Foundation Reuse

Overview, NCHRP Synthesis, MoDOT Research

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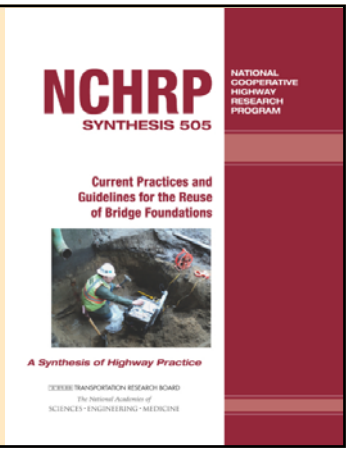
Free Download! Google "NCHRP Synthesis 505"



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

massDOT Highway Division

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**
- By reducing project cost, helps **preservation** efforts

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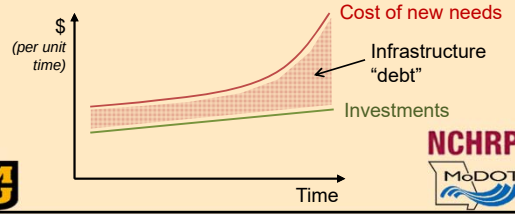

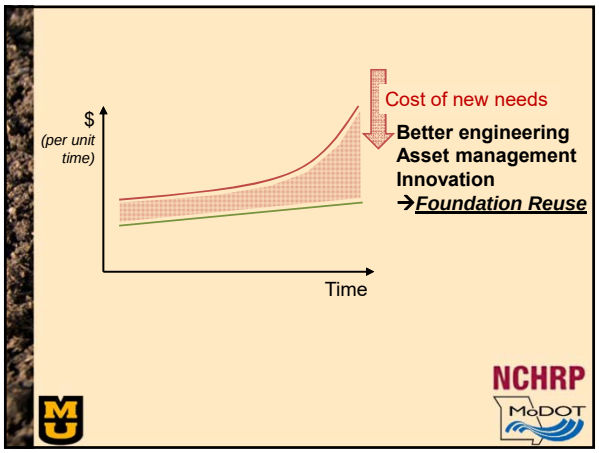

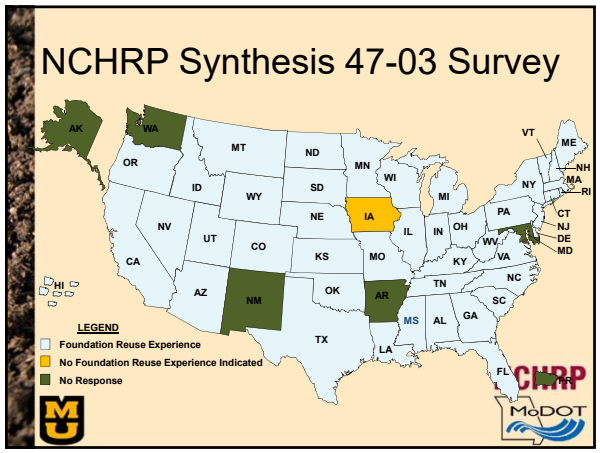

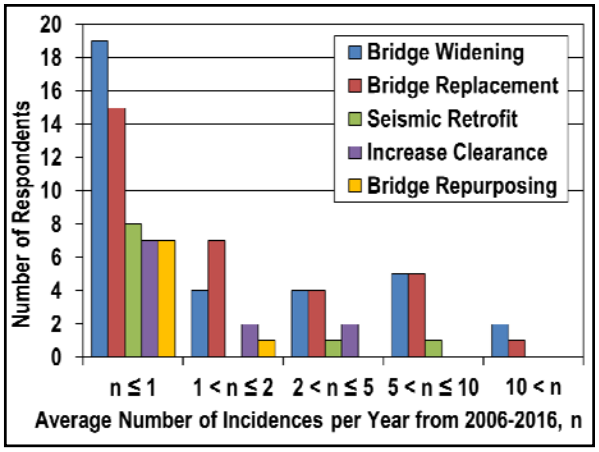

Challenges for Foundation Reuse

Four were identified by TRB Committee AFP30:

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

Add a pair:

1. Nature of risk is different
2. Assumption of risks is unclear

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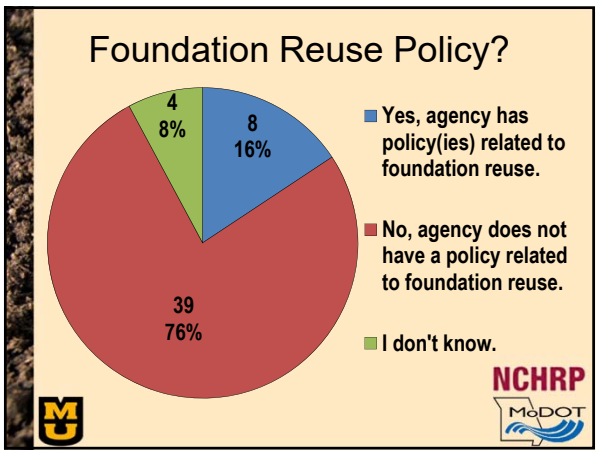

Investigation of Existing Foundations

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

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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

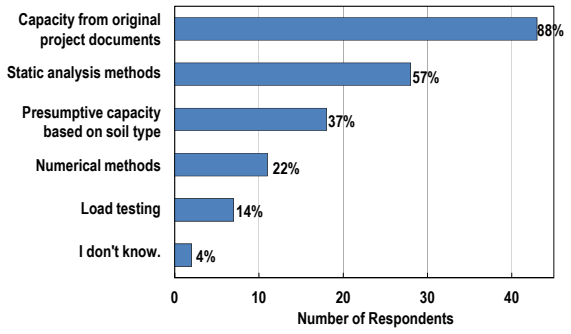
Photos courtesy of Haley & Aldrich

Parallel Seismic Testing

Results

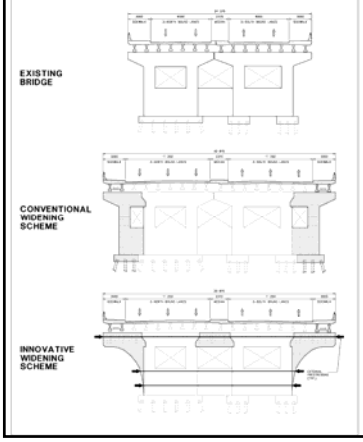
Location	Pile Tip Elevation, feet			Top of Bedrock Elevation, feet	
	As-built Lower Bound	As-built Upper Bound	Parallel Seismic	Historic Boring	Rehab Boring
Pier 5	10.2	14.8	14.9	14.3	15.4
Pier 7	−17.4	4.1	6.3	−2.4	3.5
Pier 10	−4.5	4.4	−5.5	1.8	−4.3
Pier 19	−42.7	−27.8	−17.2, −34.6	−30.2	−37.9
Abutment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

Methods used to predict existing capacity



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



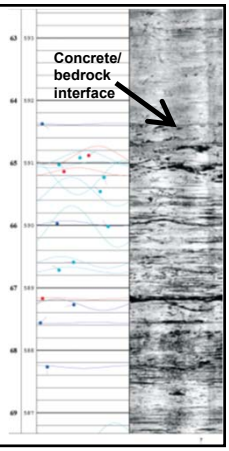
Li, Lee, Cholewa (2010), "An Innovative Solution to Integrate Existing Substructure to Effect Economy and Constructability in a Bridge Widening Project," Proceedings of the 8th International Conference on Short and Medium Span Bridges, Canada.

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
  1. Construct new superstructure on temporary foundations
  2. Reroute traffic to new superstructure during demolition
  3. Move new structure to original alignment
- 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?

Recent 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

- One bridge on ~55-ft 14" closed-end pipe piles; other on ~30-ft 16" octagonal precast piles.
- Neither is a candidate for reuse – just convenient for research.

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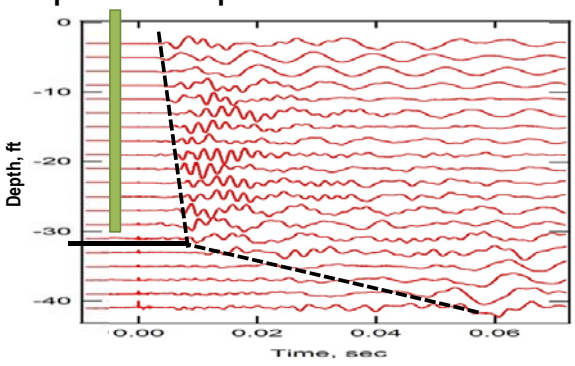


CIP Pile Extraction

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

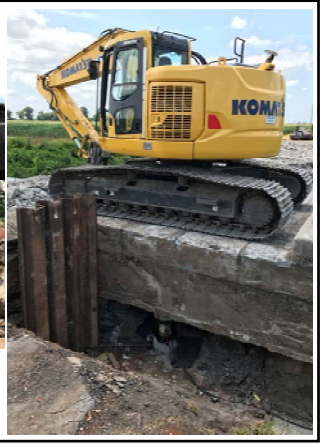
CIP Wall Thickness

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

No significant difference between corroded and uncorroded

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

Load Test



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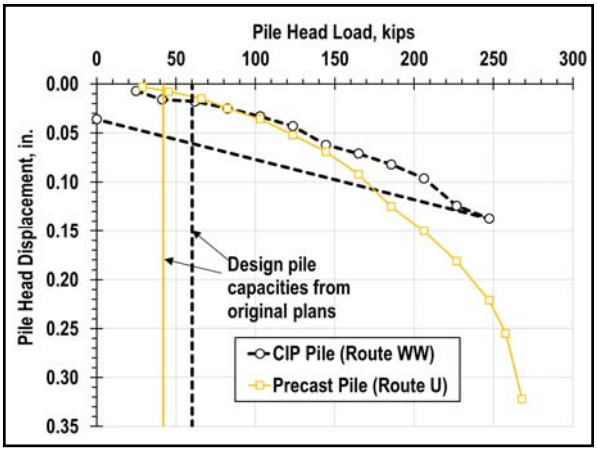

Summary of Capacity Values

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%
2016 MoDOT Report	106 - 110 40 -41%	335 - 480 136 - 194%
Load Test	>268	>247

Conclusions

- Foundation reuse is possible!
- Foundation reuse can be beneficial, even when our hand isn't forced.
- Creativity pays off – investigation and design.
- Even if we don't reuse, existing foundation performance should inform new foundation design.

Acknowledgments

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