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Optimising the returns from modern asphalt surfacings

The potential effect of reclaimed asphalt on the friction characteristics of surface course materials

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Executive Summary

This report describes one part of a collaborative research programme sponsored by Highways Agency (HA), the Mineral Products Association (MPA) and the Refined Bitumen Association (RBA). The collaborative research programme is designed to focus on the practical needs of the Agency and the Industry in providing and maintaining the UK road infrastructure. The work described is an initial investigation into the potential effect on friction characteristics of incorporating reclaimed asphalt (RA) into thin surface course systems.

A brief review of current practice is presented and a study is proposed to investigate the variability of RA and its effect on friction, when incorporated into asphalt prepared in the laboratory. Results from elements of that study carried out so far are reported; an indication of potential in-service skid resistance performance is given by measuring friction on asphalt samples after they had been subjected to controlled polishing in the laboratory. It is shown that, when the RA is sourced from a surface course, the effect on friction is very small even when it is combined in relatively large proportions with virgin aggregate with moderate resistance to polishing.

A number of scenarios are presented and it is suggested that there are some instances where the amount of RA incorporated into the surface course might be restricted only by consideration of the resulting durability rather than by concerns about the resulting skid resistance. For example, if the RA has been recovered from an existing surface course, its origin is well known, and its specification meets the specification required of the new thin surface course then, subject to quality control constraints, in terms of skid resistance, no restriction should be placed on the amount of RA used.

However, if the RA is from mixed sources then, until further analysis suggests otherwise, the amount incorporated in new surface courses should be limited, as it is now.

1 Introduction

HA specifications currently permit the use of reclaimed asphalt (RA), directly incorporated into bituminous materials. While RA is often included in base layers, for example during new pavement construction, it is not widely used in surface course materials. A large proportion of the maintenance of the HA trunk road network comprises planing off and resurfacing with a proprietary material less than 50 mm thick. There is therefore considerable interest in increasing the use of RA in surface courses in order to continue to make use of this valuable resource.

This might be achieved by increasing the allowable proportion and/or by encouraging more widespread use. However, there are likely to be implications for the skid resistance provided by the surface when increasingly large amounts of RA are incorporated. This report describes a preliminary investigation into the likely effect on skid resistance of adding RA to the surface course, by making measurements of friction on specimens prepared in the laboratory.

A brief review of current practice for stockpiling and use of RA was undertaken by circulating a short questionnaire to a number of asphalt producers; a summary of the responses received is presented in Chapter 2 of this report. In addition, extracts from the current practice regarding use of RA in the surface course are included in the same Chapter.

A brief experimental laboratory programme, using samples of RA from different sources, was devised in order to investigate the effect on friction of using increasing proportions of RA in the surface course. The methodology and results from this experiment are presented, followed by a discussion of the implications and recommendations for implementation.

2 Current practice

This Chapter is split into two sections. Section 2.1 details the questions posed to a number of companies that process reclaimed asphalt and summarises their responses. Section 2.2 summarises the current guidance available for the use of RA in the surface course (and in particular its impact on skid resistance).

2.1 Questionnaire responses

Questionnaires were sent to various companies (including all appropriate MPA members and other operators) in February 2012; a follow-up request for responses was sent in April 2012. The questions posed are shown below (in light blue text), along with a summary of the responses that were returned from seven companies. The purpose of the exercise was to get an indication of how much RA currently exists in stockpiles around the country, how it is handled, and how it is ultimately used. Two of the respondents represented large companies with responsibility for several separate asphalt recycling operations.

1. a) Do you maintain a stockpile of recycled asphalt? b) If not, do you use RA sourced from elsewhere?

All respondents maintain their own stock, although two also source RA from elsewhere.

2. a) Where is the stockpile? b) How much is there?

Stockpiles are maintained at various locations across the UK and, in the case of the large companies, at most of the asphalt plants in operation. The mass of RA is variable due to the balance between stock incoming and outgoing and values reported by the respondents vary between 200 tonnes and 15,000 tonnes. In addition it is noted that the mass of unprocessed RA is often more than twice the final stockpiled mass of processed RA.

3. What is the approximate make-up of the stockpile? (i.e. is it all from surface course, 50/50 surface/base course etc.)

Responses to this question vary widely. In general, the stockpiles are not separated by source (surface course, binder course, base course, or asphalt plant waste) except for specific trial purposes. Where it was stated, the estimated proportion of RA from various sources found within each stockpile differed significantly, for example: 70:30 surface:base/binder from two respondents compared with 25:75 surface:base/binder from another. It was also noted that relative proportions depend on current projects in operation, that it was likely to become dominated by surface course because of a reduction in structural works (as expected) and that there may be some regional variation where different surfacings (e.g. HRA vs thin surfacings) are more prevalent in some parts of the country.

4. How is it stored? (e.g. in the open, under cover, in a stockpiling area etc.)

Some respondents store all RA in covered bays or hangers (which helps to control moisture content), some store unprocessed RA in the open and processed RA in covered bays, and at some sites all RA is stored in the open. Some respondents mention specific recycling areas.

5. What tests are carried out to determine aggregate properties? (e.g. PSV, petrographical analysis etc.)

Generally speaking, very little testing is carried out specifically for aggregate properties. One respondent does carry out a limited amount of PSV testing and, more commonly, simple petrographic classification (whether the aggregate is hardstone, limestone, gravel etc.) and another mentioned analyses of grading, foreign contaminants, water content and visual assessment.

6. What tests are carried out to determine binder properties? (e.g. penetration, softening point etc.)

Again, the range of responses varies. Two respondents carry out only binder content, one only penetration, two penetration and softening point and one all of "binder content, grading, filler, softening point, penetration and presence of tar".

7. Do you keep records of routine testing and can we see them?

Generally, records are kept and in two specific responses it is noted that analyses are carried out once for every 1,000 or 2,000 tonnes of material, which is in line with guidance (EN 13108-8, British Standards, 2005).

8. How is the RA processed before incorporation into new asphalt mixtures?

Screening and/or crushing is carried out at most sites, although in one case it is noted that crushing is avoided if possible so that moisture ingress can be minimised. Screening and/or crushing is carried out to produce a 0/20 mm product at more than one site although in some cases the product can be tailored to the requirements of the asphalt in which it will be used. 0/4 mm screened RA is used in cold recycling at one site.

9. a) Are you currently using it in new surface courses? b) If yes, into what types of surface course and in what proportion?

Use of RA in surface courses is very limited with some respondents saying they do not do so at all and two using it in small quantities (5 % to 10 %) on a site by site basis. However, subject to customer approval, trials with up 20 % have been planned by one company. In one case, small size RA (0/4 mm) is used in small proportions in some surfacings but specifically excluding thin surfacings.

10. a) Are you familiar with Road Note 43? b) Do you know of any other published guidelines for use of RA? c) Do you have in-house guidelines for the use of RA in the surface course?

Fewer than half of respondents were familiar with Road Note 43, although these were the same respondents that claimed to be adding RA to surface course materials either routinely or on a trial basis. WRAP protocol, European Standards (EN 13108-8) and information from France and USA are also used; one company noted that they have their own factory production control for recycling operations.

11. What do you think would be needed, in terms of guidance or specification, to allow use of more RA in the surface course?

This is perhaps the most pertinent question in terms of the desired outcome from this project. Although durability is clearly a concern, guidance on the assessment of PSV of RA or the skid resistance of materials containing RA is also desired. In particular, if the

PSV of aggregate in RA cannot be measured then guidance concerning the maximum percentage of RA that would not affect skid resistance would be useful.

12. Please provide any other information you think would be helpful to this project.

No further information was provided by any of the respondents.

2.2 Current guidance

There are several documents that provide some guidance for the use of RA in the surface course. Although there does not appear to be comprehensive guidance, there are some suggestions relating to the resulting skid resistance of the surface. Some of the guidance, where it relates to skid resistance, is summarised in the following paragraphs. Some knowledge of asphalt and asphalt testing is assumed; details of the polished stone value (PSV) and aggregate abrasion test (AAV) can be found in EN 1097-8 (British Standards, 2009), while various bitumen tests are referred to in EN 12591 (British Standards, 2009).

2.2.1 Road Note 43

Since the operators were asked specifically if they were aware of the existence of this document it seems relevant to provide a synopsis here for ease of reference. Road Note 43, entitled "Best practice guide for recycling into surface course", deals with closed-loop recycling of asphalt reclaimed from surface courses back into surface course materials (although most of the guidance may be relevant to recycling into other pavement layers).

It is noted firstly that one of the reasons that more recycling is likely to be needed is because of the increased usage of high-specification aggregate (aggregates with good resistance to polishing in particular) in modern materials such as thin surface course systems. It is anticipated that, while the majority of RA will be used by incorporating proportions of 10 % or less in as many new surfaces as possible, it is feasible to incorporate up to 30 %.

It is recommended that, provided the RA source is well known, and the PSV and AAV of the aggregate constituents comply with specifications for the job in hand then it can be used with a minimum amount of further testing. However, if the source is not known (which may be the case for the majority of current RA stockpiles) the requirement for further testing is dependent on the amount of RA to be used in the new surface. If the source is not well known and the intention is to incorporate more than 10 % RA into the new surface then tests of PSV and AAV should be undertaken. However, PSV testing on aggregate in reclaimed asphalt is unlikely to be straightforward or particularly accurate. If the RA is from a single source, and that single source contains predominantly 10 mm coarse aggregate, PSV testing (which requires closely graded, "single-sized", 10 mm aggregate) on cleaned aggregate is feasible and the results obtained may give a reliable estimate of the coarse aggregate PSV. If the aggregate is not the correct size for PSV testing then it will be difficult to crush or grade the material in such a way as to provide a test sample that is representative of the RA stock. If the RA is from more than one source then repeated PSV testing is recommended but it will be challenging to test a sufficiently representative sample that characterises all the RA proposed for incorporation. The implications of a single returned PSV test that falls below the specification for the new surface are not clear.

The above testing recommendation and its challenges notwithstanding, there is further guidance about aggregate properties of RA. It is suggested that, if the RA source is a surface course, and that surface course was in a location where aggregate with PSV of 60 was required, it can be assumed that the aggregate will have PSV of 60 (or probably greater given the propensity for over-specification). This seems a sound argument, although an additional check that the skid resistance provided by the original surface course was sufficient may be wise. It also requires that RA from the single source is carefully recovered, and subsequently stored, in such a way that the RA is segregated. Allowance is given for blending of RA from different sources, where there is confidence that the PSV of the aggregate is broadly similar, but it is noted that skid resistance on blended aggregates may not always be predictable.

The majority of the remaining guidance focuses on mix design and durability requirements. This is, of course, an important consideration – if there is no confidence in the durability of asphalt containing a certain proportion of incorporated RA then the skid resistance it provides is, perhaps, moot.

2.2.2 Other documentation

BS EN 13043, "Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas", includes within its scope manufactured and recycled aggregates. Guidance for the use of that Standard (PD6682-2) indicates simply that their suitability should be assessed in accordance with the regulatory requirements in the place of use, and refers to Highways Agency's Manual of Contract documents for Highways Work (MCHW) Specification for Highway Works (SHW) and the WRAP (Waste and Resources Action Programme) quality protocol, which was mentioned by one of the respondents (Section 2.1), and is discussed below. Various aggregate tests are also recommended but the document refers only to cleaned aggregates, specifically excluding reclaimed asphalt.

Part 8 of BS EN 13108, "Bituminous mixtures – material specifications – reclaimed asphalt", defines aggregate and binder testing that should be carried out, and its frequency (in terms of number of samples per mass of reclaimed asphalt). Less frequent testing is allowed if less than 10 % RA is to be incorporated into a surface course. Published Document (PD) 6691:2010, "Guidance on the use of BS EN 13108 Bituminous mixtures – material specifications", recommends means of regulating the use of RA. It also highlights the two definite requirements of BS EN 13108 as follows:

- "the upper size of the reclaimed asphalt shall not exceed the upper size of the mixture"; and
- "the aggregate in the reclaimed asphalt shall conform to the requirements for aggregate in the mixture specification".

It also goes on to discuss specification requirements, foreign matter contamination and binder hardness, with explanations about the importance of the latter. The 10 % limit for RA in surface courses, except where explicitly permitted, is reiterated.

The WRAP quality protocol, and its accompanying technical note, refers back to PD6691, to the SHW and to the PSV specification in the Design Manual for Roads and Bridges (DMRB). In general the quality protocol provides a means to document and prove the conversion of a waste material into a product, ensuring that the waste meets certain criteria, chief among which is that it must be inert (non-hazardous) and that there are no risks to human health or to the environment. Following the protocol helps consistency across the industry and makes it easier to use RA.

2.2.3 Outcome

Documentation is available that provides advice and good practice guidance for the use of RA, and some of it deals specifically with the use of RA in the surface course. Furthermore, there is some information about the testing required to ensure confidence in the skid resistance performance of a surface course containing RA. However, practical implementation of some of that testing may be difficult, there is little allowance for the use of RA that has not been segregated (surface course from other layers) and the effect on skid resistance of adding even 10 % RA may not be properly understood.

The laboratory experiments described in the next chapter seek to develop a methodology to demonstrate the effect on friction of adding small quantities of RA, even if the source is not well-known, and the effect on friction of adding larger quantities when the RA is reclaimed from surface courses.

3 Methodology for laboratory experiment

The intended goal of the laboratory experiments was to determine the amount of RA that can be incorporated into a new thin surface course system without a significant effect on friction measured. Moreover, it would be desirable to be able to propose a shortlist of testing that would be required to demonstrate the suitability of any particular RA for use in the surface course. In practice, the amount of time available, given the need to source materials, limited the amount of laboratory work that could be carried out. This chapter therefore describes the proposed methodology (for the record and perhaps for future reference), and the subset of testing that was actually carried out. For clarity, however, important exclusions are highlighted in the first section.

3.1 Exclusions

There are a number of relevant factors, some not directly related to skid resistance, which must be considered before any particular RA can be used.

The upper size, D, of the aggregate in RA must not exceed the upper size, D, of the mix. There is some evidence to suggest that, within a given mix, it is the coarsest aggregate that most affects skid resistance (Dunford, 2012): if the upper size of the RA were allowed to be larger than the upper size of the mix then the RA may have a disproportionate effect on skid resistance compared to the rest of the mix. This requirement should therefore stand and this highlights the need for careful handling and segregation of RA. In the laboratory, it is proposed that any grading required to incorporate the RA into the new asphalt design will be carried out, in the first instance, without consideration of the consequences for bulk grading or storage.

The aggregate in RA must conform to the aggregate requirements of the mix. This cannot be overlooked but the PSV test in particular is likely to be difficult to carry out or, if it can be carried out, may be unrepresentative and may give erroneous results. Aside from the PSV test, tests for aggregate soundness, such as its abrasion, may become more important if larger proportions of RA are to be used, especially in terms of durability. To a certain extent this has already been considered in other work (Road Note 43); it is proposed that simple petrographic classification is used to examine the samples of RA incorporated in the laboratory experiments.

There are other matters that are beyond the scope of the current experiment, also dealt with elsewhere, and these may need to be reviewed in due course. For example, there are technical issues such as durability and mix design (especially new binder content), environmental issues such as tar content, and policy issues such as ownership and logistics.

3.2 Proposed methodology

To determine the variability of RA available from a range of operators the following procedure was proposed:

- Request samples of RA from each of the seven respondents (Section 2.1), preferably comprising four 25 kg samples from different parts of the same stockpile. The same should be requested for one graded stockpile and one ungraded stockpile if available from the respondent.

- Carry out a visual assessment of each 25 kg sample to assess appearance and simple petrographic classification (i.e. apparent proportion of hard stone or limestone).
- Combine the four 25 kg samples and then carry out the following laboratory analyses:
    - Binder content, penetration, softening point
    - Grading
    - Acid soluble test (to determine proportion of limestone present)
    - More detailed petrographic classification if required
- Calculate the maximum proportion of RA that can be incorporated into a standard 14 mm SMA blend (or whatever is appropriate given the RA grading).
- For each 100 kg combined RA sample, prepare 2 asphalt slabs in the laboratory using a common virgin aggregate source and the same, maximum, proportion of RA.
- Test the asphalt slabs using the Highways Agency's Wehner-Schulze machine to determine the friction of the asphalt after polishing.

This should enable an initial comparison of the effect on friction of incorporation of relatively large proportions of different RA sources. Perhaps, by comparison with results from laboratory analyses (petrographic classification, acid soluble test etc.), it may be possible to investigate appropriate tests that might be carried out on RA in the future to ensure satisfactory skid resistance performance when it is used in the surface course.

Using a subset of the RA, further asphalt preparation was planned, incorporating intermediate proportions of RA (e.g. 10 %, 20 %, 30 % etc.) and this may identify the point at which RA begins to have a significant effect on friction. A brief investigation, for this subset of RA, should determine whether further grading would enable larger proportions of RA to be incorporated into new asphalt.

3.3 Actual methodology

The work carried out concentrated on investigating the effect on friction of incorporating increasing proportions of RA into asphalt samples prepared in the laboratory. Two samples of RA were obtained from stockpiles at one site: one from a stockpile of nominally 0/10 mm material and one from a stockpile of nominally 0/20 mm material. Table 1 shows results from laboratory analyses and grading tests for these two samples.

Table 1 Results from laboratory tests on RA from two different stockpiles at one site

Test		0/10 stockpile	0/20 stockpile
Grading	20	100	100
% passing	16	100	98
sieves in mm	14	100	97
	12.5	100	95
	10	100	89
	8	100	78
	6.3	95	67
	4	81	54
	2	67	44
	1	56	37
	0.5	49	32
	0.25	33	21
	0.125	17	14
	0.063	12.4	9.1
For recovered binder	**Soluble Binder content (%)**	7.0	5.5
	Penetration at 25 °C (mm/10)	21	22
	Softening Point (°C)	62.6	62.2

The grading information was used to determine the maximum amount of RA that could be incorporated into the standard SMA design given in Table D.1 of PD6691 (British Standards, 2010). A 14 mm SMA design, incorporating 48 %, by mass, of the RA from the 0/20 mm stockpile, represented the largest amount of RA that could be incorporated. This is clearly more than is currently recommended or regularly used in practice. Stocks of 6/10 mm and 10/14 mm medium-PSV (nominally, 60) virgin aggregate were used to make up the balance of the mass required for SMA production, along with crushed rock fines (CRF) from the same source, and limestone filler. Table 2 shows the percentage of the constituent parts in each of six mix designs; a pair of asphalt slabs was prepared for each design. Aggregate constituents are shown as a percentage of aggregate mass, and the virgin binder added is shown as a percentage of total mass. Note that the amount of virgin binder that must be added to achieve the mix design reduces as the amount of RA increases. The resulting mixed binder (virgin and reclaimed) was not examined closely and, as stated above, its effect on durability is beyond the scope of this study.

Table 2 Percentage (by mass) of various constituents in six asphalt designs

Design ID	Virgin aggregate				RA (0/20 mm stockpile)	*Virgin binder*
	10/14	**6/10**	**CRF**	**Filler**		
1	60	10	22	0	8	*5.0*
2	56	12	15	10	7	*4.7*
3	56	12	5	20	7	*4.3*
4	56	5.5	2	30	6.5	*3.8*
5	54.5	0	0	40	5.5	*3.3*
6	50	0	0	48	2	*2.9*

The graph in Figure 1 shows the grading envelope for the specified 14 mm SMA mix – the minimum and maximum specifications are shown in black (broken and solid lines respectively) - and the achieved total aggregate grading for the mixes containing 0 % and 48 % RA are shown in blue and orange respectively. It can be seen that it is predominantly the content of material passing a 6.3 mm sieve in the RA grading that restricted the amount of RA that could be incorporated, although significant reductions in the amount of added crushed rock fines and filler are also necessary when the larger proportions of RA are incorporated.

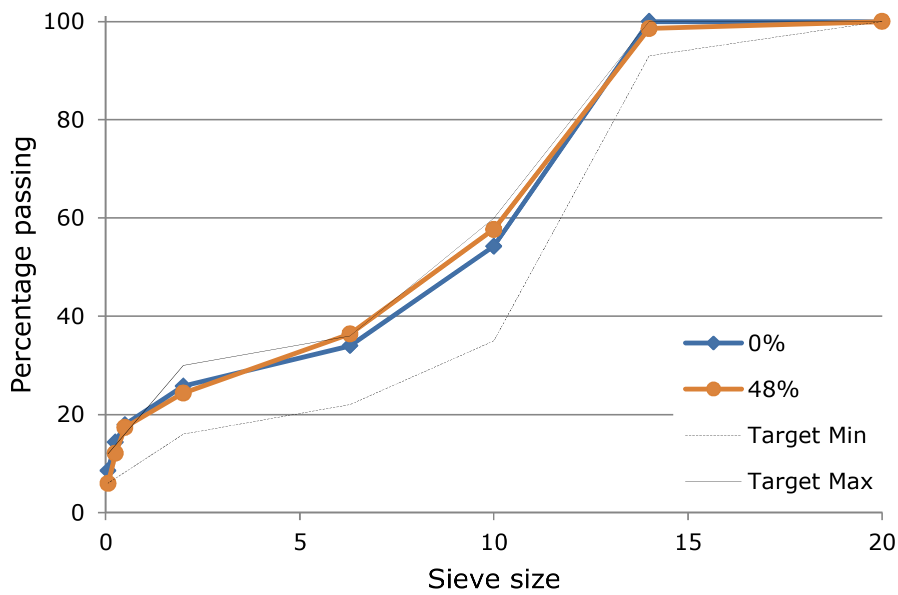

Figure 1 Grading envelope and achieved grading for 14 mm SMA asphalt with addition of RA at 0 % and 48 % by mass

For comparison, in the absence of other RA sources, the same virgin aggregate was used in blends with a low-PSV (40) limestone. Limestone coarse aggregate in sizes 4/10 mm, 2/6 mm and crushed rock fines were used to simulate the grading of the RA and were then added to virgin aggregate in the same proportions, as far as possible. The graph in Figure 2 shows the achieved total aggregate grading for the mixes containing 0 % and 40 % limestone in blue and orange respectively. The addition of 40 % limestone by mass causes the grading to cross the boundary of the specified maximum grading envelope. Without further manipulation of the aggregate grading it was not possible to achieve addition of 48 % limestone. Friction measurements made on the 40 % limestone specimens are included in the results shown in Chapter 4; the breach of the grading envelope at 14 mm may alter the friction measured on these specimens but the effect is likely to be small.

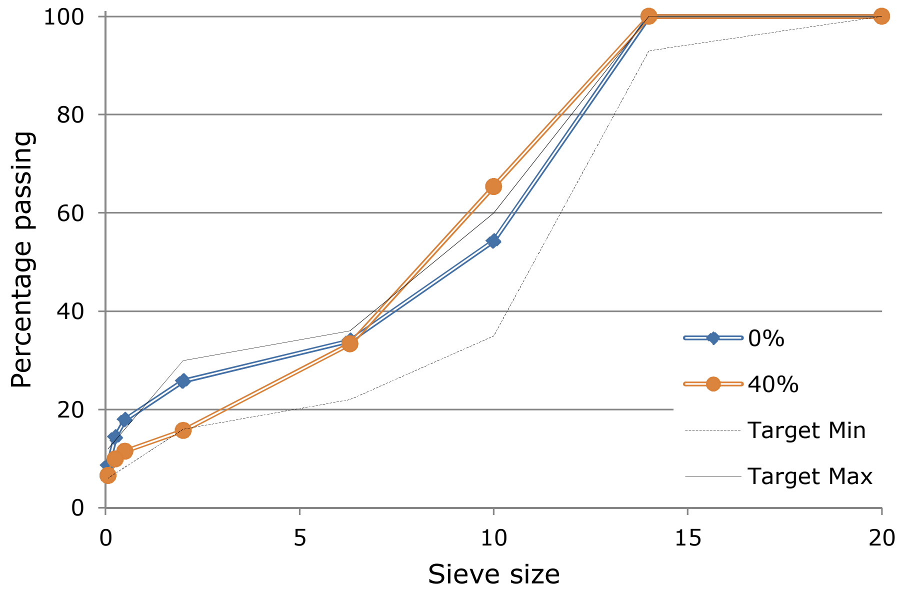

Figure 2 Grading envelope and achieved grading for 14 mm SMA asphalt with addition of limestone at 0 % and 40 % by mass

In terms of addition of RA, a worst-case scenario might be that the RA is made up entirely of limestone with low resistance to polishing. For comparison with the friction measured on asphalt incorporating RA, data can be obtained by re-analysis of other work carried out for the Highways Agency, which blended virgin aggregates. An investigation into the effect on skid resistance of blending aggregates from different sources is reported in PPR605 (Dunford, 2012). Limestone was used as part of that work and asphalt specimens were prepared containing 0 %, 25 %, 75 % and 100 % limestone coarse aggregate in combination with medium-PSV (53) and high-PSV (68) aggregates. The results are not directly comparable because the asphalt mix design used 10 mm rather than 14 mm maximum particle size, but the principle is similar. Only some of the mix designs in that project were prepared in duplicate.

In every case, after the asphalt slabs had been prepared in the laboratory their surfaces were subjected to grit-blasting to remove excess bitumen and reveal the aggregate surfaces. The specimens were polished for an hour using the Highways Agency's Wehner-Schulze machine and then friction was tested (again, using the Wehner-Schulze machine) to provide a measurement for each slab and, where possible, an average measurement for each mix design (using results from the pair of asphalt slabs, if available). Although it is not yet used in specification, the friction measured by the Wehner-Schulze machine might be considered as a proxy for skid resistance that would be measured on site (Roe & Dunford, 2011).

4 Results from laboratory experiment

All of the results below compare the average friction, measured for each mix design, to the percentage, by mass, of RA or limestone contained in the mix.

The graph in Figure 3 shows the effect on friction, measured using the Wehner-Schulze machine and denoted μ_{PWS60}, of adding up to 48 % RA, and the effect of adding up to 40 % limestone, to an SMA prepared using medium-PSV (nominally 60) virgin natural aggregate. It can be seen that the addition of this particular RA has no significant effect on friction, whereas the addition of limestone results in a substantial decrease when the proportion of limestone is greater than 20 %. The RA used in this experiment probably contains a large proportion of surface course planings. It is therefore not surprising that the effect of its addition is minimal.

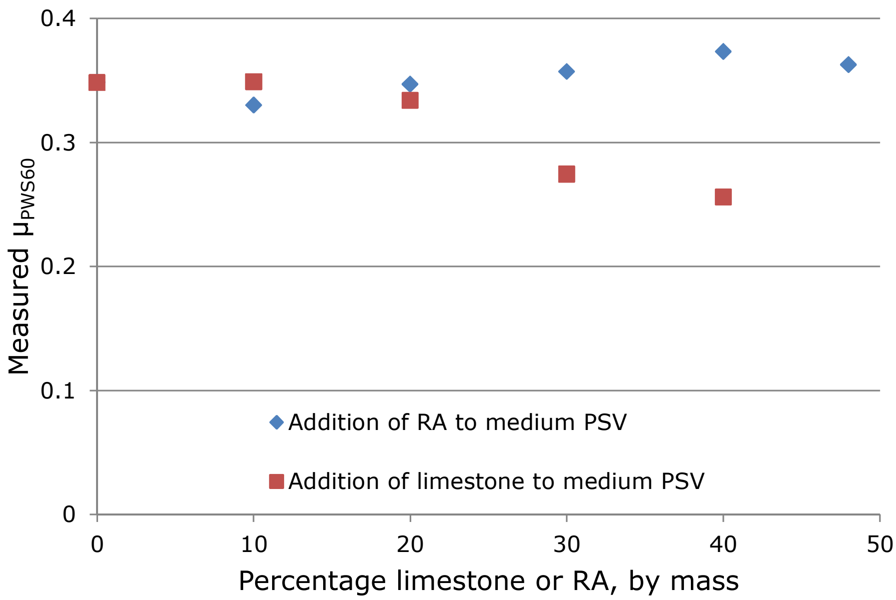

Figure 3 The effect on friction of adding RA or limestone to an SMA

For comparison, using data from a previous study, the effect on friction of adding limestone to SMA prepared with medium-PSV and high-PSV aggregates is shown in Figure 4. Note that the scales on both axes are longer than in Figure 3, to incorporate the data. The point of this comparison is to demonstrate that when a low-PSV aggregate like limestone is added to a medium-PSV aggregate, the effect on friction is somewhat less dramatic than when it is added to a high-PSV aggregate. In the study from which this data is drawn, it was shown that the effect is predictable using a mass-ratio formula, so the reduction in friction is generally proportional to the amount of limestone added (Dunford, 2012). However, the practical implication is that if a site requires high skid resistance, which can be achieved and maintained by using aggregate with high PSV, then addition of any low-PSV aggregate (or an unknown aggregate in the case of RA) may not be acceptable. Addition of low-PSV aggregate will have a lesser impact at a site where skid resistance is not considered to be an issue (e.g. low speed, non-event locations), and only medium-PSV aggregate is specified.

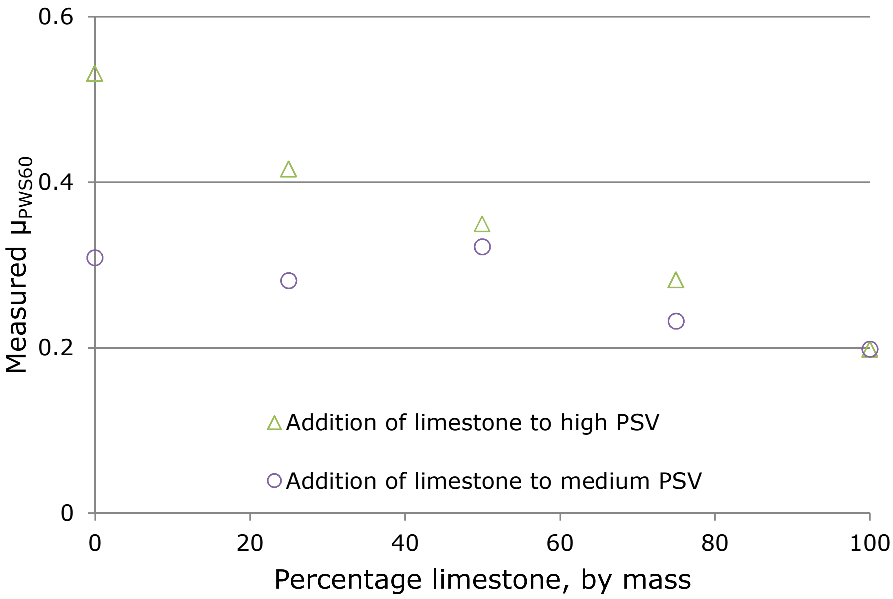

Figure 4 The effect on friction of adding limestone to an SMA (Dunford, 2012)

5 Discussion

More work is required to verify the results from the experiment described above, using friction measurements made on more specimens in the laboratory and to demonstrate that the principles follow for skid resistance measurements made on surface courses laid in practice. At present the following scenarios, and their implications for the amount of RA permitted in the surface, in terms of skid resistance, should be considered.

If RA is reclaimed from an existing thin surface course system, is handled properly, and segregated then, in terms of potential skid resistance:

- Provided the original source is well known and its specification meets the specification required of the new thin surface course then, subject to quality control constraints, no restriction should be placed on the amount of RA used.
- If the original surface course is well known but its specification does not meet the specification required of the new thin surface course then the virgin aggregate should be chosen carefully. It may be possible to select an appropriate virgin aggregate using a mass ratio formula to predict the result of blending with the RA.
- If the original surface course is not well known then the advice will depend on the specification of the required new thin surface course. If an aggregate with PSV less than, say, 53 is required then the effect on skid resistance of any surface course RA will be minimal and there should be no restriction on the amount of RA used. If the new specification is for high-PSV aggregate (63 and above) then a restriction of 10 % RA might be adopted unless a laboratory investigation can demonstrate results to the contrary.
- Measurements of skid resistance should be made to verify that the surface is performing as expected initially, and after a period of service.

If the RA is reclaimed from mixed sources then, until further work to assess the effect of variability in RA is carried out, a 10 % restriction should remain in place.

The work carried out was concerned solely with the effect on skid resistance of adding RA to thin surface course systems. In practice, more consideration would be required to handle other aspects and binder properties in particular. Road Note 27, and on-going studies from that work, suggests that incorporation of 30 % RA by mass results in acceptable durability. Provided the scenarios discussed above are considered, subject to further study, concerns about resulting skid resistance should not hinder the increased use of RA in thin surface courses.

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