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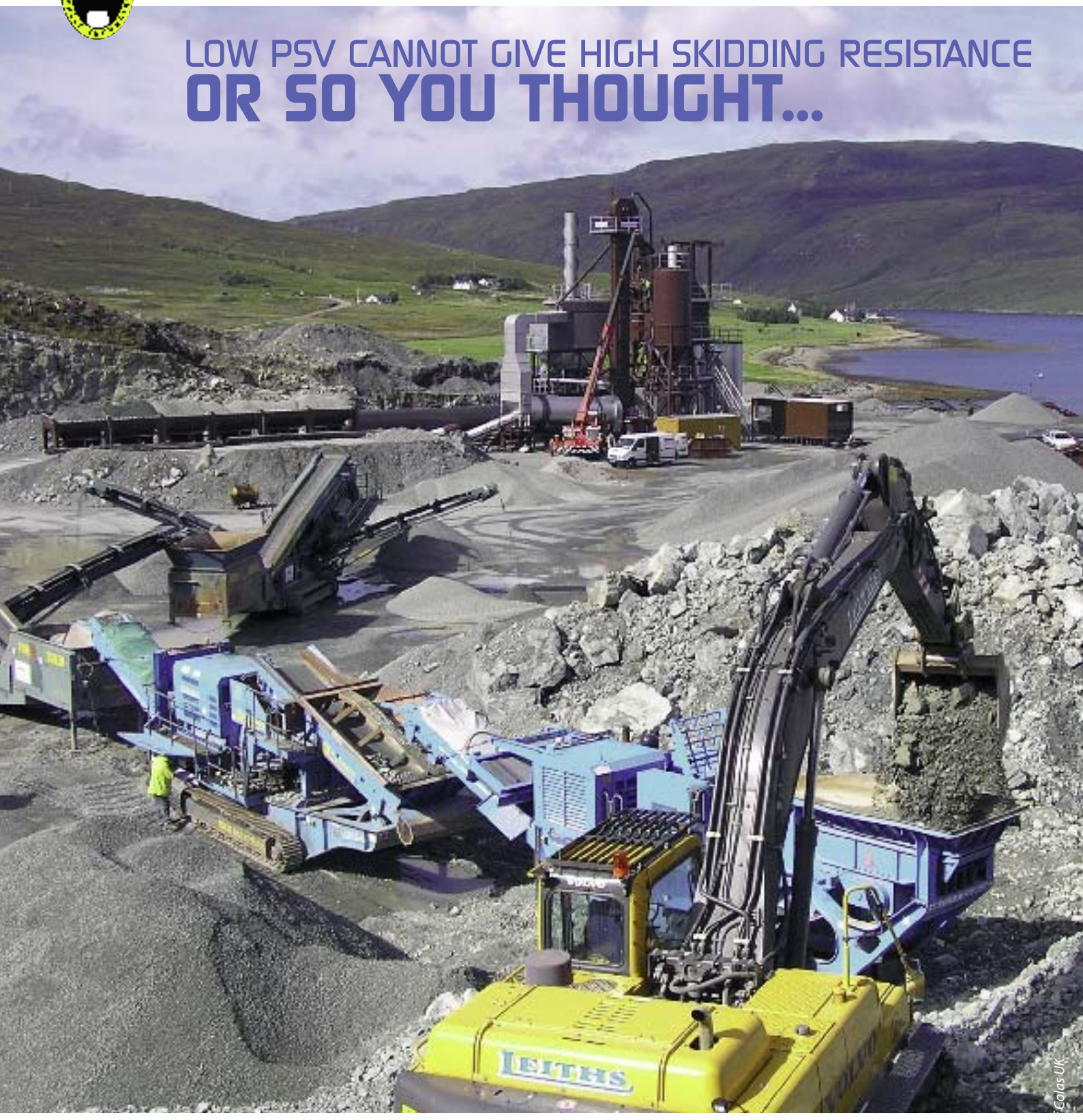
LOW PSV CANNOT GIVE HIGH SKIDDING RESISTANCE
OR SO YOU THOUGHT...



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Higher skid resistance and lower PSV

N Anderson[1]

ABSTRACT: The standards applied to the selection of aggregates for surfacing works require that compliance with minimum polished stone values (PSV) is a primary requirement. The source of high PSV stone is often far removed from the surfacing site. Inevitably this means that stone has to be transported many miles at considerable cost in order to meet PSV specification requirements.
Thin surfacings have been introduced in recent times and PSV requirements have not been changed or modified to take account of the physical properties of these relatively new materials. Many high PSV aggregates possess physical properties that are not suitable for surface dressing or thin surfacing.
In the North of Scotland the PSV of most aggregates falls within the range of 50-55. This paper was prompted by the results of a study carried out by Leith's (Scotland) Ltd using aggregates of a lower PSV to meet design requirements of skid resistance. When there is a device available such as the GripTester it is difficult to understand why the results are not accepted as evidence of skid resistance.

1

1 Introduction

The Polished Stone Value (PSV) of an aggregate is considered to be a fundamental property of any aggregate used in bituminous surface courses. The consideration of this physical property is unique to the UK and is a significant driver to the selection of aggregates for surfacing works.

Hot Rolled Asphalt (HRA) is a traditional road surfacing material in the UK and is principally a sand carpet with pre-coated chips rolled into the surface. A bitumen rich sand carpet by itself makes a slippery surface. The use of pre-coated chips produces a macro texture and the use of high PSV chips produces a good micro texture both of these are important components of skid resistant HRA surfacing. This paper demonstrates that this wisdom does not apply to other types of surfacing.

2 PSV

PSV is a standard laboratory measurement of skid resistance of a number of aggregate particles. The minimum PSV's to be applied to different categories of site and related to traffic flow are given in Table 3.1, Volume 7, Section 5 of the Design Manual for Roads & Bridges (DMRB). Table 3.2 in the same section of the manual refers to the aggregate abrasion value which is a measure of the durability of the aggregate.

Inspection of the former table shows that the minimum PSV specified for most sites would be 55. Traffic flows on most sites now are such that a 50 PSV is rarely specified.

Figure 1 – Aggregate sample: Highland Aggregates

3 Skid resistance and investigatory levels

According to the DMRB friction between the tyre and road surface consists of two main components.

1 Sliding resistance between tyre and road surface.
2 Loss of energy caused by deformation of the tyre.

And there are two main contributors to sliding resistance.

a) The fine scale micro texture of the surface aggregate.
b) The macro texture of the road surface.

Skidding Resistance Levels are checked regularly on major roads by the Sideways-force

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Coefficient Routine Investigation Machine (Scrim). A full description of the equipment used is given in the DMRB, the test produces Scrim values. A table in Volume 7 Section 3 of the DMRB shows investigatory skidding resistance levels for different site categories. The tables referred to above contain a column for the site category, and the default investigatory level is also shown in both tables. The investigatory level is defined as the level of skid resistance at or below at which site investigation is to be undertaken.

These documents and tables are quite clear; the PSV and durability of the stone is specified and the performance standard which the surfacing is required to meet is defined by the investigatory level specified. The only other requirement specified is a sand patch test which measures surface texture.

4 Surface texture

The stone type and source will determine PSV and AAV; the surface texture will be influenced by the physical properties of the aggregate and the mix properties. A combination of these factors will influence the level of skid resistance that can be achieved.

Surface texture can be influenced by a number of factors, some of the primary ones are:

1) **Poor quality aggregate.**
   The qualities of aggregate acceptable in a bituminous mix in the UK permits a wide range of aggregates to be used. This increases the risk of using an unsuitable aggregate in heavily trafficked surface courses.
2) **Poor mix proportioning or control leading to a dense smooth surfaced mix.**
   There is no fundamental requirement in the UK to design any bitumen macadam or HRA recipe mix. There are design requirements for HRA and some thin surfacing mixes used in heavily trafficked areas.
3) **Polishing of the surface by traffic.**
   Any mix which has not been designed or controlled to produce optimum properties will be more or less susceptible to polishing by traffic.
4). **Not designing the mix to obtain optimum performance properties**.

TEST	Method	Result
Polished Stone Value	BS EN 1097-8:2000	46
Aggregate Abrasion Value	BS EN 1097-8:2000	1.5%
Ten Per Cent Fines Value	BS812: Part 111:1990	350Kn Dry
Particle Density Apparent	BS EN 1097-6:2000	2.675Mg/m^2
Water Absorption	BS EN 1097-6:2000	0.9%
Soundness	BS EN 1367-2	98%
Los Angeles Abrasion	BS EN 1097-2:1998	16
Micro Deval Co-efficient	BS EN 1097-2:1998	3

Table 1 – Aggregate Physical Properties

Figure 2 – 6mm Cariphalte TS Texture

5 Critical mix design parameters

It is apparent therefore that there are a number of critical aggregate and mix properties which should be considered when designing a surface course mix.

- The ability of a mix to withstand polishing and further compaction which will result in a loss of surface texture. PSV does not necessarily assist in any resistance to polishing of the overall mix and with some aggregates high PSV and high AAV can accelerate the deterioration or loss of surface texture through wear. A high PSV does indicate resistance to polishing of that aggregate particle.
- The physical properties of the ingredients.
- The overall composition of the mix, certain gradings will produce better textures and volumetric properties.

6 Questions

The foregoing begs a number of questions with regard to the interrelation of the various important physical properties. Four of the most important questions are:

- What is the effect of PSV on skid resistance?
- How important is the maintenance of texture?

- How important is the mix composition?
- Other than PSV which aggregate physical properties are critical?

The question is further complicated by the types of surfacing available which can produce either negative or positive surface texture. The requirements in the DMRB cover all types of surfaces from surface dressing and hot rolled asphalt (positive texture) to macadams and thin surfacing (negative texture). A thin surfacing material manufactured with a 65 PSV stone is deemed to have the same skidding resistance as an asphalt with pre-coated chips of the same PSV.

7 Selection of aggregates

These requirements ultimately drive the selection of aggregates for all contracts. There is a conflict because high PSV aggregates are generally not the most durable. Aggregates used in different types of surfacing rely on different properties to produce optimum performance.

8 Site experience

The author has been involved in manufacturing bituminous mixes in the North of Scotland. A principal quarry in this area was reputed to produce aggregate with a PSV in the mid to low 50's. Recent tests have shown this assumption to be incorrect and that the PSV value is less than 50. The aggregate in question although low PSV has exceptional physical properties, see *table 1*.

Various bituminous mixes have been produced from aggregate from this quarry. The volumetric properties of a BS 4987 clause 7.3 material were verified using the Marshall mix design apparatus. The mix was proportioned within the limits of the BS 4987 envelope to produce the best texture. The

Material type	Location	Length tested metres	PSV	Grip number	Scrim equivalent	Age of surfacing	Measured texture depth mm
Clause 7.3 BS4987	A851 Armadale	5171	46-49	0.82	0.69	From 2004	1.1
6mm SMA	A855	216	46-49	0.66	0.56	2004	–
10mm SMA	Portee Ind. Estate	400	46-49	0.83	0.70	2004	1.2
14mm SMA	A87	463	46-49	0.67	0.57	2007	1.5
HRA	Skye Bridge	1256	>60	0.64	0.54	Unknown 2007	1.6
Surface Dressing	A863 Skye	4994	46-49	0.79	0.67	2006	unknown
14mm SMA	A87	1176	53	0.61	0.52	2005	unknown

Table 2 – Grip tester survey results

Material type	Location	Length tested metres	PSV	Grip number	Scrim equivalent	Age of surfacing
14mm SMA	A9 Tore	3550	>60	0.67	0.57	2004/2006
HRA	A9 Tore	356	–	0.57	0.48	unknown
6mm SMA	Maryburgh	220	53	0.65	0.55	2004
Ralumac	A890 Achnasheen	3541	–	0.78	0.66	unknown
6mm SMA	Aberdeen, Cove	394	54	0.68	0.58	2003
6mm SMA	Aberdeen, Ladyhill	872	54	0.71	0.60	2000
10mm SMA	B9077 South Deeside Road	746	54	0.79	0.67	2005
14mm SMA	A90 Cammachmore	2019	54	0.60	0.51	2001
14mm SMA	A90 Portlethen	1180	54	0.58	0.49	2000
14mm SMA	A90	2416	>60	0.73	0.62	2006
HRA	A90	816	–	0.52	0.44	unknown

Table 3 – Grip tester survey results, North of Scotland

water sensitivity of the mix was checked by making and testing samples to check compliance with the British Board of Agreement (BBA HAPAS) requirements for thin surfacing.

A number of other stone mastic asphalt (SMA) types of surface course mixes that had been produced from this quarry were also tested. All of these mixtures were manufactured to mix limits to ensure that a durable consistent product was produced.

9 GripTester Survey

In an effort to try and answer some of the questions posed above a GripTester survey was commissioned by the contractor and local authority. The survey was carried out by Findlay Irvine.

The Scrim Coefficient equivalent of the values obtained from the GripTester are tabulated in *Table 2*, on the previous page.

These results indicate that excellent values of skid resistance have been obtained from surfacing using aggregates obtained from this quarry.

Tests were also carried out in other locations in the North of Scotland, see *table 3* below. These results also show excellent values of skid resistance for the SMA type mixes.

The results in the tables above show that the SMA type materials have performed extremely well. The nominal 6 and 10mm mixes have better skid resistance than the 14mm. The HRA mixes and Ralumac (Colas Proprietary Mix) shown were included for comparative purposes and because they were adjacent to sections of SMA which were being tested.

Figure 3 – PSV Sample

10 Conclusions

A number of conclusions can be drawn from this limited study.

- Mix properties other than PSV are very important in establishing and maintaining good skid resistance.
- Low PSV aggregates can be used in properly formulated mixes to provide more than adequate skid resistance to exceed DMRB requirements.
- Higher skid resistance is obtained from the smaller aggregate sizes in the SMA mixes.

The GripTester is a portable device which can be easily mobilised. It is surprising that in the performance climate of today that the skid resistance of a mix is not considered to be a fundamental specification requirement.

Complying with specification requirements to meet aggregate PSV can be an expensive process. Blind compliance in some cases may not be in the best interest of the road user and sustainability. Specifiers are often not interested or permitted to apply engineering judgement and consequently only apply the "book".

The DMRB is quite explicit with regard to PSV requirements, the minimum values are given in table 3.1. These "are the values to be used if no other information is available. On an existing site, if the life that has been achieved by the aggregates, the skid resistance and the skidding accident rate have all been satisfactory, then the continued use of the same aggregate source, albeit with a lower PSV than that given in table 3.1 may be considered." A note 6 in table 3.1 also states;" Where designers are knowledgeable or have other experience of particular site conditions, an alternative PSV value can be specified."

Some would consider these statements from the DMRB to be too vague and there is a strong argument for the introduction of a protocol if a lower PSV aggregate is to be permitted. That protocol would have minimum requirements of grip in combination with macro-texture to be applied to the specification for the works.