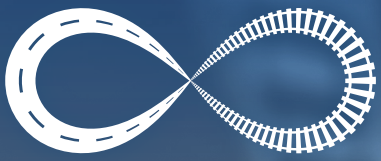

CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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COSTS OF PERFORMANCE BASED MAINTENANCE FOR UNPAVED LOCAL ROADS: CASE STUDY ALBANIA

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Abstract

Without regular maintenance, unpaved roads can rapidly fall into disrepair, preventing realization of the longer term impacts of road improvements on development, such as increased agricultural production and growth in school enrollment, which is of particular importance for a network of local (access) roads. Inadequate unpaved local roads maintenance in Albania is proposed to be solved by implementing performance based maintenance approach for which the costing exercise is presented within the paper.

Keywords: unpaved local roads, performance based maintenance, maintenance costs, road user costs

1 Introduction

Road authorities worldwide face mounting problems with maintaining the serviceability of their road networks [1]. From the period when it was directly carried out by the road authority, through the increase in the contracted element of the works (contractors applying traditional methods of contracting and measurement of works under the authority's supervision), over the last 20 years there has been a steady rise in implementing contracted maintenance through the use of performance based methods. This contracting method is generally considered to be more cost effective than the traditional, input based methods using measurement of units of work undertaken with payment at unit rates.

The essence of the Performance Based Maintenance (PBM) concept is that the contractor undertakes to carry out all necessary maintenance to a road or roads to keep them at a predetermined required standard. There is no measurement of the volume of works carried out and the agency does not dictate to the contractor what should be done or when it should be done. The contractor is free to organise the work required as and when it suits him subject only to maintaining the road at the specified standard. The contractor is responsible for quality control, both of the overall standard of maintenance and of the details of materials used and work performed. His performance is measured by monitoring a specific set of measurable values related to road condition.

The local roads system in Albania is expected to have a total length in excess of 20,000 km, split roughly 50/50 % between paved and gravel roads. Average expenditure on local roads maintenance in Albania is in the range of EUR 235-290 (ALL-Albanian Lek 32,000-40,000) per km per year [2]. This is extremely low. They effectively cover the costs of routine maintenance only, with no allowance for periodic maintenance or for improvements incurred as a result of inadequate maintenance. A substantial element of maintenance works was, effectively, offloaded onto the capital improvements budget, thereby saving immediate maintenance

expenditure at the expense of greatly increased future costs. All local authorities carried out some essential maintenance of gravel roads using some form of direct labor supported by tendering for the supply of basic gravel material. The expenditure figure above provided only the most basic standards of maintenance (effectively, just maintaining access) for the bulk of the gravel roads. The central issue to be addressed is the inadequate maintenance of Albania's local road network, and the need to change the maintenance philosophy from a reactive approach to a preventive approach. Analysis showed that this should be achieved by introducing a performance based approach [2]. Following the proposal of Level of Service (LoS) concept and relevant Maintenance Standards (MSs) for the Albanian local roads system, costing element of the system had to be prepared, and it is detailed further down below.

2 Performance based maintenance of local roads in Albania

The proposed system defines the appropriate MS to preserve a set LoS for each functional road class and traffic level, and specifies the tasks and their frequency of execution for each MS. In general, the difference between MSs lies in the frequency of execution or the permitted delay before execution of the required tasks rather than in the actual tasks themselves; in some cases, the MS also considers an acceptable level of deficiency in some road quality. The differences between the MSs result from the need to provide numerical definitions for the different intensity of maintenance operations necessary to provide the required LoS having regard to differing road classes and traffic levels. Through the use of a wide range of performance indicators they define the allowable deviations from the perfect condition and the length of time which is permitted for the rectification of identified failings or defects.
The proposal is to establish five different LoS [2]: excellent, good, satisfactory, poor and bad. LoS relate to road user expectations and the definition of each level varies with road class and traffic level. At the same time a system of maintenance classification using five different levels of maintenance is proposed [2]. These are referred to as MS1, the highest standard of maintenance, running down to MS5, forming the lowest fixed standard. In addition to the five fixed standards, basic access standard is also proposed. This would require simply that access should be preserved with no measured maintenance parameters other than some measure of the practicable speed at which the road could be driven over.
The system defines the appropriate MS to preserve a set LoS for each functional class and traffic level, and specifies the tasks and their frequency of execution for each MS. In general, the difference between MSs lies in the frequency of execution or the permitted delay before execution or the acceptable level of deficiency, of the required tasks rather than in the actual tasks themselves. The differences between the MSs result from the need to provide numerical definitions (performance indicators) for the different intensity of maintenance operations necessary to provide the required LoS having regard to differing road classes and traffic levels. Performance indicators are provided for all key aspects or tasks of road maintenance. The frequency and effectiveness of the actions which are given in the MSs define the routine requirements to meet the specified service quality levels.

3 Costs analysis

Cost estimates for routine maintenance of local unpaved roads in accordance with the proposed LoS concept were established on the basis of official rates for materials, equipment and staff at the municipality level. However, in the absence of actual data on local roads inventory and condition, it was only possible to establish a kind of hypothetical case over a period of time with assumed parameters (particularly regarding condition of pavement). Where no maintenance program is in place, cost calculations do not have to be 100 % precise at the beginning. The main point is to get started, actually to get the idea of the level of necessary resources for routine maintenance of unpaved roads in case of PBM implementation.

Maintenance of unpaved (gravel) roads is considerably simpler than maintenance of paved roads. With reasonable care, progressive deterioration can be avoided, and maintenance continued as a simple annual or biannual cycle without a need for major periodic maintenance interventions. Maintenance of the remaining elements within the road's right-of-way is mainly related to cyclic activities and can be calculated with a relatively high level of accuracy. The following assumptions have been made for calculation of routine maintenance costs [3]:

- 10 years planning period;
- unit section length of 1 km;
- single two-lane carriageway with platform width of 5 m (which can be assumed as average platform width of Albanian unpaved local roads);
- 0.5 m gravel shoulders;
- traffic flow in two directions;
- representative values of traffic volume: 50 – 100 – 250 veh/day;
- 2.0 % traffic growth rate;
- pavement condition characterized by two IRI (International Roughness Index) values, i.e. IRI=5 m/km (new road) and IRI = 10 m/km (older road);
- MSs covering basic access (BM) and full service (FM), equivalent to MS1.

3.1 Calculation of works unit rates

Tables below (Table 1 and Table 2) show summary of basic unit rates for fundamental maintenance requirements, as well as for some activities on surface repairs. BM lengthman operation to take care of routine operations which will include filling potholes and ruts using prepositioned stocks of road gravel. On the other side, FM assumes team of specialized road workers performing multiple tasks during their duty service, and supported by heavy equipment and plant when required during specialized and extensive operations. Once or twice per year a grading operation is required, while a regravelling operation may be needed at bi-annual intervals to repair the gradual gravel losses incurred in the previous period. Basically, the rates differ by the level of effort for staff and equipment. Because Albania consists of certain portion of the country that is not normally being exposed to severe winter weather and snowfalls, the rates were calculated for two cases. The first case is for use in those areas where winter maintenance service is not applicable, or at least, not normally applicable. Where winter maintenance is required the calculation must change to include this.

Table 1 Unit rates for routine maintenance of unpaved roads [EUR] [3]

maintenance standard	BM	FM
no winter service		
routine maintenance per kilometer	318.37	389.04
with winter service		
routine maintenance per kilometer	291.70	330.81
winter maintenance per kilometer	196.67	196.67
routine and winter maintenance per kilometer	488.37	527.48

Table 2 Unit rates for surface repair activities for unpaved roads [EUR] [3]

item	unit rate
regravelling per km	1,760.00
regravelling per m^2	0.35
grading per km	71.11
spot regravelling per m^2	0.41

The costs in the Table 2 above allow for regravelling and compaction of additional gravel from a local source over the whole road surface with assumed width of 5 m providing a layer of at least 50 mm thickness, at 2-year intervals. Regravelling intervals are normally related to Average Annual Daily Traffic (AADT), as well as to topography and climate, however in view of the low traffic volumes using local unpaved roads it is considered that the single bi-annual regravelling is a reasonable assumption. Plant and equipment present on site during regravelling will also make up stockpiles of road gravel at frequent intervals along the road for subsequent use by the lengthman in his routine maintenance operations. These costs would increase significantly if gravel is not available from a local source. Regravelling, grading and spot regravelling activities are extremely important for unpaved roads if proper shape and driving comfort are to be provided throughout road's life cycle, and if the roads authority wishes to preserve these assets that are normally more sensitive to traffic volume, weather and water impact than paved roads.

3.2 Condition of roads

In order to estimate condition of roads, as well as 10-year routine maintenance costs, Highway Development and Management Model 4 (HDM 4) was utilized. Relevant results are presented in the following figures (Figure 1 to Figure 6). Condition of pavement (IRI values) and development of gravel thickness depending on the assumed MS (i.e. BM and FM) clearly show assumed/proposed policy in maintenance of unpaved roads with occasional grading and regravelling. Without these operations, there would be a steady and steep deterioration rate for any of the analyzed roads, difference being only in the gradient of deterioration and final IRI value, before proceeding to some "stronger" treatment or before complete loss of the asset.

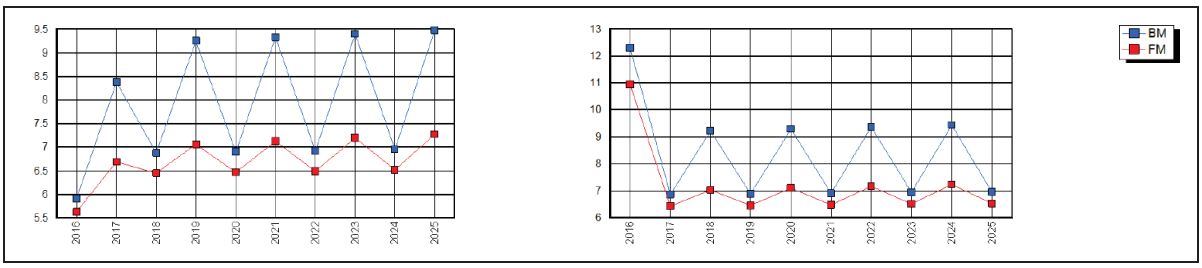

Figure 1 Average roughness (IRI [m/km]) for new (left) and older (right) road, traffic 50 veh/day [3]

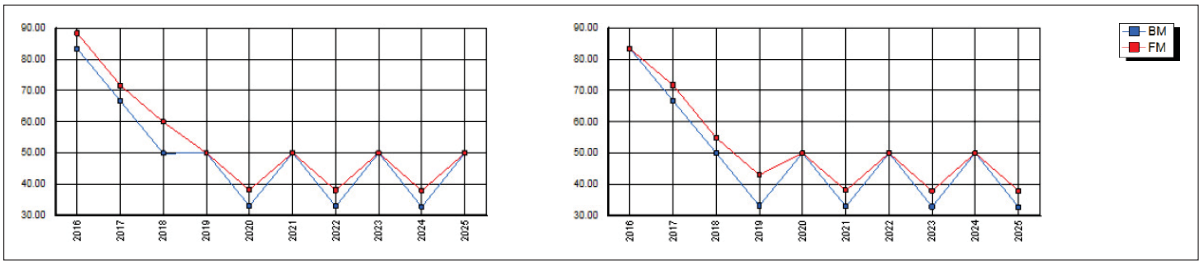

Figure 2 Progression of gravel thickness [mm] for new (left) and older (right) unpaved road, traffic 50 veh/day [3]

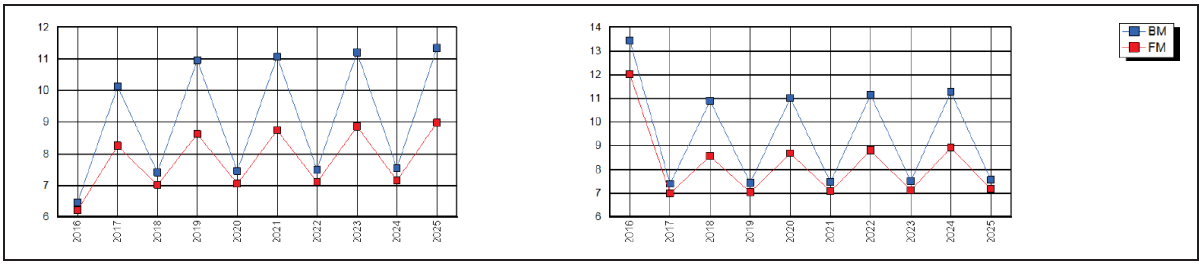

Figure 3 Average roughness (IRI [m/km]) for new (left) and older (right) road, traffic 100 veh/day [3]

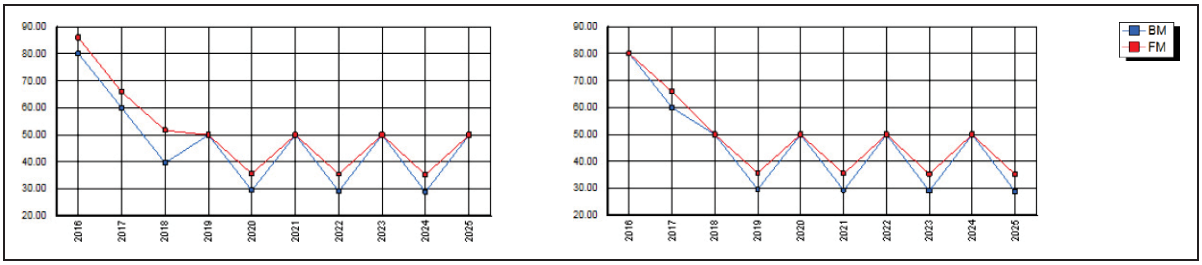

Figure 4 Progression of gravel thickness [mm] for new (left) and older (right) unpaved road, traffic 100 veh/day [3]

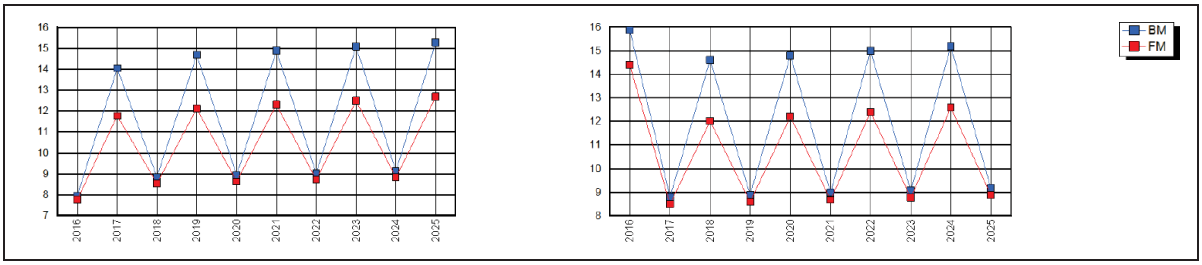

Figure 5 Average roughness (IRI [m/km]) for new (left) and older (right) road, traffic 250 veh/day [3]

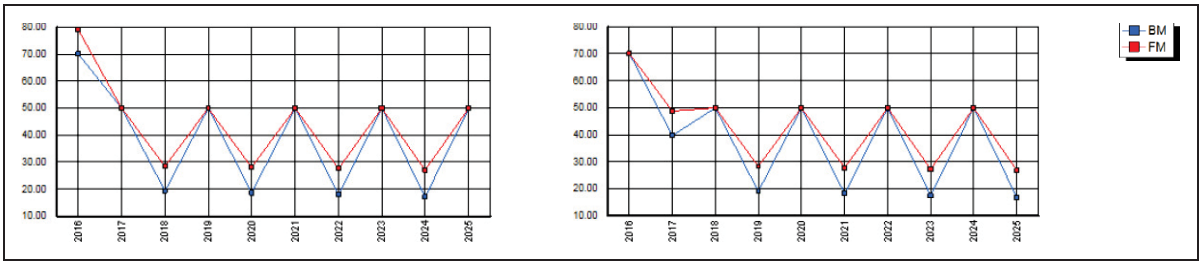

Figure 6 Progression of gravel thickness [mm] for new (left) and older (right) unpaved road, traffic 250 veh/day [3]

Even with grading and regravelling, it is visible that roughness is increasing over the planning period, which confirms well known fact that condition of road or pavement surface cannot be improved through routine maintenance. It can only cause delay in deterioration, but some major treatment (surface dressing, asphalt course) has to be applied if surface is to be improved. Figures showing gravel thickness are also a good presentation of routine maintenance effect to pavement. Due to traffic impact and water flowing over the unpaved road surface, gravel particles are being thrown aside (major cause of thickness decrease) and surface is being compacted by traffic loads to a certain extend. Therefore, gravel must be renewed at regular intervals.

3.3 Routine maintenance costs

The same analysis was used to establish routine maintenance costs over a 10-year period. Annualized costs per km of road under routine maintenance are presented in Table 3. Maintenance costs increase with traffic volume although not significantly, and are higher for FM (which is expected) for 50-60 % for both new and older road. Winter maintenance has a great influence to maintenance costs for unpaved roads, making an increase of almost 50 % for BM, and approximately 25 % for FM. Again expected because routine maintenance costs for unpaved roads are not as significant as in the case of paved roads. When discussing winter maintenance, it is questionable whether any extensive winter maintenance would be carried out on local unpaved roads. If limited amounts of such maintenance were required it could be financed through a trade off against the costs of grading and regravelling which would, of

course, fall if the road were snow covered for substantial periods; there would be no appreciable gravel losses from a snow covered road.
Although being notably lower than the same costs costs for paved roads (with a ratio of about 2 compared to BM and MS5 for paved roads) [3], these costs and proper maintenance practice of unpaved roads cannot be neglected and assets should be protected during the life cycle particularly because of much higher susceptibility to factors other than pavement strength.

Table 3 Annualized routine maintenance costs per km for analyzed unpaved roads and various traffic volumes, depending on applied MS [EUR] [3]

traffic volume [veh/day]	road	winter	BM	FM
50 (low)	new	no	341.52	555.19
		yes	511.52	693.63
	older	no	340.44	552.84
		yes	510.44	691.29
100 (medium)	new	no	359.91	562.42
		yes	529.91	700.87
	older	no	356.91	559.55
		yes	526.91	697.99
250 (high)	new	no	380.59	583.05
		yes	550.59	721.50
	older	no	378.47	581.67
		yes	548.47	720.12

3.4 Road user costs

Table 4 shows summary of estimated Road User Costs (RUC) that are directly related to pavement condition. RUCs are a bit higher in the case of older road and for BM for any of the analyzed traffic volumes. Normally, less effort in road maintenance causes greater consequences to road users.
Interesting to note, when compared to paved roads, RUCs for unpaved roads are significantly higher even with much lower traffic [3]. For instance when comparing RUCs at BM for traffic volume of 250 veh/day, this difference is 55 % in case of new road and 22 % for older road.

Table 4 Cumulative 10-year average annual RUCs per veh-km for analyzed unpaved roads and various traffic volumes, depending on applied MS [EUR] [3]

traffic volume [veh/day]	road	BM	FM
50 (low)	new	64.53	60.42
	older	66.42	62.17
100 (medium)	new	69.09	63.86
	older	70.82	65.60
250 (high)	new	81.02	74.22
	older	82.13	75.65

4 Conclusion

Presented cost calculation show an indication of the scale of expenditure which the Albanian authorities need to build up to if they are to implement comprehensive and effective road maintenance strategies designed to keep their roads in reasonable condition. Even with the BM it is evident that road maintenance expenditures have to be increased for at least 50 % comparing to current values in order to preserve asset value. FM standard, consisting of more intensive operations, would normally require higher amount of resources comparing to BM, however would be more beneficial to road users by reducing RUCs.

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References

[1] Challenges in the Implementation of Performance Based Contracting for Road Maintenance. Roughton International Ltd, Chandlers Ford, 2016.

[2] Levels of Service and Maintenance Standards Report. Support to Development of Sustainable Road Maintenance Systems in Local Government. Roughton International Ltd., Chandlers Ford, 2016.

[3] Discussion Paper on Maintenance Costs. Support to Development of Sustainable Road Maintenance Systems in Local Government. Roughton International Ltd, Chandlers Ford, 2016.