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Assessment of the Composite Arch Bridge System (Bridge in a Backpack) First Year Findings

References – Work Plan No. 2013-PIF-01

INTRODUCTION:

The Research and Development Section completed its first year assessment of the Bridge in a Backpack (BiaB) structure, or more recently referred to as the Composite Arch Bridge System (CABS) constructed in the summer of 2014 (Fairfield BRO 1448(38)). The weather was mostly sunny with a temperature of 65° and light winds. Stream flow was moderate to light. The objective of the site visit was to take observations of the condition of the bridge and to collect measurements of the arches to determine if any movement is occurring.

PRODUCT DESCRIPTION:

The Composite Arch Bridge System (CABS) is an innovative composite bridge system that is AASHTO approved. AIT claims the bridge system lowers construction costs, extends structural lifespan up to 100 years, and is a greener alternative to concrete and steel construction. ATI provide conceptual and design services for the bridge system, the fabrication of composite superstructure elements as well as installation oversight. All designs are engineered to exceed AASHTO load standards for single span bridges from 25 ft. to 70 ft. and multi-span designs exceeding 800 ft. The system uses a composite exoskeleton to fortify concrete superstructure. This adds significant strength, durability and protects the concrete from corrosion. The fabrication of superstructure elements is a proprietary process that fuses several layers (including carbon fiber) with resin to create the composite material. The exact blend is engineered to optimize the efficiency of the bridge design. Inexpensively transported to the job site, composite arches are placed in position, covered in composite decking and filled with an expansive concrete.

OBSERVATIONS:

Initially, the overall appearance and basic geometry of the bridge was evaluated. Since the last site visit a year ago, the overall appearance has not changed. No points of impacts or damage were observed. The riverbed under the bridge appeared to have experienced very little change since construction. Overall, the bridge appeared to be performing as expected. One area of concern is that the headwalls seem to be bowing outward by the lateral pressures applied to them by the roadway bed. The bowing appears to be in 1-3 inch range at this point and will need to be monitored more closely in subsequent site visits. The westerly headwall is bowing throughout its entire length in a smooth curve, where the easterly headwall seems to be held back in some places, and bowing in others with a meandering curved shape (see Figure 1 and Figure 2).

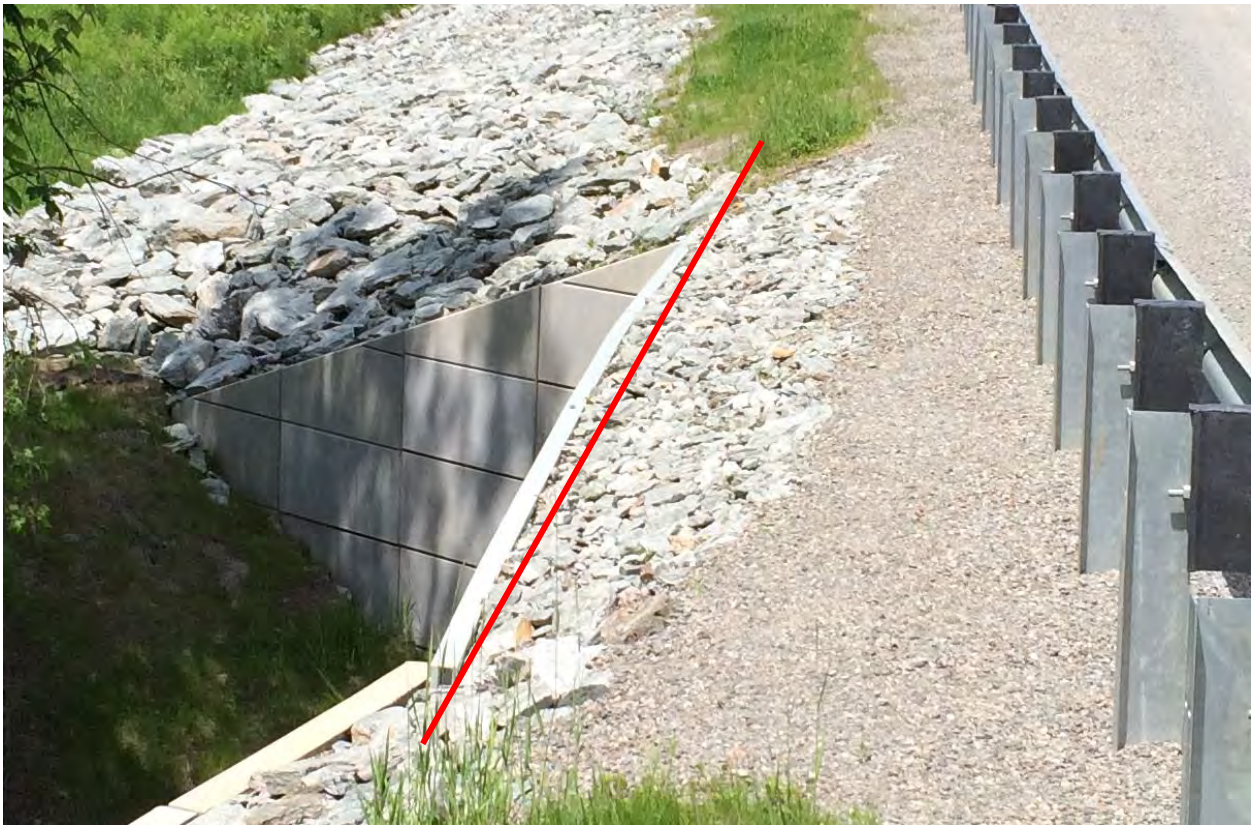

Figure 1 Westerly headwall with bowing out with a smooth curved shape

MEASUREMENTS:

As with the prior year, measurements were taken on three arches at the center of the structure. Marks were placed on the arches in October of 2014 about one inch above the abutment and another mark where a straight 7.5 ft. line intersects the arch, from the first mark. The measurements were taken between the two upper marks, the diagonals from the upper marks to the lower marks and between the lower marks. (See Figure 3) The 7.5 ft. diagonal measurements were checked. The measurements are taken with a cloth tape attached to the ends of steel rods so the field inspectors could reach the high points. This measurement method is subjected to human and equipment error. Movement will become more noticeable as future measurements are collected from the site and added to the dataset.

The overall measurements (see Table 1) averaged about 3/8 inch different from the measurements taken in 2014 discounting the sign of the dimensional change. If expansion and contraction is considered the average change is 3/16 of an inch. These represented a 1.38% and 0.68 % overall difference respectively. The differences did not indicate any significant change is occurring. One of the diagonal measurements displayed a contraction on all three arches of approximately 3/4 of inch, which is well within the capacity of the arches to redistribute loads without harm.

The data collected over the last year suggests that there is contraction occurring in the horizontal line 'A' for arch 6 of about 1/4 inch, and an expansion of about a 1/4 inch for arch 4 and 3/8 inch for arch 5. All arches showed expansion along the diagonal line 'B' from 5/8 inch on arch 4 down to an 1/8 inch on arch 6. All arches showed contraction along the diagonal line C from 3/4 inch on arch 4 to 7/8 inch on arch 6. Arch 4 showed some expansion by 1/8 inch along

horizontal line 'D' where arches 5 and 6 showed contraction by 3/8 inch. These measurements suggest that the arches are deflecting slightly in a southerly direction.

Figure 2 Easterly headwall bowing out with a meandering curved shape

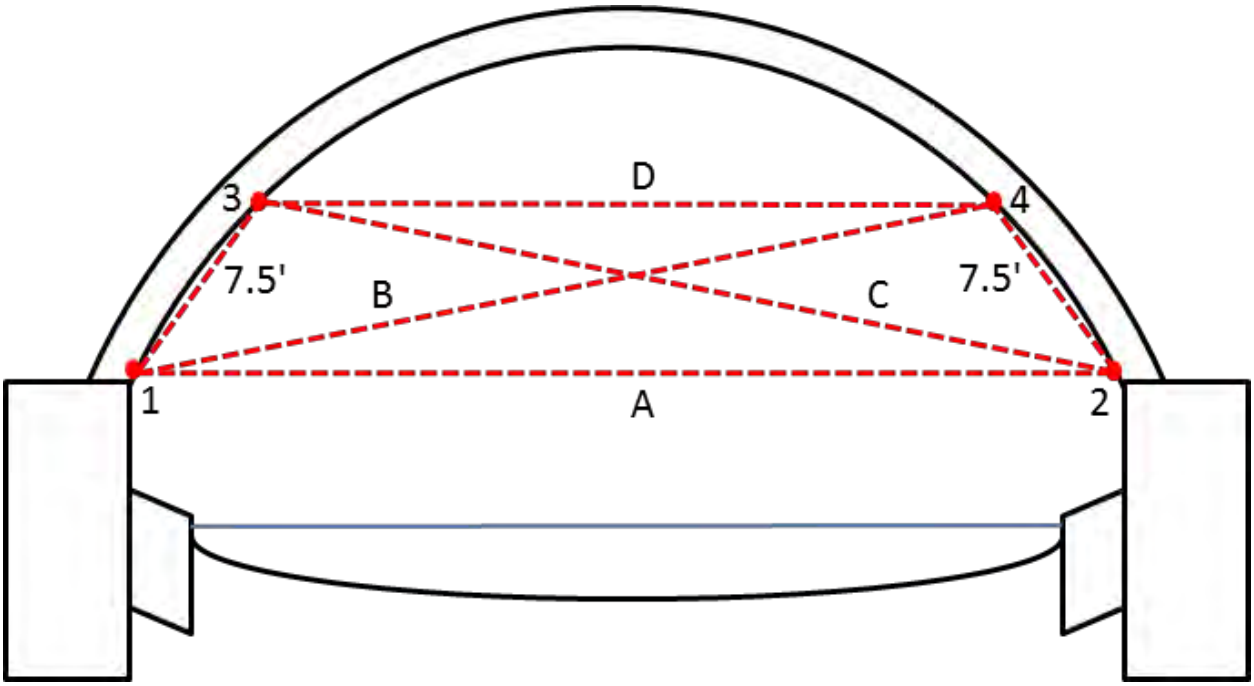

Figure 3 Measurements taken

Table 1 Measurements Taken (ft.)

	Line	Field Visit Dates	
		10/17/2014	**6/25/2015**
Arch 4	**A**	34.58	34.6
	B	28.78	28.83
	C	28.91	28.85
	D	22.47	22.48
Arch 5	**A**	34.58	34.61
	B	28.78	28.8
	C	28.85	28.81
	D	22.44	22.41
Arch 5	**A**	34.6	34.58
	B	28.85	28.86
	C	28.91	28.84
	D	22.47	22.44

CONCLUSIONS AND FOLLOW-UP:

There appears to be no change to the overall shape and performance of the externally FRP reinforced concrete arches. The arches are not exhibiting any negative environmental impacts. There is no impact damage to the arches from stream activity. The headwalls are showing some displacement, which may be due to setting of materials. Continued monitoring including a

method of measurement for the headwalls is appropriate. An inlet and outlet arch will be added to the dimensional checks in subsequent years. Notification of the change in condition will be provided to VTrans Structures, District and Geotechnical staff for their consideration.