Developing A Framework for Low-Volume Road Implementation of Pervious Concrete Pavements

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ABSTRACT

Pervious concrete pavement is one of the promising pavement technologies, as it can help overcome traditional pavement environmental impacts, assist with stormwater management, and provide an effective low impact development solution. There are many benefits associated with pervious concrete pavement such as assisting with water filtration, absorbing heavy metals and reducing pollution. The most significant aspect, which draws the attention of environmental agencies and cities and municipalities, is its ability to reduce storm water runoff. Pervious concrete is documented as the paramount solution in storm water management by the United States Environmental Protection Agency. Though it has been used in the southern United States for years, the practice of using pervious concrete is more recent in northern climates where freeze thaw is observed. In Canada, several pervious concrete parking lots have been constructed over the past few years. However barriers exist for implementing the technology, as designers are not always fully informed on the various functional and structural design considerations. In this paper, a framework is developed to identify how pervious concrete can be integrated into low-volume infrastructure. This paper also summarizes the structural performance and drainage characteristics of pervious concrete parking lots constructed in various provinces of Canada, demonstrating the viability of pervious concrete for low-volume northern applications.

1. INTRODUCTION

Pervious concrete pavement is a technology that provides a sustainable, and ecological pavement alternative. The porous nature of the material allows rainwater to percolate directly through the pavement structure and join the natural ground water system, mitigating traditional pavement impacts on natural hydrological cycles and removing the needs for other stormwater management systems. Pervious concrete also provides other benefits such as water filtration [1, 2], heat and noise control [3–5], and heavy metal removal from stormwater runoff [6].

Pervious concrete mixes typically contain single-sized aggregate with locally optimized levels of cementitious binder and water to provide a structure with at least 15% voids [7]. The amount of fine aggregate is limited and optimized to increase the strength while maintaining the required void content to facilitate drainage. This resulting pervious concrete layer is constructed on a clear stone base, which acts as a reservoir layer to store water during infiltrate to the existing subgrade soil. The thickness of the reservoir layer depends upon the characteristics of underlying subgrade soil; a subgrade with a low percolation rate would require a thicker reservoir to maintain a good precipitation rate.

The porous structure of pervious concrete results in lower compressive strength of the material compared to conventional concrete. As a result, pervious concrete is an ideal material for usage in residential streets, walkways, driveways, highway shoulders, and parking lots [3] but not highways or roads with frequent heavy trucks. Literature suggests that roads with Average Annual Daily Traffic (AADT) of 400 or less are considered as low volume roads [8]. But for high traffic volume roads there is no national or American Association of State Highway and Transportation Officials (AASHTO) definition. One of the reasons behind this is as it is a local issue; it varies from agency to agency and depends also on the area of construction. In this paper, roads are classified in four groups:

- Low Volume Road (AADT ≤ 400) [8]
- Moderate Volume Road (400<AADT ≤ 3,000) [9]
- High Volume Road (3,000<AADT ≤ 5,000)
- Very High Volume Road (AADT ≥ 5,000) [10]

Pervious concrete has been used in parts of Europe and warm climates in the United States for several years but its use in the Northern severe cold climates, such as Canada, has been limited [11]. This extreme cold climate presents an extra challenge for pervious concrete and the Centre for Pavement and Transportation Technology, at the University of Waterloo, has constructed and monitored several pervious concrete parking lots across Canada in order to characterize the performance of pervious concrete in cold climates. These sites have demonstrated that pervious concrete is able to withstand low-volume traffic [12, 13]. From these results, a framework is developed for designers to understand where they can apply pervious concrete in their infrastructure and the design process they need to follow.

1.1. Objectives

This paper will present a framework for how to implement pervious concrete into pavement infrastructure in northern regions; given the known performance of pervious