McMullan & Associates, Inc.

June 12, 2017

Ms. Maya K van Rossum, The Delaware Riverkeeper
Delaware Riverkeeper Network
925 Canal St., Suite 3701
Bristol, PA 19007   M&A 3575

RE: Headquarters Road Bridge

Dear Ms van Rossum,

As requested, we examined the PennDOT "Comment Response Document" dated May 17, 2017, page 49, specifically the response the comment on page 31, which reads as follows:

Page 31 comments: Urban provided a discussion on the Existing Structure Condition Evaluation Report at the November 4, 2013 Section 106 Consulting Party Meeting, which detailed the condition of the bridge and the reasons the bridge cannot be rehabilitated. See the meeting minutes, which are posted to ProjectPATH. In addition, as noted in the Alternatives Analysis Additional Information Memo provided to PA SHPO in June 2016 (page 15), Alternative 3, which involves rehabilitation of the piers, does not meet the project purpose and need. Since the last meeting, stone masonry design codes from the 19th century have been identified, specifically the Architect's and Builder's Pocket-Book, by Frank E. Kidder, from 1884. The book was considered the essential design reference for structural engineering in that era. The manual defines the safe working loads for rubble stone masonry based on case studies of failures, and by cataloging the materials and craftsmanship of masonry. The non-uniformity of the building material and reliance on craftsmanship resulted in a variable range of material strengths. Kidder lists safe allowable pressure for grouted rubble stone masonry to be 10 tons per square foot (TSF). He also defines a safety factor of 10 for bridge piers. Using these recommended values (which account for rubble stone masonry in good condition), the safe working stress would be 1 TSF or 13.89 pounds per square inch (PSI). This safe working stress was compared to the ultimate stress from the existing superstructure and an H-10 truck load (a representative live load vehicle from the early 1900s), and it was found to be within the allowable range by approximately 17%. However, when comparing the loads from a new superstructure that is designed for modern live loads (HS-20 truck), the resulting loads exceed the allowable stresses by 22% for a new steel superstructure and 80% for a new prestressed concrete superstructure. This does not include the typical uniformly distributed lane load that is typically included for modern bridges, which is an added safety factor that accounts for the potential for overloaded vehicles utilizing the bridge. Thus, reuse of the existing stone masonry is not feasible.

As a result of our examination of the above, we offer the following comments:

1. The reference "Architect's and Builder's Pocket-Book, by Frank E. Kidder, 1884 edition, was superseded by later versions as technology was developed. Although we could not find a copy of the 1884 version, the earliest version we did find was the 1886 version of the same book. There were many versions of the Pocket Book that were printed, including the 1942 version which contains much more updated and authoritative information on allowable rubble stone masonry stresses that are similar to those found in building codes or AASHTO.

2. The 1886 edition of Kidder's Pocket Book, states "the working strength of masonry is generally taken at from one-sixth to one-tenth of the crushing-load for piers, columns, etc." The working strength of masonry is the same as the allowable strength, and no further safety factor needs to be applied. If the referenced 1884 version of the Pocket book lists a "safe allowable pressure for grouted rubble stone masonry to be 10 tons per square foot", then it is incorrect to apply a safety factor of 10 to this value because the safety factor has already been applied to the crushing load to determine the safe working load. The allowable stress should be 10 tons / sq foot which equals 138.89 psi, not 13.89 psi.

3. The 1886 edition of Kidder's Pocket Book states "the working strength of the foundation wall can easily be determined by multiplying the area of its upper surface in square feet by six tones for brick work, two and a half tones for common rubble…". This value of 2.5 tons per square foot for common rubble stone masonry equates to a working strength of 34.72 psi, a very conservative value compared to later references.

4. The later 1942 edition of Kidder's Pocket Book, provides a safe allowable load of 100 psi for "Rubble Stone" in "Cement lime mortar". This value is similar to the AASHTO Manual for Condition Evaluation of Bridges value of 100 psi for rubble stone in type N mortar.

5. According to PennDOT's response, they calculated that the applied loads in the piers for a new prestressed concrete superstructure with HS-20 loading exceeded the allowable stresses of 13.89 psi by 80%. This means that the PennDOT calculated HS-20 applied stress equals 13.89 psi x1.8 = 25.00 psi.

6. PennDOT's calculated applied stress of 25.00 psi **is four times less** than the 1942 Kidder and AASHTO values of allowable stress. It is even 38% less than the conservative 1886 Kidder value of 34.72 psi. Clearly, **the stress in the piers is well within the acceptable limits!**

7. There are some interesting questions that arise from this PennDOT response, such as "What are the allowable working stress values used for rubble masonry foundations in PennDOT stone arch bridges?

8. In summary, we find that the conclusion "…reuse of the existing stone masonry is not feasible." to be based on out of date or incorrect information, and that according the calculated stresses provided by PennDOT, those stresses are well within acceptable limits.

Let us know if we provide any further service regarding this review,

Sincerely,

Douglas E. Bond, PE
McMullan & Associates.