Rijkswaterstaat
Ministry of Infrastructure and the Environment

ITC Blastrac trial
retexturing porous asphalt by steel shot blasting

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Contents

1 Introduction

Blastrac is a company that designs and manufactures machines for roughening surfaces. These include machines that can be mounted on a vehicle for use in retexturing road surfaces. One of Blastrac's most recent developments is a machine for pavement retexturing by steel shot blasting, a process in which small steel balls or pellets known as steel shot are blasted onto the surface to add extra texture to each individual stone and thereby increase the skid resistance of the surface. A vacuum system recovers the shot along with the material removed from the surface, after which a magnet removes the shot so that it can be reused.

Rijkswaterstaat's Innovation Test Centre (ITC) was asked by Blastrac to validate this method for use on main roads in the Netherlands. This report describes the validation trial and the conclusions.

2 Description of the innovation

The system tested was a Blastrac 2-45DTM (see Photo 1). The system consists of a shot blaster unit mounted on the front of a lorry. The blaster unit is connected to the lorry by four hydraulic and one electrical connection. Two air hoses are used to carry away the surface material removed. A magnet in the blaster housing recovers the steel shot from the surface material enabling it to be reused. Operation is from the driver's cab.

Photo 1 Blastrac 2-45DTM

Between jobs the blaster unit can be removed for transport in the rear of the lorry. See Photo 2.

Photo 2 Blasting unit in rear of lorry

The maximum width that can be treated in a single pass is 1150 mm. The blaster unit weighs 1750 kg. It can be adjusted in width so as to treat the whole width of a lane. Operating speed can be varied between 0.5 and 40 m/min.

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3 Trial requirements

To be of use to Rijkswaterstaat the innovation must satisfy a number of requirements.

The principal requirements are:

1 Use of the innovation must deliver an appreciable enhancement in skid resistance (to above the intervention level).
2 This increase in skid resistance must be sufficiently long-lasting: skid resistance must still be better six months or a year after treatment than it was before treatment.

Subsidiary requirements are:

3 No damage must be caused to the road surface. There must be no ravelling.
4 Only a very small proportion of the steel pellets used must be left in the road surface following treatment.
5 There must be no increase in susceptibility to ravelling.
6 Any shot remaining in the surface must not cause damage (e.g. as a result of rusting) or have a detrimental effect on functional qualities such as noise abatement or porosity to water.

4 Trial design

4.1 Selection of trial site

To test for the above requirements the system was used in real-life conditions at a trial site where skid resistance was close to the required standard and other damage was limited. Using this innovative system it may be possible to delay the need to replace the surface due to inadequate skid resistance until such time as other damage has also occurred.

The trial site also had to meet a practical requirement. Where work is being carried out over the entire width of the slow lane it is necessary not only to close off that lane but also the lane adjacent to it. This means that if the entire carriageway is not to be closed, it must have at least three lanes.

A site meeting these requirements was found on the A16 motorway: Carriageway 1 Right, Lane 3 Right, between km 21.7 and 21.8. This is part of the southbound carriageway between Rotterdam and Dordrecht, just south of the Van Brienenoord bridge. The road surface is porous asphalt laid in 2006. This part of the motorway is scheduled for resurfacing in 2016 but skid resistance is currently just below standard. Successful use of the new system would make it possible to avoid the need for premature resurfacing due to inadequate skid resistance.

For the purposes of the trial this section of the motorway was closed to traffic on the night of 5-6 September 2012.

4.2 Trial plan

A trial plan was drawn up to determine whether the requirements set for the trial were met. The trial site was divided into three sections: a reference section (left untreated), a section that was given more intensive treatment (section 1) and a section that received less intensive treatment (section 2). The differences between intensive and less intensive treatment lie in the treatment speed (see 4.3 below).

The following tests were carried out:

- Skid resistance readings immediately preceding and after treatment to determine the improvement in skid resistance (requirement 1).
- Repeat skid resistance readings approximately six months after treatment (requirement 2).
- Visual inspection while treatment was being carried out (requirement 3).
- Core sampling (three cores per trial section). Samples were then tested by Delft University of Technology as follows:
    - CT scans to determine the number of shot pellets left in the surface (requirement 4)
    - RSAT testing to determine susceptibility to ravelling (requirement 5).
- After approximately six months a visual inspection was carried out to determine whether ravelling was proceeding in accordance with expectations (requirement 5) and whether residual shot was causing damage (requirement 6).

4.3 Execution

The treatment was applied with the system set as follows:

- Power setting 38-40 kW, corresponding to a blast pressure of approx. 180 bar.
- Pass speed of 15-18 m/min (trial section 1) and 22-23 m/min (trial section 2).

Core samples were taken immediately following the treatment.

5 Results

5.1 Skid resistance immediately before and after treatment (requirement 1)

Skid resistance at the trial site (and abutting road sections) was measured on both 5 September (before the trial) and the following day 6 September 2012 (after the trial). Measured values are given for every 5 m so that the effect of the treatment is easily seen [i]. Table 1 shows both measurements side by side, where ‘before' refers to the values found on 5 September and ‘after' refers to those found on 6 September after the trial. The increases shown are the ‘after' values minus the ‘before' values; the increases on both sections are shown in bold type.

Table 1 Skid resistance readings immediately before and after treatment

from	to	before	after	increase	
21.700	21.705	0.43	0.40	-0.03	
21.705	21.710	0.43	0.40	-0.03	
21.710	21.715	0.42	0.40	-0.02	
21.715	21.720	0.43	0.42	-0.01	
21.720	21.725	0.41	0.58	0.17	intensive treatment
21.725	21.730	0.42	0.65	0.23	
21.730	21.735	0.42	0.66	0.24	
21.735	21.740	0.42	0.65	0.23	
21.740	21.745	0.42	0.63	0.21	
21.745	21.750	0.42	0.64	0.22	
21.750	21.755	0.45	0.65	0.20	
21.755	21.760	0.44	0.65	0.21	
21.760	21.765	0.46	0.62	0.16	
21.765	21.770	0.43	0.64	0.21	
21.770	21.775	0.44	0.65	0.21	
21.775	21.780	0.44	0.54	0.10	less intensive
21.780	21.785	0.43	0.51	0.08	
21.785	21.790	0.45	0.50	0.05	
21.790	21.795	0.45	0.48	0.03	
21.795	21.800	0.49	0.45	-0.04	

On the untreated section there was some slight variation in skid resistance, ranging from a decline of 0.03 to an increase of 0.05. This is a normal variation. On the first, intensively treated, section there was a sharp rise of between 0.16 and 0.24. An increase was also found on the second, less intensively treated, trial section: between 0.08 and 0.10. The conclusion is that the treatment had a manifest effect on skid resistance. As was to be expected, the more intensive treatment had a larger effect than the less intensive treatment.

5.2 Skid resistance after six months (requirement 2)

Skid resistance was measured again on 18 April 2013 [ii]. The results are shown in Table 2.

Table 2 Skid resistance readings six months after treatment

from	to	before	after six months	decline	
21.700	21.705	0.40	0.43	-0.03	
21.705	21.710	0.40	0.43	-0.03	
21.710	21.715	0.40	0.45	-0.05	
21.715	21.720	0.42	0.50	-0.08	
21.720	21.725	0.58	0.50	0.08	intensive treatment
21.725	21.730	0.65	0.50	0.15	
21.730	21.735	0.66	0.51	0.15	
21.735	21.740	0.65	0.51	0.14	
21.740	21.745	0.63	0.51	0.12	
21.745	21.750	0.64	0.53	0.11	
21.750	21.755	0.65	0.53	0.12	
21.755	21.760	0.65	0.52	0.13	
21.760	21.765	0.62	0.55	0.07	
21.765	21.770	0.64	0.52	0.12	
21.770	21.775	0.65	0.50	0.15	
21.775	21.780	0.54	0.51	0.03	less intensi-ve
21.780	21.785	0.51	0.50	0.01	
21.785	21.790	0.50	0.49	0.01	
21.790	21.795	0.48	0.48	0.00	
21.795	21.800	0.45	0.48	-0.03	

Six months later, skid resistance on the intensively treated section had declined by between 0.07 and 0.15 compared with immediately after the treatment. Despite this sometimes sharp drop, there was still a clear residual effect. On the less intensively treated trial section the decline was much less at only 0.01-0.03. Here again there was a clear residual effect. At the time of writing, skid resistance is about the same on both treated sections.

The changes are also shown in Figure 1. The blue line shows the level of skid resistance before the treatment, the purple line the level immediately after the treatment. The improvement is plain to see. The yellow line shows skid resistance after six months; it will be seen that by that time skid resistance was about the same on both the treated sections.

Figure 2 shows the changes over time for each trial section. It will be seen that skid resistance remains broadly unchanged on the reference section whereas on the section receiving the more intensive treatment there is a sharp increase in skid resistance followed by a decline. On the less intensively treated section skid resistance increases and thereafter remains steady.

Figure 1 Skid resistance

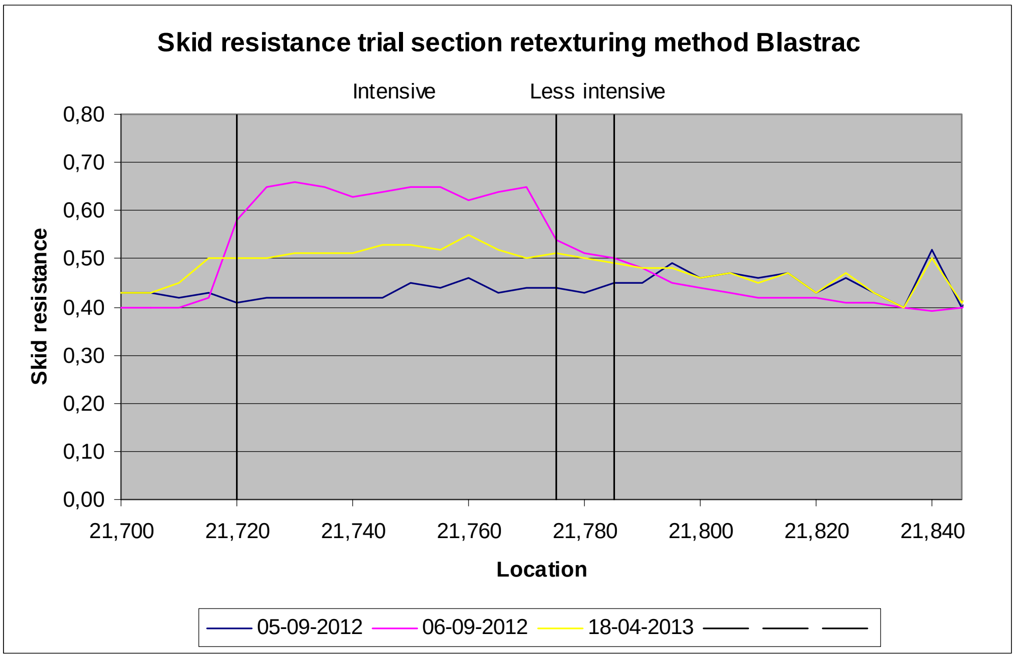
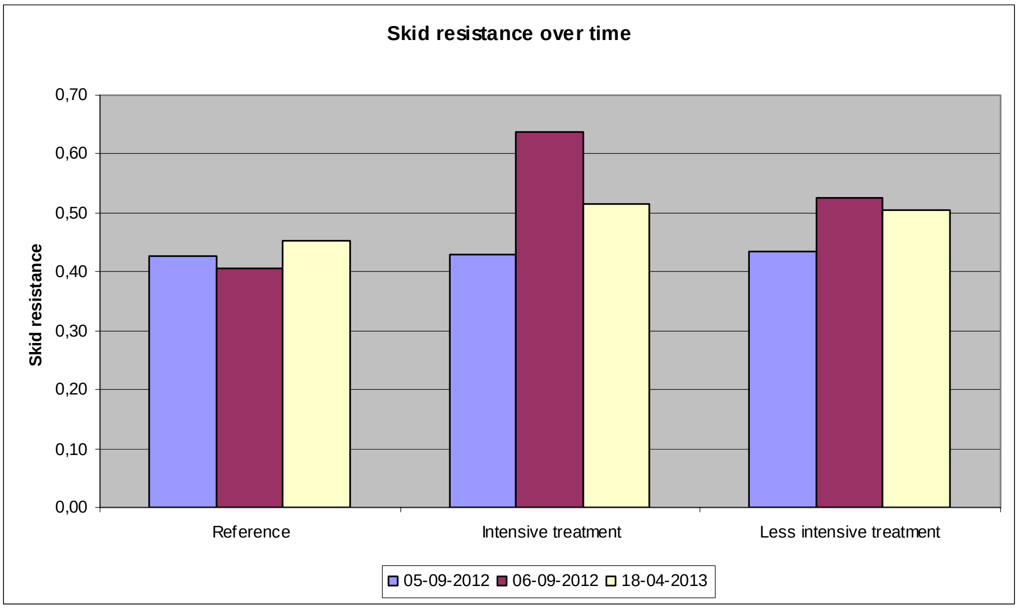


Figure 2 Skid resistance over time for each trial section



5.3 Visual inspection while treatment in progress (requirement 3)

The trial site was inspected visually as the work progressed. This revealed that on the intensively treated section some ravelling (loss of stone) was occurring, after which the treatment was continued at a lighter setting. Several weeks later this inspection was repeated and there appeared to be no further damage.

5.4 CT scans (requirement 4)

Delft University of Technology (TU Delft) carried out CT scans on core samples from the two trial sections [iii]. Horizontal cross-sections of the cores were scanned at intervals of 1.0 mm. Resolution in each scan was 0.294 x 0.294 mm. Using these scans it is possible to count the number of steel pellets in each core.

Pellets were found only in the top 20 mm of each core, the majority being in the top 10 mm. Cores from the more intensively treated section contained an average of 31 pellets, while on average those from the less intensively treated section contained nine. In other words, the heavier treatment leaves more shot in the pavement.

5.5 Rotating Surface Abrasion Test (RSAT) (requirement 5)

TU Delft used RSAT testing to determine susceptibility to ravelling. The test consists of cementing three cores from a trial section in a plate which is then loaded with a wheel bearing down on it at 0.6 MPa. The plate rotates and the material released is collected by a vacuum system. The quantity of material with a diameter of 2 mm or more is a measure of ravelling [iii].

The results are given in Table 3.

Table 3 RSAT results

Trial section	Duration (h)	Temperature (°C)	Total stone loss (g)
Reference	24	20	13.09
Intensive treatment	24	20	12.06
Less intensive treatment	24	20	38.52

Loss of stone on the intensively treated section is comparable with that on the untreated section, from which it may be inferred that the treatment does not lead to an increase in susceptibility to ravelling. Contrary to expectations, loss of stone on the less intensively treated section was almost three times that on the reference section. This would appear to point to a steep increase in susceptibility to ravelling. However, the normal distribution in the trial results was found to be quite large, so that on the basis of these results there are no grounds for concluding that there was any statistically significant increase.

5.6 Visual inspection after six months (requirements 5 and 6)

A second visual inspection of the trial site was carried out on 6 June 2013. An evaluation was made as to whether ravelling was developing in accordance with expectations and whether in the meantime the remaining pellets had caused damage to the asphalt. The inspection revealed no further damage.

6 Conclusions

The results are summarized in Table 4.

Table 4 Summary of results

Requirement	Evaluation		Remarks
	Section 1	Section 1	
1 Increase in skid resistance	✓	✓	
2 Long-term increase in skid resistance	✓	✓	
3 No damage to road surface	✗	✓	
4 Few pellets left in surface	✗	✓	
5 No increase in ravelling	✓	✓	
6 No damage from pellets	✓	✓	

Trial section 2 was found to be performing well on all points. In trial section 1 there was some initial damage, which, while it did not increase over the following six months, is nevertheless undesirable.

7 Recommendations

The principal recommendation is for a follow-up trial to be conducted on two stretches of pavement, one of relatively old and one of relatively new porous asphalt, both containing quarry material and both being below standard in terms of skid resistance. If possible, it would also be desirable to carry out planing. These trial sections would have to be treated by a contractor with access to Blastrac equipment so that it would be possible to obtain an accurate comparison between the results obtained by the Blastrac method and those obtained by conventional planing.

To determine whether the Blastrac system is suitable for RWS works, it will also be necessary to gain an insight into the costs associated with Blastrac operations and the time required for retexturing a stretch of road. Through a direct comparison of Blastrac treatment as opposed to planing it will be possible to establish whether the Blastrac method is a good alternative to planing.

Appendix Literature

[i] KOAC/NPC: Stroefheidsmetingen op een proefvak van RW016 – 5 en 6 september 2012. Project 120267601. Apeldoorn, 10 september 2012.

[ii] KOAC/NPC: Stroefheidsmetingen (proefvak) op RW016 1 HR R, 3 R- R (km 21,600 – 21,900) nabij Rotterdam. Project 130098801. Apeldoorn, 22 april 2013.

[iii] Jian Qiu, Wim Verwaal (TU Delft): Evaluation of Steel Grit Blasting on Porous Asphalt Surfaces. Report 7-12-189-1. Delft, November 2012.