The Use of Post-Consumer Tyres in Public Rights of Way Construction

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ABSTRACT: In recent years, there has been debate over the use of asphalt as a surfacing for public rights of way. Asphalt surfaces are durable and smooth but the material can be too hard for comfortable horse riding or jogging and are visually unacceptable within the countryside. Softer surfacings, such as grass or sand, provide 'give'; however, these surfacings can impede some users and are often less resistant to permanent deformation which can result in higher maintenance costs. A surface that meets the needs of both horse riders and other users might be achievable using post-consumer tyre rubber. Recycled crumb rubber has been trialled in a range of applications in order to assess the mechanical performance. In addition, the views of a range of users groups have been collected via ongoing monitoring of a trial site along a bridleway in Nottingham

The paper will focus on the technical aspects of incorporating post-consumer tyres into public rights of way surfaces and foundation layers. The specification design and associated laboratory testing will be covered in detail, along with construction methodology and performance monitoring data. This information, in conjunction with details of dissemination activities and stakeholder feedback, will highlight the numerous possibilities for using post-consumer tyres in public rights of way construction.

1 Introduction

In recent years, there has been debate over the use of asphalt as a surfacing for public rights of way. Asphalt surfaces are durable and smooth but the material can be too hard for comfortable horse riding and running. Softer surfacings, such as grass or sand, provide 'give'; however, these can impede some users and maintenance costs are higher. A surface that meets the needs of both horse riders and other users might be achievable using post-consumer tyre rubber.

The project was funded by WRAP (the Waste and Resources Action Programme) as part of an initiative to promote the use of vehicle tyres which have recently become exempt from landfill. Scott Wilson undertook the specification development and trial site design as well as the project dissemination activities.

2 Aims and Objectives

The project aim was to demonstrate the suitability of using post-consumer tyre rubber in Public Rights Of Way (PROW) surfacings. The two main objectives which were used to achieve this goal were the development of materials specifications and the construction of a trial bridleway to demonstrate the performance and life cycle costs of surfacings containing post-consumer tyre rubber. On going dissemination to PROW stakeholders has been another important objective of the project that has raised awareness of the work and helped to promote the use of tyre rubber amongst the people responsible for maintenance and resurfacing of the PROW network.

3 Methodology

The project was undertaken in five stages which allowed more flexible delivery of the project. These were:

- Site assessment
- Specification development
- Route construction
- Dissemination of information
- Ongoing performance monitoring

3.1 *Site Assessment*

Five candidate sites in Nottinghamshire were assessed during October 2005. The potential sites were subjected to condition surveys (for features such as available width and drainage), and mechanical testing to evaluate the foundation materials.
Following discussion by the project partners, the Clipstone site was chosen as the demonstration site, primarily as a consequence of its greater width and likelihood of use.

3.2 *Specification Development*

Laboratory testing of materials and subsequent specification development was completed in January 2006. This included:

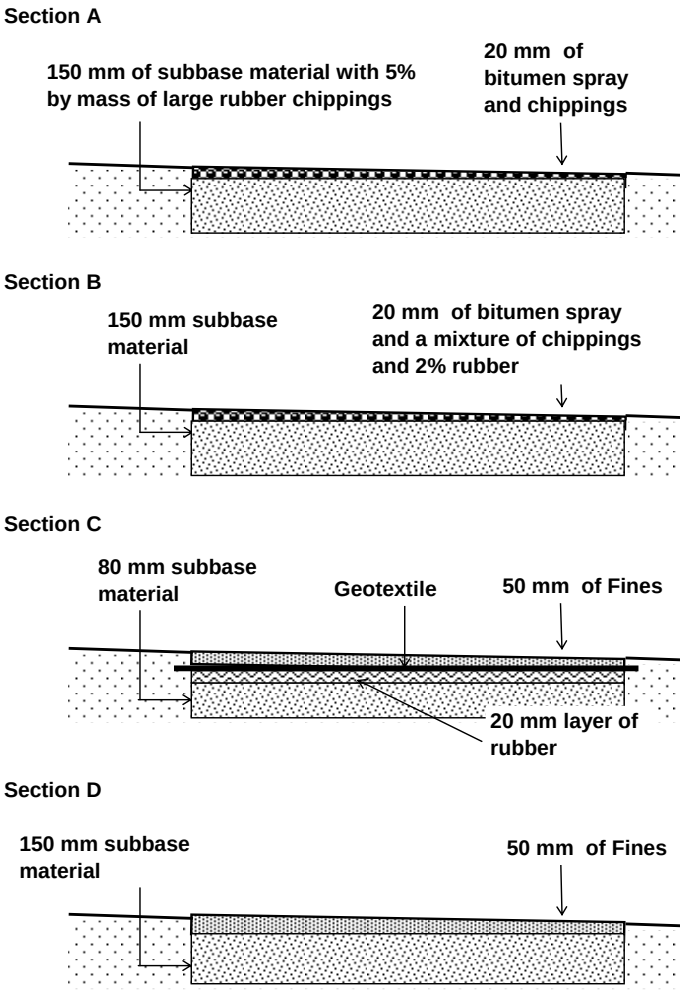
- Testing of the stability of bitumen spray and chipping surfacing when increasing levels of 10 mm rubber granules were added to the structural matrix of the surface.
- Testing the surface stiffness and permanent deformation of subbase aggregate with increasing levels of 20 mm rubber granules.

The results from testing of these mixtures were compared with tests of conventional bridleway construction materials. The following conclusions were reached:

- Replacing 2% by mass of the chippings in a bitumen spray and chipping surfacing with 10 mm rubber granules was acceptable. Greater masses of rubber affected the cohesion of the surfacing and prevented a stable surface from forming.
- Replacing 5% by mass of the subbase aggregate with 20 mm rubber granules provided sufficient deflection while also allowing adequate compaction during construction.
- The final surfacing design used a 20mm thick layer of 6 mm rubber granules covered by a geotextile and 20 mm of quarry fines. This specification provided sufficient surface deflection while allowing compaction of the quarry fines. The geotextile layer prevents any migration of rubber upwards into the quarry fines.

These specifications are illustrated in Figure 1 below.

Figure 1: Cross sections of the construction specifications for each section of the bridleway.



3.3 *Route Construction*

The demonstration route is roughly 500 m in length, 3 m wide and was constructed during April and May 2006. The route was divided into four sections. Section A, B and C were each approximately 140 m in length and contained rubber granules as described in section 3.2.

Section D was an 80 m section which was constructed in the conventional manner of quarry fines surfacing over a recycled concrete aggregate (RCA) subbase foundation layer.

3.4 *Route monitoring*

3.4.1 *Traffic and User Surveys*

Traffic counts of the site were needed in order to gauge its level of use. Radio-beam traffic counters were installed which were able to distinguish between users groups (horse riders, pedestrians and

cyclists). However, these were quickly vandalised resulting in manual head counts having to be taken.
To provide a representative sample, traffic counts were undertaken between 10 am and 6 pm on both weekdays and weekends.
While traffic counts were being carried out, a number of users were questioned over their thoughts on the new bridleway surfacing, for example they were asked; to describe the surface (choosing a number of words from a list provided), how regularly they used the route, and whether they thought the surface was visually acceptable.

3.4.2 *Performance Testing*

Post construction, mechanical performance testing was carried out on the demonstration route in order to measure stiffness and identify the likelihood of permanent deformation. Stiffness measurements were taken using a Prima machine.
Three measurements across the path were taken at 50 m intervals along the bridleway. To obtain a representative reading, five 'drops' were taken at each of the three measurement points.

3.5 *Dissemination Activities*

In order to keep interested parties up to date on the project a number of dissemination activities were undertaken throughout the project. These activities were in a number of formats.

3.5.1 *Newsletter publications*

Three short newsletters have been produced throughout the project providing stakeholders with an introduction to the project, an overview of the construction methods and a summary of the post-construction monitoring which has been undertaken. These newsletters have been circulated amongst a project contacts list of approximately 200 stakeholders, although it is believed that the actual circulation is larger than this due to further circulation by the project contacts.

3.5.2 *Press Releases*

Press releases have been used throughout the project the raise its profile and promote the open days to a wide audience. Publications included Equestrian Life Magazine, the Sustrans monthly newsletter and the proceedings of the 2006 International Public Rights Of Way (IPROW) Conference.

3.5.3 *Construction Open Day*

An open day was held for stakeholders to visit the site while the new bridleway surface was under construction. The day was well attended mainly by representatives from Local Authorities along with other stakeholder groups such as the British Horse Society (BHS) were also represented.

3.5.4 *Post-Construction Open Days*

Since completion of the site, three open days have been held. These open days provided interested parties with the opportunity to experience the surfacing and pose any questions they may have had about the project. As with the construction day these were attended by a number of representatives from Local Authorities, BHS, Sustrans and the CTC. The open days also provided the opportunity to obtain valuable feedback from a number of horse riders, a group that had been under represented during the quarterly monitoring activities.

4 Results

4.1 *Traffic Data*

During the site monitoring visits, user head counts were recorded to provide trafficking data. The site traffic totals from all monitoring visits (five visits at the time of writing) are shown in Table 3. This shows that the site is frequently used by both pedestrians and cyclists. However, since its opening, only a small number of horse riders have been recorded at the site, this has led to them being under represented in the user surveys. A concerted effort has been made to remedy this via promotion of the site and requests for feedback from this user group. This has helped to increase the number of riders on site but we are still hoping to obtain more feedback.

Table 2: Traffic Counts from five monitoring visits

Time Period	Walkers	Cyclists	Horse riders
8 am - 10 am	63	18	0
10 am - 12 pm	44	9	0
12 pm – 2 pm	28	42	0
2 pm – 4 pm	49	31	8
4 pm – 6 pm	11	20	0
Totals	195	120	8

4.2 *User surveys*

Obtaining users perceptions of the site and surfacing was paramount in gauging the success of the project. If the users were unhappy with the surface either aesthetically or from a usability aspect then the project would have been only partially successful.
A standard survey was used to obtain feedback from cyclists and walkers with a slightly modified version used for questioning horse riders. The questionnaires covered aspects such frequency of use, nature of use, describing the surface by choosing three adjectives from a list, and how users rated the appearance of the surface. Not all users provided three adjectives for each section so the numbers of user responses does not tally with the total number of adjectives selected, as illustrated in tables 3, 4 and 5.
Samples of each if these questionnaires can be found in Appendix 1. The results from these surveys are summarised in tables 3, 4 and 5.

Table 3: Perception of pedestrians surveyed

	Section A	Section B	Section C	Section D
No. of users providing a response on each section	15	8	10	6
Comfortable	11	4	5	2
Bouncy	8	5	5	0
Firm	8	4	4	3
Above average	3	0	2	1
Flat	11	4	6	4
Below average	0	0	1	0
Un-comfortable	0	0	0	0
Uneven	0	0	1	0
Unusable	0	0	0	0

Table 4: Perception of cyclists surveyed

	Section A	Section B	Section C	Section D
No. of users providing a response on each section	8	1	10	2
Comfortable	5	1	4	1
Bouncy	2	0	3	1
Firm	6	1	4	1
Above average	4	0	7	0
Flat	6	0	6	0
Below average	0	0	1	1
Un-comfortable	0	0	0	1
Uneven	0	0	0	1
Unusable	0	0	0	0

Table 5: Perception of horse riders surveyed

	Section A	Section B	Section C	Section D
No. of users providing a response on each section	4	3	4	4
Comfortable	3	1	4	1
Bouncy	2	0	4	0
Firm	1	3	0	3
Above average	3	0	2	0
Flat	3	2	2	2
Below average	0	0	0	0
Un-comfortable	0	1	0	1
Uneven	0	1	0	1
Unusable	0	0	0	0

The feedback obtained from all user groups was generally positive as can be seen from the survey summaries above. Pedestrians represent the largest user group are represented accordingly in the user surveys. From the viewpoint of pedestrians, section A received the most positive feedback with 11 of the 15 respondents choosing ‘comfortable’ and ‘flat’ from the list of adjectives. Section C also received positive feedback but this positive feedback could be attributed to the greater number of responses relating

to section A and C. While sections B and D did not receive the same number of responses as section A and C, the feedback that was received was generally of a positive nature. Overall, the pedestrian user perception of the bridleway has generally been very positive.

The same pattern of response can be seen in the feedback which was obtained from cyclists using the bridleway. A total of 18 responses were received relating to sections A and C with the most common descriptions of the surfacing being 'flat', 'firm' and 'above average'. There were a much lower number of descriptions given relating to section B and D but as with the pedestrian feedback the general perception was positive.

However, the positive nature of the feedback from pedestrians and cyclists may have been exaggerated due to the very poor state of the previous bridleway. Users may be making a direct comparison between the old and the new bridleway and may not be providing objective feedback on the new surface. Sections A and B were the most popular surfaces amongst pedestrians. It is likely that these sections were favoured because they are firm, level and provide good grip. Section A received the greatest level of positive feedback from cyclists. As with the pedestrians, this is likely to be due to the firm, level nature of this surface.

Currently, horse riders are under represented in the user surveys but it is hoped that further promotion to raise awareness of the site will help to rectify this. The feedback that has been received thus far indicates that the most popular section for horse riders is section C and to a lesser extent section A. This was expected, as section C has the lowest stiffness of all sections on site and can be seen to temporarily deform when a relatively low pressure is applied.

4.3 *Prima Data*

Table 6 presents the most recent data obtained from Prima analysis of the Clipstone bridleway. This monitoring visit took place in early November and provides an idea of how the bridleway is performing six months after construction.

Table 6: Average stiffness' of each section

Section	Description	Stiffness (MPa)
A	Rubber in subbase	34
B	Rubber in surface dressing	185
C	Rubber sandwich layer	17
D	Conventional materials	149

It can be clearly seen from the Prima results that section C has the lowest stiffness, which is unsurprising as it contains the highest mass of rubber (16 kg/m^2). The user surveys for this section also indicated it was noticeably 'bouncy' and the surface could even be seen to temporarily deform with pedestrian trafficking. As mentioned previously, section C was the most popular with horse riders, which can most likely be attributed to this low stiffness.

Section B has the second lowest stiffness which again is to be expected as this section contains the second highest mass of rubber (4 kg/m^2). During construction of this section the surface could be seen to deform under low pressure in a similar way to section C. However, this low pressure deformation has decreased since construction but the Prima data, and more importantly the user feedback suggests that section A still provides a significant and noticeable amount of 'shock absorbency'.

As section B contains rubber granules and has received relatively positive responses from users, it is surprising that the Prima equipment recorded a higher stiffness for section B than that recorded for section D. The higher stiffness of section B is likely to be due to its bound surface layer. Although very thin, the surface layer of section B contains a bitumen binder which will hold the surface aggregate together very firmly. In comparison, section D is surfaced with unbound quarry fines which would deform more readily when a force is applied. Both sections have a foundation of type 1 subbase. Therefore, the stiffness of each section's surface layer is likely to have the greatest impact on its overall stiffness. This results in section B having the highest recorded stiffness. Although the Prima equipment quantifies the stiffness of each section,

the force which it applies is design to simulate the stress of vehicle traffic and calculate stiffness accordingly. Therefore the measurement recorded does not provide a stiffness relating to pedestrian's feet, horse's hooves or cyclist's tyres and the relevance of the data should be weighted accordingly.

5 Conclusions

The bridleway has now been in use for roughly six months, and while some sections are showing evidence of fatigue (mainly a small part of section C which has received unexpectedly high level of motor vehicle traffic) there has been no major failure of any section.

Feedback from all user groups has been generally positive, and although there has been a low number of horse riders providing feedback, actions are being taken to remedy the situation.

For the most part, Prima results agree with the feedback given by users, as the most favoured sections (A and C) producing the lowest stiffness values. The exception to the rule is section B which has the highest stiffness of all four sections but has received more positive comments than section D. Ultimately, it is this positive feedback and the durability over time of each section which will demonstrate the success of the new specifications.

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