orders of priority. Of particular interest in Part D, for rational decision making, will be those sections that deal with processes leading to the development of alternatives of maintenance measures and a comparison between these alternatives.

Part E will deal with the basis for budgetary planning and resource allocation regarding a major current problem, that is, obtaining short-, medium-, and long-term financing for the necessary road maintenance. Part F will contain a collection of relevant regulations for the execution of construction and maintenance measures, as well as advice on documentation required for completed works. Finally, Part G will contain recommendations for data collection.

The introduction and development of such a management system will make it possible to achieve more rational decisions in the field of road maintenance than has been possible in the past. It is expected that the planned guideline will become an important source of information for experts involved in decision making.

Parts of the guideline will be similar to, or may even contain, accepted standards. The application of these parts will not involve extra expenditure. Other parts, however, especially those devoted to the processes of selection, are likely to introduce new techniques requiring a certain amount of training and training ability. So as not to risk the general acceptance of the system, it appeared advisable to adopt a stepwise approach toward its development and introduction. Initially this will be based on small local administrative centers.

The considerable costs involved in making such a system effective will be justified if it succeeds in ensuring that the road maintenance is based on cost benefit principles. The possible savings are considerable and are certainly more than the 5 to 10 percent forecast from new methods involving technological advances in bituminous and concrete pavement construction (2).

It will be necessary, under any circumstance, to ensure that the management system created can be applied and checked in an adequately simple fashion. At the same time, however, the system must be based on well-founded principles so that the decision maker can achieve not just apparent, but real optimization of decisions and actual operations in the sphere of road maintenance.

REFERENCES

1. C. Pingel and A. Schmuck. Konzept zur Entwicklung eines Managementsystems für die Strassenerhaltung (A Concept for Developing a Management System in Road Maintenance). Final Report to Res. Programme 9.034 of the Federal Ministry of Transport of 15.11.1981.
2. G. Oefner and A. Schmuck. Ein Beitrag zur modellgestützten Vorbereitung von Strassenbautechnischen Entscheidungen (A Contribution to the Preparation of Decisions in Road Construction Technology on Models). HSB Munich-Neubiberg, 1983.

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A Pavement Management Information System for Evaluating Pavements and Setting Priorities for Maintenance

GERHARD SCHOENBERGER

ABSTRACT

An essential task of those active in road technology is ascertaining the quality of road installations built in the last decades, and thereby ensuring objectively that the existing installations actively satisfy the requirements as described for the road in question. The German Road and Transportation Research Association has developed a national system to assess the road condition. A condition survey is conducted by both visual and technical means to arrive at a condition index. The decision of when to execute certain maintenance measures is based on a minimum acceptable value for the condition index.

The increasing number of projects and the high volume of public expenditure, coupled with constant concern over the financial investment in the road infrastructure, have made it essential to take steps to maintain the existing road stock, just as it would be necessary to maintain any other major economic asset that is subject to constant deterioration. This will ensure that the road system fulfills the expectations set by its design. It is desirable, therefore, to develop objective problem evaluation techniques, not hitherto attempted, within the framework of a pavement management system (shown in Figure 1).

The basis of every management system is an objective analysis of the problem area. For the management system discussed in this paper the pavement condition must be defined, observed, and evaluated

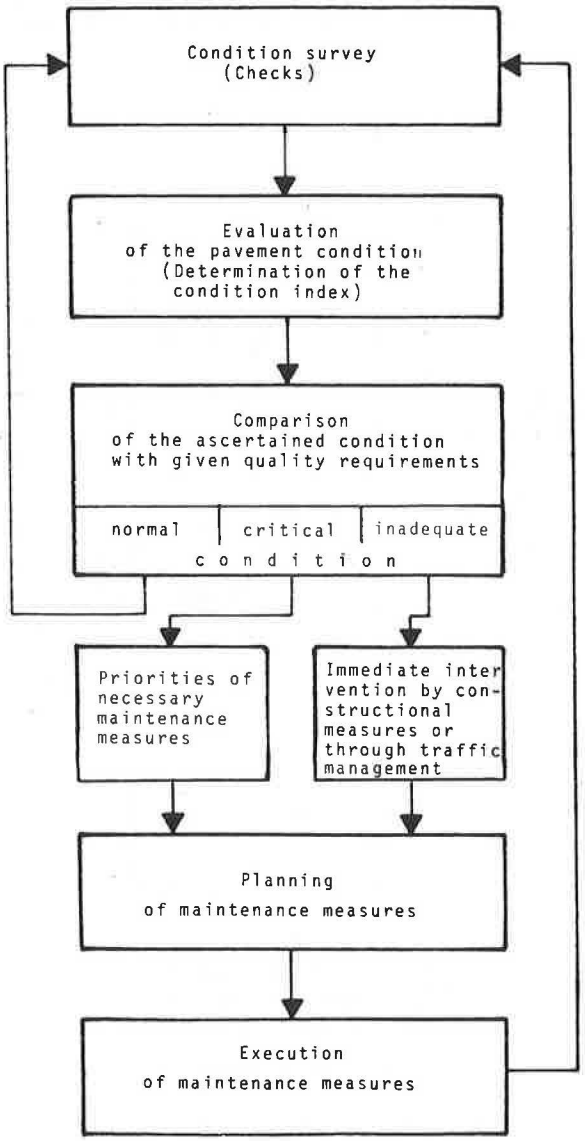

FIGURE 1 Pavement management system.

and a condition index assigned to it so that the characteristics can be described in an objective manner and changes in these characteristics, relative to a desirable quality standard, can be predicted. It follows that it is necessary to devise a basis for a pavement management information system.

ANALYSIS OF THE PROBLEM

The condition index of a road is hard to define and to present, owing to the many different parameters affecting it. In general, it is necessary to rely on available experience with the understanding that the condition index is a function of slope of the pavement, evenness, damaged areas, characteristics relating to construction materials, bearing property, and frost resistance.

In practice, it is axiomatic that the condition index deteriorates continuously under traffic according to the design, construction, maintenance strategy, traffic load, and climatic conditions. When, after some years, the minimum acceptable value is reached, the pavement must be rehabilitated through appropriate measures. In Germany up to the present this minimum value has not been defined. Therefore deciding whether to initiate maintenance work and, if so, what particular maintenance work is to be carried out are matters of judgment.

Conclusions are drawn concerning various condition criteria, the structural state of the road, degree of impairment, safety, and comfort of road users. These are part of decision making in the following problem areas:

- Priority assessment of a large number of maintenance measures according to urgency, and
- Comparison of variants among several alternative design and maintenance strategies.

METHODOLOGY FOR CONDITION SURVEY AND EVALUATION

A methodology has been worked out, based on hitherto accepted concepts in the field of condition survey and evaluation, that takes into account practical experience as well as theoretical design considerations. One can deduce from Figure 2 that several condition criteria are used to describe the pavement condition. In this it is possible to distinguish among the so-called basic criteria (roughness, evenness, cracks, holes, damage spots, and so forth) and such derived criteria as skid resistance, reflection, and noise emission. Basic criteria define the surface structure, surface damage, and changes related to road strengthening. General effects of the road surface are represented by the derived criteria. In this way, a meaningful picture can be formed of the pavement structure as a whole.

The condition criteria may be described quantitatively by indicators. The values thus obtained are transferred to a scale. To summarize these figures in a meaningful manner, the relevant values must be given an appropriate weighting, as they represent different functions.

In the future a distinction will be made among requirements for the pavement condition, that is, acceptance value, monitory value, and limit value. An example of this concept is shown in Figure 3. The acceptance value represents an agreed upon quality standard at the point of completion of the construction. The monitory value of the intervention zone marks a quality standard whose transgression is indicative of further condition deterioration and therefore of a need for maintenance. When the limit value of the intervention zone is reached measures involving traffic management must be considered (e.g., closures and weight limitations).

Thus, these values determine to a great extent the need for finance (i.e., road expenditure) and directly determine the quality standard of the roads. It should be noted that the need for carrying out maintenance measures can be triggered either by reaching the limit of an individual criterion value, or the limit of the condition index arrived at in the course of an overall assessment. Fitting the required values (acceptance, monitory, and limit) to the differing road categories is extremely important. It is necessary to group the roads, according to their significance to traffic, into federal highways, rural roads, country roads, and so forth. It may be advisable also to include the design speed as a characteristic.

In the process of evaluation and weighting, the needs of different interests could cause special difficulties (Figure 4). Thus, road users, public agencies, and third parties each may differ in their views of the significance of a given quality factor, which may be reflected by different maintenance objectives.

SURVEY TECHNIQUES

There is a distinction between visual techniques and

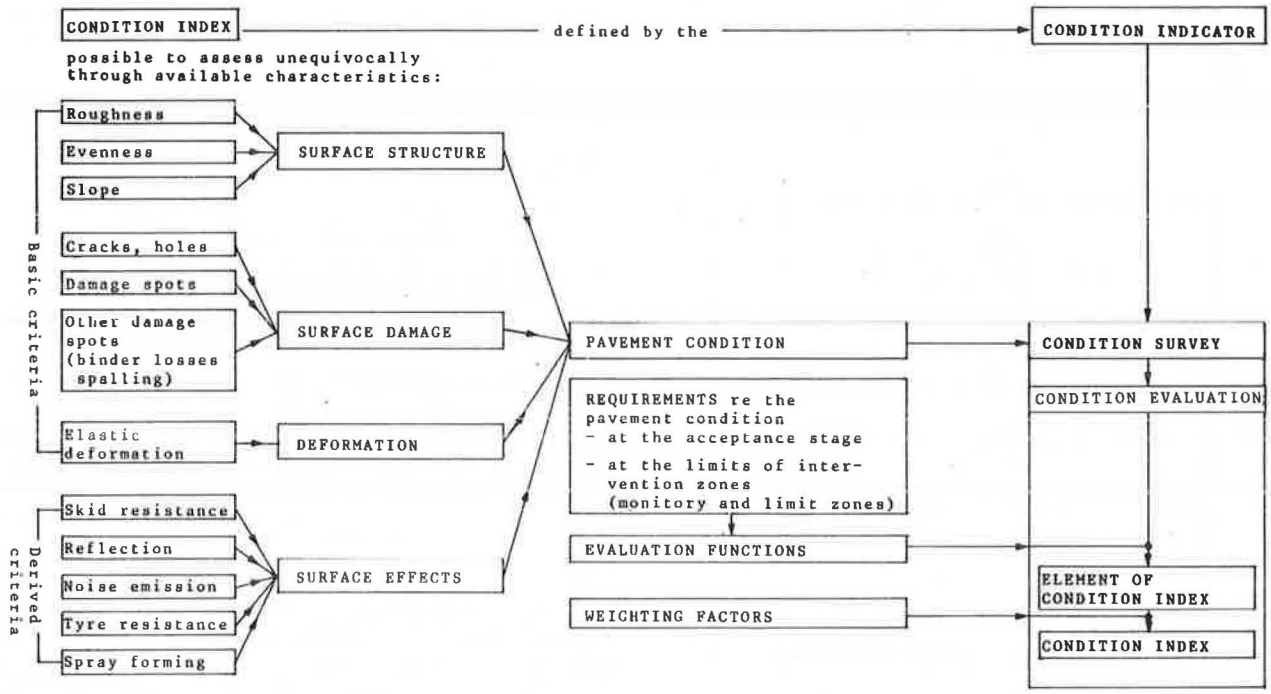

FIGURE 2 Methodology for survey and evaluation of the pavement condition.

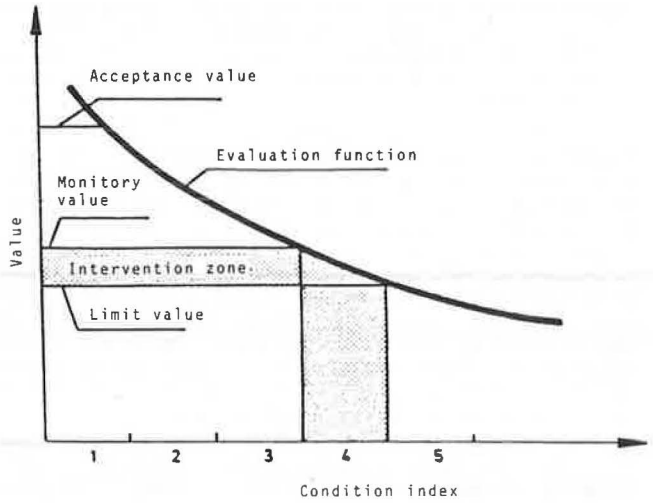

FIGURE 3 Acceptance value, monitory value, limit value, intervention zone.

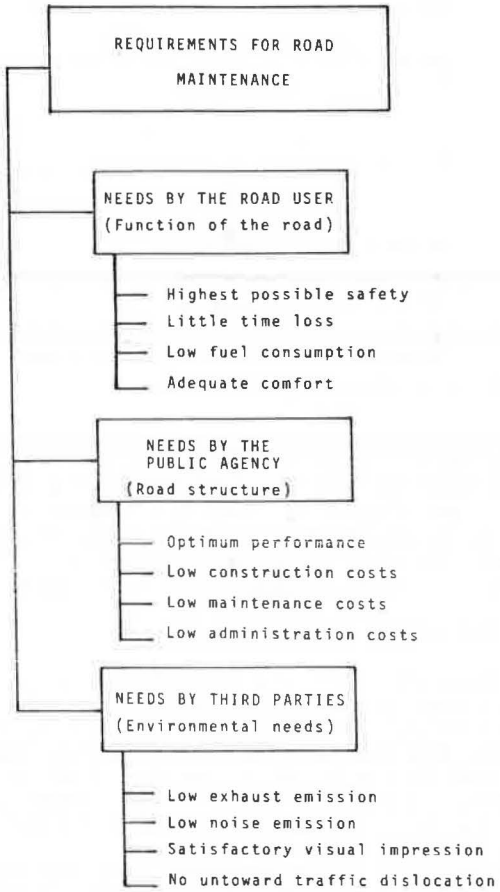

FIGURE 4 Requirements of road maintenance.

techniques based on measurement. Only very simple instruments are used for a visual inspection, whereas in an examination based on measurement, large (complex) measuring instruments are employed. Experience shows that even where the focus of the examination is on the measurement of characteristics, a visual inspection is still desirable.

A detailed analysis is being conducted currently of all the different types of measuring instruments available for condition surveys. The purpose is to draft recommendations for the use of appropriate devices in particular situations. These studies are still in progress and cannot be reported on further at this stage.

For a visual inspection of the pavement condition the human eye and simple devices (e.g., rule and aligning pole) are used in a simple and systematic way. The requirements of visual inspection comprise the following:

- Simple and ascertainable application,
- Ensuring an objective condition survey,
- Rapid data evaluation, and
- Possibility for reproducing the pavement condition.

Two models are being tested at present for the inspection of bituminous rural roads:

Model A. The pavement condition is surveyed using a car driven on the road. One or two stops are required within each road section to make the necessary inspection and collect data. In addition a similar paved section is surveyed in more detail by assessing five criteria (patched spots, eruptions, crazing, ruts, and evenness); following this an overall assessment is made. The survey is based on generally used quality acceptance terminology, for example, "not discernible" or "clearly visible." The great advantage of this technique lies in its rapidity; one observer can inspect approximately 10 to 20 km of pavement per hour.

Model B. This is similar to the Texas system. Eleven condition criteria are assessed for small sections of pavement, for example, 25 m long; the result should be a wide-ranging and clear picture of the road. An index is applied in accordance with the pavement condition depending on location; the assessment is supported by hard data based on detailed measurements. The disadvantage of this technique is the considerable time expended. According to the road section and the condition of the pavement, two observers should be able to survey 600 m per hour.

A definite conclusion has not been reached as to which of the models is more useful. However, it must be kept in mind that the choice will be influenced by the type of public agency and the compatibility of the condition survey with the existing hierarchy. It should also be remembered that both models can be applied in combination.

DATA STORAGE

The data acquired must be stored to make them available when detailed information is needed to assist objective decision making. The following requirements have been established for the documentation:

- Cost-effective data recording,
- Possibility of consolidating data,
- Rational preparation of information, and
- Easy access.

One cannot do this without a data bank because in a pavement management system only completed cycles are studied. Plans are being made in Germany to establish data banks with catalog files and data processing equipment.

RESULTS OF INVESTIGATIONS

On the basis of the preliminary results the following condition criteria in the order given below are valid for carrying out maintenance:

1. Individual cracks,
2. Damage spots,
3. Plucking, holes, spalling,
4. Unevenness laterally,
5. Crazing,
6. Loss of binder or porosity,
7. State of joints and seams,
8. Unevenness longitudinally, and
9. Deformation.

Following a service life of about 12 years, surface damage on rural roads (not motorways) occurs on an average of 12 percent and general unevenness on an average of 10 percent of the total road area. Lateral unevenness with ruts to a depth of 10 to 12 mm is to be expected over approximately 10 percent of the total pavement area. The condition is critical if general surface damage appears over 25 percent of the total area or ruts are 15 mm deep. Damage at the edges occurs on narrow roads (under 6 m wide) generally after a short period of use.

A relationship exists between deterioration of the pavement condition and the period of service life. However, this can be documented only by means of a very few correlations. Apart from that the parameter "service life," which has an implicit relationship with many time-dependent service variables, appears much more suitable for drawing meaningful conclusions concerning changes than the parameter "number of load applications." The poor correlation is indicated by the wide variance in condition index and that it is affected by numerous, not easily defined parameters. As a consequence it is difficult over a long period to predict quality changes on the basis of visual inspections.

OUTLOOK

The survey and evaluation of the pavement condition is of fundamental importance for a pavement management system. In the future the related problems will require an intensive study of special areas of road technology that in the past have not been intensively investigated. Such study is closely linked to establishing an appropriate information system to provide practical and readily understandable data.

The objective of these efforts is to allow the public agency to intervene at the proper time on the basis of meaningful and scientifically based information. Furthermore, it is of great importance--especially in times of financial stringency--to indicate to those responsible for policy that the substantial funds for road maintenance are essential. It is also important to be able to specify the damages likely to arise should the necessary road repairs not be carried out and the consequences resulting from traffic restrictions or the necessary allied traffic management measures.

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