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Spray injection patching for pothole repair using 100 percent reclaimed asphalt pavement

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HIGHLIGHTS

- Determining the optimal binder contents of pothole patching materials for spray injection applications.
- Investigation of spray injection patching materials for pothole repair that utilize 100 percent RAP and virgin aggregates.
- Evaluating the performance of patching material by comparing the laboratory test results.

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ABSTRACT

Pothole repair of asphalt pavements is one of the most commonly performed roadway maintenance operations, and it is costly. Reclaimed asphalt pavement (RAP) has become an increasingly attractive material for pothole repair due to its economic and environmental advantages. This study investigated the performance of spray injection patching materials for pothole repair that utilize 100 percent RAP and compared the results to the performance of patching materials made with virgin aggregate. This study was designed to investigate how well different patching products resist critical types of distresses that are observed in the field and typically require patching. The primary characteristics examined in the study include stability, adhesion, moisture susceptibility, and durability of the patching material. The performance of various combinations of materials was observed in laboratory tests to determine the most cost-effective and best-performing patch material. The results show that the material's performance depended on the type of aggregate and emulsion used in the mixtures. The results also indicate that the mixtures that contained RAP had good stability and adhesion properties compared to the mixtures made with virgin aggregate. This research proved the feasibility and advantages of using RAP for spray injection pothole repair.

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1. Introduction

Pavement cracks accumulate as asphalt pavements age and undergo traffic loading. If timely maintenance is not performed, the distress is compounded and cracks become potholes. Potholes are the most common form of asphalt pavement deterioration and present hazards for the traveling public. Pothole repair is costly. In 1999, it was estimated that more than $1 billion were spent annually in the United States on pothole and spall repair [1], and those costs have increased since then. When potholes are repaired as soon as possible after they appear, this rapid repair can help control further deterioration of the pavement and further expensive repairs. However, when potholes are not patched soon after they appear, water has time to enter the subgrade and cause more serious pavement structural failure.

Spray injection is a method for repairing potholes, especially in wintertime. This method requires a truck or trailer-mounted unit that contains an emulsion tank, aggregate tank, heating components, and a high-volume sprayer. The patching operation consists of cleaning the damaged area with compressed air to remove loose materials and debris, applying a tack coat of hot asphalt emulsion, and spraying the combined aggregate and emulsion into the pothole with forced air. Research conducted under the Strategic Highway Research Program (SHRP) in the late 1980s and early 1990s concluded that the spray injection patching method was the least expensive method and provided a much better patch service life

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compared to other patching methods, including the edge seal, semi-permanent, and throw-and-roll methods [2]. State highway agencies also prefer the spray injection patching method over other patching methods because pothole patching during the winter using the spray injection method is more successful than cold-mix patching that is normally used in cold weather [3].

This study examined the feasibility of using reclaimed asphalt pavement (RAP) for spray injection patching of potholes. RAP is considered a viable alternative to virgin materials because it reduces the need for the most expensive components in asphalt concrete, i.e., virgin aggregate and new asphalt binder [4]. Therefore, RAP has become an increasingly attractive material and its use has increased dramatically due to its environmental and economic advantages. In this study, an optimum binder content was determined for each of the mixtures made with 100 percent RAP and with virgin aggregate to investigate the possibility of replacing the virgin aggregate with RAP for spray injection patching. Three different asphalt emulsions were mixed with RAP and with virgin aggregate, and the performance of these mixtures was compared using laboratory performance tests.

2. Objectives

The primary objectives of this study are to:

1. Determine the optimal binder contents of pothole patching materials for spray injection applications that are made with 100 percent RAP and with virgin aggregate.
2. Evaluate the performance of patching material by comparing the laboratory test results obtained from patching materials made with 100 percent RAP and with virgin aggregate.

3. Experimental plan

The quality of the patching material is important for successful pothole repair. The experimental program is designed to determine the optimal binder content of patching materials and to investigate the performance of each mixture in terms of typical failure mechanisms that are observed in the field. The primary performance characteristics investigated are stability, adhesion, moisture resistance, and durability of the materials. Laboratory tests were performed to investigate the resistance of patching materials to the distresses that are caused when these characteristics are lacking. Table 1 provides a summary of this study's laboratory performance testing.

3.1. Materials

RAP and virgin aggregate mixtures were used to evaluate the performance of spray injection materials that contain different emulsions. Two sizes of aggregate were used in the mixtures to account for different-sized potholes. The RAP was obtained from Westgate Quarry and the virgin aggregate was obtained from Sunrock Quarry; both quarries are in North Carolina. Table 2 provides a summary of the aggregate properties.

Table 1
Laboratory performance testing.

Performance Characteristics	Desired Outcome	Test
Stability	Optimum binder content	Marshall Stability Test
Adhesion	Bonding of patching materials	Wet Track Abrasion Test (1 h)
Moisture resistance	Water resistance	Wet Track Abrasion Test (6 days)
Durability	Rutting resistance	Wheel Tracking Test

Table 3 presents the binder properties for the three emulsion types, Types A, B, and C, used in this study. These emulsions were mixed with RAP and with virgin aggregate to evaluate their effects on the performance of pothole patching materials. Type A and Type B were manufactured in South Korea and Type C is a typical CRS-2 emulsion used in North Carolina. The Marshall stability test and the wheel tracking test were conducted in South Korea and the wet track abrasion test (WTAT) was conducted in North Carolina. Therefore, the Type C emulsion was shipped from North Carolina to South Korea and the Type A and Type B emulsions were sent from South Korea to North Carolina.

4. Mixing procedure

4.1. Gradation

Spray injection patching materials consist of crushed aggregate and emulsified asphalt. Typically, the aggregate used in spray injection patching is a one-size stone similar to chip seal aggregate. The use of single-size aggregate allows the aggregate particles to be coated with a uniform thickness of asphalt. The SHRP study reported that the spray injection method uses single-size aggregate with a top layer size of 9.5 mm [2].

This study used two sizes of single-size aggregate, 9.5 mm and 4.75 mm. The larger size (9.5 mm) was used in an aggregate base mixture to fill deeper holes and the smaller size (4.75 mm) was used in an aggregate mixture to fill shallower holes.

4.2. Binder content

The binder content used in the tests ranged between 9 percent and 12 percent by weight of aggregate for the RAP mixtures and between 8 percent and 11 percent by weight of aggregate for the virgin aggregate mixtures to simulate the low and high binder content levels, respectively. Then the optimal binder contents were determined based on the Marshall stability test results.

4.3. Mixing

The virgin aggregate was heated at 110 °C ± 5 °C for 24 h to dry. It was left to cool to room temperature prior to mixing. However, the RAP aggregate was dried at room temperature for 24 h to avoid extra aging. A calculated amount of dry aggregates was placed in a bowl and 1 percent water by weight of aggregate was mixed with the dried aggregates. The emulsion was heated to 60 °C for an hour until uniform; a measured amount of the emulsion was added to the aggregate and mixed in using a spoon. This mixing process usually takes about three to five minutes depending on the amount of mixture prepared.

4.4. Compaction

An asphalt slab roller compactor was used to compact all the asphalt samples for the Wet Track Abrasion Tests (WTAT). The compactor applies loads that are equivalent to those of full-scale compaction equipment. Thus, this method can produce asphalt samples that are similar to materials used in actual highway pavements. This study utilized a multi-purpose roller compactor and the machine compacts specimens using a neoprene rubber sheet with three cycles in one direction and three cycles perpendicular to the first direction.