Freeze-Thaw and Salt Durability of Pervious Concrete

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Pervious Concrete (PC)

PC continues to gain popularity as a surface course pavement in the United States due to its ability to perform as a structural pavement while limiting stormwater runoff. PC incorporates uniform graded aggregate, zero slump, and little or no fine aggregate. PC is intended to exhibit a significant infiltration capacity while maintaining adequate strength. Concerns persist regarding PC durability in cold climates related to freeze-thaw and salt. This investigation studied freeze-thaw durability with salt exposure of PC in a laboratory environment representative of field conditions. Variations included the addition of sand, replacement of cement with slag, replacement of cement with slag and silica fume, curing time, and saltguard treatment.

Testing Methods

PC specimens of different mix designs were prepared as 4-inch diameter by 6-inch tall cylinders. PC specimens were then subjected to 100 freeze-thaw cycles including dipping in an 8% saline solution. Samples were allowed to drain freely to better simulate field conditions, and weighed each cycle. Five samples were prepared for each mix and curing variable for the freeze-thaw testing. Sample weight loss of 15% was considered failure in this testing.

Variation of sand addition was performed by adding sand at 0%, 5% and 10% to the base mix. Replacement of 20% of the cement with slag, and slag with silica fume testing was coupled with curing duration variations of 7, 28, and 56-day curing times before freeze-thaw testing. Saltguard treatment was applied using two methods: spraying on the surface and fully dipping PC specimens in saltguard.

Figure 1 – PC samples used in testing on top of a pre-cast PC slab

Results Summary

1. Sand:
   - Generally, adding sand to a PC mix design, without making adjustments to paste volume, is not beneficial.
2. Slag and slag with silica fume replacement of cement:
   - Replacing up to 20% of cement with slag or slag with silica fume appears to have benefits in improving freeze-thaw durability of PC.
   - Use of slag or slag with silica fume appears to yield better durability than using fly ash as cement replacement.
3. Curing time:
   - Slag and slag with silica fume replacement of cement PC exhibited a slight increase in durability with increased curing time.
   - PC without cement replacements were found to be more durable with increased curing time.
4. Saltguard:
   - Dipping PC in saltguard appears more beneficial than spraying the surface.

Conclusions and Recommendations

- An improved PC mix design with a replacement of up to 20% cement with either slag or slag with silica fume represents a more durable mix.
- Sand addition results in thicker cement paste and decreased workability of the PC mix and lower densities of PC.
- Sand replacing a portion of the coarse aggregate is likely a better method of incorporating sand.
- Saltguard treatment is promising; however, its possible environmental impacts need to be investigated.
- It is worth considering using very well-made precast PC slabs that may allow much better quality control (e.g. extended curing time, dipping in saltguard) and quality assurance (e.g. uniformity, target void content, durability). In comparison to cast-in-place PC, precast PC slabs may allow removal and replacement as needed as part of routine maintenance.
- Rather than building the entire lot of PC, a combination of asphalt and PC may facilitate longevity. For PC pavements, the application of salt should be avoided, delayed, or at a minimum limited.

Acknowledgments

This work was funded by the Vermont Agency of Transportation (VTrans) and the United States Department of Transportation through the University of Vermont Transportation Research Center.

References

Anderson, Ian and Dewoolkar, Mandar M., "Laboratory Freeze-and-Thawing Durability of Fly Ash Pervious Concrete in a Simulated Field Environment". American Concrete Institute Materials Journal. Vol. 112, Issue 05, September 1, 2015, pp. 603-612.