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SUMMARY TEST REPORT

US 401 HPC Bridge Girders

Charlotte, North Carolina
Spring and Fall, 2000

FHWA MCL Project # 0001

Federal Highway Administration
Office of Pavement Technology
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400 7th Street, SW
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Summary Report
0001, HPC Girders, NC
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This report presents the results from a concrete materials test program conducted by FHWA's Mobile Concrete Laboratory (MCL) on the casting of two AASHTO Type IV high performance concrete (HPC) bridge girders for use in the US 401 bridge over the Neuse River in Wake County, North Carolina. The objective of the MCL involvement with this project was to aid NCDOT and NC State with their materials test and instrumentation plan and to supplement their extensive materials test plan with on-site testing capabilities. The overall objective of NC State's test program is beyond the scope of this summary, and is discussed in NC State's project reports.

The test program involved providing early-age compression and modulus of elasticity (MOE) results as well as match cured specimens for later-age testing of compression, rapid chloride permeability (RCP) and coefficient of thermal expansion (CTE). All early-age testing was performed in the MCL at the pre-casting facility during the week of March 13th 2000. Later-age tests were performed in the Mobile Concrete Laboratory at Turner Fairbank Highway Research Center in McLean Virginia. A total of 16 four-by-eight inch concrete specimens were cast from each girder. Seven of these were temperature match-cured to their respective girder. Match curing for girder A-4 used temperature probes inserted near the centroid of the lower flange at **mid-span**, while for girder B-4 temperature probes were inserted near the centroid of the lower flange near (within 6" of) the **end of the girder**. This was done to illustrate how concrete at different locations within the girder cures at different temperatures. During placement on March 15th, workability problems relating to the admixture dosage and haul time, resulted in severe slump variations (2 to 8 inches) which in turn resulted in difficulties with concrete placement and consolidation. Upon form removal, severe honeycombing was revealed in girder B-4, and vertical mid-span cracks were evident in girder A-4 (see Figure 1).

Both girders were consequently rejected, and NC State terminated all further data collection from the girders.

Figure 1. Honeycombing in Girder B-4

As a result of the failures in these girders, the test program was repeated for the casting of two more girders on October 3rd and 5th, 2000. Due to scheduling conflicts, the MCL was unable to provide on-site assistance, and participated only in later age RCP and CTE testing.

Few meaningful conclusions can be drawn from the data collected by the MCL, since the results are part of a much bigger test program conducted by NC State and NCDOT. However, the following observations are made based on the MCL's test data:

1. The match-cure compressive strengths were significantly higher for girder B-4 than for A-4 at both 28 and 90 days. This is probably related to a lower air content and a lower water content (as evidenced by a significantly lower concrete slump) for girder B-4. Girder B-4 had an air content of 4.4% and a slump of 3¾ inch, while girder A-4 had an air content of 5.8% and a slump of 8¼ inch. Appendix A shows the mixture proportions, plastic concrete test results, compressive strength results, as well as strength development curves.

2. The early-age match-cure strength of girder A-4 however, was greater than that of girder B-4. This is due to the higher early-age temperatures experienced by the A-4 match-cure strength specimens. Girder A-4 was instrumented with temperature probes at mid-span, whereas girder B-4 was instrumented near the end of the girder. The heat generated at mid-span is significantly greater than at the girder ends due to the greater surrounding thermal mass (difference in maximum temperature of 37^{o}F). Appendix B shows the temperature histories of the girders, the match cure specimens, the field cure specimens and the outside temperature.

   It should be noted that while the higher early-age temperatures experienced by girder A-4 match cure specimens resulted in higher early age strengths, the 90 day strengths were 4000psi lower than the match cure specimens for girder B-4 (see Appendix A). This is consistent with expectations as well as previous field experience.

   The slight discrepancies between the match cure temperatures and the girder temperatures for both girders are probably related to the presence of honeycombing and inadequate consolidation resulting in poor contact between the thermocouples and the concrete.

   In girder B-4, the field cure specimen temperature is observed to continue to rise, even after both the girder temperature and the match cure specimen temperature have started to fall. Also, when the field cure specimen temperature eventually starts to fall, it falls at a much lower rate than the match cure or girder temperatures. This is most likely a function of where the field cure specimens were placed. Consistent with normal practice, the field cure specimens were placed on a shelf along the girder form. As the shelf can only accommodate one row of cylinders, the specimens inevitably had to be placed along the shelf in a row toward the girder center. Consequently, these specimens were on average several feet away from the girder end, and adjacent to concrete experiencing temperatures much higher than the concrete at the girder end (see Appendix B).

3. Early-age MOE is slightly higher for girder A-4 than for B-4. This is not unexpected, since the early-age strength is slightly higher as well (see bullet item 2.). No systematic or statistically significant difference was detected in early-age MOE for match-cure versus field cure specimens. Appendix C presents MOE results.

4. RCP tests conducted on samples cast on March 15, 2000 indicate that the rapid chloride permeability of the concrete for both girders was low to very low. For both concretes the RCP values dropped significantly from 28 days to 56 days, indicating that the permeability is continuing to improve. RCP tests conducted on samples provided by NC State for concrete placed on October 3 and 5, 2000 however, were high to moderate at 56 days and moderate to low at 90 days. It is unclear why the RCP values are significantly higher for the concrete placed in October than the concrete placed in March (indicating a more permeable concrete). Appendix D presents all RCP results.

5. CTE tests indicate that the thermal coefficient of the concrete mixture placed in October is significantly lower than that placed in March. Average 56 day CTE results for the Type III and Type IV girders placed in October are 7.4 $in^{-6}/in/^{o}C$ and 8.7 $in^{-6}/in/^{o}C$, respectively, while average 28 day CTE results for girders A-4 and B-4 placed in March are 11.1 $in^{-6}/in/^{o}C$ and 10.4 $in^{-6}/in/^{o}C$, respectively. It is unclear why we have this difference. Appendix E shows the CTE summary results.

All available raw test data was provided to Dr. Paul Zia with NC State first on July 17^{th} 2000, and again on March 20, 2000. If you have any comments or questions about these findings/results, please contact Leif Wathne, Concrete Materials Engineer with the Mobile Concrete Laboratory at (202) 366-1335 or *leif.wathne@fhwa.dot.gov*.