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BRIDGE REPLACEMENT INNOVATIONS

Railroad Flat Car Bridges

Railroad flatcars can be an attractive option for bridge superstructures – particularly for lower volume roads. Railroad flatcar bridges are quick and easy to install; can be placed on existing abutments; are available in a variety of lengths; require minimal maintenance; and are very economical. The availability of retired railroad flat cars can fluctuate and should be considered. Railroad flatcars utilized for bridges should be designed to accommodate 80 or more tons per car. Railroad flatcar bridges do not require more frequent inspection.

Cost Savings: 50% – 60%

COST PER BRIDGE:
$120,000
vs. $275,000 – $350,000 (prevailing method)

APPLICABLE:
Low volume roads throughout rural America

STRUCTURAL INTEGRITY:
Can support loads far in excess of legal loads

CONSTRUCTION TIME:
15% – 25% faster

TIME TO CONSTRUCT:
6 weeks
vs. 7 – 8 weeks (prevailing method)

Research source(s): Iowa State University Bridge Engineering Center;
https://bec.iastate.edu/research/completed/field-testing-of-railroad-flatcar-bridges-tr-498/

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Railroad Flatcar Bridge – Buchanan County, Iowa;
Photo credit: Brian Keierleber

Railroad Flatcar Bridge – Buchanan County, Iowa;
Photo credit: Mike Steenhoek

Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS)

The Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) provides durability and decreases bridge construction time and cost due to the simplicity in design and accessibility of necessary materials and equipment. As a result, they are an ideal solution for counties and municipalities utilizing their own work crew for bridge construction. GRS-IBS bridges are constructed using alternating layers of compacted granular material and geosynthetic reinforcement.

Cost Savings: 25% – 60%

COST PER BRIDGE:
$250,000 – $350,000
vs. $350,000 – $650,000 (prevailing method)

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Can support legal loads

CONSTRUCTION TIME:
50% – 75% faster

TIME TO CONSTRUCT:
8 weeks
vs. 16 weeks (prevailing method)

Research source(s): Federal Highway Administration;
https://www.fhwa.dot.gov/engineering/geotech/grs_ibs.cfm

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GRS-IBS Bridge – Defiance County, Ohio; Photo credit: Warren Schlatter

GRS-IBS Bridge – Midland County, Michigan; Photo credit: Mike Steenhoek

Vibratory H-Piling Drivers

Vibratory pile driving is an alternative pile installation method in which a vibrator hammer grabs a pile and inserts it into the ground by vertical vibration. The vibrator hammer is attached to a hydraulic excavator. The prevailing method of utilizing a crane to drive piling is not necessary. In contrast to the traditional method of impact pile driving, vibratory pile driving produces less noise and damage to the pile. Perhaps most consequentially, vibratory pile driving can result in significantly faster penetration. Vibratory pile driving has been successfully used in most types of soils, including sands and clays. Worker safety is enhanced by no longer needing to climb the leads as required in traditional pile driving. Adapting a drop hammer to the hydraulic excavator alleviates any concerns with achieving complete load bearing.

Cost Savings: 90%

COST PER BRIDGE:
(to drive 10 piling, e.g.) **$2,000**
vs. $25,000 – $40,000 (prevailing method)

APPLICABLE:
Most types of soils, including sands and clays

STRUCTURAL INTEGRITY:
Equal to prevailing method

CONSTRUCTION TIME:
50% faster

TIME TO CONSTRUCT:
(to drive 10 piling, e.g.) **4 – 6 hours**
vs. two days (prevailing method)

Research source(s): Hindawi Journals;
https://www.hindawi.com/journals/sv/2017/7236956/#abstract

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Vibratory H-pile driving – Howard County, Iowa;
Photo credit: Nick Rissman

Buried Soil Structures

Buried soil structures are arch, three-sided, or box-shaped structures with unsupported spans greater than 20 ft. that rely on soils for support. Buried soil structures are economical to construct and quick to install, result in significantly reduced maintenance, and offer enhanced durability. Buried soil structures can result in increased load capacity compared to conventional bridges due to load sharing with the soil embedment. While periodic inspection may be necessary, buried soil structures do not include bridge decks or approaches, which can be expensive to clean, maintain, or replace. On the underside of the bridge, routine maintenance involves removing debris or vegetation – similar to other bridges.

Cost Savings: 50% – 60%

COST PER BRIDGE:
$75,000 – $95,000
vs. $150,000 – $200,000 (prevailing method)

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Equal to prevailing method

CONSTRUCTION TIME:
20% – 25% faster

TIME TO CONSTRUCT:
6 – 8 weeks
vvs. 8 – 10 weeks (prevailing method)

Research source(s): Transportation Research Board; http://onlinepubs.trb.org/onlinepubs/webinars/160623.pdf; National Council of Structural Engineers Associations; https://www.structuremag.org/?p=12752

Buried soil structure – Appanoose County, Iowa;
Photo credit: CONTECH Engineered Solutions, LLC

Buried soil structure – Houston County, Minnesota;
Photo credit: CONTECH Engineered Solutions, LLC

All Steel Piers

All steel piers have been found to provide enhanced strength, resistance to corrosion, and lower maintenance costs compared to reinforced concrete. Cost savings become more pronounced when the bridge location is distant from sources of concrete – eliminating the added transportation costs to deliver concrete to the site. Labor cost savings can also be achieved due to reduced pouring of concrete during construction.

Cost Savings: Material costs more expensive but recovered due to faster construction time and reduced lifecycle costs

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Equal to prevailing method

CONSTRUCTION TIME:
Comparable to prevailing method

TIME TO CONSTRUCT:
2-3 months

Research source(s): Sage Journals; Transportation Research Board;
https://journals.sagepub.com/doi/full/10.1177/1687814017709936

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Bridge with All Steel Piers – Buchanan County, Iowa;
Photo credit: Brian Keierleber

Bridge with All Steel Piers – Buchanan County, Iowa;
Photo credit: Brian Keierleber

Galvanized H-Piling

Galvanized H-piling can serve as an alternative to concrete encased steel piling in order to reduce deterioration and corrosion. Galvanized H-piling can achieve a 75-year service life without any maintenance. Some of the painting systems can result in an increase in surface friction and therefore enable the bridge to achieve higher load carrying capacity. The use of galvanized H-piling will result in shortened construction time by three weeks due to replacing cast-in-place concrete encasement.

Cost Savings: Material costs more expensive but recovered due to faster construction time and reduced lifecycle costs

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Comparable to prevailing method

CONSTRUCTION TIME:
20% – 25% faster

TIME TO CONSTRUCT:
3-4 months
vs. 4-5 months (prevailing method)

Research source(s): Iowa State University Bridge Engineering Center; https://intrans.iastate.edu/research/in-progress/evaluation-of-galvanized-and-painted-galvanized-steel-piling/

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Completed bridge with galvanized H-Piling – Buchanan County, Iowa; Photo credit: Brian Keierleber

Galvanized H-Piling; Photo credit: Galvan Industries, Inc.

Press Brake Tub Girders

The key feature of a press brake tub girder bridge is a trapezoidal box girder formed from cold-bending a weathering or galvanized steel plate. A reinforced concrete deck is cast on the girder at an off-site location, which then allows it to be transported to the bridge site as a composite unit – resulting in accelerated construction and decreased traffic interruptions. Costs are significantly reduced from employing a press brake, rather than cutting and welding plates together. Because the entire girder until is shop-fabricated, greater quality control is achieved. Press brake tub girders also enable greater structural integrity over a longer span and a more economical option for longer bridges compared to traditional methods.

Cost Savings: 30% – 50%

COST PER BRIDGE:
$200,000
vs. $300,000 – $400,000 (prevailing method)

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Equal or stronger than prevailing method

CONSTRUCTION TIME:
Slightly faster than prevailing method

TIME TO CONSTRUCT:
2-3 months
vs. 3-4 months (prevailing method)

Research source(s): American Institute of Steel Construction:
https://www.aisc.org/globalassets/nsba/conference-proceedings/2014/barth---2014-wsbs-final.pdf

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Press Brake Tub Girder – Muskingum County, Ohio; Photo credit: American Galvanizers Association

Press Brake Tub Girder Bridge – Muskingum County, Ohio; Photo credit: American Galvanizers Association

Galvanized Steel Beams

Galvanized beams can be a lower cost alternative to stainless steel while maintaining comparable strength. The process of galvanizing results in a hard surface coating of the beams that protects against rust.

Cost Savings: Material costs more expensive but recovered due to reduced lifecycle costs

APPLICABLE:
Throughout rural America; Optimal in humid environments

STRUCTURAL INTEGRITY:
Equal to prevailing method

CONSTRUCTION TIME:
Comparable to prevailing method

TIME TO CONSTRUCT:
2-3 months

Research source(s): Federal Highway Administration: https://www.fhwa.dot.gov/bridge/steel/pubs/hif16002/volume19.pdf

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Bridge with Galvanized Steel Beams –
Buchanan County, Iowa;
Photo credit: American Galvanizers Association

Construction of Bridge with Galvanized Steel Beams –
Buchanan County, Iowa;
Photo credit: American Galvanizers Association

Prestressed Precast Double Tees

The use of prestressed precast double tees in conjunction with a monolithic spread footing can provide significant cost savings. This design can be constructed without a bridge contractor. A local contractor employing a crane is usually needed to set the precast double tees. An engineering service is necessary for hydraulic analysis and for any needed adjusting of backwall length and/or height. The approach is particularly economical due to the simplicity of design enabling construction with the bridge owner's own staff and equipment. The design is ideally suited for bridges 30 to 40 ft. in length. It is less appropriate for longer bridges or at sites with high water flow or velocity.

COST PER BRIDGE:
$75,000
vs. $225,000 (prevailing method)

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Comparable to prevailing method

CONSTRUCTION TIME:
20% – 30% faster

TIME TO CONSTRUCT:
7-8 weeks
vs. 10 weeks (prevailing method)

Cost Savings: 60% – 70%

Research source(s): National Precast Concrete Association; https://precast.org/2014/10/strength-double-tee/; Mountain-Plains Consortium; https://www.ugpti.org/resources/reports/downloads/mpc19-389.pdf

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Bridge with prestressed precast double tees – Grant County, South Dakota; Photo credit: Kerwin Schultz

Construction of bridge with prestressed precast double tees – Grant County, South Dakota; Photo credit: Kerwin Schultz

Precast Inverted Tee Slab Span Bridges

The use of precast inverted tee slab bridges as an alternative to cast in-place concrete slab span bridges can result in faster installation and cost savings – particularly with repetitive use. During construction, the prestressed inverted tee sections are positioned side by side, providing both a structural beam and the bottom form for the composite deck pour. A reinforcing cage is then set in the joint area between sections and cast-in-place concrete is placed over the top of the sections, filing the joint and forming the roadway surface. The reinforced joints provide load transfer between sections, enabling the entire system to act as a solid slab span.

Cost Savings: Currently more expensive, but cost savings likely with repeated utilization.

COST PER BRIDGE:
$375,000 – $510,000
vs. $315,000 – $465,000 (prevailing method)

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Equal to prevailing method

CONSTRUCTION TIME:
20% – 40% faster

TIME TO CONSTRUCT:
2 months
vs. 3 months (prevailing method)

Research source(s): Minnesota Department of Transportation:
https://lrrb.org/media/reports/TRS1203.pdf

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Precast inverted tee slab span bridge – Chisago County, Minnesota; Photo credit: Minnesota Department of Transportation State Aid Office

Construction of precast inverted tee slab span bridge – Chisago County, Minnesota; Photo credit: Minnesota Department of Transportation State Aid Office

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BRIDGE REPAIR INNOVATIONS

Many of the following repair innovations involve an initial financial investment in the effort to safely enhance or extend the life of bridge. Those engineers who have successfully employed many of these innovative approaches affirm that the initial cost of the repair was more than recovered due to delaying future replacement or major rehabilitation.

Piling Encasements

Scour, the erosion of bank material or streambed from a bridge foundation due to flowing water, is one of the primary causes of bridge deterioration and failure. As scour removes soil from around the bridge piles, a greater length of the pile becomes unsupported. Encasing piles has demonstrated to increase the stability and the overall bridge capacity – resisting much of the deterioration potentially caused by scour.

APPLICABLE:
Throughout rural America; Can be employed for both concrete and timber piling

STRUCTURAL INTEGRITY:
Can result in an improvement – including the removal of load limits

Research source(s): Iowa State University Institute for Transportation: https://intrans.iastate.edu/app/uploads/2018/09/pile_assessment_tool_t2.pdf

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Concrete Pier Piling Repairs

The use of concrete to make repairs to the underwater pier pilings can result in extending the life of a bridge.

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Helps preserve original condition

Research source(s): Federal Highway Administration:
https://www.fhwa.dot.gov/bridge/nbis/pubs/nhi10029.pdf

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Driving Piling through Decks

Driving piling through bridge decks may be a viable option when confronted with the alternative of closing the bridge altogether.

APPLICABLE:
Throughout rural America; Ideal for steel beam bridges

STRUCTURAL INTEGRITY:
Can result in an improvement – including the removal of load limits

Research source(s): Federal Highway Administration:
https://www.fhwa.dot.gov/engineering/geotech/pubs/hif17044.pdf

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Epoxy Deck Injections

The injection of epoxy resin into the cracks of bridge decks has been found to enhance preservation – particularly after the bridge has experienced degradation from the intrusion of water and salt.

APPLICABLE:
Throughout rural America; Most applicable on paved road bridges; Less applicable for bridges along gravel roads

STRUCTURAL INTEGRITY:
Helps preserve original condition

Research source(s): Iowa State University Institute for Transportation:
https://intrans.iastate.edu/app/uploads/2019/02/bridge_deck_epoxy_injection_process_w_cvr.pdf

Deck Overlays with Type O Concrete and Plasticizers

The use of type O concrete and plasticizers can be a viable solution for bridge deck rehabilitation. Type O concrete and plasticizers have demonstrated very low permeability and good resistance to freeze-thaw damage, resistance to abrasion and rutting, reduced cracking from shrinkage, and high strength and stiffness.

APPLICABLE:
Throughout rural America; Most applicable on paved road bridges;

STRUCTURAL INTEGRITY:
Helps preserve original condition

Research source(s): Federal Highway Administration:
https://www.fhwa.dot.gov/publications/research/infrastructure/bridge/17097/17097.pdf

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Deck Patching

Concrete deck patching involves the removal of all contaminated and degraded concrete until reaching the steel bars. The steel bars are subsequently cleaned via sandblasting or, if necessary, replaced. The exposed area is then patched with high quality concrete or mortar.

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Helps preserve original condition

Research source(s): Indiana Department of Transportation and Purdue University:
https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3106&context=jtrp

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Thin Polymer Concrete Overlays

Polymer overlays have demonstrated to provide an effective level of protection against deicing salt and enhanced skid resistance. Thin polymer concrete overlays result in minimal additional dead weight to the bridge and can be applied more rapidly than other types of overlay.

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Helps preserve original condition

Research source(s): Wisconsin Department of Transportation and the University of Wisconsin-Milwaukee: https://wisconsindot.gov/documents2/research/12-06-2nd-final-report.pdf

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Penetrating Concrete Sealers

The penetration of water and deicing salts into bridge deck cracks and pores of the concrete are a significant source of bridge deterioration – for both the concrete and reinforcing steel. The use of environmentally friendly concrete sealers can provide effective and economical protection – significantly extending the life of bridges when resources are limited.

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Helps preserve original condition

Research source(s): Purdue University Joint Transportation Research Program:
https://docs.lib.purdue.edu/jtrp/1628/

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Spot Cleaning and Painting Steel Beams

Bridge coatings are one of the predominant means of preventing the corrosion of steel bridges. Spot painting has been demonstrated to restore corrosion protection and economically extend the life of existing bridge coating.

APPLICABLE:
Throughout rural America; Most applicable on concrete or steel bridges

STRUCTURAL INTEGRITY:
Helps preserve original condition

Research source(s): National Cooperative Highway Research Program: https://www.nap.edu/catalog/25089/spot-painting-to-extend-highway-bridge-coating-life-volume-1-guidance

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Concrete Overlay on Adjacent Box Beams

Precast concrete adjacent box beams are widely utilized due to their ability to be fabricated in a controlled environment without the need for casting the concrete in place at the bridge site. An approach to repairing degradation of adjacent box beams is installing a concrete overlay – helping preserve strength and serviceability.

APPLICABLE:
Throughout rural America

STRUCTURAL INTEGRITY:
Helps maintain original condition

Research source(s): Federal Highway Administration:
https://www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/17093/001.cfm

Disclaimer: The innovative concepts for bridge replacement and repair featured in this document are, in no way, an exhaustive and comprehensive catalog. Numerous other innovative concepts exist and are worthy of being explored. The goal of the project participants was to highlight a relatable number of innovative concepts that have been validated by credential engineers, have the potential to provide notable cost savings, and would be accessible in a large section of rural America. When adopting any of the above profiled concepts, cost savings may be realized in the up-front construction costs, lifecycle costs, or a combination of the two. The featured bridge replacement and repair concepts reflect the broad consensus of the principal analysts and advisory committee members. Readers should not assume the bridge replacement and repair concepts featured in the above list are in complete alignment with the lists of each individual principal analyst or advisory committee member.

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