Restrained Expansion of Type K Shrinkage Compensating Concrete

Stephen Roswurm, Chris Ramseyer, Ph.D., P.E.
University of Oklahoma, School of Civil Engineering and Environmental Science, Norman, Oklahoma

Abstract

The primary deficiency of Portland cement concrete (PCC) is that over time it will develop cracks. These cracks allow water infiltration, and freeze-thaw cycles, coupled with the use of deicing agents, which gradually degrade the concrete. This process results in unsightly aesthetic damage and eventually causes corrosion of the reinforcing steel, potentially compromising the structure. One of the major causes of premature cracking in concrete pavements is restrained drying shrinkage (Phillips et al, 1997). This process occurs when a PCC element is cast, and the water in the concrete begins to evaporate over time. The evaporation decreases the volume of the concrete, and since concrete is naturally weak in tension, shrinkage cracks generally form throughout the life of the pavement. The purpose of this research was to determine whether shrinkage-compensating concrete (SCC) made with Type K expansive component could sufficiently offset the effects of drying shrinkage, when the concrete is cast adjacent to a structural element, such as a mature slab. This is critical because external restraint works against shrinkage compensation.

Behavior of SCC slab (Seth Roswurm et al, 2013)

Acknowledgements

Thanks to the CTS Cement Manufacturing Corporation for supporting this project. Thanks also to the students who helped throughout the project – Jacob Roswurm, Dakota Gennings, Adam Aab, and Ousmane Ndure. Thanks to Mike Schmitz and the Fears Structural Laboratory for providing resources for the experiments.

GALLOGLY COLLEGE OF ENGINEERING
DONALD G. FEARS STRUCTURAL ENGINEERING LAB
The UNIVERSITY *of* OKLAHOMA

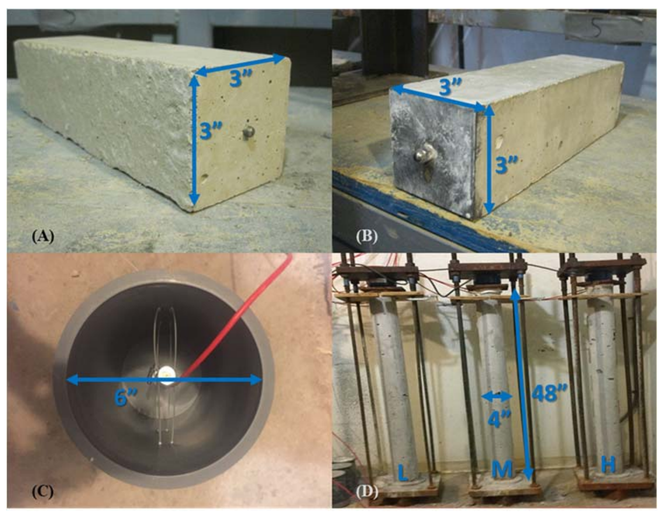
Background and Goals

- **The economic impact of poor infrastructure in the U.S. is expected to cost almost $4 trillion by 2025, according to ASCE's 2017 Report Card [1].**
- **The goal of this research is to develop concrete for crack-free roads and bridge decks that reduce slow, costly construction joints.**
- **Past research has contended that SCC is unable to fully compensate for drying shrinkage if it is cast against a stiff boundary, like another slab.**
- **These experiments involve casting SCC specimens under different levels of external restraint and monitoring their expansion using both manual means and advanced sensors.**

[1] http://www.infrastructurereportcard.org/the-impact/economic-impact/

Materials and Methods

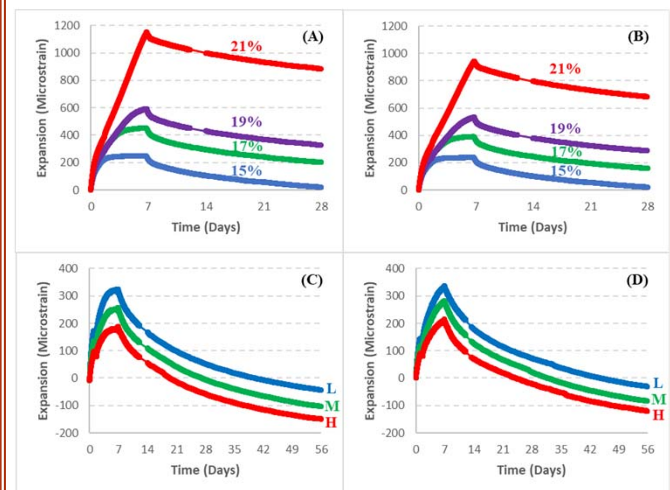
This experiment utilizes different percentages of Type K mineral component (meeting ACI 223) in proportion with Portland cement to cause expansive behavior. Two arrays of steel frames were used to replicate the levels of restraint that would be provided by mature concrete slabs.



(A) Unrestrained expansion prism, ASTM C157, (B) Restrained expansion prism, ASTM C878, (C) 6"x12" expansion cylinder, equipped with vibrating wire strain gage (VWSG), (D) 4"x48" restrained columns with low, medium, and high restraint stiffness.

Results

- **The presence of Type K expansive mineral component resulted in an expansive strain during the 7-day wet cure. This delayed the onset of drying shrinkage and decreased the overall net shrinkage.**
- **Higher Type K content corresponded to higher expansion, while added restraint reduced peak expansion.**



(A) Unrestrained expansion cylinders, with varying expansive component, (B) Restrained expansion cylinders, with varying expansive component, (C) 4"x48" restrained columns, with 19% expansive component and varying restraint stiffness, (D) 4"x48" restrained columns, with 21% expansive component and varying restraint stiffness.

Conclusions

- **Mix designs with more Type K expansive component exhibited more expansion, which aided shrinkage-compensation**
- **Specimens subjected to more stiff boundary restraint exhibited reduced expansion, but the expansion was not eliminated**
- **The VWSG produced far more data points with less user sensitivity than the manual ASTM standard tests, thus providing more consistent results**
- **Mix designs including Type K component offset shrinkage for weeks, allowing the concrete to mature before the onset of tensile stresses**