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Case Study

Monitoring in situ performance of pervious concrete in British Columbia—A pilot study☆

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ABSTRACT

Modern day infrastructure calls for use of impervious surfaces and curb and gutter systems on pavements to rapidly collect and transport rain runoff. Due to this stormwater reaches the receiving water bodies rapidly, in greater volume and carries more pollutants than natural conditions. Porous pavement on parking lots, sidewalks, and driveways provides a solution to this problem. One such material that can be used to produce porous surfaces is pervious concrete. Even though no-fines concrete mix has been used for many years, there are still many outstanding issues related to its structural performance and issues with reduced percolation capacity over time especially when exposed to real conditions. This paper presents a case study describing a project in British Columbia, Canada where 1000 ft^2 of asphalt was replaced with a pervious concrete system. The details of the unique construction technique including details of the material used are described in this paper. On-going tests to monitor the performance of this test slab are also described.

1. Introduction

Stormwater management has become a concern for cities and municipalities due to increased urbanization of residential and commercial neighborhoods. In a built environment with significant amount of impervious surfaces and integration of curb and gutter systems in our pavements, stormwater reaches the receiving water bodies much faster, in greater volume and carries more pollutants. Cities and municipalities along with engineers, researchers and developers are exploring different ways to reduce the impervious surfaces and to deal with stormwater management in a sustainable and environment friendly manner. Porous pavement is found to be an effective measure to mitigate the impact of urbanization on the environment. Without occupying any additional space, porous pavement on parking lots, sidewalks, and driveways provides multiple benefits, i.e. promotes infiltration, reduces peak flows and runoff volume, improves water quality, and reduces thermal pollution, thus helping to maintain our delicate ecological balance and the environment we live in. Using materials that allow water to permeate into the ground helps contribute to the ground water table. One such material that can be used to construct porous pavements and porous urban surfaces is "pervious concrete." This type of concrete has high permeability and allows rain water to permeate.

According to Sustainable Concrete Canada (2012), the pervious concrete system can have the following impact on the environment: eliminating time consuming and costly storm water detention facilities and underground piping systems, allowing water, air and nutrients to tree roots promoting healthy tree growth without damaging your pavement surface, increasing the quantity of water which can be retained on your site and infiltrate into aquifers thus promoting healthy water

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levels which sustain our streams and drinking water, eliminating the expense of curbs and gutters, reclaiming valuable property otherwise consumed by stormwater tanks and ponds, preventing harmful hydrocarbons, and other pollutants from reaching our waterways which commonly occur with conventional storm water systems. Pervious concrete is being used for many applications including use as a paving material for parking lots, lightweight structural walls, tennis courts, and greenhouse floors (ACI Committee 522, 2006). Pervious concrete is also known as "no-fines" concrete. Pervious concrete reduces storm water pollution at the source, control storm water runoff, and eliminate or reduce the size of storm sewers (Schokker, 2010). However, there are many issues related to pervious concrete that still need to be further investigated to improve its life and performance during service. Some of the current issues for pervious concrete are as follows.

1.1. Clogging

When small material such as dirt and fine sand are carried by storm water through the pores of pervious concrete, the debris can eventually reduce the effectiveness of the drainage and permeability of the concrete. Such clogging could then lead to flooding and the concrete being susceptible to extensive freeze–thaw cycles (Deo et al., 2010). One issue associated with this is the requirement to maintain the slabs by frequent power washing to unclog the pores.

1.2. Abrasion resistance

As the bonding in pervious concrete is aggregate-to-aggregate rather than the aggregate embedded in a cementitious paste like in regular concrete, pervious concrete has poorer mechanical properties. Pervious concrete is susceptible to abrasion failure caused by the surface course being worn off or crushed under traffic loads (Wu et al., 2011). This phenomenon is sometimes referred to as "raveling."

1.3. Freeze and thaw

When pervious concrete is exposed to cold climates, there is a possibility the concrete would undergo extensive freeze–thaw cycles if the placement was fully saturated. This leads to pressure on the thin cement paste surrounding the aggregates and a loss of durability of the concrete (Kevern et al., 2010).

To study these issues, a project was recently initiated by the author at British Columbia Institute of Technology (BCIT) in Canada. This project involved replacing a section of the asphalt paved surface in a parking lot with pervious concrete. The aim of this project is to determine the feasibility of using pervious concrete on a larger scale, especially as an alternative to using asphalt for paving. The pilot slab is being exposed to real environmental conditions and traffic. The observations and test results from this study will help address above-mentioned issues and determine the feasibility of using larger placements in the future especially when using in regions that are prone to freeze–thaw cycles. In this paper, the procedure used to construct this non-traditional system of pervious concrete as a pavement is discussed and the on-going tests to monitor the performance of the pavements are described. Some of the initial test results are also presented.

2. Construction details

The site is located at the northern area of Parking Lot F at the Burnaby campus of BCIT, Canada (Fig. 1a). The placement size is 24 ft × 40 ft, and covers three parking stalls (794, 795, and 796) and the roadway adjacent to it. The site location was specifically chosen to study the effect of standing traffic, moving traffic, and turning vehicles.

The construction of the concrete slab was completed in three major stages: excavation and asphalt removal, subbase fill, and the concrete placement and curing. The details of each are described below.

2.1. Excavation

The existing asphalt was saw cut to form straight edges and 12 in. deep excavation was done. The soil below the asphalt pavement consisted of sandy soil for the top 6 in., and sandy clay in the lower 6 in. Sets of perforated pipes were placed below lanes 795 and 796 located at west end of the test slab (Fig. 1b). One set was placed at the bottom of the clear crush and one at the bottom of the 6 in. thick pervious concrete slab (Photos 1 and 2). Separate pipes were used at each level under lot 795 and 796 to study the reduction in percolation capacity (if any) by not maintaining (power washing) one section of the pavement. In this study, lot 795 will be maintained and lot 796 will be left unmaintained. A small portion of the ditch north of the placement (outside the test slab) was also excavated to accommodate a water collection system for testing purposes (Photo 3). The perforated pipes were 3 in. in diameter, 7 ft in length, and made from PVC.

2.2. Subbase fill

Once the excavation was complete, 6 in. of fractured clear crush with a maximum aggregate size of ¾ in. was deposited above the subgrade. The fill was then compacted using a vibratory roller and measured to gain a uniform depth of 6 in.