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Road and Rail Infrastructure V

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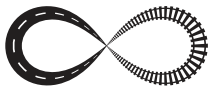
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IMPLEMENTATION AND BENEFITS OF A LOW COST PMS FOR MUNICIPAL ROAD NETWORKS

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Abstract

Local road authorities in Belgium manage about 90 % of all roads but these municipalities often only dispose of a very limited budget for road maintenance. Preventative maintenance actions have to prevail for optimising the use of the budget. For this, only an objective observation of the current network condition allows decision making and planning of the most cost-effective and technically efficient maintenance works at the right time. In this contribution we present a pavement management system (PMS) for assistance on technically sound decision making that needs very little of the limited financial and human resources of the local authorities. The approach consists of simple tools for the set-up of an inventory, a method and tools for visual inspection at network level, the definition of a “visual index” and the categorisation of the inspected road sections by the use of thresholds, a first straightforward interpretation of maintenance planning for road sections, simple prediction models, and advanced analysis techniques and software for the technical and financial optimisation of road maintenance with long term planning. In the paper we will show that this stepwise approach is feasible and sound, and that it can be applied in an autonomous way by the technical staff of a local authority as well as by service providers. We will discuss the immediate technical benefits (improved network conditions, reduced number of urgent local repairs) and the long term financial benefits. We will describe hurdles, challenges and organisational advantages encountered when introducing this PMS approach.

Keywords: pavement management, monitoring, municipal road network, analysis

1 Introduction

The Belgian road network consists of approximately 154.000 km of road and 90 % of these are managed by cities and local municipalities. Road maintenance is often considered as an important cost for their meagre budgets. However, a road network is a common heritage with a high initial value on investment and is beneficial to the local economy and the whole community. Cost-effective and technically sound road maintenance is an investment in its preservation.

Under the pressure of existing financial limitations, it is important to base the planning of future road works on an objective observation of the current network condition. Budget spendings can be optimised by concentrating on preventative rather than on curative maintenance. Decades of experience of the Belgian Road Research Centre (BRRC) with Pavement Management Systems (PMS) ([1-3]) are now distilled in a publically available, technically sound approach ([4, 5]) that is within reach of all local authorities. It is based on a visual inspection technique dedicated to network management of communal roads, the definition of a “visual index” and thresholds, simple prediction models and a financial optimisation of the needed maintenance.

Regional or national roads and motorways are often inspected with dedicated, highly sophisticated monitoring devices, including properties like skid resistance, rutting, longitudinal unevenness (or roughness) and cracking, sometimes completed with deflection measurements ([6, 7]). In many countries visual inspection of surface defects are considered a sufficient input for maintenance management of local roads. Guidelines and standards have been published (e.g. France [8], Germany [9] and [10], The Netherlands [11], USA [12]).

In this paper, the approach proposed by BRRC will be described in Section 2. This stepwise approach is feasible and sound as shown in Section 3. Several local authorities have started with the implementation of the approach. In Section 4 the encountered hurdles and challenges as well as the observed organisational advantages and technical and financial benefits will be addressed. The novelty in this paper is the full description of the approach and the demonstration of its realisability and effectiveness as a real world application. The authors are convinced that in many countries PMS is still underdeveloped and they hope that the experiences reported here will inspire others beyond the Belgian borders.

2 Description of the PMS approach

Until recently very few Belgian local authorities had experience with PMS. Therefore the BRRC opted for the promotion of PMS in general and the BRRC approach in particular. This led to two publications (both in French and Dutch): a detailed description of the visual inspection method ([13]) and the corresponding PMS approach ([14]) developed by BRRC. These documents are aimed at municipal road managers and at service providers. So far the BRRC also organised six training sessions for (future) visual inspectors. Meanwhile, several tools have been developed by BRRC and by private companies as to maximise the efficiency of such inspections. The PMS approach of BRRC is implemented by the company Kiwa-KOAC in their software ViaBEL. Today, service providers offer local authorities visual inspections following the BRRC method, as well as data interpretations with ViaBEL or with their own PMS method and software.

2.1 Network inventory

As a start, the road manager must have a full description of the road assets to be managed. Nowadays, maps of all roads in the country exist and GIS tools are easily available. With these, the road manager can subdivide all roads in separate road segments. Each segment must be inspected separately and will get a score (a value for the “visual index”) expressing its current condition. The BRRC suggests subdividing the road network in “road sections” (usually portions of streets between two crossings) and “nodes” (crossings, squares,...). Each road section is then further divided into segments (usually one segment for each of the lanes). Sections, segments and nodes can easily be defined and uniquely identified by polygons on GIS maps. These sections, segments and nodes can then be connected to a database of attributes (such as the visual index). The visual inspection is to be executed on a regular basis (BRRC suggests at least every other year). For the evaluation of the evolution of the condition over time, conditions during the inspection must be as similar as possible. For segments it is recommended to store the sense in which the inspection is executed. For nodes, it is best to store the position(s) from which (part of the) node is inspected.

2.2 Visual inspection for communal road network analysis

the BRRC approach of visual inspection is only valid for the area where motorised vehicles circulate. Practical instructions and a catalogue of defects were published ([13]). Inspectors must identify only a small number of defects. There are three different lists of defects: one for cement concrete, one for asphalt concrete and one for block pavements. Presence and extent

of damage must be reported but not its severity or its cause. The results of the inspections are to be independent of the tools used by the inspectors: inspection on foot with a piece of paper or a dedicated tablet, inspections from the passenger seat of a vehicle, inspections at the office from images or film are all acceptable.

2.3 Visual index, global index, thresholds, maintenance categories

the visual index I_v is defined by Eq. (1), where P_i is the percentage of the road surface of the inspected segment or node affected by the i -th type of distress and w_i is the weight assigned to the i -th type of distress. The global index I_g is computed by Eqs. (2) and (3). Thresholds on I_g trigger a maintenance operation in the PMS approach, as described in Table 1.

$$I_v = \max \left\{ 0.9 - \left(\sum_i (w_i \cdot P_i) \right) ; 0 \right\} \quad (1)$$

$$I_s = 1.2 \cdot I_v - 0.18 \quad (2)$$

$$I_g = (I_v + I_s) / 2 \quad (3)$$

Table 1 Classes for maintenance operations based on index I_g

Ig value range	Type of maintenance
$0.9 \geq I_g > 0.8$	Only routine maintenance
$0.8 \geq I_g > 0.5$	Local repairs
$0.5 \geq I_g > 0.3$	Generalized surface treatments
$0.3 \geq I_g \geq 0$	Reinforcement (or rebuild)

2.4 Prediction models and long term planning

evolution models were designed for each indicator (see details in [14]). Empirical models were derived from inspections on three local road networks of which the age of the roads were known. A group of experts estimated the effect of different road maintenance operations. These estimates were compared to theoretical computations of lifetime expectance. The evolution models predict in how many years from now a given segment or node with a current value for I_g will reach the next threshold and how I_g will evolve after a maintenance intervention. Several maintenance strategies are defined, each foreseeing a particular set of maintenance interventions, one at each of the thresholds. For each strategy, all maintenance can be planned for the next 20 years. When associating a cost to each maintenance intervention, the most economical strategy can be identified. The effect of each strategy on the global condition of the network (expressed in values for I_g) and its evolution in the next 20 years can be computed.

2.5 Reporting

Reporting PMS results with graphs, tables, lists and maps allows the road manager to illustrate the effects of current budget restrictions on the quality of the network in future, to show the implications of delaying some maintenance, and to propose a cost-effective investment strategy – even with a limited budget.

2.6 Preparations and execution of road works

the PMS planning only provides a priority list and a rough estimate of the annual budget needs. The thresholds on Ig are mainly motivated by a financial optimisation approach. Once the future maintenance strategy is chosen, the road manager must revisit the list of road segments that need attention in the next few years according to the PMS planning. For each of these road segments some deeper investigations are usually needed in order to determine the causes of distress and the most appropriate maintenance intervention techniques. Road works on adjacent road segments may be combined or must be coordinated with other interventions, such as the replacement of the sewer system underneath.

3 Feasible and sound implementation of the PMS method

Several prerequisites are necessary for the implementation of a PMS method by a road manager to be feasible. The visual inspection technique must be as objective as possible and tools must be available for making the inspection time-efficient and economic. The theory behind the PMS method must be sound and adapted to the road network, and some software implementation of the method must be available and accessible.

3.1 Visual inspection

The BRRC has a long experience with visual inspection for network management. In order to make the visual inspection into a measurement technique, the inspection results must be repeatable and reproducible. Limiting the inspections to a small number of defects and to the reporting of existence and extend of the distress favours the achievement of this. The quality of the results is increased thanks to the training courses. The repeatability and reproducibility is good enough for network evaluation, as discussed in [5]. In response to needs identified during the training course the catalogue of defects is currently revised.

Over the years BRRC developed several devices with dedicated keyboards for the registration of distresses. One device was for inspections from the passenger seat in a very slowly moving vehicle and was connected to the odometer of the vehicle. Several private companies now offer visual inspection as a service and they developed their own tools: a tablet and very accurate GPS coupled to a map for inspection from within a vehicle, ergonomic software for visualisation of images and the encoding of distress, and camera solutions to be mounted on a vehicle for the taking of images of the road surface. For the training sessions BRRC developed simple software for inspections based on images.

3.2 In-house solution or service provider

different road administrations prefer different ways of implementation of PMS. Some local authorities like to do everything by themselves and do not want information on their network to be stored in an external database or in the cloud. Other ones see the implication of external service providers as a guarantee for objectivity in the results of the inspections and of the proposed maintenance planning. Any of these ways of implementation are now available in Belgium.

3.3 Prediction models and PMS software

The thresholds and the first prediction models of the BRRC method were developed more than 25 years ago. They are “general” models that predict “average” behaviour of roads in Belgium. By publishing in [14] the details on the ways in which the models were developed and where they stand for, road managers (also abroad) can verify if the assumptions are valid for their

road network, they can adapt the existing models or they can develop similar ones. Software and service providers can do so too. The BRRC is ready to assist Belgian road administrations in such verifications. Still, recent practical experiences show that the original models give quite reasonable results: rarely a road manager is surprised by any of the proposed maintenance operations.

3.4 Different levels of implementation

in order to get a road authority started with PMS, it is best to offer a solution that can be implemented stepwise. The BRRC method can be limited to the creation of the asset inventory, one visual inspection of the whole network and a categorisation of the road segments with thresholds on I_g . In this way a type of maintenance is assigned to each road segment. The road manager can argue that maintenance preventing a road segment from a change of category is a good investment. Also on the longer term, it is best to get to a situation where most road segments have values of I_g as far away as possible from a threshold and where as little as possible road segments are in “bad shape”. For this, no sophisticated PMS with prediction models is needed although the PMS system would provide even more and better insights for policy making.

4 Praxis: introduction of PMS and its benefits

Since the publication of the inspection method ([13]) and the first training session associated to it, several municipalities started implementing the method.

4.1 Hurdles and challenges

It may seem obvious that an efficient cost-effective management of all pavement assets cannot be done without an inventory of the assets and the results of a recently conducted, objective condition survey. But in reality, the introduction of a PMS system is a change in the working culture and needs an investment from both political representatives and technical personnel. Often the first hurdle is the resistance to change, also because a PMS system may seem very complicated.

Usually the need for an objective and global condition survey is recognised. But the survey cannot be performed without the existence of an inventory. In small municipalities setting up an inventory is often considered as a very difficult task. Although much simpler today with GIS facilities and existing maps at hand, small municipalities do not often have the expertise on GIS in house and need help.

The time needed for the visual inspection when done in a non-optimal way by personnel of the road authority itself may be too important.

The financial benefits of maintenance planning with PMS are not easily estimated and may not seem important enough with respect to the cost of building an inventory and executing regular condition surveys. This is especially true for municipalities with a very low budget for road works, where road maintenance is reduced to urgent local repairs and occasional rehabilitations that are mainly financed by subventions or by independent organisations managing the sewer system under the pavement.

The benefits of preventative maintenance can only be appreciated over time whereas the rehabilitation of a road segment is immediately visible. Putting the priority on prevention must therefore be well-motivated and explained to all personnel of the local road administration, the local politicians and the population.

4.2 Immediate benefits and long-term advantages

The use of a well-defined method for condition evaluation of the road network is in itself an improvement over well-intended individual initiatives of the road administrator. A systematic and complete visual inspection gives a global view of the current condition of the network and of the maintenance needs.

An inventory with the current condition of the road network allows the road administration to prepare an underpinned request to the elected town council for a maintenance budget for the following 3 to 6 years.

The city of Namur started to invest in preventative maintenance: less expensive maintenance on many roads in fair condition were privileged over a few rehabilitation projects. In a few years' time many more roads reached a good condition, hence there is much less a demand for local repairs by the population and there is a significant drop in the number of such local interventions ([15]).

4.3 Initiatives at local municipalities in Belgium

Cities like Antwerp, Ghent and Namur already took initiatives independently and have some kind of PMS in operation. The Port of Antwerp has been using ViaBEL for years ([16]). Several smaller towns initiated a first condition survey on their entire road network or on part of it, using the Dutch inspection method ([11]) or the BRRC method ([13]).

Since the publication of the document on visual inspection for network management ([13]) in 2015, 6 sessions of the training course were organised for in total 100 participants from 48 municipalities, 7 service providers, provinces or inter-municipal organisations and 4 other organisations.

Several communal road networks and an industrial park were or will soon be inspected by commercial service providers following the BRRC method. One road administration did a first visual inspection of the whole road network by own personnel after following the BRRC training course. They now investigate how they can outsource inspections, preventative maintenance planning and the maintenance operations themselves in one single market.

A province and several inter-municipal organisations as well as several service providers, software and hardware providers are interested in using the BRRC method for visual inspection and the associated PMS approach.

5 Conclusions

This paper presented the PMS approach of BRRC and its implementation in practice. The method is based on visual inspections and is initially intended for use on local road networks in Belgium. Its promotion since 2015 was motivated by the lack of any PMS in most of the municipalities in the country. The paper demonstrates the realisability and effectiveness of the method as a real world application. The method is proven sound and reliable: the visual inspection technique is repeatable and reproducible, the PMS approach is based on realistic assumptions and produces results acceptable for any experienced manager of local roads. Since 2015, the BRRC method has been introduced successfully in several municipalities. This success is due to the completeness of the method and to the accessibility of simple tools for its implementation. This paper demonstrates that PMS is in reach of all municipalities in Belgium and elsewhere as soon as all necessary bricks are available in a practical way and at low cost.

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