



PUBLISHED PROJECT REPORT PPR 315

MEASURING SKID RESISTANCE WITHOUT CONTACT; 2006-2007

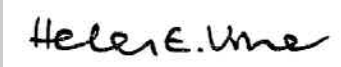

by A Dunford

Prepared for: Project Record: Contactless Microtexture Assessment
Client: Transport Research Foundation
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Executive summary

Skid resistance can be measured by various types of equipment, but all devices suitable for routine use rely on measuring the forces generated when a rubber tyre or slider is dragged across a wetted surface. The skid resistance offered by a surface is believed to be related to fine scale texture, or “microtexture”, present on aggregate chippings and a method of measuring and quantifying surface microtexture may therefore provide an indication of the skid resistance.

A programme of experiments is being undertaken by TRL Ltd for the Transport Research Foundation to determine whether detailed imaging of the road surface has potential to be applied to the determination of microtexture.

This report describes work carried out in the 2006-2007 financial year. Specimens of typical road aggregates were photographed, using a line scan camera system, before and after artificial polishing. Images of the aggregates in the different states of polish were examined automatically, by developing bespoke software, to assess if a change in the microtexture could be detected and linked to the measured change in friction on the specimen surface. The method for analysis, including masking of the image to isolate aggregate surfaces, and the algorithms that examine changes in image intensity, are briefly described. The correlation between parameters determined from image analysis and friction measurements on the specimens is presented.

Introduction

Routine monitoring of skid resistance is an important component of maintaining road surfaces in a safe and serviceable condition. Skid resistance can be measured by various types of equipment, but all devices suitable for routine use rely on measuring the forces generated when a rubber tyre or slider is dragged across a wetted surface. The logistics of obtaining water to wet the road surface severely limits productivity, making skid resistance surveys relatively expensive. It is also difficult to combine skid resistance measurements with other traffic-speed surveys, partly because the wet surface is incompatible with the requirements of the laser profiling and imaging equipment used for detecting road shape and cracking, and partly because seasonal variations in skid resistance limits measurements to one window during the year. Current skid resistance measurements are confined to a small proportion of the road width, generally a single, continuous line in the nearside wheel path of lane 1, and so other areas of low skid resistance may go undetected. Skid resistance measurements made in this way are also dependent on speed, resulting in errors being introduced when it is not safe to maintain a constant speed amongst live traffic. A contactless method of quantifying the road surface skid resistance has the potential to avoid many of these disadvantages.

The skid resistance offered by a surface is believed to be related to fine scale texture present on aggregate chippings, with physical dimensions in the range 0.001mm-1mm. This is the scale of the “microtexture” of a surface. A method of measuring and quantifying surface microtexture may therefore provide an indication of the skid resistance.

A programme of experiments is being undertaken by TRL Ltd for the Transport Research Foundation to determine whether detailed imaging of the road surface has potential to be applied to the determination of microtexture and then to the measurement of skid resistance. The ultimate objective of this work is the development of a method suitable for implementation on a traffic-speed survey vehicle. Except for the section below headed ‘Image Capture System’, the work reported in this document is part of the Transport Research Foundation’s ongoing research programme. All rights to the intellectual property of this work remain with the Transport Research Foundation (excepting that described in the section entitled ‘Image Capture System’).

Aggregate samples; polishing and photographing

In previous work (Dunford and Viner, 2006) we used digital still images taken of small areas of incrementally polished asphalt slabs made using gritstone, granite or limestone. These specimens represented the widest range of the skid resistance found on UK roads – high represented by highly polish resistant gritstone, as used in high risk areas such as junction approaches and bends; low, represented by limestone, which is very susceptible to polishing, and rarely used as coarse aggregate in the UK; mid-range represented by widely used granite. In this most recent work, however, we have used a greater number of samples, using aggregates that are very typical of those used in the construction of UK roads. These were photographed using a line scan camera system, which has been developed separately for Highways Agency and is described at the end of this report. In both experiments artificial polishing and friction testing was carried out using the Wehner Schulze polishing machine, which is owned by Highways Agency and operated by TRL Ltd, so that the change in surface texture could be examined.

The new specimens were made using seven aggregate sources. Aggregate particles are bound together into discs using epoxy resin and sand (examples are shown in Figure 1 below). Note that the epoxy resin and sand mortar binding the aggregates in the specimens is green in colour. For each aggregate source, the discs were made in duplicate with a range of aggregate sizes – 6mm, 10mm, 14mm and 20mm. Although the range of skid resistance simulated was expected to be quite limited (the very low end of the skid resistance scale not being represented), a range of aggregate type could be examined, including gritstone from more than one source, granite from more than one source, basalt and porphyry. Photographs were taken of every sample before and after each stage of concentrated polishing.



Figure 1 Aggregate specimens after polishing

Following image collection the images required processing to characterise the microtexture. This was achieved by analysing and masking the image to isolate chippings from the remaining surface, followed by processing of the image of isolated chippings.

Image masking

A critical part of this project has been the automatic pre-processing of images in order to isolate the chippings. In our previous work, this was done manually to obtain small ‘windows’ of each full image for analysis, which was very slow, and considerably reduced the amount of image actually used. It was found that many small areas were required for analysis before a stable result could be achieved. By automatically masking everything but the upper stone surfaces in the image it is now possible to use the images to their full extent. During this experiment the use of green sand and green resin in the specimens made this process quicker and more accurate, but the algorithms developed do also work on standard asphalt samples. The stages of the masking algorithm are described briefly below.

Stage 1: The original image is loaded into the software. One side of one of the polished gritstone specimens is shown in Figure 2.



Figure 2 Original image

Stage 2: Pixels with intensity below a user defined threshold are converted to the masked area (represented in pink)

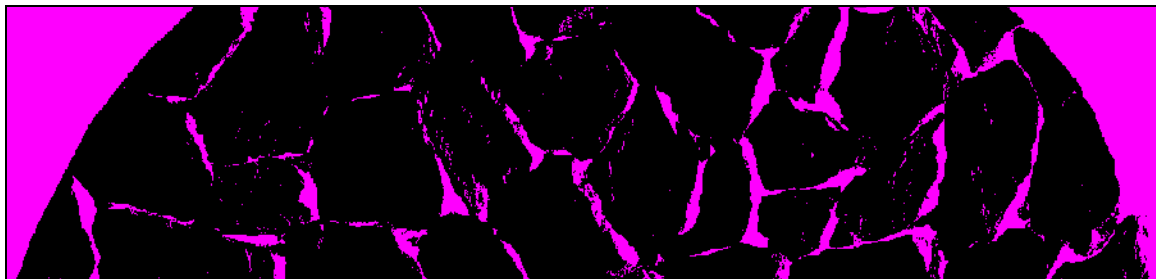


Figure 3 Intensity mask

Stage 3: Pixels with hue within a user defined range – ‘green’ in this case – are included in the mask.

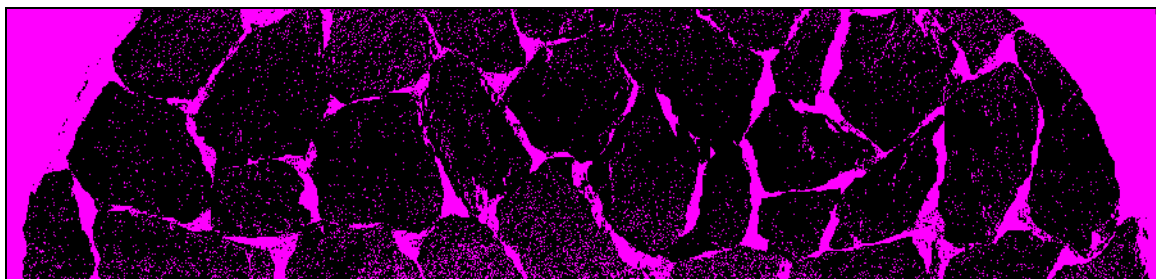


Figure 4 Hue and intensity mask

Stage 4: Areas of adjacent pixels designated as mask in the previous steps are analysed, and those areas smaller than a user defined size are removed from the mask, i.e. the original pixels are replaced – represented below with white for the mask, and blue for non-mask.

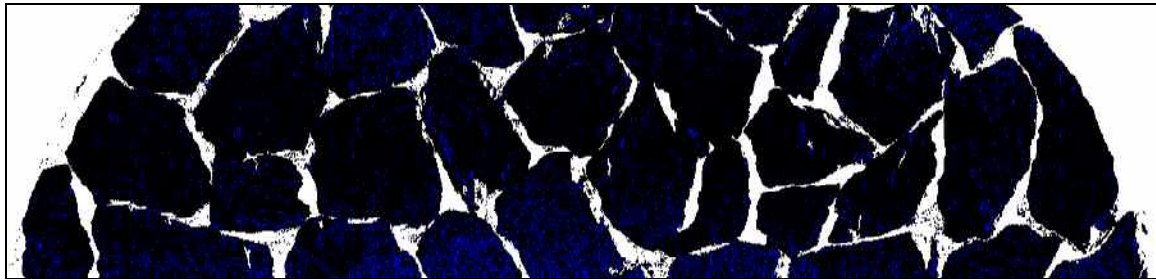


Figure 5 Mask area consolidated

Stage 5: The remaining adjacent masked areas are joined up and then the edges of the masked area are smoothed. This is called expansion and erosion.

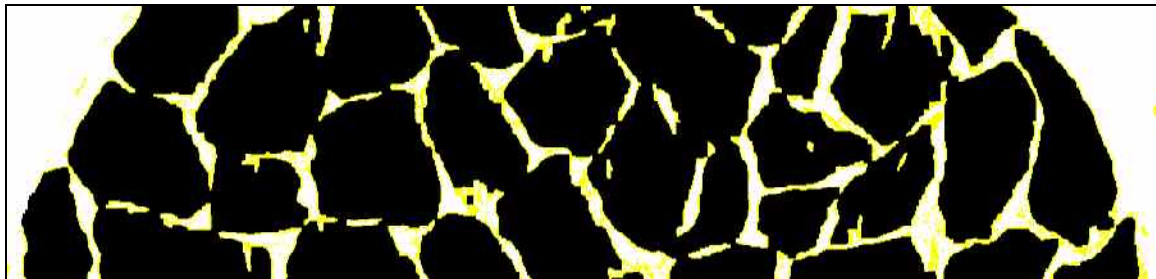


Figure 6 Mask after expansion and erosion

Stage 6: The masked image is saved and can be used for analysis.



Figure 7 Final masked image

Currently, the parameters used in this process can be changed by the user at each stage. However, work is ongoing to make this process more automated. Once that is implemented, the masking process can be fully automatic and only limited by the speed of processing.

Microtexture algorithms

The second stage of the image processing is that of assessing the microtexture (and therefore the friction) on the regions of the image segmented by the mask.

A characteristic parameter was developed in the previous stage of this work to assess the microtexture, called “CMT1”. This parameter utilises the intensity of each pixel and considers the density of pixel intensities within the image. The parameter was found to correlate successfully with the measured coefficient of friction, although the relationship depended on the material being examined (see Figure 8).

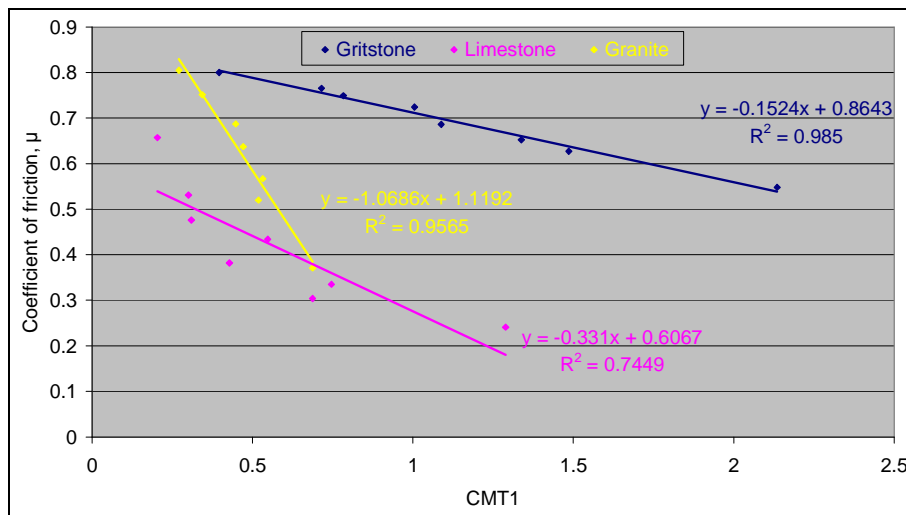


Figure 8 CMT1 correlation with μ

This stage of the project sought to improve on the results using “CMT1”, again using intensity, but attempting to achieve a material-independent relationship. A new parameter “CMT2”, developed using an initial set of the polished specimens, uses a comparison of the intensity of each pixel with the intensities of adjacent pixels, rather than with a pre-defined threshold, as in CMT1. It is this comparison to in-image factors that should allow the parameter to be independent of the type of aggregate. The graph in Figure 9 shows the relationship between μ and CMT2, for aggregates of two different types.

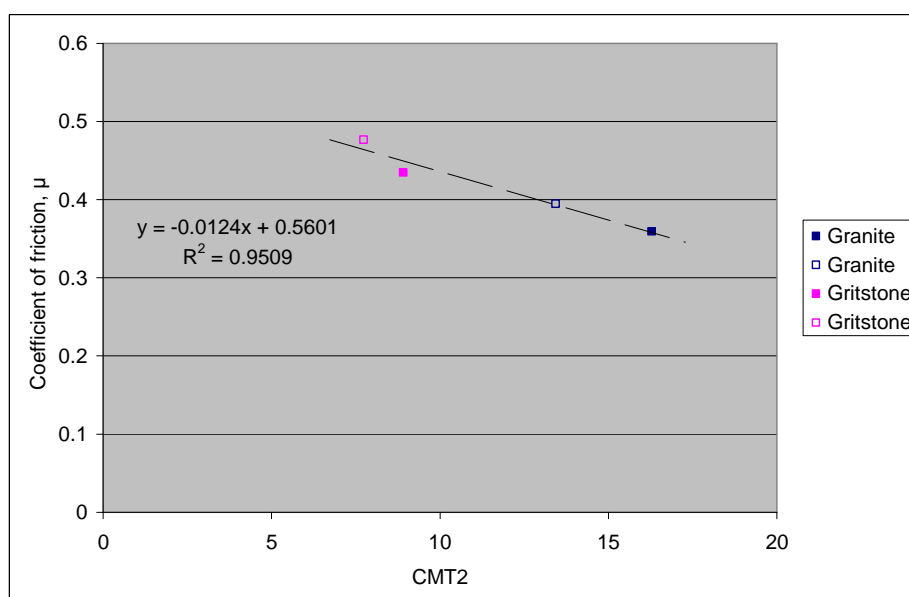


Figure 9 μ against CMT2

Unfortunately, the relationship in Figure 9 did not hold after analysis of further aggregate types. Therefore, the CMT2 parameter was altered to use the distribution of values calculated during analysis as well as the values themselves, and the parameter “CMT2A” was created. The relationship between CMT2A and μ is shown in Figure 10. It can be seen that CMT2A predicts the friction well for all but one sample, which has been treated as an outlier, and not included in the line of best fit shown.

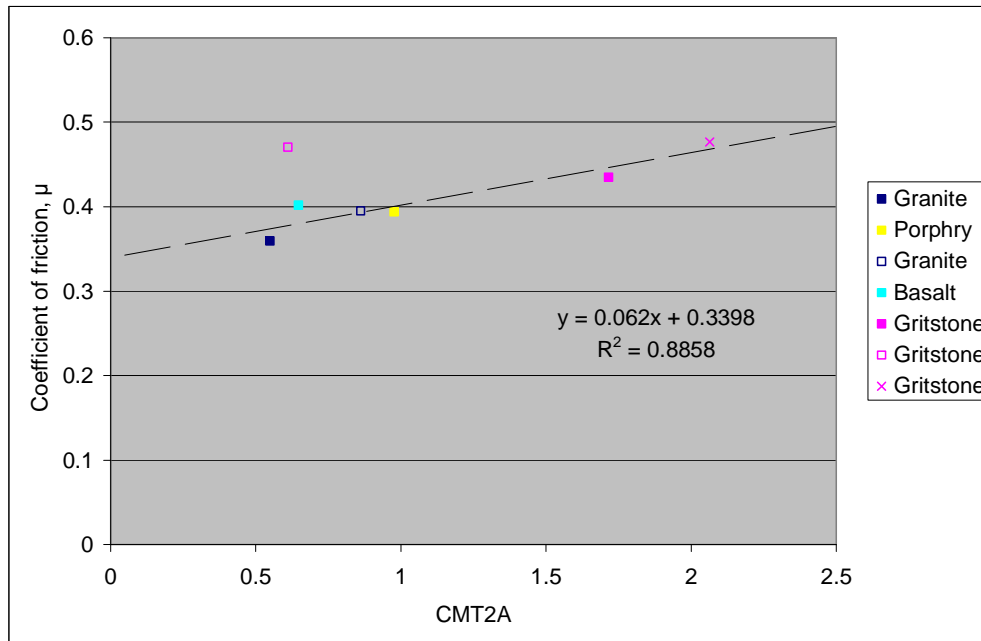


Figure 10 μ against CMT2A

Inspection of the friction measurements taken on the outlying gritstone specimen, and the condition of the specimen itself, revealed nothing to suggest a reason for the anomalous measurement. Similarly, inspection of the images and of the data used to produce the CMT2A parameter did not reveal any reason for the outlying result. It will be important in future work to determine the likelihood and impact of erroneous measurements. Furthermore, it will be necessary to investigate changes to the image analysis that will improve performance, such as collection of many more images to gain a more stable average parameter value.

The next stage of work will again attempt to improve on these findings. In particular, there will be a step towards using images of in service roads, where long continuous strips of images can be collected and analysed. With improvements and further automation of the analysis procedures it should be possible to handle the large quantity of image data that will be required.

Image capture system

In a parallel programme of work carried out by TRL Ltd for the UK Highways Agency a system is being developed to collect high resolution images of the road surface at traffic-speed. A slow-speed prototype version of this system has been produced that uses a digital colour line scan camera to collect images. This system has provided the images for the analysis described above, carried out for TRF. Figure 11 shows photographs of the trolley system designed to house the line scan camera and lighting.



Figure 11 Microtexture capture system

The high-speed colour line scan camera collects a single pixel wide image 2048 pixels long at a scan rate of 11kHz. The resolution in the transverse direction is determined by the lens used and the distance of the camera away from the surface. In fact the outermost pixels in the line tend to become distorted unless a special collimating lens is used, so with the present lens only the central 1024 pixels are used. The distance of the camera from the surface allows a width of approximately 55mm to be photographed, giving a transverse resolution of approximately 54 μ m. Distance is measured, and the camera is triggered to capture, using a shaft encoder mounted on a small wheel in contact with the road surface. The line scan camera can be triggered to record a line of image once every 25 μ m. In practice however, this restricts the speed at which the trolley can be moved, and the images used in this stage of work were created from line scans every 50 μ m.

The trolley, and the work carried out to optimise the images obtained, will be described in full in a forthcoming published project report for Highways Agency.

References

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