NHDOT SPR2 PROGRAM
RESEARCH PROGRESS REPORT

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a progress report at least every three months during the project duration. Reports are due the 5th of the month following the end of the quarter. Please provide a project update even if no work was done during this reporting period.

Project # 26962P		**Report Period** Year: 2017 ☐Q1 (Jan-Mar) ☐Q2 (Apr-Jun) ☐Q3 (Jul-Sep) ☒Q4 (Oct-Dec)
Project Title: Reducing Cracking in New Bridge Curbs		
Project Investigator: Eshan Dave **Phone: 603-862-5268**		**E-mail: eshan.dave@unh.edu**
Research Start Date: December 1, 2016	**Research End Date:** September 30, 2019	**Project schedule status:** ☒ On schedule ☐ Ahead of schedule ☐ Behind schedule

Brief Project Description: In recent years a number of newly constructed concrete curbs on NHDOT bridges have suffered from premature, early-age cracking. This project focuses on proposing necessary changes to the materials specifications as well as construction and maintenance practices to lower the propensity for early age cracking. The scope of the project involves developing a crack measurement system to quantify cracking in curbs, using the measurement system on a number of newly constructed curbs with different concrete mixes (varying cementitious material amounts, water amounts etc.), construction practices, and curing strategies. Analysis of results from field trials and development of recommendations will also be completed.

Progress this Quarter (include meetings, installations, equipment purchases, significant progress, etc.):
Over this quarter, an additional site visit was made to the bridge site in Alexandria. One curb still has not undergone cracking after nearly four months past the placement. The other curb is experiencing cracking that has been typical of other bridges with more severe cracking near the western headwall. The cracked-free curb was wet cured for 14-day after placement.

A Microsoft Excel template was created during this quarter to store, analyze and visualize curb cracking data. The data collected from previous bridge curbs was imported into the template. The template creates crack maps to visualize the cracking on the curb. Crack maps from the Alexandria bridge curbs are presented at the end of the report in Figures 1 and 2. The x-axis of the graphs represent the distance from start of the curb. For Alexandria, the east end of the curb is the starting position and for Hampton it is the west end. The y-axis of the graphs is the severity index. The severity index was developed by researchers to try to describe the length and width of a crack by a single index. Currently, the severity index is calculated by multiplying the intensity index, which describes crack width, by the length index, which characterizes crack length, and taking the square root of the product. This can be seen in the equation shown below.

$$S_i = \sqrt{I_i \cdot L_i}$$

The figures below only show the cracking on the north curbs for each bridge. For Alexandria, the south curb has shown no cracking which is why it is excluded. The south curb was also given a 14-day wet cure as opposed to the traditional 7-day wet cure. The severity maps for Alexandria show several higher intensity cracks at one area along the curb. This area is the approximate location where the bridge deck ends. The curb continues for several more feet beyond the bridge deck which is similar to the east side configuration. The difference is that on the west side of the curb, an expansion joint was not placed near the end of the deck. This may restrict increase restraint leading to the development of larger cracks. It is also interesting to note the distribution of cracks along the curb. Most of the cracks occur on the ends in areas where the curb is resting on the ground and not on the span. The bridge deck starts at 16.5 feet and ends at 46 feet from the east end of the curb. On the south curb the copings do not continue straight beyond the ends of the deck but instead wrap into the abutment wing walls.

For Hampton, the south curb was excluded because the earliest investigation date already showed considerable cracking in the south curb making it difficult to show crack propagation over time. The early visits to Hampton were conducted prior

to the use of an intensity or length index so severity information could not be determined. The severity index from the last Hampton visit appears to indicate that the cracking was less severe than the Alexandria site. An additional metric that was created is the Curb Cracking Index (CCI) which is the average spacing between cracks divided by the average severity index. A larger CCI will indicate a curb with fewer or smaller cracks compared to a curb with a low CCI.

Three thermocouples were acquired by UNH in order to monitor the curing process of future curbs. Two loggers have thermocouple wires for embedment in concrete to measure internal temperature. Third logger has internal thermocouple and relative humidity (RH) gage to measure the temperature and humidity conditions in the curing enclosure. The loggers will be able to determine temperature inside the curb following construction and can be reused on multiple curbs. Researchers will analyze the data gathered by the thermocouples in order to determine how quickly the curbs gain strength. The thermocouples will also help determine if the housing used for curing is adequate. Researchers have already conducted tests in laboratory to determine the devices for measurement deviation.

Three bridges have been scheduled to have curbs replaced this winter, all three of these will be used to conduct trails with different remedial measures to lower the propensity for early age curb cracking. One bridge is in Tamworth. One of the Tamworth curbs will be constructed using the traditional NHDOT AA mix; the other will be a NHDOT A mix with 6-9% air entrainment and a compressive strength of 4,000 psi. For the bridge curbs in Marlborough, it is the intent of the researchers to do one curb on each bridge with a 7-day wet cure and the other with a 14-day wet cure. This will help determine if the results seen in Alexandria are related to the curing duration.

Items needed from NHDOT (i.e., Concurrence, Sub-contract, Assignments, Samples, Testing, etc…):
Continued cooperation from NHDOT regarding construction dates and coordination of test variables is required in the following months. NHDOT will need to work with researchers on making arrangements to have the thermocouples inserted into the formwork before concrete is placed. Following curb placement, NHDOT will need to send batch slips and concrete strength data to UNH researchers.

Anticipated research next 3 months:
The following key topics will be undertaken by the research team during next 3 months:
(1) Placement and investigations of the Tamworth and Marlborough bridge curbs.
(2) Conduct one-year curb investigations on the Hampton bridges.
(3) Preparation for any bridge curbs to be placed in Q2 and Q3 of 2018.
(4) Preliminary analysis of data from recently placed curbs.

Circumstances affecting project: Describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope, and budget, along with recommended solutions to those problems.
No challenges effecting the progress of the project have yet occurred. Although the construction of concrete curbs appears to be behind schedule the next quarter will see 3 additional bridges completed.

Tasks (from Work Plan)	Planned % Complete	Actual % Complete
1. Review of Current Practices	**100**	**100**
2. Construction of Concrete Curbs	**42**	**20***
3. Survey of Concrete Curbs for Cracking Performance	**10**	**20****
4. Analysis of Results and Recommendation Development	**0**	**0**

* Actual percent completed was determined assuming a total of 5 bridges will be constructed during the current Task 2 period including the bridge in Alexandria.
** Actual percent completed was determined assuming a total of 5 bridges will be analyzed during the Task 3 period including the bridge in Alexandria.

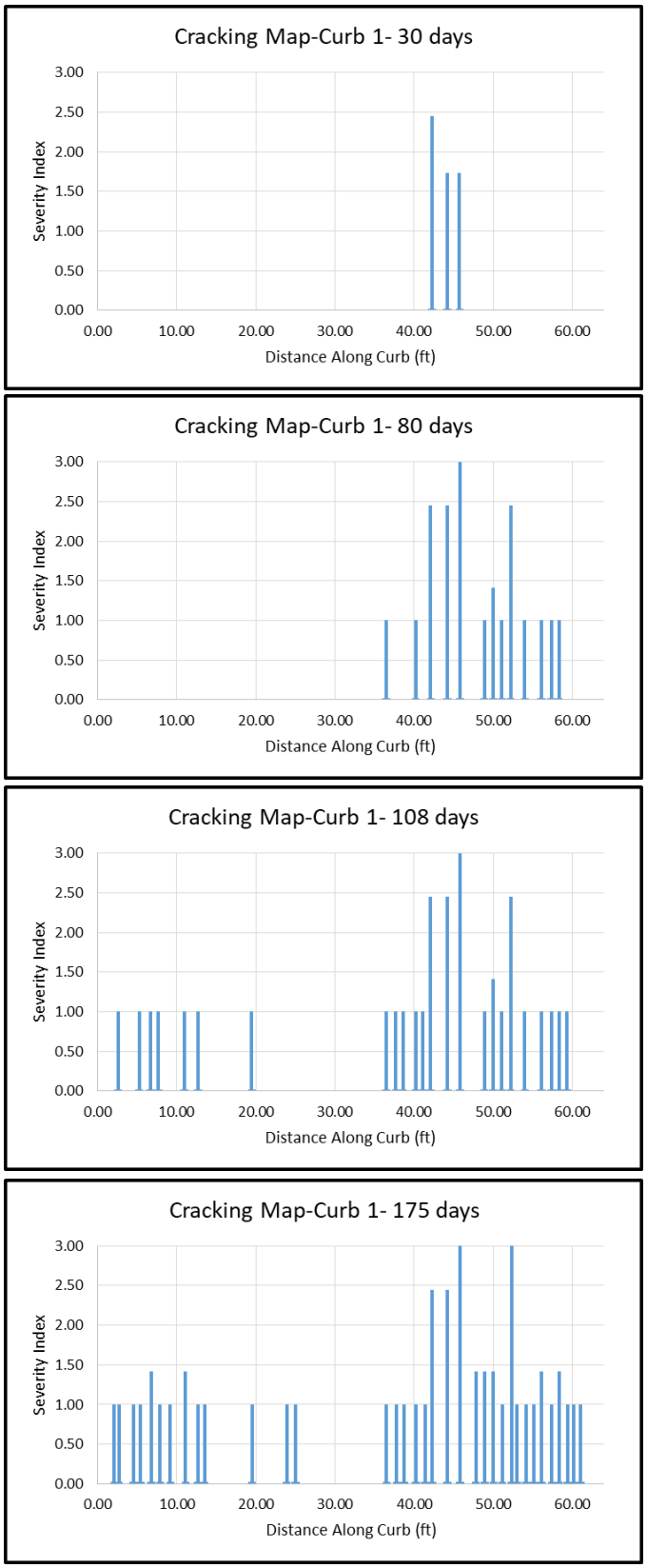

Figure 2: Progression of cracks at the Alexandria bridge site on the north curb.

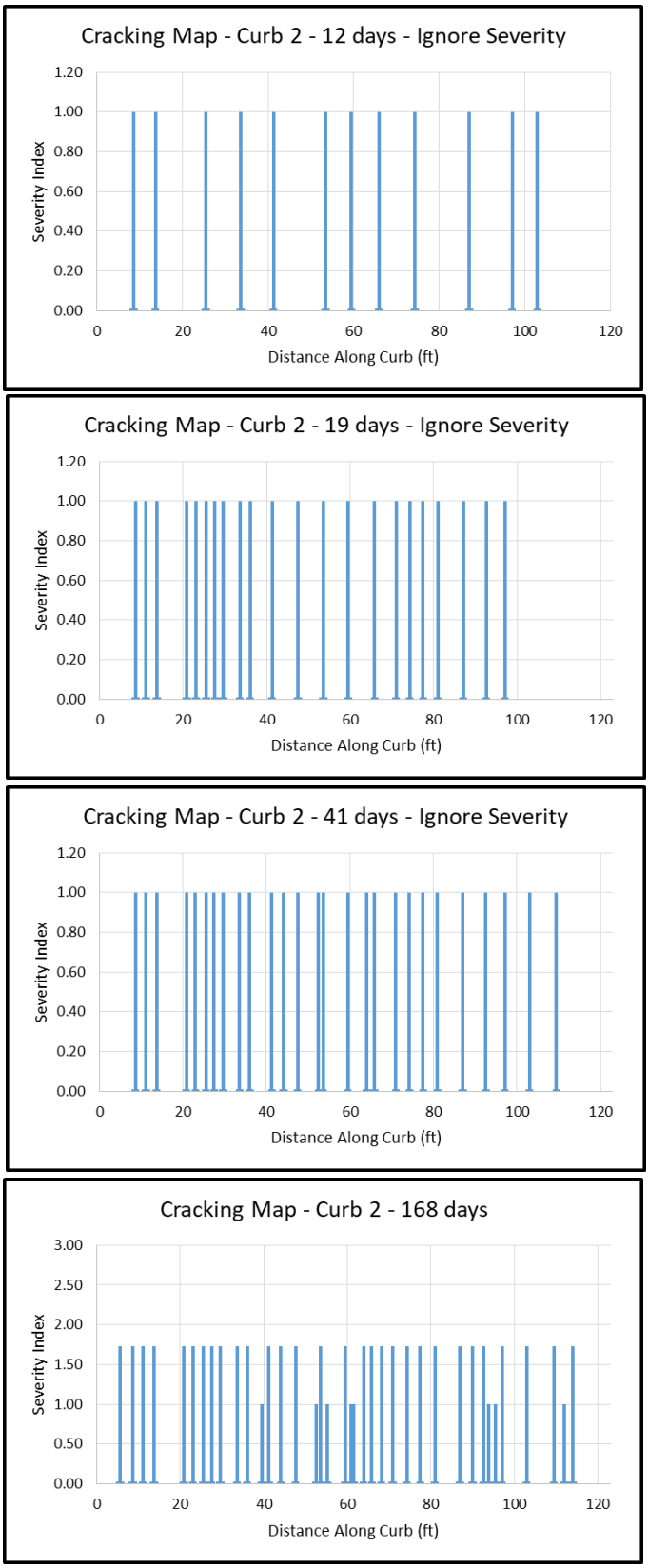

Figure 2: Progression of cracks at the Hampton bridge site on the north curb. The severity index on the top three graphs is unreliable.