The work of PIARC Technical Committee C1 Surface Characteristics relevant to Australia

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Abstract

The World Road Association (PIARC) Technical Committee C1 Surface Characteristics has, in recent years, conducted research and produced reports on topics very relevant to Australian road authorities. This paper describes some of the highlights of this recent work and the current projects being undertaken by the Work Area Groups of this Committee.

The International Experiment to Compare and Harmonize Skid Resistance and Texture Measurements, and the soon to be conducted International Experiment to Harmonize Longitudinal and Transverse Profile Measurement Procedures, are briefly described. The research findings will continue to influence purchases of equipment, the instigation of research studies and the establishment of a means of correlation between Australian standards for skid resistance, surface texture and roughness with overseas standards. The work of PIARC/C1 can give an important input to the knowledge of people concerned with road safety, road noise and vibration impact on roadside communities, construction of road surfaces and on the management of road surface maintenance on both a project and the network level.

Refereed Paper

This paper has been critically reviewed by at least two recognised experts in the field.

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The objectives and key activities of The World Road Association (PIARC) Technical Committee C1 on Surface Characteristics were redefined after the 1995 World Congress in Montreal in terms of the related goals of the PIARC Strategic Plan as follows:

1.1 developing best practices in construction and maintenance;
1.4 improving quality standards in design, construction and maintenance;
2.3 improving road management;
3.4 reducing noise nuisance; and
4.4 integration of road safety considerations into road design.

Australia has a representative on PIARC/C1 under the auspices of Austroads, the national association of road transport and traffic authorities in Australia and New Zealand. The brief report which follows is a summary of this Committee’s activities.

Over the years, the importance of different aspects of surface characteristics have been pre-eminent. In the late 1950s to 1960s of greatest importance seems to have been skid resistance; its measurement and its relation to road safety. The First International Skid Prevention Conference was held in Charlottesville, Virginia in 1959 and an International Colloquium on Highway Skid Resistance and Traffic Safety under Wet Conditions, arranged by the Technical University Berlin, was held in 1968. By 1977, at the Second International Skid Prevention Conference in Columbus, Ohio, the importance of other aspects of surface characteristics was recognised. Road surface roughness by direct measurement and computer simulation, rather than by response type devices, grew in importance. Though the relationship between roughness and pavement design/performance had been long recognised, its use in pavement maintenance management attracted increased interest. Into the 1980s and till the present time, environmental concerns and the relationship between surface texture and noise nuisance have become more dominant.

INTERNATIONAL EXPERIMENT TO COMPARE AND HARMONISE SKID RESISTANCE AND TEXTURE MEASUREMENTS

A major activity of PIARC/C1 over recent years has been the conception, planning, staging and reporting on a co-operative International Experiment to Compare and Harmonize Skid Resistance and Texture Measurements. The experiment was conducted on a very large scale with a wide variety of pavement types with different surface characteristics in order to obtain ‘harmonisation’ of the different friction measuring devices used throughout the world.

There are two basic types of fullscale friction testing devices: sideforce and longitudinal braking. The sideforce devices are a fixed slip measurement for a given test speed. The longitudinal braking devices can be locked wheel (100% slip), fixed percentage slip or variable percentage slip. Some of the variable slip systems detect the peak friction and some vary the slip in an attempt to operate around the peak.

Locked wheel braking testers are most common in the United States, where all 50 states use locked wheel data in their skid reduction programs. Some conduct annual surveys, whereas others only use them to rate and approve aggregates for their construction projects. Sweden, France, Germany, Greece and Taiwan, among others, also use locked wheel measurements to some extent.

The locked wheel braking systems produce a 100% slip condition equivalent to panic braking in the wet in a non-ABS fitted car. The brake is applied and the force is measured and averaged for one second after it is fully locked. The locked wheel force is usually around 80% to 90% of the peak force, depending on vehicle speed and road texture. The relative velocity between the rubber and the pavement surface is equal to the vehicle speed. A variation of this is a transient slip operation whereby the friction is recorded as a function of the slip, from free rolling (zero slip) to fully locked (100% slip) — more of this later. The locked wheel testers are usually fitted with a watering system to provide a nominal waterfilm of 0.5 mm thickness.
A variation of the locked wheel tester is favoured by vehicle handling and tyre researchers of the vehicle industry. In this variation the brake is released immediately after the peak is passed and the system recycles at a rate of around one second. The test is done in both the wet and the dry and is called the CHIRP test because of the noise made.

The sideforce systems maintain the test wheel in a plane at an angle to the direction of motion while the wheel rolls freely. The sideforce perpendicular to the plane of rotation is measured. The sideforce is thought to be directly related to loss of control by skidding while cornering but of course it is also a measure of friction on straight roads. The British-designed SCRIM is the most widely used system of this type for highway friction used throughout the world; it is used in the United Kingdom, Germany, France, Belgium, Italy, Spain, to name a few, as well as in Australia by RTA NSW and VicRoads. It operates with a wheel yaw angle, $Y$, of 20° and is fitted with a self-watering system to supply a nominal waterfilm thickness of 1 mm. The MuMeter, also of British design, has two test wheels each yawed out at 7.5°. The MuMeter was developed for evaluation of airfields and because of its wheel spacing is unsuitable for highways. The Belgians also use a sideforce device called an Odoliograph which has either a 15° or 20° yaw angle but is not self-watering and must follow a waterspray truck that puts down lots of water.

The relative velocity between the rubber and the road for these devices is of the order of $V \cdot \sin Y$ and is therefore a low sliding speed measurement, primarily sensitive to microtexture, even though the vehicle velocity ($V$) is high. Therefore, they are usually used in conjunction with a macrotexture measuring system. This has resulted in the later model SCRIMs being fitted with a laser macrotexture measurement system on the front of the vehicle ahead of the water spray.

Fixed slip ratio longitudinal braking devices have an advantage over locked wheel devices in that they provide a continuous record and the wear on the tyres is less and more uniform, provided a small slip ratio is selected. They usually operate at between 10% and 20% slip. These are also measuring low sliding speed friction proportional to $\% \text{slip} \cdot V$. The Saab Friction Tester and the Runway Friction Tester are of this type but have been criticised by airline pilots because they do not measure at the friction peak and on snow- and ice-covered surfaces can give measures very far away from the peak. When used on highways, like the sideforce devices, they are often accompanied by macrotexture measurements.

Variable slip ratio devices like the Norsemeter are designed to measure at any desired slip ratio or to sweep through a predetermined set of values to seek the maximum friction. The German Stuttgarter Reibungsmesser is also designed to find the peak in a manner similar to the ABS system being fitted to modern expensive cars. For some operational purposes for aircraft runways, finding and displaying the Friction versus Slip Ratio curve is desirable. The curve contains a large amount of information about the frictional characteristics of the tyre/surface interaction under the prevailing conditions.

Many attempts have been made to correlate data between different items of pavement friction measuring equipment and although good correlation has sometimes been obtained when the surfaces have been of similar type, a general correlation has not been obtained. It was believed that in order to relate friction data obtained with different measurement methods such as longitudinal braking by locked wheel, fixed or variable slip and sideforce, it would be necessary to include in the correlation relationship surface texture information.

**The experiment**

The International Experiment to Compare and Harmonize Skid Resistance and Texture Measurements was conducted in Belgium, Spain and the United States in the fall of 1992 and the spring of 1993. The experiment was aimed at establishing relationships between the existing types of road friction measurement devices and the principles on which they are based; sideforce or longitudinal braking by fixed or variable slip or by locked wheel devices and portable devices like the Japanese DF Tester and the British Portable (pendulum) Tester. This experiment, unlike others carried out before, was designed to include information about the road surface texture in calculations as it was believed that in so doing it would be possible to establish good relationships between the different types of measuring devices which measure friction under wet conditions.
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The experiment was conducted on a scale capable of being done only by a co-operative effort from many authorities. Field testing was conducted on 28 different sites in Belgium (with its mid-European climate) and 30 in Spain (with its Mediterranean climate). Of these sites 40 were on roads, 14 on airports and 4 were on race tracks. Testing was conducted over 7 weeks in September and October 1992. In addition, 7 measures were made at the Wallops Island NASA test site in the United States in May 1993. Each road site was closed to traffic for a whole day while testing of the chosen uniform 150-m long section was completed. By scheduling, the devices were generally able to test at 2 sites on the one day before moving on to the next pair. Forty-seven different measuring systems, making 52 different measures (15 texture and 38 friction, including 8 of the SCRIM type devices used in Australia) from 16 countries (Austria, Belgium, Canada, Denmark, France, Germany, the United Kingdom, Italy, Japan, the Netherlands, Norway, Poland, Spain, Sweden, Switzerland and United States) were involved in this experiment. The majority of the 15 texture measuring devices were laser profile devices (10) but also included 2 water outflow meters, 2 pendulum devices (like the British Portable Tester which measures friction at low speed and gives test result values considered to be a surrogate for microtexture), and of course all were compared with sand (glass bead) patch texture measurements.

A wide variety of pavement types with different surface characteristics were examined. Friction tests were conducted at the speeds of 30, 60 and 90 km/h (unless they were hand operated and unless the standard speed for operation of the device was different from one of those selected — for example, 50 km/h was substituted for 60 km/h for SCRIM). Relationships between the tested types of road friction measurement devices and the principles on which they are based, sideforce or longitudinal braking, have been determined from the test data collected. Since pavement friction is speed dependent, models have been developed that incorporate at least one texture measure to relate sideforce, slip and locked wheel measures. The models for each of the device types give a friction value at a nominal sliding speed, 60 km/h, and a Friction/Speed gradient related to texture. This will enable friction values to be forecast at any speed, based on one friction test (eg. the standard speed of 60 km/h or 50 km/h for SCRIM) and one texture measurement.

Results

A formula has been developed to convert results produced by the different devices to an International Friction Index (IFI). This IFI can be used as a basis for international standardisation of the friction value measured on a particular surface or on the standards applied by the different countries for their low friction intervention levels.

IFI is in two parts, F60 and S_p, defined as follows:

- F60 is the standardised friction measure at 60 km/h slip speed; and
- S_p is the gradient of the Friction versus Speed curve (an indicator of the speed dependency of the standardised friction measure) and is related to surface texture.

The formulae developed, which are of the type shown below, will enable forecasts to be made of friction at any speed based on a measurement of friction at one speed by any of the friction measuring devices involved in the experiment and a texture measurement made by one of the macrotexture measuring (profile) devices involved in the experiment:

\[ IFI = F60, S_p \]  
\[ F60 = A + B \cdot FR_S \cdot \exp \left( \frac{S - 60}{S_p} \right) \]  
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\[ S_p = \frac{\text{measured Friction at sliding speed } S \text{ km/h}}{\text{standard slip ratio braking}} \]  
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The maximum errors forecast for F60 were:

\[ \pm 0.028 \text{ for sideforce devices; or} \]
\[ 0.033 \text{ by fixed slip ratio braking; or} \]
\[ 0.030 \text{ by locked wheel braking.} \]
Example:

For measured SCRIM value FR$_s$ = 0.5 at 50 km/h (17.1 km/h sliding speed) and measured Mean Profile Depth = 0.5 mm:

F60 = 0.32 ± 0.03

IFI = 0.32, 95,

and for measured Mean Profile Depth = 1.0 mm:

F60 = 0.38 ± 0.03

IFI = 0.38, 165.

The overall objective of the experiment was to compare the many different skid resistance measuring methods used around the world and to develop a formula for converting results produced by the different devices to an International Friction Rating (IFR), and thus provide a basis for international standardisation. The results of the study have shown that good correlation could be obtained between the different device types ($R > 0.7$) and that excellent correlation could be obtained between the devices within a type group ($R > 0.83$). Each country (device type user) will thus remain free to keep on using its own measuring method. Each of the friction devices was able to predict the harmonised friction coefficient with a standard error of less than 0.03. However, to get true harmonisation it will be necessary, for a particular device type user who was not involved in the experiment, to do a local correlation with a device that was in the experiment. It would obviously be very difficult to transport one of the SCRIM type devices to Australia to do this unless a new pre-calibrated device is being purchased. Alternatively harmonisation could be achieved in Australia by a test program involving one or more of the other devices used in the experiment which has been pre-calibrated.*

Discussion

Thus, the result of this experiment was the demonstration of an extremely strong correlation between surface texture and Friction/Speed gradient, and the derivation of an International Friction Index (IFI). It was shown that if appropriate allowance is made for slip speed and texture, the types of skid resistance measurement devices used throughout the world could be bought into good agreement or ‘harmonised’ to measure IFI. This means that IFI can be used as a basis for international standardisation of the friction value measured on a particular surface or on the standards applied by the different countries for their low friction intervention levels. Furthermore, as an index of surface properties the IFI allows calculation of the friction index at any speed even though the friction test was conducted at a single standard speed. This may be of some importance for road safety measures, particularly for high speed roads. The harmonisation that has been carried out does not consider intervention levels. It will still be up to the respective road authorities in the various countries, for a particular road type, to adopt their own intervention levels in terms of either IFI, or friction value measured by a particular device at a particular speed plus either a Friction/Speed gradient or a texture depth. The report on the experiment was published by PIARC and released at the XXth World Road Congress in Montreal, Canada in September 1995. Follow-up studies are reported in a later section of this paper, ‘Current Activities of PIARC C1 — Work Area A’.

THE THIRD INTERNATIONAL SYMPOSIUM ON PAVEMENT SURFACE CHARACTERISTICS

The Third International Symposium on Pavement Surface Characteristics was held in Christchurch, New Zealand on 3-4 September 1996. PIARC/C1 was a sponsor of the Symposium in conjunction with Austroads, Transit New Zealand, and The University of Newcastle, Australia. The event was organised by ARRB Transport Research Ltd in conjunction with the Roads 96 Conference (Sept. 1 – 6, 1996). The 82 participants from 17 countries who attended the PIARC Symposium were also able to attend selected sessions of the Roads 96 Conference. The Third International Symposium on Pavement Surface Characteristics covered a wide field of interest in both highway and airfield pavements. The following brief summary of the Symposium Sessions gives an insight into the activities of PIARC/C1.

This Third International Symposium was one of the first international forums since the World Road Congress in Canada, and thus participants were able to present discussions on the International Experiment and to discuss the application of the International Friction Index in their local regions.

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* A calibrated Norsemeter ROAR unit has been purchased by MR Qld. and a Griptester has been ordered by DoT South Australia.
The technical sessions at the Symposium were devoted to the presentation of papers and discussion on the above topics related to the IFI and to the following topics:

- Equipment and methods for measuring pavement surface characteristics:
  - A. Texture, skid resistance; and
  - B. Roughness, transverse profile, cracking;
- Road surface characteristics and road safety;
- Comfort of road user and of road frontage residents (noise, vibrations, emissions);
- Performances of materials and construction technologies to meet surface requirements;
- Vehicle operating conditions (tyre wear, vehicle maintenance, fuel consumption); and
- Surface characteristics in pavement assessment, pavement maintenance and maintenance management.

One of the most popular sessions at the Symposium — in terms of number of papers submitted and attendance of delegates — was the one on noise generated at the tyre/road interface, thus reflecting the still-growing importance of this road feature in road surface characteristics and road management.

Several papers in the proceedings are considered outstanding:

- the keynote paper by Henry, outlining the details of International Experiment to Compare and Harmonize Skid Resistance and Texture Measurements and the development of IFI;
- a paper by Huschek and a summary paper by Sandberg dealing with noise generation at the tyre/road interface; and
- the paper by Gothie, in which he details the accident reduction and cost/benefits of improved skid resistance derived from a very extensive data-base in France.

The current activities of C1 can be summarised by reference to the activities of the Working Groups.

**Work Area A — Analysis of the Results of the International Experiment to Compare and Harmonize Skid Resistance and Texture Measurements**

Additional analysis and exploitation (applications) of the results of the International Experiment to Harmonize Skid Resistance Measurements; validation of the extension of the results in the cases of porous asphalt and winter conditions.

**Progress:** Several follow-up experiments with a limited range of equipment and surface types not considered in the first experiment have already been conducted. The Netherlands, Denmark and Germany have conducted a joint experiment to assess porous asphalt. Twenty-four test sections, each 200 m long, were tested in July 1996 by 5 different testing devices. Analysis is almost complete and a report is to be presented before the end of 1997.

Transport Canada, FHWA and NASA USA have conducted a Joint Winter Program of testing by domestic and military aircraft and several types of skid testing equipment on an airfield in North Bay, Canada and the NASA facility at Wallops Island in the United States. The experiment has been followed-up now over two winters. Analysis is being done by Transport Canada. Speeds used have generally been greater than highway speeds with tyres more related to airfield runways. An index of the type developed from the C1 experiment and tentatively called the International Runway Friction Index (IRFI), involving both speed and texture, is being developed.

A follow-up study sponsored by FEHRL (Forum of European Highway Research Laboratories) is being supervised by C1 Committee Secretary Descornet (Belgium) with an aim to develop a European Standard for measurement of Skid Resistance of Road Surfaces (calibration requirements etc.). Stages under way (2 years completed of 4-year study) are:
1. Pursue data analysis of the experiment (precision of IFI, with reference speed $S_p$ of 60 km/h, or some other speed). Results to date indicate that an $S_p$ value of 30 km/h was best and this may lead to an EFI (European Friction Index).

2. New tests for surfaces not previously considered; 24 sites comprising porous asphalt, stone mastic asphalt, transverse grooved concrete, superpave, and calcined bauxite. Test devices: Scrimtex, locked wheel trailer, etc.

CEN (the European Standards Committee) is also looking to develop guidelines for standardisation of IFI (or EFI) in collection of data, e.g. (i) take more than 3 repetitions and (ii) take macrotexture measurement by ISO method. The Netherlands is developing a standard calibration method for equipment to measure IFI and a paper from the Netherlands and another from Japan, describing calibration methods, were presented at the International Conference on Pavement Surface Characteristics in Christchurch in 1996 (The American Society for Testing and Materials) is to publish a Standard on IFI in its 1998 volume.

**Work Area B — International Experiment to Harmonize Longitudinal and Transverse Profile Measurement Procedures**

Following the success of the Experiment to Harmonize Skid Resistance Measurements, C1 has set itself the task of conducting another International Experiment with the aim to collect data for comparing different measurement equipment and procedures used in pavement profiling in different countries.

Road unevenness is regarded as one of the most important road surface characteristics. Evenness has an influence on vehicle fuel consumption, tyre wear and mechanical deterioration. It also influences effects on road users such as internal noise, infrasound, ride comfort and driver fatigue. Furthermore, there are environmental effects such as exterior noise and air pollution influencing people around the road. High dynamic wheel load variations are also caused by the rough surface. The measures presently used to describe road unevenness are generally good at predicting ride comfort because they were developed for that reason. The correlation between measures of road unevenness and other functional characteristics of the road may need further development.

Road unevenness is used as an indicator of both pavement functional performance and structural condition. Evenness assessment methods vary widely and include those that measure profile, those that measure response to road unevenness, and subjective evaluation. Profiling equipment and methods to measure longitudinal and transverse unevenness vary widely from country to country. The purpose of this experiment is to provide a means to compare the results of measurements carried out using different equipment and different measurement methods. The results of this experiment will be invaluable in realising consistent pavement management practices (with respect to longitudinal and transverse unevenness and cross slope, as well as the assessment of their effects on the road user, road owner and environment) across country boundaries. Furthermore, it is necessary that the measurement reporting be harmonised to standardise pavement specifications.

In the past there have been several other studies to compare longitudinal unevenness measuring equipment. The most notable was the World Bank International Road Roughness Experiment (IRRE) to establish correlation and calibration standards (World Bank Technical Paper Number 45). This experiment was conducted in 1982 in Brazil. In the IRRE both response type and profile type of evenness measuring equipment methods were included. From this experiment the International Roughness Index (IRI) was developed.

Since this 1982 study many new types of profile measuring equipment have been developed to measure and report IRI; many also measure transverse profile and rut depth. Technical Committee C1 believes there is a real need to update the previous work and to include transverse profile as well.

The experiment aims to study procedures for relating pavement unevenness, longitudinal and transverse, as measured by different standard methods of test. The various devices will be evaluated for accuracy (vertical, longitudinal and transverse) and evaluated for their ability to achieve the accuracy required to produce the various summary statistics used in pavement management for longitudinal, transverse and rutting measurements.
Harmonisation aims to develop a method so that each profile device can make an estimate of the ‘true profile’ from which all indexes would be calculated. This will allow each device to report the value it normally did in the past and still harmonise it to a common true profile of the required accuracy. This then will also allow calibration of other and new items of equipment since they also can be correlated to the true profile.

The general objective of the experiment is thus twofold:

1. Harmonise and correlate measures of longitudinal and transverse road surface profiles for application in pavement construction and management. This requires that the project will:
   - provide the data so that other organisations can set requirements and/or ranges and be able to evaluate the analysis methods used by pavement managers for roads and airports in order to establish the accuracy requirements.
   - evaluate the ability of each device to produce standard measures of longitudinal and/or transverse evenness to facilitate interchange and harmonisation.

2. Provide a basis for the assessment of the reliability of road profile information. This requires that the project will:
   - evaluate the accuracy and repeatability of longitudinal and transverse profiles obtained by each device by direct comparison with the ‘true profile’. These comparisons will be obtained under various conditions of lateral placement, speed, climate, pavement type, reflectivity and texture.
   - determine sampling rate and/or sample size required by the various methods to achieve the desired accuracy of the applicable summary statistics; and quantify repeatability and errors associated with the various devices.

**Progress:** A Draft Proposal outlining the development of an experimental plan is available on application to the author (see Contact details at the end of this paper). The experiment is to be conducted by three separate local operational groups: (i) Arizona USA in the spring (April–May) 1998 (local US organiser, James Wambold); (ii) Hokodate, Japan, following US stage (local organiser, Prof. Kasahara); and (iii) Europe (local organiser, Bjarne Schmidt, Denmark). This European stage of the experiment, if it is to proceed at all, will follow at a later date after assessment by FEHRL (Forum of European Highway Research Laboratories). There is still some disagreement among PIARC/C1 members about the objectives of the experiment and its technical content (for example, on the data analysis procedures). Moreover, there is still a need to differentiate clearly the analysis of longitudinal and transverse evenness measurements. In spite of these misgivings, the local organisers in the United States received the endorsement of C1 to the proposal. The local US organising group aims to conduct the first stage of the experiment in Arizona in late April 1998.

ARRB Transport Research Ltd has a group concerned with profile measurements which aims to participate with its Walking Profiler at all three locations, and perhaps with its high speed laser profilometer at one of the test locations. The Walking Profiler could be suitable as a standard device to determine the true profile against which the generally laser-based, high speed profilometers could be judged. In this regard, ARRB’s Walking Profiler would be an alternative to the US manufactured Dipstick.

**Work Area C — Performances of Available Pavement Techniques**

Integration of surface characteristics into management models (accuracy, segmentation, thresholds ...).

Surface distresses: harmonisation of definitions, characterisation and quantification methods, performances of automatic measurement systems.

**Progress:** Follow-up from last 4 years’ study report presented in Montreal. Extent and severity dimensions and details measured for indices used in different countries. Another analysis is being done on the questionnaire survey data collected from 1991 to 1995. Analysis from the International Experiment may identify whether it is possible to get distress from profile (and/or rut depth) measurements.
**Work Area D — Surface Characteristics and Pavement Quality of Use**

Influence of surface characteristics on users comfort and road (un)safety: criteria for thresholds (analysis of the consequences in terms of legal aspects and responsibility of road administrations), taking account of the road user’s point of view. This work area has been refined to the generation (and the propagation) of rolling-noise tyre/pavement.

**Progress:** This group has been extremely active in gaining the co-operation and assistance of vehicle manufacturers through their technical association FISITA (International Forum of Society of Automobile Engineers and Technicians) particularly in relation to tyre/road noise. It has been suggested that C1 and FISITA co-operate to develop another International Experiment which would involve the measurement of noise on both real roads and proving grounds surfaces including any standard surfaces that would exist at that time. The noise measurements would embrace both the standard test to date, using the various pieces of apparatus which are currently on the market together with any other method that may be derived by the time of the experiment, i.e. trailer methods and quiet vehicles. It would be hoped that in addition to the standard procedures, surface and tyre variables would be included, and also the use of quiet vehicles obtained from vehicle manufacturers in order that they may see the need to consider road surfaces in any future vehicle development. Liaison with PIARC/C7 (Concrete Roads) will need to occur regarding the outline of the experiment.

**Analysis of the methods for translating surface characteristics (texture, evenness) in terms of the functional characteristics of the roads (comfort, safety).**

**Progress:** Some related work has been reported at a recent RPUG (Road Profile Users Group) Meeting by Berthelo (US) and will be reviewed.

An inventory of the specifications for surface characteristics of new pavement and the acceptable levels of serviceability for in-service pavements.

**Progress:** Literature survey in preparation. Santos (Portugal — corresponding member, C1) has done some work in this area. CEN Group inquiry by BASt in Germany is studying this area. Berthelo (US) is also working in this area, looking at relationships between road unevenness and acceptance as well as when rehabilitation measures need to be taken. A new enquiry will be sent to members of PIARC/C1, C6, C7 and C8.

**Work Area E — Interaction Road (Pavement)/Vehicle (Tyre)**

Synthesis of available knowledge on the propagation of vibrations due to traffic (heavy vehicles) to the buildings in the vicinity of the road.

**Progress:** A road reconstruction project is to be undertaken in Portugal, in which road surface characteristics and vibrations are to be closely examined prior to and post reconstruction. Technical Committee C1 is to be involved in developing the variables to be assessed in the experiment; the measurement and reporting of the road unevenness; type of traffic, etc. during vibration measurements. (A specified selection of heavy vehicles with known suspension characteristics will be used and driven at different speeds.) A Japanese report on this topic is to be translated and included in the C1 report. Reports are available from Sweden (Magnusson) and the United States (Kennis FHWA).

RELEVANCE TO AUSTRALIA

The work of Technical Committee C1, especially the just-completed International Experiment to Compare and Harmonize Skid Resistance and Texture Measurements and the soon to be conducted International Experiment to Harmonize Longitudinal and Transverse Profile Measurement Procedures, is of great relevance to road authorities in Australia and New Zealand. The research findings will continue to influence purchases of equipment, the instigation of research studies and the establishment of a means of correlation between Australian standards for skid resistance, surface texture and roughness with overseas standards. With the growing influence of the well-being of roadside communities to road administrations, knowledge of noise and vibration generation and propagation is essential for the design and construction of surfaces with the best possible surface characteristics. I believe that the work of PIARC/C1 is an important input to...
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this knowledge. The Third International Symposium on Pavement Surface Characteristics, jointly sponsored by Austroads, Transit New Zealand, The University of Newcastle, Australia and PIARC/C1 was successful in attracting to New Zealand (and to Australia) world experts in these fields. This Symposium, and a C1 Committee Meeting held in conjunction with it, were a means of showing to the world our expertise and conversely allowing many roads practitioners/researchers in Australia and New Zealand to see the workings of PIARC/C1 first hand.

REFERENCES


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has lectured in highway engineering and concrete technology subjects at the University of Newcastle for more than 30 years after initial experience in local government. He has engaged in periods of research at the Transport and Road Research Laboratory in the UK, at McMaster University, Hamilton, Ontario, Canada and at the Pennsylvania Transportation Institute attached to Penn State University, in the United States. His main research interests have been in road surface skid resistance, road pavement base materials and concrete technology. With his roots in Newcastle many of the topics he has studied have been related to by-product materials from the steel industry, particularly their use on roads. He has published widely in his fields of interest, as well as being a regular contributor to Institution of Engineers and Australian Road Research Board conferences. Brian is a member of the Technical Committees of the Australasian Slag Association and the Australian Concrete Paving Association, and is the representative for Australia on The World Road Association (PIARC) Technical Committee C1 Surface Characteristics.

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