Relationship between Skid Resistance and Accidents on Local Roads in the South West of England

Chris Kennedy, Director of Civil Engineering Services, *WDM Limited*
John Donbavand, Project Development Manager, *WDM Limited*

ABSTRACT

An analysis has been carried out to determine if the skid resistance investigatory levels in the HD28/04 standard for trunk roads are suitable for the local roads.

Three highway authorities were included in the study to determine the relationship between the skid resistance and the accident rate for the local roads in the South West of England.

It was found that there was a correlation at a significant level for a number of the sites. It was also found that in general the regression curves produced for each site were very similar for each of the authorities.

The findings generally supported the IL values in the HD28/04 standard and their applicability to local roads. However, it was found that there was justification for specifying the bends with radius <100m separately to the other bends and also to specify approached to roundabouts separately to the approaches to the minor and major junctions.

1. INTRODUCTION

The Highways Agency (HA) implemented a revised skid resistance policy in 2004 HD28/04 contained in the Design Manual for Roads and Bridges. An Interim Advice Note (IAN) 98/07 was issued in September 2007 to provide further guidance on the implementation of the skid resistance policy. The documents HD 28/04 and IAN 98/07 are for use on the UK trunk roads, however, in the absence of a skid policy specifically designed for the local roads many Highway Authorities managing local road networks have adopted the HA standard.

In the revised skid policy, there have been significant changes to the site categories and investigatory levels (IL) which in some cases has increased the required skid resistance at various sites. This has had the effect of increasing the length of the local road network that is at or below the IL and requires investigation. With a sudden change in the proportion of the network apparently deficient in terms of skid demand, it is appropriate to question if the investigatory levels identified for trunk roads and motorways in the United Kingdom are appropriate for use on Local roads. Three county councils Cornwall CC, Dorset CC and Somerset CC commissioned WDM Ltd to review the skid resistance requirements on their roads.

2. METHODOLOGY

Each of the County Council's has access to both historical accident data and skid resistance measurements for the whole of their major road network. These datasets provide a unique opportunity to investigate the relationships between accident rate and skid resistance for the South West local roads. An assessment has been applied to each of the SCRIM site categories to determine if the revised investigatory levels are appropriate for the local roads in the South West. Relationships as they exist are displayed as plots of wet accident rate versus skid resistance. Where there is a relationship, regression equations have been developed to determine the optimum investigatory level (IL) for each particular site category. These findings are compared to the IL in HD 28/04 and a comparison carried out between the HD28/04 standard and the IL as recommended in the study.

Routine surveys are undertaken on each of the county council road networks to measure the skid resistance. The results from these measurements, known as the Mean Summer SCRIM Coefficient, MSSC, are compared with the Investigatory levels to decide if a location is complying with the standard or should be investigated because it falls below the investigatory level and, therefore, might contribute to accident rate in the wet. The mean summer value is used because skid resistance will generally be at its lowest during the summer months rising to its highest levels during the winter. The county councils are moving to the Characteristic SCRIM Coefficient (CSC), which is in effect the long term equilibrium MSSC, but 4 years of data will need to be collected before it can be implemented and since the CSC cannot be calculated retrospectively, MSSC values have been used in this study.

Although the same analysis was carried out for each of the county council's each was done separately and the results have been compared.

2.1 DEVELOPING THE VALID DATA SETS

2.1.1 Collating the Accidents into Skid Resistance Bands

To enable the accidents to be plotted against the skid resistance, the MSSC data were put into bands for each site category and the wet accidents occurring in each MSSC band for each site category were grouped together. Thus, even though the x-axis on the plots only has one MSSC value it represents a band as shown in Table 1 below.

Table 1 Bands Used for the Graphs

MSSC value on graphs	MSSC band	
	from	to
0.25		<=0.24
0.27	0.25	0.29
0.32	0.30	0.34
0.37	0.35	0.39
0.42	0.40	0.44
0.47	0.45	0.49
0.52	0.50	0.54
0.57	0.55	0.59
0.62	0.60	0.64
0.67	0.65	0.69
0.72	0.70	0.74
0.75	>=0.75	

2.1.2 Accident Data

Five years of accident data from July 2001 to June 2006 was used for Somerset and Dorset CC but 10 years of accidents were used in Cornwall CC because the maintenance records were complete.

It should be noted that in this analysis there is a strong reliance on the chainages and accuracy of the site categorisation. For instance, approaches to junctions are generally only 50m in length so a relatively small error in the chainage or site category assignment may place the accident in an incorrect site category, although because of the number of data points the allocation is likely to be mostly correct.

2.1.3 Excluding Accidents Due to Maintenance

To ensure that the SCRIM readings were related to the equilibrium skid resistance at the accident sites, only accidents that occurred at least one year after surfacing were included. The 365 days after surfacing was used to give the surface time to settle to its plateau skid resistance level. Accidents were also excluded from the analysis if the site was surveyed less than 365 days after any maintenance.

2.1.4 Accident Rates

As stated above the MSSC for each site category was represented in summary bands of 0.05 MSSC. The wet road accident rate was reported for each summary band in each site category, in terms of accidents per 100 million vehicle km using data from the traffic flow and total length in each category.

3. CORRELATION AND REGRESSION ANALYSIS

Plots of wet accident rate versus skid resistance were produced for each site category for the A class roads, these plots are shown in Figures 1 to 13.

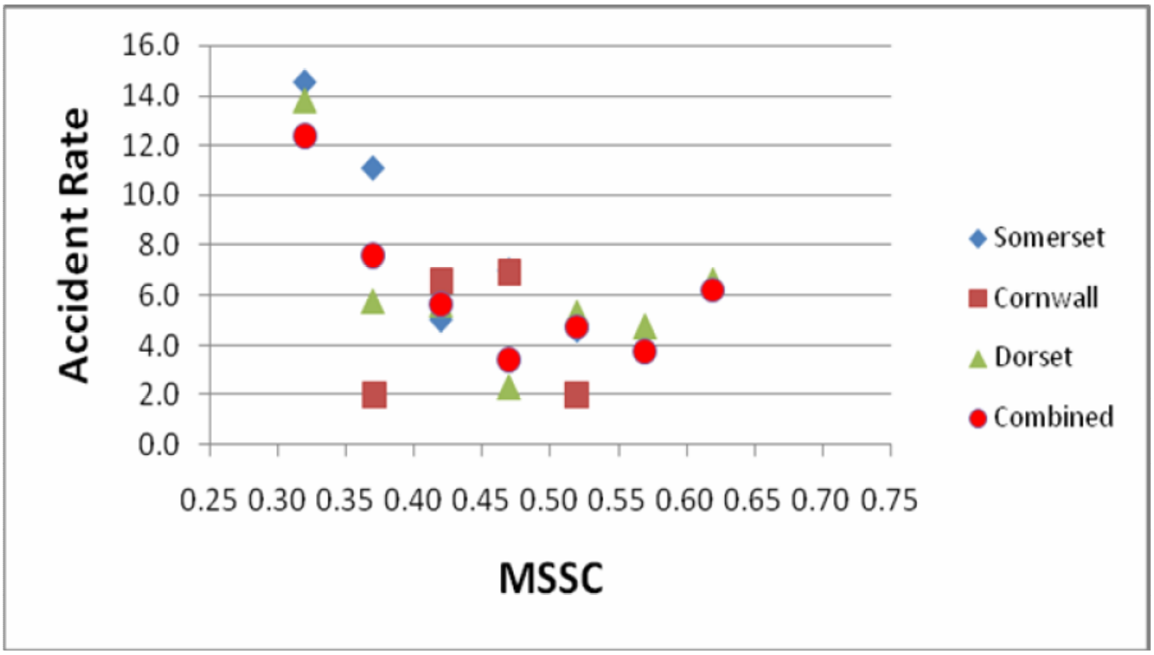
Certain MSSC bands only contained very short lengths of a particular site category and this data can produce anomalous results. To avoid this, the length of the data for any one MSSC band for a site category had to be at least 1km or the length for the band needed to be at least 1% of the total length for the particular site category, whichever is longer.

It was found that on occasions there were sites with high MSSC's that also had high accident rates. This type of result has been observed in many studies. It is usually argued that these are sites that have been considered black spot areas and the maintenance engineer has resurfaced using high PSV stone to obtain an improvement. However, the fact that the accident rate is still high indicates that either, the treatment was inappropriate, because skid resistance was not a major factor in the accidents, or, the treatment has been successful in reducing the crash rate from Very High to Moderately High but that factors other than the road surface still influence the accident rate.

When appropriate a best-fit trend line has been drawn through the points and the Coefficient of Determination (r^2) calculated.

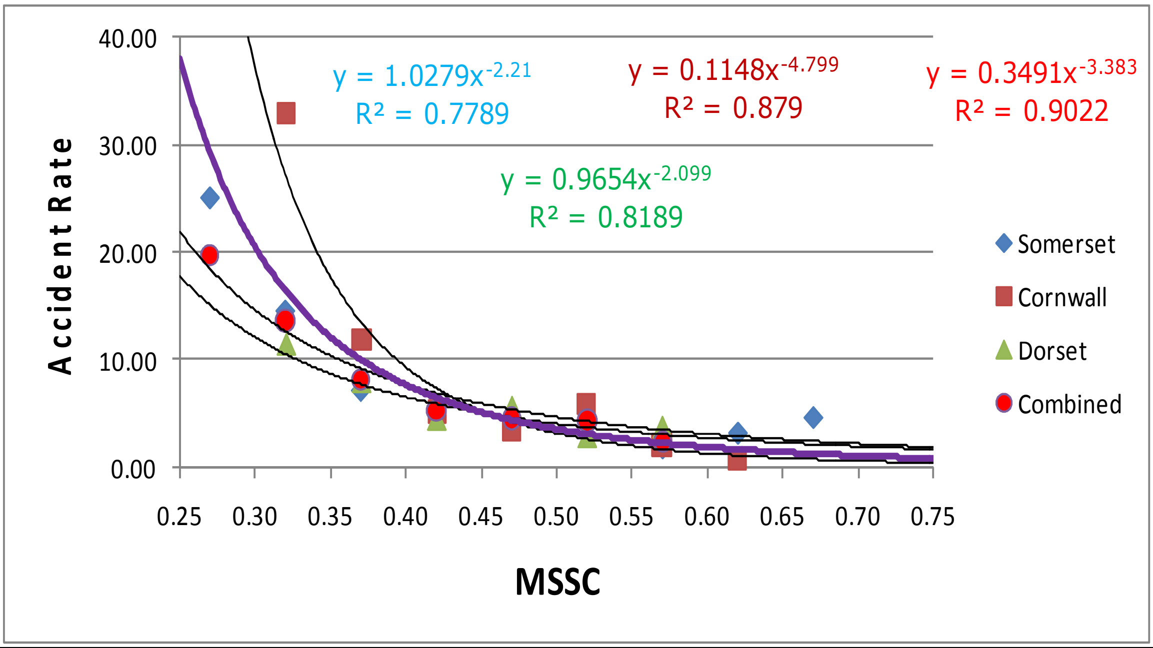
Initially an acceptable background risk in terms of accident rate needed to be established so each site could be compared against this background risk. It is appropriate to select the lowest risk site category as the background. It is generally accepted that dual non event sites present the lowest risk on the local road network. The plot for the dual carriageways for each of the county councils in the study and the combined results are shown in Figure 1. As seen, there is a definite tendency for the accident rate to increase as the skid resistance decreases, but the relationships are very tenuous and there is a relatively small amount of dual carriageway compared to the general network, consequently it was decided to use the single carriageway non event roads which are shown in Figure 2.

Figure 1 Accident Rate Versus Skid Resistance for Dual carriageway Non event Roads



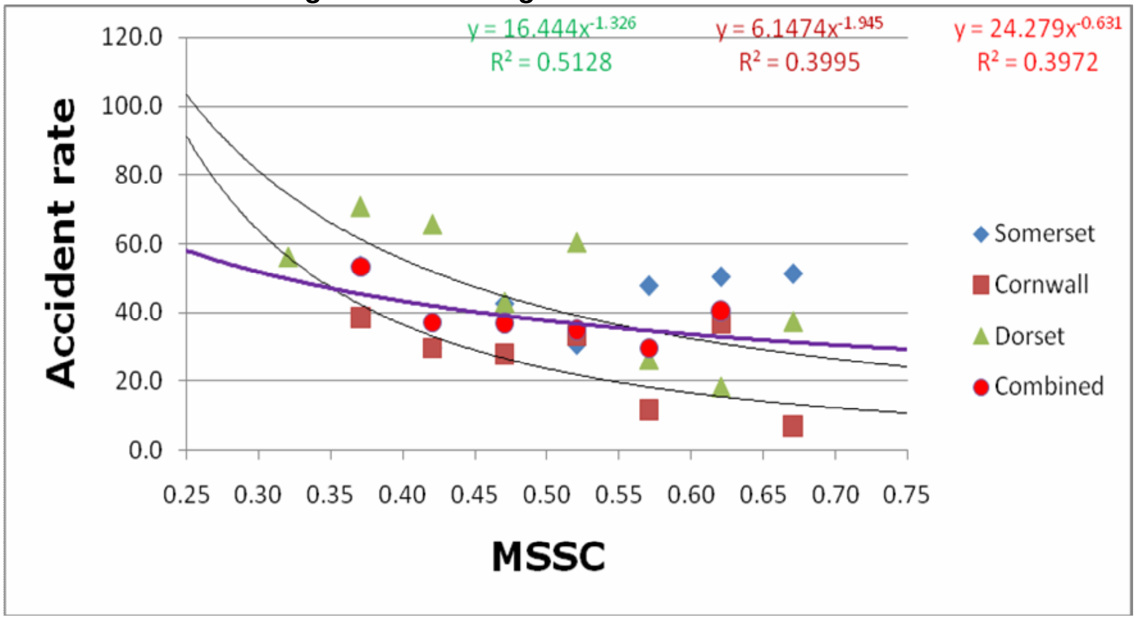
As can be seen from Figure 2 there is a reasonable correlation between the skid resistance and the accident rates for the county councils with the lowest r^2 produced by Somerset of 0.78. Each of the county councils gives similar results. The accident rate at the default investigatory level (IL) of 0.4 is between 6.6 and 9.3 the best correlation occurs when each of the county councils is combined providing an r^2 of 0.90. The accident rate at the default IL for the combined data is 7.7 accidents/Mvkm. Thus, it appears reasonable to make the background accident rate 8.0 Acc/Mvkm.

Figure 2 Accident Rate Versus Skid Resistance for Single carriageway Non event Roads



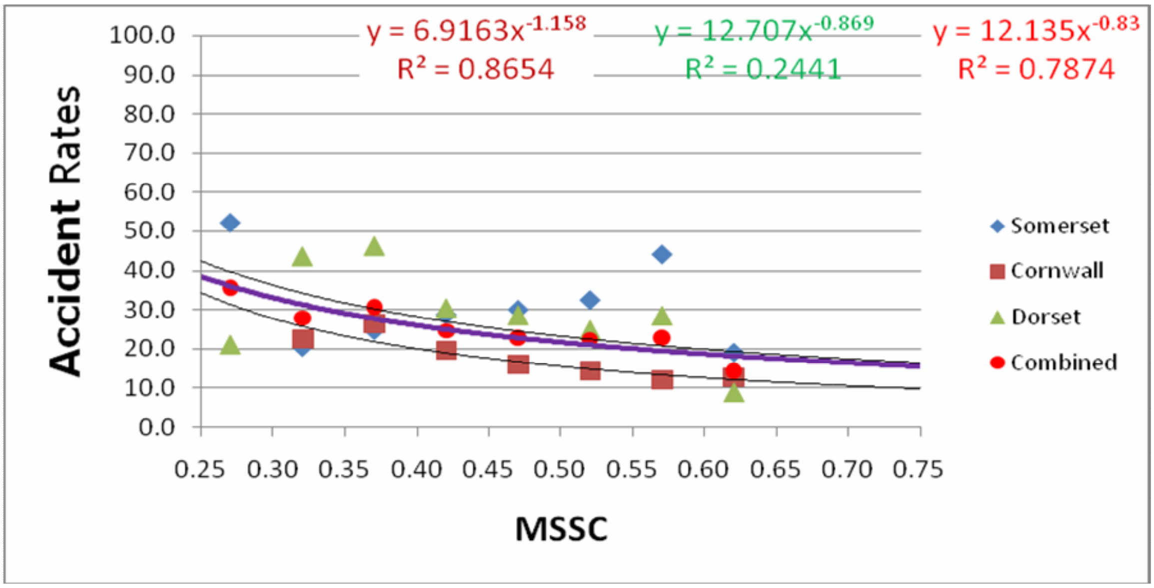
The information for the approach to pedestrian crossing and other high risk places is shown in Figure 3. As seen, there is only a poor correlation between the accident rate and the MSSC with r^2 reading between 0.4 and 0.51. There was no correlation for the Somerset data therefore no trend line has been included. The accident rate is significantly higher than for the non event sites.

Figure 3 Accident Rate Versus Skid Resistance for Approach to Pedestrian Crossings and other High Risk Sites



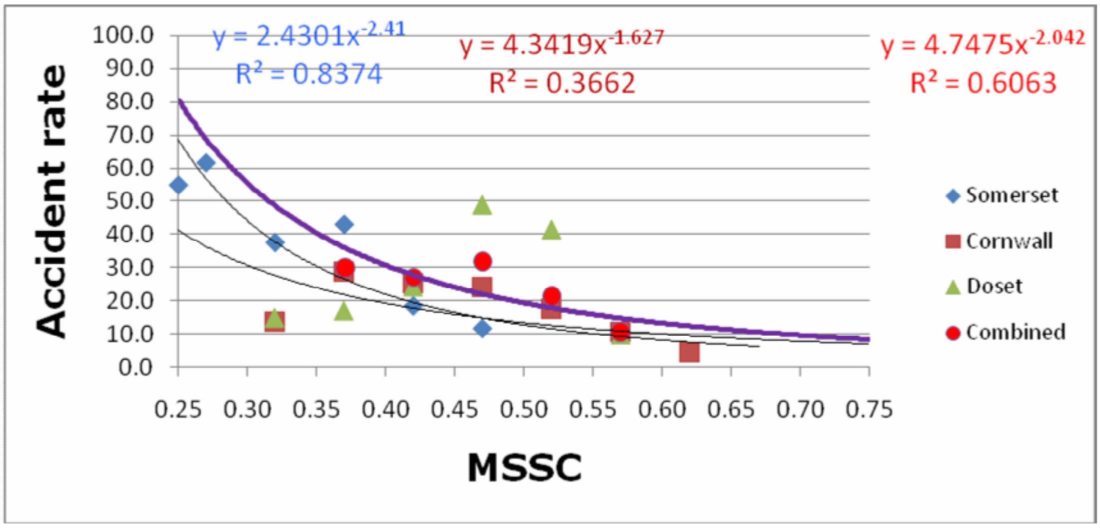
The data for the approach to junctions is shown in Figure 4 There is a good relationship between the accident rate and the skid resistance for Cornwall but not for the other two highway authorities.

Figure 4 Accident Rate Versus Skid Resistance for Approach to Minor and Major Junctions



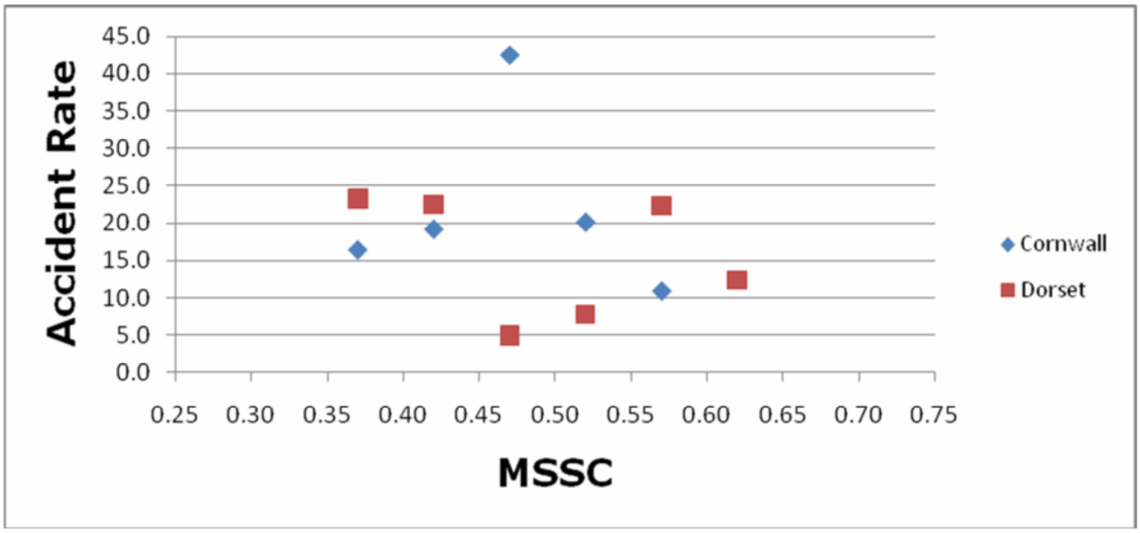
Even though HD28/04 combined the approach to roundabouts with the approach to junctions under the category Q, it was considered worthwhile looking at these sites separately. The results for the approach to roundabouts are shown in Figure 5. The best correlation is from the Somerset data. The accident rate for the approach to roundabout is higher than for the approach to junctions.

Figure 5 Accident Rate Versus Skid Resistance for Approach to Roundabouts



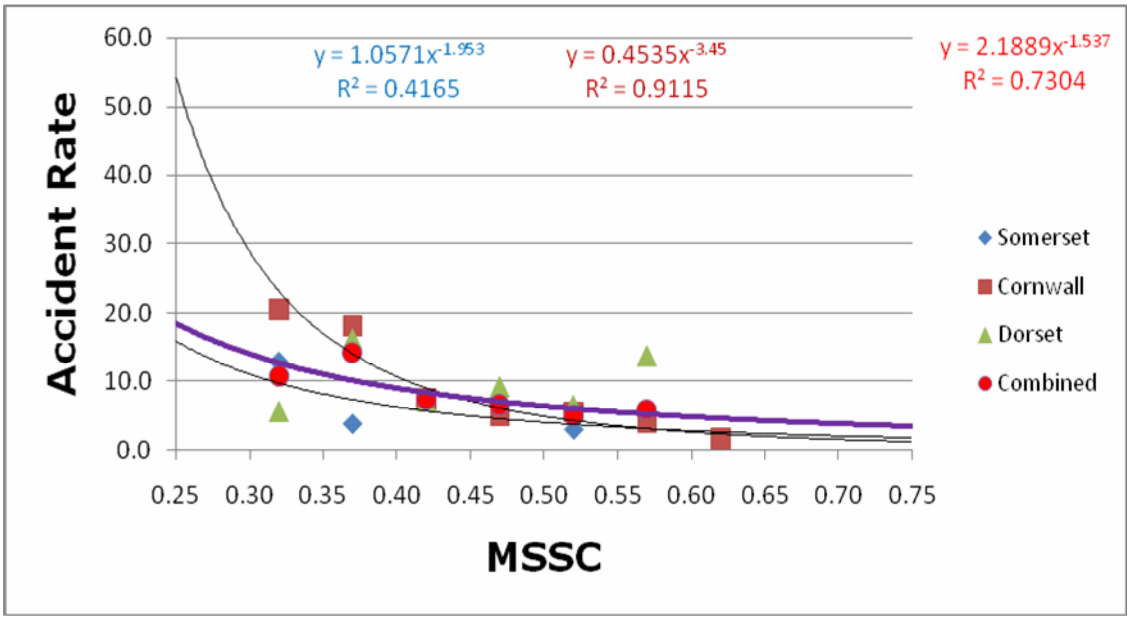
The information for the 10% gradients is shown in Figure 6. As seen there is no correlation for either Cornwall or Dorset. There was only 2.4 metres of 10% gradients in Somerset and no accidents were recorded.

Figure 6 Accident Rate Versus Skid Resistance for Gradients >10%



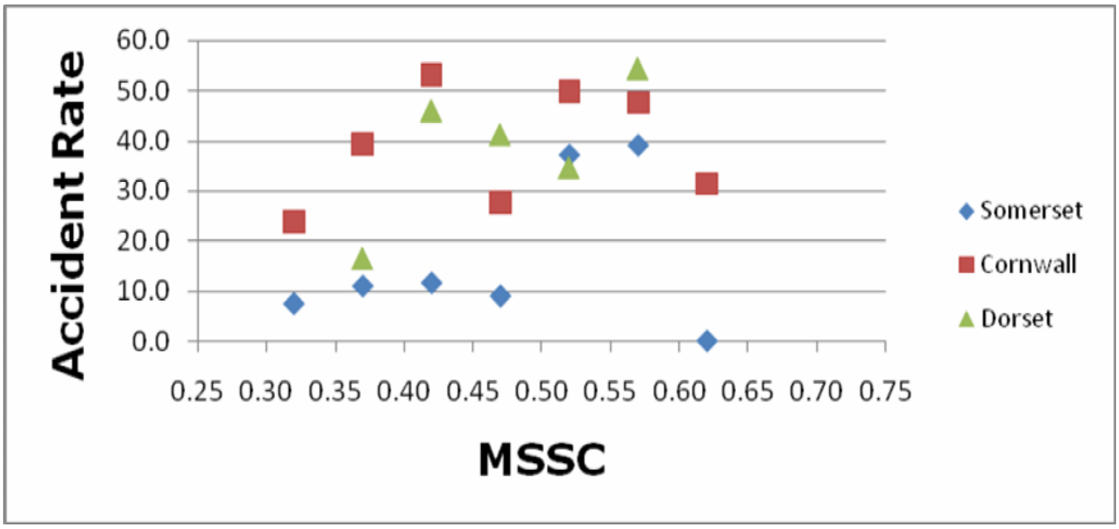
The results for the 5 to 10% gradients are shown in Figure 7. There is a good relationship for the Cornish roads with an r^2 of 0.91 but Somerset gives a poor correlation and there is no correlation at all for Dorset. The combined values provide a reasonable correlation. At the default IL of 0.45 the accident rate is at the target background level.

Figure 7 Accident Rate Versus Skid Resistance for Gradients 5% 10%



The data for the roundabouts is shown in Figure 8. As can be seen there is no correlation for any of the highway authorities. This indicates that there are many variables involved in the wet accidents on roundabouts and that the skid resistance is not a major influence.

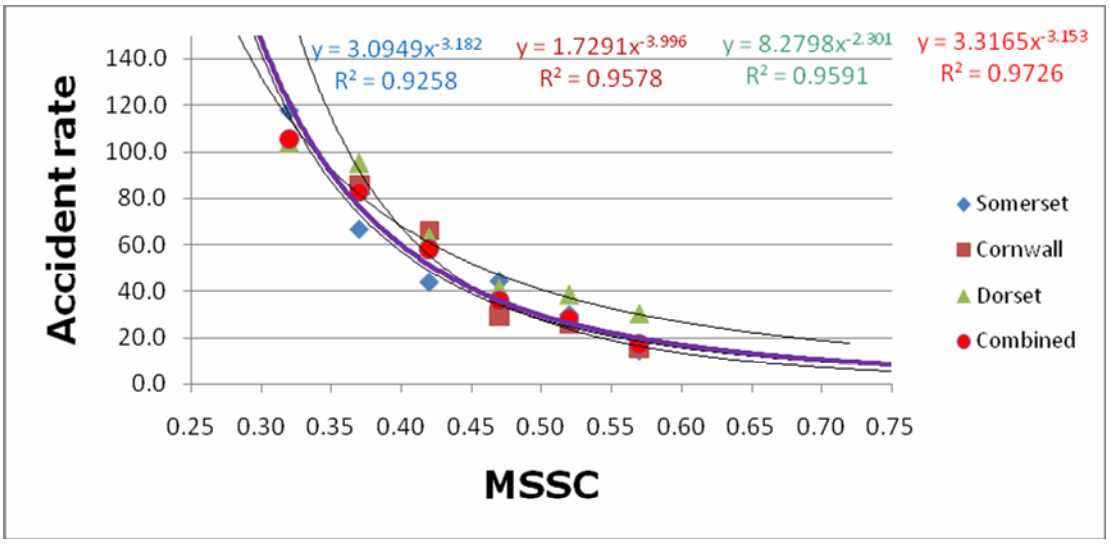
Figure 8 Accident Rate Versus Skid Resistance for Roundabouts



3.1 ACCIDENT RATES ON BENDS

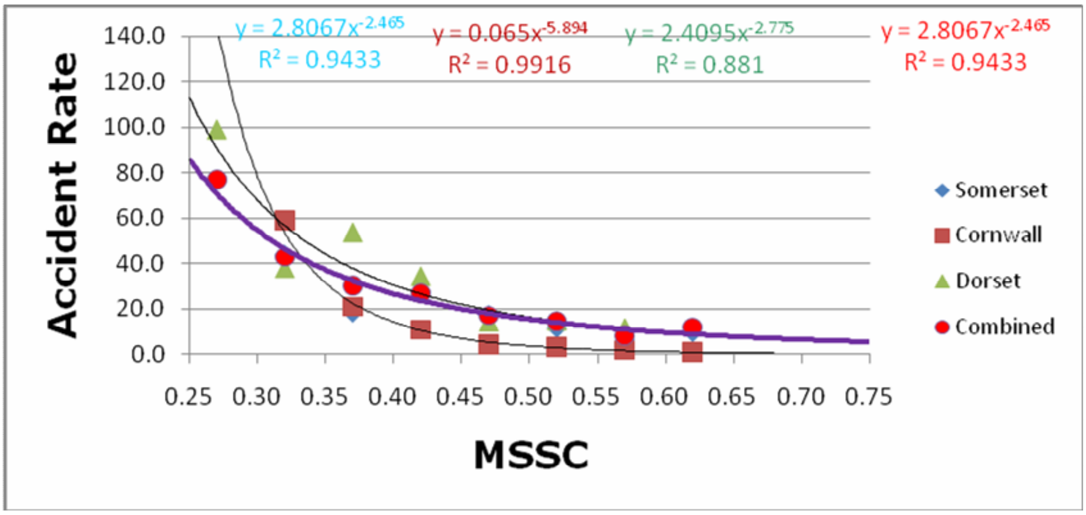
The bends have been analysed in different radii bands viz. <100m; 100m to 250m and 250m to 500m. Figure 9 shows the information for the bends with radii of <100m. As seen, there is a significant correlation for each of the Highway Authorities and all of the curves are very similar. It can also be seen that the accident rates are relatively high.

Figure 9 Accident Rate Versus Skid Resistance for Bends <100m Radii



The information for the bends with radii between 100m and 250m is shown in Figure 10.

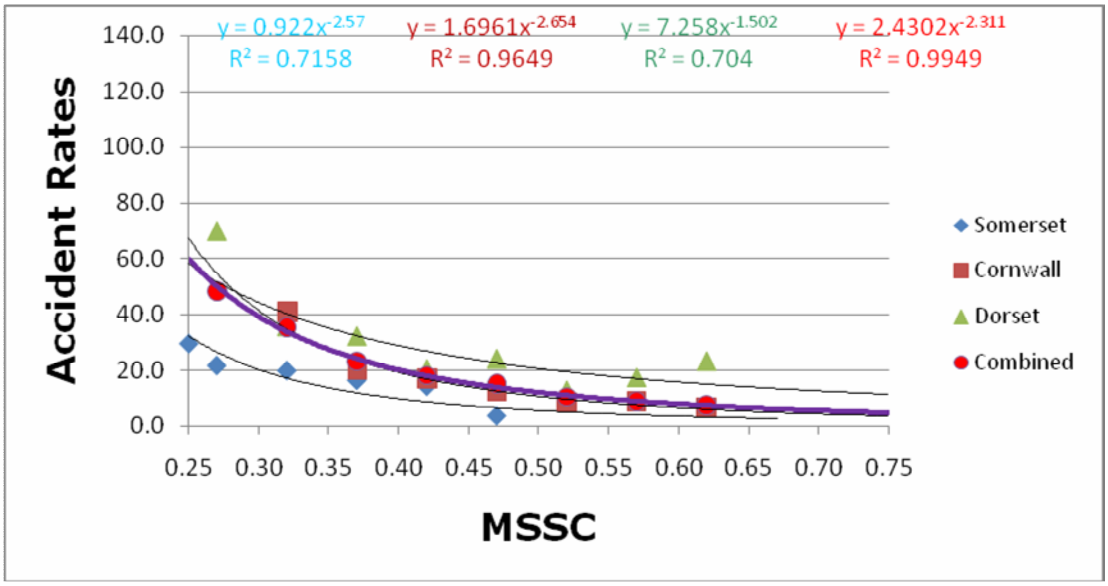
Figure 10 Accident Rate Versus Skid Resistance for Bends with Radii Between 100m and 250m



There was also a significant correlation between the accident rate and the skidding resistance for the bends between 100m and 250m although the accidents rates are lower particularly at the higher skidding resistances.

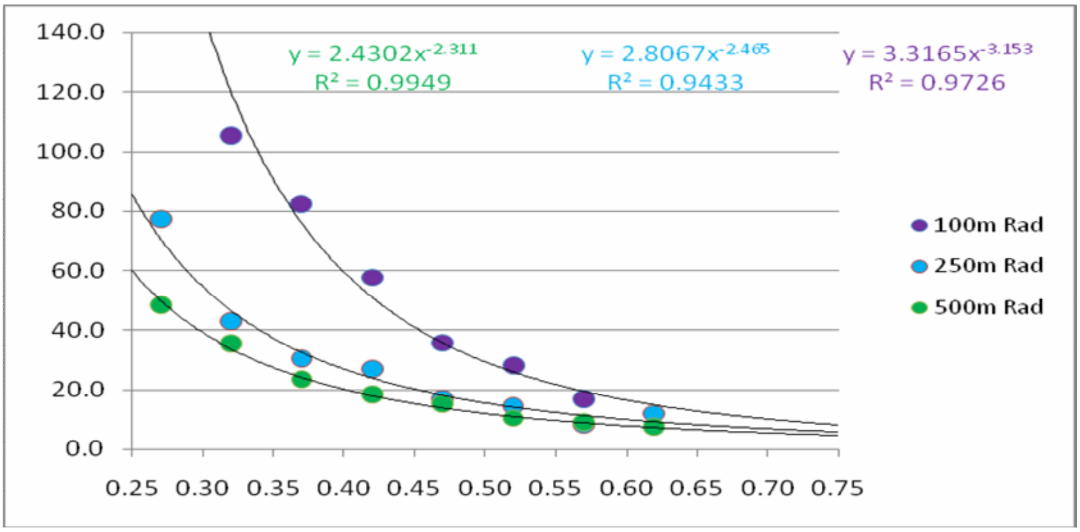
Figure 11 shows the results from the Bends that have radii between 250m and 500m. In this case, the correlation for the bends for Somerset and Dorset is slightly less than for the tighter bends but is still reasonable.

Figure 11 Accident Rate Versus Skid Resistance for Bends with Radii Between 250m and 500m



The accident rate is slightly lower than for bends with the tighter radii, this can be seen more easily in Figure 12. In Figure 12 the combined values for each radius of bend has been plotted on the same graph.

Figure 12 Accident Rate Versus Skid Resistance for Bends with Radii <100m; Between 100m and 250m and between 250m and 500m



It can be clearly seen that the bends with radii <100m have the significantly higher accident rate than the other bends. The bends with radii between 100m to 250m have a slightly higher accident rates than bends with radii between 250m and 500m but the 2 curves tend to merge at skidding resistances > 0.50.

4. DISCUSSION OF RESULTS

The aim of a skid policy is to have a uniform risk of wet skidding accidents across the network. This can be achieved by varying the skid resistance at different site categories to align the skid resistance with the risk. The regression equations from each of the plots of accident rate versus skid resistance, when available, have been used from the combined results to calculate the required skid resistance for each site to meet the background accident rate of 8 are shown in Table 2. Also shown in the table are the IL bands from the new skid resistance standard HD28/04 so they can be compared.

Table 2 Required IL to Meet the Background Accident rate- Calculated fro Regression

Site Category		Calculated from Regression	IL bands from HD28/04 Roads
Q	Approach to Junctions	1.65	0.45 to 0.55
Q	Approach to Roundabouts	0.77	0.04 to 0.55
G1	Gradient 5 to 10%	0.43	0.45 to 0.50
S2*	Bends on radius <100m Single Carriageway	0.76	0.50 to 0.55
S2*	Bends on radius 100m to 250m Single Carriageway	0.65	0.50 to 0.55
S2*	Bends on radius 250m to 500m Single Carriageway (Rural)	0.59	0.50 to 0.55

S2* Selected S2 sites with specific radii not complying with the new HD28/04

As the calculated values show, it would not always be possible to meet the required skid resistance calculated by the regression equation. This is particularly so if the curve is very flat. Therefore, the values calculated from the equation are not necessarily the best practical application. It is the point just before the accident rate starts to accelerate where the IL should be set rather than selecting a point on a plateau. These points have been identified visually and are shown in Table 3.

From Table 3 it can be seen that selecting optimum IL's by estimating when the accident rate starts to accelerate produces values that are consistent with those from HD28/04. However, there does appear to be justification for specifying the tighter bends with radius of <100m separately to the other bend and to specify approaches to roundabouts separately from the approaches to junctions.

Table 3 Required IL to Meet the Background Accident rate- Visual Assessed from the Regression Curves

Site Category		**Calculated from Regression**	**IL bands from HD28/04 Roads**
Q	Approach to Junctions	0.50	0.45 to 0.55
Q	Approach to Roundabouts	0.55	0.04 to 0.55
G1	Gradient 5 to 10%	0.45	0.45 to 0.50
S2*	Bends on radius <100m Single Carriageway	0.55	0.50 to 0.55
S2*	Bends on radius 100m to 250m Single Carriageway	0.50	0.50 to 0.55
S2*	Bends on radius 250m to 500m Single Carriageway (Rural)	0.50	0.50 to 0.55

5. CONCLUSIONS

It was found that a number of site categories gave a positive correlation between the skid resistance and the accident rate for the three highway authorities studied.

A background accident rate of 8 was obtained using the information for the single carriageway non-event sites. Where a correlation between the skid resistance and the accident rate existed, regression equations were used to calculate the IL required to meet the background rate. It was found that the results from this exercise were not practical particularly if the curve was very flat.

As an alternative using a visual evaluation of the curves, a point was identified where the accident rate started to accelerate. This procedure produced a far more practical result and it was found that the required IL's were within the HD28/04 bands for the particular site.

It was also found that there was justification for splitting some sites in particular the bends where it was found that the bends with radii <100m had a higher risk of have wet accidents than bends with larger radii. In addition, it was found that the approaches to roundabout were higher risk than approaches to minor and major junctions and therefore justified having a higher IL.

Three sites did not show any correlation between the skid resistance and the wet accident rates these were approaches to Pedestrian crossings and other high risk situations, Roundabouts and Gradient >10%. In the case of Roundabouts and Pedestrian crossings etc it is likely that there are a large number of factors influencing the wet accidents rate and the skid resistance is not one of the major factors. However, if the ratio of wet to dry accidents is high on a roundabout or on the approach to a pedestrian crossing then consideration should be given to adopting the HD28 for these site categories. For the Gradient >10% there was only a small quantity of data so it could not be considered statistically robust.

ACKNOWLEDGEMENT

The authors wish to pass on their thanks to Cornwall County Council, Dorset County Council and Somerset County Council for allowing their data to be used in this paper.