Is Pervious Concrete Ready for Structural Applications?

By Matthew Offenberg, P.E.

In 2008, the answer is, "Not quite yet." If you're reading this article after 2010, however, the answer might be, "Absolutely!"

First, a little terminology for you. If you remember way back to your concrete class in college, (mine was with Dr. Scholer) you might remember a technology that went by the name of 'no-fines concrete'. This was concrete made with Portland cement, coarse aggregate, water, and admixtures. The reason it was called 'no-fines concrete' was because it had little or no fine aggregate. Concrete made from such batch ingredients was often honeycombed, sticky, and difficult for the average concrete finisher to work. The term 'no-fines concrete' became 'pervious concrete' once the most popular use became pavement applications. As with Kleenex, the term 'pervious concrete' has now become the catchall term for any no-fines concrete application.

Fresh pervious concrete delivered to the jobsite.

History

Historically, no-fines concrete construction had its first boom in post-World War II England where it was used structurally in the construction of two-story homes known as the Wimpey Houses. The Wimpey Houses were celebrated for their ease of construction and great insulating properties. With labor in short supply, there weren't enough skilled masons to rebuild England after the war. So, George Wimpey developed a system where unskilled workers could erect forms and place no-fines concrete walls for multi-story homes. With a 60-year history of using no-fines concrete for such structural applications, why is this technology not yet deemed ready for use as a structural material in buildings or heavy structural works?

In the United States, pervious concrete is mostly used for light-duty pavement applications, such as residential streets, parking lots, driveways, and sidewalks. Of course, such applications require the pervious concrete pavement to carry a normal traffic load. In other parts of the world, pervious concrete applications also include channel linings, retaining walls, and sound walls.

The biggest difference in performance between pervious concrete and plain concrete comes from consolidation. Both types of concrete require densification to develop their maximum strength. However, in normal concrete, aggregates are well graded and there is paste between the aggregates, which allows the concrete to flow when vibratory energy is applied in the form of rodding or mechanical vibration. This flowing property is what allows concrete to be consolidated to a consistent, repeatable density. With pervious concrete, however, there are no fine aggregates and only a thin coating of paste exists between the coarse aggregate particles, so this flow does not occur when the concrete is vibrated. The only way to get repeatable and predictable density is to apply a large amount of compactive energy.

From a practical standpoint, then, we need to know what is the least amount of compactive energy we can apply to achieve a predictable density, such as by tamping or using a drop hammer. The required compaction energy to achieve proper consolidation will depend on the specific concrete mixture being used, and will vary with aggregate gradation, aggregate angularity, and paste rheology. When pervious concrete is compacted to achieve this predictable density, the voids should be approximately the same size as would be expected in a well-compacted sample of the coarse aggregate. Presence of large voids indicates insufficient compactive energy was applied to the concrete.

Looking Forward

It seems pervious concrete would be a natural choice for use in structural applications in this age of 'green building'. It consumes less raw material than normal concrete (no sand), it provides superior insulation values when used in walls, and through the direct drainage of rainwater, it helps recharge groundwater in pavement applications. But the U.S. concrete industry's consensus is that we need to develop a better understanding of current test methods for pervious concrete, so they more reliably predict the material's performance in the structure. This means generating sufficient data on consistent, repeatable test methods for pervious concrete. This applies both to cast specimens and cores. Further, design assumptions and methods need to be confirmed for this technology.

These are temporary hurdles. ASTM subcommittee C09.49 is looking at the existing test methods for plain concrete, and other construction materials, and analyzing how to apply them to pervious concrete. The list of test methods under review includes fresh and hardened density, porosity, compressive strength, and flexural strength. Other useful test methods, not yet under review, might include visual determinations of hardened porosity and fresh concrete consistency (similar to the Visual Stability Index for Self Consolidating Concrete) and methods for evaluating the in-place strength of hardened pervious concrete. Once these standards are in place, the industry can review existing, in-service, pervious concrete applications, and measure its structural performance to confirm the design methods currently in development.

There are a few other items that need to be addressed before pervious concrete is truly ready for structural applications in the United States. Bond and development of steel reinforcement to pervious concrete needs to be further studied and tested, to assure adequate performance of structural members. Research suggests that the fatigue behavior of pervious concrete is the same as normal concrete in pavement applications, but this also would need to be studied as pervious concrete is expanded to structural works. Further analysis of pervious concrete with respect to other material properties, including creep, shrinkage, and modulus of elasticity, is also needed.

Clearly, the performance of this material in structures for over 60 years shows that it can perform well in a variety of applications. But, in today's paradigm of test-evaluate-retest, widespread acceptance of this material in structural applications is dependent on the upcoming test methods.▪

Hardened pervious concrete typically has about 20% interconnected voids.

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