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: 2019 ☒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[1]

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.):
This quarter included several site visits to curbs placed during the study. Site visits to these curbs included one year visits to Marlborough and Tamworth. An approximately 8 month visit was made to the Grantham bridge site. Additionally, five other existing bridges were visited to provide information more information on cracking for bridges around 40 ft. in length.

Analysis of all the collected data to date has been conducted, this included importing all bridge curb cracking data into a single database, calculating various indices to represent cracking extent and severity as well as statistical evaluations on the datasets. Several of the key outcome of the analysis in form of select graphs are attached at the end of the report. The analysis indicates that proximity to guardrail posts does not affect the amount of cracking the curb experiences. This can be seen in Figure 1 which shows that the percent amount of cracking near guardrail posts matches the percent length of the curb near guardrail posts. This means that relative to guardrail posts, cracking along the curb appears to be randomly distributed. The curbs are separated between bridges under 40 ft. in length and over 40 ft. in length.

The impacts of wet curing duration immediately after concrete placement was also evaluated at during this quarter. The study found that for curbs placed on the same bridge, the curb with the longer wet cure duration experienced less cracking. The data for the curb pairs is limited and can be seen in Figure 2. A similar comparison between pairs of curbs was performed for cementitious content and can be seen in Figure 3. From the curb pairs, it appears that curbs with a lower cementitious content have a larger average uncracked length which indicates less cracking.

Additionally, analysis of additional data further indicates that longer bridges have more cracking than shorter bridges. There is also less cracking seen in the ends of the curbs compared to the rest of the curb. Both of these were mentioned in previous reports and further data appears to strengthen the results although the cause for the change in cracking is still not understood. These can be seen graphically in Figure 5 and Figure 6.

[1] Task 2 is delayed slightly due to delay in curb construction. Overall project is expected to be on time.

Other analyses were conducted through graphical comparisons, student t-tests, and Pearson correlation matrices, although they have been omitted from this report for brevity. Some additional things that do not appear to effect curb cracking include the outside air temperature after placement and the average daily traffic experienced by the bridge. Additionally, many of the items that significantly affect cracking only seem to effect the average uncracked length and do not significantly affect the average length index or average intensity index of the curbs.

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 variables procedures applied to test curbs. 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) Westmoreland and Meredith bridge site visits.
(2) Further analysis and refinement of gathered data with the addition of data from Westmoreland and Meredith.
(3) Development of the draft final report and recommendations development.

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.
Two bridges are currently planned to be constructed during the study. One bridge in Westmoerland will begin in early April 2019 and one bridge in Meredith will begin in late May 2019. This means that Task 2 of the research project will extend longer than initially indicated. The extension of Task 2 means that Task 3 may be delayed as well. Fortunately, a significant portion of the analysis in Task 4 has already been completed and will just need to be updated based on information from the new bridge sites. This means the research project can still be completed on schedule providing there are no large delays in curb reconstruction. Some preliminary analysis on the curbs has been conducted for Task 4 and may help keep the project on the original timeline although newly collected data will still need to be analyzed.

Tasks (from Work Plan)	Planned % Complete	Actual % Complete
1. Review of Current Practices	**100**	**100**
2. Construction of Concrete Curbs	**100**	**90[2]**
3. Survey of Concrete Curbs for Cracking Performance	**82**	**80***
4. Analysis of Results and Recommendation Development	**0**	**40**

[2] * Actual percent completed was determined assuming a total of 5 bridges will be constructed during the study. The current bridges constructed include Alexandria, Tamworth, Marlborough, Grantham, and Westmoreland (111/072). Marlborough is counted as only half a bridge since only one curb was replaced.

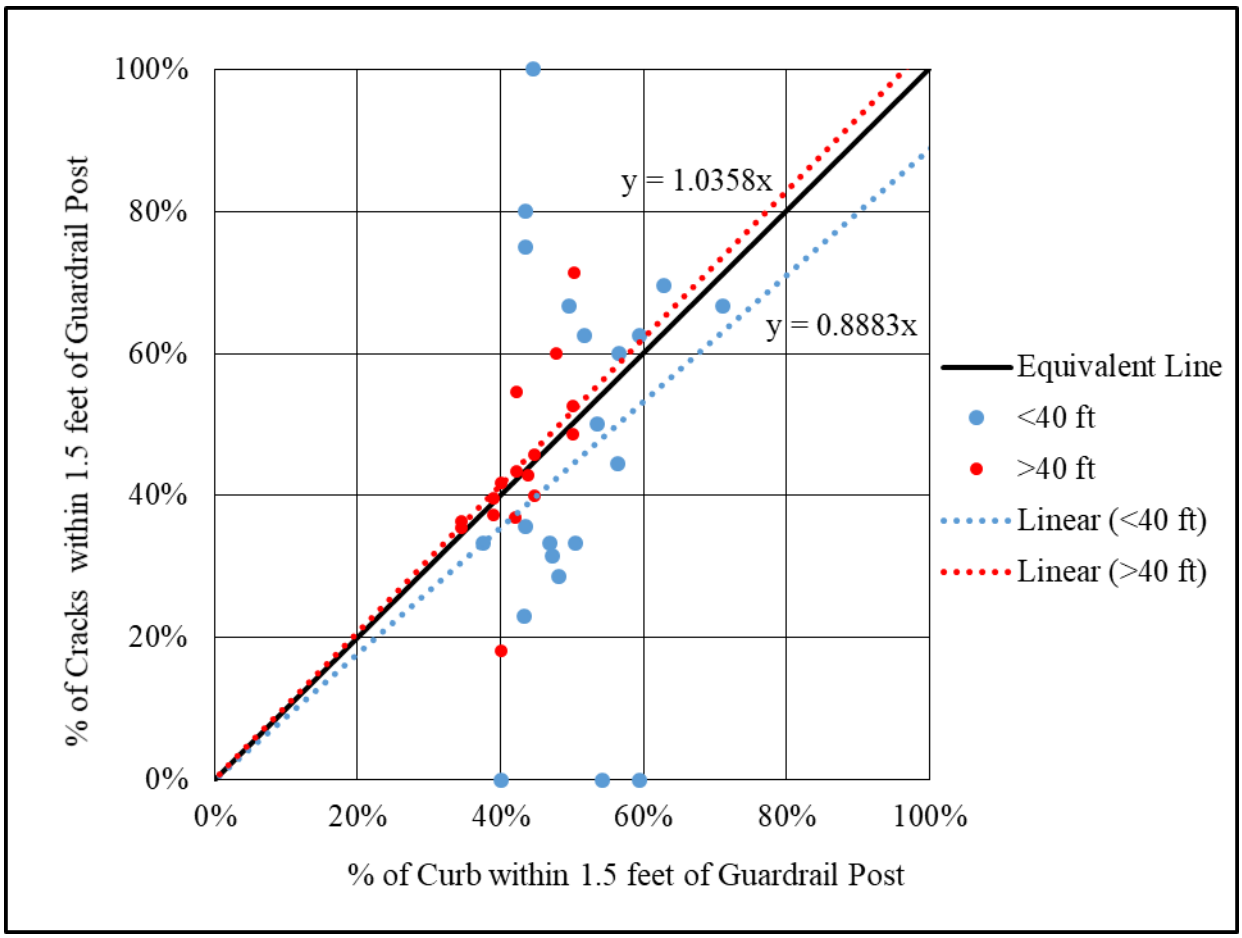

Figure 1: Comparison of the percent of near-post cracking compared to the percent of the curb that is near-post. Curbs with no cracking removed.

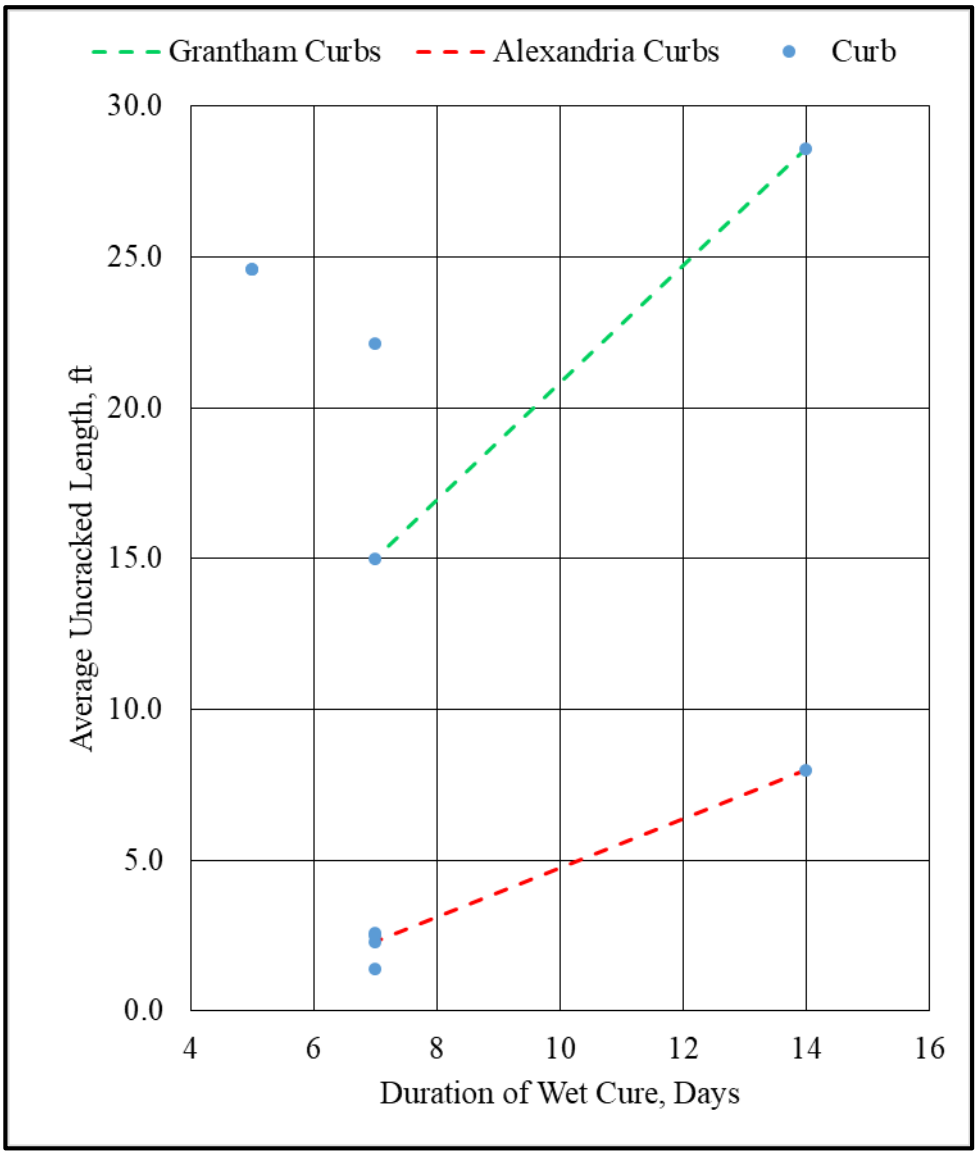

Figure 2: Average uncracked length and wet cure duration.

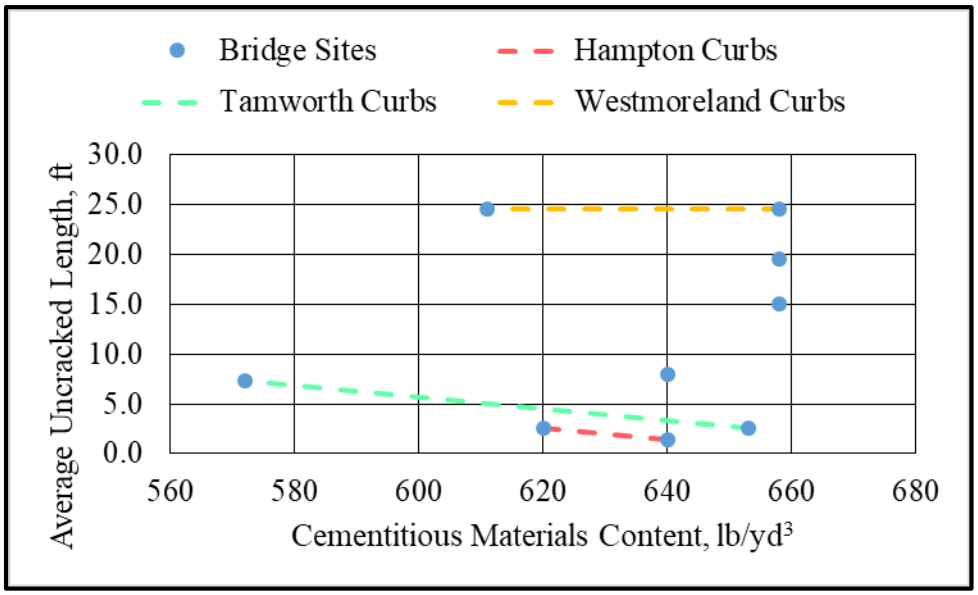

Figure 3: Cementitious content compared to average uncracked length.

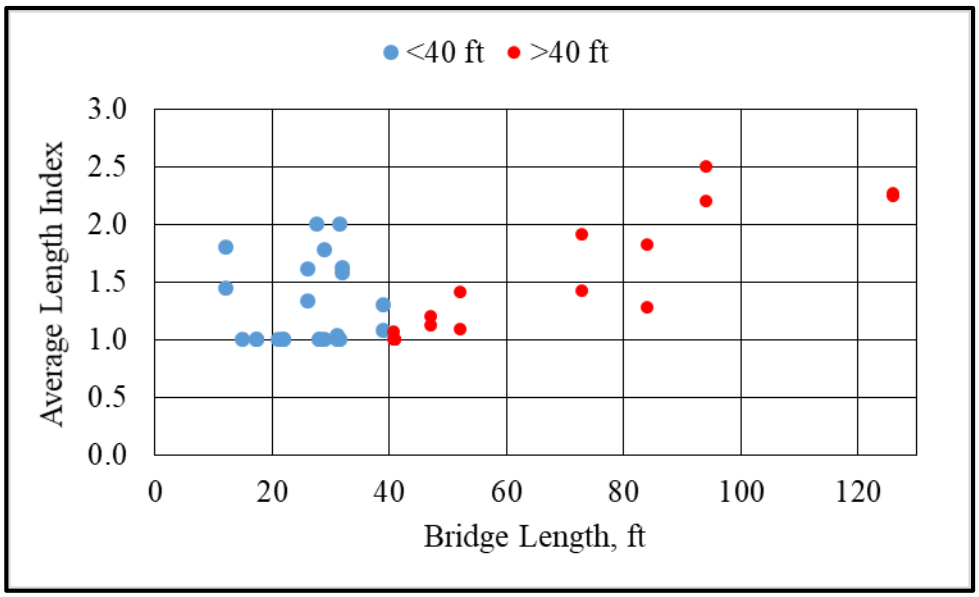

Figure 4: Effect of bridge length on average length index.

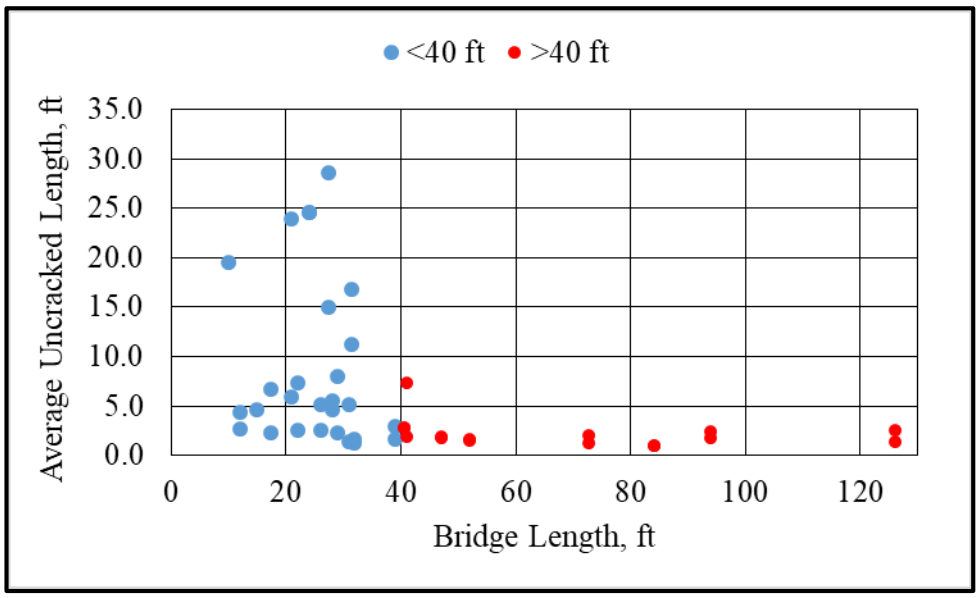

Figure 5: Effect of bridge length on average uncracked length.

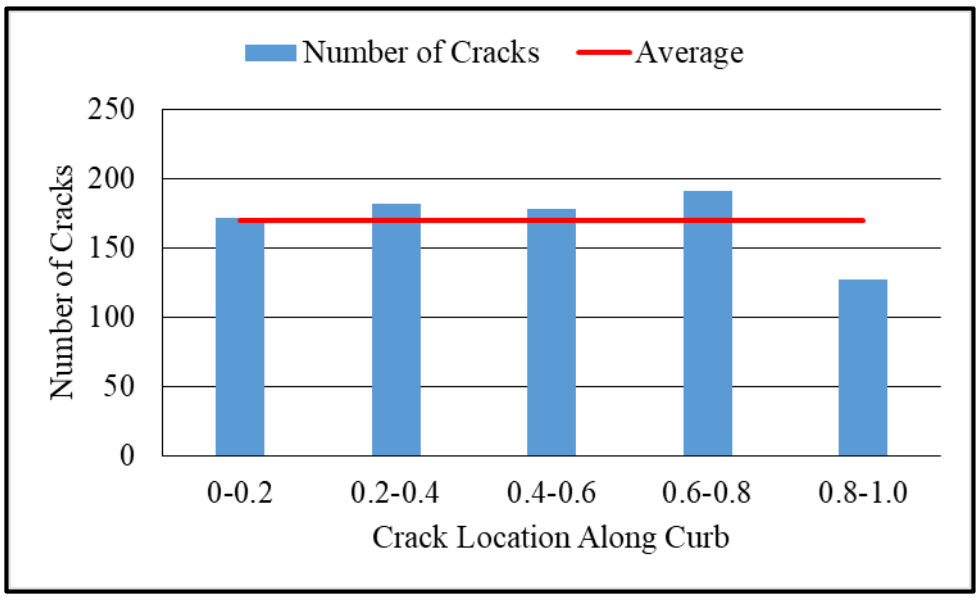

Figure 6: Amount of cracking at various sections along the curb. Zero refers to the center of the span and one to the ends of the curb.