Predicting the potential of local aggregate in surfacing mixes without the risk of road trials

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ABSTRACT

The selection of aggregate used in surfacing mixtures is typically based on PSV. Many years of product development and road testing has identified those aggregates that are considered safe and those that are not so good. The implementation of the Construction Products Regulation (CPR) in 1st July 2013 has resulted in standard and specification revisions to make them CPR compliant. Construction products to expected to perform during life. Road trials are typically used in the later stages of BBA HAPAS or TS2010 product accreditation to prove performance of the system. This paper considers how the potential performance and durability of surfacing systems can be assessed without the risk of something going wrong in full-scale trials. The investigations are based on test slabs subjected to accelerated simulated trafficking. The development of properties such as skid resistance and texture depth are determined through the early, equilibrium and later stages of life. This allows combinations of good and what may be traditionally regarded as unlikely local aggregates and mix types to be quickly assessed under the same conditions. Examples of local aggregate use that would typically not be considered suitable as a surfacing are given in this paper.

KEY WORDS: CPR, performance, friction, laboratory prediction, RTM.

1. INTRODUCTION

Full implementation of the Construction Products Regulation (CPR) took place on 1st July 2013. This European Regulation aims to break down technical barriers to trade in construction products within the European Economic Area. The CPR has four main elements i.e. a system of harmonised technical specifications, an agreed system of conformity assessment for each product family, a framework of notified bodies and CE marking of products. Key to CE marking is a product that is consistent to its Declaration of Performance (DoP). Seven basic requirements for constructions works are stated (i) mechanical resistance and stability, (ii) safety in the case of fire, (iii) hygiene, health and the environment, (iv) safety and accessibility in use, (v) protection against noise, (vi) energy economy and heat retention and (vii) sustainable use of natural resources.

Two of the 35 products areas in the CPR are road construction products and aggregates. European Specifications for asphalt are currently being revised to be compliant with the CPR. The seven basic requirements of the CPR pose challenges if reliance is placed on current harmonised European Standards to predict the long term frictional performance and durability of surfacing materials.

This relies on the EN harmonised PSV test method and the draft Friction after Polishing test (FAP) also known as the Wehner Schulze (WS) test. Research has shown that the PSV test offers limited prediction of performance. It is a ranking test and gives a single value of friction for a single size 10mm aggregate that relates to the testing condition. Change the test condition e.g. increase the load, test duration or polishing media and a different value of friction will result. With regard to a Declaration of Performance and CE marking an aggregate test method being used to predict all in-service conditions will inevitably lead to problems.

The FAP test is seen as an improvement as it can assess both single size aggregates and surfacing mixtures. A source of aggregate can be used to prepare a range of surfacing mixtures based on mixture type or nominal size and their friction determined. This can show how aggregates can be better optimised i.e. it can address the CPR requirement of making better use of local materials that may not have the higher values of PSV required to meet current specifications.

However, one of the problems with the FAP test in the UK and other European countries is the limited number of apparatus currently available. For example, there is only 1 FAP test apparatus in the UK that is owned by the Highways Agency and operated by the TRL. So, although the FAP offers better possibility of addressing the CPR requirements its current limited availability and cost will restrict this method of test for some foreseeable time.

This paper considers how the potential performance of surfacing materials can be assessed without the risk of something going wrong in full-scale trials. The investigations are based on test slabs subjected to accelerated simulated trafficking on the Road Test Machine located at University of Ulster. The development of properties such as skid resistance and texture depth can be measured through the early, equilibrium and later stages during simulated trafficking. This allows combinations of good and what may be traditionally regarded as unlikely local aggregates and mix types to be quickly assessed under the same conditions. Two studies are considered. The first looks at the use of natural aggregates in high friction surfacing systems. The second looks at blends of aggregates in thin surfacing systems.

2. HFS INVESTIGATION

High Friction Surfacing systems (HFS) were originally developed in the 1960's. Since then their use has increased due to ability to reduce serious and fatal accidents. The rock type typically used is calcined bauxite. In terms of using local materials there is no source of calcined bauxite in the UK or Europe with the two main sources being South America and China. The following study considers whether there is potentially natural aggregate that could be used in HFS that is commonly available in the British Isles.

The aggregates were chosen on their local availability and not on their expected performance. They included limestone, basalt, granite, quartzite, greywacke and sandstone. Each rock type was supplied as 10 mm aggregate with a declared PSV. This was crushed to produce a 3 mm aggregate. Test specimens were prepared by bonding the 3 mm aggregate to 10 mm SMA test specimens using a 2 part resin binder. Figure 1 plots the development of Pendulum Tester Value (PTV) data measured up to 100,000 wheel passes. Initial data shows the HFS specimens having a PTV range of 81 to 98. After a little variation in the first few hundred wheel passes, PTV decreased steadily throughout the remainder of testing. After 100,000 wheel passes PTV ranged from 42 to 76.

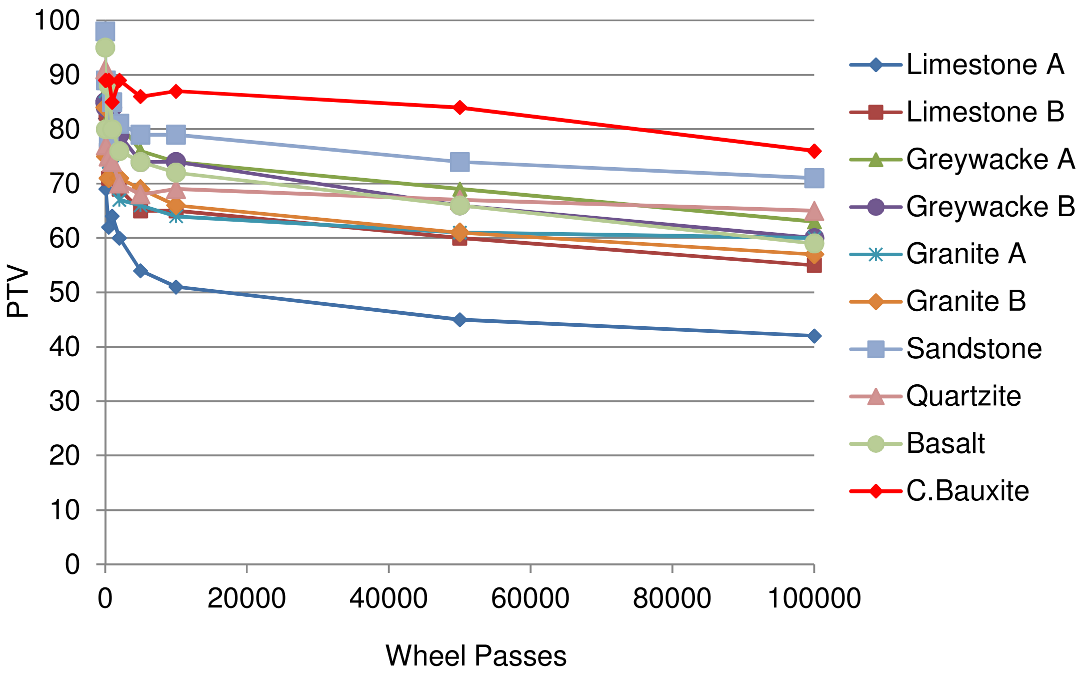

Figure 1. Development of HFS wet friction

Figure 2 plots the development of PTV and volumetric sand patch texture depth for the natural aggregates and the reference calcined bauxite test specimen. This shows the natural aggregates to follow a similar trend to the calcined bauxite i.e. loss of both textured depth and friction with time.

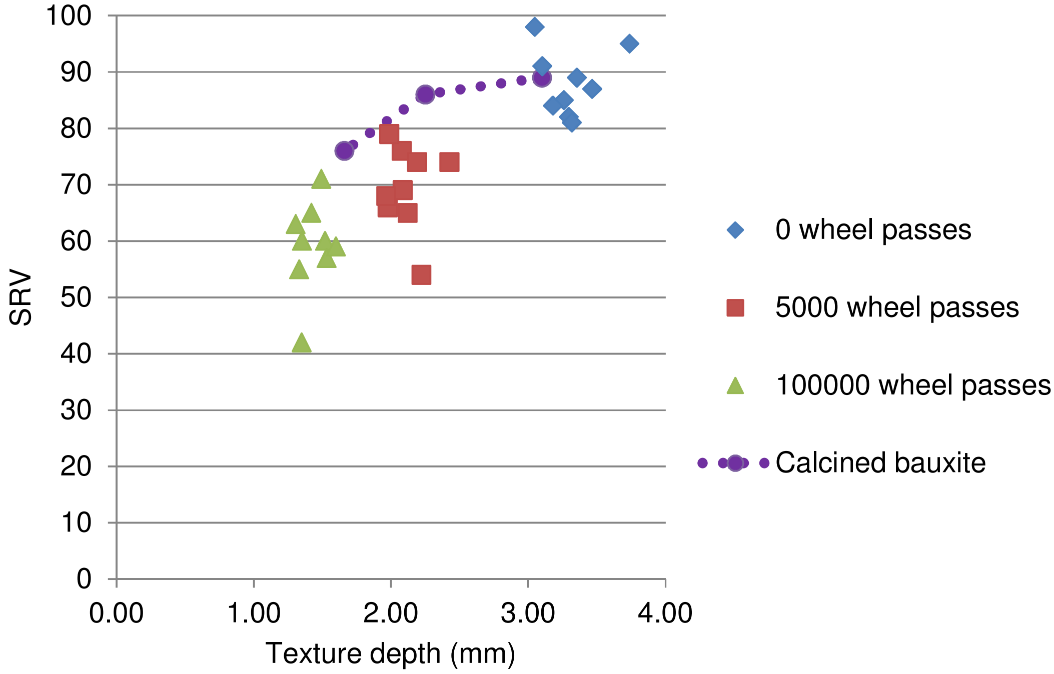

Figure 2. Development of wet friction and texture depth at three stages during testing

Table 1 summarises the declared PSV for the original 10 mm aggregate and found RTM data along with HFS specification requirements. Type 1, 2 and 3 HFS systems are required to have PTV values ≥ 70, ≥ 65 and ≥ 65 respectively (BBA, 2008). The found data is ranked in terms of PTV after 100,000 wheel passes. As expected the calcined bauxite gave the best wet friction with limestone having the lowest wet skidding resistance. The other rock types fall within this range. For the sources assessed, greywacke, granite, basalt and limestone had a PTV less than the minimum of 65. However, testing did identify naturally occurring sandstone that meets the Type 1 requirement of ≥70 with the quartzite meeting the Type 2 and 3 requirement of ≥65. All of the specimens met the requirements for texture depth.

Table 1. Declared PSV, texture depth, PTV and HFS specification requirements

<table>
<tr><th rowspan="2">HFS Slab</th><th rowspan="2">Declared PSV</th><th colspan="2">After 100,000 wheel passes</th><th colspan="3">HFS specification requirements after 100,000 wheel passes</th></tr>
<tr><th>Texture depth (mm)</th><th>PTV</th><th>Type 1</th><th>Type 2</th><th>Type 3</th></tr>
<tr><td>Calcined bauxite</td><td>70+</td><td>1.7</td><td>76</td><td rowspan="5">PTV ≥ 70</td><td rowspan="5">PTV ≥ 65</td><td rowspan="5">PTV ≥ 65</td></tr>
<tr><td>Sandstone</td><td>70</td><td>1.5</td><td>71</td></tr>
<tr><td>Quartzite</td><td>58</td><td>1.4</td><td>65</td></tr>
<tr><td>Greywacke A</td><td>65</td><td>1.3</td><td>63</td></tr>
<tr><td>Greywacke B</td><td>68</td><td>1.4</td><td>60</td></tr>
<tr><td>Granite A</td><td>55</td><td>1.5</td><td>60</td><td rowspan="5">Texture depth ≥ 1.1</td><td rowspan="5">Texture depth ≥ 0.9</td><td rowspan="5">Texture depth ≥ 0.8</td></tr>
<tr><td>Basalt</td><td>53</td><td>1.6</td><td>59</td></tr>
<tr><td>Granite B</td><td>55</td><td>1.5</td><td>57</td></tr>
<tr><td>Limestone B</td><td>54</td><td>1.3</td><td>55</td></tr>
<tr><td>Limestone A</td><td>40</td><td>1.3</td><td>42</td></tr>
</table>

3. THIN SURFACING BLENDS

The second study considers the blending of >10 mm limestone aggregate with higher PSV aggregate on the friction properties of a 14 mm Clause 942 thin layer surface course. This simulates the scenario where an imported higher PSV aggregate is blended with a local Carboniferous limestone aggregate with lower PSV. This study addresses the CPR requirement of using local materials and the sustainable sourcing of aggregates.

It involved preparing slab test specimens with increasing amounts of limestone aggregate and using the RTM to simulate trafficking to determine an upper limit percentage of limestone aggregate content that will not significantly affect skid resistance. The lower PSV aggregate used was Carboniferous limestone. This is widely available across the British Isles with almost all sources having a PSV that does not meet the basic specification requirement for PSV. The study considered three higher PSV / lower PSV combinations:

- Combination 1 - declared PSV 72 Carboniferous sandstone blended with declared PSV 52 Carboniferous limestone.
- Combination 2 - declared PSV 62 Silurian Greywacke blended with found PSV 54 Carboniferous limestone.

- Combination 3 - declared PSV 62 Silurian Greywacke blended with found PSV 36 Carboniferous limestone aggregate.

The aggregates used for Combination 1 were 14 mm and 10 mm declared PSV 72 Carboniferous sandstone, 14 mm and 10 mm declared PSV 54 Carboniferous limestone, asphalt sand and limestone filler. The bitumen was polymer modified. The aggregate < 10 mm in size used in the manufacture of each test specimen was kept constant i.e. a mixture of asphalt sand and limestone filler. Ten slab specimens 305 x 305 x 50 mm were made using a Cooper Rolling compacter. The 14 mm and 10 mm size fractions of each test specimen were adjusted to create limestone blends ranging from 0 to 100 %.

Figure 3 plots the development of wet friction (PTV) with increasing number of wheel passes using the RTM equipment for Combination 1. The data shows agreement in the order of PTV ranking based on the percentage of > 10 mm limestone aggregate present in the mix i.e. increasing amounts of limestone caused friction to decrease. Wet skidding resistance equilibrium conditions were achieved for all specimens at approximately 20,000 wheel passes.

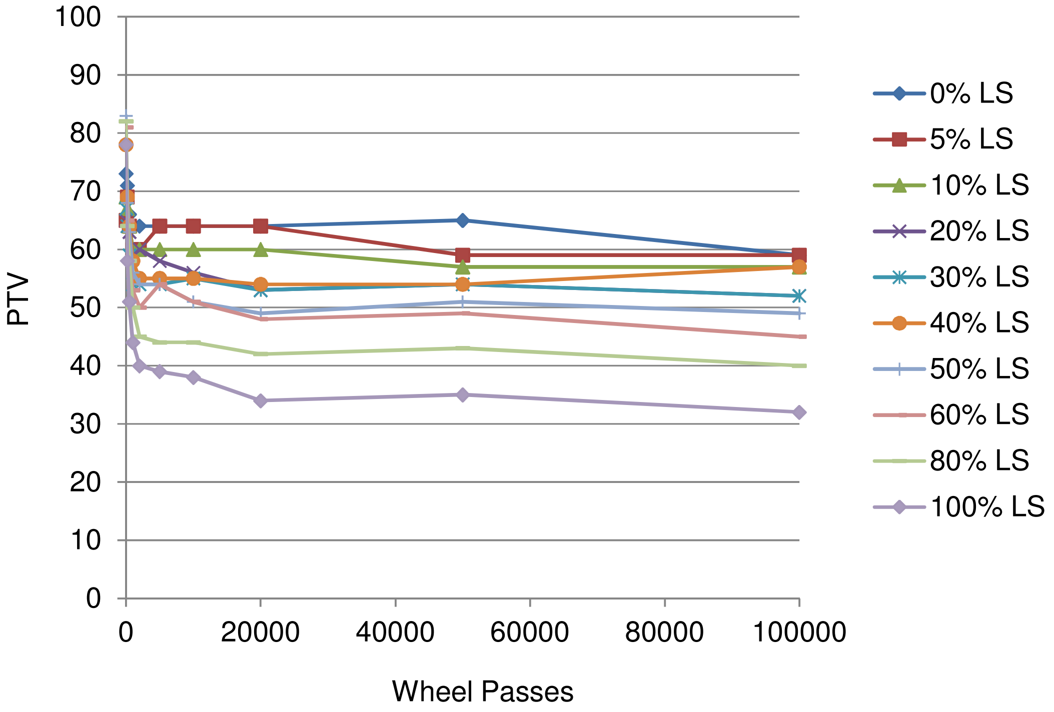

Figure 3. Combination 1 - development of wet friction

Figure 4 plots wet friction and percentage of limestone as the RTM test progressed. The data shows a step in the data at approximately 30 % limestone aggregate content illustrated with the dashed vertical line. The data to the left of the dashed line is for the lower limestone contents and suggests linear trends. The data to the right shows an initial increase in friction during the earlier stages of testing i.e. the limestone aggregate is performing better than the higher PSV aggregate used in the blend. This is related to aggregate exposure with the limestone becoming exposed faster so causing higher early life friction. During later stages of simulated trafficking the exposed limestone becomes increasingly polished causing lowering of the found wet friction.

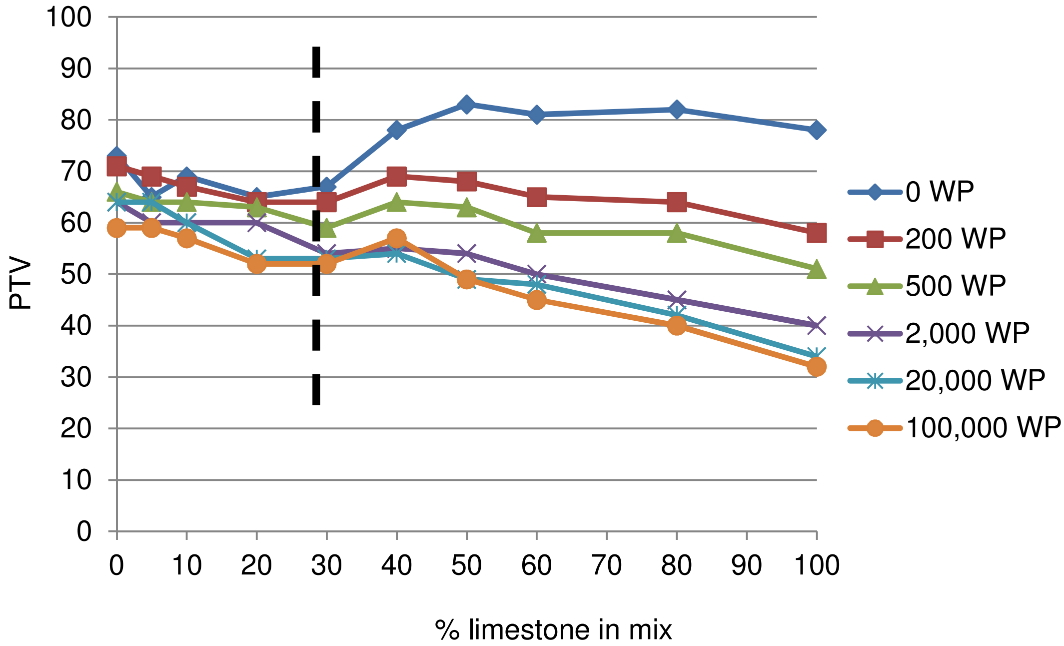

Figure 4. Combination 1 - plot of PTV and limestone content

In Combination 2 the aggregate < 10 mm in size was kept constant i.e. a mixture of dust and limestone filler. The higher PSV aggregate was a Silurian greywacke with a declared PSV of 62. The Carboniferous limestone had a found PSV of 54. Chemical analysis found its composition to be 28% SiO_2, 32% CaO and 27% organic content. In Combination 3 the same Silurian greywacke was blended with a found PSV 36 Carboniferous limestone.

The lower PSV of the limestone reflects its 1% SiO_2, 55% CaO and 44% organic content. Nine slab test specimens were made with different ratios of greywacke and limestone. One slab contained 100% greywacke as the > 10 mm size and was used as a control. Four slab specimens contained the PSV 54 limestone with fours slabs contained the PSV 36 limestone. The bitumen was polymer modified.

Figure 5 plots the development of PTV with increasing number of wheel passes for Combination 2 specimens i.e. PSV 62 Silurian greywacke blended with PSV 54 limestone. PTV ranged from 65 to 79 before simulated trafficking and after 100,000 wheel passes ranged from 46 to 56. Again wet friction equilibrium conditions were achieved for all test specimens at approximately 20,000 wheel passes.

Figure 6 shows the relationship between wet friction and percentage limestone as the RTM test progressed. This show the greatest range in measured friction values to occur for the test specimens with highest limestone content. Figure 7 plots the development of PTV with increasing number of wheel passes for Combination 3 test specimens i.e. PSV 62 Silurian greywacke blended with PSV 36 limestone.

Initial PTV ranged from 68 to 78 before simulated trafficking and after 100,000 wheel passes ranged from 31 to 55. Again, the data shows agreement in the order of PTV ranking based on the percentage of > 10 mm limestone aggregate present in the mixes. Wet friction equilibrium conditions were achieved for all test specimen blends at approximately 20,000 wheel passes. Figure 8 shows the greatest range in friction to occur for the test specimens with the greatest limestone content.

Figure 9 plots change in friction with the amount of limestone in each of the Combinations. This shows similar trends for the three higher psv aggregate / three lower psv limestone blends. The plots suggest that some of the declared psv values may be a bit optimistic in relation to how the aggregate performed in this asphalt test specimen test.

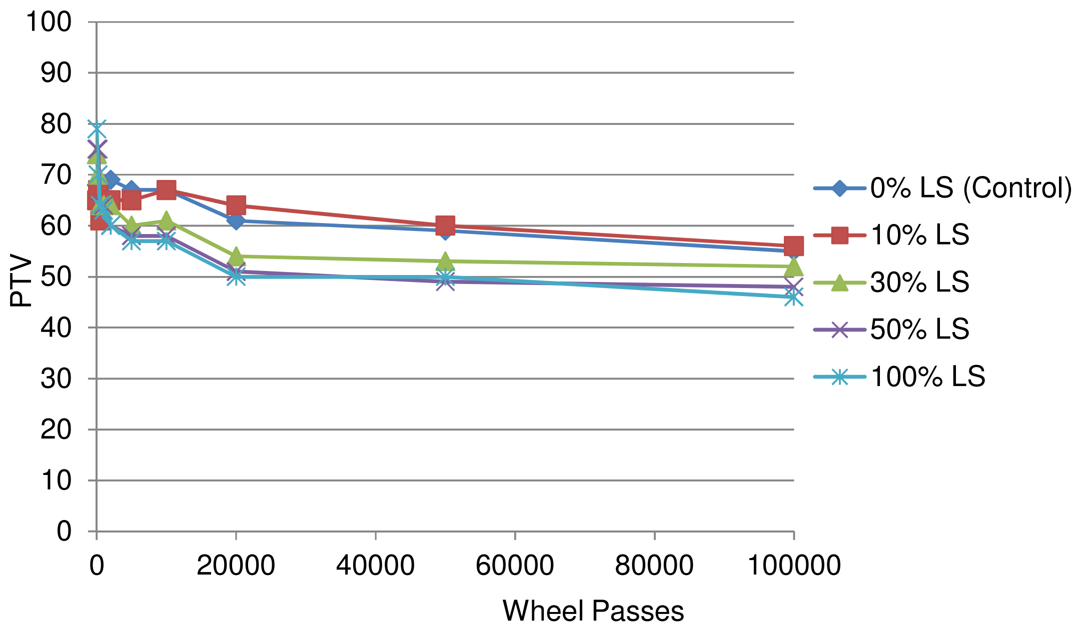

Figure 5. Combination 2 – development of wet friction

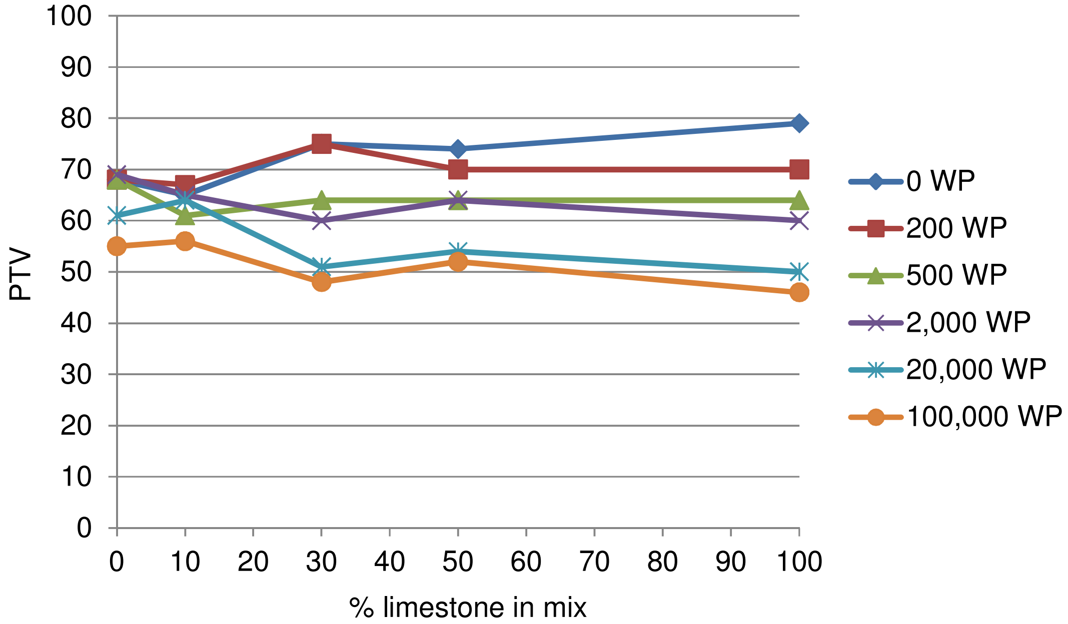

Figure 6. Combination 2 - plot of PTV and limestone content

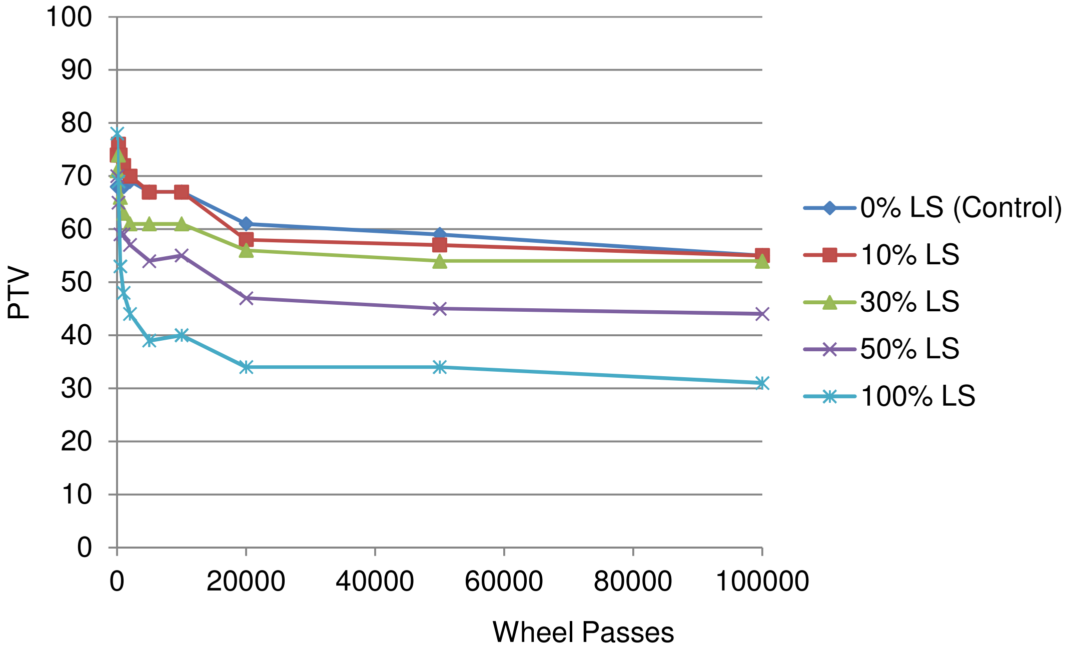

Figure 7. Combination 3 - plot of PTV and limestone aggregate content

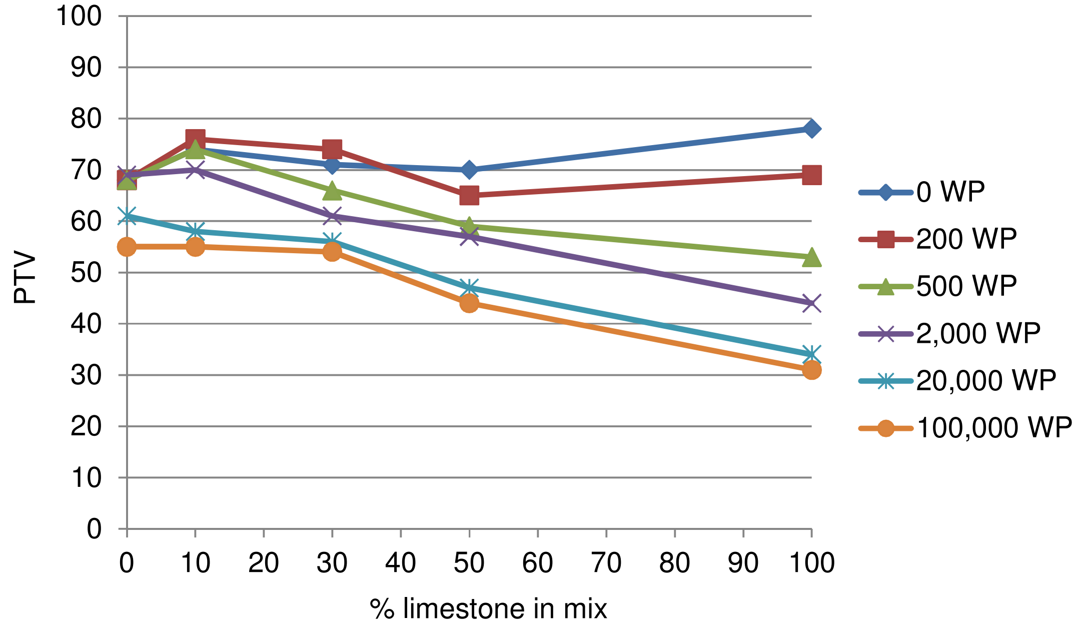

Figure 8. Combination 3 - plot of PTV and limestone content

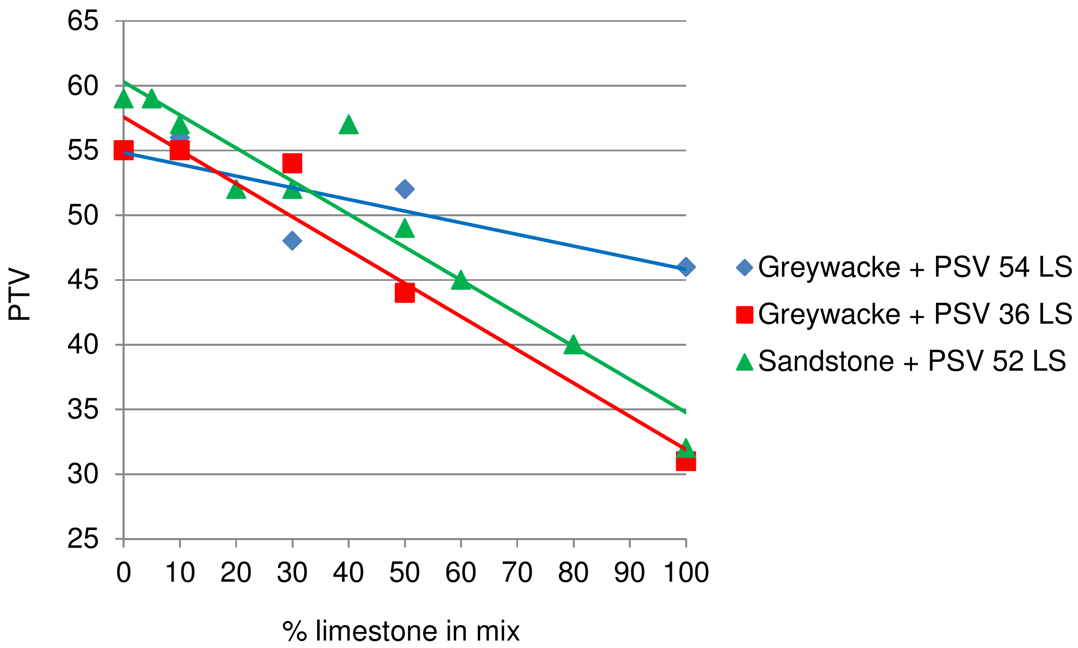

Figure 9. Comparison of the three Combination blends after 100,000 wheel passes

4. CONCLUSION

This paper has considered the assessment of 2 surfacing systems in the laboratory without the need for full scale road trials. Both studies have shown the improved prediction of performance achievable by considering the asphalt mixture. Each study has shown that it is possible to make better use of local materials that existing specifications may not allow.

Author Biography

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Reader in Highway Engineering at the University of Ulster and responsible for the Highway Engineering Research Group. Graduated from the Ulster Polytechnic in 1982 with a Combined Sciences degree in geology and geography, a Masters of Philosophy in 1988 looking at High Friction Surfacing and a Doctor of Philosophy in 1995 looking at the predicting of surfacing aggregate performance. He is a member of the CIHT, IAT, IOQ and IEI and represents the IAT on British standards committee B/510/5 Surfacing Characteristics for road and other trafficked areas. Research interests include aggregate performance, the tyre / surface interface, surfacing characteristics and sustainable highway technologies.