Wet-weather accidents

What can road authorities do about them?

INSTITUTE FOR ROAD SAFETY RESEARCH SWOV

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The Institute

The Institute for Road Safety Research SWOV was founded in 1962. Its object is, on the basis of scientific research, to supply the authorities with data for measures aiming at promoting road safety. The information obtained from this scientific research is disseminated by SWOV, either as individual publications, or as articles in periodicals or via other communication media.
SWOV's Council consists of representatives of various Ministries, of industry and of leading social institutions.
The Bureau is managed by E.Asmussen, SWOV's Director. Its departments include a.o. Research Co-ordination, Research Services, Pre-crash Research, Crash and Post-crash Research, Methods and Techniques, and Information.

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Foreword

The Institute for Road Safety Research SWOV is conducting large scale research intro traffic hazards in the province of Noord-Brabant for that province's Council and the Minister of Transport and Waterways.
Besides the specific problems in Noord-Brabant, research is also being carried out into more general problems. Use is being made of available knowledge obtained in earlier research by SWOV, from literature studies or from practical experience. One such problem is the occurrence of accidents on wet road surfaces. An interim report on this has already been made. Although the report is focused on the situation as regards Noord-Brabant provincial roads, much of the information is also useful for road authorities in other provinces, since the situation in Noord-Brabant is unlikely to differ much from that in the other provinces of The Netherlands. This is indicated by the number of wet surface accidents as compared with the total number of accidents. This ratio is about the same in Noord-Brabant as in the country as a whole.

These considerations have induced SWOV to publish this booklet, specially intended for road authorities. They are the very ones who can make an effective contribution towards controlling wet weather accidents. The booklet, with the list of recommended literature at the end is intended to assist them in this. Moreover, SWOV at all times welcomes questions or comments from readers.
To keep the booklet readable, extensive scientific arguments supporting the contents have been omitted. Anyone interested in these can find them in a series of three reports: Wet weather accidents I, II and III, SWOV R-79-27, R-79-28 and R-79-29. (Only in Dutch, with English summary)

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Accidents on wet road surfaces: extent and causes

The likelihood of being involved in an accident is over twice as great on a wet road surface as on a dry one. The increased risk is the greatest for private car occupants; on a wet road they are nearly three times as likely to have an accident as on a dry one. Moreover, this road user category has the most casualties on wet road surfaces in absolute terms: 948 car deaths out of a total of 2004 wet weather accident deaths in the years 1974/1976.

Calculation of the risk increasing factor was based on roads being wet 15% of the time.

The higher risk on wet road surfaces is partly explained by vehicles skidding. An extensive study of this subject has been made by the SWOV Working group on 'Tyres, Road Surfaces and Skidding Accidents'.

When there is a film of water on the road, contact between tyre and surface is impeded and there is less friction. This makes it more difficult for a driver to keep his vehicle under control by steering and braking and the accident

Deaths 1974/1976	Pedestrians	Cyclists	Moped riders	Car occupants	Others	Total
Total	1,207	1,424	1,102	3,013	553	7,299
On wet roads	333	329	261	948	133	2,004
Risk-increasing factor	2.2	1.7	1.8	2.6	1.8	2.1

Injured 1974/1976	Pedestrians	Cyclists	Moped riders	Car occupants	Others	Total
Total	19,336	32,497	61,709	62,940	12,005	188,487
On wet roads	4,743	7,562	14,808	21,465	2,629	51,207
Risk increasing factor	1.8	1.7	1.8	2.9	1.6	2.1

risk will increase. Further analyses have shown that the type of road, traffic volume and the proportion of goods vehicles in the overall traffic flow also play a part in wet-weather accidents. But friction has the greatest influence of all.
All factors governing friction between tyre and wet-road surface will influence the occurrence of accidents. These factors are: road-surface quality, vehicle speed, type of tyre, depth of tread and puddle forming due to unevenness, changes in banking, inclines or poor water removal to the verge. The first of these factors – road surface quality – relates to micro and macro road surface roughness. Micro-roughness can be defined as unevenness of 0.1 to 0.5 mm, and macro-roughness from 1 to 20 mm.

The thicker the water film on the road becomes, the less friction there is between tyre and surface. Even with 2 to 3 mm water on the road the available friction is drastically reduced, especially at high vehicle speeds and slight macro roughness of the surface. The other factors then hardly play any role. It is therefore of the *greatest* importance to prevent such films being formed.
If there is only a thin film of water on the road, the friction at low speeds is determined mainly by the micro-roughness of the surface. As speeds increase the friction will decrease, but less so the better the micro roughness is. On road surfaces with inferior macro-roughness, especially the influence of the depth of the tyre tread is an important factor. Water in the contact area between tyre and road surface is then largely expelled via the tread. Hence, the friction may still be great enough. SWOV measurements have shown that about one and a half per cent of private cars in The Netherlands have one or more tyres with a tread less than 1 mm thick (the legal norm). About five per cent have one or more tyres with a tread less than 2 mm.

Once enough friction is available, this is nog guarantee that it is fully utilised. Various additional measures are possible to do this. They may be focused on people (by influencing behaviour by signalling, speed limits and driver training) or on vehicles (by means of effective braking systems with anti-locking devices).

Skidding is one of the major causes of accidents on wet road surfaces.

The road authorities' tasks

The previous section has indicated that road-surface quality is of the greatest importance in controlling skidding accidents. It is the road authority that can directly influence the principal factors governing friction between tyre and road surface. Before the road authority takes action to reduce wet-weather accidents it will have to weigh the cost and benefits against the cost and benefits of other road-safety measures. In order to employ available resources as effectively as possible, its preference will be for measures giving the best cost/benefit ratio. As all the information really needed for such decisions is not actually available, the policy will have to be based on limited data. The first question that has to be answered is whether wet-weather accidents are to form an aspect of policy or not. It is important to know the maximum effect of measures aimed at reducing accidents on wet road surfaces. Basically, it is possible to reduce the accident hazard on wet roads to the level of that on dry ones, so that the total number of accidents can be reduced at most by 12 to 15%. If the road authority decides that wet-weather accidents should form an aspect of its road-safety policy, it will have to set priorities. It can then:

- Establish norms for a number of factors influencing the friction between tyre and wet road-surfaces.
- Trace locations where the number of wet-weather accidents is comparatively high.

Establishing norms

The road authority can establish norms for a number of factors influencing tyre/surface frictions. It can measure the actual condition of a road surface compared with the norm, and can then set priorities. The locations deviating most from the norm quality first for action. The various factors for which the road authority can establish norms are:

- skidding resistance;
- variations in skidding resistance by time and place;
- reduction in friction as speeds increase;
- the thickness of the water film on the road.

At present a guide value exists only for the skidding resistance level, though only for national highways. The minimum level established for these roads is 0.51 in measurements by the Dutch State Road Laboratory method. In 1974, over ten per cent of national highways were found not to meet this minimum standard. If the same norm had applied to the other roads in this country, thirty to forty per cent of them would not have met it. There is unlikely to have been any substantial improvement since then. There are no norms at all for the other factors. The Dutch State Road Laboratory, however, has carried out extensive research into the influence of the depth of the film of water on the road. This showed that tyre/surface friction is already very greatly reduced with a film 2 to 3 mm thick. It is therefore recommended taking steps to ensure that such films of water cannot form.

In establishing norms, the road authority will have to take various aspects of the traffic system into account, such as: safety, smooth flow, comfort, cost and harm to the environment. In order to weigh all these aspects against one another, a system is being developed, known as rational road management. Rational road management is at present in the stage of building a theory and initial experiments. It may take some time before the system is fully operational.

Two approaches are possible in setting priorities by reference to norms. The first is based on the driver's pattern of expectations. If he is able to make certain braking and steering manoeuvres on a good road surface, he will tend to think that he can do the same on other surfaces. Moreover, differences in the quality of various road surfaces are often beyond his powers of observation. In order to meet his pattern of expectations, all road surfaces should in theory have the same uniform characteristics. But in practice, such an approach will be no easy matter.

But one can assume instead that the need to brake and steer is not the same for every category of road and every road section. At intersections, in bends, at other discontinuities and at locations with a poor view, more and bolder manoeuvres will have to be made than on straight stretches of road where the view is unobstructed.

At locations of the first type, the surface properties will have to be better than elsewhere. This is to avoid big concentrations of wet-weather accidents. With this approach, some locations would have to meet higher standards than others.

Tracing locations with a comparatively large number of wet-weather accidents

There may be various causes why a comparatively large number of wet-weather accidents happen at a given location. For instance, at intersections the available friction may be insufficient because a poor view necessitates bolder manoeuvres. Or may be localised puddles form on the surface, for instance where the banking changes. In order to trace the causes, locations with a comparatively large number of accidents must be examined more closely. First of all, skidding resistance data will have to be collected. In addition, visual inspection will be required. This inspection is to establish what circumstances

At intersections, in bends and at places where the view is obstructed good road-surface quality is needed to prevent accidents on wet road surfaces.

obstruct the view, what irregularities there are in the course of the road, bends, exits, bus stops, absence of marking lines, signs or boards and so on. Such things can cause bolder manoeuvres.

Visual inspection should take place during rainfall, so that it can also be ascertained whether there are any puddles on the road. With reference to this information, priorities can be set and it can be decided per location or group of identical locations whether and, if so, what measures are required.

To sum up, the foregoing leads to the following recommendations for the road authority's policy:
In the short term (one or two years) it can trace wet-weather black spots. The criterion could be the number of wet-weather accidents as compared with the total number of accidents. This would allow precisely those places to be dealt with where many wet-weather accidents happen. As this relates to a small part of the roads system, the cost will be comparatively low.
In the medium-term (three to five years) it can examine whether the information gained in the short-term approach lends itself for drawing general conclusions. By reference to this it can trace locations where greater concentrations of accidents are likely in the future.

Furthermore, it should chart road sections with the skidding resistance qualifications 'dangerous', 'very slippery' and 'slippery'. It can at the same time examine the resistance of adjoining road sections and locations where skidding resistance greatly decreases in successive years. Parallel to this it can chart locations with thick films of water during rainfall (2 to 3 mm). With the aid of all this information it can draw up a list of priorities.
In the long term (five to ten years) the road authority can derive the benefits of rational road management. In weighing objective criteria of safety, comfort, smooth traffic flow and environment, norms are established for a number of factors influencing tyre/surface friction. If the actual situation is compared with the norms, it can be examined which locations qualify for action first.

What action can the road authority take?

The road authority can take steps to prevent accidents or reduce their severity. Measures reducing their severity are not specifically effective while the road surface is wet. Guiderail structures, impact attenuators, yielding lighting columns and so on function with accidents on dry surfaces as well. The greatest effect can thus be expected from accident-prevention measures.

Poor visibility through falling and splashing water, glare from reflected sunshine or headlamps, poorer visibility of road markings and a reduction in frictional forces between tyre and road surface are factors that may contribute to wet-weather accidents. Both during and after rainfall, these factors are influenced adversely by the thickness of the film of water on the road surface. The road authority is responsible for designing, paving and maintaining a road so that puddle-forming is avoided as far as possible. Where this is unavoidable, measures must be taken to keep any adverse effects to a minimum.

Road design

The road designer's responsibility comprises road geometry (track, longitudinal and cross sections), and also provision of information to road users. In order to avoid wet-weather accidents as fully as possible, the road designer will have to watch a number of points.

Geometry

The road designer must aim at not causing road users to make sudden steering movements or reduce their speeds suddenly. Places where road users often have to apply their brakes are: intersections, exit lanes, places where there are regularly queues. It should be avoided siting such locations in bends or on downward inclines, because braking at such points requires greater frictional forces, whereas those available are in fact slighter. Continuous water films on the surface must be prevented especially at places where road users often have to brake or steer. This demands a good combination of longitudinal and transverse gradients, for instance where the banking changes. It must not be possible for the wind to build up water at such places. Nor must water removal be impeded by the thermoplastic markings.

Providing information

Poorer visibility and glare often form impediments to road users driving on wet roads. In these circumstances good information on the design of the road is very important, especially at discontinuities (bends, ungraded intersections, and so on).
Information provided by clear boards, signs and markings enables the user to predict the situation ahead. This will often enable sudden braking or steering to be avoided.

The presence of water on the road not only reduces available friction, but splashing water may also greatly reduce visibility.

Road pavement

Given the road geometry (track, longitudinal and cross sections) a number of areas requiring the attention of the pavement designer can be indicated. A good choice of materials will ensure that no water films occur, or that their thickness remains limited.
In addition, the pavement surface can be provided with such micro and macro-roughness that the adverse effects of any water film there may still be on tyre/surface friction are kept to a minimum.

Porous asphaltic concrete

The best solution of all is to avoid any water film whatever, however thick. This is possible if the water falling on the pavement is disposed of straight through the surface and stored in the upper pavement layer. This requires a top layer with a very high proportion of cavities. If the water is to be removed through the layer to the verge the cavities must have open access to one another.
There is a bituminous paving material that meets these requirements.
It is usually known as porous asphaltic concrete.

In The Netherlands this material has been tested mainly at the instigation of the Road Construction Research Centre SCW and the State Road Laboratory. Their conclusion was that porous asphaltic concrete is a material that can be widely used to control water nuisance. This relates not only to the forces that can be transferred between

Thick water films may be formed in ruts and greatly impede contact between tyre and road surface.

tyre and road surface. But in particular the huge reduction in nuisance due to splash and spray and the relatively good reflective properties in rainy weather should be mentioned.
As against these favourable aspects, however, there are several drawbacks. For instance, the cavities gradually get clogged with dust, sand, dirt and oil residues. This reduces drainage properties, but hardly affects the frictional forces between tyre and road surface. Another problem is wintertime measures against icing. Especially when it is snowing, a road section with a porous asphaltic concrete top layer demands extra attention.
In many cases where there is or may be water nuisance, the use of porous asphaltic concrete should nevertheless be considered. Construction costs will be barely higher than for the asphaltic concrete mixes generally used.

Choice of mix with a view to rutting

When the customary paving materials are used a continuous water film will inevitably form during or shortly after rainfall.
The designer can limit the thickness of this film the moment he makes a selection from the available materials. This choice has great influence on the speed and extent to which ruts will form. It is particularly in these ruts that very thick water films often form. With a rut depth of 17 mm and a transverse gradient of 2.5 per cent, the thickness of the water film in the rut is theoretically 5 to 6 mm! Such a film greatly reduces tyre/surface friction. (A rut of 17 mm is about the limit permitted for national highways; a transverse gradient of 2.5 per cent is prescribed for new roads).
Limitation of rutting and hence water nuisance necessitates, among other things, more stable asphaltic concrete mixes or even cement concrete mixes.

Macro roughness of the pavement surface

In The Netherlands, the texture depth is usually taken as a measure of macro-roughness of a pavement surface. This is the mean depth of the cavities between the road surface unevennesses. As this texture depth increases, the water film on the pavement surface becomes thinner, though not much. This is not the main argument, therefore, to aim at great texture depth in composing the mix for the top layer. Of much greater importance is the fact that the system of channels this brings about can ensure rapid removal of water from the contact area between tyre and road surface. When most of the water has been removed from this area, a very thin film of water will remain between the rubber of the tyre and the grit on the pavement surface. In this event, the extent of the frictional forces between tyre and road surface is determined mainly by the energy losses occurring by compression and re-expansion of the rubber of the tyre: known as hysteresis. Hysteresis increases the greater the texture depth is.
Measurements by the State Road Laboratory show that the frictional forces between a tyre and a wet road surface are greater at all speeds and at practically every water-film thickness the more the texture depth increases.

Micro roughness of the pavement surface

The extremely thin water film that may still exist on the pavement even with good macro roughness can be broken by small sharp points in the surface. The points will penetrate into the tyre's rubber tread and adhesive forces can thus be transferred between tyre and surface.
The choice of stone materials for the top layer must also take into account the decrease in surface rougnness through the polishing effect of traffic.

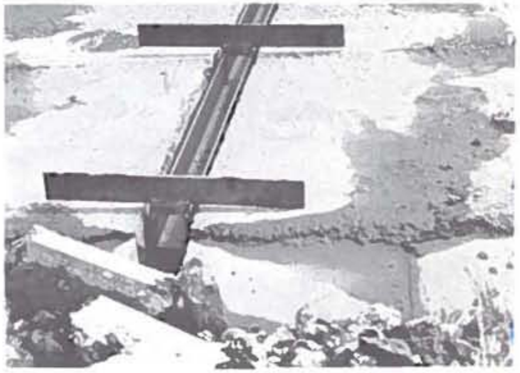
Obviously, measures for new roads should firstly be considered for locations where road users are likely to have to brake and steer often. In the case of road sections being reconstructed, the main attention must be paid to locations where there have already been wet-weather accidents.

Road maintenance

For new or reconstructed roads the latest knowledge on road design and pavement technology can be taken into account both in the geometry and in designing the pavement structure. Most of the Netherlands' existing roads will not be in conformity with this latest knowledge. If imperfections in road geometry and construction and composition of the pavement structure affect the user's road safety, these imperfections will have to be remedied by the road authority. The road authority need not be empty-handed in controlling water nuisance on road surfaces. A number of measures will now be reviewed.

Eliminating ruts

If the water nuisance is caused by ruts, the following action can be considerd.
1. *Filling*. A major requirement for the materials is that the road surface must be skid-resistant even at high speeds. Non-textured or sealed surface materials do not satisfy this requirement when road surfaces are wet.
2. *Planing the surface*. This increasingly popular measure is possible if the pavement has enough bearing capacity and is still constructionally sound. But it should be remembered that rutting will continue again afterwards.
3. *Applying a new top layer*. If the pavement is not only uneven but has structural defects as well, a new top layer is applied in many cases. As the new layer is not uniformly thick and the traffic load is not the same throughout the cross-section, unevenness may reappear very soon after the new surface is applied. This depends on the stability of the paving material, both of the new top layer and of the pavement structure under it. If the pavement is planed before the new top layer is applied, it will take longer for the surface to become uneven again. It might also be considered machining away the old top layer altogether.



Transverse discharge channels ensure good water removal to the verge, especially at torsion sections. A slot is made in the road surface and is partly filled with a slurry of synthetic resin. A steel U-channel is fixed in this. The transverse strips on the sectional steel enable them to be fitted accurately; they are removed after placing. The gutters do not perceptibly interfere with traffic.

Making transverse discharge channels

If water nuisance arises through flowing away along lines roughly parallel to the road axis, i.e. over a great length, transverse discharge channels may provide the answer.
Provided they are made carefully, their construction need cause no problems. The cost is very acceptable. If they are well designed, there is little perceptible interference with traffic; so far no effect similar to that of expansion strips on bridges has been observed. The channels will have to be cleaned regularly in order to function properly.

Improving macro-roughness

If a pavement surface has no constructional defects but lacks enough macro-roughness, various measures may be considered.

Cutting transverse grooves is one way. Besides increasing frictional forces between tyre and road surface, this improves the reflecting properties of (wet) pavement surfaces. The effective life of these grooves in asphaltic concrete is very brief. Especially with high traffic volumes and if the mix contains few large stones. The life of these grooves is, of course, much longer if they are made in a cement-concrete pavement.

(Longitudinal grooves will also increase friction between tyre and road surface. They are cheaper to make than transverse grooves. Yet this solution is not recommended because of the adverse effects on motor cyclists' riding behaviour.)

Transverse grooves not only improve the macro-roughness of a road surface, they also improve reflection. But they do not last long in asphaltic concrete mixtures.

As stated earlier, porous asphaltic concrete prevents continuous water films forming on the pavement surface. Besides which, it provides the surface with good macro-roughness. This latter effect can probably also be obtained with thinner layers (2 to 3 cm) of porous asphaltic concrete. Experiments are at present being made with this.

A measure much better known than the previous two is surface treatment. First of all, mainly for cost considerations, attention is given to treatment with a bituminous bonding agent. This is being widely used. But if not carefully done, or if the weather suddenly changes, this surface treatment may be a complete failure. Immediately after it is applied, moreover, pebbles that are not properly bonded cause the danger of shattered windscreens. Another drawback is that the effective life of this surface treatment may be greatly reduced by long periods of high temperatures.
Using synthetic resin as a bonding agent disposes of some of these drawbacks. Especially when a stone material with a high polishing value is used, permanently rough, sharp texture is obtained. Because of the high cost of surface treatment with synthetic resin as a bonding agent, its use will be limited for the time being to carefully selected road situations. Intersection surfaces of traffic arteries, for instance.

Information

Information on and along the road requires constant servicing so that, especially when weather and lighting conditions are poor, good visibility of the boards and signs is guaranteed. Regular repair and cleaning is necessary. Markings have an important traffic guidance function especially in poor lighting and weather conditions. The use of thermoplastic marking materials is intended to make markings clearly visible even when road surfaces are wet. Care must be taken that the markings do not interfere with rainwater removal. A large amount of water is liable to accumulate especially on longitudinal inclines along such markings, which flows down the incline. At such places, therefore, the marking should consist of painted strips, unless the thermoplastic is interrupted at regular intervals. Regular road inspection during rainfall or shortly after is necessary to detect such places. Such inspection is recommended for other reasons as well. It enables places to be traced where water remains unnecessarily on the pavement. For example, deep ruts, verges that are too high, longitudinal and transverse seams not made with due care, and so on.

Accident control on existing roads

Accident control on existing roads when the surface is wet can be illustrated from a strategy developed by the Provincial Public Works Department of Noord-Brabant. The short term objective is to improve road sections where there have been a comparatively large number of wet-weather accidents in the recent past. Based on an inspection at these locations, combined with skidding-resistance data, measures have been recommended. Detection of these locations was limited to provincial roads outside built-up areas. As regards provincial roads inside built-up areas, no skidding resistance data are available, besides which the problems are more complicated.
Long term policy is aimed at tracing and improving road sections where there are at present few, if any, wet weather accidents but are likely in the future.

The short term

In order to trace locations that are comparatively dangerous in wet weather, a computer was used to find locations where there had been a wet-weather accident in 1976 (the last year for which information is available). From each such place, road sections with a fixed length of 2 kilometres were plotted. It was next ascertained how many accidents had happened on wet

road surfaces in each such section. In order to eliminate chance influential factors as fully as possible, only sections with four or more wet-weather accidents were selected. To avoid distorting the picture, it was moreover checked how many of such accidents had occurred at intersections. The following quotient was determined from the road sections selected in this way: wet-weather accidents / dry + wet-weather accidents. Based on this quotient and the absolute number of wet-weather accidents, the road sections were then classified in danger categories A to F. The least dangerous categories, E and F, were disregarded for the time being. As to those in categories A to D in 1976, it was examined which categories they were in 1975 and in 1974. The road sections in categories A to D in each of the three years formed a final selection of twelve road sections qualifying for inspection.
By taking the lower limit for the absolute number of wet weather accidents as four, a consistent pattern was obtained for the period 1974 to 1976. If the minimum had been put at three or less, statistical reliability would have been slighter.

The twelve locations ultimately selected were inspected in November 1978, attention being paid to the following characteristics:
– type of pavement; its condition; skidding-resistance level;
– water removal;
– traffic volume and flow;
– discontinuities (intersections, exits, bus stops);
– circumstances obstructing the view.

In nearly all cases a combination of various adverse characteristics was found. The conclusion was that wet-weather accidents happen especially at locations which put road users at risk even in good weather and when the surface is dry.

That the method employed is highly selective is evident from the fact that the selected road sections represent only a very low percentage of the total road-length investigated, though about one third of all wet weather accidents occur there.

The medium term

In order to trace road sections where there are still few, if any, wet weather accidents, but are likely in the future, norms would have to be available for the following friction related factors:
– skidding resistance;
– variations in this by time and place;
– decrease in friction at increasing speeds;
– thickness of the water film on the road.

As no norms have been established for any of these factors for provincial roads and as research into them will not produce any results in the immediate future, a pragmatic approach must be chosen at this moment. Lists can be drawn up, with the help of skidding-resistance reports, of road sections not meeting the skidding-resistance norm for national highways (0.51). For these sections, the traffic volumes, quotient of wet weather and dry + wet-weather accidents and also pavement type are next ascertained. A classification can be made for each of these characteristics, each category being given a numerical rating.
A category rating is established for each road section, which is multiplied by a weighting factor. The resulting figures are totalled for each road section. That given the highest rating qualifies first for improvement.

It should be added that the Provincial Public Works Department of Noord-Brabant has been conducting an experiment since 1976, in which skidding resistance deterioration of various pavements is examined at various volumes. Furthermore, the locations where resistance measurements are made will have to be mapped.

Depending on the volume and the trend of skidding resistance, preventive action can then be taken. This approach is now in the preparatory stage.

In the future, a fifth characteristic is to be added: the thickness of the surface water film. As data on this factor will take some time to collect, it has been disregarded for the time being. Meanwhile the necessary information is being collected by the service engineers who, after all, know their road sections better than anyone else.

The following classification can be used for *skidding resistance*:

0.46 – 0.50	category 1
0.41 – 0.45	category 2
0.36 – 0.40	category 3
<0.36	category 4

For *traffic volume* (per day):

<5000	category 1
5,001 – 6,000	category 2
6,001 – 7,000	category 3
7,001 – 8,000	category 4
8,001 – 9,000	category 5
9,001 – 10,000	category 6
>10,000	category 7

For the *accident quotient*, categories A to F can be used as in the preceding section, figures now being substituted for letters:

category F becomes category 1
category E becomes category 2
category D becomes category 3
category C becomes category 4
category B becomes category 5
category A becomes category 6

The following categories can be used for *pavement types*:

concrete	category 1
asphalt	category 2
paving bricks	category 3
setts	category 4

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