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Road quality service levels and innovations to meet user expectations

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Summary

In accordance with the thematic areas covered by strategic theme ST 1, the Austrian national report will provide details on the following innovations and developments from the past four years:

- Innovations in the field of earthworks and road pavements
  - Continuous compaction control
  - New guidelines for stabilised base courses
  - Research into asphalt pavements
- Periodic skid resistance measurements on motorways, expressways and federal highways
- Stipulation of quality indicators for pavements as part of the implementation of a Pavement Management System

All these developments promote the improvement of road construction technology and road maintenance, and thereby increase the service to the road-user.

1 Introduction

In accordance with the thematic areas covered by ST 1 and the appropriate Technical Committees (C1 – Surface Characteristics, C718 – Road Pavements, C12 Earthworks, Drainage and Subgrade), the Austrian national report will provide information on new developments in the following areas: earthworks and road pavements, periodic skid resistance measurements on motorways, expressways and federal highways, and pavement management quality indicators.

All of these developments promote the improvement of road construction technology and road user safety.

2 Innovations in the field of earthworks and road pavements

2.1 Continuous compaction control

Many ground structures, such as infrastructures, are constructed in layers. The individual layers of such ground structures are usually compacted using dynamically excited rollers (e.g. vibratory rollers).

Continuous compaction control (CCC) uses the movement pattern of the dynamically excited roller drum to measure the bearing capacity of the compacted soil. In short, the appropriately equipped roller (Fig. 1) is both compaction plant and measuring device in one.

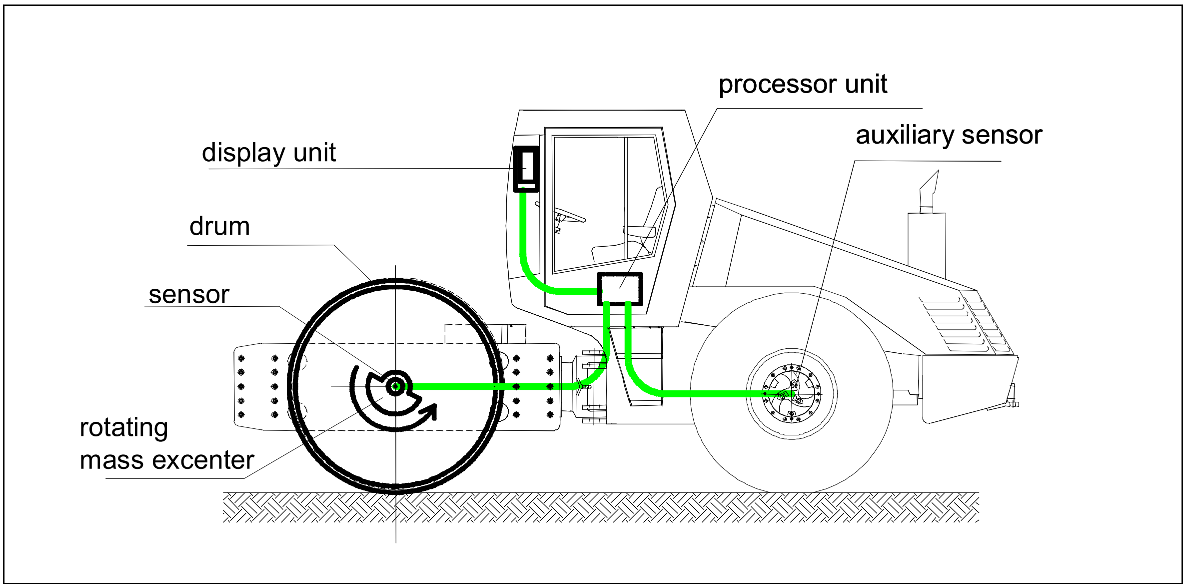

Fig. 1: Vibratory roller and the CCC principle

This means that it is possible to monitor the compaction process online and to save the measured values safely together with the appropriate position. Because the data is protected against manipulation, it can be used for control and acceptance tests.

In July 1999, the new guideline RVS 8S.02.6 ‘Continuous roller-integrated compaction proof’ [1] was published in Austria. This guideline contains the most recent research findings in this field and has consequently become the most comprehensive set of CCC regulations. It requires four criteria to be met before a tested area is accepted: the measured values may not be lower than either the required average value or the required minimum value; the uniformity of the measured values must be guaranteed; and the increase in compaction between two consecutive tests over the same area is limited. The purpose of these criteria is to make the most of the strengths of this modern method, because unlike conventional test procedures, CCC does not check the compaction at different individual points but continuously while the soil is being compacted. Weak points are identified immediately and can easily be eliminated. Moreover, CCC can also be used to quickly identify the optimum method of construction (material, thickness of the individual layers, compaction plant and its settings etc.). In addition to these and other construction benefits, CCC offers two other decisive advantages: it significantly improves the quality of a ground structure at no extra expense and documents this improvement comprehensively.

2.2 New guideline for stabilised base courses

In 2002, a new guideline for the stabilisation of base courses with binders was drawn up (RVS 8S.05.14 [2]).

The following materials are stabilised: aggregate, often fine gravel with large amounts of cohesive substances, and primarily over the past few years, recycled materials that may contain large amounts (over 50 per cent) of asphalt granulate that have been acquired during the reconstruction of existing roads. Cement, base course binders, bitumen, and bitumen and cement are used as binders.

2.2.1 Stabilisation with cement and base course binders

In addition to cement that conforms with ÖNORM-EN 197-1, base course binders HRB 22.5 that conform with prEN 13282 have often been used in recent times. In accordance with ÖNORM-EN 196-1, the compressive strength of the latter amounts to a maximum 50 per cent of the 28-day value after seven days. This additional requirement means that the tensile strength of the stabilised material is initially lower (increases the likelihood of cracking) but subsequently higher (increases the comfort and safety index (CSI)) than is the case with cement stabilisation of the same compressive strength.

The seven-day compressive strength requirement for the stabilised material is lower for binders that harden slowly and consequently have greater subsequent hardening, than it is for more rapidly hardening binders, namely those with at least 2.5 N/mm² for HRB 22.5 and CEM 32.5 N, 3.0 N/mm² for CEM 32.5 R and 3.5 N/mm² for CEM 42.5 N (individual control test value on sample cylinders from plant-mix).

For layer thicknesses of more than 25 cm, a vibrating sheep's foot roller must be used to ensure good compaction of the layers and the lower areas.

To avoid disturbing reflection cracks in a bituminous wearing course, it is in no way sufficient to aim for stabilisation with the lowest possible strength. On the contrary, one of the following steps must be taken:

A layer stabilised with cement should be compacted on the day after construction (good results have been achieved on natural clay ground);

Deep notches (at least two-thirds of the thickness of the layer) should be added to a layer stabilised with cement, e.g. created using the French CRAFT machine;

Shallow notches (at least one-third of the thickness of the layer) should be added to a layer stabilised with base course binder, e.g. with the help of vibratory plates or a circular cutter.

Notching should be carried out in a square pattern across the width of the lane immediately after compaction.

2.2.2 Stabilisation with bitumen or bitumen and cement

No reflection cracks occur in asphalt structures that have been stabilised with bitumen (emulsion or foamed bitumen)—whether with or without cement. This means that unlike stabilisation with cement or base course binders, notching or compaction is not necessary.

Bitumen and cement stabilisation is permissible for all load classes. The binder content (which is often around 3 per cent in each case) should be fixed in such a way that after seven days the highest possible indirect tensile strength and ultimate strain values—at least 0.2 N/mm² or 0.1 per cent—are achieved in the indirect tensile strength test. Bitumen stabilisation is only permissible for load classes IV and V (lower traffic performance); here, the ultimate strain must amount to at least 0.4 per cent.

Mixtures with bitumen require different compaction to those that use only cement or base course binders. A vibrating roller is just as unsuitable as the sole compaction plant on a construction site as the Proctor test is in the laboratory. In addition, pneumatic-tyred rollers or vibratory rolling compactors must be used and test pieces must be constructed in the laboratory using cyclic-static compaction (double-piston principle: multiple application of a force of 100 kN, sample cylinders of 150 mm diameter).

The same type of compaction and test piece production should also be employed for mixtures to which only cement or base course binders are added if they contain more than 50 per cent asphalt granulate.

2.2.3 Stabilisation of materials containing tar

If tar-bound layers are visible when reconstructing existing roads, they are stabilised together with part of the frost blanket and/or using other recycled materials in such a way that all harmful substances are sufficiently integrated. Special base course binders and bitumen emulsions with cement have both proven extremely suitable for this purpose.

2.3 Research into asphalt pavements

In view of the increasing load exerted on asphalt roads by heavy traffic, growing importance is being attached to the improved selection of materials and the development of analytical pavement measurement models. Over the past few years, important work on analytical methods of modelling the deformation properties of flexible pavements [3] have been published in Austria, some as part of European cooperation projects. Basic principles for taking account of temperature and other climatic influences when measuring the thickness of asphalt roads have also been developed [4, 5].

One of Austria’s most important national activities in the field of pavements in the year 2002 is the establishment of a so-called Christian Doppler Laboratory (a research laboratory that is run by Universities and industry, and receives considerable financial support from the national research fund) for research into the use-oriented optimisation of flexible pavements at the Technical University of Vienna and the further development of numeric models for forecasting the development of ruts on asphalt roads. The main scientific orientation and area of activity of the newly established research laboratory are the development and standardisation of use behaviour-oriented testing methods for bituminous bound materials on the basis of effective mechanical parameters that are suitable for the specification of mix properties with a view to defining an appropriate material quality for invitations to tender and the creation of mix designs. Based on the results of the technological asphalt research, improved numeric methods for reliably forecasting behaviour during service are being developed. When combined with use behaviour-oriented tests, these methods will allow for a simulation of the effects of road construction caused by traffic load and thereby for an improved forecast of the use behaviour of flexible pavements over the course their entire technical lifetime.

Three different research modules are planned. The first module foresees the drawing up of basic principles for the introduction of behaviour-oriented asphalt tests. These principles will be based on experience gained with Marshall tests in Austria and existing findings from extended binder tests. On the one hand, it is intended that these asphalt tests will be used to determine the mechanical and physical properties of the construction material and to derive the rheological parameters required for numeric models. On the other hand, the focus will also be on the development of corresponding parameters that will allow industrial users to conduct practical evaluations of material properties and derive specifications for them in everyday applications. Leading on from the improved test methodology, another module will involve the modification and improvement of the Marshall procedure, which has been used to date in Austria to determine the composition of the asphalt mix used especially for flexible pavements that are subjected to higher loads. Parallel to this, another module will focus on further developing known numeric models that will in future allow for a structurally improved and, therefore, more economical dimensioning of flexible pavements (new construction and reinforcement).

3 Periodic skid resistance measurements on motorways, expressways and federal highways

In 1990, the new Stuttgarter Reibungsmesser (SRM, Stuttgart friction meter) went into operation at arsenal research, the Austrian Research and Testing Centre. Since then, the unit has been modified to include equipment for measuring the longitudinal and transverse evenness and the surface texture of the road and is now known by the name RoadSTAR (Road Surface Tester Arsenal Research).

In 1991, systematic measurement of skid resistance and ruts got underway on Austria’s top road network (which includes motorways (A), expressways (S) and federal highways (B)). Since then, the comprehensive measurements have been continued at network level.

3.1 Measuring methodology

The standard measurement conditions for the skid resistance measurements using RoadSTAR (Stuttgart friction meter measurement principle) include:

- 60 km per hour vehicle speed for all road types,
- Constant measuring wheel slip (18 per cent),
- PIARC measuring tyres (longitudinally grooved),
- Wheel load: 3500 N,
- Tyre pressure: 2 bar,
- Simulation of a wet pavement by applying a 0.5 mm thick film of water in front of the measuring wheel,
- Measured values are averaged every 5 m.

3.2 Results and evaluation of the skid resistance measurements

The first series of measurements at network level were completed in three parts in the years 1991-96 [6]. Measurements were conducted on a total of 4,300 kilometres of Austria's motorways and expressways (A+S). Generally speaking, the right-hand lane was measured. The extreme left-hand lane was only measured as well in selected cases.

A total of 7,900 kilometres of federal highways (B) were measured, whereby measurements were only made in one direction as a rule. In all, measurements were carried out on 100 per cent of the motorway and expressway networks and approximately 80 per cent of the federal highway network.

The second series of measurements began in 1999 with 3,700 kilometres of motorways and expressways [7]. The measurement of the federal highways (B) began in 2001 and will be completed by the end of 2002.

Fig. 2 illustrates the frequency distribution of the results of both series of measurements. The frequency distribution was used to assign skid resistance classes according to international practices [6].

3.3 Conclusions drawn from the skid resistance measurements

In accordance with international practices and on the basis of the first series of measurements, the borderline between condition classes III and IV was identified as the provisional warning value, corresponding to 10 % fractile where μ = 0.45, and the limit between condition classes IV and V as the provisional threshold value, corresponding to 5 % fractile where μ = 0.38 [6]. The evaluation background may need to be reviewed once the second series of tests is completed at the end of 2002.

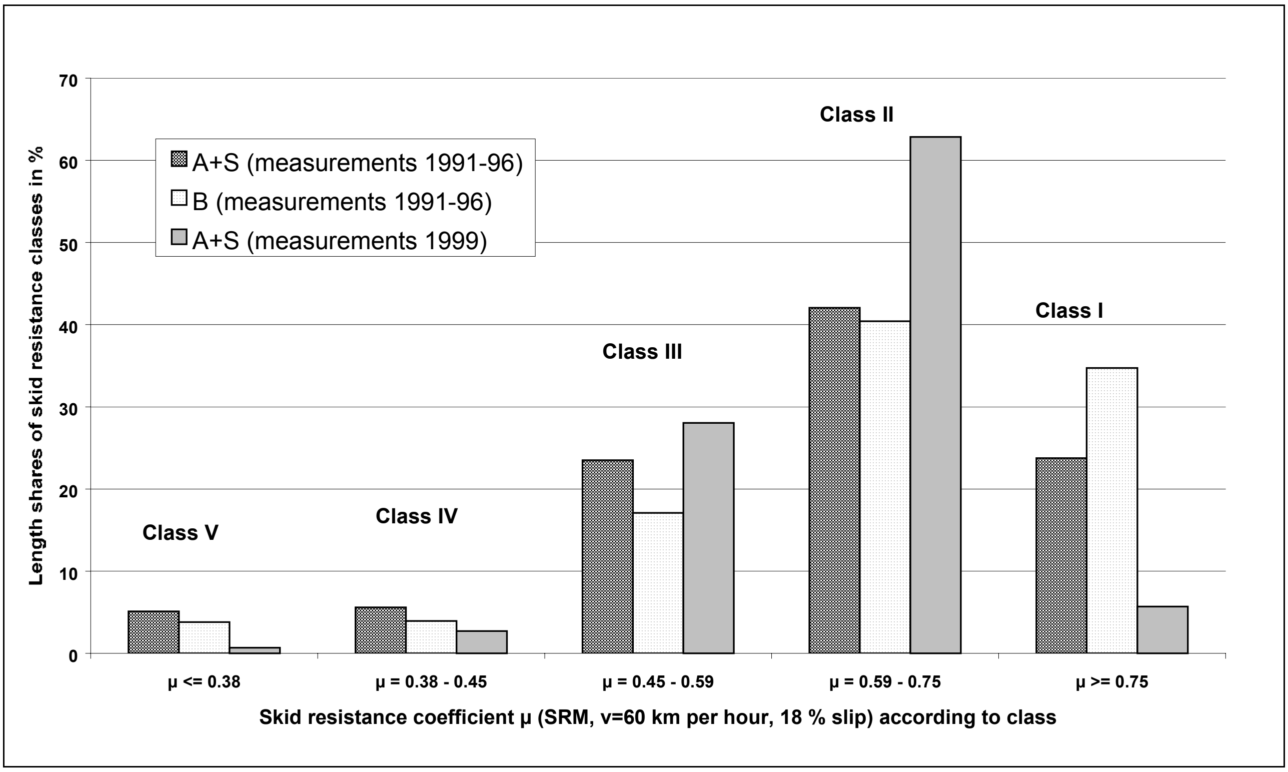

Fig. 2: Frequency distribution of the speed measurements

4 Quality indicators and the implementation of a Pavement Management System

In 1998, Austria began implementing a uniform Pavement Management System (PMS) for its federal highways network. Since early 2000, this system, which serves as an objective basis for the strategic planning of road maintenance, has been available to those responsible for maintaining the country's motorway and expressway networks.
The main aim of this system is twofold: firstly to improve the efficiency of large-scale maintenance strategies in the medium to long term and secondly, to ensure optimum distribution among those responsible for large-scale maintenance of the growing share of the overall road construction budget that is allocated to road maintenance.

4.1 Road condition quality indicators

An important prerequisite for the assessment and evaluation of a section of road as part of maintenance planning is the calculation of descriptive parameters and characteristics relating to the condition of the road. Here, variables relating to the road condition—such as ruts, skid resistance, longitudinal evenness, cracks etc.—and information about the structure of the road (construction data) and the load exerted on it by traffic and climate (temperature and precipitation) play an important role. By linking the information regarding the road condition (condition indices) with corresponding condition forecast models, it is possible to make predictions about the future condition of the road and therefore about future large-scale maintenance requirements over a specific period of time.

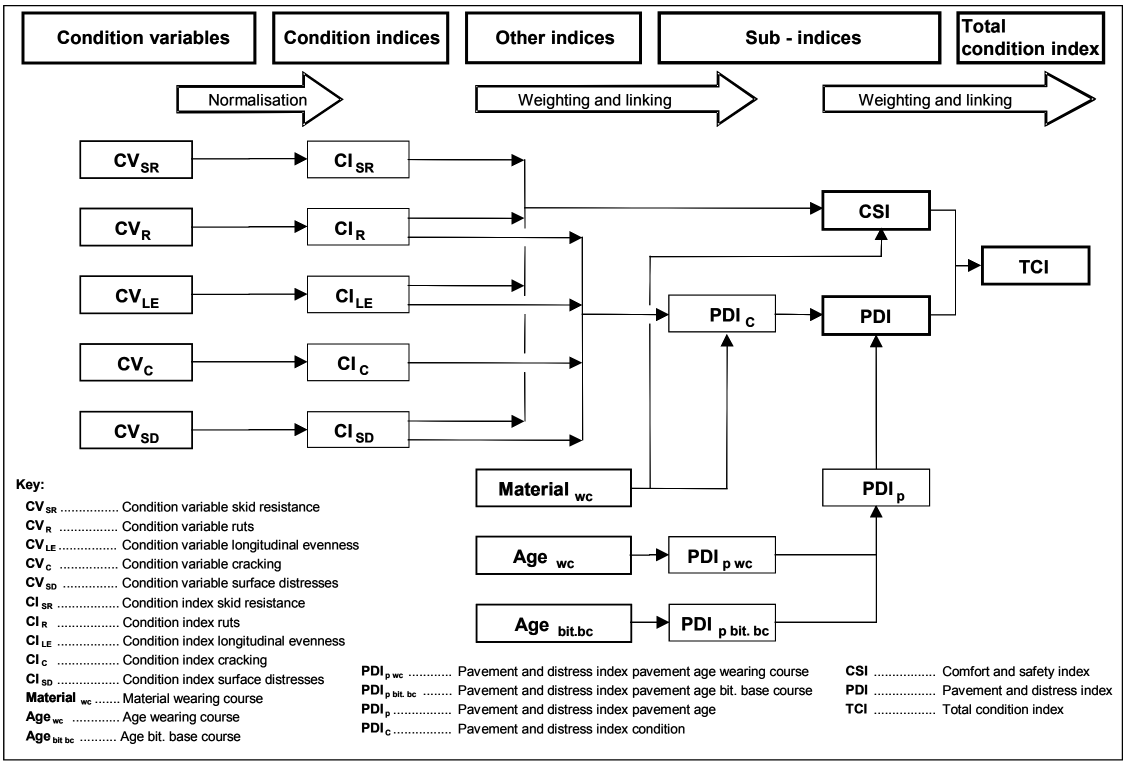

Fig. 3: Road condition assessment procedure for bituminous pavements in accordance with [8]

Because an individual condition characteristic usually only describes one particular property of the road condition, it is useful to transform the recorded condition variables into dimensionless condition indices (normalisation) at every point within the evaluation period and, while taking other information (e.g. data pertaining to the pavement) into account, to bring them together to form sub-indices and an total condition index (value synthesis).

In principle, the sub-indices can be divided up into variables that describe the substance of the road, the pavement and distress index (PDI), and those that describe driving safety and driving comfort, the comfort and safety index (CSI). Both sub-indices are then used to calculate the total condition index (TCI) that characterises the road condition using the relevant linking and weighting rules [8] (see Fig. 3). Because, from a mathematical point of view, only a specific objective function can be used for optimisation, the total condition index is used for optimising the road condition with given budgetary restrictions.

4.2 Computer-assisted management system

Two systems are used for the practical application of the Austrian PMS: firstly, a database that contains all the data required for the analysis (VIABASE_AUSTRIA) and secondly, an analysis system that uses a deterministic optimisation model to select the optimum large-scale maintenance strategy (VIAPMS_AUSTRIA). Both systems allow for an individual definition of the algorithms and models by the users and can therefore be optimally adapted to the appropriate road network and its framework conditions.

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