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TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: International Perspectives and Case Histories on Foundation Reuse

April 15, 2025

1:00 – 2:30 PM



PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.



Purpose Statement

This webinar will cover how different agencies have approached the development of programs for reuse of existing infrastructure foundation elements. Presenters will share specific technical approaches on projects where foundation elements were reused for new superstructure construction.

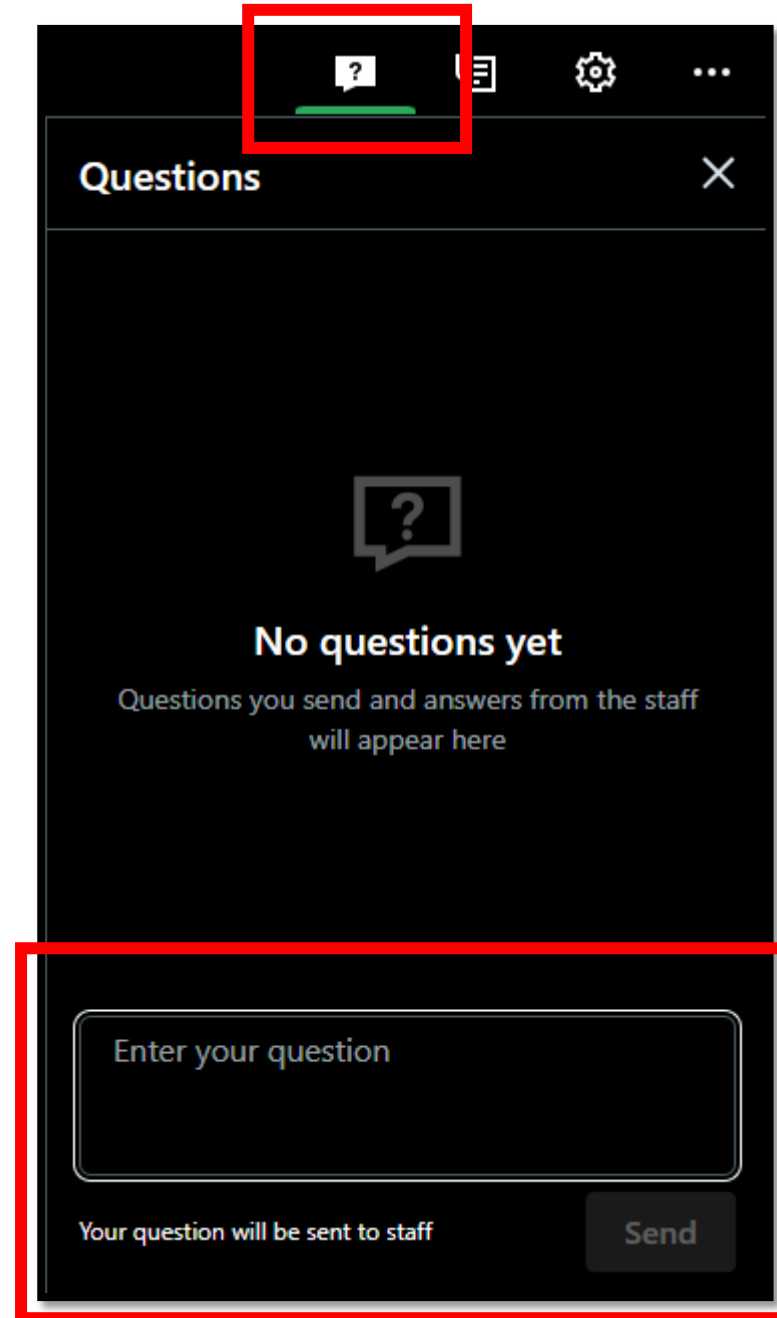
Learning Objectives

At the end of this webinar, you will be able to:

- Consider whether existing infrastructure foundations are suitable to be reused as part of a new structure
- Identify uncertainties in subsurface, layout, and foundation element geometry and conditions
- Understand how international agencies have managed and considered risk-based decision making

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters



Andrew Boeckmann
aboeckmann@dba.world
Dan Brown and Associates



Tony Sangiuliano
Tony.J.Sangiuliano@ontario.ca
Ministry of Transportation of Ontario Canada



Gerald Verbeek
gverbeek@verbeekservices.com
Verbeek Management Services



**NATIONAL
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International Perspectives and Case Histories on Foundation Reuse

Introduction

The philosophy



Economic models

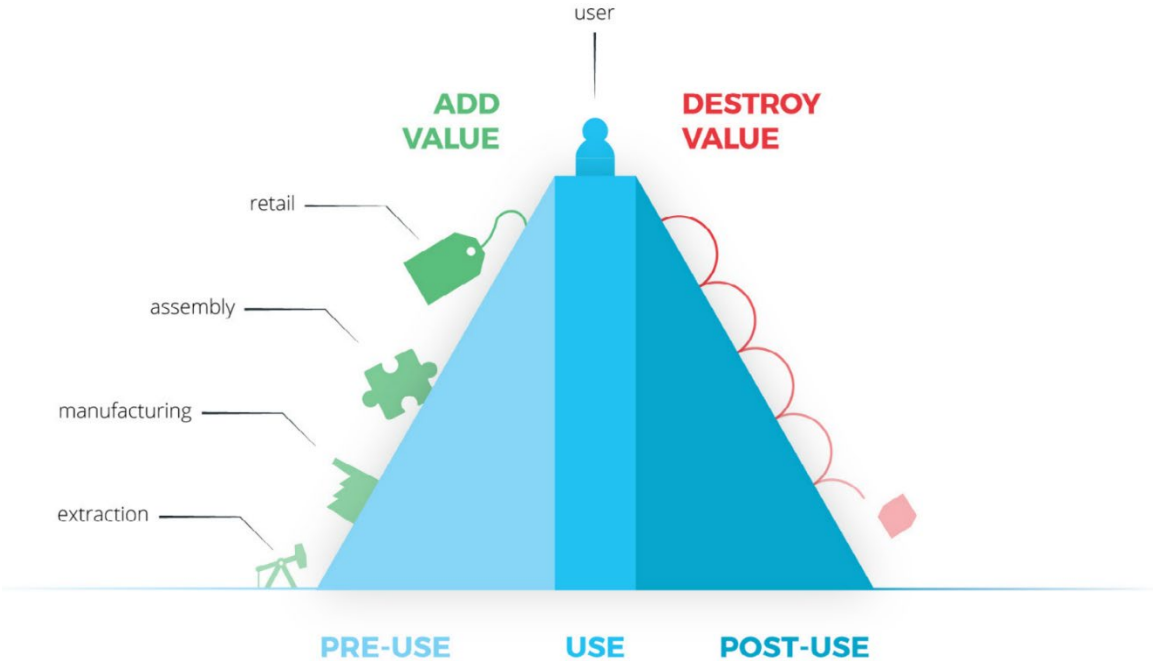


The philosophy

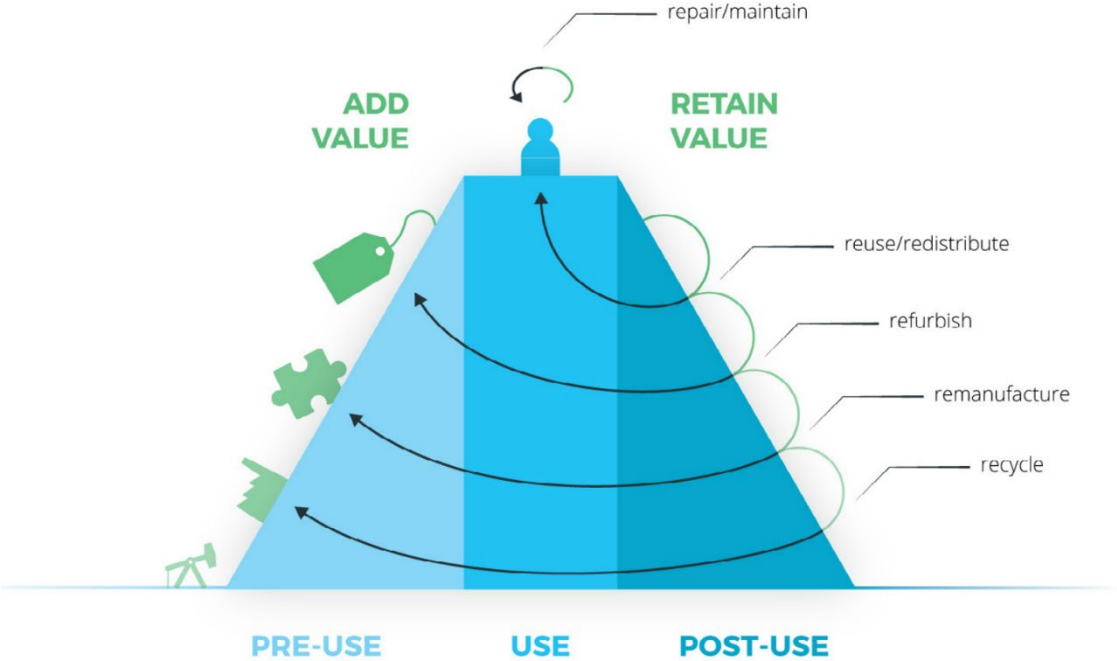


Economic models

The linear economy



The circular economy



[1] <https://www.circle-economy.com/master-circular-business-with-the-value-hill/#.XE...>



Conference on Foundation Decarbonization and Re-use



MARCH 21-23, 2023 | AMSTERDAM, NETHERLANDS

www.foundationreuse.com



A Typical Discussion

The parties involved





A Typical Discussion

The parties involved



For the geotechnical engineer foundation reuse may require him to assess the condition and capacity of existing foundation elements, with the associated risks.



A Typical Discussion

The parties involved



For the structural engineer it may mean adapting the design to match the existing foundation layout.



A Typical Discussion

The parties involved



For the architect it may restrict the design options for the same reason.



A Typical Discussion

The parties involved



For the owner it may mean dealing with requests for additional upfront investigations that may result in overall project savings and with members of his project team that feel constrained.



A Typical Discussion

The parties involved



For the regulatory body it means that they have to assess an approach that is relatively novel and for which limited guidance is available.



A Typical Discussion

The parties involved



For the insurance company it means having to assess risks of a new vs. an old existing foundation.



A Typical Discussion

The parties involved



X X X X X X

“Besides, the existing foundation would have to be supplemented anyhow, so you might as well install an entirely new foundation. You then also know what you have in the ground”.

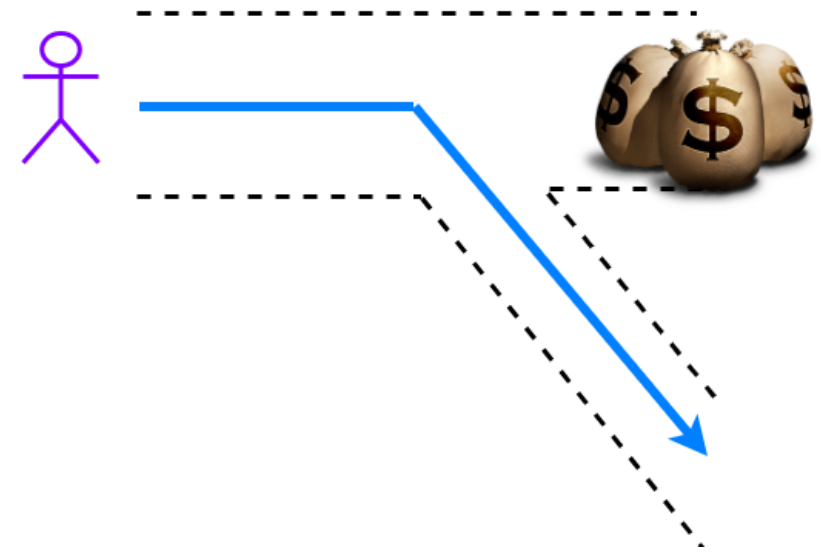


A Typical Discussion

The parties involved



X X X X X X





A Deeper Understanding

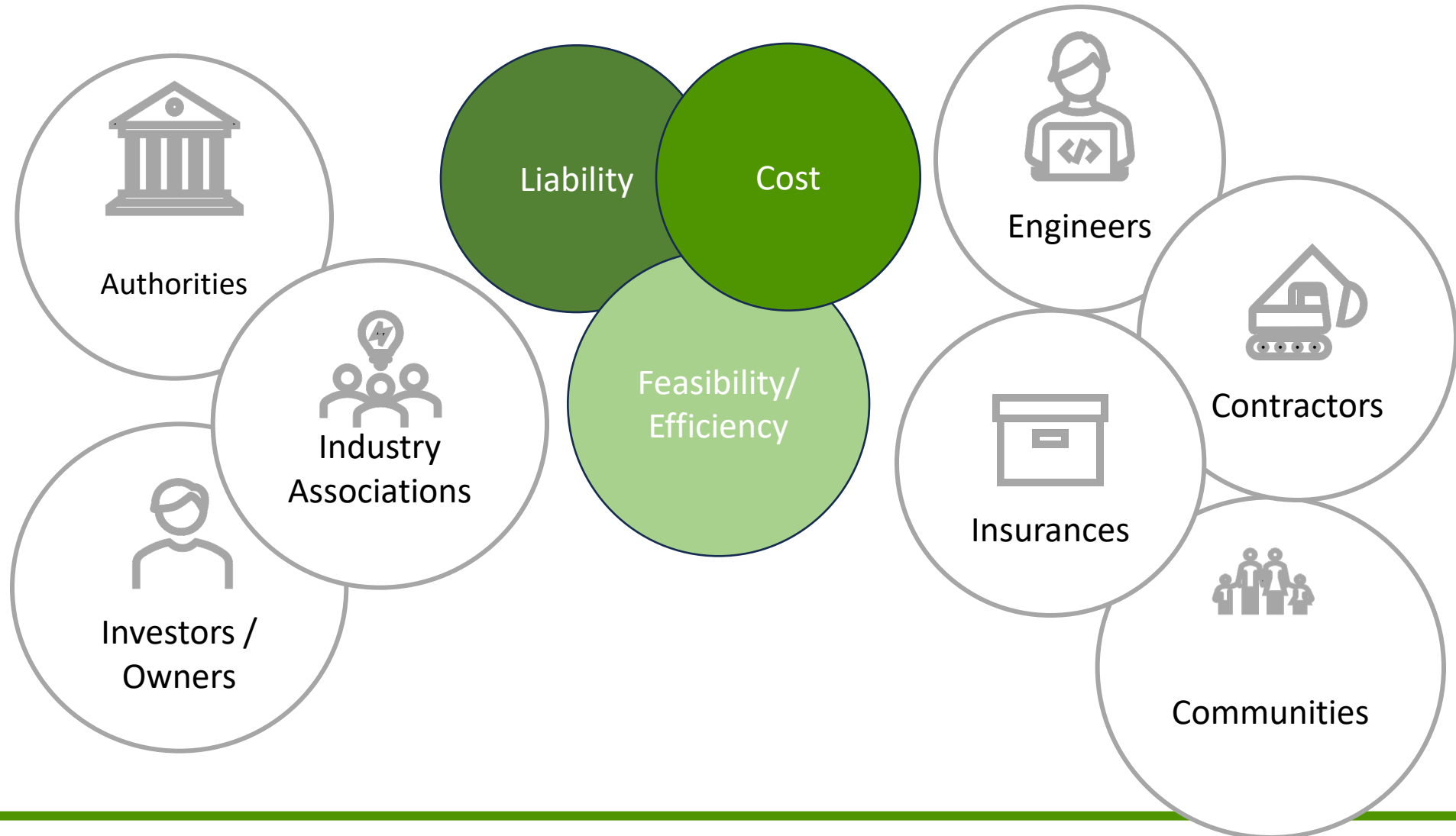
The parties involved

With thanks to Natalia Rucinska,
Environmental Director Menard





Stakeholders



Key Challenges



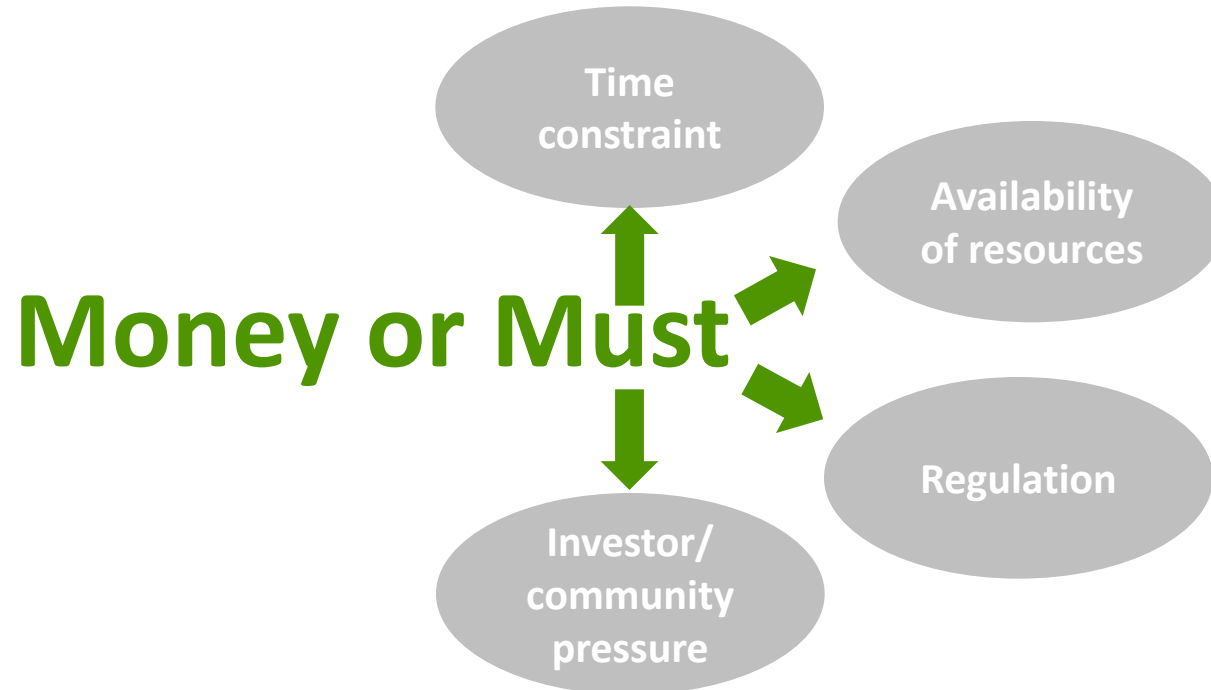
Everyone wants the solution to be cheaper

Nobody wants to take risk for the design and performance

In many cases no existing regulations/codes for decarbonization or re-use of foundations

Decision to decarbonize or re-use foundation has to be made in advance

What drives the Re-use Approach







Re-use and Lean Foundations:
joint efforts required to
make it a common practice





Transition strategy

With thanks to Maya Sule,
Program Manager Rijkswaterstaat

1. Ambition: What do we want to achieve?
2. Paths: Where can we have impact?
3. Approach: How are we going to realise the transition?



[1] <https://open.overheid.nl/documenten/ronl-9a139fb8-3bbb-4710-91a0-ecd523266bae/pdf>



Ambition: What do we want to achieve?

Climate agreements

Paris



Max 2°C



EU



55% ↓
in 2030 i.c.t. 1990

Carbon neutral in 2050



NL



55% ↓
in 2030 i.c.t.. 1990

Carbon neutral in 2050

Ambition Dutch Ministry of Infrastructure and Watermanagement

0 CO2 emissions and working circular in 2030

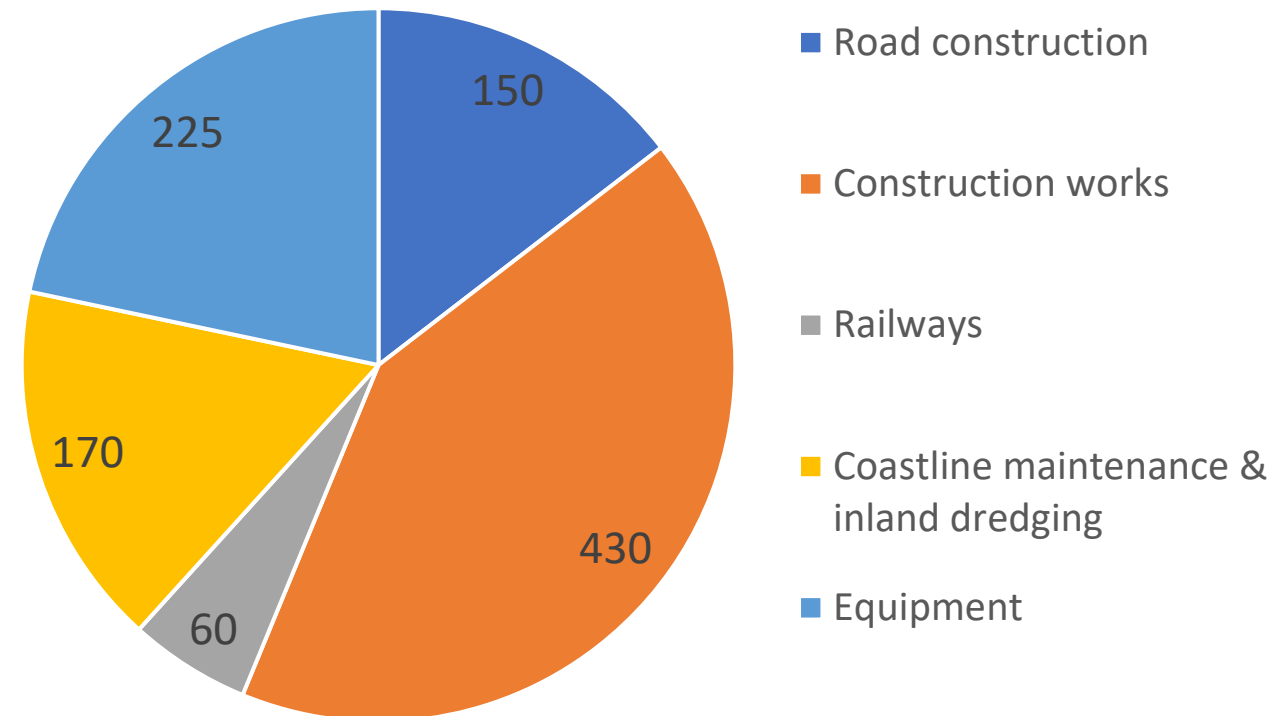


Paths: Where can we have impact?

CO₂ emissions

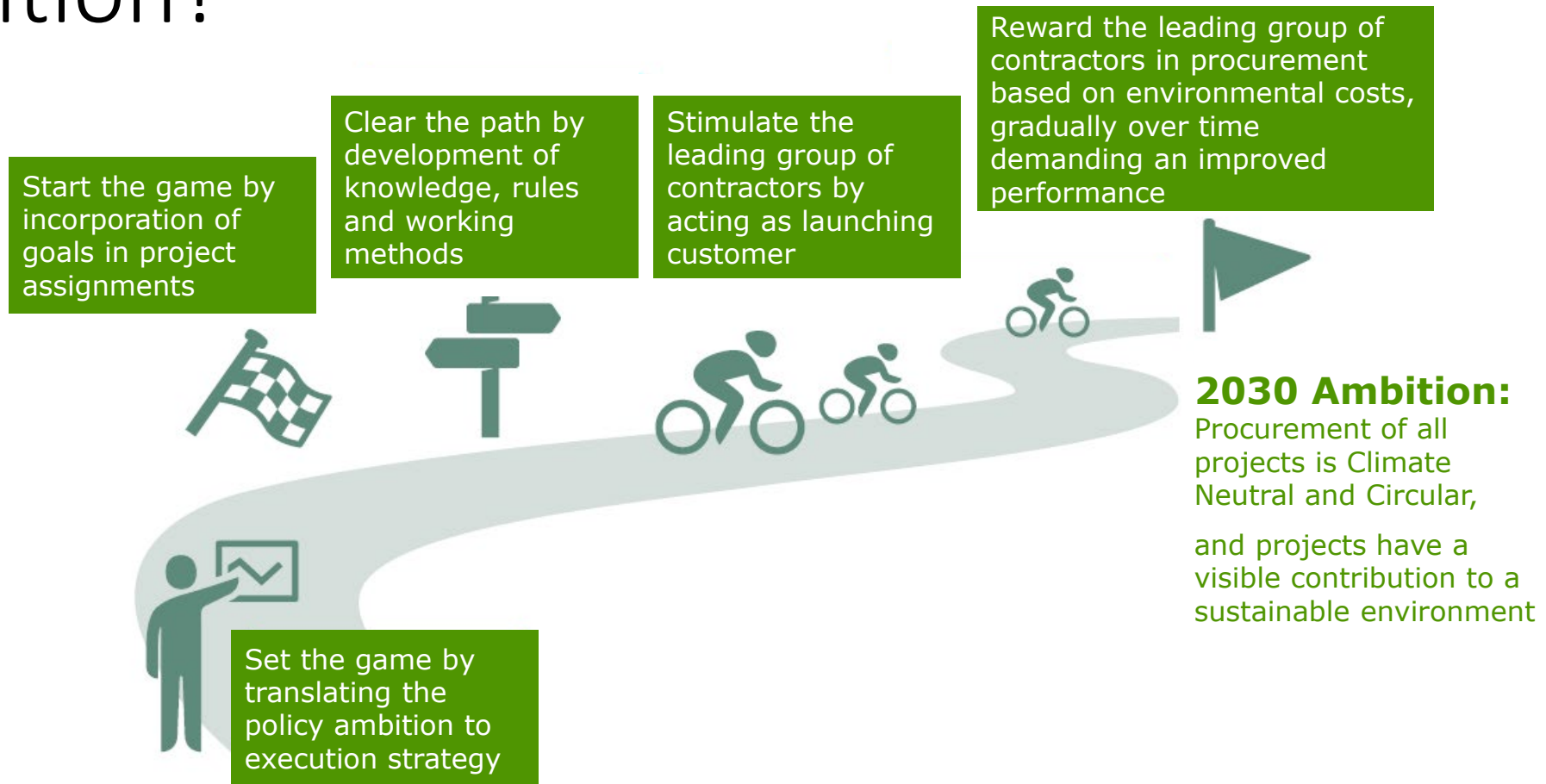
- National authorities
~1 Mtons/year
- Regional authorities
~2 Mtons/year

CO₂ emissions national authorities (ktons/year)





Approach: How are we going to realize the transition?





Re-use

An essential part of working circular and contributes to lowering

- Usage of primary material
- Carbon emissions
- Other environmental impacts

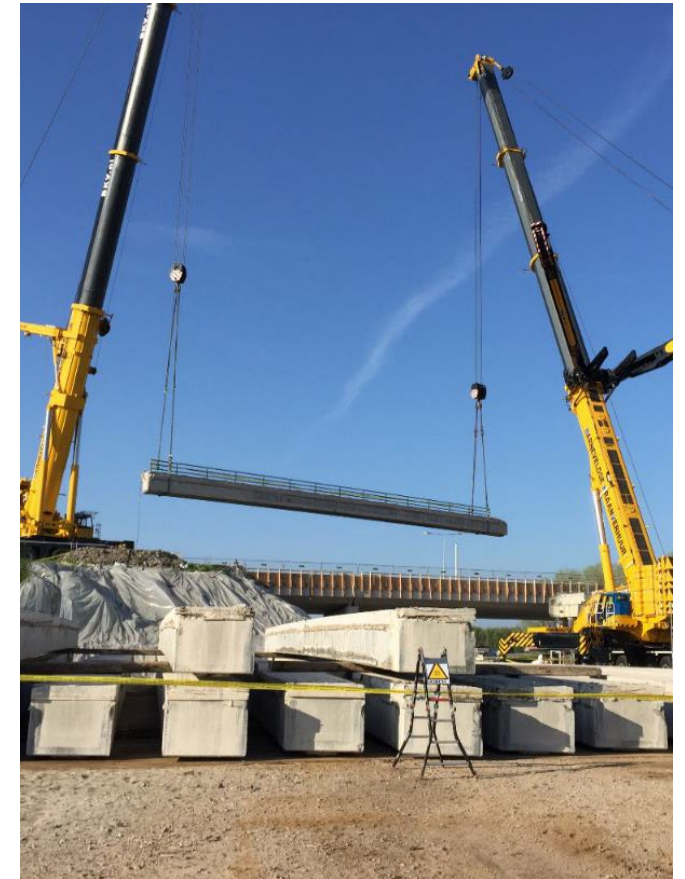
A solid option for

- Shortening the project schedule
- Reducing the project cost



New game, new rules, new roles?

- Who takes which part of the risk?
- Who is the owner of used elements?
- Who stores used elements before they are re-used?
- Who matches demand and supply?
- How can we stimulate/ask for re-use?
- How can we settle project costs versus organisation benefits?





Advice on re-use

- State of art of re-use in public works
- Best practices
- Advice which strategy to follow





What is needed to re-use in public works in general?

- Design choices have to be reconsidered
- Depending on the object: standards and regulations have to be adjusted
- In order to increase market maturity re-use has to be stimulated by owners temporarily
- Sometimes this means owner has to take another role (e.g., becomes supplier of products)
- Costs and benefits have to be calculated and organized across projects (might not be applicable for foundations)



...and for re-use of foundations?

Comparing to the other objects:

- Re-using in place has the advantage that they do not have to be stored

But...

- Is quality control too expensive and does it cost too much time?
- With rising carbon prices, is it responsible to leave unused foundation in the ground?



Conclusion

- Re-use is possible
- Examples of re-use in the civil infrastructure sector (www.foundationreuse.com)
- Young people want to work on sustainable solutions

Why Rebuild it When You Can Reuse It?

*Concepts, Examples, and
Research on Foundation Reuse*

Andy Boeckmann
Dan Brown and Associates



Acknowledgments

- NCHRP
- Maine DOT: Laura Krusinski
- MoDOT: Matt Kraus, Matt Wilkerson, Brandon Nelson
- Penzel Construction Company, Inc.
- MU: Brent Rosenblad, John Bowders, Levi Good, Mohammed Khan, Erik Loehr
- DBA: Paul Axtell, Tim Siegel

Learning Objectives

By the end of this webinar, attendees will be able to...

- (1) Identify the motivations for foundation reuse
- (2) Compare design for foundation reuse projects with design for new foundation projects
- (3) Identify the folly of using old plan capacity values as the capacity for new projects

Motivations for Foundation Reuse

- Lifespan of foundation generally exceeds lifespan of overlying structure
- Reduce project costs (save money)
- Reduce project duration (save time)
- Minimize mobility impacts (transportation)
- Historic preservation
- Ground congestion



93 Fast 14

- 14 structures
- ADT: 200,000 NB/SB
- 10 consecutive 55-hour work weekends over summer
- No impact to weekday rush hour traffic

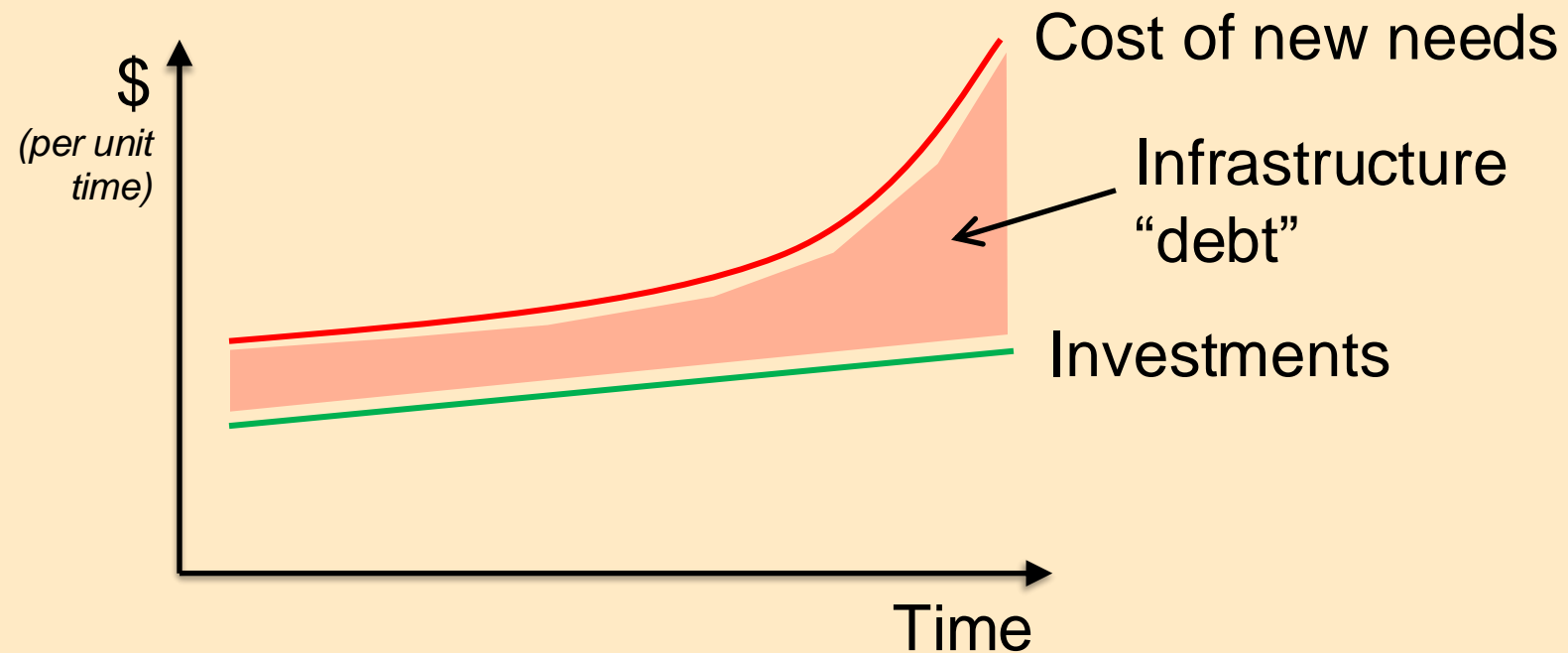
Slide credit:
Pete Connors, MassDOT

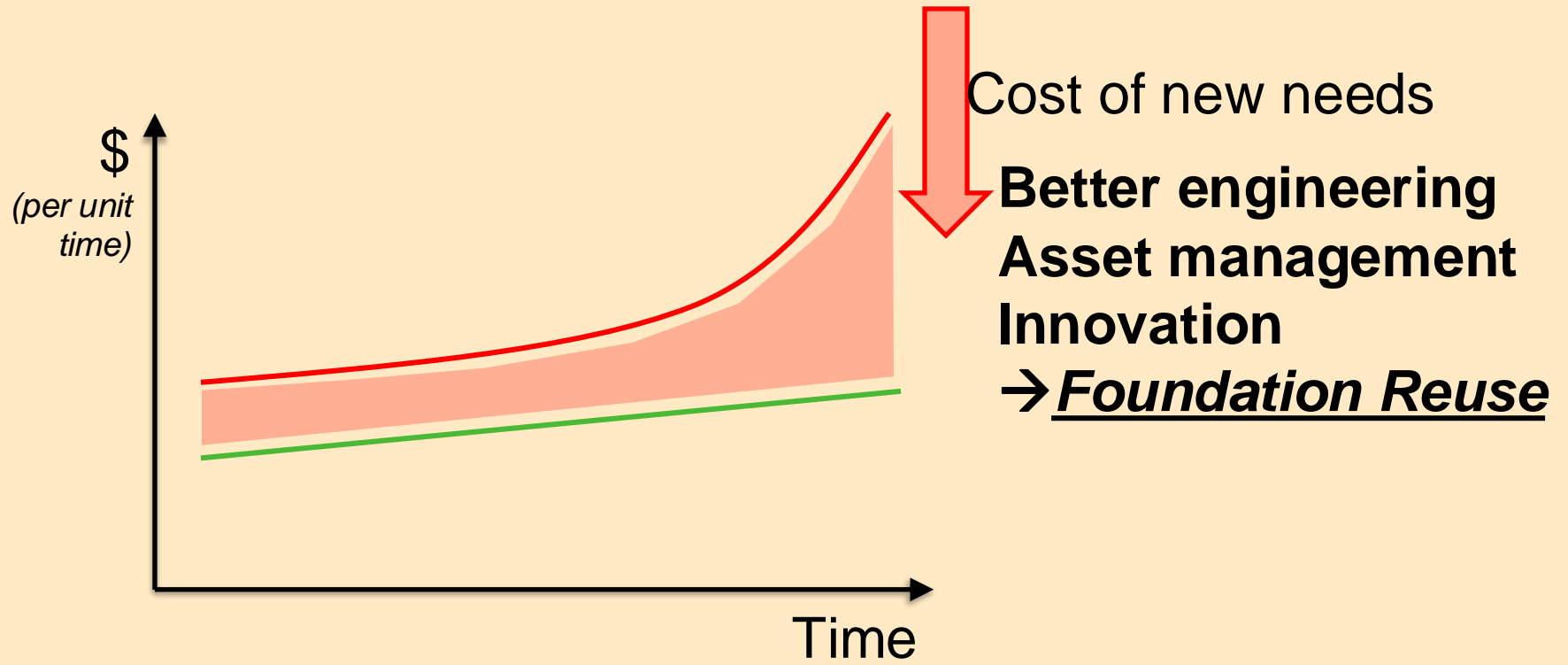
More #Motivations: Trending

- **Reliability**: A used foundation is a tested foundation
- Reuse is fundamentally **sustainable**
- Reuse “fits” with sound **asset management**

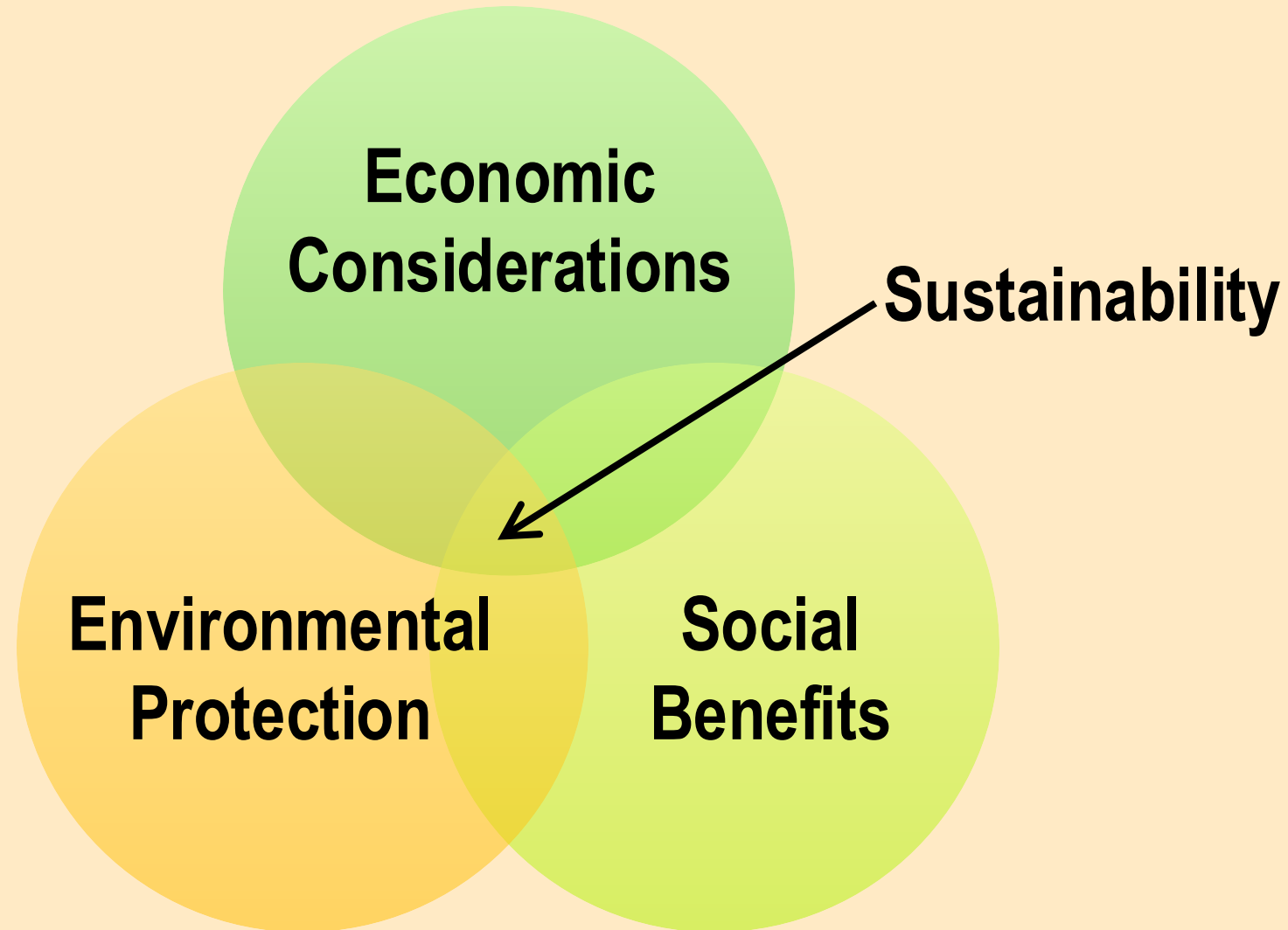
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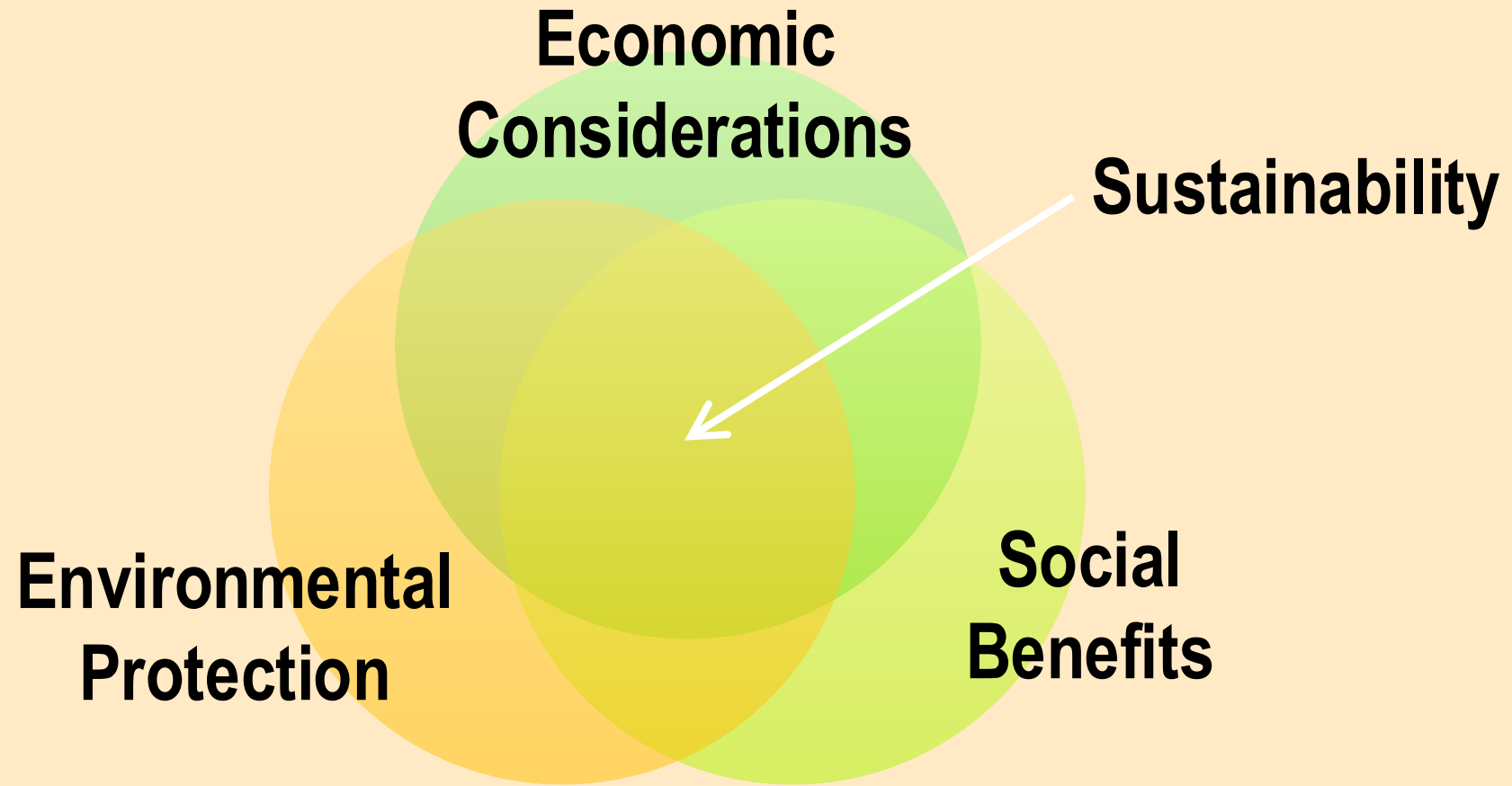


Sustainability



from World Conservation Union, 2005

Sustainability: Infrastructure Design



New DFI Committee

- Task force on reuse started in early 2021
- Meeting monthly since 2021; officially committee in February 2024
- Mission: Reduce impediments to foundation reuse through outreach, promotion of technical advancements, and development of guidance
- <https://dfi.org/communities/foundation-reuse/>
- Committee formation evidence of interest in the topic
- Developing a guide spec for reuse.

DFI Case Examples



DEEP FOUNDATIONS INSTITUTE
SUBSURFACE CHARACTERIZATION
COMMITTEE PRESENTS

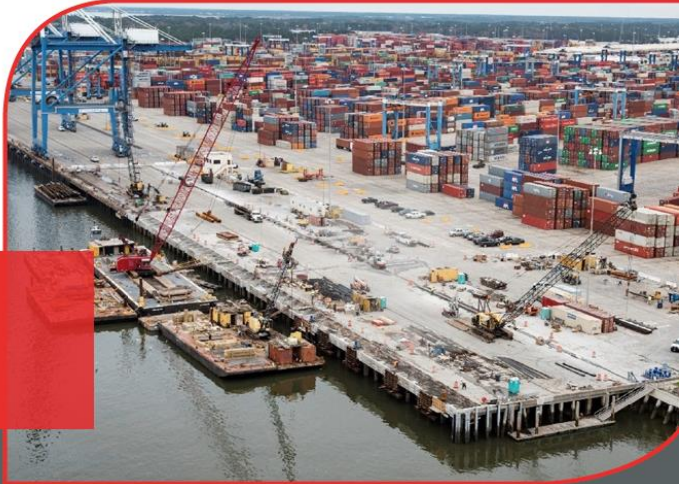


WATERFRONT DEVELOPMENT:
-Use of Existing Pier Piles

Massachusetts Port Authority



DEEP FOUNDATIONS INSTITUTE
SUBSURFACE CHARACTERIZATION
COMMITTEE PRESENTS

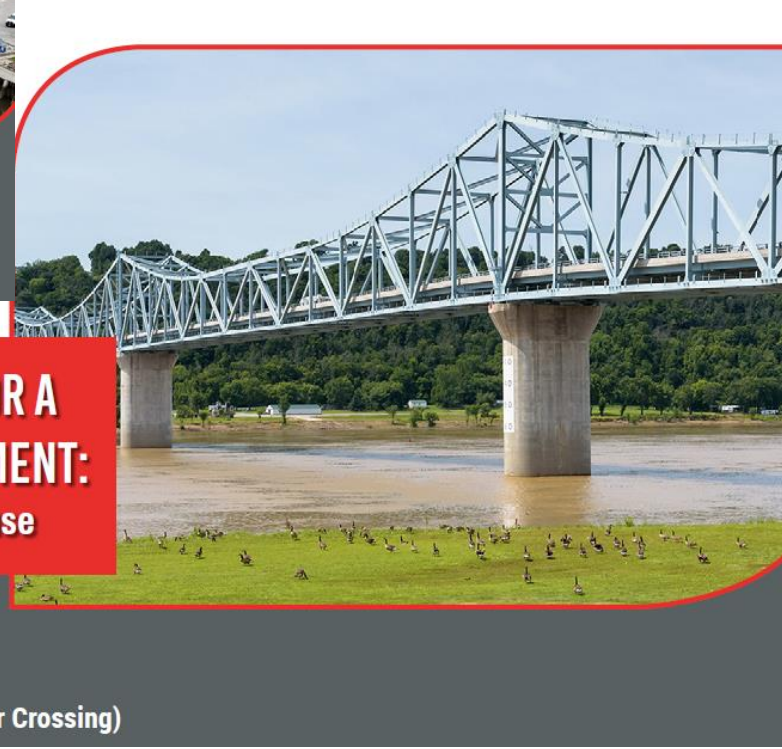


REUSE SAVES \$9M
for Port Reconstruction

South Carolina Ports Authority
Charleston, SC

SCOPE OF FOUNDATION WORK

COMMITTEE PRESENTS



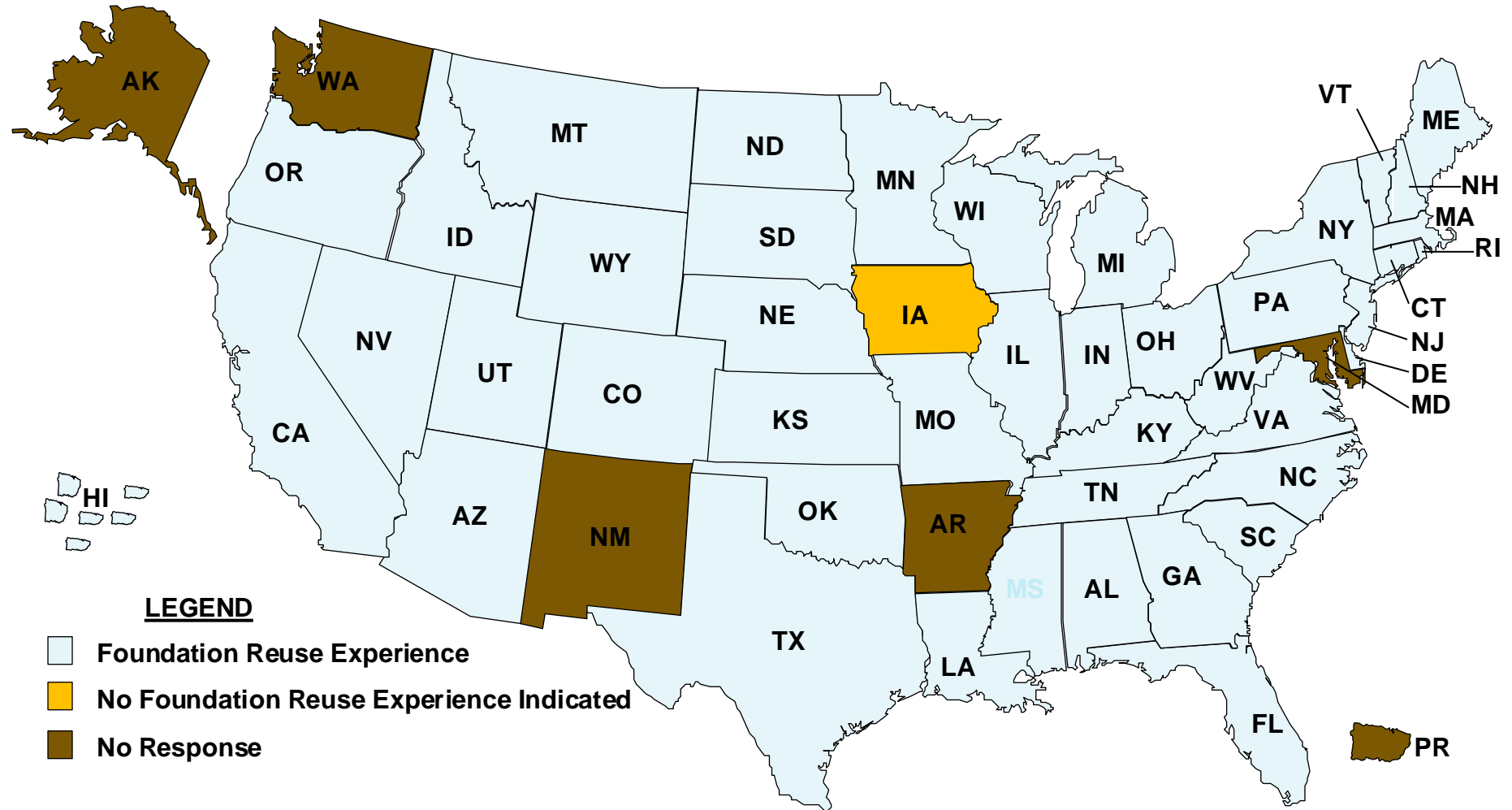
MAJOR MOBILITY MITIGATION FOR A MAJOR RIVER BRIDGE REPLACEMENT:
Milton-Madison Bridge Foundation Reuse

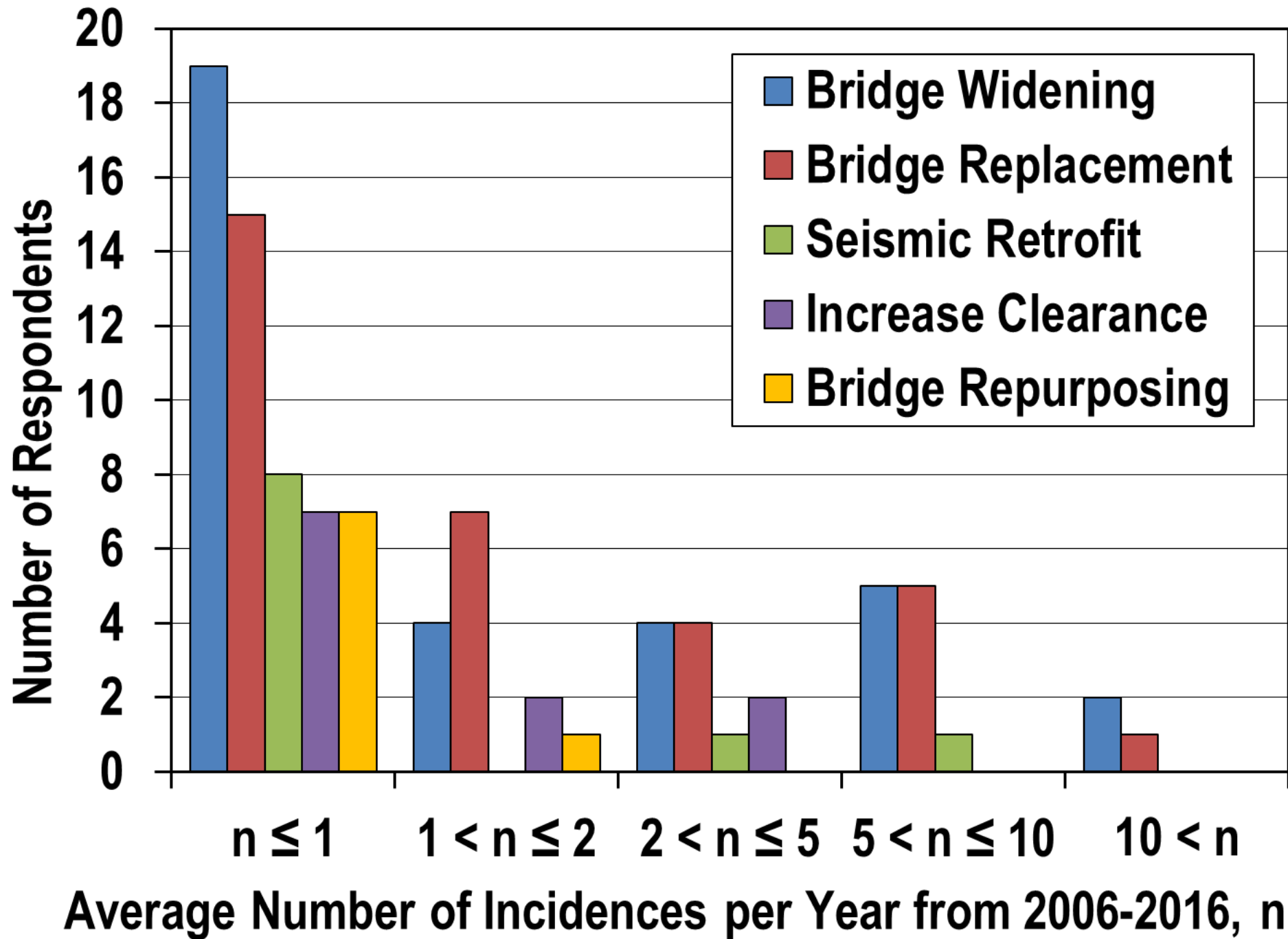
Indiana DOT, Kentucky
Transportation Cabinet, USDOT
Madison, Indiana and Milton, Kentucky (Ohio River Crossing)

NCHRP Synthesis 505

- <https://www.trb.org/NCHRP/Blurbs/175558.aspx>
- Or Google “NCHRP Foundation Reuse”
- NCHRP Synthesis program
 - ~20 topics studied each year to establish state of practice
 - For each topic, survey all 50 transportation agencies
 - Select agencies studied in depth for case examples
- Survey performed almost 10 years ago
- Limited to transportation sector

NCHRP Synthesis 47-03 Survey





Challenges for Foundation Reuse

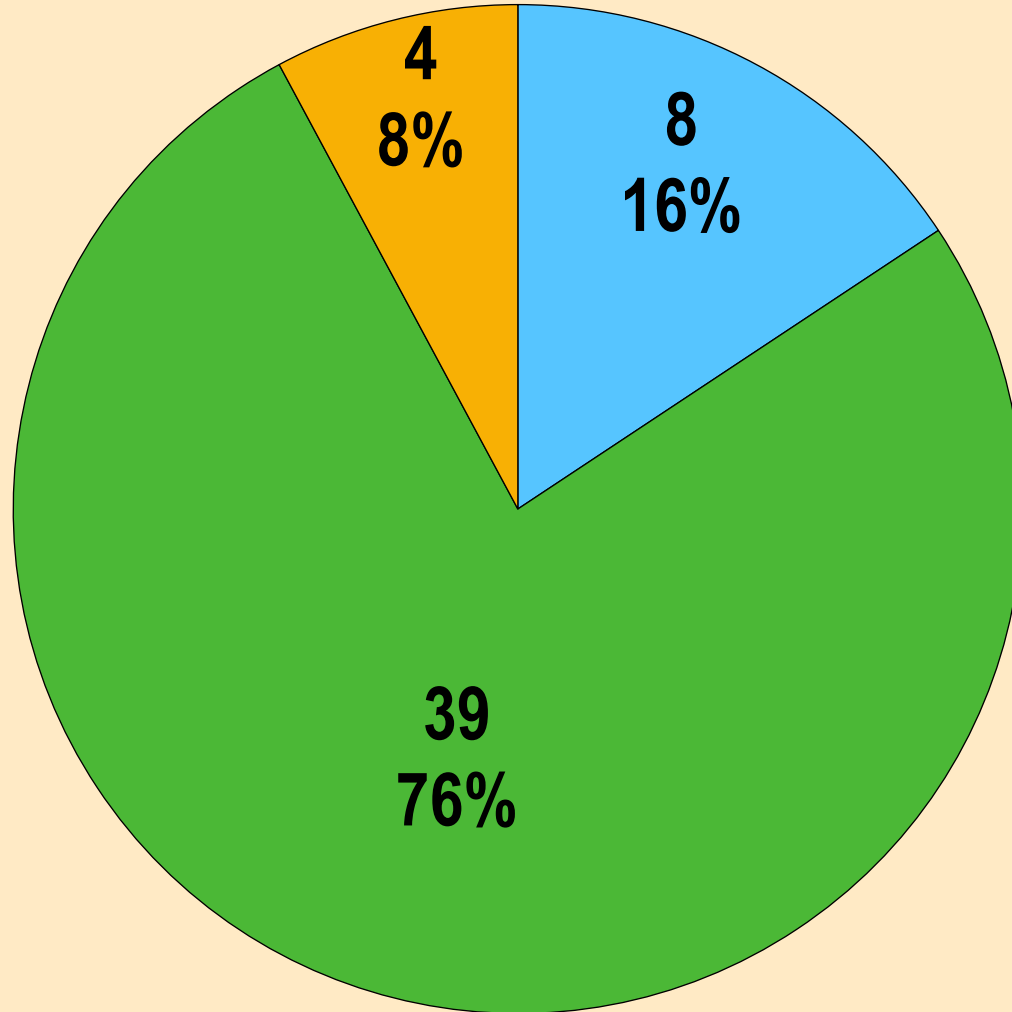
Four were identified by TRB Committee AFP30:

1. Condition assessment
2. Load capacity
3. Remaining service life predictions
4. Design codes

Add a pair:

5. Nature of risk is different
6. Lack of guidance

Foundation Reuse Policy?



■ Yes, agency has policy(ies) related to foundation reuse.

■ No, agency does not have a policy related to foundation reuse.

■ I don't know.

Investigation of Existing Foundations

- As-built records
- Excavation
- Core drilling of foundation
- Pile integrity testing (e.g. sonic echo)
- Surface geophysical methods
- Borehole geophysical methods
- Others?

Maine DOT: U.S. Route 1 Viaduct

- 1300-ft long, 20 span structure in Bath, ME.
- Replaced from ground up in 2016
- 11 piers, 1 abutment on H-piles
- Other bents are on spread footings on rock
- Conventional investigation techniques included borings and lab testing

Test Pits



Photos courtesy of Haley & Aldrich

Parallel Seismic Testing

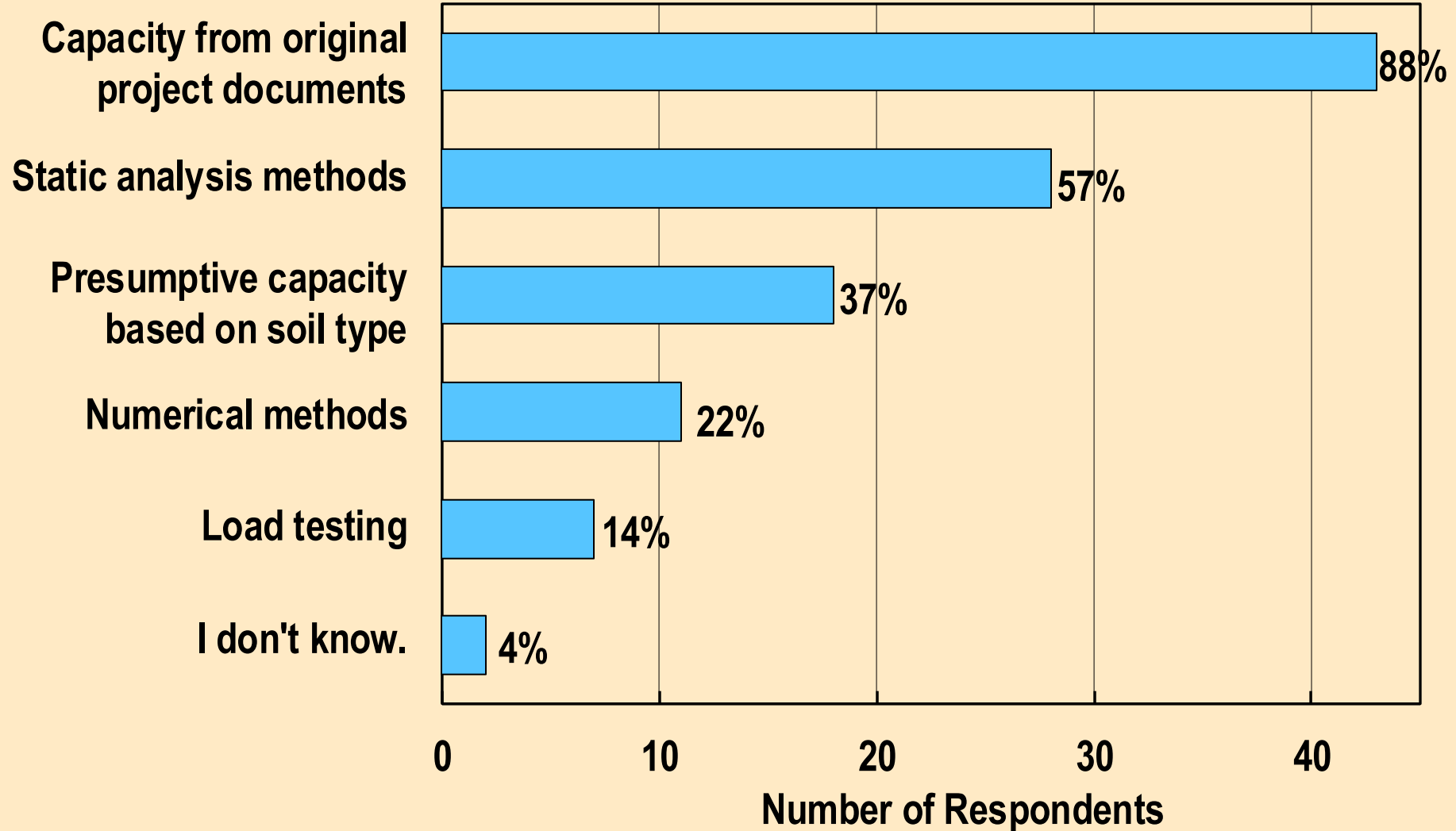


Photo courtesy of Olson
Engineering

Results

Location	Pile Tip Elevation, feet			Top of Bedrock Elevation, feet	
	As-built Lower Bound	As-built Upper Bound	Parallel Seismic	Historic Boring	Rehab Boring
Pier 5	10.2	14.8	14.9	14.3	15.4
Pier 7	-17.4	4.1	6.3	-2.4	3.5
Pier 10	-4.5	4.4	-5.5	1.8	-4.3
Pier 19	-42.7	-27.8	-17.2, -34.6	-30.2	-37.9
Abutment 2	-40.0	-19.9	-25.2	-28.2, -23.4	-30.6

Methods used to predict existing capacity



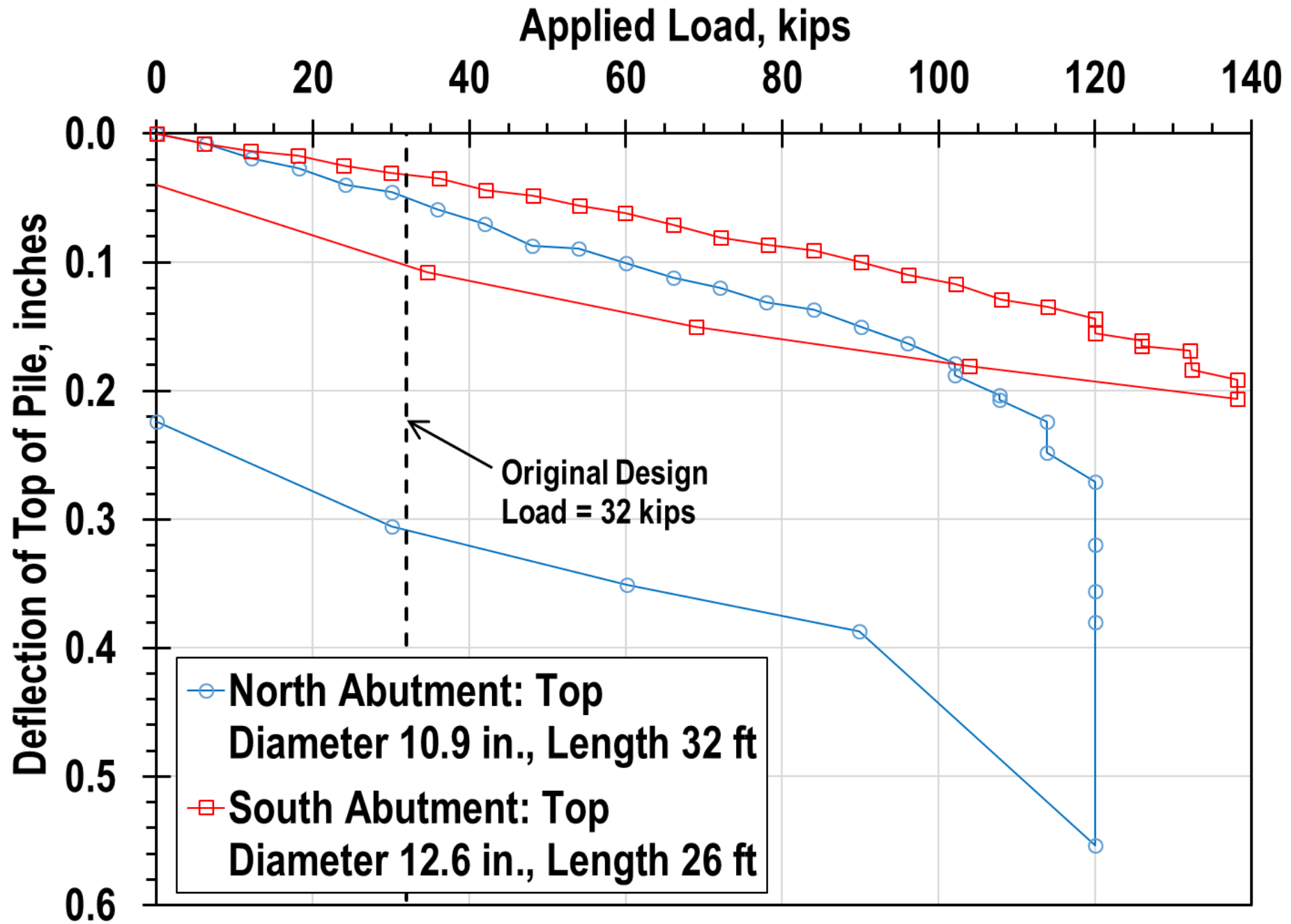
Maine DOT: Haynesville Bridge Replacement

- Three spans over Mattawamkeag River
- Abutments on treated timber piles
- Piers on untreated timber piles
- Investigation included borings, pile integrity testing, and load testing.
- Piles driven through alluvial sand and silt with gravel over bedrock, appx. 30 ft deep.
- Excavation exposed piles; no signs of decay.
- SE/IR indicates piles driven to rock, consistent with plans

Load Test Existing Piles



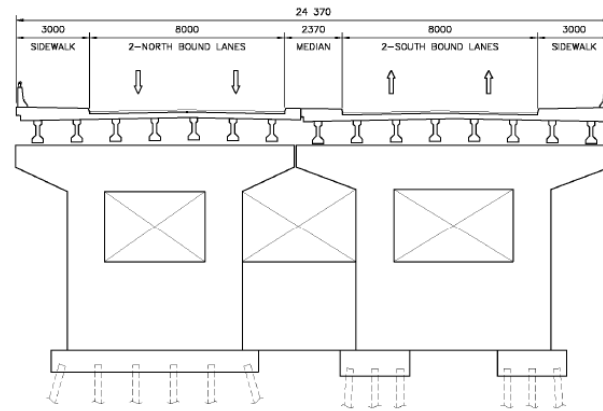
Photos courtesy of GZA
GeoEnvironmental



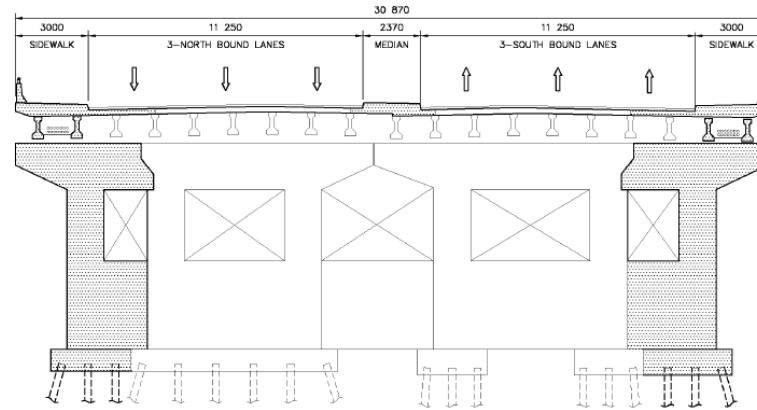
Improvement Techniques

- Enlarged footing
- Additional foundation elements:
 - Piles, shaft, micropiles, tiebacks
- Replacement of backfill with lightweight fill
- Ground improvement
- Pier stem widening
- Electrochemical chloride extraction

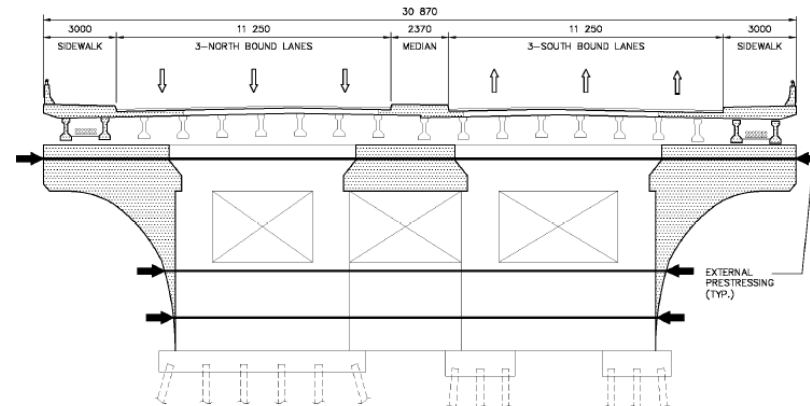
**EXISTING
BRIDGE**



**CONVENTIONAL
WIDENING
SCHEME**



**INNOVATIVE
WIDENING
SCHEME**



Li, Lee, Cholewa (2010),
“An Innovative Solution to Integrate
Existing Substructure to Effect
Economy and Constructability in a
Bridge Widening Project,”
Proceedings of the 8th International
Conference on Short and Medium
Span Bridges, Canada.

Decision Methods (Europe)

- Sustainable Project Appraisal Routine (SPEAR) – “bullseye” figure
- Reuse of Foundations for Urban Sites (RuFUS) – flowchart
- Construction Industry Research and Information Association (CIRIA) Document C653 – simple flowchart
- Hybrid method by Laefer and Farrell (2015) – modified SPEAR plus chart

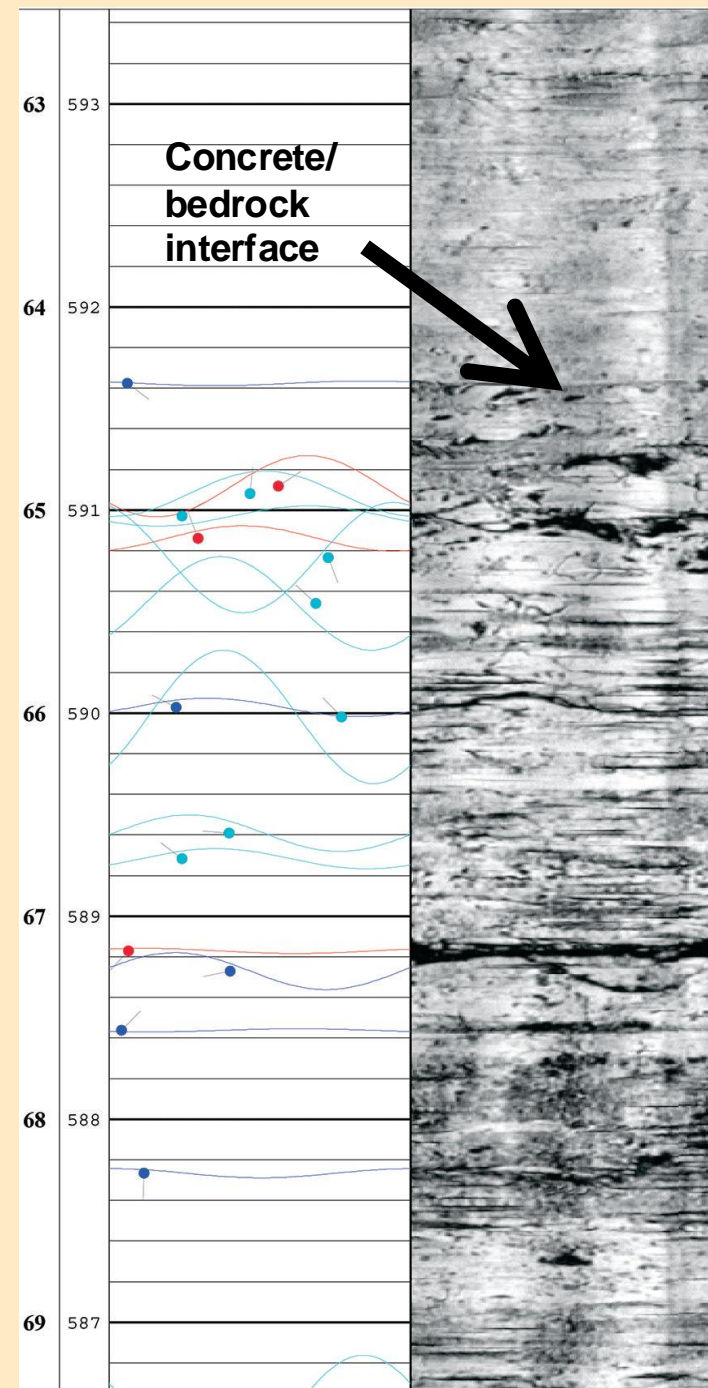
Hurricane Deck Bridge Replacement

- 2012 MoDOT project at the Lake of the Ozarks
- Original bridge built in 1920s and 1930s on pneumatic caissons



Axtell, P.J. and T.C. Siegel (2014), "Sustainability and Consideration of the Re-use of Foundations for the Hurricane Deck Bridge," Proceedings of the 39th Annual Conference of the Deep Foundations Institute, p. 163-170.

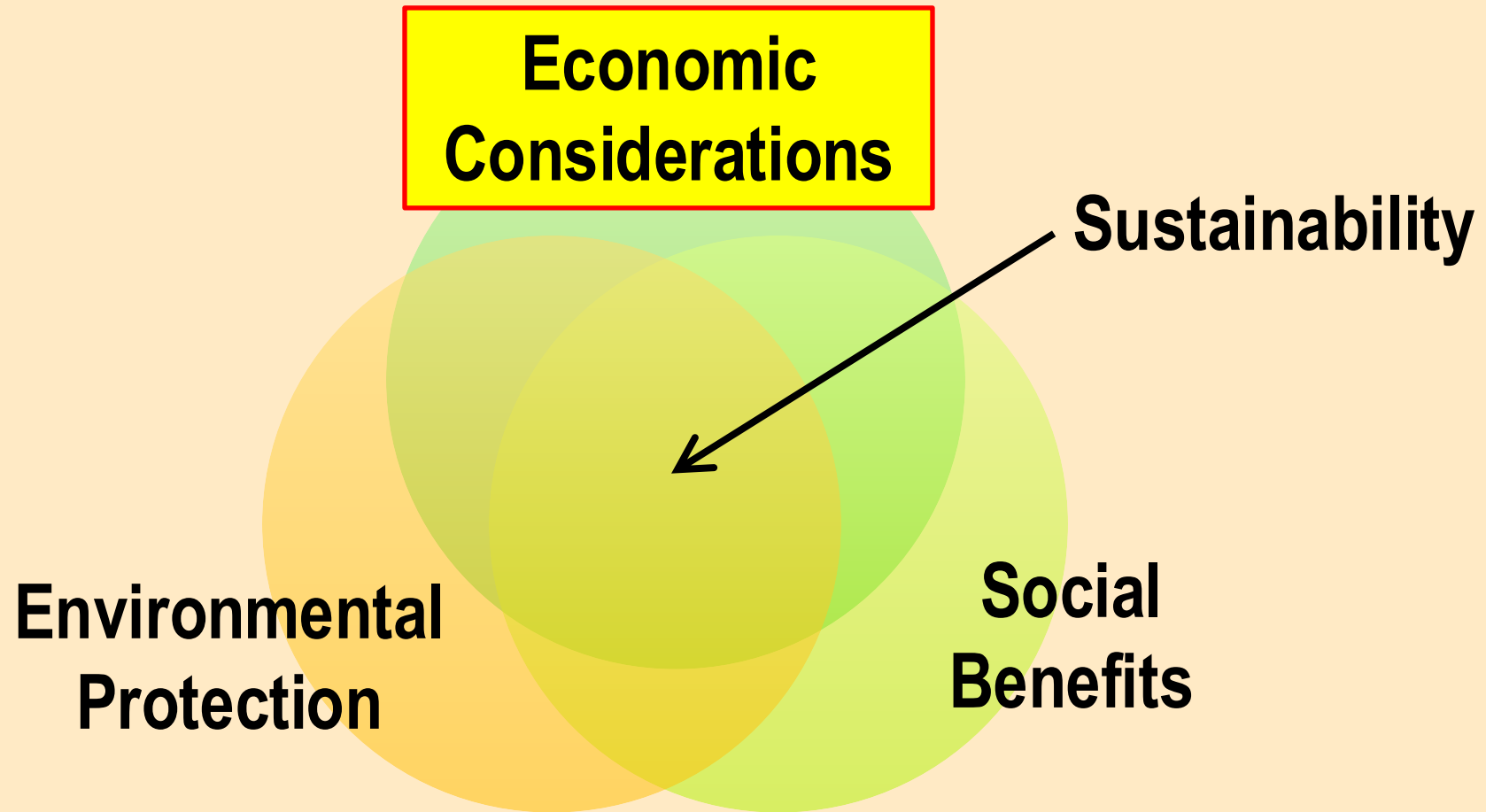
Investigation



Hurricane Deck: Design Alternatives

- Baseline: Reuse caisson foundations
 - With temporary foundations and new superstructure slide
- Alternative Technical Concepts (ATCs) allowed
- One ATC: new permanent bridge alignment with shorter spans. Supported on new shafts.
- Ultimately this ATC was selected. Cost 1% less than lowest baseline bid.
- Conclusion: sustainability versus economy – false choice?

Alternative Decision Method



Alternative Decision Method

- Spending more than necessary is not sustainable.
- Reuse vs. rebuild: if all other factors equal
 - Cheaper option is probably better for the environment (less material)
 - Cheaper option is better stewardship of public money (social benefit).
- We're better at predicting costs than social or environmental factors.

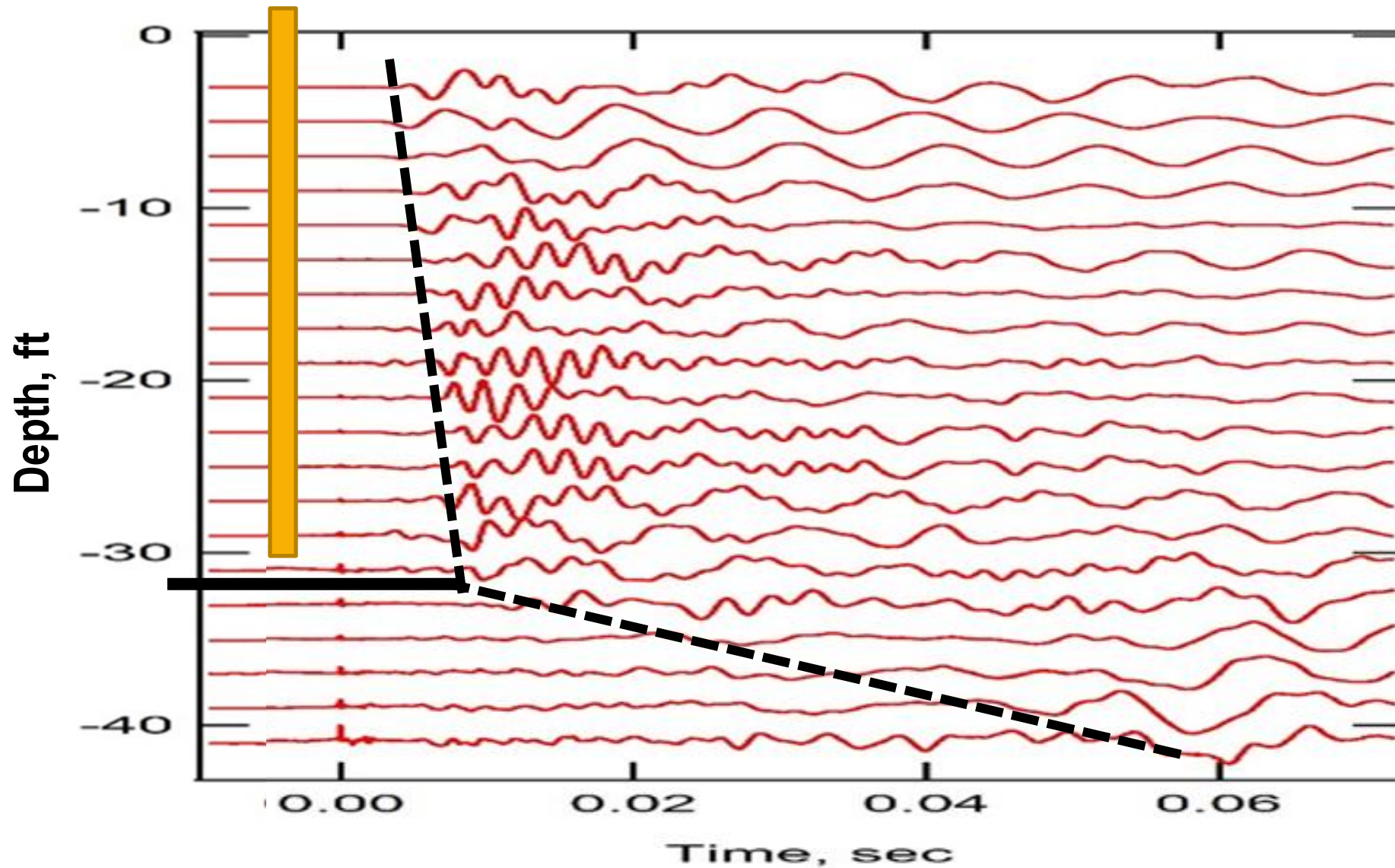
2016 MU/MoDOT Research

For two bridge replacements in SE MO:

1. Predict pile lengths using SE/IR and parallel seismic
2. Load test piles
3. Restrike piles with PDA
4. Exhume piles



Depth from old plans = 30 ft



CIP Pile Extraction



CIP Pile Extraction



Extracted Precast Piles



Extracted Precast Piles



Extracted Precast Piles



Extracted CIP Piles



Extracted CIP Piles



Extracted CIP Piles



Extracted CIP Piles



CIP Wall Thickness

Pile	Section	Corroded?	Wall Thickness Measurements, in.			Average
1	Pile Top	No	0.264	0.260	0.270	0.265
	Top Cut	Yes	0.264	0.256	0.260	0.260
	Bottom Cut	No	0.264	0.262	0.260	0.262
2	Pile Top	No	0.275	0.258	0.238	0.257
	Top Cut	Yes	0.290	0.268	0.274	0.277
	Bottom Cut	No	0.255	0.268	0.283	0.269
3	Pile Top	No	0.250	0.262	0.270	0.261
	Top Cut	Yes	0.265	0.265	0.269	0.266
	Bottom Cut	No	0.255	0.265	0.258	0.259
4	Pile Top	No	0.287	0.265	0.275	0.275
	Top Cut	Yes	0.265	0.261	0.265	0.268
	Upper Middle Cut	Yes	0.255	0.275	0.300	0.278
	Lower Middle Cut	No	0.265	0.255	0.248	0.256
	Bottom Cut	No	0.264	0.260	0.270	0.265
5	Top Cut	Yes	0.275	0.295	0.270	0.280
	Bottom Cut	No	0.275	0.280	0.265	0.273
6	Pile Top	No	0.280	0.284		0.282
	Top Cut	Yes	0.283	0.285	0.280	0.283
	Bottom Cut	No	0.270	0.269	0.264	0.268

CIP Wall Thickness

Corroded?	Wall Thickness Measurements, in.		
	Average	Std. Dev.	COV
No	0.266	0.010	3.9%
Yes	0.272	0.012	4.6%

Difference between corroded and uncorroded:
2.5% (about $1/2 \sigma$; not significant)

Minimum wall thickness per 1960s
specification: 0.23 in. (or 0.25 in.?)

Load Test

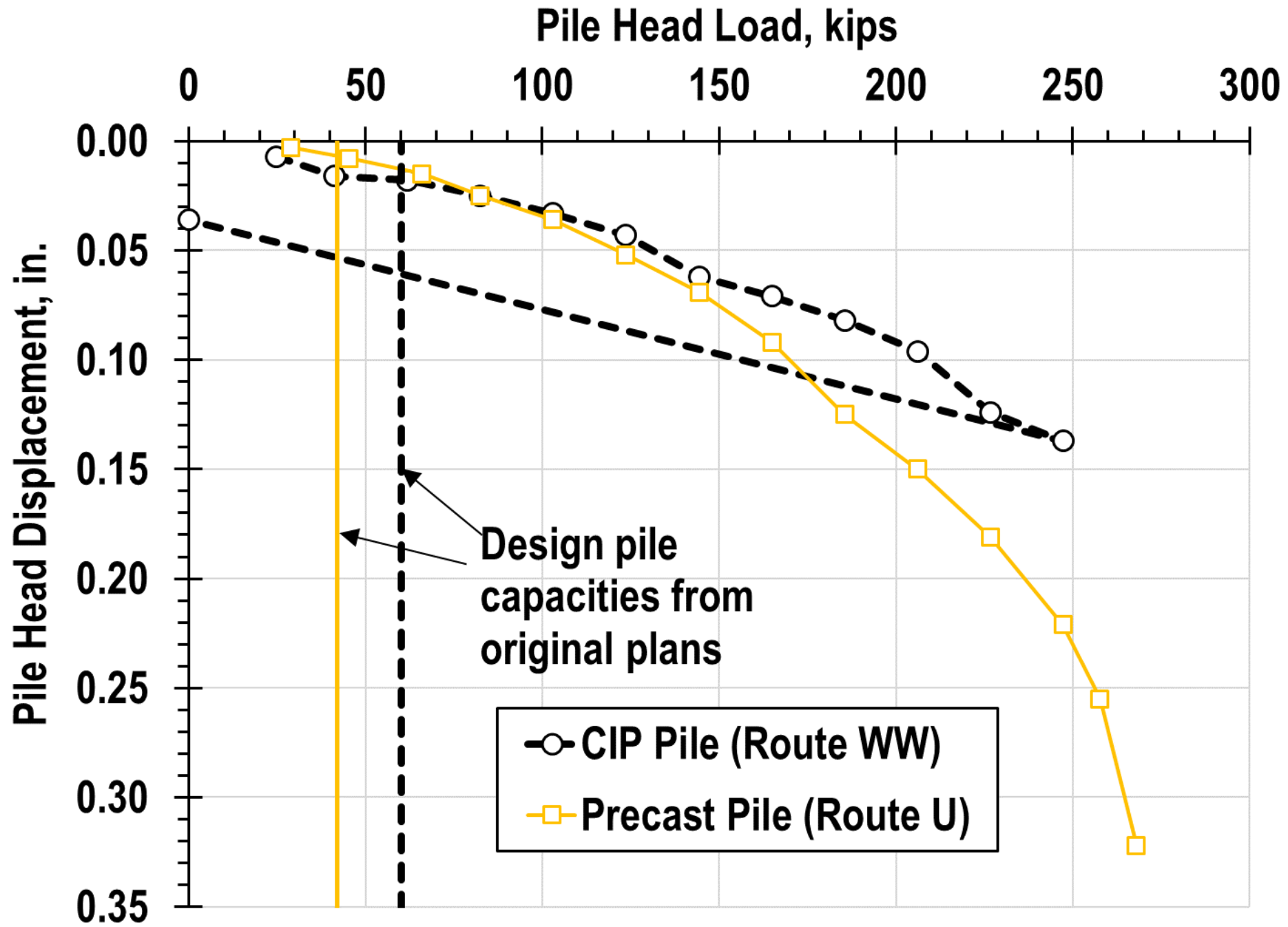


Load Test



Load Test

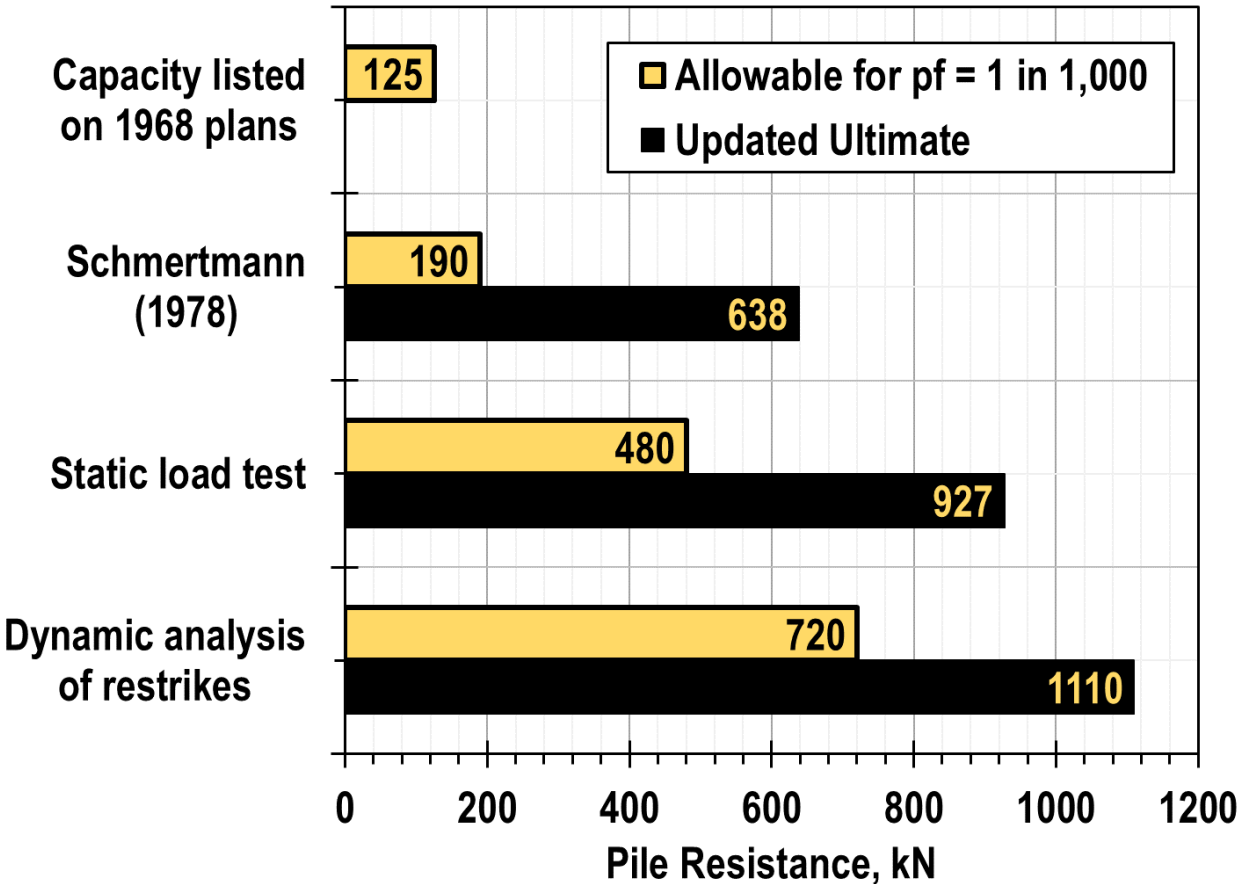




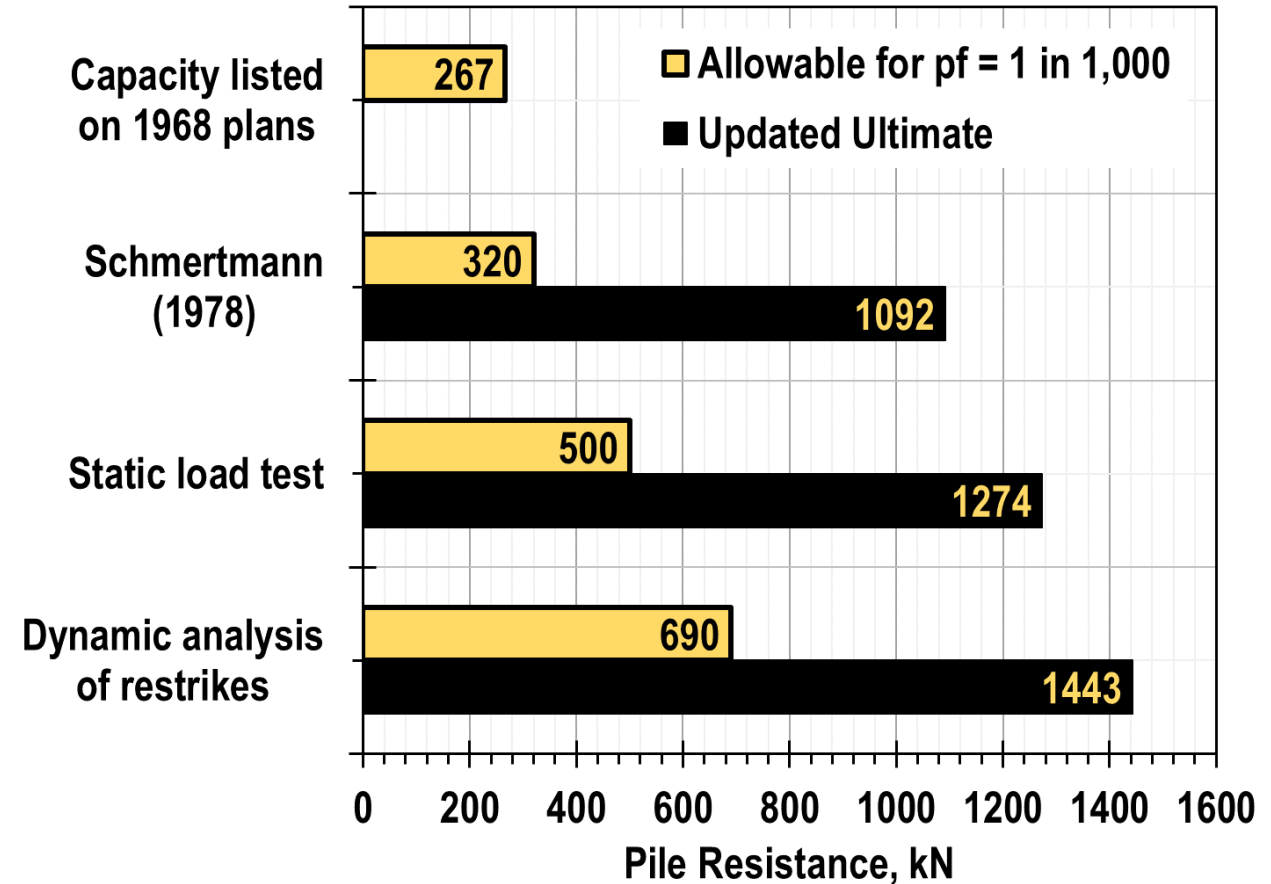
Summary of Capacity Values

Method	Ultimate Resistance in kips (% of load test value)	
	Precast	CIP
1960s Plans, assume FS = 3	126 47%	180 73%
Range of Static Predictions (MU)	130 - 574 49 - 214%	213 - 630 86 - 194%
High-strain Dynamic Restrike (Did not mobilize full tip resistance)	>270 >100%	>270 >110%
Load Test	>268	>247

Use Bayesian updating to perform reliability analysis...



Precast Piles



CIP Piles

New INDOT Research on Reuse of Driven Piles

- Indiana DOT has lots of “minor” reuse projects (bridge widenings, small bridge replacements) with small increases in pile demand that currently impede reuse
- Can we demonstrate that the existing piles have sufficient reserve capacity to be reused?
- Six sites (!) with testing scheme similar to MoDOT work
- Calibrate design resistance factors that depend on analysis method
- Develop guidance with provisions for investigation and design

Learning Objectives

By the end of this webinar, attendees will be able to...

- (1) Identify the motivations for foundation reuse
- (2) Compare design for foundation reuse projects with design for new foundation projects
- (3) Identify the folly of using old plan capacity values as the capacity for new projects

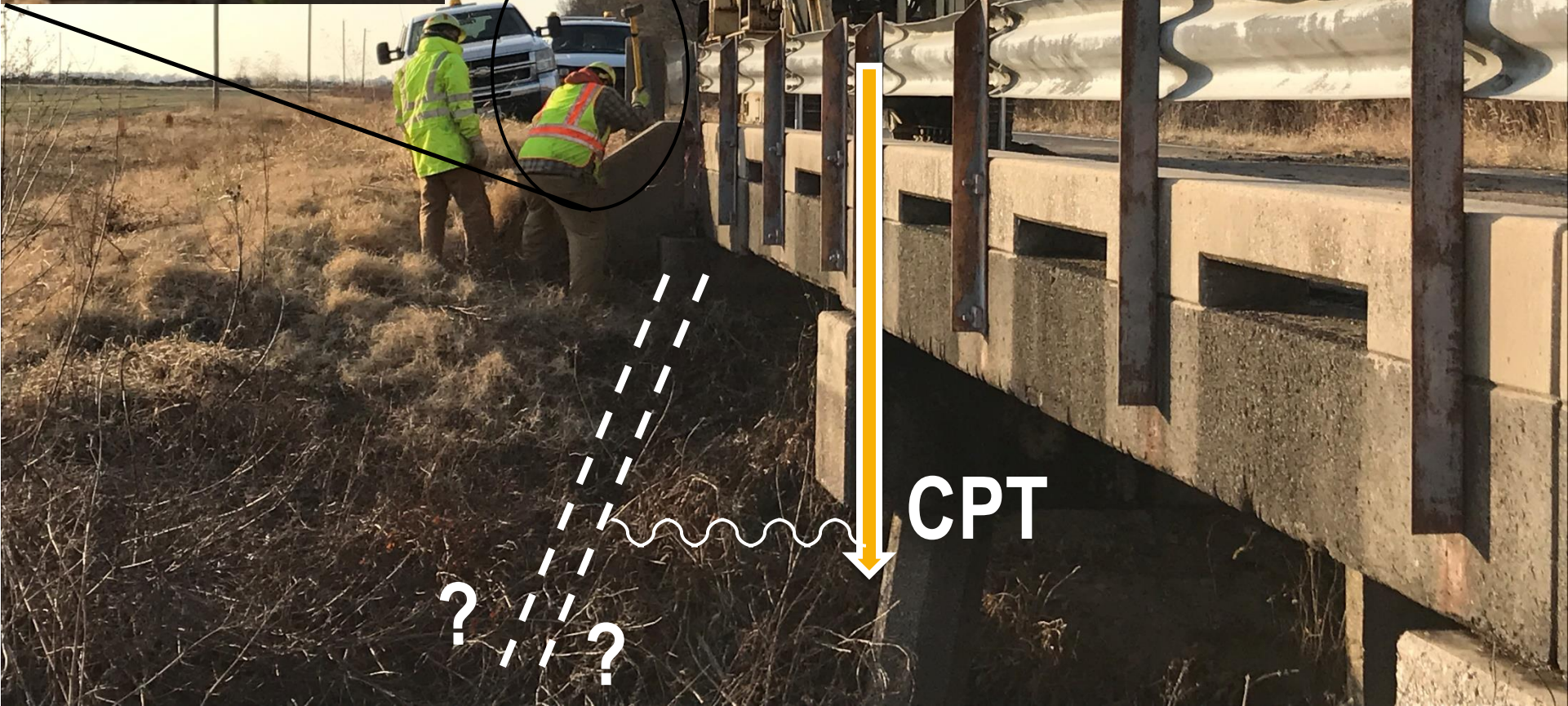
Conclusions

- There are a lot of reasons to reuse.
- Foundation reuse introduces new challenges for foundation designers.
- The challenges are surmountable, but often require a greater level of investigation and engineering effort.
- Creativity pays off – investigation and design.
- Even if we don't reuse, existing foundation performance should inform new foundation design.
- Plan for future reuse.

Join the DFI Committee!

- Meet monthly
- Half meetings “on agenda” discussions of efforts related to:
 - Outreach
 - Guidance
 - Research
- Other half meetings “off agenda” discussions of case histories, technologies, local practices, etc.

**Thank you!
Questions?**



???

CPT



Contact information:

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aboeckmann@dba.world

Reuse of Existing Steel Pile Foundations Highway 401 and Hallecks Rd Brockville, Ontario, Canada



Tony Sangiuliano – Ministry of Transportation of Ontario (MTO) Canada

Presentation Outline

- Background – Reuse of Existing Foundations at MTO
- Highway 401/Halleck's Rd
 - Introduction
 - Subsurface Conditions
 - Investigation Procedure
 - Pile Extraction
 - Visual Examination
 - Ultrasonic Testing
 - Chemical Analysis and Strength testing
 - Soil and Groundwater Analyses
 - Geophysical Testing
 - Discussion
 - Corrosion Potential and Pile Section Loss Assessment
 - Capacity Assessment
 - Conclusions



Ministry of Transportation of Ontario

- 3000 Bridges
- 17000 km of highways
- 5000 Structural Culverts
- Total Asset Value \$100 B
- \$ 3 B Goods and Services moved on our highway system daily

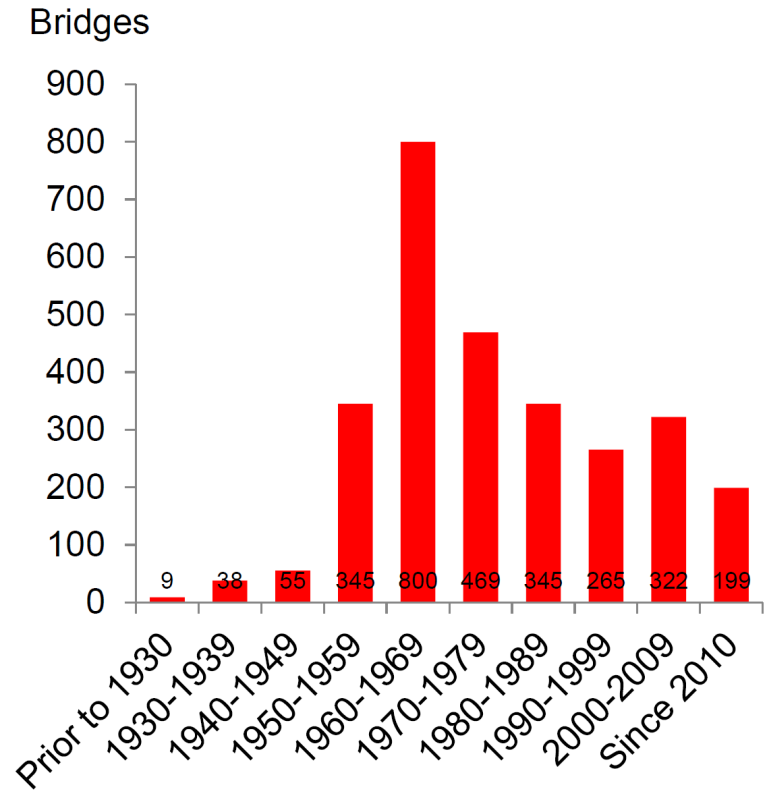


Reuse of Existing Foundations Guideline

- Management of the MTO aging infrastructure is one of the most important challenges that the Ministry faces.
- As this infrastructure ages, existing bridges will need to be rehabilitated or replaced, depending on the level of deficiency
- In many cases, bridges will require superstructure replacement, while the foundation still has significant functional value
- Reuse of bridge foundations may be a viable option that can present a significant cost and time savings in bridge replacement and rehabilitation efforts



Ageing Bridge Infrastructure



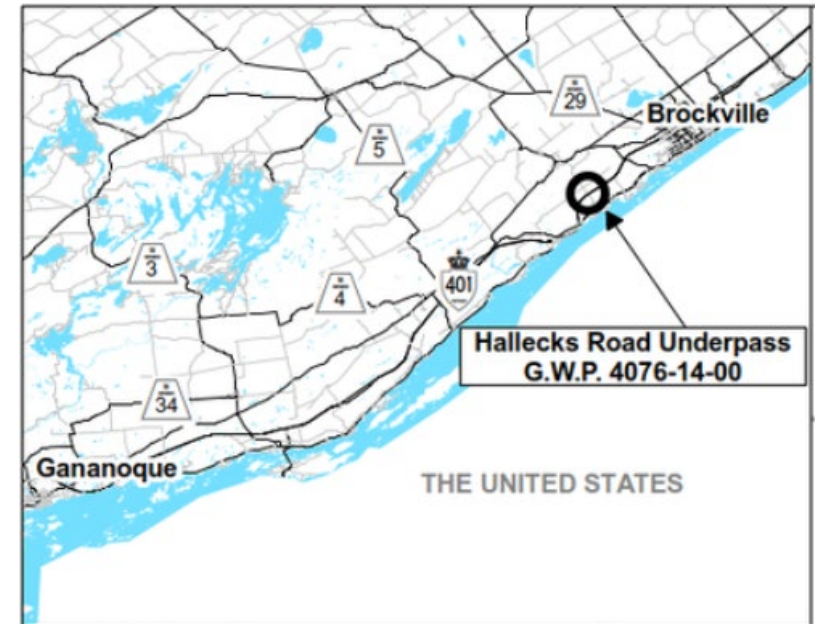
Reuse of Existing Foundations Guideline

The major steps of the decision-making process shall include:

1. Preliminary Assessment
2. Risk Analysis
3. Life Cycle Cost Assessment
4. Capacity Assessment
5. Estimating the remaining service life of the foundation
6. Environmental
7. Social

Introduction

- Located on Highway 401, west of Brockville
- Contract 2021-4089: Structure to be demolished and replaced
- Existing foundations NOT to be reused
- Corrosion assessment of existing piles included as part of contract

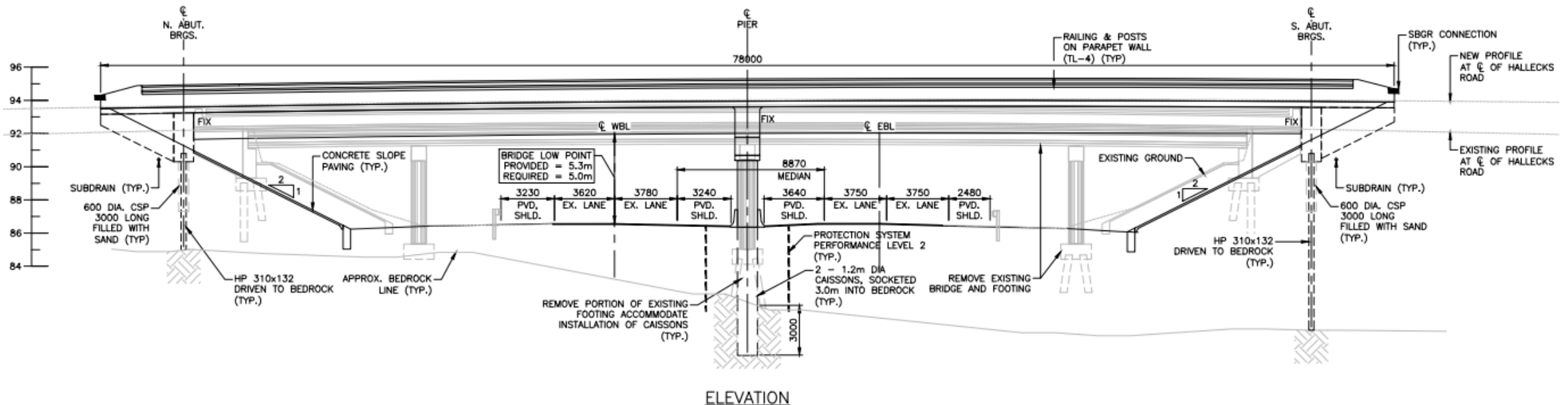


Existing Structure

- 4 spans, 5 girders
- 67.3 m long by 10.3 m wide
- Built in 1967, last major rehab in 1984
- Precast, prestressed AASHTO girders
- Steel H piles driven to bedrock; 1.5-7 m deep

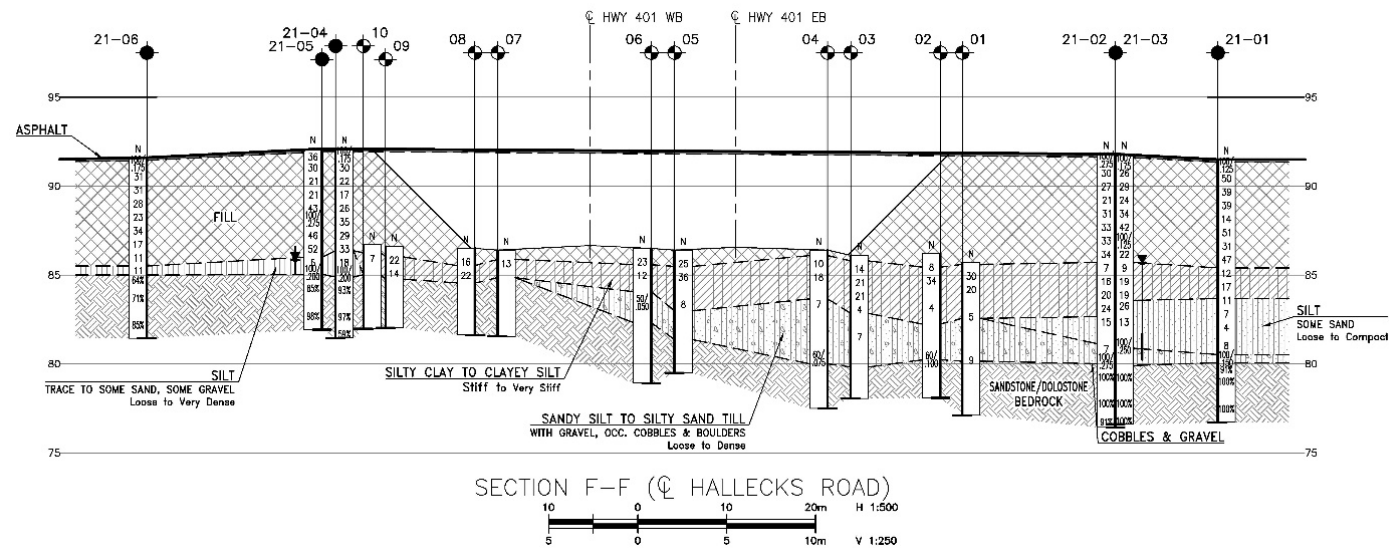
New Structure

- 2 spans, 4 girders
- 78 m long by 11.1 m wide; 25% larger
- Center pier caissons 3 m drilled into bedrock
- Integral abutments: Sand filled corrugated steel pipe with steel H piles driven to bedrock
- Foundations 6-10 m deep



Subsurface Conditions

- Embankment fill over stiff clay and loose to compact silt
- At the north abutment, the silt layer overlies bedrock. At the south abutment a thin layer of glacial till is present between the base of the silt and the bedrock surface
- The bedrock consisted of grey to grey-white, fresh to fresh jointed dolostone and sandstone, located 6.6 to 11.9 m below grade.
- The bedrock surface dips from the Elev. 85m at the north abutment to the Elev. 80m at the south abutment.
- Groundwater level generally is at the Elev. 86m.



Investigation Procedure

- Four existing piles to be extracted and assessed: 2 from pier and 2 from abutment
- Tests include:
 - Visual inspection and ultrasonic thickness measurement
 - Chemical analysis and tensile testing of steel
 - Soil and groundwater aggressivity testing
 - Geophysical methods to assess pile length (addendum)
 - Borehole Magnetometer and Parallel Seismic methods

Pile Extraction & Assessment

Sections of Extracted Piles



Bitumen Coating



Pile Extraction & Assessment

Pier Pile C2 – minimal evidence of corrosion (Pile C1 similar)



Pile Extraction & Assessment

Abutment Pile A1

– no evidence of corrosion on web



Abutment Pile A1

– corrosion and scale on flange (bottom 300 mm)



Pile Extraction & Assessment

Abutment Pile A2

– heavy corrosion near bottom (left), coating at right



Abutment Pile A2

– corrosion near bottom of pile



Soil and Groundwater Analyses

- 2 BHs advanced with monitoring wells installed, and soil and groundwater samples were retrieved.
- Soil samples collected from each borehole were combined to create a composite sample, i.e. S1 from BH1 and S2 from BH2

Soil and Groundwater Chemical Testing

Parameter	Soil Sample 1 (S1)	Soil Sample 2 (S2)
pH	7.74	7.82
Resistivity	7,400 ohm-cm	4,300 ohm-cm
Chloride	Not Detectable	Not Detectable
Sulphate	Not Detectable	75 µg/g
Parameter	Water Sample 1 (MW1)	Water Sample 2 (MW2)
Alkalinity	240 mg/L	190 mg/L
Chlorine	Not Detectable	Not Detectable
pH	8.19	8.24
Resistivity	420 ohm-cm	1,500 ohm-cm
Sulphide	Not Detectable	Not Detectable
Chloride	520 mg/L	60 mg/L
Sulphate	100 mg/L	51 mg/L

Moderately to very corrosive when compared to Eurocode 3 – Design of Steel Structures – Part 5, Piling, Tables 5 to 7

Corrosion Potential and Visual Assessment

- Groundwater with chloride level at 520 mg/L indicates moderately corrosive.
- Chloride and resistivity results indicate that the soil is mildly corrosive, which is in agreement with those of two soil samples collected at depths from north and south abutments during earlier foundation site investigation and design stage.
- PH content of the soils and groundwater tested indicates non-corrosive (alkaline) and neutral environment.
- Visual inspection of the piles extracted from the pier indicates coating is present intermittently over 40-50% of its surface and little evidence of corrosion is noted along the webs and flanges.
- For the south abutment piles, coating is present on much of the piles but heavy corrosion with localized pitting near the bottom 300mm of the piles is noted.

Corrosion Potential and Pile Section Loss Assessment

- Average annual section loss is impacted by the presence of a coating
- Attack on the web and flanges would occur from both sides.
- The corrosion mechanisms for buried piles are not linear, but rather they tend to follow a geometric function that increases with time.
- When discussing corrosion rates, it needs to be understood that these values are averages across specific time periods that are used to simplify complex corrosion mechanisms to make the comparison easy.

Pile Section Loss

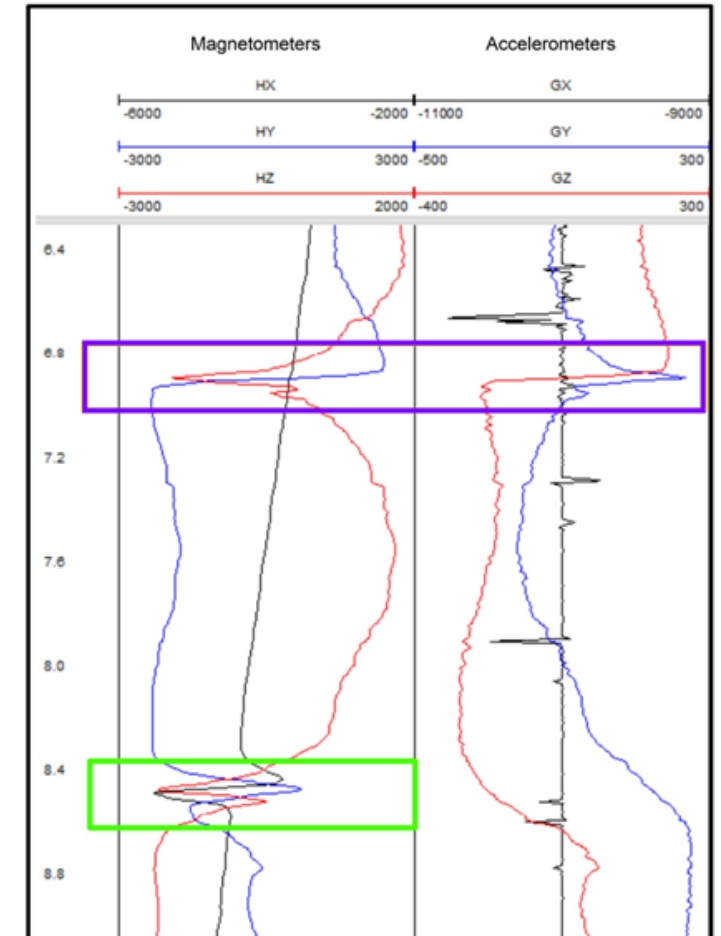
- Ultrasonic thickness measurements on cleaned piles

Pile	Loss (mm)	Loss (%)	Loss (mm/yr)	Comments
Center Pier Pile C1	0.23	2.1	0.004	
Center Pier Pile C2	0.28	2.5	0.005	
Abutment Pile A1	0.48	4.4	0.008	
Abutment Pile A2	1.35	12.4	0.024	At 4m from pile tip where localized pitting present

- The calculated average annual section loss is below the values set in the Guidelines
 - Eurocode 0.015mm per side of pile
 - BS8002 2015 0.015mm per side of pile
 - Ottawa LRT Specifications 0.015mm per side of pile
 - CALTRANS 0.025mm per side of pile

Geophysical Testing

- Objective: confirm pile length and bearing stratum
- Drilled borehole within 2m of existing pile, extending 5m into bedrock and grouted casing in place
 - Top of bedrock identified at elev. 80.6m
 - Previous borehole from design phase identified top of bedrock at elev. 80.4m
- Conducted downhole geophysical testing:
 - Borehole Magnetometer Testing
 - Signals indicate an anomaly at a depth of 8.5m (elev. 80.5m)
 - Parallel Seismic Testing
 - Strong response recorded at a depth of 8.5m (elev. 80.5m)
- Geophysical testing suggests piles were driven to bedrock



Capacity Assessment

- Structural Resistance - factored axial compressive resistance of the 8.0m long 12BP53 piles:
 - Assuming 230 MPa steel strength (CHBDC 14.7.4.2 based on year of construction)
 - Resistance factors from 6.11.4.4 and 10.22.2 of the CHBDC
 - Section loss based on measured section loss from extracted piles (worst case)

Level of Corrosion	Pile Factored Structural Resistance (12BP53)
No pile corrosion or section loss	1200 kN/pile
12.4% section loss due to pile corrosion (2023 at 56 years of age)	1050 kN/pile
50% section loss due to pile corrosion (2058: 35 year service life extension)	600 kN/pile

At this site, design loads were not available to make a direct comparison between the available resistance and demand loads.

- Geotechnical Resistance - factored axial compressive resistance:
 - End-bearing on bedrock
 - Bedrock unconfined compressive strength (UCS) >200 MPa
 - Local practice: geotechnical resistance >structural resistance
 - Empirical methods (Rehman and Broms, 1971, ultimate = 5x UCS), ULS = 3990 kN

Conclusions

- Piles generally exhibited limited corrosion
- Corrosion was most prevalent in lower portion of piles where coating was not intact
- Severe corrosion was observed in lower 300 to 600 mm of one of the piles (Pile A2)
- Relatively high chloride and low resistivity detected in groundwater could have accelerated the corrosion process
- The borehole magnetometer testing provided a good indication of the pile length, which in combination with the borehole data, provided confirmation that the pile had been driven to bedrock
- The estimated section loss (up to 50% within next 35 years) suggest that it would have been difficult to achieve an acceptable service life for a new superstructure while reusing the existing foundations. This is based on conservative / worst case section loss scenario
- This project is demonstrative of MTO's commitment to assess technologies and applications that support Ministry's initiative and operational needs and specifically to encourage the reuse of existing foundations

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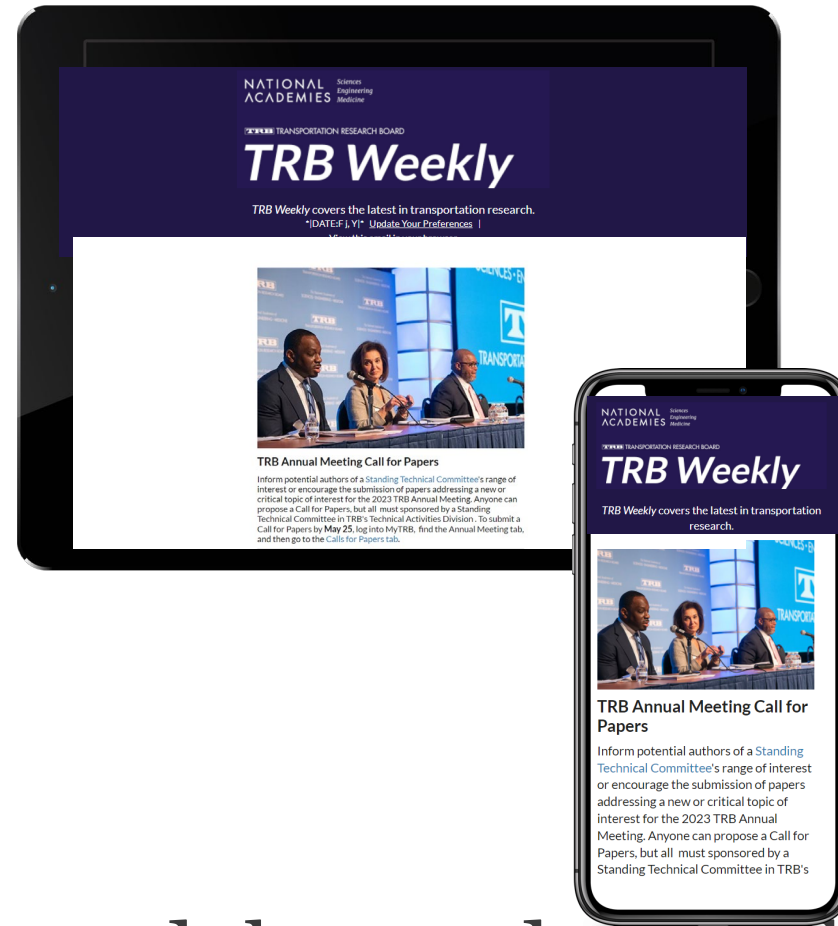


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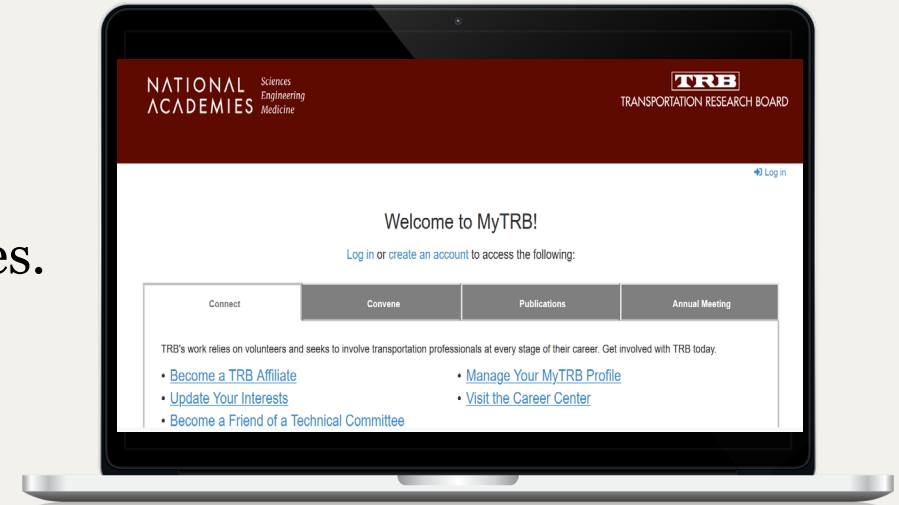


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