Research Summary

Construction and Materials Best Practices for Concrete Sidewalks: Phase II – Long-Term Performance and Hot-Weather Placement Effects

Research Need

Due to the rapid deterioration of concrete sidewalks caused by scaling statewide, it is urgent that concrete practices and materials be studied to determine their effect on the durability of concrete. The Commonwealth of Massachusetts experiences extreme winter weather conditions which has lead to rapid degradation due to scaling of concrete sidewalks, leading to costly maintenance and reconstruction costs.

Goals/Objectives

This research study is the second phase of a two-phase project to identify the causes that lead to surface scaling of concrete sidewalks after winter treatment. In Phase I, sidewalks were placed during the fall season to capture construction practices typical of cold weather. The research in Phase II primarily targets the effects of hot weather concreting procedures on scaling performance of concrete sidewalks after being exposed to winter environment and various treatment procedures that might lead to scaling. Other construction practices included in Phase II are mixture design and curing practices since these were identified as critical on performance of sidewalks studied during Phase I. Determining the best practices to limit the effects of winter weather conditions on concrete sidewalks maximizes the efficiency of the materials and other costs of construction while minimizing the need for maintenance and re-building costs that the State funds to maintain and rebuild.

Methodology

To determine the performance of concrete sidewalks placed using hot weather concreting practices, both an in-situ sidewalk study and laboratory studies were conducted simultaneously. The in-situ study involved placing 48 unique sidewalk panels at the University of Massachusetts Amherst in July 2021, following hot-weather concreting procedures. Five mix designs, four curing methods, and three de-icing methods were employed. Laboratory specimens were subjected to the same placement and curing procedures as the in-situ sidewalk panels. The sidewalks were monitored over one year. Laboratory experimentation included scaling resistance test via ASTM C672, fresh and hardened concrete properties tests and testing of aggregate system.

Key Findings

To achieve durability in concrete sidewalks, materials, construction, and maintenance practices should be carefully monitored. The performance of concrete sidewalks is highly dependent on the properties of the near surface layer of the concrete body. The placement and construction practices along with the mix design influence the air void system, w/cm ratio and strength of top layer of concrete. An adequate air void system, low w/cm ratio, necessary strength is required in the top surface to resist the exposure to freeze-thaw cycles and deicing agents. Quality assurance (QA) and Quality control (QC) are both important throughout the process of placement and maintenance of the concrete sidewalks to achieve durable sidewalks.

The concrete placement and finishing must be done following Sections 5.3.2 and 5.3.4 of ACI 301-16 and also National Ready Mix Concrete Association (NRMCA) Flatwork Best Practices. Concrete curing must be done following Sections 5.3.6 of ACI 301-16 and ACI 305R-20. In addition to the specifications, the recommendations mentioned in ACI 305R-20 should also be followed to ensure a durable concrete is achieved from hot weather concreting procedure.

Due to the placement of sidewalks during summer, the concrete (most of the sidewalks) matured and gained enough strength to resist the effect of freeze-thaw cycles and application of deicing agents. It is recommended that the concrete gains a minimum of 4500 psi strength before freezing, thawing, or de-icing cycles begin. The sidewalks in this study were placed 120 days prior to commencement of freezing, thawing, or de-icing cycles, following the proper curing and placement practices and allowing the concrete to mature before application of deicing agents. These procedures resulted in favorable scaling resistance.

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Project Information

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Key Words:
concrete sidewalks, hot weather concreting, scaling of concrete

Use of Findings

These findings will immediately inform the Commonwealth of Massachusetts Department of Transportation Standard Specifications, and will be implemented in all new concrete sidewalks placed in the Commonwealth. Recommendations stemming from the research project encompass the entirety of the concrete design, batching, placement, and maintenance process. The work will be disseminated through the MassDOT Specification, webinars, conference presentations, and academic publications.

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