

Technical Annex

COST Action Performance Indicators for Road Pavements

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A Background

A.1 Introduction

The specification of performance criteria from the perspectives of both road users and road operators is a key prerequisite for the efficient design, construction and maintenance of road pavements. Particularly the increasing use of life-cycle analyses as a basis for the selection of road pavements and the decision of whether or not to implement a systematic road maintenance scheme calls for an exact definition of the goals to be achieved and/or the performance criteria to be satisfied. The extent to which goals are reached or performance criteria satisfied can be quantified by calculating special indexes characterizing the road pavement, which in turn permits an assessment of the efficiency of certain approaches from both a commercial and a macro-economic standpoint.

For a Europe-wide harmonization of standards to be met by road pavements it therefore appears useful and appropriate to specify pavement characteristics in terms of uniform "performance indicators" for different road categories (motorways, national roads, local roads, etc.).

A.2 Current status

In the Anglo-American world, efforts to describe certain road pavement characteristics by means of indexes were initiated more than one decade ago. These indexes, which as a rule are composed of several information components (such as road condition, pavement data, road geometry data, etc.) are a measure of the effects perceived by the road users as well as a measure reflecting the structural condition of a road pavement. The Pavement Management Guide published by the American Association of State Highway and Transportation Officials (AASHTO) in 2001 contains the "Present Serviceability Index" (PSI) as a measure of riding comfort along with information about structural indexes - specifically the "Pavement Condition Index (PCI)" and the "Road Condition Index (RCI)" - and their use as part of pavement management systems. The "Highway Development & Management Tool HDM 4" developed by the World Bank in co-operation with PIARC (the World Road Association) likewise uses special indicators (such as the PSR - the Present Serviceability Rating) as measures of pavement characteristics. In 1995 a research project entitled "Performance Indicators for the Road Sector" was established by the OECD (Organisation for Economic Co-operation and Development) and aimed at the investigation of existing road indicators (with only little relation to road pavements) in the member countries. This project was finished 1997.

In Europe, a number of studies have been conducted at the national level, on the basis of which specifications have been developed that define pavement characteristics in relation to the requirements of road users, road operators and road administration authorities. Modelled on clearly defined maintenance planning goals, the RPE-Stra 01 guideline (guidelines for planning road pavement maintenance measures) published in Germany in 2001 uses a structural index rating the structural condition of road pavements as well as a service index rating riding safety and comfort. In the United Kingdom the highways agency has used a performance Indicator for the effective maintenance of the national road network for more than 3 years. Similar systems and procedures are in use in the Scandinavian countries as well

as in France, Switzerland, Italy and Austria (cf. articles on the 1st European Pavement Management Systems Conference 2000 in Budapest, Hungary, and on the 5th International Pavement Management Systems Conference 2001 in Seattle, USA). It was found that, with minor exceptions, the individual performance indicators used by the various European countries are hardly or only to some extent comparable (use of different factors, rating systems, measuring procedures, etc.).

A.3 Solutions

The development of uniform performance indicators and indexes for road pavements is the key to performance evaluation and assessment and thus to the future planning of European road networks. Considerations towards this objective have already been undertaken by WERD (West European Road Directors) and the European Union within the framework of TERN (Trans European Road Networks). Within the Third Strategic European Road Research Program (SERP III) drafted by FEHRL (Forum of National European Highway Research Laboratories), this theme has been assigned high priority.

It is only the Europe-wide harmonization of specific road pavement performance indicators that permits international comparisons of existing road pavements from the perspectives of both the road users and the road operators. Uniform performance indicators could constitute a key prerequisite for future investments in road infrastructure projects at the European level.

It is envisaged that the application of such uniform indexes will allow the specification of minimum European standards for road pavements. In addition, it would also be feasible and useful to filter out those areas of the European road network where more investment is needed to attain such minimum standards (depending on the road category). Performance indicators for road pavements could, however, also be used as inputs to pavement management systems (PMS), for calculating maintenance needs and thus to provide objective arguments for the need of reinvestment in road pavements.

A.4 Reasons for a COST-Action

Results from previous COST Actions and European research projects will form a valuable basis for the work within this project. COST 324 (Long-Term Performance of Road Pavements) and the PARIS-project were dealing with the evaluation of road condition and the development of performance prediction models. COST 325 (New Pavement Monitoring Equipment and Methods) and COST 336 (Use of Falling Weight Deflectometers in Pavement Evaluation) were focused on condition monitoring of road pavements.

Based on these previous results the definition and assessment of individual representative performance indicators and the development of combined performance indexes will be conducted. A separate COST Action offers an excellent framework to bring together the existing knowledge from a large number of countries and national road administrations including also experts from research laboratories and universities. This group will ensure the conduction of the scientific program specified in

this Technical Annex as well as the future implementation of the results in national specifications and legislation.

B Objectives and Benefits

B.1 Objectives

The **main objective** of the Action is the definition of uniform European performance indicators and indexes for road pavements taking the needs of road users and road operators into account.

A quantitative assessment of individual performance indicators provides guidance regarding present and future needs in road pavement design and maintenance at both the national and the European levels. By specifying limits and acceptance values (e.g. target values, alert values, threshold values, etc.) for individual performance indicators minimum standards can be laid down for both projected and existing road pavements. Performance indicators should be defined for different types of pavement structures and road categories.

A **further objective** is the grouping of these individual performance indicators or indexes into representative combined performance indexes as

- Functional performance indexes (demands made on road pavements by road users)
- Structural performance indexes (structural demands to be met by the road pavement)
- Environmental performance indexes (demands made on road pavements from an environmental perspective)

Finally, based on the combined performance indexes a global performance index will be defined for describing the overall condition of the road pavements, which can be used for general optimisation procedures.

B.2 Benefits to different types of users

The potential benefits arising from the action are substantial for road operators and road users as well. The primary use of such indicators is for the comparison of different road networks and the identification of investment requirements where relevant minimum standards have been defined taking into account the requirements of road users.

For the development of international standards regarding to road pavement condition harmonized performance indicators are an essential prerequisite. In this context they can be used on the one hand for international and national road audit but also on the other hand for widening the market for supervision and construction within Europe and thus strengthen the competition.

Performance indicators can be used in particular as target criteria in life cycle analyses within the context of pavement design and/or systematic road maintenance at the national and the European levels. Uniform performance indicators permit an evaluation of the effects of different design and maintenance strategies but they can also be used for predicting road performance and for improving and developing new prediction models. Performance indicators are thus an objective tool for use in road construction and maintenance at various administrative levels, from local roads to international highways.

A further benefit will arise for the road construction industry. In connection with increasing privatisation of road construction and maintenance in Europe, the objective

assessment of condition or performance indicators is gaining special importance. Such indicators may be used in awarding maintenance contracts to private enterprises and, in particular, within the framework of the new awarding procedures being contemplated in many European countries (private-public partnership contracts PPP, build-operate-transfer contracts BOT). Clearly defined harmonized performance indicators are an important precondition for the successful application of these new types of contracts.

C Scientific Programme

C.1 Specification of Requirements

C.1.1 Collection of existing basic information

For the development of unified performance indicators or indexes it is necessary to collect in a first step all the available information about existing pavement evaluation procedures on national level. Therefore a comprehensive inventory will be made of performance indicators used throughout Europe. This inventory will cover on the one hand the different types of individual performance indicators for pavements and on the other hand the necessary measurements and data collection procedures (national studies and standards as well as international studies, e.g. FILTER). In this context the existing limits and acceptance values (e.g. target values, alert values, threshold values, etc.) for the various indicators are of special interest. Additionally information shall be collected about the transformation from measured or monitored values to dimensionless classification indexes and the related classification systems.

Beside the evaluation of individual characteristics the inventory shall include also information about the use of combined indexes and global performance indexes in the different countries and the procedures to calculate these indexes.

C.1.2 Selection and assessment of individual performance indicators

Following the collection of information suitable factors are to be selected in a first step. The criteria for the selection of the various individual indicators shall be its importance with respect to the given targets, the availability, and the possibility of net-wide high-speed measurement or data collection.

As the collection and measuring methods as well as any calculation procedure used for specific characteristics vary greatly across Europe, it appears useful in this context to seek harmonization as part of the data collection activities or to rely on existing international rules developed under the FILTER, HERMES, COST 324, COST 325, COST 336, PARIS, etc. projects. Before an initial selection of potential factors can be made, a framework has to be specified for possible data collection methods. In this process, more than one collection method may be defined for individual characteristics provided that the results obtained are interchangeable. Procedures that do not satisfy this condition should no longer be used in the future.

A key component for the harmonization of performance indicators is also the definition of unified limits and target values for each selected individual indicator. The target values and limits required for an assessment have to be adapted, of course, to the different needs of road users and road operators. These specifications depend significantly on the road category to be assessed and, where possible, should be made not only on the basis of statistical and empirical studies (laboratory and field tests) but also on the basis of analytical evaluations.

As a result for each of selected individual performance indicator the measured or monitored indicator value (e.g. rut-depth in mm, IRI in m/km, cracked area in %) can be evaluated according to the given limits and target values. To enable the

comparison of different individual performance indicators it is necessary to convert the indicator value into dimensionless index by using individual transformation functions. The result of this procedure is a classification index according to a classification system, which has to be set up (e.g. scale from 1 – very good – to 5 –very poor).

Besides the objective classification of each individual performance indicator it is now possible to combine several indicators as described in the next step.

C.1.3 Combination of individual performance indicators

By the combination of individual performance indicators or indexes into combined performance indexes, a single representative value will be available for each of the objectives described in Chapter B (functional, structural, and environmental index). The combination should be carried out by applying special weighting and composition rules. Each individual performance index has to be assessed with regard to its influence, significance and correlation with other characteristics.

The procedure for creating combined performance indexes will be designed with sufficient flexibility to allow calculations to be performed with respect to the amount of available information. This means that ultimately several variants are available for compiling performance indicators and that the best procedure can be selected in each case from the variety of input information at hand.

C.1.4 Development of a general performance indicator

Finally, on the basis of the results of the inquiry a procedure has to be developed to bring together the combined performance indexes described in Chapter C.1.3 to a single general performance indicator. This combination is of benefit when procedures employing optimisation methods are used for life-cycle analyses. Since, with the given constraints, only one specific target function can be optimised mathematically (maximized or minimized), it may be effective to use a general performance indicator for this purpose that comprises functional as well as structural and environmental requirements.

C.1.5 Final report

The results of the tasks described above will be compiled in one Final Report. In addition, the Final Report will be supplemented with a recommendation for the practical implementation of the performance indicators. The final report is thus the final deliverable of the subject COST Action and a key element of the dissemination plan.

The research work carried out to produce the deliverables will satisfy the main objectives of the Action. Work in a COST Action involving key experts from many European countries and possible from countries outside Europe as well, will ensure the desired exchange of ideas and experiences and generate a broad knowledge base from which to progress.

C.2 Work programme

The Action aims at producing the following deliverables:

- Data base on individual pavement performance indicators used throughout Europe including limit values, classification systems and measurement and data collection procedures
- Review of existing methods and practical guide for choice and application of individual pavement performance indicators including measurement and data collection procedures
- Practical procedure for developing combined performance indexes and proposed areas of application
- Practical procedure for developing a general performance index and proposal for application
- Final report of the action

The work programme to be carried out under this COST Action is subdivided into five work packages set up to deal with the tasks outlined in Chapter C.1 each producing one the five deliverables. Each work package is in turn broken down into a number of research tasks, which are listed in Table 1 below.

<i>Work package No</i>	<i>Contents</i>	<i>Research Task No</i>	<i>Contents</i>
1	Collection of existing basic information	1.1	Inventory
		1.2	Database
2	Selection and assessment of individual performance indicators	2.1	Selection of suitable performance indicators
		2.2	Definition of target values and limits
		2.3	Development of transformation functions
		2.4	Practical guide
3	Combination of individual performance indicators	4.1	Development of combination-procedure
		4.2	Report on practical procedure
4	Development of a general performance indicator	5.1	Development of combination-procedure
		5.2	Report on practical procedure
5	Final report	6.1	Draft
		6.2	Final version

Table 1: Working programme with working areas and research tasks

Work Package 1 will involve an inventory on performance indicators for road pavements used across Europe, taking into account different road categories and pavement types. The inventory will cover also information of each individual performance indicator about the target values and limits as well as applied

transformation functions, classification systems and methods of measurement and data collection.

The technical approach to the work in this Work Package will be working through questionnaires and subsequent discussion by the technical experts of the Action. The final deliverable of this Work Package will be the database with the information on the individual pavement performance indicators, which are described above.

Work package 2 will start with the selection of suitable individual pavement performance indicators based on the information, which are stored in the data base. After the selection of individual performance indicators the target values and limits of each single indicator will be developed based on statistical and empirical studies as well as on analytical evaluations. For the comparison of the different individual performance indicators transformation functions will be defined in a next step. To calculate dimensionless performance indexes a special classification system will be set up.

The deliverable of this Work Package will be a practical guide for the choice and application of individual performance indicators including limit values, classification systems and measurement and data collection procedures.

Work package 3 will start with the comparison of the existing combination procedures to form combined indexes from several individual performance indexes. Consequently a harmonized procedure with unified weighting factors will be developed, which will be described in detail in a report on the practical procedure and the application of combined indexes.

Work package 4 will have the same structure as work package 3, this time dealing with the unification of several combined performance indexes to one general performance index. The deliverable of this Work Package is a practical procedure for the development of a general performance index and its application.

The deliverables of Work package 1 to 4 will form the basis of the Final Report of the Action to be developed in Work Package 5. Additionally to the compilation of the four Work Package Reports the Final Report will include proposals for the implementation of the results of the Action.

D Organisation and Timetable

D.1 Organisation

Several working groups will be needed for conduction the research tasks in the individual work packages set out in the working programme described in Chapter C.2. These working groups will be composed of experts delegated by the participating countries. The number of participants per working group has to be set so as to enable efficient working and to produce the deliverables. Nevertheless it seems to be useful that at least on of the experts already engaged in one working group takes part in the subsequent working group to ensure an effective flow of information. The working groups will submit their findings to the Management Committee for discussion and approval.

In that way the work of the five working groups will be stimulated and directed by the Management Committee. In specific key areas it also appears useful and appropriate to integrate additional experts and/or observers from administrative, research and industrial backgrounds into the work.

In addition, according to the EU-US science and technology cooperation agreement attempts will be made to invite experts from the USA (e.g. Transportation Research Board TRB, Federal Highway Administration FHWA) to co-operate and contribute their findings to the subject Action.

Figure 1 shows the Work Breakdown Structure of this COST Action.

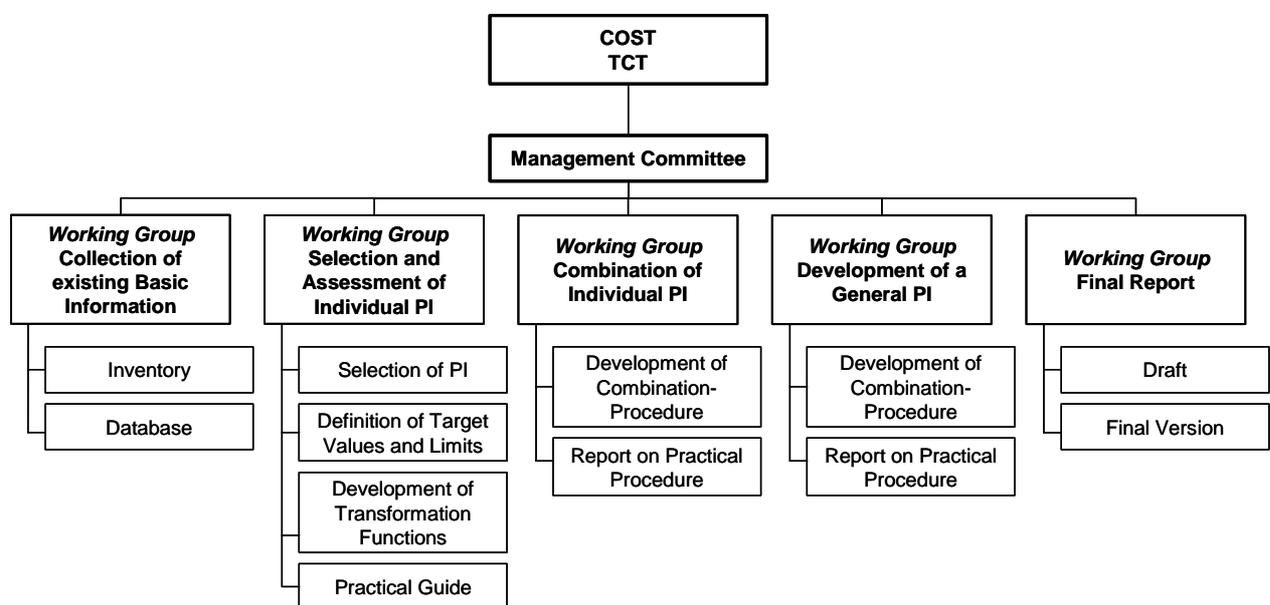


Figure 1: Work Breakdown Structure (PI = Pavement Performance Indicator)

D.2 Timetable

The timetable for the subject COST Action is organised so as to enable continuous work. As the results of the individual working areas generally constitute the basis for subsequent work, the timetable must take this fact into account. A certain overlapping period is provided for the transition from one work package to the next in order to, firstly, ensure a smooth delivery of the results of the research work and, secondly, give those dealing with the next work package the opportunity of discussing any questions that may emerge with the previous working group.

For the subject COST-Action a total duration of 4 years is scheduled.

Figure 2 below shows the timetable for the subject COST Action.

WP	TASK	YEAR			
		1	2	3	4
1	1.1	[Shaded]			
	1.2	[Shaded]			
2	2.1	[Shaded]			
	2.2	[Shaded]			
	2.3	[Shaded]			
	2.4	[Shaded]			
3	3.1	[Shaded]			
	3.2	[Shaded]			
4	4.1	[Shaded]			
	4.2	[Shaded]			
5	5.1	[Shaded]			
	5.2	[Shaded]			

Figure 2: Timetable

E Economic dimensions

The following COST-countries have actively participated in the preparation of the Action to date or have otherwise indicated their formal or informal interest:

Austria	Belgium	Greece
Poland	Slovenia	Germany
United Kingdom	Sweden	Netherlands

For a comprehensive processing and a maximum contribution of experiences it is intended to increase the number of participating countries and experts. The first contacts were taken with a number of experts, which are all listed in the enclosed "List of Experts"

On the basis of national estimates provided by the representatives of these countries the overall costs of these activities to be carried out under the Action has been estimated, in 2002 prices, at roughly 6.5 Mio Euro.

The estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

F Dissemination

Road transport provides over 80 per cent of all transportation in Europe. A well designed and maintained road infrastructure therefore is essential to Europe's economic development. The objective of the dissemination plan is to promote the results of the COST-Action, to enable a practical application of the outputs, and the propagation of knowledge and experiences in the best possible way. The following list contains the target groups for the dissemination of the results of the COST-Action:

- Participating experts of the COST-Action
- European level policy maker
- National government policy maker
- Regional planner
- Local authority engineer
- Road and vehicle operators/industry
- Research institutes/academia

For the dissemination of the results the following media are going to be used:

- Hard copies of the interim reports (reports of the work packages) and the final report
- Electronic version of all reports (CDRom)
- Publications on national and international conferences, seminars and meetings
- Internet: Separate homepage on the COST Transport website and on the website of the Institute for Road Construction and Maintenance, TU Vienna (ISTU), with a download-area for downloading of the interim reports and the final report