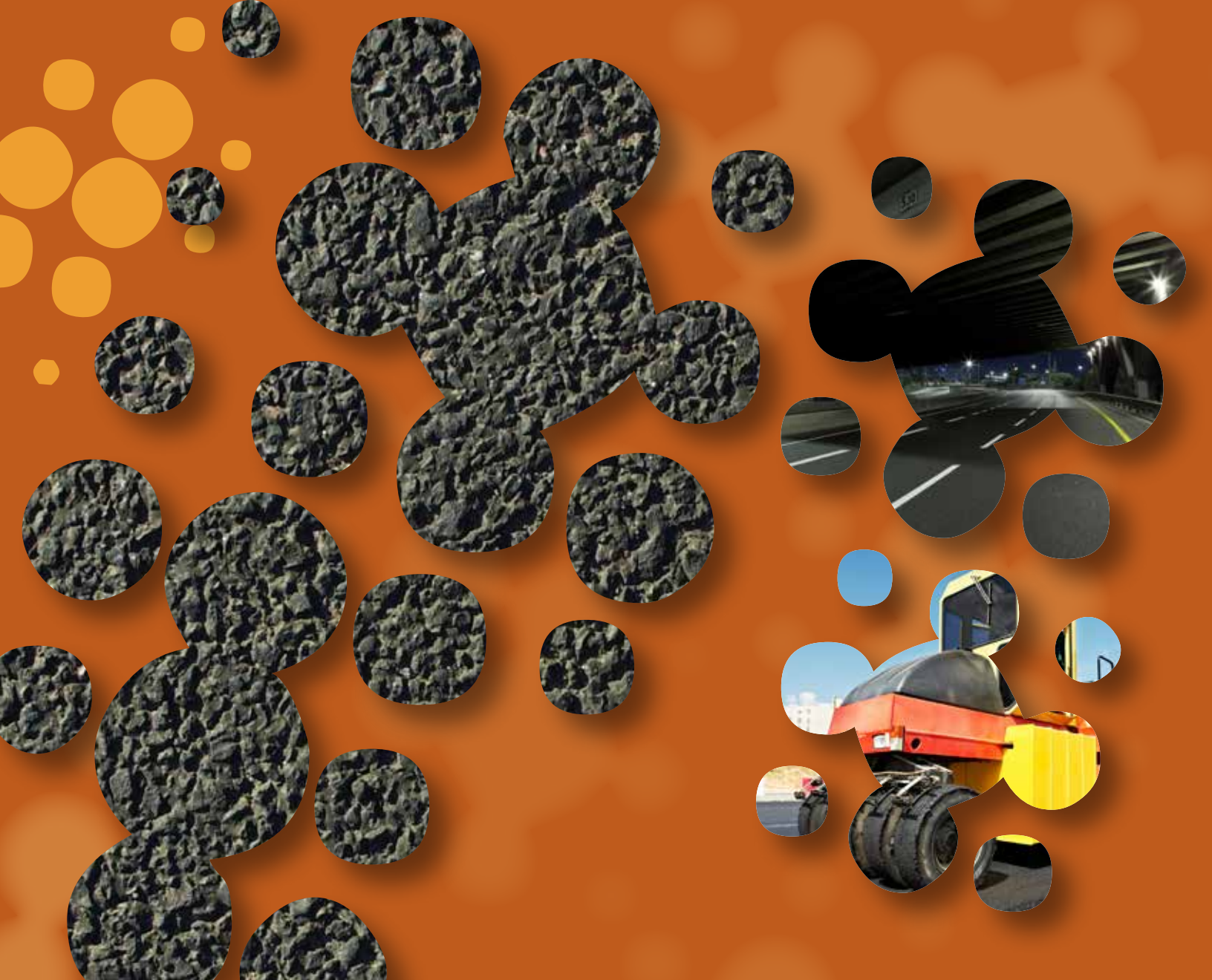




MANUAL FOR
EMULSION-BASED CHIP SEALS
FOR PAVEMENT PRESERVATION

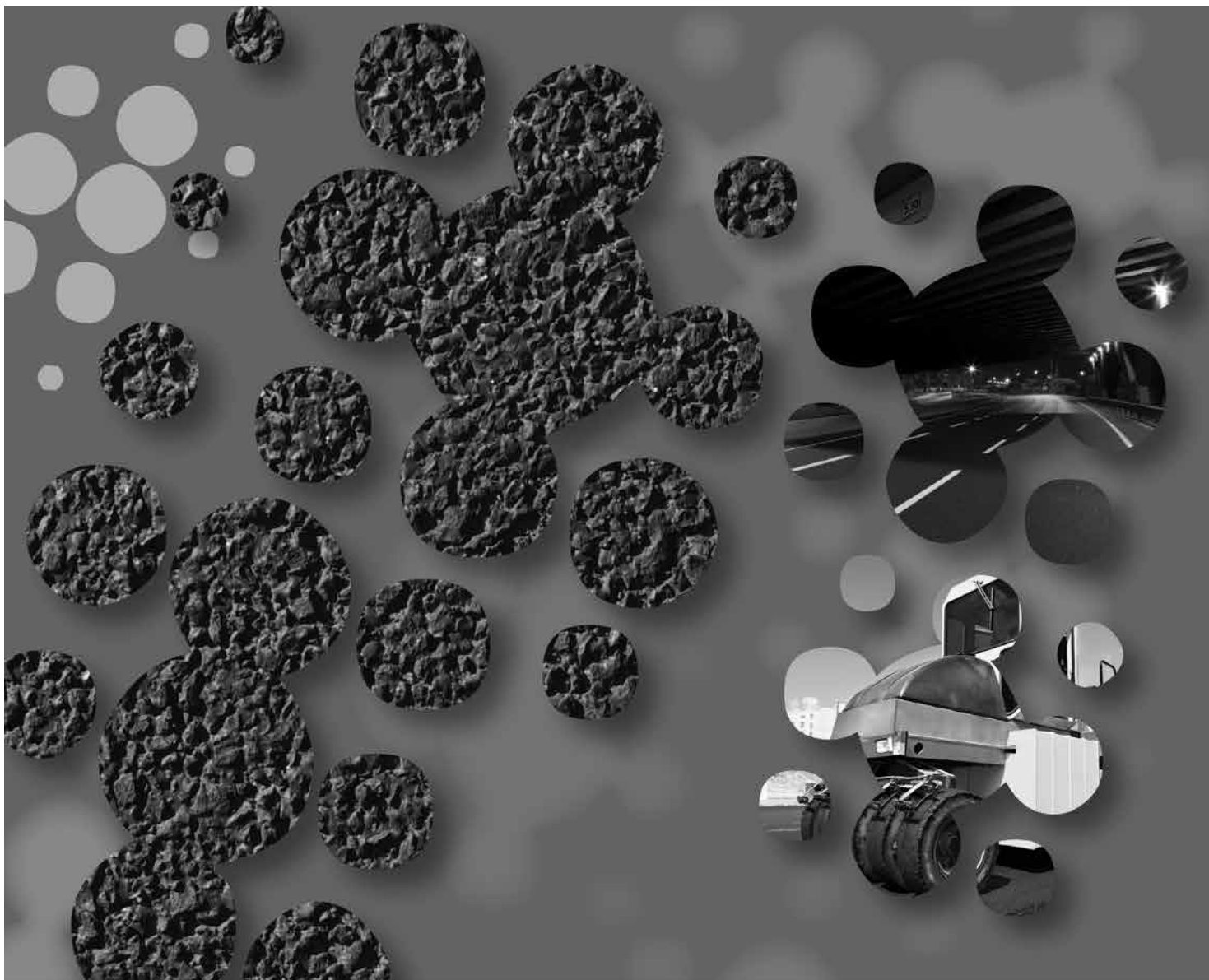
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Publication Code: MEBC-1
ISBN: 978-1-56051-530-2



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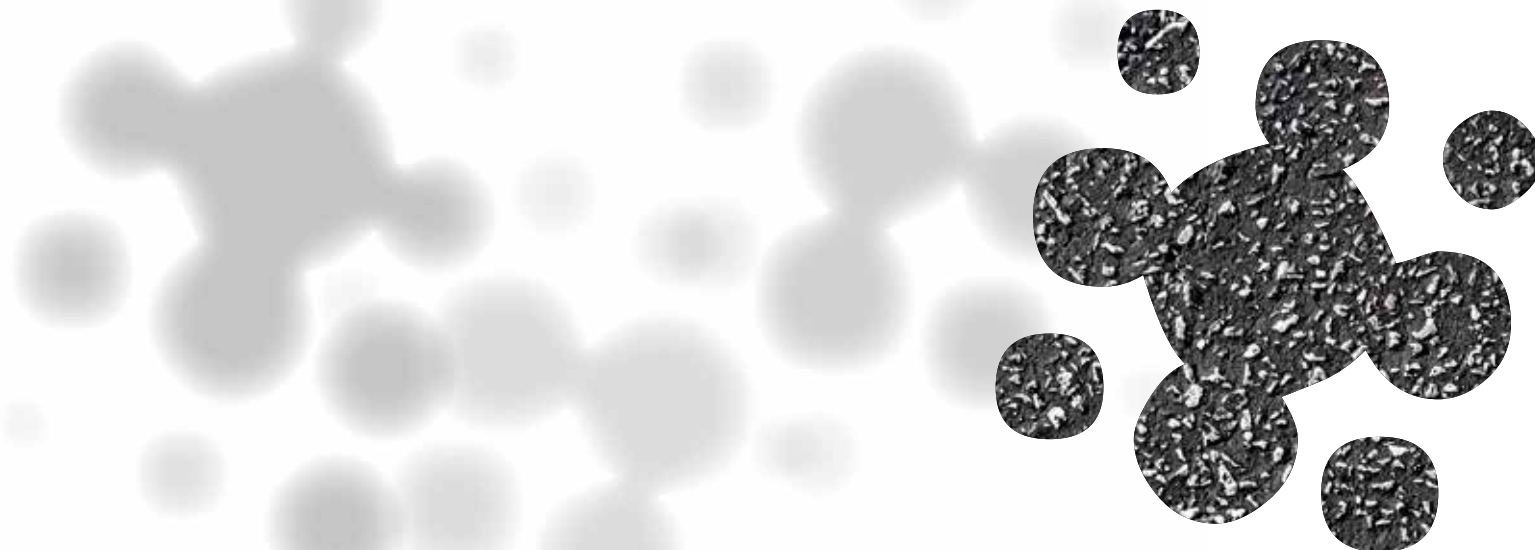
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AUTHOR ACKNOWLEDGMENTS

The research reported herein was performed under NCHRP Project 14-17 by the Department of Construction Management at Colorado State University (CSU) and the department of civil engineering at Texas A&M University (TAMU). CSU was the prime contractor with TAMU as a subcontractor.

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FOREWORD

Emulsion-based chip seals are the most commonly used chip seal type in the United States. These seals are frequently used as pavement preservation treatments on flexible pavements to seal fine cracks in the underlying pavement's surface and prevent water intrusion into the base and subgrade. Because chip seals are not expected to provide additional structural capacity to the pavement, benefits ideally are accrued by their application early in a pavement's life before a great degree of distress is exhibited. Although a large body of research is available on chip seal design practices, the design process in the United States remains empirical in nature—based on experience and judgment. Procedures that consider the surface condition of the existing pavement, traffic volume, environment, and other relevant factors in determining the characteristics and application rates of aggregates and binder have not been widely used in the United States.

In spite of their apparent benefits, the use of chip seals for pavement preservation in the United States is hampered by the lack of nationally accepted guidance on their design and construction and appropriate specifications and testing procedures for constituent materials. Thus, research was needed to identify the factors that influence chip seal design and performance and to develop a manual that documents design and construction practices and delineates necessary testing and specifications. Such a manual will provide highway agencies with the information necessary for designing and constructing long-lasting chip seals and preserving pavements.

Under NCHRP Project 14-17, “Manual for Emulsion-Based Chip Seals for Pavement Preservation,” Colorado State University of Fort Collins conducted a review of available information relevant to design and construction practices of emulsion-based chip seals, conducted laboratory tests and field investigations to evaluate the factors affecting chip seal performance, and prepared a manual for designing and constructing chip seals over hot mix asphalt pavements together with test methods for evaluating some aspects of chip seal construction.

The manual and test methods presented in the NCHRP report will be particularly useful to highway agencies because the manual provides a rational approach for the design of chip seals used in the preservation of pavements and the test methods provide appropriate means for control of chip seal construction.

The appendices contained in the research agency's final report provide further elaboration on the work performed in this project. These appendices are not published herein but are available on the NCHRP Report 680 summary webpage at <http://www.trb.org/Main/Blurbs/164090.aspx>.



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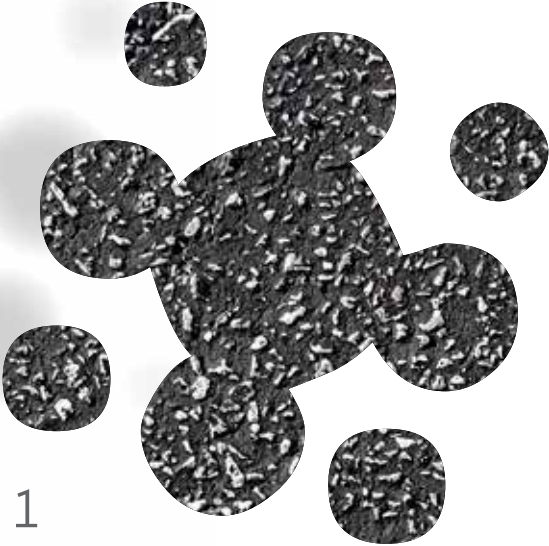
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CHAPTER 1

INTRODUCTION

This manual was developed for use in designing and constructing chip seals over hot mix asphalt pavements. It documents best practices based on the findings of research during NCHRP Project 14-17, *Manual for Emulsion-Based Chip Seals for Pavement Preservation*. In addition, certain subjective or qualitative judgments previously needed during chip seal construction have been eliminated in favor of field and laboratory testing. These include the moisture content of the seal before traffic can be released, judging surface condition so emulsion application rate can be adjusted for surface demand, and measuring the emulsion consistency in the field. The introduction of these new techniques should improve the probability of success when designing and constructing chip seals, but they do not replace the significant judgment required. Also, the success of any chip seal depends on conformance to best practices, and variance or elimination of these practices often leads to disappointing performance.

1.1 Definition of Chip Seals

Chip seals described in this manual are based on emulsified asphalt binders and natural mineral aggregate chips. The chip seal is constructed by spraying the asphalt emulsion onto the existing asphalt pavement and then dropping the aggregate chips into the asphalt emulsion. The purpose of the chip seal is to seal minor cracks in the surface of the asphalt pavement and provide additional friction.



CHAPTER 2

FACTORS AFFECTING CHIP SEAL PERFORMANCE

The performance of a chip seal depends on many factors, including the condition of the pavement to which the chip seal is to be applied, pavement geometry, traffic volume and type, materials, and construction practices. The following discussion describes these factors and their effects on the performance of the chip seal.

2.1 Pavement Behavior and Condition

2.1.1 Deflection of Substrate

The amount of deflection is an indication of whether future fatigue can be expected. If deflection is significant, a chip seal may be inappropriate. The maximum level of deflection will vary depending on the traffic volume; however, if fatigue cracking is already present, chip seal performance may be reduced. However, a chip seal may reduce moisture infiltration into the subgrade, thus reducing the potential for future fatigue. Therefore, the decision to chip seal over existing fatigue cracking requires judgment depending on the performance expectation of the existing pavement.

2.1.2 Cracking Severity

Chip seals are most effective as a pavement preservation technique before cracks are ranked as high severity (Peshkin et al., 2004), defined as a crack width of $\frac{3}{8}$ in. Although the chip seal binder has the ability to seal cracks greater than this width, as crack width increases, the emulsion residue is less effective at bridging the gap across the crack and sealants should be used to fill these cracks prior to chip sealing.

2.1.3 Flushing/Bleeding

Chip seals may be applied to remedy friction loss, but penetration of chips into flushed pavement surfaces may limit effectiveness unless chips can be retained with lower emulsion application rates. Flushing and bleeding of the existing

surface often occurs in wheel paths. If this occurs, the emulsion application rate must be reduced in the wheel paths to prevent future flushing and bleeding. This can only be accomplished with variable spray rate distributors or by varying the size of the nozzles in the distributor spray bar.

2.1.4 Texture

Surface roughness affects the amount of emulsion needed to hold aggregate chips in place. The texture of the substrate pavement should be evaluated using the sand patch test or circular texture meter (CT meter) prior to chip sealing to determine whether an adjustment to the design emulsion application rate is appropriate and to what level.

2.1.5 Soft Substrate Surface

A soft substrate surface can allow chips to be embedded in the surface after trafficking, resulting in possible flushing. The ball penetration test has been shown to be an effective tool for measuring this potential.

2.1.6 Uniformity

The amount of emulsion applied to the substrate may need to be varied if the substrate surface does not have the same texture and compliance along the alignment. Uniformity should be mapped prior to construction to identify locations where emulsion application rates should vary from design. Uniformity can also vary transverse to the centerline, which often occurs when wheel paths are flushed. In this case, the emulsion application rate should be reduced in the wheel paths by using a distributor equipped with a variable application spray bar or placing smaller nozzles in the conventional distributor spray bar in locations that will affect the wheel paths (Shuler 1991), (Martin 1989).

2.2 Traffic Characteristics

The traffic volume and type of traffic affect the selection of materials used on chip seals. Generally, higher traffic volume and a higher percentage of heavy trucks on an undivided roadway present a greater likelihood for vehicle damage if traffic is not adequately controlled during construction. In addition, the volume and type of the traffic are directly related to the potential for chip embedment in the substrate. Also, traffic acceleration affects chip seal performance as chips are more likely to be dislodged under these loads than at constant speeds, which can lead to flushing and bleeding of the surface. This section discusses the factors that influence the material's selection process depending on traffic volume, type of traffic, and speeds.

2.2.1 Chip Selection

Larger chips provide more tolerance for emulsion application variance and are less likely to become totally embedded by traffic if the substrate is resistant to embedment. Larger chips require higher emulsion application rates for proper embedment, thus increasing the sealing ability of the chip seal. However, large chips are noisier and provide higher risk of vehicular damage during construction.

2.2.2 Emulsion Selection

Emulsions modified with elastomeric polymers provide higher adhesion for aggregate chips, often both during construction and later in the life of the seal. Also, research (Shuler 1991) indicates that on high traffic facilities (i.e., greater than 7,500 vehicles per day per lane), modified asphalt emulsions are required to hold chips in place due to reduced emulsion application rates that are necessary to reduce the potential for embedment in the substrate and consequent flushing.

2.2.3 Fog Seal

The application of a fog seal over a fresh chip seal provides high color contrast that improves visibility of striping, and short-term performance improvement (Shuler 2007). Care should be taken whenever applying a fog seal since pavement friction could be reduced if the fog seal is applied at too high an application rate, the fog seal emulsion has a high residue content, or the fog seal has not broken sufficiently to support uncontrolled traffic.

2.3 Geometry

2.3.1 Divided/Undivided

Divided alignments generally reduce the possibility for vehicle damage caused by loose, flying chips because of the separation of opposing traffic.

2.3.2 Gradient/Curves

Steep inclines and curves may adversely affect performance due to tractive forces and slower moving vehicles. Therefore, traffic control may need to remain in place until the emulsion has cured sufficiently to retain the chips.

2.3.3 Intersections

Turning, acceleration, and deceleration can cause chip loss and flushing. Therefore, traffic control may need to remain in place until the emulsion has cured sufficiently to retain the chips.

2.3.4 Width

Vehicle movement tends to be more concentrated on narrow, secondary roads than on wider primary facilities. This results in a greater tendency for flushing in the wheel paths on these types of pavements.

2.4 Highway, Residential, Urban, or Rural

2.4.1 Highway

Chip seals can be successfully constructed on highways with over 7,500 vehicles per day per lane with little or no consequences with respect to vehicle damage (Shuler 1991) if important principles are followed. However, other factors should be considered regarding the use of chip seals on high traffic highway pavements. Because noise increases with increasing traffic volume and chip size, smaller aggregates are often desired for high traffic facilities. However, more accuracy relative to emulsion spray rate is needed when using smaller aggregates because the smaller embedment depth increases the potential for chip loss.

2.4.2 Residential

Chip seals constructed with larger aggregates are rough textured. This rough surface texture is often unpopular among residential users such as roller skaters and skateboarders or individuals who need to lie on the pavement to repair vehicles.

2.4.3 Rural

Rural settings are the most appropriate for chip seals. Traffic tends to move more consistently with less stopping and starting, and volumes are often lower, creating wider vehicle separation providing less possibility for vehicle damage.