Sustainable Maintenance of Rural Roads in Slovakia

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Abstract: Systematic approach to the maintenance of rural road network is a very important issue from the viewpoint of public costs. Most countries developed custom PMS (pavement management systems) based on deterministic or probabilistic approach. The main goal is to ensure safety and continuity of road traffic on road network with low intensity and lower technical requirements. Article presents PMS used for Slovakia rural road network based on road construction diagnostics, traffic volume, climate factors and evaluation of maintenance works economics effectiveness by using of software tools like HDM-4 developed by World Bank. Local road administrators of rural road networks often lack the software equipment, most PMS, however effective, are often cumbersome, demanding in regard to energy, know-how and software equipment. The majority of local road administrators of rural road networks thus resort to non-effective reactive maintenance strategies. This article describes an easy to use method, based on predetermined maintenance repair and rehabilitation standards. A simple method, based on road user cost, is introduced that administrator can use to prepare a list of road section eligible for repair according to their repair priority.

Key words: Pavement management system, rural roads, maintenance repair and rehabilitation.

1. Introduction

Road administrators capabilities differ significantly in accordance with available budget, length of roads they are responsible for, demands put on their assets, demands put on acquisition of new assets and many other issues, yet their task is the same. Their task is to develop and maintain a safe, eco-friendly and efficient transport system.

1.1 Road Network of SR (Slovak Republic)

The road network of Slovakia consists of 391 km of limited access roads (motorways and express roads) and 174,367 km of 1st, 2nd and 3rd class roads. The main objective of motorway network is to provide transit according to Pan-European transport corridors, namely the IV, V and VI corridor. The purpose of express road network is to collect and transfer the transport generated by Slovak republic’s regions and contra wise to distribute transport from foreign countries from motorways to the body of Slovak Republic. The 1st class trunk roads fulfill the service task of transportation between regions of Slovak Republic. 2nd and foremost 3rd class roads compose a rural road network. On top of this network, a network of urban communications and minor purpose communication is connected. Different types of roads have different owners and administrators with their executive offices. Their general task is to securing a fluent and safe transport on them entrusted roads by providing maintenance, winter service, repair, reconstructions and acquisition of new assets according to concept of development of road network of Slovakia.

This paper is aimed on the topic of road maintenance of low class road network (2nd and 3rd class roads) which constitutes the majority—three quarters—of the whole SR road network, as shown in Fig. 1, therefore the viewpoint of administrators of this road network will be crucial.

1.2 Sustainable Maintenance of a Road Network

The purpose of MR&R (maintenance repairs and rehabilitation) of asphalt pavements is to extend the useful life of the pavement, maintain a smooth riding
surface and prevent water from entering the underlying soil. Limited manpower and resources have increased the importance of MR&R for the service life of a pavement. To keep a pavement in the best possible condition, it is important to use an effective pavement management system. Basic PMS logical structure is depicted in Fig. 2 [1].

Pavement management system is a subsystem of asset management. It should ensure an adequate dividing of assigned funds from state budget and additional regional tax funds [2]. These funds are very limited, thus, sustainability principles have to be implemented so that the road network can provide the road users with socio-economical benefits. These benefits elevate the living standards of the society, which, in turn, is then more prone to spending which means more taxation money. Previous sentence denotes that the relations form a cycle—sustainability cycle—which is depicted in Fig. 3.

From the economical viewpoint, the sustainability principle means to balance the spend funds with generated funds which again can be spend, and so on, in an infinite cycle.

2. Implementation of Sustainable Road Maintenance in Rural Road Network of Slovak Republic

At present, the ratio of 2nd and 3rd class roads in critical or poor condition and the amount of available resources of road administrators of this network is beginning to reach critical levels. While a thorough and effective road asset management even of motorways and 1st class roads is still far from completion a substitution solution which have to be made to help road administrators of lower class roads. Since the rural roads are not surveyed systematically and their condition is not being tracked and used as an input for PMS, the municipal administrators of these roads rely on fixed MR&R standard. The MR&R procedures prescribed by fixed maintenance standard do not always correspond with the actual needs of the road conditions, nor do they take into account the budget possibilities of the road administrator, it is merely an empirically based schedule of pavement treatment works, which guarantees a good condition of the road throughout its whole life cycle. The downsides are obvious, the overall idea does not (mainly a high cost of this standard) correspond with the procedures described in asset management theory. Thus, road administration does not work effectively. Therefore, a search for lower-cost maintenance standards and the process of assigning them to individual rural roads started as a part of research on University of Žilina. The aim is to assess the possibilities
of cheaper maintenance while ensuring fair pavement quality to the society. This also means that instead of having part of road network maintained in sub-optimal and part in over-optimal condition, more homogenous ride quality on whole network will be achieved.

2.1 The Previous Results

In the last part of research [3] at our department, we have assessed the suitability of lower-cost maintenance standards for rural road network.

The condition of pavement related to service life for different variants is shown in Fig. 4. Variant 1—v1—is not shown in this picture, as the variant itself is responsive and not fixed. Fig. 5 shows the costs of different variants.

The results in Fig. 5 show five alternate MR&R variants, each with different cost and effects on pavement conditions. The variants are ranked for cost, technical suitability, economic effectiveness and from overall point of view. Following conclusion was drawn from this research:

Variant 1: current maintenance variant—very expensive variant appropriate only for road sections with heavy traffic load;

Variant 2: microsurfacing based variant—safe to use on all rural roads;

Variant 3: balanced cover layer exchange based variant—may be appropriate even for 3rd class roads with traffic load under 1000 AADT (annual average daily traffic) especially, if they are not subject to excessive high load vehicles encumbrance;

Variant 4: one major cover layer exchange based variant—fairly safe to use on all rural roads.
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2.2 Next Steps

The road network is inhomogeneous and dynamic environment. The traffic load, condition of particular road section, volume of maintenance on this section in contrast to road administrator capabilities and others factors, all play an important part for choosing the appropriate MR&R standard. Ranking of variant as seen in Table 1 is appropriate, however, use of a more in-depth multi-criteria analysis is advised. A sound method which can be used for multicriteria analysis based on third party programs like HDM-4 may be derived from Ref. [4].

In an ideal case, road administrators would use analytical software to estimate which MR&R standard should be used to maximize the socio-economic benefits for road users. For now, a complementary and easier method must be used. The method should enable road administrators to quickly calculate socio-economic benefits for one vehicle, which, when combined with traffic survey, would enable them to calculate socio-economic benefits for the whole road section. Note, that regional road administrators would have to implement a basic road condition survey system as some pavement data will be the input for such a system.

3. Sustainable Pavement Maintenance Solutions for Regional Road Administrators

As we know, there are several factors influencing economical effectiveness of road maintenance and repair works, it is mainly the difference between technical parameters of maintained (do something) and un-maintained (do nothing) road, and costs of these works. Since MR&R works do not influence the fixed technical parameters like geometrical alignments or width of communication, it is the surfacing parameters which changes are generating the benefits. It is assumed, that the main pavement condition parameter is the IRI (international roughness index) which usually is the main indicator of road surface condition [5]. To prove this assumption we did an experiment in HDM-4—to show the influence IRI has on vehicle operating speed which change is the main indicator of road user benefits. Subsequently, we transformed known mathematical equations used to calculate operating speed in relation to IRI to better suit the environment of rural road network of Slovak Republic.

IRI as a factors influencing operating speed of

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vehicles, for this experiment, first, a straight and level road section was created. Very low traffic intensity (1,000 AADT) was set and the operating speed was calculated for different IRI ranging from 1 to 12 on this road. Subsequently, the test was performed both in urban and un-urban environment for private cars and lorries.

As an alternative, a geometrically tortuous variation of this road was made (resembling a typical alignment for rural road section in SR environment). This way, we could examine the speed difference between two different alignments to estimate the impact of curvature of the road. The third run raised the low 1,000 AADT traffic intensity to a high 10,000 AADT.

The results shown in Fig. 5 denote that on a typical rural road, neither the alignment, nor intensity plays a marginal role in vehicle speed reduction. The mayor difference pertains to IRI. The full results are shown in tabular format in Table 2.
With the result in mind, we have derived a conclusion that a road administrator of a rural road network is capable to assess the importance of MR&R action by a simple calculation where the IRI and traffic intensity of are the sole inputs for calculation of MR&R action efficiency. He would not be able to calculate user cost directly, but he can collate road sections under his administrations and make a schedule of works with top priority MR&R actions being on top. Using Table 2 and Eq. (1), he can calculate PI (prioritization index).

\[
{PI} = \frac{{VOS_{BA} - VOS_{AA}}}{{AADT}}
\]  

where,

- PI prioritization index;
- VOS<sub>BA</sub> vehicle operating speed before action;
- VOS<sub>AA</sub> vehicle operating speed after action.

Table 2 shows the impact of IRI on vehicle operating speed traveling on respective type of a road. Graphical representation of these results is shown in chart depicted in Fig. 6. Higher PI denotes a more effective MR&R action. Provided we assume that vehicle operating speed is the main indicator of road user costs, the PI is proportional to user cost savings.

Two main factors are neglected in this approach—the cost of MR&R action and length of a road section. The premise is that length ads cost as well as benefits. This is a coarse statement but valid for road sections with length of about 0.2-5 km.

This sound and easy method may be used as a basic decision making tool. Administrator still has to select technologically correct MR&R technology, but it is a step to a proactive pavement management strategy.

4. Conclusions

The sustainability of rural road network requires an easy to use decision making method for regional road administrators of this road network. Method described in this is easy to implement and adapt. Only minor calibrations are needed for application:

1. MR&R standards should be identified by a national road administration body as this step is too elaborate for a local administrator to do;
2. The ranking of these variants is best to be performed by national transport research institution of a respective country.

Local road administrator is also advised to apply this method on a limited part of road network within his whole road matrix and assess the results before a full-scale implementation.

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