The practical application of research in the development of a local authority skidding policy

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ABSTRACT

The UK Highways Agency has recently published its policies with respect to skidding measurement and assessment, HD 28/04 [HA 2004], and PSV requirements HD36/06 [HA 2006] for Trunk Roads and Motorways. The first of these specifically warns that it may not be applicable to local authority roads. Trunk Roads and Motorways are overwhelmingly heavily trafficked, run at the national speed limit and are rural. Local Authority roads on the other hand are mainly lightly trafficked, typically 70% carry less than 100 cv/l/d and have a very high proportion of urban roads (30mph or lower speed limit); they also are often more 'bendy'.

The paper reviews the research carried out at the TRL and its predecessors over the last 40 years on skidding and accidents together with other sources of data that would assist in the task. The ultimate outcome is a policy that is tailored to a particular local authority [Catt 2006].

The main differences between the HA and the local authority policy is the greater emphasis on lightly trafficked roads, the lowest traffic level in HD 36 is split into three, account is taken of aggregate size and low texture materials and the bends category S2 is split into 2 at 250 m radius. Since it is not feasible to carry out routine skid tests on all roads much greater emphasis is placed on the use of accident data in highlighting problem sites where site investigation is required.

1. INTRODUCTION

This paper is a summary of the development of a skidding resistance policy over some 40 years in Warwickshire, England.

Research into skidding and accidents has been carried out in the United Kingdom for at least 80 years with the first version of a device for measuring the sideways force coefficient being produced as a motor cycle combination in the early 1930s. In addition a road trial on Kingston Bypass in 1930 investigated different aggregates with the SFC being measured using the device. For more information on the early history of skidding research see the State of the Art Review [Hosking 1992]

The first device for measuring skidding resistance usable by highway practitioners was the Portable Skid-Resistance tester using the pendulum principle the development of which is described in Road Research Technical Paper no 66 [Giles et al 1964]. Instructions for its use was given in Road Note 27 [RRL 1969], this also gave suggested minimum values of skid resistance for 3 types of site: difficult, Motorways and A roads, and 'all other sites'. It also gave a minimum texture depth requirement of 0.65 mm for high speed roads (speed > 95 km/h).

2. EARLY DEVELOPMENT OF POLICY

The first policy was unstated but in essence consisted of Road Note 27 skidding levels. Testing was only carried out on an ad hoc basis since the test procedure was, and is, slow and laborious. Its main use was to investigate complaints of 'slippery surface' or to carry out trials of new materials.

The next development was the publication of H16/76 [Dept of Transport 1976] which specified the aggregate properties, polished stone value and aggregate abrasion value, for bituminous surfacing of new roads. Warwickshire essentially followed this advice in its entirety until 1983.

In 1978 the authority started to use a surfacing material known colloquially as medium temperature asphalt (MTA) which would now be known as 55/10F hot rolled asphalt with 100 pen bitumen binder. This was initially used on very lightly trafficked roads where it was proving to be much more durable than the dense bitumen macadam which it replaced. Because of this improved durability there was pressure from the Divisional Surveyors within the County to use MTA on more heavily trafficked roads. As the, then, materials engineer for Warwickshire I gathered up the available research on skidding resistance, essentially that available from the Transport and Road Research Laboratory (TRRL). The relevant papers were: LR 20 [Sabey 1966], LR 504 [Szatkowski and Hosking 1972], LR 510 [Salt and Szatkowski 1973], LR 553 [Hosking 1973] and SR 103 UC [Hosking and Tubey 1974]. This review resulted in my first published paper: An alternative view of TRRL's research into skidding resistance [Catt 1983]. This showed that MTA with its very low texture depth, typically 0.4-0.6 mm, could be used on reasonably heavily trafficked roads using the PSVs given in H16/76 providing that where traffic speeds were higher the resultant loss of skidding resistance with speed was compensated for by increasing the PSV requirement. The research also demonstrated that the small aggregate as used in MTA effectively gave an increase in effective PSV of between 3 and 8 units

compared to using the same aggregate as 20 mm chippings in hot rolled asphalt wearing course.

In 1994 the Department of Transport published the first edition of their current system of skid policy: HD28/94 [DoT 1994a] and HD36/94 [DoT 1994b]. The first dealt with the routine measurement of skidding resistance using the mean summer SCRIM coefficient (MSSC) and the second with the PSV and texture requirements for new and maintenance surfacing. HD 28/94 introduced the concept of risk rating which acknowledged the fact that there is no level of skidding resistance above which skidding accidents do not happen. If the MSSC is below the investigation level of the risk rating then a site investigation must take place to determine whether the site has a higher than normal skidding accident rate or not and thus determine whether a maintenance treatment should be carried out. The overall aim is to equalise the risk of skidding accidents across all sites.

To do this across all the motorway and trunk road network SCRIM surveys were required on one third of the network each year with three measurements taken over the summer period which were then averaged to determine the MSSC. This process is obviously not possible on a County Highway Network as there are many roads along which a SCRIM machine could either not travel or not attain 50 km/h. This led to a consideration of a 2 stage process whereby both MSSC below investigation levels and/or accident clusters could trigger a site investigation.

With the two stage approach and the variation covering low texture materials HD 28/94 and HD 36/94 became the County's skid resistance policy.

3 NEED FOR A POLICY

In 1994 there was no great need for a Local Authority to have a formal policy and the actual policy outlined above was operated on a fairly informal basis, more as guide than a requirement. Since 1994 however the general public has become more litigious and the need both to have and to operate a formal policy became necessary to protect the Community Charge payer from unnecessary claims.

The Highways Agency revised their policy with the publication of revised documents as HD 28/04 [Highways Agency 2004] and HD 36/06 [Highways Agency 2006]. HD 28/04 introduced the concept of characteristic SCRIM coefficient (CSC) which requires that a SCRIM survey is carried out on the whole network every year with the average over the last three years becoming the CSC. HD 28/04 explicitly states that the investigatory levels given therein may not be appropriate for local authority roads. There are three main reasons for this:

- A very high proportion of roads with low speed limits,
- A very high proportion of roads with low or very low traffic flows
- Road geometry can be very different particularly in relation to horizontal alignment

These facts lead to the need for each local authority to develop its own policy. If a local authority does decide to do this other potential advantages accrue such as optimising the use of local materials, making use of the latest SCRIM run to check that no extreme low values have occurred (local roads are more prone to, eg mud contamination from fields), and to using alternative methods of measuring skidding resistance such as the GripTester.

4 A LOCAL AUTHORITY SURFACING POLICY

4.1 BACKGROUND

In 2004 I was asked by Warwickshire CC to assist them in the development of a revised surfacing and structural maintenance policy as part of which a skidding policy was to be developed. The simplest option would have been to have implemented the Highways Agency policy as it stood but there were a number of significant objections to and problems with this direct approach. These can be summarised as follows:

1. It is not feasible to run SCRIM over more than a small proportion of the network
2. Most, 87% of road sections, of the County network are in the lowest traffic category (0-250) cv/l/d which means that they are undifferentiated in the HA tables. This includes significant lengths of principal roads.
3. Bends less than 500 m radius are undifferentiated by the HA; probably because they have too few bends to separate them statistically. They are very common on Warwickshire roads, particularly in the 250-500 m band. This could result in the application of unnecessarily high investigation levels (IL) to many roads.
4. HD 28 specifically states that the ILs given may not apply to local authority roads many of which are covered by a 30 mph speed limit.
5. The HA documents cannot optimise the use local aggregate sources.
6. The HA policy did not take into account the concerns of the British Horse Society with respect to metal on aggregate skidding resistance; horses rarely use trunk roads unless they cannot be avoided and they are banned from motorways.

The HA document is fairly simplistic in that it only considers PSV, traffic levels and site difficulty. It does not take into account the other factors that have been found to significantly influence skidding resistance such as aggregate size, the relationship between speed and skidding resistance, particularly at low speed, and the non-standard relationship between PSV and CSC of some aggregates. It also does not consider alternative means of maintaining adequate resistance to skidding on high speed roads other than the use of high texture surfaces. Because all HA roads are surveyed by SCRIM there is no consideration of the use of alternative methods of measuring CSC or of investigations being driven by accident rates rather than by low CSC results.

As much applicable research as was available was assembled:

- The earlier research listed in 2 above
- Road Aggregates and Skidding [Hosking 1992]
- The Design and performance of road pavements [Croney and Croney 1991]
- TRL 322 The polished stone value of aggregates and in-service skidding resistance [Roe and Hartshorne 1998]
- TRL 367 High and low speed skidding resistance: the influence of texture depth [Roe et al 1998]
- Use of warning signs for new asphalt road surfaces IAN 49/03 [HA 2003]
- TRL 622 Accidents and skidding resistance standard for strategic roads in England [Parry and Viner 2006]
- Quieter surface dressing for harder asphalt surfacings [Yaccob et al 2005]
- UL-M thin surfacing BBA/HAPAS certificate 01/H047 [BBA 2003]
- Learning curve over skid resistance [Stephenson 2006]

- The early life skid resistance of asphalt surfaces [Roe and Lagarde-Forest 2005]
- Horses and highway surfacing [CSS/BHS 2006]
- Skidding resistance, CSS guidance note [CSS 2005]

The research can be divided into two phases: that which took place in the 1960s and 70s and is associated with Hosking although other researchers were involved and the research which has been done in the last decade or so initiated by the two reports by Roe and others in 1998. in the rest of the paper these are referred to as old research and new research respectively. All the research was targeted on defining the PSV requirements needed to achieve the necessary MSSC or CSC but other factors were researched as part of the overall programmes.

Warwickshire's surfacing policy follows the philosophy of HD 36/06 by setting out the preferred surfacing materials for the various types of road within the Authority together with the PSV requirements for the aggregates. The main changes are the splitting of the lowest traffic category into 3, the omission of traffic categories above 1000 cv/l/d, the separation of bend severity into two categories and the omission of motorways.

4.2 EFFECTS DUE TO AGGREGATE SIZE

Both sets of research used to determine appropriate PSV requirements also investigated the effect of aggregate size on the MSSC value that results from the use of a particular PSV aggregate in a given location. Warwickshire has, for at least 25 years, used high stone content hot rolled asphalt on the majority of its network when resurfacing and surface dressing as a surface maintenance treatment. It can be seen from table 1 that considerable advantage has accrued from this practice in terms of improved effective PSV from a given aggregate compared to using HRA with 20 mm chippings.

Aggregate size	Old research	New research
mm	PSV change from 10mm	PSV change from 10mm
20	-8	No data
14	-4	No data
10	0	0
6	+6	+11
3	+14	+15

Table 1 Effect of aggregate size on effective PSV

The new research has also examined this factor but only in laboratory studies using a modified PSV test apparatus. The PSV test is normally carried out on 10 mm (would now be 6/10 mm) aggregate particles which are placed in a mould and polished. The way the chippings are placed is similar to the way chippings are placed on the road and therefore it is probably more appropriate to compare the results obtained this way with the results obtained in the earlier research for chipped surfaces. This recent research was fairly limited and only studied this factor on the PSV control stone for 10 mm, 6 mm and 3 mm nominal aggregate sizes. A

comparison between the two sets of data is given in the table. The data has been zeroed on 10 mm to provide a direct comparison.

In addition to the above there has been two other pieces of work:

1. The first is reported in the BBA/HAPAS certificate for UL-M. The data compares 20/10 UL-M (ie 20 mm thick with 10 mm aggregate) directly with hot rolled asphalt with 20 mm chippings on adjacent sections on the same length of road using the same aggregate and laid essentially at the same time. Measurements of MSSC were taken for 4 consecutive years and the average difference was 0.04 MSSC with the UL-M being the higher.
2. The second comes from research at Ulster University on the development of quiet surface dressings. This research confirmed that smaller aggregate has higher skidding resistance.

The effects of aggregate size has been covered in the Warwickshire Policy by requiring an increase of PSV by 5 points where 14 mm is used and permitting a decrease of 5 points where 6 mm aggregate is used. The general policy is based on 10 mm aggregate materials.

4.3 EFFECTS DUE TO TEXTURE DEPTH

Both sets of research looked at the effect of macro-texture on skidding resistance. The old research considered the factor and found that the fall off of skidding resistance was related to the texture depth. The data are fairly sparse but it was found that at 30 mph (50 km/h) the effects of texture were minimal and also that with a sand patch texture of 2 mm the effects of speed were minimal. At the other extreme, ie 0 mm texture the skidding resistance fell by up to 50% between 30 and 70 mph.

Croney and Croney, figure 27.9, shows that below 30 mph low textured surfaces have a higher skidding resistance than high textured surfaces with coarse textured surfaces having essentially the same SFC from 30 mph down to zero whereas for fine textured surfaces the SFC increased by 50%.

The later research in TRL 367 and TRL 622 confirms the general findings from the earlier work. A particularly useful graph in this context is figure 14 of TRL 622. Advantage was taken of the findings and the low textured high stone content asphalt has been defined as the standard surfacing in all urban areas. Where it is used on roads with 40 mph or higher speed limit the PSV must be increased by 5. On higher speed roads with 100 cv/l/d traffic or more then BBA/HAPAS thin surfacings are used with an appropriate level of texture.

4.4 TRAFFIC LEVELS

The old and new research arrived at very different relationships between SFC, PSV and traffic in commercial vehicles per day (CVD). The old research (LR504) showed the relationship of:

$$Sfc = 0.033 - 0.664x10^{-4}CVD + 0.98x10^{-2}PSV \quad [r^2 = 0.85]$$

Whereas the new research shows a number of different relationships depending on the site difficulty but the one covering the traffic situation closest to that used in the old research showed the relationship of

$$MSSC = [6.18x10^{-3} \times PSV] - [0.0225 \times \ln(CVD)] + 0.252 \quad [r^2 = 0.11]$$

The very different correlation coefficients from the two sets of data is probably due the different range of PSVs covered by the data sets. The old research covered PSVs ranging from 32 to 75 whereas the range of PSVs covered in the new research was from 56 to 68. The data for the old research was from 13 full scale experiments where the range of aggregate types were used on each site but the new research used real roads where the PSV was controlled by the specification in use at the time of laying. Since H16/76 the use of any aggregate with a PSV below 60 on trunk roads and motorways is rare.

A comparison of the SCRIM coefficients obtained from the two formulae for a number for traffic levels with a PSV of 60 is given in Table 2. The sites used for the old research formula included commercial vehicle counts from 1 to 4040 cv/l/d, the new formula used some of the old data with the addition of more heavy traffic sites with traffic levels up just over 6000 cv/l/d. It is clear that the new research shows that SFC is much more sensitive to traffic levels at very low flows but less sensitive at high vehicle flows. This would justify splitting the lowest category of traffic in HD36/06 into narrower bands. This enables more precise targeting of lower PSV aggregates. The 0-250 cv/l/d band in HD 36 has been split into bands of 0-20, 21-100 and 100-250 which are consistent with the bands in the surface dressing design guide 5th edition although they have been changed in the 6th.

Traffic level cv/l/d	SFC – old research	MSSC – new research
1*	0.621	0.623
50	0.618	0.535
100	0.614	0.519
250	0.604	0.499
500	0.588	0.483
* If 0 is input into the formula for new research the MSSC calculates as ∞ so 1 has been used		

Table 2 Theoretical comparisons of SCRIM coefficients at 60 PSV for old and new research

4.5 LOCAL AGGREGATES

The cost of hauling aggregates is very high (and increasing) so maximising the use of local aggregates is a significant factor in determining the surfacing policy. All the aggregates local to Warwickshire are from igneous rocks of one sort or another with PSVs ranging from 55-62 with PSV 65 available at an intermediate distance. The haul length for the highest level of PSV is high – over 100 miles. Aggregates with PSVs lower than 55 are available at an intermediate distance and virtually always cost more than the locally available aggregates. Overall the use of PSVs lower than 55 is not included in the policy and the use of PSVs higher than 62 and more particularly higher than 65 are minimised.

The resulting polished stone value requirements for the Warwickshire surfacing policy are given in appendix A.

5 SKIDDING RESISTANCE POLICY

5.1 INTRODUCTION

The policy used by the Highways Agency is set out in HD 28/04. Warwickshire follows the same policy with some modifications to suit a different network type [WCC 2006]. The changes are summarised as:

1. Not all roads are tested by SCRIM
2. A specific investigation level has been chosen for each site category until investigations are carried out as a result of CSC data. The ILs chosen are the suggested default values given in HD28.
3. The bend category has been split into two.

5.2 SCRIM PROGRAMME

The Highways agency routinely carries out SCRIM surveys on the whole of its network. Warwickshire has decided that this is inappropriate on its network and so carries out SCRIM surveys on a selection of the network. The selection consists of 3 categories:

1. All principal (class A) roads
2. All class B roads in Urban areas
3. Heavily trafficked (over 100 cv/l/d approx) class B roads in rural areas

These are all surveyed in both directions using the Highways Agency procedure to determine CSC. The total length of route surveyed is 508 km.

It is known that some Authorities use the GripTester for their routine surveys. Warwickshire decided against this for a number of reasons the main one being the wealth of comparison data directly available rather than having to calculate the equivalent CSC. There is also some 30 years history of use of the SCRIM in the County with routine surveys starting in the mid 1970s. The County considered using the GripTester for routine work but the survey costs are very similar to SCRIM so there is no financial saving in using the non-standard device. The County has owned a GripTester since 1990 and has used it extensively for investigation work.

5.3 SITE INVESTIGATIONS

Site investigations use the same basic procedure as for the Highways Agency ones where SCRIM surveys are carried out. Unlike the HA system which uses only CSC the Warwickshire system also looks at very low results highlighted by the most recent survey as a significant and rapid change may have taken place such as fatting up of surface dressing. A third trigger has been instituted for those roads where SCRIM surveys are not routine and this is based on accident data. The categories are currently defined as follows:

1. Category 1: - sites where the most recent SCRIM coefficient is at or below 0.25
2. Category 2: - sites where CSC is more than 0.1 below IL and the top 10 ranked crash sites not on the SCRIM programme
3. Category 3: - sites where the CSC is between 0.05 and 0.1, inclusive, below IL
4. Category 4: - sites where the CSC is less than 0.05 below IL and the next 20 ranked crash sites

The investigations are carried out in category order and generally with the worst in each category being done ahead of the others. Site investigations on accident data led sites must include a GripTester survey as part of the investigation but otherwise they are carried out in same manner as CSC led sites.

Investigation levels are reviewed every 3 years with one third of the network being reviewed each year.

5.4 CHANGES TO SITE TYPE

It is not unusual for additional features to be added to the network such as a pedestrian crossing of one sort or another or changing a junction to traffic light control. These changes will, often, change the IL from that on the existing road. It is County Policy to either check the existing SCRIM values, or if they are not available do a GripTester survey. If the results meet the new IL then no surface treatment is needed on skid resistance grounds. However if it is judged that the polishing action of the traffic is likely to more severe under the new regime then the site will be checked for skidding resistance in the following summer and then if below IL carry out a site investigation and accident analysis as usual.

6 OTHER FACTORS

There are two other matters that have been included in the policy. They are: early life skidding and problems with horses. In both of these case national guidance is followed.

For early life skidding the relevant documents are IAN49/03 from the Highways Agency and a CSS guidance paper which refers directly back to it. Warwickshire follows the general advice given therein.

The CSS/British Horse Society (BHS) guidance paper gives advice with respect to road surfaces and horses. From my own experience riders have complained about road surfaces for many years since long before the advent of negatively textured surfaces. It should be borne in mind that horses are the last remaining user of roads that use metal for their contact patch; all other users use resilient materials of one type or another; rubber, leather or plastic. The BHS guidance for horses is that roads should not be ridden on if the horse's shoes are 'shiny and/or thin' and where road nails are used checks should be carried out regularly to ensure that they have not been lost. They also recommend that owners should 'note the requirements for the MOT and minimum tread depth' .

7 CONCLUSIONS

The conclusions to be drawn from this development are:

1. It is inappropriate, for a number of reasons, for the Highways Agency policy on skidding to be used by a local authority without change
2. There is plenty of research available which can apply to local authority roads and because SCRIM is essentially unchanged for half a century even old research is still valid.
3. It is not difficult to form a policy that is appropriate to the road network of the authority concerned and to ensure that it is not unnecessarily onerous to apply. This is greatly assisted if the wider research findings are included in the development of the policy.

8 THE FUTURE

Since the policy was published in early 2006 two pieces of research have come to light; one is the analysis by Cornwall [Stephenson 2006] of the relationship between accident data, bend severity and MSSC on the Cornish network and the other is a PhD on early life skidding which

was presented at the conference on Developments in Pavement Assessment where it was called 'Slippery when Dry' [Bullas 2007].

The Cornish paper confirmed that for at least one local authority network there is a very significant relationship between bend severity and crash rate for any given level of skidding resistance. The relationship for Warwickshire may be different but is a confirmation of our experience with bends in the range 250-500 m radius.

The Bullas paper showed that early life skidding is nothing new although it is more obvious with the tougher binders now used for surfacing. It also showed, indirectly, that the problem will diminish with time as the mechanism seems to be the heating of the binder by locked wheels. This wheel locking is prevented by anti-lock brakes (ABS) and since they are now mandatory for all new vehicles the proportion of vehicles not fitted will reduce with time but in the mean time the safeguards of IAN 43 should remain in place.

A small scale piece of research is being undertaken by an MEng student at Nottingham University under Tony Parry looking at the relationship of SCRIM, accident rate and site type using Warwickshire's own network and data.

It is known that there are some road trials investigating a direct comparison with different aggregate sizes under way being run by TRL. Warwickshire are looking forward to considering the early results from these comparisons.

Following this conference the policy will be reviewed to see what changes will be needed to keep up to date with available research and information.

9 ACKNOWLEDGEMENTS

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Appendix A

Minimum Polished Stone Value of Chippings

The minimum polished stone values given in the table are for 10 mm aggregate in surface dressing, thin surfacing and, where the speed limit is 30 mph or less for 55/10F asphalt.
The minimum PSVs given in the table shall be **increased by 5** where 14 mm aggregate is used in any surfacing and where 55/10F asphalt is used on roads with 40 mph or higher speed limits.
NOTE: 65 will be increased to 68+
The minimum PSVs given in the table shall be **decreased by 5** where 6 mm aggregate is used in the any surfacing. (for this purpose only 68+ is assumed to be 70)
HD 36 on which this table is based is in the process of revision. It is likely that the detail of this table and the classification groups will change following its publication.

Site group	Site Description	**Minimum PSV required for given IL, traffic level and type of site**						
		IL	Traffic (cv/lane/day) at design life					
			0-20	21-100	101-250	251-500	501-750	751-1000
1	Dual carriageways and single carriageways where traffic is generally free-flowing on a relatively straight line.	**0.40**	50	50	50	50	50	55
		0.45	55	55	55	55	55	60
3	Approaches to major and minor junctions or other hazards on all-purpose dual carriageways and single carriageways where frequent or sudden braking occurs but in a generally straight line, mini-roundabouts	**0.45**	55	55	55	60	60	65
		0.50	55	55	60	65	65	68+(70)
		0.55	55	60	65	68+(70)	68+(70)	68+(70)
4	Steep Gradients (>5%) longer than 50 m	**0.45**	55	55	55	55	55	60
		0.50	55	55	60	65	65	68+(70)
		0.55	60	60	65	68+(70)	68+(70)	68+(70)
5	Bends on all types of road (<500 m radius note 1); roundabout circulation areas except mini roundabouts; approaches to hazards that require combined braking and cornering.	**0.45**	55	60	60	60	65	65
		0.50	60	60	65	65	68+(70)	68+(70)
		0.55	65	65	68+(70)	68+(70)	HFS(75)	HFS(75)

Notes: 1. Shaded lines are the default Investigatory levels for that group except that for bends with a radius between 250 and 500 m when the default IL is 0.45

2. Where '68+' material is listed in this Table, none of the three most recent results from consecutive tests relating to the aggregate to be supplied shall fall below 68.

3. HFS means that high friction surfacings complying with MCHW 1 Clause 924 will be required.

4. Investigatory Level (IL) is defined in Chapter 3 of HD 28 (DMRB 7.3.1)

5 Figures in parenthesis are used to calculate the reduced PSV required when 6 mm aggregate is used