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Durable laboratory rubber friction test countersurfaces that replicate the roughness of asphalt pavements

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ABSTRACT

This article presents the development of a method for manufacturing durable countersurfaces for testing the friction of rubber samples in a laboratory. The surface sample was designed to replicate the surface roughness characteristics of a predefined road surface. Four different types of samples were manufactured: two bitumen bound stone mastic asphalt samples, one concrete bound sample, and one epoxy bound sample. In addition, the surfaces were sandblasted to remove binder from the top of the surface. The similarity in surface roughness between the predefined target road surface and the laboratory surface samples was evaluated using optical 3D surface roughness measurements and surface roughness power spectrums. The durability of the surfaces was investigated by repeated dry rubber sliding friction tests. It was found that out of the studied surface samples the best one to both replicate the surface characteristics of the target surface and to produce a durable surface in terms of wear was the one using epoxy resin as a binder. By replacing bitumen with epoxy, more friction tests could be run without significant changes in the surface topography or rubber friction. In addition a reasonable correlation between the surface roughness power spectrums and the friction results was found, which supports the use of roughness power spectrums as a roughness metric for road surfaces in the context of rubber friction.

1. Introduction

Understanding tire–pavement interaction and especially tire friction is very important for tire manufacturers to develop tires with continuously increasing performance and safety. An important research tool for reaching this goal is a laboratory rubber friction tester that can compare the friction performance of various rubber samples. However, performing meaningful friction tests with rubber samples even in laboratory conditions is challenging due to the effect of the pavement surface roughness. On one hand, the surface roughness of the laboratory road sample should match that of the intended tire–road application. On the other hand, the roughness should also remain as constant as possible throughout test programs to provide comparable results for the different rubber samples and to reduce test variability. It is known that rubber–road friction evolves during the lifetime of the pavement as a result of the aggregate polishing and wearing, binder removal and the aging of the binder [1]. Therefore, developing a test surface for laboratory tests that minimizes these changes during the targeted life span of the surface allows more repeatable and meaningful results from laboratory rubber friction tests. Developing a method for manufacturing such surfaces and their quantitative comparison is the main topic of this study. The study focuses on dry rubber friction and does not include the effects of studded tires, water, or abrasives.

Different kinds of sandpapers and corundum surfaces provide quite durable countersurfaces that are easy to source for laboratory rubber friction testing. However the surface roughness of these surfaces is typically quite different from those of pavements, which represent the final application for tires. Another possibility is to take core samples from existing road surfaces, but this is of course destructive to the target surface and cannot guarantee repeatable properties for the samples in the long run. Different methods for producing durable surfaces that resemble asphalt for laboratory testing can be found in literature, such as the mosaic of coarse aggregates glued together with epoxy resin presented in [2] and the two-step casting method explained in [3]. In the casting method the macro-roughness of the pavement was replicated by covering the surface with liquid silicone, hence creating a negative profile of the surface. This negative profile was then used to cast a positive profile in a more durable material, namely synthetic resin

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loaded with corundum particles. These methods can produce durable surfaces, but do not replicate the roughness of real pavements on all length scales. As in principle rubber friction depends on roughness at all length scales [4–6], a method for replicating the full roughness spectrum needs to be developed.

To reach the goals of both surface roughness characteristics and durability, countersurface samples were prepared using three alternative binders: bitumen, epoxy and cement. Epoxy and cement were chosen as binder candidates due to their well-known ability to bind aggregates together. In addition, a second bitumen sample was built using polished aggregates. The mixtures were compacted to small slabs and the applicability of each surface type was assessed using 3D surface topography scans and repeated laboratory rubber friction measurements.

2. Materials and methods

2.1. Experimental procedure

The experimental procedure for the four test samples is illustrated in Fig. 1. The purpose was to attain similar surface roughness as in a target stone mastic asphalt SMA8 road surface. Thus, aggregate sizes up to 8 mm were used in all of the four surface types. Additionally, the target was to achieve a durable surface to allow more repeatable results from rubber friction tests. Since the hardness of the aggregates is one of the main factors of road surface wear resistance, the aim was to select the hardest available aggregates. Furthermore, because the aging of bitumen is one of the principal factors for asphalt pavement deterioration [7], two alternative binders, namely epoxy and cement, were used in addition to bitumen. In order to avoid changes in the friction levels due to binder removal, as shown in [2], the binder was preemptively removed from the fresh sample surface by sandblasting. After the binder removal was completed, the initial friction and roughness levels of the test sample surfaces were measured. Then, the surfaces were polished by sliding a rubber sample against them 100 times before measuring the friction and surface roughness again. These polishing sessions were repeated 1–10 times, depending on the durability of the samples.

2.2. Aggregate selection and job mix formula

Granite from Koskenkylä quarry, located in southern Finland, is widely used on high-volume roads in Finland due to its high resistance to wear by studded tires. This type of granite typically

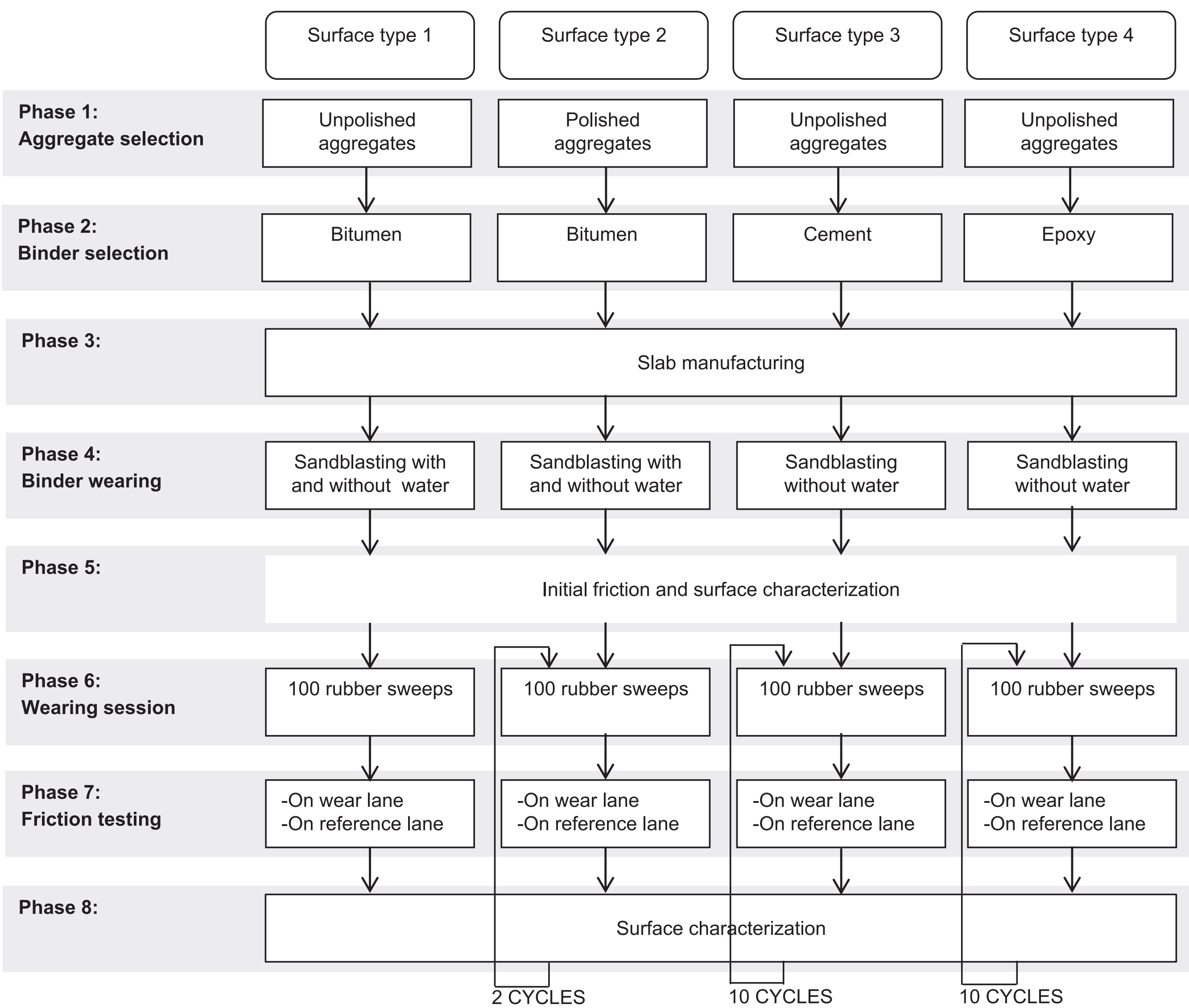

Fig. 1. Schematic diagram of the experimental procedure.