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Effective surface treatment techniques for refinishing oil-stained road surface

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HIGHLIGHTS

- Using tack coat and chip seal (CRS-2) to refinish the oil-spilled road can be completed in 1–1½ h.
- Chip seal (CRS-2) is a promising method to refinish the oil-spilled road for all types of oil.
- Chip seal specimen with pre-wash yields higher pull-off strength than that without pre-wash.

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ABSTRACT

Oil spillage on pavement surface is a hazard for all road users as it causes road slipperiness. Although there are various applications of oil removers for cleanup of oil spillages, many of which would require time-consuming treatment, no research has been conducted to develop temporary and fast road resurfacing technique which can be completed within a short time (1–2 h). The objective of this research is to develop a fast-setting asphalt surface treatment to respond to oil spillages on roads so as to allow resumption of traffic movements, for up to 2 days before surface rejuvenation. A series of surface treatments were selected for experimentation based on the consideration of ease of application and effectiveness to satisfy the road performance requirements. A tack coat of CRS-2 asphalt emulsion with chip seal coating was applied to refinish the oil-spilled dense- and open-graded specimens. The oil types were diesel, hydraulic oil, engine oil, and cooking oil. A British pendulum skid resistance tester was used to measure the skid resistance of the treated surfaces. The results show that using a tack coat with chip seal (CRS-2) applications to refinish the oil-spilled road can be completed within 1–1½ h. With adequate skid resistance performance, chip seal (CRS-2) application is a promising method to refinish oil-spilled road for all types of oil. A tack coat (CRS-2) application may be an option for the practitioner to use as a surface treatment to remedy oil spillage on dense-graded specimens, while asphalt emulsion alone shall not work well for oil spillage on open-graded specimens. PosiTest (pull-off tester) was carried out to determine the pull-off tensile strength of the applied surface layers, i.e., chip seal from the pavement surface. The results show that chip seal treated specimen with pre-wash yields higher pull-off tensile strength than chip seal treated specimen without pre-wash.

1. Introduction

Oil spillage on roads is of great concern to road agencies and road users alike. Any substantive oil spill shall necessitate closure of affected lane(s) for safety consideration, often at the expense of traffic congestion. A major oil spill during peak period can spiral into protracted traffic congestion, and result in road closure lasting well over 10 h [1]. Hence, it is of great interest to apply a quick temporary surface treatment to allow resumption of traffic movements during heavy flow periods and then doing a proper treatment within the next available opportunity, typically during the evening period.

The intensity of responses to oil spillage on the roads depend on the scale and severity of the spillages and the oil types [2]. Oil spillage is a particular concern for two-wheelers, as oil spillage on road surfaces can drastically reduce the skid resistance thereby threatening the stability and safety of road users especially motorcyclists and cyclists. Most oil spillages had involved diesel spill which is considered a road surface contaminant. Meitei et al. (2010)

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conducted a study to determine potential products available to assess performance and cost-effectiveness for resolving oil spillage on road. Although there are no national guidelines to cope with oil spillage because the response is dependent on the severity of the spillage, the Environment Agency (EA) in United Kingdom allows application of absorbent granules for cleaning up on diesel spillage. The EA favours use of inert and biodegradable absorbents which have minimum environmental impacts. After use, these absorbents must be collected, bagged, and discarded appropriately [2]. However, the whole process of using absorbent in oil spillage cleanup requires a long processing time thereby affecting the time required to reopen the affected road to traffic. Clearly, it is imperative to develop an effective and quick surface treatment to remedy oil spillage so as to minimise the impact on traffic flow and the surrounding environment whenever such incident occurs.

Advent of asphalt technology nowadays has provided more manufacturing choices and capability to road authorities. One of the choices that is widely used in many countries is cold/warm mix. It uses asphalt emulsion which is an environmentally friendly, energy efficient and cost effective product for use in today's road paving and preservation efforts. Surface treatments with asphalt emulsion are used as a sealing coat to rejuvenate an asphalt pavement that requires fast opening to trafficking. There are several types of surface treatments such as fog seal, chip seal, double chip seal, and microsurfacing which increase the friction and prolong the service period of the pavement [3]. Therefore, in this research, several surface treatments using asphalt emulsion were evaluated for road resurfacing after oil spills.

2. Materials and experiments

2.1. Materials

Crushed granite was chosen as it is prevalently used in pavement construction in Singapore which were used as coarse and fine aggregates for both the dense and open-graded road specimens. Two types of asphalt binder were selected, namely Penetration Grade 60/70 (PEN 60/70) and Performance Grade 76 (PG 76). PEN 60/70 was used in the fabrication of dense-graded specimen while PG 76 was used in the fabrication of the open-graded specimen.

Four types of oils, namely diesel, hydraulic oil, engine oil and cooking oil were used in the experiment. These oils were chosen as based on their frequencies of spillages on roads. Their properties are shown in Table 1.

Table 1
Properties of oil utilised to simulate oil spillage.

Type of oil	Properties	Value
Diesel	Odour	Strong
	Flash Point (°C)	79
	Density (kg/L)	0.830 (at 15 °C)
	Viscosity (mm^2/s)	29.8 (at 40 °C)
Engine Oil	Odour	Strong
	Flash Point (°C)	–
	Density (kg/L)	0.8590 (at 15 °C)
	Viscosity (mm^2/s)	84 (at 40 °C)13.8 (at 100 °C)
Hydraulic Oil	Odour	Bland
	Flash Point (°C)	235
	Density (kg/L)	0.8590 (at 15 °C)
	Viscosity (mm^2/s)	64.6 (at 40 °C)8.4 (at 100 °C)
Cooking Oil	Odour	Odourless
	Flash Point (°C)	290
	Density (kg/L)	0.916 (at 25 °C)
	Viscosity (mm^2/s)	25.3 (at 40 °C)10–20.10 (at 100 °C)

2.2. Experiments

Simulated oil spillage on road was carried on fabricated specimens in the laboratory. Surface treatment methods to refinish the oil-spilled specimen were established. Performance tests were conducted to evaluate the mechanical and functional capability of the treated specimens. A key performance parameter was the skid resistance which was tested to determine the effectiveness of a refinished road.

The effectiveness of the surface refinishing treatment of oil-spilled road is affected by various factors or conditions including wearing course, binder type, oil type, and weather conditions. To develop effective technologies that adequately address various possible scenarios pertaining to oil spillage on roads and the conditions during oil spillage remediation, a robust experimental programme as shown in Table 2 was adopted in this research.

3. Preparation of test specimens

3.1. Wearing course specimens

Two gradations of specimens were utilised namely dense- and open-graded specimens. The experimental laboratory specimen preparation included the mixing and compaction of asphalt slabs using a steel segmented Roller Compactor (RC) to simulate in-situ compaction as shown in Fig. 1. In addition, the optimal binder content for dense and open mixes would comply with Marshall Design Criteria tested using ASTM D1559 test method [4].

The gradation of aggregates for dense- and open-graded road specimens is shown in Fig. 2a. The dense- and open-graded road specimens were 300(W) × 400(L) and 30(H) mm with air voids of 4% and 18.2%, respectively.

3.2. Surface treatment specimens

After simulating oil spillage on the fleshly prepared road specimens, the specimens were segregated into two groups whereby the oil-spilled specimens would be subjected to either pre-wash with water or without pre-wash before surface treatment. The specimens in both groups underwent surface treatment whereby the specimens would be refinished with a fresh surface layer. In this research, the methods of surface treatment were selected based on the consideration of ease of practical application and effectiveness to satisfy the road performance requirements. The asphalt emulsion was selected based on the conditions of fast

Table 2
Experiment design showing scope of evaluation and attendant variables.

Factor	Variables
Mixture Type	Dense Open
Oil Type	Diesel Engine Oil Hydraulic Oil Cooking Oil
Binder Type	CRS-2
Surface Treatment	Tack Coat Chip Seal
Condition	**Variables**
Simulated Weather Condition	Dry Wet