Skid resistance policy in the UK – where did it come from and where is it going?

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ABSTRACT

The UK led the world in research and policies that led to the improvement of skid resistance of roads. By addressing the dual problems of providing skid resistance through appropriate material properties and developing measurement techniques, it was possible to introduce a national policy for in-service skid resistance supported by routine monitoring on the most heavily trafficked roads. Similar strategies have subsequently been adopted by many other road administrations. However, since then, traffic loads have increased, vehicles, tyres and surfacing materials have developed, and formal targets for casualty reduction on UK roads have been introduced by Government.

This paper reviews the historical background to the introduction of UK policy for managing skid resistance on trunk roads, its subsequent evolution and application to other parts of the UK road network. The paper then looks ahead to future challenges.

1. INTRODUCTION

In the first half of the 20th Century, growth of motorised traffic, capable of ever greater speeds, created a pressure to find ways of making road surfaces that could both withstand the increased loads and provide grip for the tyres of the vehicles using the roads. Surfacings and structures that had been designed for horse-drawn traffic and slow-moving vehicles with steel or solid rubber tyres were no longer suitable. Cobbled streets, wooden blocks between the rails in tramways in cities and unsealed surfaces in rural areas were inadequate for the demands of modern traffic.

Great strides were made in this period but it was not until the second half of the century that research had progressed and the technology developed to the point that a central policy could be introduced that would allow Highway Authorities to set standards for skid resistance that would help to reduce accident risk and save lives.

To achieve this, it was necessary to address the dual problems of providing skid resistance through appropriate material properties and developing measurement techniques that would allow conditions in service to be monitored. A standard for the in-service skid resistance was eventually introduced on Trunk Roads in the UK in the late 1980s that has proved a foundation for other administrations around the world to build on to introduce policies of their own.

Other papers in the conference will discuss aspects of the policy and its success in more detail, including application of some of the principles in developing countries. This background paper outlines the history of this standard, primarily from a technical perspective, and then goes on to look forward to challenges now faced.

2. MEASURING SKID RESISTANCE

2.1 THE EARLY YEARS

Research to try and understand the problem of providing grip for road vehicle tyres began in Britain in the inter-war years with the development of a device that could be used to measure skid resistance on in-service roads. The motor cycle and side-car with its angled wheel and mechanical linkage to transfer the frictional forces from the tyre to a chart recorder has become an iconic image in the study of road surface characteristics. A small fleet of these machines was developed and used in the 1930s to establish some fundamental principles that continue to be used to this day (Bird and Scott, 1936).

Developments in measurement techniques continued after the Second World War, moving to rather safer front-wheel drive cars with an internally-mounted angled wheel to measure sideways-force coefficient (SFC) and a towed trailer with a small, lockable wheel to measure braking force coefficient (BFC) at different speeds. It rapidly became apparent that standardisation of test conditions was important and so these devices tended to use standard tyres with smooth tread and were operated at controlled speeds.

Other machines were built in that period that allowed the performance of different tyres to be assessed but work on road surfaces depended primarily on the use of the side-force cars and brake-force trailer. As research progressed, important factors – such as the decrease in skid resistance with increasing speed, the microtexture on the aggregate and the influence of surface texture depth – became known and better understood.

2.2 ROUTINE MONITORING EQUIPMENT

As explained below, suggestions for possible skid resistance levels for UK roads were first made in the late 1950s (Giles, 1957). However, at that stag,e measurement techniques were confined to the specialised SFC cars and BFC trailer plus the portable skid resistance tester – the "pendulum" (Giles et.al, 1964) – that could be taken to a local site to measure the skid resistance of the road.

However, the test vehicles needed support from water tankers if any length of road was to be measured. The BFC method could only measure very short lengths and both types of equipment recorded their data on paper charts. The pendulum could only make spot-checks. These techniques were really only suitable for research use or localised checks. Before national standards could be contemplated, a machine was needed that could make continuous measurements of the skid resistance over long distances, together with a means of processing the large volumes of data that would be collected.

The advent of digital computers in the 1960s provided a solution to the data-processing problem and the Sideway-Force Coefficient Routine Investigation Machine (SCRIM) was developed at TRL (then the Road Research Laboratory) in the late 1960s as a potential network level survey tool. The concept combined the well-established side-force coefficient principle with a large capacity on-board water supply and electronic data recording.

With some development, the prototype proved successful and in the early 1970s the first production machines were introduced, built under licence by WDM Ltd of Bristol who have made them ever since. With the production machines came the direct recording of the data on punched paper-tape as an on-board storage medium which meant an easy transfer of data for computer analysis. At that stage the machine was still primarily used for research but the Department of Transport centrally began to use it to assess portions of its network and one or two County Councils purchased machines to monitor their own local networks.

A period of further refinement to improve reproducibility followed (Hosking and Woodford, 1976,1978) that continued into the 1980s, during which period comparison exercises were carried out that have evolved into an annual accreditation trial in which the whole UK and Ireland fleet of SCRIMs comes to TRL for cross-checking every spring. Fourteen machines attended the 2008 trials. With a fleet of machines capable of routine monitoring of the network, by the mid-1980s the main practical barrier to introducing in-service skid resistance standards had been overcome.

3. THE TRUNK ROAD STANDARDS

3.1 THE GROUND WORK

Suggestions for in-service skid resistance levels were first made by Giles in the late 1950s. He recognised that it was unrealistic to have the same levels of skid resistance all over the network and he introduced the idea of different levels of difficulty of site, reflecting the demand for skid resistance, suggesting in effect that skid resistance would need to be related in some way to skidding risk. However, at that time network monitoring was not practical.

The recognition that aggregate properties played an important role in developing skid resistance in turn drove a significant programme of research to establish suitable tests that could be used both to identify materials that would be suitable for use in road surfacings and to form the basis of specifications in parallel with the development of monitoring equipment (Szatkowski and Hosking, 1972; Hosking, 1976).

In 1976, standards for the polishing resistance of aggregates used in new surface courses were introduced for trunk roads. This linked the polished stone value (PSV) of the aggregate to the level of traffic expected use the road, thus attempting to provide surfacings that would maintain sufficient microtexture to provide adequate skid resistance. At the same time, minimum texture depth levels for new surfaces were set to limit the loss of skid resistance at higher speeds. As research had found that the most polish-resistance aggregates tended to wear away quickly in traffic, limits on abrasion resistance were introduced as well.

The idea of setting skid resistance levels for in-service roads in relation to accident risk was developed further and, in the early 1970s, Salt and Szatkowski (1973) introduced the concept of “risk rating” different categories of sites to allow ranges of skid resistance levels to be assigned to the network. This report, LR510, in conjunction with the new materials standards and the development of SCRIM had provided a platform on which an in-service standard could be based but further time was to elapse before a full policy could be introduced.

3.2 DEVELOPING A TRUNK ROAD STANDARD

The next stage was to develop a standard for trunk roads. (These are the long-distance, heavily-trafficked strategic routes for which central government agencies, such as the Highways Agency in England, are responsible). The argument for doing so relied upon the hypothesis that improving and maintaining skid resistance at appropriate levels would reduce accidents.

It was decided that the concepts proposed in LR510 would be taken forward. The network would be divided into sites of different categories representing different broad levels of accident risk. An “Investigatory Level” for skid resistance would then be assigned to each site that would trigger an investigation of whether or not treatment to improve skid resistance was needed. However, before a standard could be introduced, a number of issues had to be considered:

- Research was needed to link the proposed Investigatory Levels to actual accident risk. (Rogers and Gargett, 1991).
- Cost-benefit analysis was needed to demonstrate that the additional costs of upgrading the network were justified (the analysis carried out suggested a benefit to cost ratio of 5:1).
- Monitoring regimes had to be established and software developed that could process the data produced.
- Legal implications had to be discussed, including whether warning signs were needed for those locations that would need resurfacing.

Eventually, the new standard for the in-service skid resistance of UK Trunk Roads was introduced on 19 January 1988.

3.3 CONTINUING DEVELOPMENT

After the introduction of the standards, traffic levels grew and often exceeded those covered in the original research, raising questions as to what to specify. It was found from experience of using the original materials specifications that some aggregates did not always deliver the required levels of skid resistance, leading to a tendency to over-specify. Further research led to improvements in the materials requirements specifications to match them more closely to the need to deliver the skidding policy (Roe and Hartshorne, 1998).

Developments have also been made to SCRIM, the most significant of which has been the introduction of dynamic vertical load measurement on the test wheel (Roe and Sinhal, 1995), which has provided for greater flexibility in test speed allowing safer operation of the equipment on modern high-speed routes.

A full review of the policy and revision of the standards was made at the start of the present decade which included a full study of the link between skid resistance and accidents on the modern network and the introduction alternative approaches to monitoring and dealing with seasonal variation. The revised standard, which retained the same key principles and broadly similar requirements of the original, was published in October 2004 and came into practical effect in 2005. Progress with this will be discussed in other papers at this Conference.

4. FUTURE CHALLENGES

In future, the skidding standards in the UK will face a number of interesting and exciting challenges. The trunk road standards are well established and contributing to road safety but more can be done. In this section of the paper some challenges for the future are outlined.

4.1 TOWARDS A TRULY NATIONAL STANDARD

When first introduced, the UK skidding standards applied only to trunk roads, but it was quickly recognised that the principles could equally well be applied to roads managed by Local Authorities and increasingly the trunk road standards were seen in litigation as “best practice” in the absence of local policies.

Some Local Authorities, mainly those that already owned and operated SCRIM machines, soon developed their own standards modelled on trunk road practice. A code of good practice was published that included some advice and suggestions on ways to adapt the trunk road skidding resistance standard for local road use (Local Authorities Association, 1989). However, the challenge of moving to a consistent set of standards that apply to all main roads in the UK still remains.

Updated advice for Local Authorities in the light of the 2004 revision to the trunk road standards has been developed and included in the latest good practice guide (Road Liaison Group, 2005) and authorities with established policies have reviewed their practice accordingly. Some authorities have carried out accident studies on their own networks to review the site categories and investigatory levels that they use: an example of a recent approach to this issue has been presented in this conference session.

Nevertheless, some UK local authorities have not yet developed fully-fledged policies and there is a little way to go before a truly national standard is in place.

4.2 ADAPTING TO NEW TECHNOLOGY

4.2.1 Materials performance and testing

An important aspect of a skid resistance policy is the ability to provide surfacings or surface treatments that will provide the required skid resistance performance, either when a new surfacing is installed for any reason or after monitoring has identified a need for treatment to improve skid resistance. In the UK the PSV test enables highway authorities to exploit the range of aggregates available to match the aggregate source to performance demands and expected traffic. However, useful though the PSV test is, it has its limitations and alternatives that might provide an even better ability to predict performance and help select the most appropriate aggregates continue to be considered.

One such is the Wehner-Schulze test developed at the Technical University of Berlin which is now becoming more widely considered outside Germany with the availability of commercially-produced test equipment. The Highways Agency purchased the test equipment in 2006 for initial evaluation at TRL (Woodbridge et al, 2006) and is actively pursuing a programme of research to establish whether the test could have a role in relation to materials specifications in support of the skidding standards in the UK. The Agency is also working with the UK asphalt Industry through the Quarry Products Association and its member companies in using the equipment to assess new types of surfacing materials or aggregate sources, as another paper in this Conference will discuss.

If this work shows that the new test has a role in the UK, then there will be the challenge of introducing it into routine use, whether for source approval or verification of material compliance. Potentially, this could involve the development of predictive models that can be used to prepare modified specifications, introduction of additional test facilities and quality management.

4.2.2 New surfacing technology

The specifications that support the UK skidding standards are essentially based on the hot rolled asphalt with pre-coated chippings (HRA) and surface dressing materials that were traditionally used on the network. However, in recent years, different types of asphalt mixtures – the so-called "thin surfacings" – have become more widely used in the UK and are the first choice for new surfacings on trunk roads where their of reduced tyre/road noise and speed of laying bring advantages.

However, it is less easy to make these materials to comply with current specifications, particularly in relation to texture depth. Also, the shape and form of the texture could mean that these materials develop better skid resistance for a given level of polishing resistance. This raises the possibility of greater flexibility of aggregate choice in some situations.

There is therefore a new challenge to establish appropriate criteria for their use. To this end, collaborative research (supported by the Highways Agency, Quarry Products Association and Refined Bitumen Association) is in hand that is studying the performance of modern asphalt surfaces using different sizes of coarse aggregate (including 0/6, 0/10 and 0/14 mm mixtures) in relation to their texture depth and skid resistance at higher speeds (Roe et al, 2008). Texture depth requirements for these types of materials in some situations are currently being revised.

4.2.3 Microtexture measurement

There are a number of research studies currently investigating alternative ways of measuring microtexture, including in the UK. If reliable non-contact, traffic speed technologies could be developed then a new era will be introduced in which monitoring can be achieved without the use of rubber-tyred wheels and water.

However, many technical challenges remain to be overcome before this position can be reached but this is one of the most exciting possibilities in this field over the next ten years. If reliable measuring equipment and methodologies can be developed, there remains the challenge of adapting standards to take account of this different approach to assessing the road surface.

4.3 TRADE-OFF BETWEEN DIFFERENT PROPERTIES

Skid resistance is a measure of the road surface's contribution to the friction developed between the tyre and the road. Maintaining this is an important part of the asset management process but in the final analysis it is the friction available to vehicles in specific conditions that is of primary importance in potential accident situations.

Road/tyre friction is a product of the interaction between microtexture, texture depth and tyre tread depths and currently these are specified independently. A future challenge is to understand better how these components complement one another. It may be possible to optimise standards for so that benefits can be realised from trade-off between the various requirements.

4.4 MONITORING

4.4.1 Test equipment

Since the standards were introduced in 1988, they have required that the network should be monitored exclusively using an approved fleet of SCRIM vehicles that are checked against one another annually. This has maintained the link with historic research and enabled consistent data to be recorded, such as that used for the more recent accident analysis to review Investigatory Levels.

Some improvements to SCRIM have been made over the years, including the recent addition of dynamic load measurement. This has allowed faster test speeds, with consequent safety improvements on busy roads. However, an immediate challenge is to improve operational efficiency. This includes the need to extend survey range and reduce water consumption, both to reduce survey costs and to save water. Work to improve water flow control and assess the scope for reduced consumption is in hand.

However, there are also parts of the network (such as smaller roundabouts and access roads) where SCRIM, because of its size, may not necessarily be the ideal measuring vehicle and smaller alternatives might need to be considered. In the longer term, non-contact methods of measuring microtexture could provide an alternative approach.

4.4.2 Harmonisation and Europe

Increasingly it will become more important to be able to compare the requirements for roads across Europe, especially on the pan- European strategic network. There is a wide range of devices that can measure skid resistance in some way: more than 18 different types of device are operated in Europe alone. However, because each operates on a different principle, and under different standard conditions, the results each device gives can differ from other devices.

For this reason, work in Europe, to which TRL, supported by the Highways Agency has contributed, has explored the options for harmonising the results from different devices by means of linking them to a common scale. An international experiment organised by PIARC in the early 1990s proposed an International Friction Index (Wambold, et al, 2005) and the HERMES study, organised by the Forum of European national Highway Research Laboratories in the early part of this decade (Descornet et al, 2006), took this forward specifically in relation to devices used in Europe. This work, although not fully conclusive, made significant progress. It demonstrated that defining a common scale (known as the European Friction Index, or EFI) was possible and an associated procedure for calibration of devices to the index was demonstrated.

Work at TRL for the Highways Agency has applied the EFI principles to assess the possibilities for harmonising the devices commonly used for measuring skid resistance in the UK, namely SCRIM, GripTester and the Pavement Friction Tester (a locked-wheel device based on the US ASTM friction trailer). These devices have different potential applications but it would be helpful to be able to compare their results more easily. The early results have been encouraging.

The challenge remains, however, to provide a reliable harmonisation methodology that can be accepted by road administrations across Europe and work towards this continues. The challenge includes the development of standardised surfaces with consistent, predictable skid resistance properties that can be used to calibrate different devices to one another or to provide reference levels by which a future standard measurement device can be controlled.

4.5 SUSTAINABILITY AND CLIMATE CHANGE

The world is changing, and issues of sustainability and climate change present challenges to UK skidding standards in the future.

The sustainable use of materials (such as premium aggregates) will become more important. Not only will there be increased pressure to avoid unnecessary quarrying, there is an imperative to reduce the environmental impact in terms of oil consumption and CO_2 emissions associated with moving large quantities of aggregate from one part of the country to another. Issues such as rolling resistance and noise, and the interactions associated with reducing these without prejudicing safety present further challenges.

Changes in the climate will also affect the way in which monitoring is carried out and the kinds of conditions that need to be taken into account. Hotter, drier summers, for example, could lead to increased polishing and lower levels of skid resistance over all. Heavier rainfall when it does occur may place greater demands on the surfacing to disperse water in tyre contact areas. Changed seasonal patterns are already being observed in the UK that may influence the way in which monitoring of skid resistance should be programmed.

All these influences will demand greater flexibility in the setting of standards and in their application and it may be that other measures to reduce accident risk will be needed to make this possible.

5. CONCLUSION

The UK led the world in research and policies that led to the improvement of skid resistance of roads. Over a period of fifty years, the dual problems of providing skid resistance through appropriate material properties and developing measurement techniques were overcome until in 1988 it was possible to introduce a national policy for in-service skid resistance supported by routine monitoring on the most heavily trafficked roads. Twenty years of experience have led to further developments of the standards, test equipment and monitoring strategies but the original concept has proved sound.

However, challenges remain for the future. Changing technologies, environmental considerations and the potential influence of climate change will all have an influence on the future development of standards within the UK and elsewhere. Highway Authorities need to work towards a truly national standard for in-service skidding resistance and at the same time explore alternative strategies to reduce accident risk as engineers continue to strive to provide and maintain a safer road network.

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