Implementing a Revised Skid Policy into Scotland

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ABSTRACT

The previous skid resistance standard was introduced was introduced into Scotland in 1994 since that time, major changes in the levels and type of traffic flow have occurred in Scotland. In particular, there has been a significant increase in traffic volumes, changes in the composition of the traffic with increasing numbers of four wheel drive sport utility vehicles, van like people carriers, and developments to the braking and suspension systems Therefore, in 2003 Transport Scotland decided to review the current standards. As part of this review not only were the current investigatory levels considered but also the site categories were reviewed to determine if a number of new site categories including approaches to: Lay by's, Bus Stops, on and off Slips and exits to garages, should be included in the standard.

By analysing the accident rates and densities at different sites categories and at different skid resistances, it was possible to determine a set of optimum investigatory levels. It was found from this study that there was no justification for adding the new site categories. Benefit cost calculations were undertaken and it was found that there was economic justification for implementing a number of revised investigatory levels. The results were discussed with TRL who were commission by the Highway Agency to undertake a similar study for the English trunk roads and it was found that with few compromises a single standard could be established for England and Scotland and a revised standard HD28/04 was implemented in 2004.

A procedural manual was written with the aim to provide clear unambiguous procedures for Managing the Skid Resistance of the Road Surface on the Scottish Trunk road system. This manual was released in September 2004 and since then, there has been various changes made and it is anticipated the manual will be rewritten to incorporate these changes in 2008. It should be noted that there are some changes between the Scottish procedures and those used in England. The key points of the Scottish procedures are outlined in the paper.

1. INTRODUCTION

Scotland has had a Skid Policy in place for the Trunk roads for many years, and in 2003, it was decided by the Scottish Trunk Road Network Management to review the current standards for skid resistance. The Standards at that time were based on HD 28/94 and it was realised that since the development of these standards there have been significant changes in the composition of the type of vehicles including the traffic flow, the speed that vehicles can achieve and the sophistication of vehicle braking systems. The revision included a review of the current Investigatory Levels, and Site Categories to ensure that optimum standards were in place. In Scotland, Highway Maintenance is provided through four Operating Companies (OC) each of whom are responsible for about a quarter of the network. The revision therefore also included the development of a "Procedural Manual" for skid resistance to ensure consistency of application by the OC in each of the areas.

2. REVIEW OF INVESTIGATORY LEVELS AND SITE CATEGORIES

Transport Scotland has access to both historical accident data and skid resistance measurements for the whole of the trunk road network. This dataset provided an opportunity to investigate the relationships between accident rate and skid resistance for Scottish trunk roads. The database was also used to consider additional site categories that have not been applied previously.

2.1 NEW SITE CATEGORIES

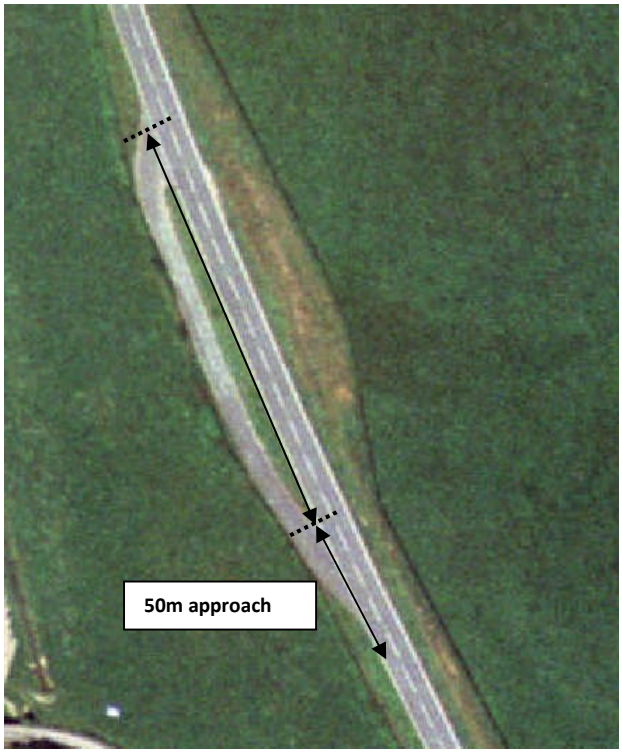
The new site categories included Lay by's, Bus Stops, Approaches to on and off Slips and Approaches and exits to garages, these are discussed below.

2.1.1 Lay-bys

The reason for investigating lay-bys was the potential skidding hazard on the carriageway for vehicles braking on entering the lay-by causing following vehicles to brake and also for vehicles on the main route braking, from potentially high speeds, to avoid vehicles pulling out of the lay-by.

The length assigned to the lay-by site was 50m back from the start of the lay-by through to the centreline of the exit see Figures 1.

Figure1. Lay-by Event showing 50m approach



2.1.2 Bus Stops

Bus stops were referenced as potential hazard situations where a driver's view ahead is obstructed before overtaking the stationary bus. In addition, pedestrians will be crossing the road to board or alight from the bus at these locations.

The bus stops were referenced in a similar way to the lay-bys with the length of the site being 50m from the start of the bus stop markings through to the end of the markings, only for the side of the carriageway that the bus stop is on. For situations where there was only a bus stop sign and no road markings, a site length of 60m from the sign was used for the site. This takes into account the 50m run up to the bus stop and allows 10m for the manoeuvring in front of the bus stop sign.

2.1.3 Approaches to On and Off Slips

The approaches to on and off slips on dual carriageways and motorways were also considered potential hazards and worthwhile new categories to investigate. The length of the site of an approach to an off slip was taken as 100m (due to the increased speeds) from the start of the markings to the off slip through to the nose of the off slip (the point beyond which a vehicle can no longer exit the carriageway).

For approaches to on slips the length of the site was taken as 100m back from the point at which a vehicle could join the carriageway through to level with the end of the road markings for the on slip.

2.1.4 Garages

Most petrol stations have a large number of vehicles entering and leaving each day therefore these sites were investigated as a new category. A garage event was classified 50m distance from the entrance of the garage through to the exit of the garage on the side of the road it is situated.

2.2 Validating the Location of the Site Categories

An essential prerequisite for the analysis of the SCRIM and accident data has been accurate site category information exists in the Scottish Government database. Therefore, initially the videos of the network connected to the Scottish PMS were viewed to verify that the site categories were located correctly, including the additional new site categories.

2.3 Comparing the Skidding Resistance with Accidents

Relationships as they exist have been displayed as plots of wet accident rates versus skid resistance. Where there is a relationship, regression equations have been developed to determine the optimum investigatory level (IL) for each site category.

2.3.1 Accidents used in Analysis

The accident study period used was 3 years. It is known that skidding accidents are significantly underreported, therefore it was decided to incorporate all accidents that occurred on wet/damp road surfaces, not just wet skidding accidents. This process has been used before with success by Young A.E, Kennedy.C.K[(1)] and Young A.E[(2)]. In order to ensure that the accident data are related to skid resistance, sites were removed where there was any resurfacing within the accident study period.

The skid resistance at each accident used in the investigation was collated into average MSSC bands as shown in Table 2.

Table 2 MSSC Bands

MSSC value on graphs	MSSC band from	to
0.25		<=0.24
0.30	0.25	0.29
0.35	0.30	0.34
0.40	0.35	0.39
0.45	0.40	0.44
0.50	0.45	0.49
0.55	0.50	0.54
0.60	0.55	0.59
0.65	0.60	0.64
0.70	0.65	0.69
0.75	0.70	0.74
0.80	>=0.75	

2.3.2 Traffic Flows

The volume of traffic is an important factor when comparing the accidents with skid resistance levels from different locations. For Instance, the number of accidents at a heavily trafficked intersection might need to be compared against low trafficked bend and gradient sites, to compensate for the difference in traffic volumes the accidents are converted to accident rates, which are accidents/one hundred million vehicles per km per year (Acc/100Mvkm/yr).

2.4 ANALYSIS

2.4.1 Correlation and Regression Analysis

Once all the required data was in the appropriate format, the SCRIM Site categories were grouped together and accident rates were compared against the MSSC bands. It was found that on occasions there were sites with high MSSC's that also had high accident rates. This apparent inconsistency is commonly found in studies of this sort because these sites will have been considered black spot areas and the maintenance engineer has resurfaced using high PSV stone to help to achieve an improvement, but generally in these situations skid resistance will not have been a significant factor. This produces sites that have a high skid resistance but also high accidents.

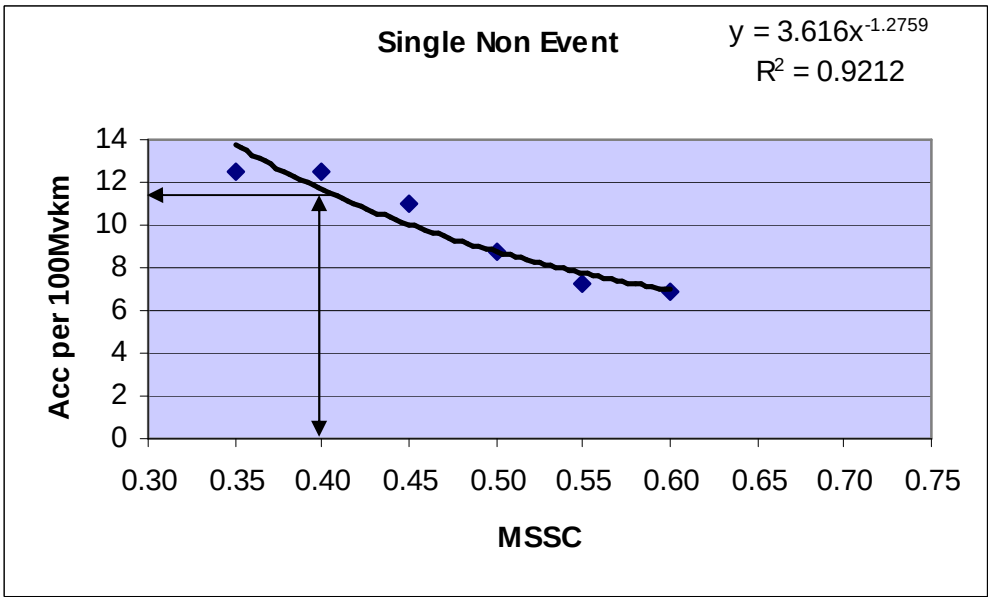
When a correlation existed a trend line using a power relationship has been drawn through the points and the Coefficient of Determination (r^2) has been calculated. Samples of the graphs are shown in Figures 2 to 12.

2.4.1.1 Single Carriageway Non Event

Figure 2 shows the Single Carriageway Non Event. The results for the single carriageway non-event sites produced the classic shape; as the skid resistance decreases the accident rate increases with an r^2 of 0.92. The overall investigatory level for non-event single carriageway is 0.4 and this is marked with a double headed arrow on the graph. The aim of a skid policy is to provide an equal risk of wet road skidding across the network regardless of the site.

The single carriageway non- event accident rate has been used to define the benchmark for standardising the accident rate across all other site categories. This value as calculated by the regression equation is 11.6 accidents per 100Mvkm/yr and is also shown by the arrow pointing towards the Y axis.

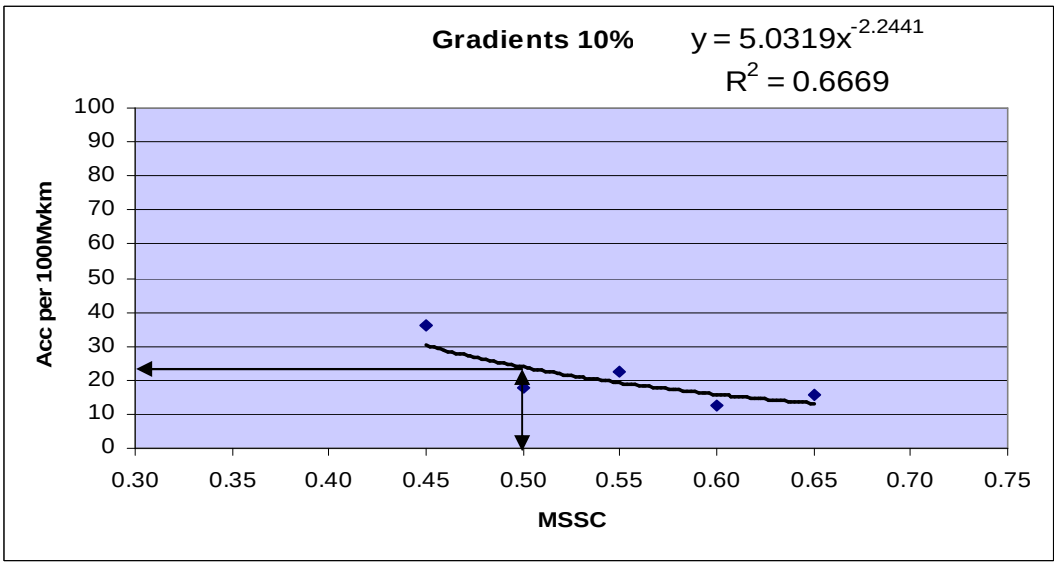
Figure 2 Single Carriageway Non Event



2.4.1.2 Gradient >= 10%

The plot for the 10% gradients is shown in Figure 3. The IL for these sites was 0.50, this is shown on the graph using a double headed arrow. The accident rate at the IL is twice that of the single non even sites indicating that an increase in the IL would be required to bring the accident rate down to the background rate.

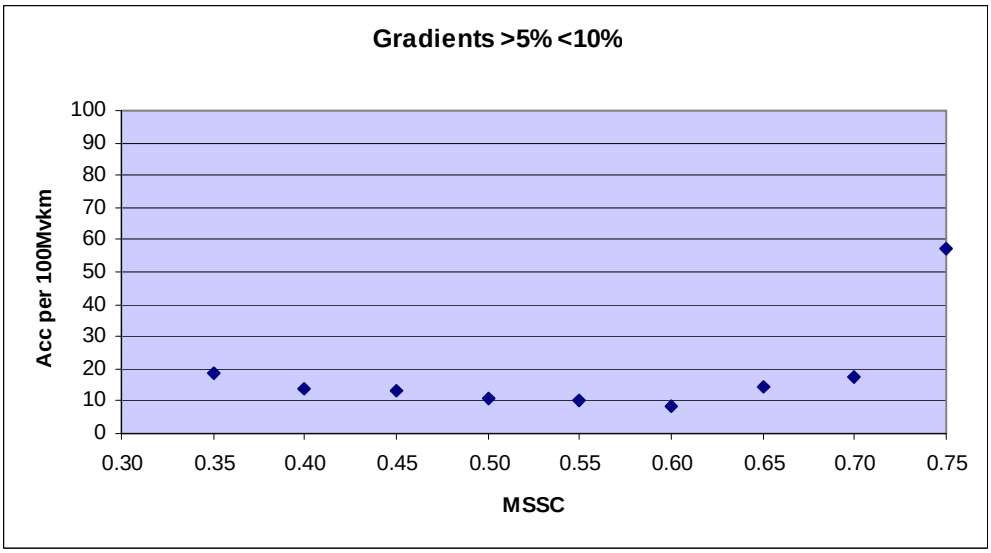
Figure 3 Gradients >=10%



2.4.1.3 Gradient >=5% <10%

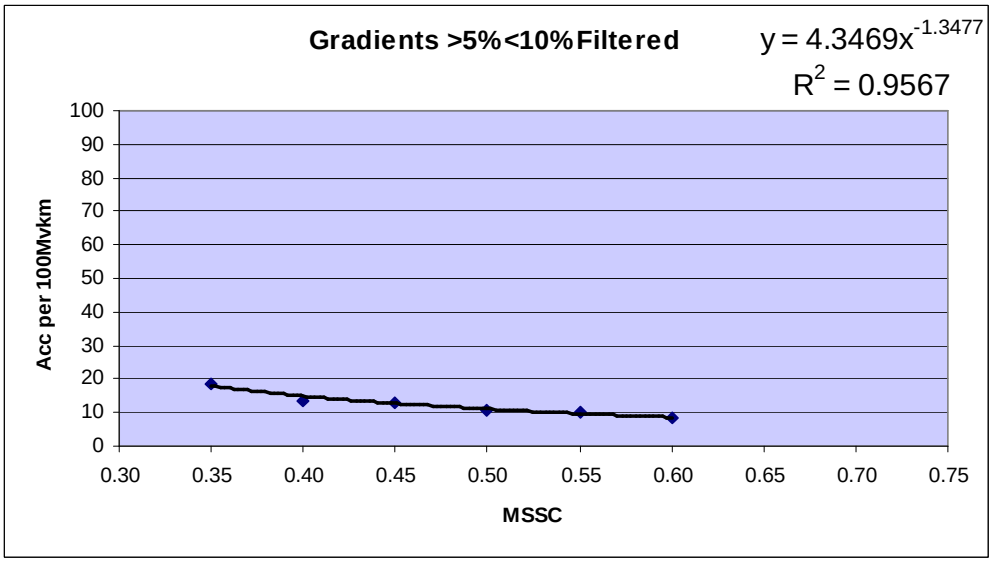
The data for the 5% gradients are shown in Figure 4 note the data points showing high accident rates for the sites that also have a high skid resistance (i.e MSSC bands 0.65 and above). This has been discussed previously and is likely to be due to black spot sites and can be considered atypical.

Figure 4 Gradient >=5% <10%



The sites that are greater than an MSSC of 0.65 have been removed and the graph redrawn and is shown in Figure 5.

Figure 5 Gradients >5% <10% Filtered Data

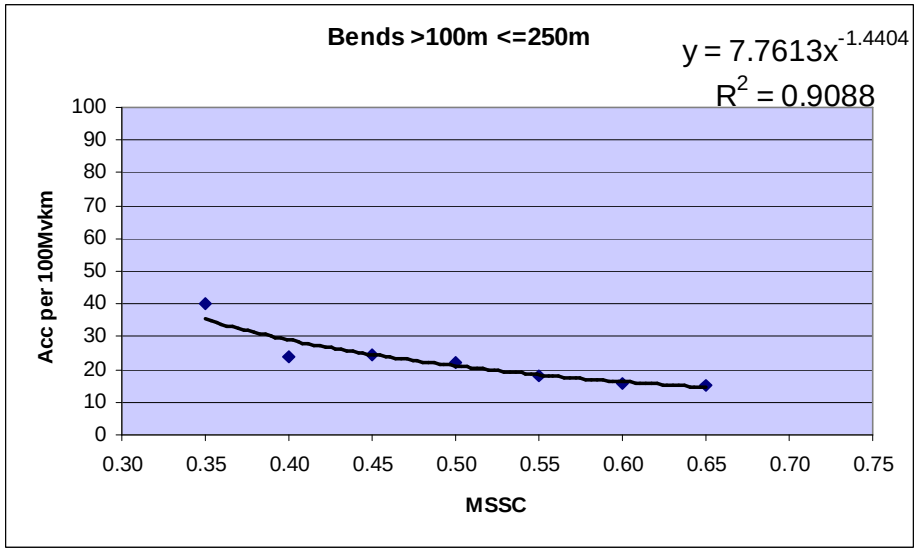


As seen the correlation between MSSC and accident rate improves considerably with an r^2 of 0.96. The accident rate at the IL (0.45) is equivalent to the background risk indicating that no increase in the IL is required.

2.4.1.4 Bends with Radius >100m <=250m

Figure 6 is the graph for the bends at >=100m radius and < 250m. The IL for this site category is 0.45 so it can be seen that at the IL the level of accidents is higher than the proposed background risk given by the single non- event sites and may benefit from an increase in the IL.

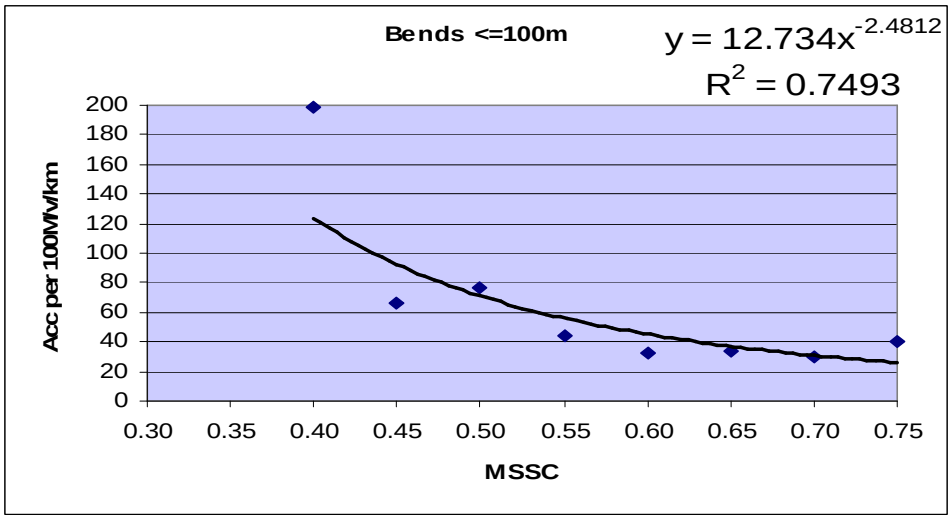
Figure 6 Bends with Radius >100m <250m



2.4.1.5 Bends with Radius <100m

The results for bends with radius <100m is shown in Figure 7. The data indicates that there is a reasonable relationship between skid resistance and accidents but even at the IL of 0.65 the accident rate is significant greater than the proposed background rate. In cases such as these additional steps may need to be incorporated to mitigate the risk such as a reduction in the advisory speed.

Figure 7. Bends <100m. Speed Limit



2.4.2 Analysis of the new Site Categories

The same plots were constructed for the new categories and are shown in Figures 8 to 12.

2.4.2.1 Slip Road Merging Areas

Figures 8 and 9 show the results for the approaches to off slips and on slips. Both the Scottish and Welsh data indicate that there is a relatively low risk of skidding accidents occurring at these sites, in general.

Figure 8. Approach to Off Slips

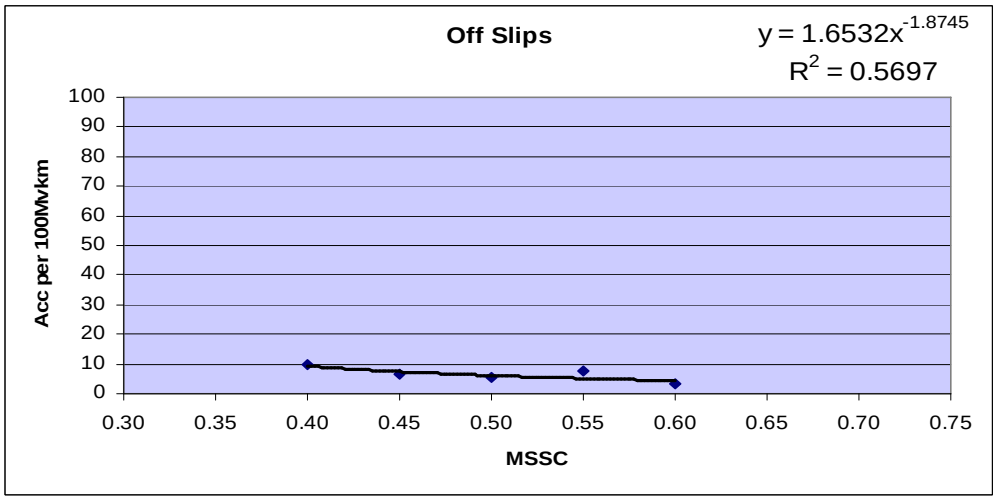
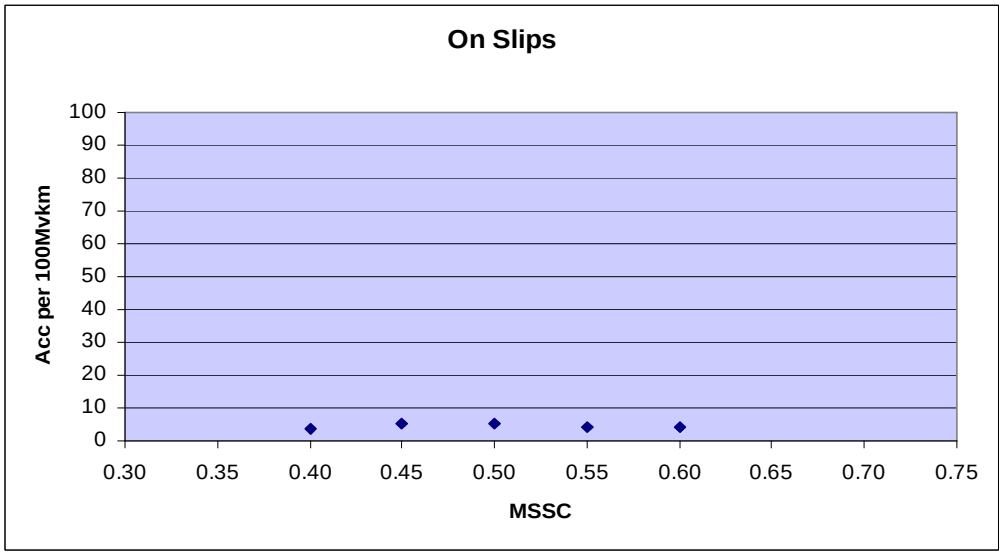


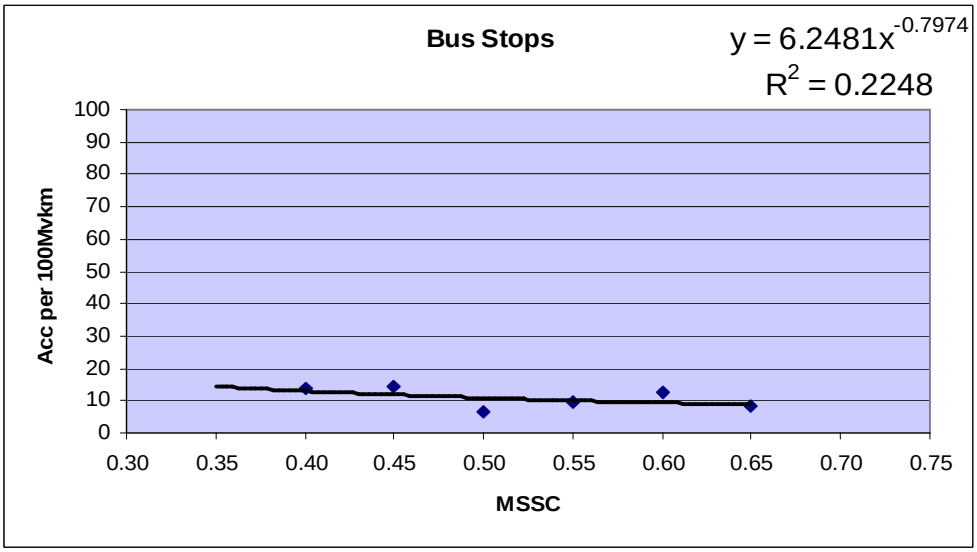
Figure 9. Approach to On Slips



2.4.2.2 Bus Stops

The results for bus stops are shown in Figure 10. The accident rate is about the same as the background risk and there is a poor correlation between MSSC and wet accidents therefore Bus Stops were not introduced as a new site category. This suggests that when sighting bus stop locations care is being taken to provide adequate sight distances.

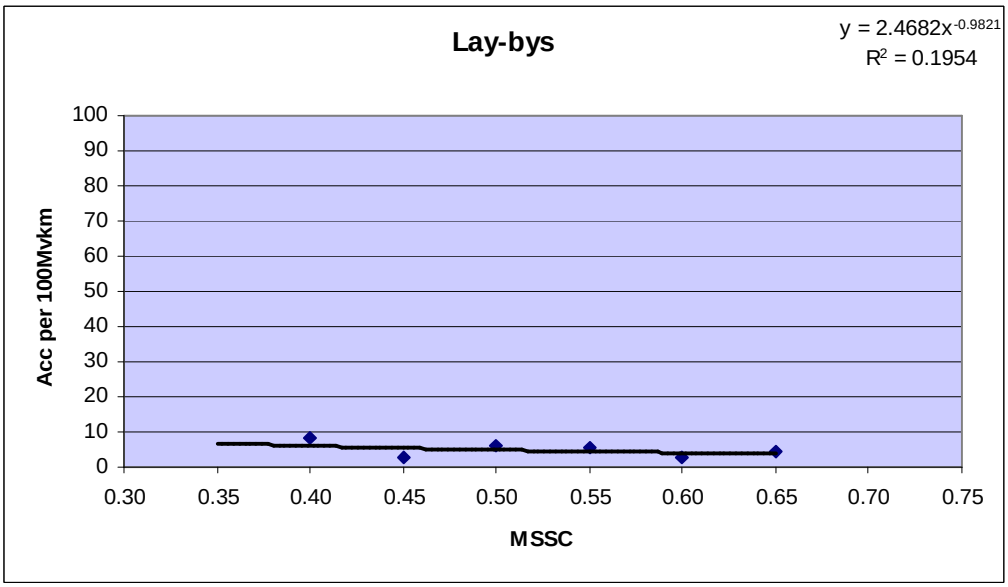
Figure 10. Bus Stops



2.4.2.3 Lay-bys

Figure 11 shows the results of the lay-bys. The accident rate is lower than the proposed background risk and additional skid resistance requirements are not required.

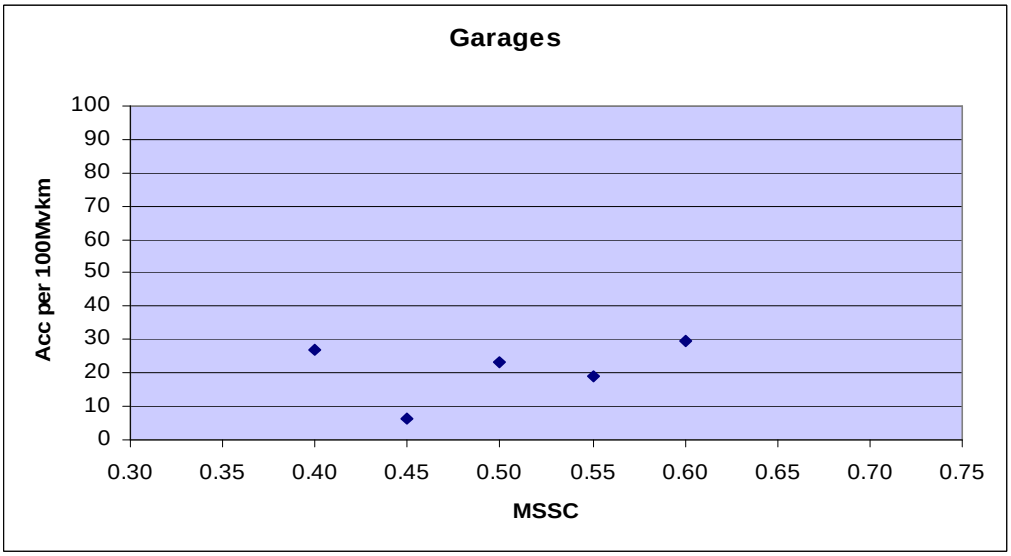
Figure 11. Lay-bys



2.4.2.4 Garages

Garages were another of the new categories because they were considered a source of skidding accidents. As Figure 12 shows the accident rate at approaches to garages is relatively high but there is no correlation between the skid resistance and the accident rate indicating that there are other factors influencing the accidents at these locations.

Figure 12. Garages



2.5 RECOMMENDATIONS FOR THE INVESTIGATORY LEVELS

From the analysis performed recommendations can be made with regard reviewing the IL of the site categories and the proposed introduction of new site categories see Table 2.

Table 2. Initial Recommendations

Site category	Recommendation	Comments
Single carriageway non- event	No Change	These sites are at the background risk.
Dual non event	No Change	These sites are below the background risk and are on the lowest IL.
Roundabouts	No change	No correlation between the skid resistance and the wet accidents
Approach to Roundabouts	No Change	These sites are below the background risk at the IL
Traffic Signals	Possible increase to IL	There is a reasonable relationship between accidents and skid resistance and the accident rate is significantly above the background risk.
Bends <100m	Possible increase to	There is a good relationship between skid

Site category	Recommendation	Comments
radius.	IL.	resistance and accidents.
Bends>=100m and <250m radius.	Possible increase to IL.	An increase in the IL is supported by the regression analysis .
>10% Gradients	Possible increase to IL.	The data indicates a reasonable correlation between accidents and skid resistance and the accident rate at the IL is above the background risk
5% to 10% Gradients	No change	There was one occurrence exceeding the high risk criteria but there was no evidence from the accident rates that suggests an increase to the IL.
Dual Minor Junctions	No change	There is very little data available for these sites.
Single minor junction	Possible increase to IL.	There is a reasonable relationship between accidents and skid resistance these sites have been identified as high risk.
Major Junctions	Possible increase to IL.	There is no apparent correlation between accidents and skid resistance but the accident rate is much higher than the background risk and it is believed that skid resistance is influencing some of the wet accidents.
Approach to off slips	Do not introduce new Site category	This is not currently a site category and there is no evidence from the analysis that suggests it should be.
Approach to on slips	Do not introduce new Site category	This is not currently a site category and there is no evidence from the analysis that suggests it should be.
Bus stops	Do not introduce new Site category	This is not currently a site category and there is no evidence from the analysis that suggests it should be.
Lay-bys	Do not introduce new Site category	This is not currently a site category and there is no evidence from the analysis that suggests it should be.
Garages	Do not introduce new Site category	This is not currently a site category and there is no evidence from the analysis that suggests it should be.

2.7 BENEFIT COST ANALYSIS

It has been shown that a review of some of the skid resistance investigatory levels may be merited in terms of accident risk but to revise a national policy it must also be shown that the change is cost effective and that the benefits accrued outweigh the costs. Consequently, a benefit cost analysis was carried out using the cost savings associated by the predicted reduction of accidents from increasing the IL as the benefits and these were compared with the costs to construct the new surface.

The assumptions used in this analysis are :

- Surfacings will last for 10 years;
- The Major junctions and the Traffic Signals were only treated on one side of the road when using specialist anti skid treatments;
- The road width given for roundabouts is 5 metres;
- The discount rate is 3.5%;
- Treatment costs occur in year 1 accident savings occurs in every year for 10 year life of pavement.

It was found that for most of the proposed increases, the benefits would outweigh the costs

Following this study a revised list of Investigatory Levels was developed. This coincided with a similar study that was being done by the Highway Agency who had commissioned TRL Ltd to review the investigatory levels for the English trunk roads. The results from Scotland were discussed with TRL and it was found there was general agreement with the results and the recommended changes therefore it was possible for Scotland to use the revised standard HD28/04. Since then an interim advice note has been issued IAN 98/07, which, provided further guidance on the effective application of a skid policy.

Although it was found that there was agreement between Scotland and England with regard to the investigatory levels there are differences between the operations of the Highways Agency and Transport Scotland so although the skid policy for the Scottish Trunk road system is based on the HD 28/04 and associated documents additional guidance notes for Scotland were required.

3. PROCEDURAL MANUAL

A procedural manual was written with the aim to provide clear unambiguous procedures for Managing the Skid Resistance of the Road Surface on the Scottish Trunk road system. This manual was released in September 2004 and since then, there has been various changes made and it is anticipated the manual will be rewritten to incorporate these changes in 2008. It should be noted that there are some changes between the Scottish procedures and those used in England. The key points of the Scottish procedures are outlined below.

3.1 SKID RESISTANCE INVESTIGATORY LEVELS

As already stated the investigatory levels used in Scotland were from HD 28/04[(3)]. The SCRIM investigatory levels are shown in Table 3 To avoid a tedious manual exercise the site categories were changed using a bulk up-date if there were 2 IL's in the band the lowest value was selected as a default if there were three the middle value was selected. It is the responsibility of the Operating Companies to confirm the default investigatory levels are appropriate for each site.

Table 3 SCRIM Investigatory Levels

Site category and definition		Investigatory level at 50km/h							
		0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
A	Motorway class								
B	Dual carriageway non-event								
C	Single carriageway non-event								
Q	Approaches to and across minor and major junctions, approaches to roundabouts								
K	Approaches to pedestrian crossings and other high risk situations								
R	Roundabout								
G1	Gradient 5-10% longer than 50m								
G2	Gradient >=10% longer than 50m								
S1	Bend radius <500m – dual carriageway								
S2	Bend radius <500m – single carriageway								

3.2 IDENTIFYING SITES FOR INVESTIGATION

To obtain a consistent approach between the operating companies and to minimise resources two standard reports have been produced that can be overlaid onto a map background. One of the reports highlights all sites with a skid resistance of 0.05 above the IL and all sites at and below the IL. Different colours are assigned to each 0.025 band down to 0.099 below the IL after which all readings are in red. The second report shows all wet accidents that have occurred in the previous 3 years. Note that wet accidents are used rather than wet skidding accidents since skidding accident are known to be under reported.
Using the 2 reports sites are identified and placed into the following priority:

Priority 1 Sites where MSSC ≤ IL and have had at least one wet accident in the past 3 years.
Priority 2 Sites where MSSC ≤ IL -0.1and have not had any wet accidents in the past 3 years.
Priority 3 Sites where the MSSC is > IL and ≤ IL + 0.05and have had at least one wet accident in the past 3 years.
Priority 4 Sites where the MSSC is ≤ IL and > IL - 0.1 and have not had any wet accidents over the past 3 years.

Sites can be listed within each priority band and the sites within each priority band are ranked using a worst - first principle.

If it is not possible for all sites on the list to be investigated further due to the availability of resources, it will be agreed between the OC and Transport Scotland the minimum number of sites that can reasonably be assessed for the current year and that number of sites in priority order are selected for further investigation.

For the following year, providing a resurvey has not been undertaken, any identified sites still remaining on the list that fell below the cut-off level for further investigation are used to form the next batch of sites for investigation. Once a resurvey has been undertaken, a new review will be carried out to identify sites for investigation.

3.3 REVIEW OF THE SITE CATEGORIES AND INVESTIGATORY LEVELS

HD 28/04 stipulates that the IL's should be reviewed on a 3 year rolling programme. This involves a review of the site category and the investigatory level although this appears appropriate, in practice this is an onerous task. The site category can be checked using a video or map whereas the investigatory level generally requires a risk assessment on site. It is considered that in Scotland the review of IL can be captured better when identifying sites for investigation.

For example if the skid resistance of the site is below the IL it will be listed for review, also even if the site is up to 0.05 above the IL and has wet accidents it will also be listed. Therefore, there will be 3 instances where sites will not be picked up when identifying sites for investigations, viz:

1. Sites that have an MSSC between the IL and 0.05 above the IL with no wet accidents over the past 3 years. In this case, if there are no wet accidents there is a high probability that the IL will not be moved therefore a review of the IL would not be cost effective.

2. Sites that have an MSSC > IL +0.05 and have wet accidents. Since a 0.05 increase in the skid resistance would probably move the site to the top of the IL band it is unlikely that the skid resistance is a major factor in causing the accidents. Sites with significant accidents will be picked up by the Accident Investigation and Prevention staff.

3. Sites that are > 0.05 above the IL and have no wet accidents. There would be no reason to change the IL therefore a review would be futile.

Consequently, the 3 yearly reviews in Scotland only involves reviewing the types and locations of the site categories and **not** the investigatory levels.

The review is done on a section-by-section basis, providing all the site categories are correct within a section the section is ticked off with a date stamp. If a site category has been found to be incorrect, the site category is changed and a request is made from the OC to Transport Scotland to update the database. Transport Scotland advises the OC when all updates have been made within a section so the section can be marked as reviewed and correct.

3.4 SITE INVESTIGATION

3.4.1 Timing

The site investigations are performed in a timely manner and it is expected that all investigations will be complete before the beginning of May following the identification of the site.

3.4.2 Preliminary Investigation

As a time saving devise, where no wet accidents have occurred over the previous 3 years the OC's apply an initial (preliminary) investigation before a decision is made to perform a full risk assessment (Secondary Investigation) on site. The preliminary assessment should confirm that the condition of the site fits the data from the SERIS/PMS and that treatment may be required. There are many reasons why sites may not require treatment even though the SERIS/PMS data indicates that the skid resistance is deficient, these include:

1. The skid resistance appears to be incorrect.

   This may be because there was a temporary reduction in the skid resistance and it was not due to the road surface ie clay being washed onto the road from the verge, spillages, binder on the surface of the aggregate etc. This can become apparent if a section of road is deficient yet a site in the same area with the same category using the same aggregate is above the IL. Further evidence of either a temporary reduction in the skid resistance or possibly the SCRIM data being incorrect for some other reason may be if the skid resistance has been above the IL for many years previously and no significant changes to the traffic has occurred. In these cases, a repeat SCRIM survey of the area is obtained the next time the SCRIM is in the area and the data is reviewed as a priority.

2. The site category is incorrect.

   For example, the site is listed as an approach to a pedestrian crossing but there is no crossing within 50 metres.

3. The accidents are due to poor geometry or visibility and improving the skid resistance is not likely to affect the accident rate significantly.
   In this case, treatment should be considered but as they are not to increase the skid resistance it should be remembered the benefits are likely to be marginal.

4. The investigatory level of the site should be reduced and once it is, the skid resistance will be above the investigatory level.

For situation, 1 and 2 above a video review is generally sufficient to decide on the course of action. If there is any doubt then a site visit should be undertaken. For situations 3 and 4 at least a drive over is required.

One or more of the following conclusions should be reached from the preliminary investigation the site:

- Does not require further investigation.
- Requires a secondary investigation because treatment may be recommended.
- Requires a repeat survey test to at the earliest opportunity when the SCRIM is in the vicinity.

A preliminary investigation form is completed for each site. If it is found that a secondary investigation is not required then this is noted on the form with reasons and approved by the appropriate staff member within the OC. All preliminary forms are filed to provide an audit trail.

3.4.3 Secondary Investigation

A secondary investigation is triggered by recommendation from a preliminary investigation or the occurrence of wet accidents happening on the site over the previous 3 years. A secondary investigation is a full risk assessment of the site as recommended in HD 28/04 paragraphs A4.18 to A4.22 and following the guidance stated in section 5.4 of IAN 98/07 .

A report will be completed from the secondary investigation recommending:

- a change in the investigatory level, with reasons;
- a treatment to improve the skid resistance, with details of what is required e.g. minimum PSV;
- a treatment other than for the skid resistance, include reasons why and to whom this information will be communicated to ensure the necessary action is taken;
- no treatment is required , include reasons why.

3.5 APPROVALS

The OC's have been given delegated approval to change the site categories and site investigatory levels but the actual changes to the database are carried out by Transport Scotland.

3.6 TREATMENT SELECTION

If the treatment is applied to improve the skid resistance then the properties of surface aggregate will be selected to meet the site requirements as stated in HD 36/06. It is preferable to use local knowledge regarding aggregate properties but if this is not available then the aggregate should be selected that will meet the requirements of the Minimum PSV and the Max AAV tables in HD 36/06.

3.7 SIGNAGE

The use of Slippery When Wet signs is permitted in Scotland but to stop the proliferation of their use, approval must be obtained from Transport Scotland prior to their erection.

4. AUDIT

The first audit of the skid policy are to be carried out in 2008 and will be ongoing. Initially, the audit will be carried out by teams experienced in implanting skid policy and assessing risk associated with skid resistance. An outcome from this process will be a procedure to allow less specialist auditors to carry out the process in future.

5. CONCLUSION

An investigation has been carried out to revise the Skid Policy for the Scottish Trunk roads. It was found that the results from the 'analysis of accidents versus the skid resistance' were similar to those obtained in simultaneous studies by the Highways Agency on the English roads and the Welsh Assembly on the Welsh trunk roads. Therefore, it was possible to establish one set of revised investigatory levels for all. To ensure that the policy was clear a procedural manual was produced for Scotland the principles are the same as those in HD 28/04 plus IAN 98/07 but there are some variations which have been outlined in the paper.

References :

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