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Sealing system selection for jointed concrete pavements – A review

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Abstract

Concrete pavement joints are cracks intentionally formed in the pavement to accommodate expansion and contraction due to temperature changes. Today, 98% of the agencies building and maintaining concrete roadways, and 100% of the agencies building and maintaining concrete airport pavements in the United States require the sealing of these joints for new pavements. There are two major reasons for sealing rigid pavement joints. The first is to reduce the amount of water infiltrating the pavement structure, which results in slab erosion and loss of support. The second reason is to minimize the entry of incompressible materials into the joint reservoir, resulting in point loading when slabs expand under hot temperatures and subsequent joint spalling damage. Another reason for sealing rigid pavement joints is to reduce the potential for dowel bar corrosion by reducing entrance of de-icing chemicals. The proper sealing and maintenance of concrete pavement joints thus seems to be essential for the overall performance of the rigid concrete pavement. This paper seeks to find out the factors that affect sealant life and performance and how to mitigate these to improve performance and reasonably extend sealant and thereby pavement life.

Keywords: Sealant; Concrete; Pavement; Life

1. Introduction

Joints are created in concrete pavements so that premature cracks due to temperature or moisture changes can be minimized and locally controlled. The performance of concrete pavements depends to a large extent on the satisfactory performance of these joints. The common types of pavement joints are described by their function. These include transverse, longitudinal, construction and expansion joints. Most jointed concrete pavement failures can be attributed to failures at the joint rather than to inadequate structural capacity [1]. Distresses that result from joint failure include faulting, pumping, spalling, corner breaks, blowups, and mid-panel cracking. A joint sealant is a material introduced into the joint to minimize the infiltration of surface water as well as incompressible material into the joint system. Secondarily, sealants are also purported to reduce the potential for dowel bar corrosion by reducing entrance of de-icing chemicals [2]. The infiltration of water into a pavement's layers contributes to subgrade and subbase softening leading to pumping of subgrade or subbase fines under heavy traffic. This degradation can result in loss of structural support, pavement settlement and/or joint faulting. When incompressible material enters the joint reservoir, they obstruct pavement expansion in hot weather and create compressive pressure along the joint faces. This contributes to spalling and sometimes induces pavement migration and blowups. The main joint sealant failure types are adhesive, cohesive, intrusion, and extrusion. The failure of the sealant itself is not catastrophic. However this failure

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can lead to a great reduction of the service life of the surrounding pavement section. The depth, width, rheological properties and most importantly, workmanship quality, affect the performance of the joint sealants. The failure mechanisms of the joint systems need to be better understood in order to select a more compatible sealant for use in any joint system.

1.1. Objective

Since the failure of the sealant in a concrete pavement joint can lead to deterioration of the pavement and subsequently reduce the life of the pavement, it is important to find a way to select the most appropriate sealant from the host of available sealants. This would help prevent/minimize premature sealant failures. Understanding the factors, and in what way these factors lead to sealant failures, is therefore essential for the preservation of pavement life.

The main objective of this study is therefore to propose a procedure for the selection of the most compatible sealing system for any given transverse joint system usable by any state in any climatic region including Delaware especially. This objective will be achieved by finding out what factors affect the performance of joint sealants and how these factors contribute to sealant failure.

2. Literature review

As it is not practicable to construct and continuously maintain a completely watertight pavement, highway agencies have generally resorted to inserting sealants into the joints of concrete pavements to minimize the infiltration of water and incompressible materials. One major problem facing these agencies involved with the maintenance of these concrete pavements is the premature failure of the sealant materials with the attendant deterioration of the joint performance. This leads to the need for additional repair at extra cost to the agencies.

The most common types of pavement joints are as defined by their functions [3,4]:

1. Transverse joints
2. Longitudinal joints
3. Construction joints
4. Expansion joints

2.1. Transverse contraction joints

Transverse contraction joints are saw formed or tooled grooves in a concrete slab that create a weakened vertical plane. They regulate the location of the cracking caused by dimensional changes in the slab. For this purpose, contraction joints should be deep enough to ensure that cracking occurs at the desired location rather than in a random pattern. These are the most common types of joints introduced in concrete pavements. Transverse joints control the cracking that results from the tensile and bending stresses in slabs due to cement hydration process, traffic loading, and the environment. Because these joints are so numerous, their performance significantly impacts on pavement performance. A distressed transverse joint typically exhibits faulting and/or spalling. Poor joint performance frequently leads to further distresses such as corner breaks, blowups, and mid-panel cracks. Such cracks may themselves begin to function as joints and develop similar distresses. The performance of transverse joints is related to three major factors, namely:

1. Joint spacing
2. Load transfer
3. Joint shape and sealant properties

2.2. Longitudinal joints

These are used to relieve warping distresses and are generally needed when slab widths exceed 4.57 m (15 ft). Longitudinal joints should, whenever possible, coincide with pavement lane width to improve traffic operations. Load transfer at longitudinal joints is achieved through aggregate interlock. These joints should be tied with tie bars to prevent lane separation and/or faulting. Tie bars should be mechanically inserted and placed at mid-depth.

2.3. Construction joints

There are two types of construction joints, transverse and longitudinal. A transverse construction joint should normally replace a planned contraction joint. They should, however, not be skewed as satisfactory concrete placement and consolidation would be difficult to obtain. These joints should be doweled and butted as opposed to keyed. This is because keyed construction joints tend to spall and are not recommended. It is recommended that transverse construction joints be sawed and sealed. The reservoir dimensions should be the same as those used for the transverse contraction joints.

The top of the slab above a keyway frequently fails in shear. For this reason it is recommended that keyways not be used when the pavement thickness is less than 254 mm (10 in.). In such cases, tie bars should be designed to carry the load transfer. When pavement thickness is 254 mm (10 in.) or more, however, a keyway may be used to provide the necessary load transfer. It is rec-