APPLICATION OF KNOWLEDGE OF PAVEMENT SURFACE PROPERTIES IN FRANCE

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GENERAL

Improved highway safety is a priority objective of highway officials in France. An attempt is made to take into account any improvement in knowledge in order to determine the operational action necessary to enhance highway safety, whether it be relative to the vehicle, the driver or the facility. With regards to the prevention of skidding accidents due to the surface properties of the pavement, it is necessary to distinguish between the case of general network sections and the case of accident-prone areas.

Application in the Case of General Network Sections

On the highway network it is important to avoid to the extent possible any relatively long sections on which the skid-resistant properties of the pavement are insufficient. These sections are determined by means of the side force coefficient routine investigation machine (SCRIM apparatus, developed in England, which every year examines 6,000 km of pavements out of France's 30,000 km of national highway network (Fig. 1). The following statistical data have been obtained:

	On Motorways	On national highways
Average of SFC	0.60	0.64
Standard deviation	0.11	0.13
Percentage < 0.50	16%	9%
Percentage > 0.70	21%	32%

The results are generally slightly lower on motorways because until recent years very few surface dressings were applied on them. It is these pavement surfaces which offer the best skid-resistant properties.

More recently on freeways the investigation is being completed by the passage of a gyroscopie apparatus (GYROS) which makes it possible to measure the yaw, roll, and pitch angles and to calculate by a computer program the "water height coefficients" (1). By the combination of the SCRIM and GYROS investigation methods, we are in a position to determine the sections which exhibit either low friction coefficient values or points favoring accumulation of water heights such that, regardless of pavement friction properties, a major risk of accident due to skidding is involved (Fig. 2).

We have also endeavored to use techniques making it possible to obtain surface layers exhibiting very high geometrical roughness. The following are among the techniques employed:

1. Requirements have been introduced regarding the polished stone value (PSV) which, leads in particular to the prohibition of the use of limestone aggregates. In order to obtain high geometrical roughness and to control rutting in bituminous concretes, we have developed "granular" formulations characterized as follows:

High proportion of stone (65% of 2/10 mm in bituminous concrete).

Exclusive use of crushed materials.

Use of hard bitumens (60/70 or 40/50 penetration).

These formulations require very thorough compaction to obtain a satisfactory density. Composition characteristics, manufacturing method, and placement are covered by very strict regulations which must be complied with by contractors.

2. Since pavements exhibiting the greatest geometrical roughness are those with surface dressings, it is considered necessary to improve this technique so that they may be applied even on the most highly traveled roads (Fig. 3). This has been made possible by improved binders, very strict selection of aggregates, and improvement and supervision of placing equipment. At the present time these surface dressings are applied on French national roads and freeways, including concrete paved freeways.

3. For cement concrete pavements deep grooving has now replaced the former simple grooving. These techniques are now applied during construction and maintenance work, and it is thus possible to observe a gradual improvement in the degree of skidding resistance offered by French pavements on the general network.

Application to Accident-Prone Areas

Skidding accident-prone areas are those in which a large number of skidding accidents occur. However, the occurrence of a large number of accidents does not necessarily indicate low skid-resistant properties but may be related to surrounding conditions (alignment, configuration, etc.) that require very high skid-resistant surfaces.

The detection of accident-prone areas, which cannot be investigated along general network sections, is carried out on the basis of bodily injury records. A data processing progam makes it possible to analyze the ratio of the number of accidents on wet pavements divided by the total number of accidents. It is then possible to determine the areas in which this ratio takes on an abnormally high value, thereby enabline a predominant role to be assigned to skidding. A systematic study of the "skidding ratio" carried out in connection with a weather study, has made it possible to establish that generally in France 26% of total accidents take place on wet pavements, whereas the pavements are wet only about 14% of the time (rain representing only 7% of the time).

Once the areas in which the skidding ratio is abnormally high have been determined, a detailed study of these areas is carried out using a multidisciplinary approach involving human-engineering specialists, psychologists, highway engineers, vehicle dynamics specialists, etc.. It is thus possible to diagnose the problem and propose the right treatment (Fig. 4). The treatment may be a geometrical improvement (rectification of curves, modification of intersections, etc.), modification of the highway environment (signposting, etc.), or the application of a special skid-resistant surface.

Figure 1. Systematic investigation of the network with the SCRIM apparatus (SFC versus number of measurements).

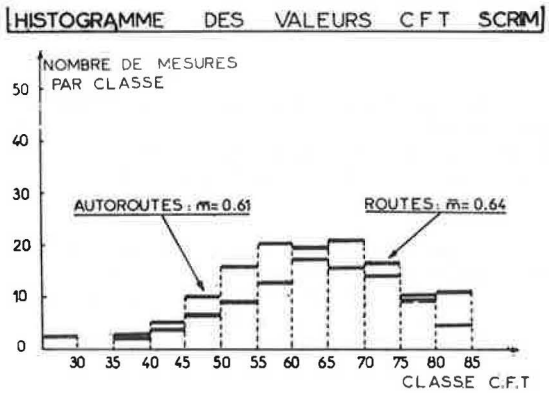

Figure 2. Points requiring correction due to accumulation of water.

Figure 3. Example of rough textured surface dressing.

Figure 4. Correction of slippery sites: (top) before treatment and (bottom) after treatment.

Skid-resistant surfaces are available. They make use of special binders, in most cases epoxy or polyurethane resins, and natural aggregates which either have very good accelerated polishing characteristics and hardness, or artificial aggregates such as bauxite or calcined bauxite.

It has thus been observed that following improvements on these accident-prone areas the percentage of accidents on wet pavements was reduced from 75% to 20% and the annual number of victims was reduced to approximately one fourth with an accompanying reduction in accident severity.

REFERENCES

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APPLICATION OF KNOWLEDGE OF PAVEMENT SURFACE PROPERTIES IN GERMANY

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Apart from initial activities before World War II, skid resistance measurements have been carried out in the Federal Republic of Germany since the end of the fifties. Since that time we have used a locked wheel testing machine (Fig. 1). Those members of this audience who participated in the 1962 skid correlation tests at Tappahannock, Virginia, are familiar with this machine which we call the "Stuttgart" apparatus. Since that time the machine and the auxilliary equipment have been much improved. Today five test vehicles with a Stuttgart apparatus are in use, two of them are operated by the Federal Road Institute at Cologne, one each is employed by the Technical Universities of Stuttgart and Berlin, and one is owned by the State of Bavaria.

To provide skid-resistant surfaces there are three principal directions of work:

1. Examination of newly laid surfacings before opening to traffic.
2. Accumulation and application of experience with regionally standardized mix compositions.
3. Systematic evaluation of the accident statistics with regard to wet weather accidents.

I would like to say a few words on each of these points.

Examination Of Newly Laid Surfacings

Most of the difficulties experienced with insufficient skid-resistant highways in recent years occurred with newly laid surfacings. In this case low resistance to skidding is caused primarily by a lack of microtexture rather than a lack of macrotexture. For instance, a newly laid asphaltic concrete surfacing can fail to offer a harsh microtexture due to excess binder accumulated at the top of the layer during rolling. This behavior has been observed primarily with mix compositions rich in binder and mortar which were designed to offer a high resistance to studded tire wear. As another example, newly laid cement concrete pavements offer slippery surfaces when wet due to insufficient treatment of the fresh concrete surface.

In all these cases the characteristic feature of the friction number versus speed relationship is that friction numbers are low even at low speed (Fig. 2). To identify slippery surfaces of this type it is not necessary to use full scale machines which are able to measure at speeds of say 60 or 80 km/h. It is sufficient to use the portable pendulum type skid tester developed in Britain. Pendulum measuring at low speed is comparatively inexpensive and readily available. With these advantages in mind a program was started in the Federal Republic of Germany in 1972 to implement the wide-spread use of the pendulum tester as a first aid in identifying slippery pavements. Under a special scheme the Federal Road Institute at Cologne has taken the responsibility for regularly checking and calibrating the instruments in use throughout the country.

Accumulation Of Experience

Road construction in the southern and western parts of the Federal Republic of Germany relies on the availability of good quality natural road stone, whereas the northern parts must depend upon road stones imported mainly from Scandinavia and Ireland. As a consequence of these regional differences there is much effort placed towards regional standardization of mix compositions with regard to skid resistance as well as with regard to other quality requirements. Among these efforts repeated skid resistance measurements with the locked wheel braking force machine are performed at least twice a year and at speeds up to 120 km/h. This forms a major part of a research program which has been continued since the early sixties. In order to select the most promising alternatives, this program incorporates selected individual pavements of typical mix composition for the region as well as experimental sections with a sequence of 5 to 10 alternatives in mix composition or surface treatment. Much regionally and generally valid experience has been and is still being gathered in this way, and this enables the highway authorities and the road contractors to achieve pavements with long lasting anti-skid properties. In this context limestone has been excluded from the top layers since the mid sixties.

Experimental sections were also devoted to the question of improving the initial skid resistance of asphaltic concrete surfacings. Following practices in Holland and Belgium, spreading of crushed sand onto the hot layer during the rolling process (Figs. 3 and 4) has proved highly successful. Another series of experimental sections of road were devoted to treatment of the fresh concrete pavement surface to obtain a harsh and coarse texture or to enrich the top two millimeters with hard and sharp sand particles. Due to the spreading of crushed stone onto the hot surfacing immediately after laying, no problem of initial skid resistance exists with gussaspahlt surfacings (Fig. 5).