16.0 kips
H 5	2.0 kips	8.0 kips

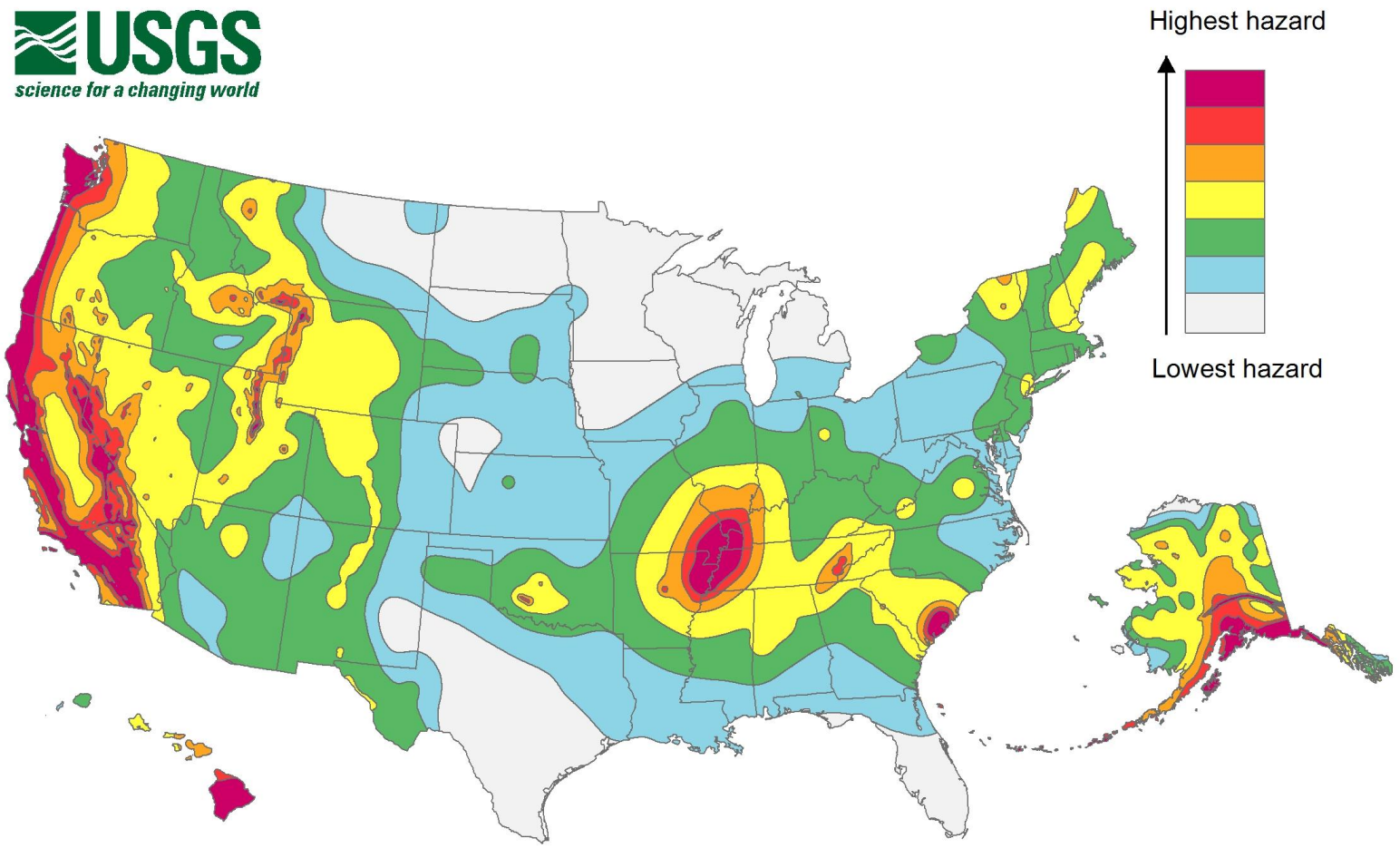
Live Load of 100 psf

Lateral Loads – Wind

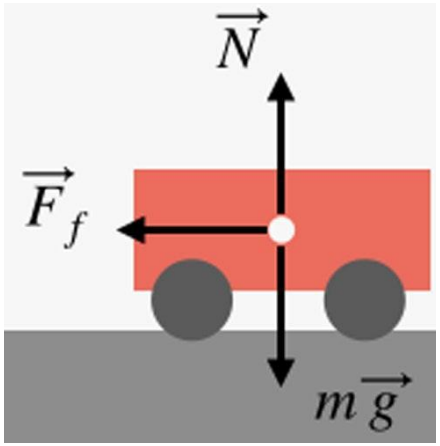


$$W = \frac{1}{2}\rho v^2$$

Lateral Loads – Seismic



Other Loads



- Braking = 25% of Design Truck Axle Load
- Snow
- Water (submerged boardwalks)
- Temperature

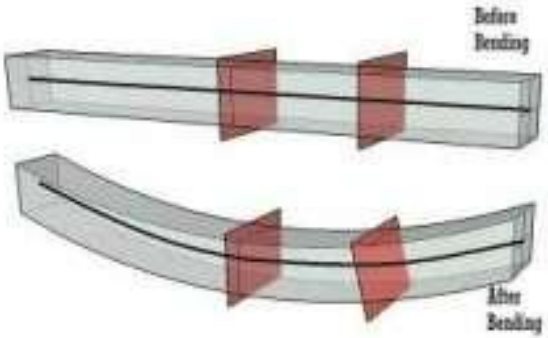
Load Combinations

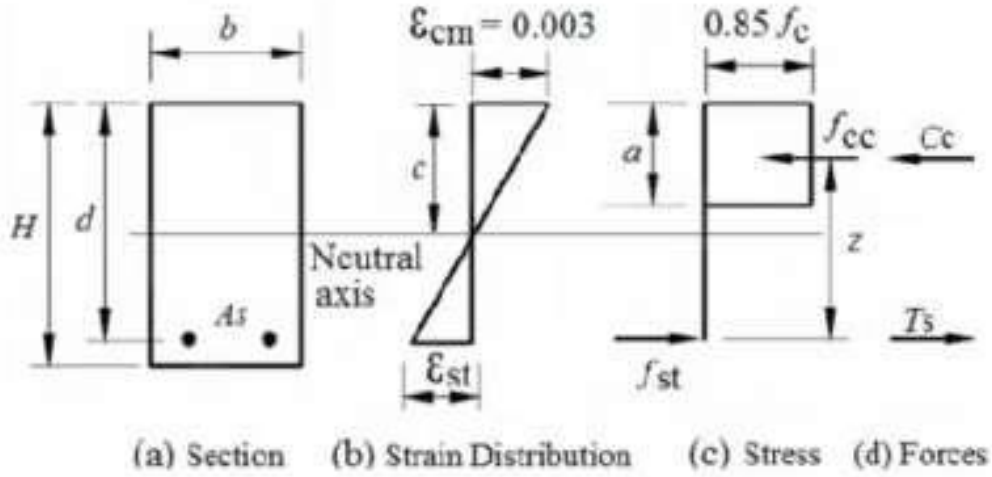
Table 3.4.1-1—Load Combinations and Load Factors

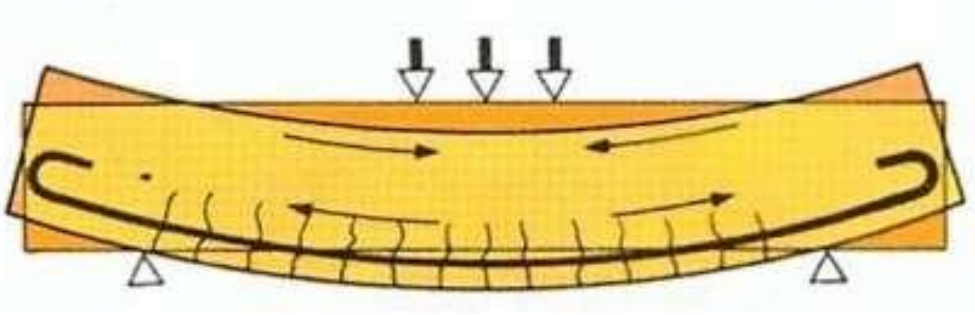
Load Combination Limit State	*DC DD DW EH EV ES EL PS CR SH*	*LL IM CE BR PL LS*	*WA*	*WS*	*WL*	*FR*	*TU*	*TG*	*SE*	Use One of These at a Time				
										EQ	*BL*	*IC*	*CT*	*CV*
Strength I (unless noted)	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength III	γ_p	—	1.00	1.00	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—	—
Strength V	γ_p	1.35	1.00	1.00	1.00	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Extreme Event I	1.00	γ_{EQ}	1.00	—	—	1.00	—	—	—	1.00	—	—	—	—
Extreme Event II	1.00	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00	1.00
Service I	1.00	1.00	1.00	1.00	1.00	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—	—
Service III	1.00	γ_{LL}	1.00	—	—	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service IV	1.00	—	1.00	1.00	—	1.00	1.00/1.20	—	1.00	—	—	—	—	—
Fatigue I— *LL, IM & CE* only	—	1.75	—	—	—	—	—	—	—	—	—	—	—	—
Fatigue II— *LL, IM & CE* only	—	0.80	—	—	—	—	—	—	—	—	—	—	—	—

If you only remember one.... 1.25 DL + 1.75 LL

Reinforced Concrete Design

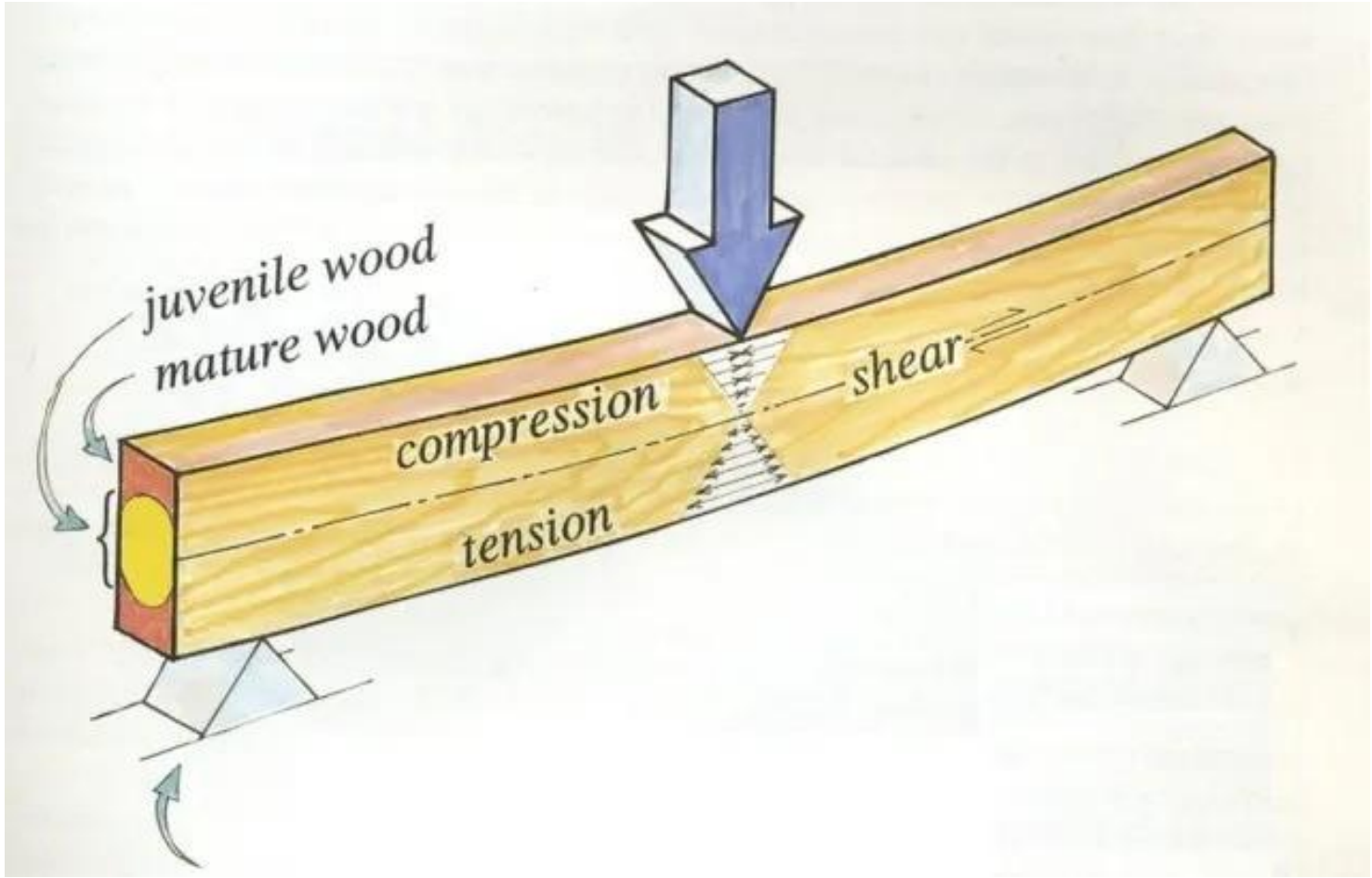






$$\phi M_n = \phi A_s f_y \left(d - a/2 \right)$$

Timber Design



Composite Design

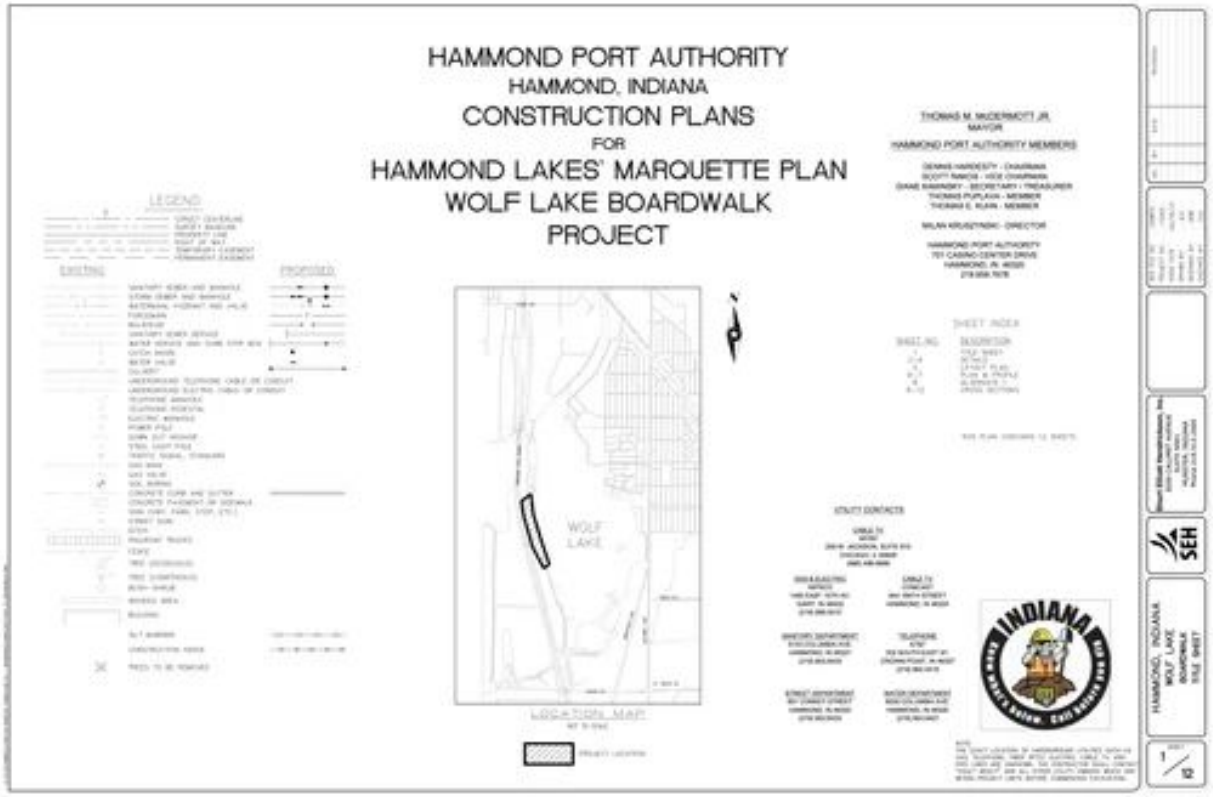
Solid

Scalloped

Hollow

Importance of Good Specifications

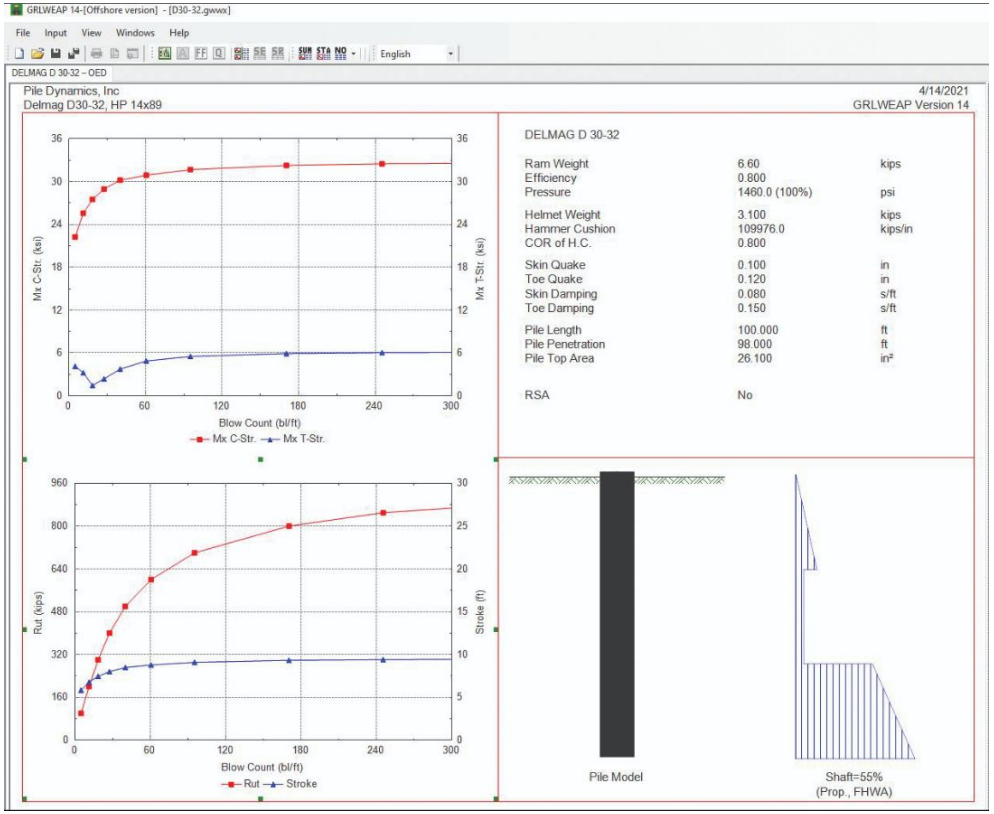
- Sets clear quality standards
- Ensures fair product competition
- Protects against inferior alternatives



Foundation Selection

First Step: A Geotechnical Report!

- Geotechnical investigations are crucial for successful boardwalk foundations
- Different foundation types require specific geotechnical data for design
- Proper foundation design ensures smoother installation and better outcomes



Foundation Selection

- Timber Piles
- Composite Piles
- Drilled Shaft
- Driven Steel Piles
- Steel Helical Piles
- Driven concrete piles
- Concrete piers
- Cast-in-place spread footings

Deep Foundations

Timber Piles

Fiberglass Composite Piles

Drilled Shaft or Concrete Caissons

Driven Steel Piles (H-Piles)

Steel Helical Piles (Screw Piles)

Driven Concrete Piles

Shallow Foundations

Precast Concrete Piers

Cast-in-Place Concrete Footings

Handrail vs. Curb

Do I Need a Handrail?

Less than 30”

No Handrail Required

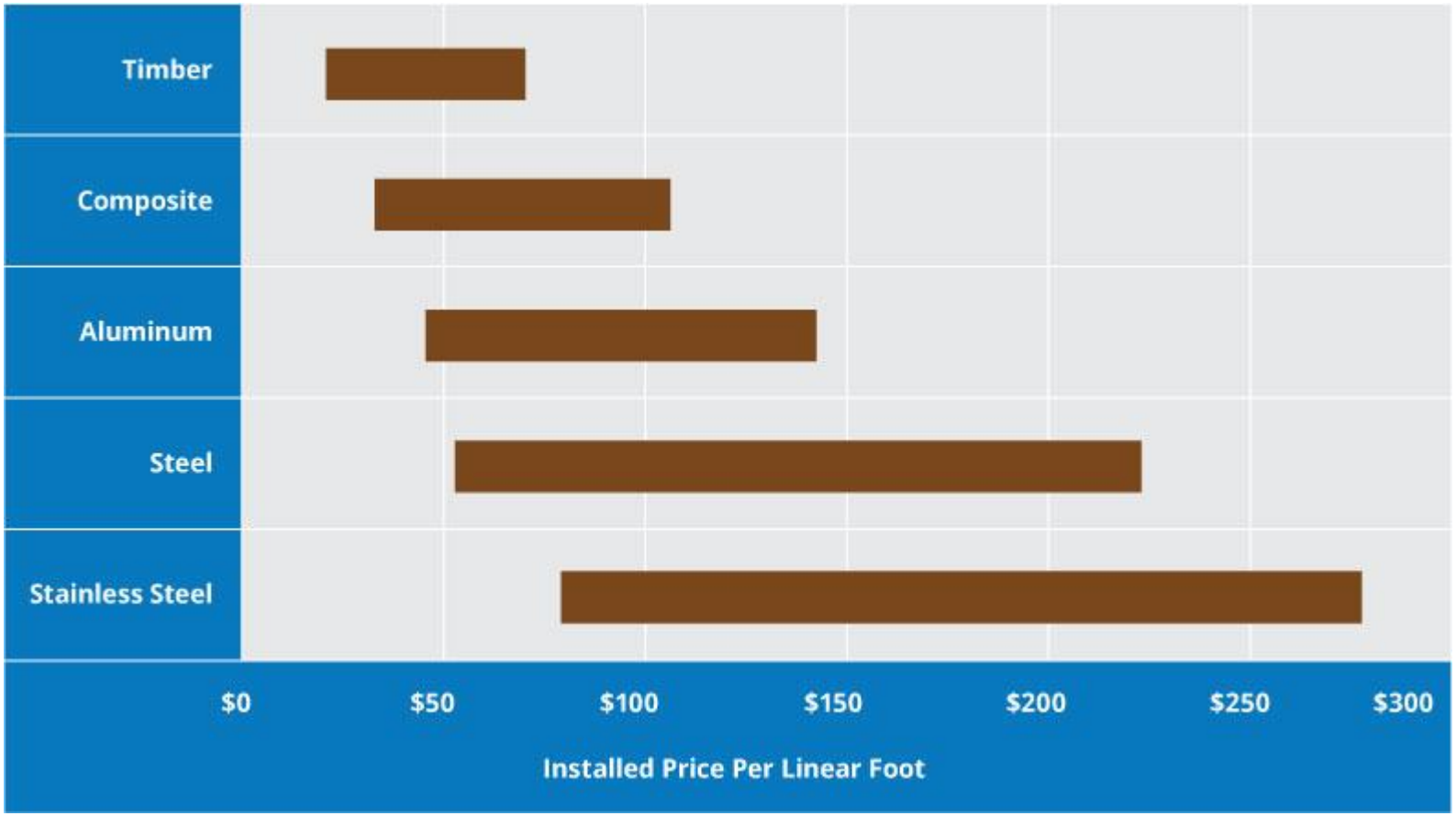
Handrail Design Loads

AASHTO
50 PLF + 200 LB.

IBC
50 PLF OR 200 LB.

Handrail Options

Handrail Cost

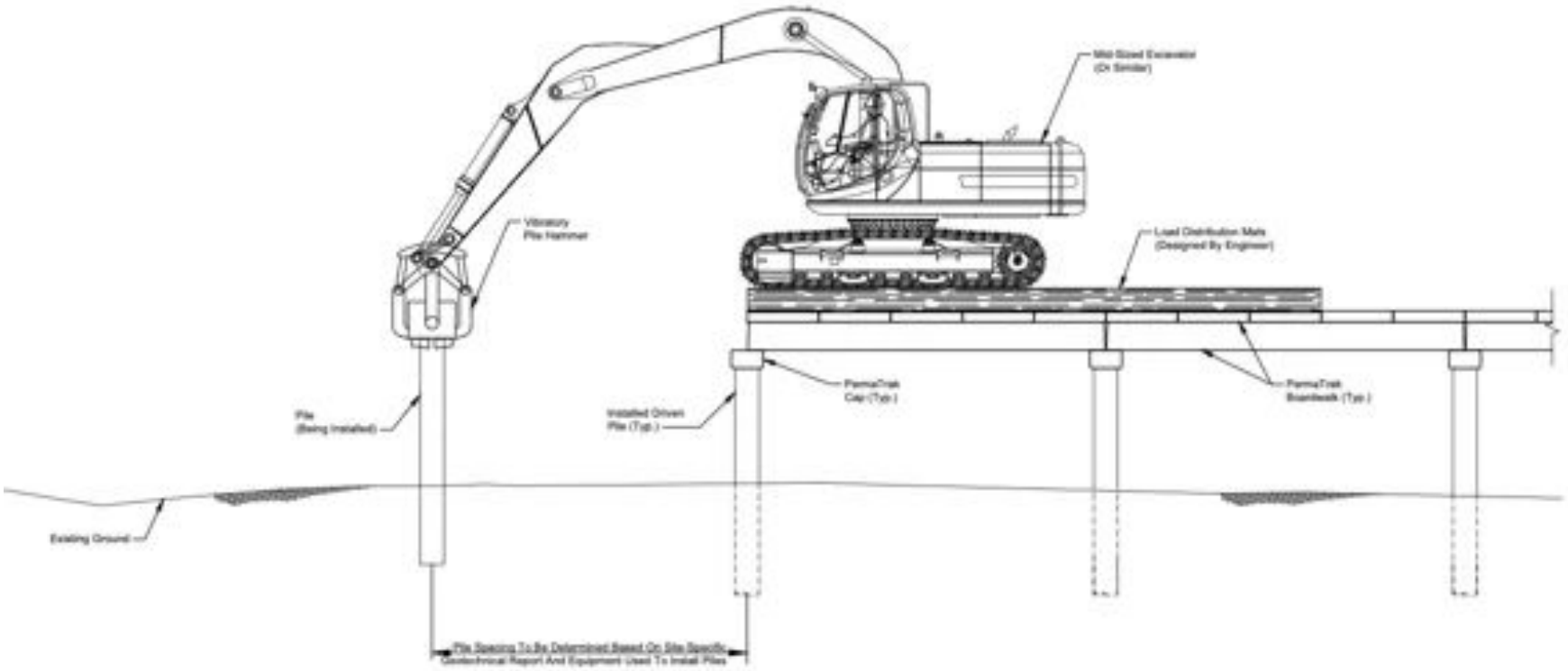


Constructability Considerations

Typical Construction Approaches

- Traditional from adjacent ground
- Foundations installed from ground with boardwalk installed top-down
- Full-top down with no equipment on the ground

Top-Down Construction



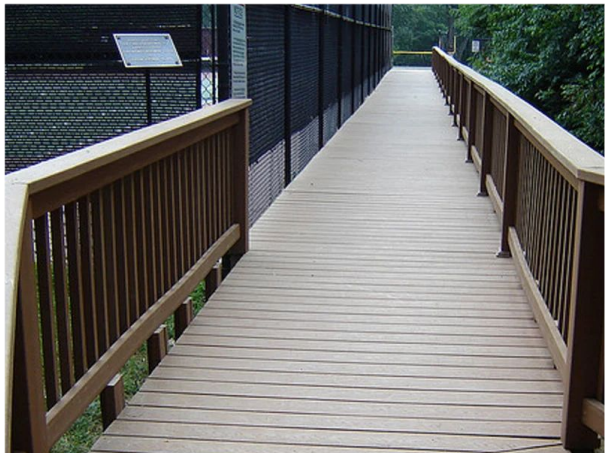
Top-Down Construction Video

Material Selection

Material Selection

Timber vs. Composite vs. Precast Concrete

- Slip Resistance
- ADA Compliance
- Durability
- Aesthetics
- Environmental



Slip Resistance

Slip Resistance Testing Report

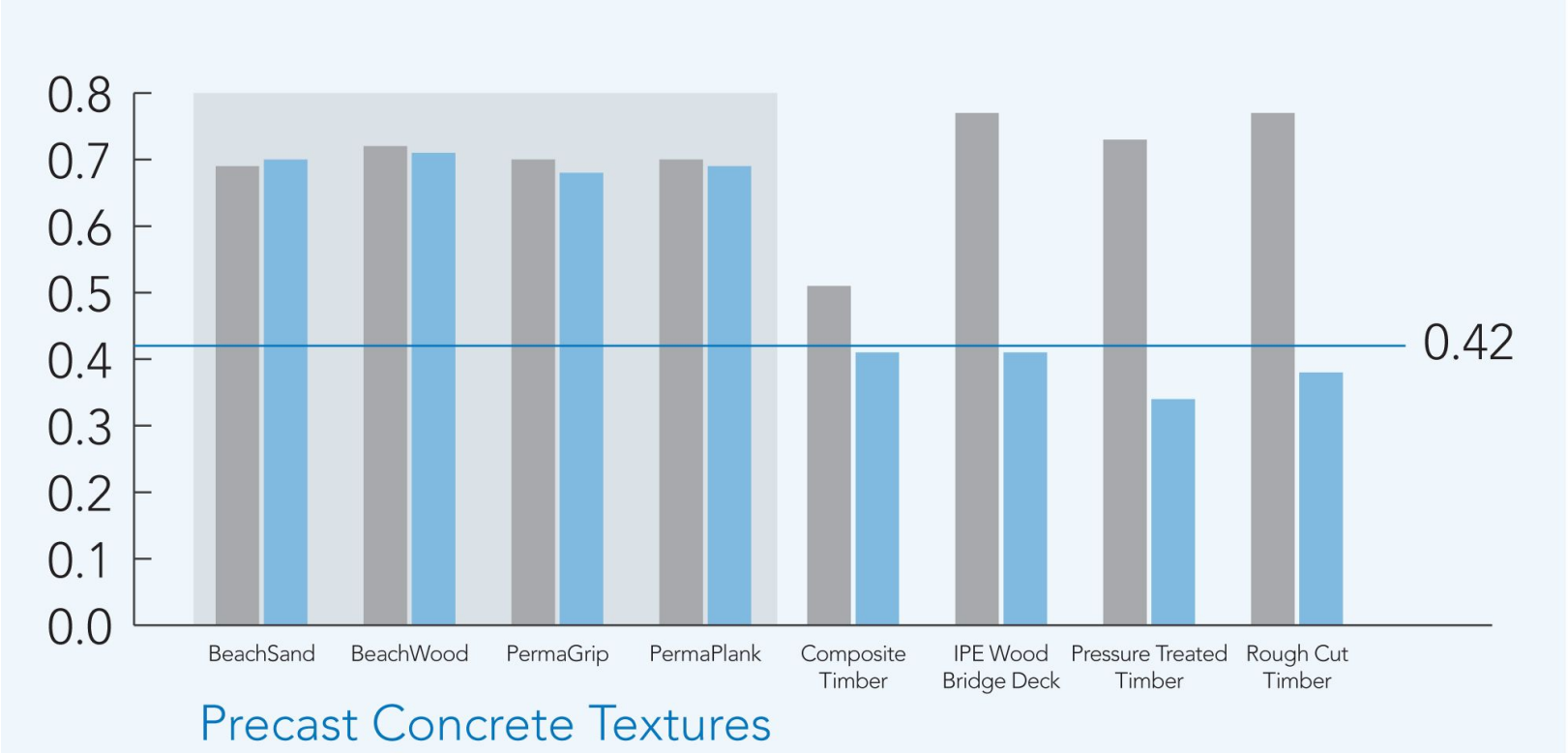
BOT-3000E Tribometer on PermaTrak PermaGrip Boardwalk Surface Texture

Prepared for:
PermaTrak
Charlotte, North Carolina

Prepared by:
Theorem Geo Associates Engineering, PLLC
Charlotte, North Carolina

December 2020

Slip Resistance



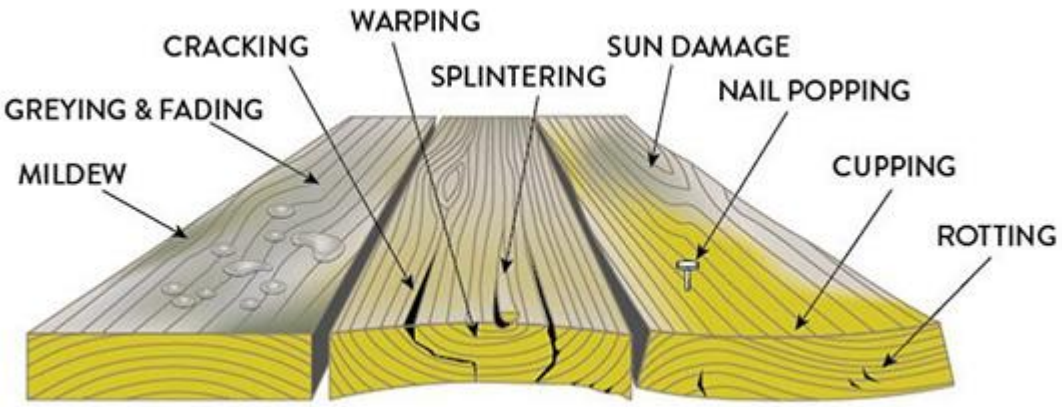
Precast concrete textures perform well in wet environments!

ADA Compliance

Vertical and horizontal boardwalk gaps must remain ADA-compliant

Durability

- **Timber:** Potential swelling, rotting and warping, leading to ADA compliance and safety issues
- **Composite:** Vulnerability to mold and algae, especially under heavy shade.
- **Precast concrete:** 50-75 year design life, no maintenance



When it comes to durability, timber has issues with swelling, rotting & warping.

Aesthetics

- **Timber:** Traditional boardwalk look and feel; however tendency to rot and swell can lead to eyesores (and safety issues)
- **Composite:** Very common for outdoor residential decking, can be used to replicate the look and feel of traditional boardwalk
- **Precast concrete:** Multiple colors & textures available to align aesthetics with goals of project

Environmental

- **Timber:** Pressure-treated timber can contain chemicals that leach into soils.
- **Composite:** Eco-friendly, biologically inert material, not chemically treated. That being said, it is non-renewable and non-biodegradable.
- **Precast concrete:** Eco-friendly, not chemically treated

Case Studies & Applications

Tree-Root Crossings

3 Mile Creek Greenway– Mobile, AL
Designer: Dix Hite & Partners
Owner: City of Mobile

Tree-Root Crossings

Davis Dr– Winston Salem, NC
Designer: Stimmel Associates
Owner: Wake Forest University

Tree-Root Crossings

Main St.- Broussard, LA
Designer: Duplantis Design Group
Owner: City of Broussard

Tree-Root Crossings

Flat Branch Nature Preserve – Charlotte, NC
Designer: Henson Foley
Owner: Mecklenburg County

Tree-Root Crossings

Dayton Ave – Shoreline, WA
Designer: Osbourne Consulting
Owner: WSDOT

Boardwalks

South Lake Tahoe Greenway – South Lake Tahoe, CA
Designer: El Dorado County
Owner: California Tahoe Conservancy

Coastal

Galveston Island State Park Dune Crossing- Galveston Island, TX
Designer: SWA Group
Owner: Millis Development & Construction

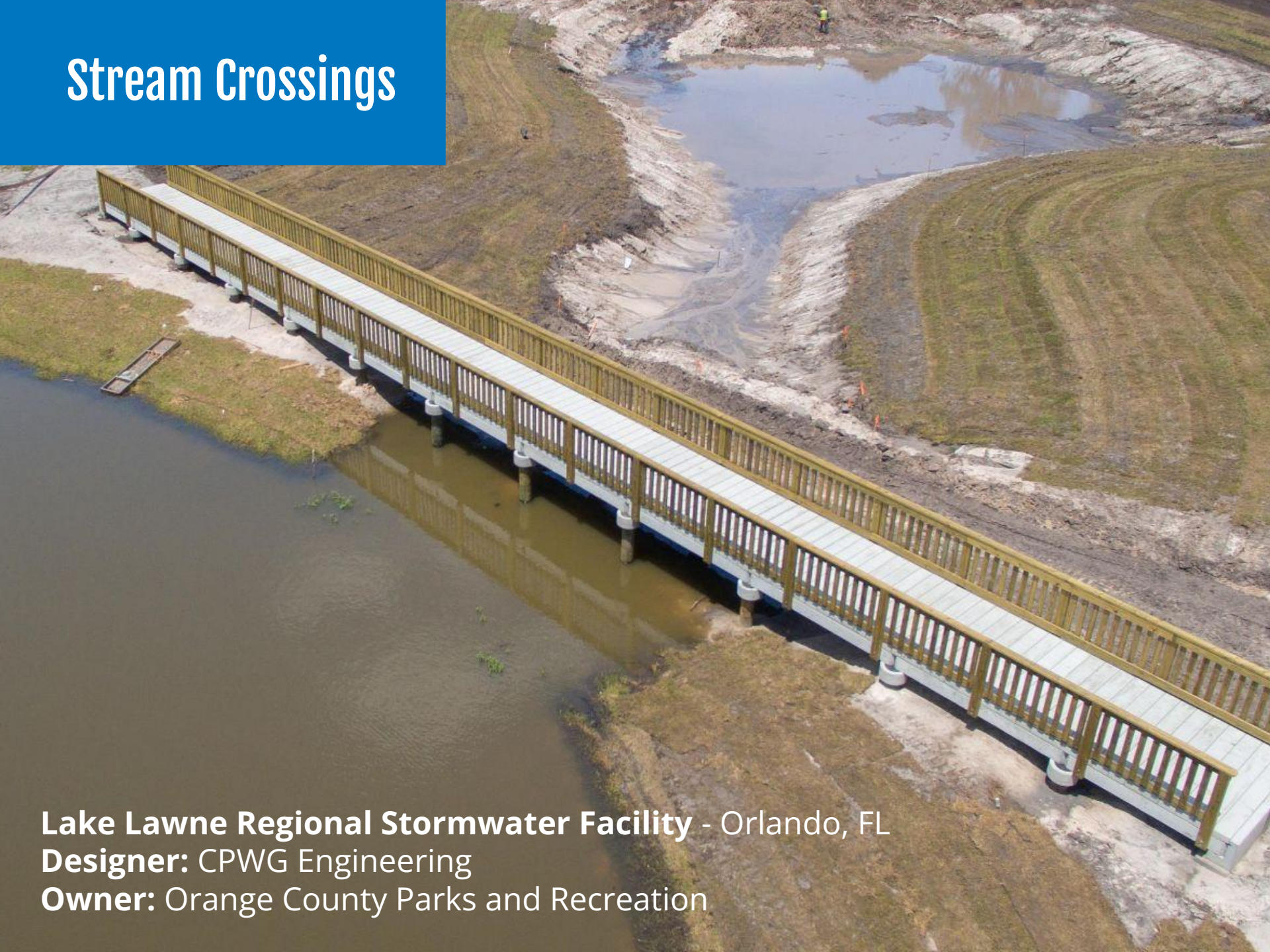
Lakes & Lagoons

Logan Lake Boardwalk at Adams Park – Sumter, SC
Designer: Pond and Company
Owner: Park Pride

Observation Decks

Judaculla Rock – Cullowhee, NC
Designer: Equinox Environmental
Owner: Jackson County, NC Parks & Recreation

Stream Crossings



Lake Lawne Regional Stormwater Facility - Orlando, FL
Designer: CPWG Engineering
Owner: Orange County Parks and Recreation

Urban

Michael Zone Recreation Center Park – Cleveland, OH
Designer: McKnight Associates Ltd.
Owner: City of Cleveland

Wetlands & Floodplains

Louisiana Children's Museum – New Orleans, LA
Designer: Mithun
Owner: Louisiana Children's Museum

Fishing Piers

Harborwalk – Charlotte County, FL
Designer: Kimley-Horn
Owner: Charlotte County, FL

Multi-Use Trails

Shot Pouch Greenway – Sumter, SC
Designer: Alta
Owner: City of Sumter

Multi-Use Trails

White Oak Greenway – Cary, NC
Designer: Kimley Horn
Owner: Town of Cary

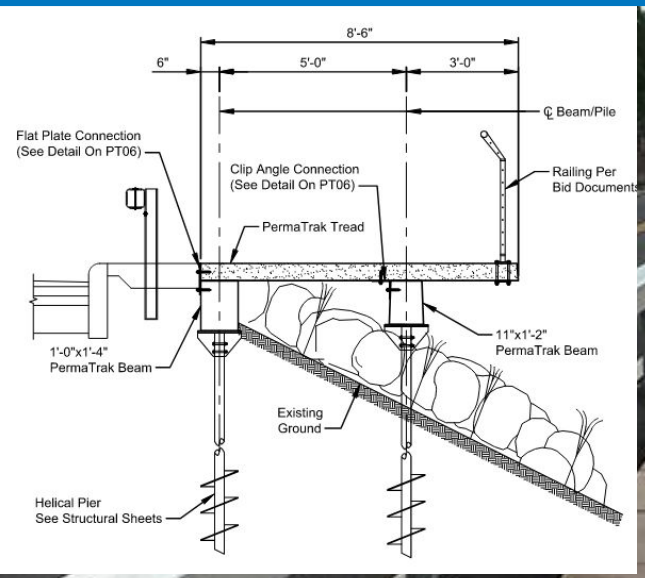
Multi-Use Trails

Upper Tampa Bay Trail – Tampa, FL
Designer: Cardno TBE
Owner: Hillsborough County, FL

Curved Alignments

Spencer Creek – St. Peters, MO

Boardwalk Along Street – Cantilevered Boardwalk



Elliott Way – Croton-On-Hudson, NY

Harsh Climates

Pikes Peak – Colorado Springs, CO

DOT Projects

- VDOT
- INDOT
- ILDOT
- WSDOT
- NYSDOT
- CALTRANS
- & OTHERS

Boardwalk Replacements

Before

After

Lilburn, GA – Camp Creek Greenway

Q&A

PermaTrak®
The Concrete Boardwalk Company

Contact:
Carrie Parada, P.E.
cparada@permatrak.com

Learn more at www.permatrak.com