

Friction on Polished vs. Newly Re-Rocked Oil-and-Chip Roadway Surfaces

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ABSTRACT

Roadway tractive capabilities are an important factor in accident reconstruction. In the absence of full-scale experiments, tire/road coefficient of friction values are sometimes quoted from reference textbooks. For the various types of road construction, the values are given only in the form of a wide range. One common roadway type is oil-and-chip construction. We examine stopping distances for newly-rocked oil-and-chip roads vs. similarly constructed roads that have been traffic-polished. The examination was conducted through full-scale braking experiments with instrumented vehicles. Results show that the differences between newly-rocked oil-and-chip roads when compared to roads that are traffic-polished are on the same order as vehicle, tire and ABS algorithm differences, and that full-scale testing is required for accurate μ -values.

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INTRODUCTION

In the absence of aerodynamic forces, the only external forces that can be applied to modify the trajectory of a vehicle must come from the tires at the tire/road interface. Tire/road coefficient values have thus been of interest almost since the invention of the pneumatic tire.

Modern methodology and equipment makes measurements of deceleration level and stopping distance a relatively easy task. Devices such as the VBox © [2] use GPS to perform such measurements. The equipment is readily available, reasonably inexpensive and easy to install in a vehicle.

Unfortunately, in accident reconstruction work there are times when a full-scale test is either impossible or impractical. Traffic conditions may preclude doing such experiments safely. Roadway surfaces may have been modified since the accident, thus any experiment hoping to duplicate accident conditions cannot be performed. Other situations may make testing too expensive or impractical to perform.

Many rural roads are constructed using oil-and-chip technology. Such surfaces consist of one or more layers of rock or stone, laid down onto a substrate which itself may be of the same composition. Once the stone has been applied over a layer of oil, one or more additional layers of oil may or may not be applied. Vehicular traffic then compresses the stone and oil mixture into a roadway surface that may exhibit tractive changes over time. The timing and duration of the changes depend on many factors: traffic density, weather, materials used and percentages of oil vs. stone are only a few potential characteristics that cause variation in the tire/road μ -value.

EXPERIMENTAL DESCRIPTION

Accident reconstructionists routinely refer to published values for tire/road μ -values in the absence of full-scale experiments. One popular and widely used set of values is shown below [1]:

Table 1. Table of tire/road μ -values [1]

DESCRIPTION OF ROAD SURFACE	DRY				WET			
	Less than 30 mph		More than 30 mph		Less than 30 mph		More than 30 mph	
	From	To	From	To	From	To	From	To
PORTLAND CEMENT								
New, Sharp	.80	1.20	.70	1.00	.50	.80	.40	.75
Travelled	.60	.80	.60	.75	.45	.70	.45	.65
Traffic Polished	.55	.75	.50	.65	.45	.65	.45	.60
ASPHALT or TAR								
New, Sharp	.80	1.20	.65	1.00	.50	.80	.45	.75
Travelled	.60	.80	.55	.70	.45	.70	.40	.65
Traffic Polished	.55	.75	.45	.65	.45	.65	.40	.60
Excess Tar	.50	.60	.35	.60	.30	.60	.25	.55
GRAVEL								
Packed, Oiled	.55	.85	.50	.80	.40	.80	.40	.60
Loose	.40	.70	.40	.70	.45	.75	.45	.75
CINDERS								
Packed	.50	.70	.50	.70	.65	.75	.65	.75
ROCK								
Crushed	.55	.75	.55	.75	.55	.75	.55	.75
ICE								
Smooth	.10	.25	.07	.20	.05	.10	.05	.10
SNOW								
Packed	.30	.55	.35	.55	.30	.60	.30	.60
Loose	.10	.25	.10	.20	.30	.60	.30	.60

A brief examination of Table 1 shows the wide range of tire/road μ -values that exists for packed/oiled roads (dashed box in Figure 1).

In order to investigate actual tractive changes, full scale braking experiments were conducted. The vehicles used are described in the Appendix, and span three decades of manufacture, several generations of ABS hardware and software, three vehicle types and manufacturers, and three vehicle categories.

All experiments were conducted on CR1100N (new rock) and CR1200N (traffic-polished) in Champaign County, Illinois. These roads were used because they had sections containing the desired characteristics. The newly re-rocked segments were coated with washed and dried $\frac{1}{2}$ " limestone [3]. Rerocked, new segments of the roadway are shown in Figures 1 & 2; traffic-polished segments are shown in Figures 3 & 4:

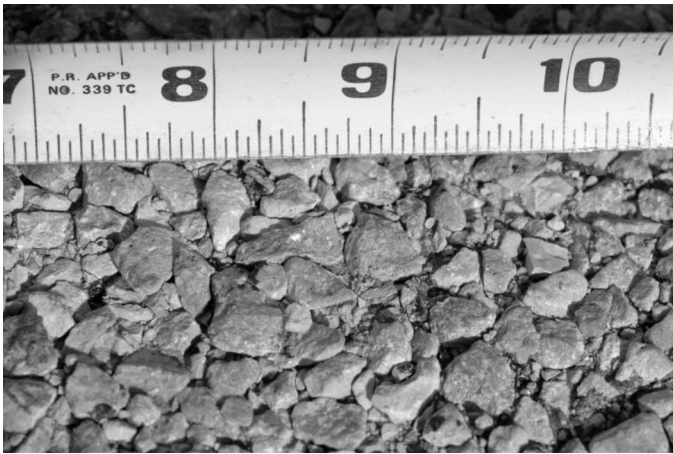


Figure 1. Re-rocked, new surface close-up view



Figure 2. Re-Rocked, new surface segment overview

CR1100N and CR1200N were surveyed prior to testing and found to be flat in the test areas employed to within 61 cm (± 2.0 ft.).

Each test vehicle was fitted with a VBox © IISX data acquisition system before conducting the experiments. The experiments all consisted of maximum intensity braking maneuvers conducted from nominal pre-braking speeds of 48 km/h (30 mph) and 96 km/h (60 mph). Data recorded consisted of stopping distance, actual speed at initiation of braking and average deceleration rate. Each braking

maneuver was replicated 3x for a total of 36 tests and averages were calculated. A VBoxmanufactured brake trigger was used to determine the instant when brake pedal pressure was applied; see Figure 5.

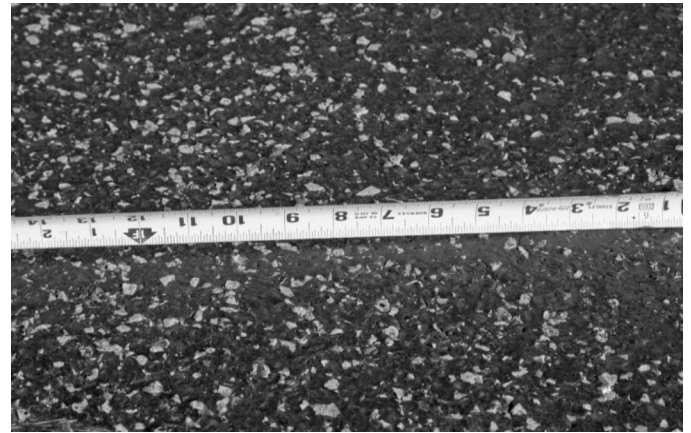


Figure 3. Traffic-polished surface close-up view



Figure 4. Traffic-polished surface segment overview

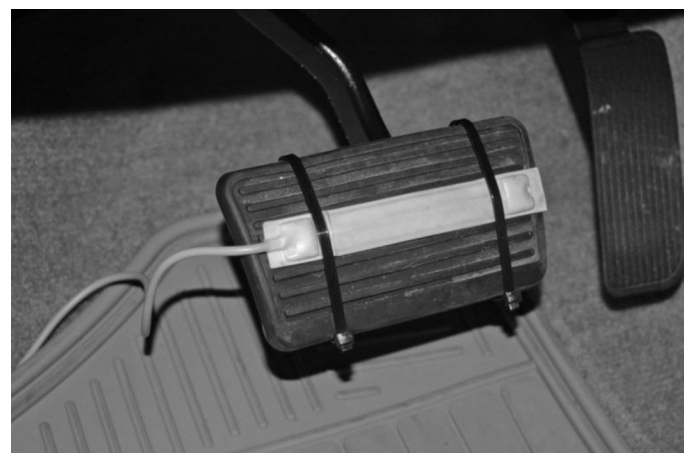


Figure 5. VBox brake trigger installed on v. 3

All maneuvers were conducted with the vehicle ABS systems in operational condition, and in all 36 tests the force applied to the brake pedal was sufficient to activate the vehicle ABS system throughout the duration of the maneuver, or until vehicle speed had slowed to the