Exhibit 8.5.3. Time-lapse video

Note: Redaction in "Exhibit 8.5.3 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

Exhibit 8.5.4. Time-lapse video

Note: Redaction in "Exhibit 8.5.4 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

Exhibit 8.5.5. Time-lapse video

Note: Redaction in "Exhibit 8.5.5 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

Exhibit 8.5.6. Time-lapse video

Note: Redaction in "Exhibit 8.5.6 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

Exhibit 8.5.7. Time-lapse video

Note: Redaction in "Exhibit 8.5.7 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

Exhibit 8.5.8. Time-lapse video

Note: Redaction in "Exhibit 8.5.8 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

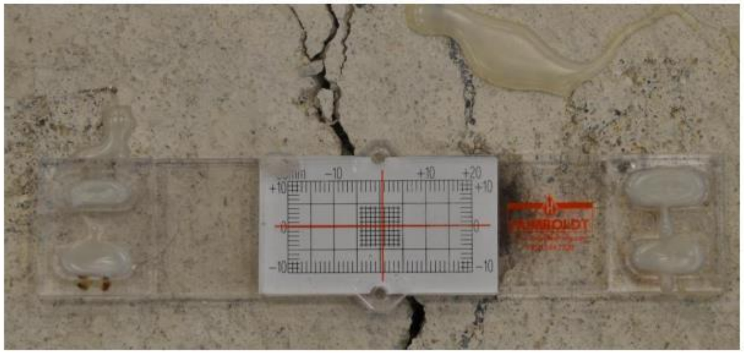
Exhibit 8.5.9. Time-lapse video

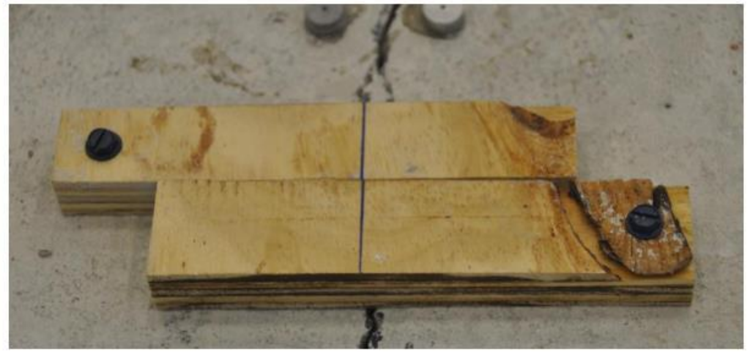
Note: Redaction in "Exhibit 8.5.9 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

Exhibit 8.5.10. Time-lapse video

Note: Redaction in "Exhibit 8.5.10 Time-lapse video" as per NTSB Operations Bulletin CIO-GEN-016.

Exhibit 8.6.1. Comparison of crack monitoring methods for 0.02 inch change in crack width





Upper left: Humboldt crack gauge

Upper right: Wood block crack gauge

Lower left: Crack comparator

9 SUMMARY OF FINDINGS AND CONCLUSION

The following summary of findings and conclusion follow from the research and analysis described in Sections 2 through 8 of this report. The section that relates to each conclusion is indicated.

Failure Pattern (Section 2). A debonding and sliding failure at the construction joint below Member 11 led to breakout failure of the north-end diaphragm and ultimately collapse, triggered by sudden crushing of Member 11 near its base.

Construction Joint Conditions (Section 3). Despite FIGG's confirmation to MCM that the FDOT Standard Specifications requiring roughening of the ***hardened*** concrete must be followed, the construction joint surface below Members 11 and 12 appeared to have been left in an as-placed (non-roughened), relatively smooth condition.

Interface Shear Transfer Testing (Section 4). The primary finding from the experimental program is that intentional roughening of the construction joint following FDOT Standard Specifications improved the shear capacity of the cracked interface by a factor of 1.78. This factor reduces by 5 to 13 percent if adjustment for Florida aggregate is made based on slant shear tests. This finding is consistent with relative difference according to the AASHTO Code: the maximum allowable shear stress for a roughened surface (1.5 ksi) is 1.88 times that for a non-roughened surface (0.8 ksi).

Comparison of observed axial strengths of the as-placed (non-roughened) specimens to the calculated force in Member 11 after the shoring was removed suggests that the construction joint was weakened or at least partially debonded when the shoring was removed.

More significantly, the axial capacities of the roughened specimens, before or after adjustment for Florida aggregate, are substantially greater than the calculated axial force in Member 11 at the time of the collapse. As such, if the construction joint were roughened as required by the FDOT specifications, the collapse would not have occurred. This conclusion is valid for hardened concrete surfaces intentionally roughened in accordance with FDOT Standard Specifications even if the surface roughness is considered to be less than the 1/4 inch amplitude referenced in the AASHTO Code. Also note that this conclusion neglects the additional capacity from breakout resistance of the north end diaphragm, which if included would provide additional capacity to the connection.

Structural Analyses (Section 5). A finite-element model of the main span was developed to determine truss member forces and bending moments during construction.

AASHTO LRFD Design Compliance. The Member 11/12 deck connection was evaluated in accordance with the AASHTO Code, assuming resistance by shear-friction across the entire construction joint. Although inconsistent with the actual failure mode, resistance by shear-friction across the entire construction joint is the likely design assumption. Based on WJE test results, the AASHTO friction coefficient for a roughened surface (which calls for 1/4-inch roughness amplitude) was assumed. However, AASHTO does not provide specifics on preparation of the joint (including intentional roughening of hardened concrete) or how roughness is measured. The FDOT Standard Specifications, as proven by laboratory testing, achieves the requirements of AASHTO Code. The capacity-to-demand ratio was found to be 1.09 if AASHTO load modifiers for ductility and redundancy are excluded, and 0.99 if they are included, indicating compliance with AASHTO design requirements.

Estimated Capacity for Non-roughened Joint. For the assumption of an un-roughened surface, factored capacity calculated in accordance with the AASHTO design code was much less than the factored demand, indicating a significant deficiency if the bridge is not built in compliance with the FDOT Standard Specifications for preparation of construction joints.

Capacity Analysis for Observed Failure Pattern. The Member 11/12 deck connection was also evaluated based on results of the interface shear transfer testing in combination with breakout resistance consistent with the actual failure pattern, ACI 318 design equations, and related research. The results indicate that the combined shear-friction and breakout resistance is consistent with the calculated horizontal force in the Member 11/12 deck connection at the time of the failure. This explains the failure due to the unroughened construction joint surface.

Evaluation of Peer Review (Section 6). Berger's peer review fell far short of their contractual obligations. In particular, by their own admission, Berger did not even attempt to assess the conditions at the construction stage shown in the plans that was being built at the time of the collapse, which was required by their contract. Furthermore, the Berger finite element model could not have been used to reasonably estimate the forces in the concrete truss members during construction or in the structure's final configuration because it did not address the construction phasing.

Evaluation of Twist Exceedances during the Main Span Transport (Section 7). Cracks in the region of the connection of Members 11 and 12 to the deck increased dramatically after the move from the casting yard to the final location, as evidenced by photographs taken before and after the move. The deformations associated with exceeding the established twist limits caused high stresses in the region. Along with other factors, this stress may have been a contributing factor to damage in the region and ultimately to the collapse.

Re-Stressing of Member 11 (Section 8). Contrary to FIGG's instructions, no one closely monitored cracks in the north-end diaphragm during re-stressing of Member 11, even though both MCM and Structural/VSL were aware of the instruction. Also, Structural/VSL's shop drawings state that stressing operations should stop if existing cracks widen or new cracks are observed. Evidence shows the construction joint was not roughened, so the existing cracks would have widened during re-stressing, and the widening could have been readily detected by several means. In accordance with FIGG's instruction and Structural/VSL's awareness of crack monitoring per their shop drawings, widening of the cracks would have required stopping the re-stressing, thereby preventing the collapse.

Conclusion. In conclusion, most significant finding from WJE's research and analysis is that full-scale tests show that if the construction joint below Members 11 and 12 were roughened as required by the FDOT Standard Specifications, the collapse would not have occurred. It is also highly significant that, for the observed failure pattern and relatively smooth as-built condition of the construction joint, the combined shear-friction and breakout resistance determined from testing and analysis is consistent with the calculated horizontal force in the deck connection at the time the failure.