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September 15, 2010

Historical Commission
East Brandywine Twp
sent via email
1214 Horseshoe Pike
Downingtown, PA 19335

Re: Hadfield Bridge Review

Dear Commission members:

In response to your request, I have visited the Hadfield Bridge and have reviewed the Hadfield Bridge 2008 NBIS Inspection Report, dated 11/7/08 and the Interim Inspection Report dated 11/21/09 performed by the County's bridge engineer, Ms. Sandra G. Martin of McCormack Taylor Associates (MTA). In addition, I have reviewed the recent email correspondence between Ms. Martin and Scott Piersol, manager of East Brandywine Township, dated August 19, 2010. Ms. Martin raised several points in support of the demolition and replacement of the Hadfield Bridge, in lieu of rehabilitation, which bear scrutiny:

In the first paragraph, Ms. Martin refers to her 2008 rehabilitation cost estimate of $131, 540 on page 6 of the Inspection Report and states that:

> "… *The inspection costs are by no means accurate. They are based on a standardized PennDOT costing system that is more than a decade old and do not take into consideration anything site specific about a given bridge.* " The text continues: "… *this is by no means an attempt to give a cost estimate for rehabilitation, nor does it address site specific issues or costs associated with making the repairs…*"

Developing accurate cost estimates is essential for making important spending decisions regarding replacement vs. rehabilitation. Especially since the replacement cost of $3.1 million is more than twenty times the PennDOT formula estimate for rehabilitation. Is this the standard of care that is deemed acceptable by the County?

In the third paragraph it is stated that:

> "*…the rehabilitation option does not address some very critical deficiencies of this bridge. The Hadfield Road Bridge is weight restricted at 12 tons…*"

Actually, the rehabilitation option does address the most critical deficiencies. As the Inspection Report states, this rating is based on the deteriorated condition of the deck floor beams (the small steel cross pieces spanning the width of the bridge), rather than on the condition of the main girders (the large visible beams spanning the length across the stream). Because of their current condition, the deck floor beams are the "weak link" in the chain. The report, along with the previous load rating report, makes clear that the main girders have far greater capacity than the 12-ton rating would imply. If the County were to replace the deck floor beams, the 12-ton rating would likely be adjusted upward.

In the correspondence the term "Fracture Critical" is used to describe the bridge:

> "*…and the bridge is fracture critical. Fracture Critical means there is no redundancy of the load*

paths and if one of the girders should fail due to fatigue, vehicular impact damage, flood impact damage, deterioration, or an inherent defect, the bridge will collapse."

Correct, but this term can sound alarming to the lay public and should be understood in the technical context. The following is taken from the AASHTO Subcommittee on Public Affairs web site in partnership with the Standing Committee on Highways and Subcommittee on Bridges and Structures, where "Fracture-Critical" is defined as:

A fracture-critical bridge is one that does not contain redundant supporting elements. This means that if those key supports fail, the bridge would be in danger of collapse. This does not *mean the bridge is inherently unsafe, only that there is a lack of redundancy in its design.* (Emphasis in original text).

This is basically another way of saying that the bridge is a simple, single span, like thousands of other robust functional bridges in the Country. This bridge has been "fracture critical" since the day it opened in 1913.

The third paragraph of the MTA correspondence goes on to say

"*…Several of these photos depict the girder/floorbeam connection which is severally deteriorated and beyond repair. As inspectors, we are no longer able to identify potential cracking in this area due to the amount of pack rust and deterioration present. A crack propagating from this connection could cause the collapse of the bridge due to its fracture critical status."*

The replacement of the deck floor beams would involve the inspection and repair/replacement of the connections to the main girders. At that time the girders would be visually inspected and possibly tested (magnetic particle testing, dye penetrate) locally for any indication of crack propagation, which if detected, could be arrested and repaired. It should be noted, however, that the MTA Interim Report from last year (pg.4, 2nd para.) discusses the floor beam-girder connection:

"*…The out of plane bending detail of the floorbeam-girder connection shows no signs of fatigue or fracture."*

This would seem to contradict the statement quoted above regarding the ability of inspectors to identify potential problems in these areas.

In the fourth paragraph it is stated that:

"*…in addition to the fracture critical status, it should be noted that steel has a fatigue life and with each overload it experiences, the fatigue life is reduced. The County is aware that this bridge has been subjected to loads in excess of the 12-ton restriction, particularly during the closure of the E. Reeceville Road Bridge. I like to use the analogy of the wire coat hanger to demonstrate fatigue life. You can bend a wire coat hanger a number of times, but eventually it is going to snap in half. This is essentially what happens when fatigue life of steel is reached due to a determinant number of loading cycles*."

Again, all true but not relevant to the case in question. As mentioned above, a deck floor beam replacement and girder repair would result in an up-rated bridge. Thus, the "fatigue life" of the current deck floor beams, rated at 12 tons, is irrelevant since they will be replaced. For the repaired girder, its fatigue life would be extended. The analogy of the wire coat hanger is not particularly useful in this case. Repeatedly bending a

coat hanger until it breaks implies taking the metal well beyond its yield strength over a number of cycles.

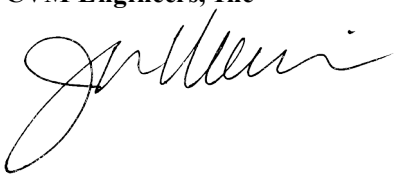
However, bridge engineering is based on limiting bending stresses to a fraction of steel's yield stress, and is premised on keeping the material at lower levels of linear elastic stress-strain behavior (the so-called "Factor of Safety" i.e. the normal use of the coat hanger). If the fatigue life of the main girders is truly in question, it should be quantified. It was not noted in the inspection report. The MTA report does however note that average daily traffic (a measure of loading cycles) is a very low 282 vehicles per day as of 2002.

Based on the data presented in the inspection reports, the County has failed to adequately maintain this historic bridge so as to prevent continuing deterioration. However, with the proper approach, it appears that the Hadfield Bridge could feasibly be repaired and continue in service as an important part of the historic fabric of the Township. Although the referenced MTA correspondence makes it clear that the County's Bridge Engineer is not confident in the costs that it provided earlier in its inspection report, I'm confident that a rough estimate in the range of $300,000 to $350,000 is reasonable and is a fraction of the full replacement cost of $3.1 million.

The forgoing should not be construed as minimizing the importance or relevance of the ongoing bridge inspection process or of the results and findings that have been catalogued. Just the opposite is true. These reports, properly interpreted, highlight the importance of effective inspection, maintenance and repair of the County's historically significant infrastructure. To that end, we recommend that the County, without delay, engage a qualified bridge preservation engineer, experienced with the inspection, metallurgical testing and design of repairs of historic steel bridges, to perform at least a preliminary study to establish a repair scope of work and accurately estimate of costs for the rehabilitation of the Hadfield Bridge.

Sincerely Yours,

CVM Engineers, Inc



Jon E. Morrison, P.E.
President