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Mr. Walsh,

I have reviewed information on Monmouth County Three Bridges web site, as well as newspaper reports and other information about this project in recent times, and offer the following comments, focused on W-9 Bridge (Brielle Road over The Glimmer Glass), also known as "Glimmer Glass Bridge".

Compared to previous version of March 5, 2018, comments are revised to reflect further information about design of early rolling-counterweight bascule bridges in US.

I am professional engineer (PE) with 40 years overall experience, specializing in structural engineering. During first half of my career, I had extensive experience with design of railroad bridges as well as roadway ("overhead") bridges over railroad.

From 1996 to 2000, I worked as engineer having primary responsibility for design of railroad bridges for Southern New Jersey Light Rail Transit System (SNJLRTS) between Trenton and Camden. I was intimately involved with historic preservation efforts for bridges and other structures along historic railroad right of way.

Proposed New Bridge Project

Requirements For New Bridge

While I understand points and overall position of those who have been calling for current moveable span to be maintained, I believe that construction of new bridge, including new moveable span, is warranted.

Certainly, severely deteriorated timber piles of existing timber-trestle approach spans, which make up about 90-percent of total bridge length, must be replaced, such that it is reasonable to conclude entirely new approach spans are necessary. Trying to then maintain short, narrow moveable span, which has already demonstrated operational problems, in middle of new bridge with wide lanes, just does not make much sense.

Although I am supportive of efforts to preserve historic and unique bridges, buildings, and other structures, this bridge is just not unique or special enough to continue paying costs for maintenance and operation, while still having inadequate lane widths and less-than-adequate load capacity.

Existing Rolling-Counterweight Bascule Span

Almost all of original rolling-counterweight bascule (hinged) bridge span, which is not all that "vintage" to begin with (circa 1938), has been replaced or rebuilt, including entire deck, counterweight-track and tower.

Original moveable span was not even designed for current location. Name of designer is (apparently) not known.

Rolling-counterweight design is unique for bascule bridge span. However, it is unique primarily because the design did not prove to have much, if any, net benefits compared to other bascule-bridge designs.

When cost of energy was relatively high compared to cost of labor, this design at least had potential to provide substantial benefit compared to other designs which used more energy to operate. However, cost of energy turned out to be much less important than was the case when rolling-counterweight design was first adopted by railroads in 1890s; see below.

Theoretical design, based on modeling assumptions that could not be replicated for practical design, resulted in cardioidal-arc shape of counterweight-track. For practical design, different and more complex arc-shapes had to be used.

As discussed in several publications noted later in this discussion, calculation methods were developed by American railroad engineers in 1890s. However, it is likely that complexity of such calculations, which of course had to be performed without computers, contributed to lack of widespread use for this type of bridge design.

Key feature of this bridge worthy of preservation is not physical remains of original design and construction. Of much greater importance, worthy of preservation, is spirt of innovation that motivated engineers and supporters to attempt development of better moveable bridge design.

- ☑ Best way to preserve that spirit of innovation is to design new bridge that also attempts to provide improved performance and usefulness.

Among many ideas, the following should or could be considered;

1. Hydraulic power or other energy-efficient power system.

2. Solar panels to power lights on bridge.

3. Reuse of existing components in other parts of new bridge, or in other bridges or structures.

4. Separate lanes for pedestrians and bicycles.

5. Develop educational resources for math teachers to be used for students to calculate theoretical and practical shapes of tracks for rolling-counterweight design.

6. Tilt-bridge with curved roadway that would provide “traffic calming” function; see Gateshead Millenium Bridge.

7. Design competition.

Rolling-Counterweight Bascule Bridge Design & Construction

The following description of design development is provided in publication entitled "Plaquing Nomination for the McFarlane Bridge, McLane NSW – A curved-track bascule bridge" by Don Fraser "for Northern Rivers Group Engineers Australia" and "McLean District Historical Society", August 2005;

> *The concept for this distinctive bascule bridge, with its counterweights rolling down a pair of curved tracks, was first presented in 1729 by Bernard Forest de Belidor. He was an eighteenth-century mathematician and military engineer of the French School whose concern was to simplify the balancing mechanism during operation of the bascule span and to place as much of it as possible within the protection of the fortress gate tower. The mathematical definition of the curved track, so as to give a continuous smooth balanced operation, was the key factor in the design. Belidor suggested part of a sine curve but subsequent analysis showed it to be a cardioid. Friction along curved stone tracks was the main cause of poor performance, few were built.*
>
> *However, by the 1890s in the USA the basic merits of the concept was recognised and performance was improved by a combination of low friction between cast iron counterweights and steel tracks, better gearing and lubrication, and a practical definition of the curve by a graphical method. A few were built but there were many other competing patented types of bascule bridges in the USA.*

Unfortunately, there is not much published information to explain reasons why curved-track counterweight bascule bridge design faded away.

Detailed discussion of how counterweight track must be designed is provided in "Curved Track Bascule Bridges: From Castle Drawbridge To Modern Application" by Donald J Fraser and Michael A B Deakin for 7th Historic Bridges Conference (Cleveland; September 2001).

Calculation effort to develop effective design of track geometry was undoubtedly one reason that many other bridges of this design were not attempted.

In recent newspaper reports, claims have been made that Glimmer Glass Bridge is the only remaining bridge of this design "in the world".

Glimmer Glass Bridge has likely been the last rolling-counterweight bascule bridge operated as moveable bridge, until recent shutdown. However, structures of several bridges of this type remain that are not operating as moveable spans, including bridge in Maine.

Design & Construction in Europe & Australia

As described in article ("The Belidor Bascule Bridge Design") in November 2013 issue of "The International Journal For The History of Engineering & Technology", three such bridge spans (out of 8 originals) remain in Australia (each with "historic" status) although operating mechanism of each moveable span is "locked".

As reported in that same article, written by mathematician (Michael A B Deakin) at Australian university and professor of structural mechanics (Fabrizio Barpi) at Italian “Politechnico”, a relatively new bridge, using "Belidor" design concept, has also been built in Australia for purposes of maintaining the concept, not for functional or efficiency purposes.

The following statements from Deakin - Barpi article discuss design of this type of bridge, with underline made for this discussion;

> *The design is usually attributed to the eighteenth-century engineer Bernard Forest de Bélidor, but in fact is earlier.*
>
> *The design was first attempted (very crudely) in the ninth-century fortress of Bonifacio in Corsica (12) well before the advent of any systematic theory. An eighteenth century example is provided by the Medusa gate at Königstein fortress near Dresden (13) although this employs circular arcs rather than cardioidal ones as the shape of the tracks. A recent thesis by Ferrara gives details of a considerable number of other examples constructed in Europe during historic times, as well as describing two more modern examples (Glimmer Glass Bridge and Forton Lake Bridge) (14).*
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> *A full list of the Australian examples was provided by Deakin (15). A list of five American ones was given by Deakin and Fraser but has always been known to be incomplete (16). It omits in particular the Glimmer Glass bridge at Manasqua[n], New Jersey (17) and there may very well be other omissions. As far as we know, no attempt has been made to compile a complete inventory of the American bridges of this type. However, it was the use of the design in the USA that led to its implementation in Australia. Its American use was in its turn both subsequent to and almost certainly derived from the European examples.*

Initial Design & Construction In United States

Deakin – Barpi article, referencing article in Railroad Gazette (Volume 28; November 27, 1896), states that an Erie Railroad bridge over “Berry’s Creek at Hackensack Meadow near Jersey City” was designed by “O E Hovey” (Otis Ellis Hovey) about 1896. However, cited references (Railway Gazette, Scientific American) for this claim do not provide any information about Mr. Hovey.

Otis Ellis Hovey (1864 – 1941) wrote books “Moveable Bridges” (two volumes), published in 1926. In volume 1, at end of chapter “Type of Movable Bridges”, Bibliography” (page 33) includes brief description of six (6) “Belidor Bascules”.

Earliest “Belidor Bascule” listed in US is stated to have been built in “1895 – 96” for “Chicago and Northern Pacific and Union Stock Yards”. Mr. Hovey states; “Designed by the author under the direction of the late George S Morison”.

Listed next is “Berry’s Creek Bridge on the Erie Railroad”. Mr. Hovey states; “Designed by the author for Union Bridge Co” and “Built in 1896.”.

Referenced Railroad Gazette article provides detailed description of “Berry’s Creek” railroad bridge design, including several large illustration and graphs.

The following statement is made about responsibility for design and construction;

> *The bridge was built by the Union Bridge Co. under the direction of Chs. W. Buchholz, chief engineer of the Erie Railroad.*

As Chief Engineer for Erie Railroad, Mr. Buchholz was responsible for design and construction of major bridges and structures for the railroad. As Assistant Chief Engineer for Reading Railroad, Mr. Buchholz was responsible for design and construction of Wissahickon Creek Viaduct, large stone arch railroad bridge in Philadelphia.

Article in Scientific American magazine dated November 28, 1896, provides brief description of railroad bridge with bascule span, built over “Berry’s Creek near Rutherford NJ”, using rolling counterweight design. Large illustration of bridge in raised position is also provided.

The following statement is made about responsibility for design and construction;

> *The structure was built by the Union Bridge Company, of New York City, under the direction of C. W. Buchholz, chief engineer of the Erie Railroad, to whom we are indebted for the above particulars.*

In volume 1 of "Movable Bridges", at end of chapter "Bascule Bridges", Mr. Hovey makes the following statements;

> *It is not feasible to describe all of the designs that have been proposed for balanced bascule bridges. Probably no phase of moveable bridge construction has received as much study as the design of such structures. Several types have been designed but not built, and others are represented by only one, or a very few, bridges.*
>
> *Some designs have not been promoted vigorously by their inventors; others, for various reasons, have not been received with favor.*

Design & Construction In Maine

The following, about Wadsworth Street Bridge in Thomaston, Maine, is from "Historic Iron and Steel Bridges in Maine, New Hampshire and Vermont" (2012) by Glenn A Knoblock (with underlines made for this discussion);

> *The choice of bridge type made by the State of Maine when it came to the building of this distinctive span is somewhat of a mystery. By the time it was fabricated by the Boston Bridge Works in 1928, this rolling counterweight bascule bridge was considered an obsolete design and one that was noted for being difficult to maintain, as most bascule bridges used fixed counterweights by this time. The Wadsworth Street Bridge is now a true rarity, it being the only surviving example of this type of moveable bridge remaining in Maine, as well as the state's only historic bascule bridge overall.*
>
> *About 1966, probably never having opened in years, the bridge was made a fixed span. Though the curved Pennsylvania truss portion of the bridge (72 feet in length) that acted as the counterweight tower and track still remains, all the other operating mechanisms, such as motors and gears, counterweights, chain lifts and wheels, and the operator's house, were removed for good.*

The following is from web site historicbridges.org (as of March 4, 2018);

http://historicbridges.org/bridges/browser/?bridgebrowser=maine/wadsworth/

> *Also, it should be noted that the Glimmer Glass Bridge, although operable, suffers from a substantial loss of original bridge material. Much has been replaced. In contrast, while the mechanics are lost on the Wadsworth Street Bridge, the structure that remains is largely in its original condition and design, and thus unaltered.*

Description On "Three Bridges" Web Site

On "Three Bridges" web site, the following statements are made relative to "historical significance" of W-9 ("Glimmer Glass") Bridge;

- Architecturally significant as a representative example of a little-used technology developed in the 1890s.
- Technologically and historically significant as the only example of its type in New Jersey and exemplifies advances made in movable bridge technology in the late-nineteenth and early-twentieth centuries for the transportation of vehicles over navigable waterways.
- Continues to operate as originally constructed and retains the basic technologies developed in the 1890s, therefore retaining its integrity of design.

I realize that in discussion of historic preservation issues, terminology such as "architecturally significant" tends to be repeated, essentially as formulaic. However, to describe bridge structure of "Glimmer Glass" bridge as "architecturally" significant is grossly misleading and plainly incorrect.

This bridge, as well as other bridges of "rolling counterweight" design and other bascule bridges of different designs, were not designed by architects. These bridges were designed by those, mostly termed "civil" engineers at the time, who were skilled in principles of structural and mechanical engineering.

☑ Appearance of Glimmer Glass Bridge is result of engineering design and is not result of architectural design.

Description should emphasize structural design which is most essential feature.

Discussion of design should at least note one or more persons responsible for design, if known, or should note that original designer is not known. However, there is published information about development of design for this type of bridge. First bridge of this type in US was built in New Jersey.

Description of "little-used technology" should more accurately be described as "little-used bridge design".

Claim that this bridge-design should be considered to demonstrate "advances in moveable bridge technology" is debatable. More appropriate description is that this design was an attempt to improve moveable bridge design, based on economic and technical conditions at the time. However, this design was not further developed for many other bridges because it was found too complex and did not offer substantial benefits compared to other designs.

Railroad bridges, which was initial use for rolling-counterweight design, are much heavier than roadway (highway) bridges since they must support much greater loads from trains. Therefore, energy required to lift railroad bridge is also much greater. Design to minimize use of energy, which was relatively high cost at the time, was likely considered important. However, in relatively short time, cost of electricity decreased greatly and availability increased.

Third claim contains two glaring errors that should be corrected. Current bridge is not as “originally constructed”. The following statements, relative to moveable span, are from “New Jersey Historic Bridge Data” by NJDOT Bureau of Environmental Services (November 12, 2002);

> The bridge has been rebuilt several times. The wood tower column and track were redone in 1957 and 1971, and the steel grid deck on the ca. 1950 deck girder movable span was installed in 1962. The significance of the structure is derived from the fact that it maintains integrity of original design.

Description of “[circa] 1950 deck girder moveable span” essentially means that entire deck structure was replaced about 1950. Decking was again replaced in 1962 with “steel grid deck” that was not even available for original design and construction. Counterweight “track”, which is reasonably considered most essential distinguishing feature, was “redone” in 1971.

Claim that “basic technologies” for this bridge were “developed in the 1890s” is misleading, especially without any description of person or firms that “developed” design. As stated previously on “Three Bridges” site, moveable (bascule) span was designed as “temporary” bridge in 1922 by “New Jersey Highway Department” for different site and eventually installed in 1938 at current site, based on updated plans.

- ☑ However, as highlighted in NJDOT “Historic Bridge Data”, design concept in United States was clearly developed by railroad engineers. At very least, this essential fact should be noted in “Three Bridges” commentary.

- ☑ Considering that C W Buchholz and Otis Ellis Hovey (to be verified) are only names of American engineers found in readily available information about rolling-counterweight bridge design, their names should be highlighted in discussion about this type of bridge.

Recommendations – "Three Bridges" Web Site

Description of existing W-9 (Glimmer Glass) bridge should be revised (at least) as follows;

- ☑ Emphasize structural design and eliminate misleading and incorrect "architectural" description.
- ☑ Discuss development of design concept, especially by American civil engineers, Otis Ellis Hovey and C W Buchholz of Erie Railroad.
- ☑ Explain how much of existing rolling-counterweight bascule span has been rebuilt or replaced.
- ☑ Discuss likely reasons that rolling-counterweight design was not used for many other bridges.

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