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LOW COST PAVEMENT MANAGEMENT SYSTEM (PMS) FOR SMALL COMMUNITIES WITH MS EXCEL

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Abstract

The maintenance and rehabilitation of roads is a major factor in providing a safe road network and the preservation of the invested assets. The 2356 municipalities in Austria invest about 8% of their funds or approximately 500 million € per year in the area of roads, water treatment and transport. In the province of Styria (435 communities, 1.1 million inhabitants) around 12000 € per kilometer of road are invested every year by the local municipalities for the construction, maintenance and rehabilitation of roads.
The challenge in the small structured municipalities in Austria with an average road network length between 30 to 150km lies in the implementation of a modern pavement management system with cheap and user-friendly features producing reliable results with the least effort possible. For the development of such a PMS - Tool MS Excel was chosen because the program is cheap, widely used and offers a variety of already built-in functions. With this PMS - tool the condition assessment, analysis and planning of maintenance and rehabilitation measures including cost estimates are possible. The selected measures can be planned in detail for each road section and priority is given depending on the importance of the road and the urgency of the implementation. The results of the condition assessment and selected treatment options can be exported into any GIS or CAD - System.
In spring 2009 the City of Weiz with 8800 inhabitants and a road length of about 50km was selected for a first application of this PMS - tool. The input of the collected data as well as the analysis and the interpretation of the results proved to be relatively easy and can be continued by the local authorities in the future. Furthermore a systematic maintenance and rehabilitation was achieved with relatively simple means. The tool is thus suitable for the large number of small communities in Austria and abroad.

Keywords: pavement management system; small communities, life cycle costs, maintenance and rehabilitation of roads, budgeting, user friendly

1 Introduction

The ongoing maintenance and rehabilitation of roads is a major factor to ensure safe roads and the preservation of investments in road assets. A systematic asset management enables communities to maintain the facilities and to optimize the expenses for construction, administration, maintenance, rehabilitation and demolition in a comprehensive life cycle approach. The term asset management refers to a holistic approach which will be considered for all road investments (roads, bridges, walls and neighboring areas) while a pavement management focuses on the maintenance and rehabilitation of road pavements [1].

1.1 Typical aims of Pavement Management Systems (PMS)

- Planning & Preservation: A Pavement Management System (PMS) should provide a framework for a systematic, forward-looking design and preservation of the road network in the community.
- Prioritization & work program: With the implementation of road categories, a construction program and PMS strategies based on the importance of each road can be created
- Achieve savings: Efficient road maintenance and rehabilitation methods in a PMS should provide means for a better choice and timing of standard measures thus creating savings and better road conditions at the same time (possible savings between 10 – 15%)
- Budget needs & spending policy: A PMS should provide data on the financial needs and the achieved pavement condition for different investment scenarios. Based on these scenarios the authorities are able to negotiate the necessary budgets with the politics
- Improved Cooperation: Cooperation of communities based on a PMS allow sharing of resources and the use of the "economy of scales" thus providing better value for money (possible savings between 10 - 20%)
- Legal certainty: The municipalities are legally responsible for the road condition and the safety of users. A PMS helps the community to meet this responsibility and is an important evidence in court cases

1.2 Steps for a practical implementation of a PMS

Based on past experience and literature surveys [1],[2]? the following steps are recommended for the implementation of a pavement management system (PMS) in small communities or a joint PMS management of several communities:

- Priorities and road categories: Establishment of road categories and priorities in consultation with local planning authorities and policy stakeholders. Usually three categories for paved roads (high, medium, low) and two for unpaved roads (keep, decommission) are sufficient [2]
- Road condition and failure causes: The road condition in small communities is usually assessed by means of visual reception of different failure types on certain road sections with a length between 20 to 200 meters in a two man team. If an additional assessment of the deflection is needed a Benkelman beam or Falling Weight Deflectometer (FWD) can be employed [4]. The average daily performance depends on the length of the sections and the detail level of the assessment and can be estimated with 6 to 8km per day and team [2],[3]. The failure causes can be manually addressed or automatically assigned through typical failure types/failure combinations [1],[4]
- Maintenance and Rehabilitation Measures: The maintenance and rehabilitation measures are standardized in tables with a general description, cost, service life, annual costs, and length of work zones as well as typical pictures of their implementation. Furthermore a treatment recommendation for different failure types and causes is given. The optimal treatment option can be found through selection of technically efficient measures and choice of those with the least annual costs [1]
- Costs, budget & forecasting: With the assignment of optimal treatment options for all road sections the individual cost is directly determined. The actual required budget can be calculated based on a general approach with 1.5 – 2.0% of the costs of a new road network or more specific as sum of all annual costs of the selected treatment options for all road sections. Based on different budget scenarios it is also possible to forecast the development of the pavement condition on road network and road section level. On secondary road networks this is usually not necessary if the pavement condition is reassessed after a period of five years or less. For planning purposes and coordination with other projects the

actual road conditions are usually graded (green=good, yellow=fair, red=bad) and presented as maps [1],[3]

- Construction program & decision: For the decision-making and tendering each maintenance and rehabilitation measure on individual road sections has to be condensed into a project. The different projects are then compiled into a construction program with priorities, total costs and year of implementation. The presentation of the maintenance and rehabilitation projects with their realization schedule in form of maps has also been proven as useful [1],[2],[3],[4]
- Implementation & Quality Management: After invitation of tenders, acceptance of bids, and implementation of the measures the derived costs and service life among other data can be updated in the PMS. Thus the experiences of the past can be used and the results will be more accurate after each year of implementation [1]

2 Road inventory and condition survey

Every condition survey starts with the setup of the road inventory and additional information on the alignment. Furthermore the typical failure types of road, sidewalk, shoulders and drainage have to be defined. Figure 1 shows a selection of failure types for asphalt pavements. With the definition of specific condition indices for these failure types a standardized assessment catalogue can be developed and adjusted through condition functions or condition limits [1], [4].

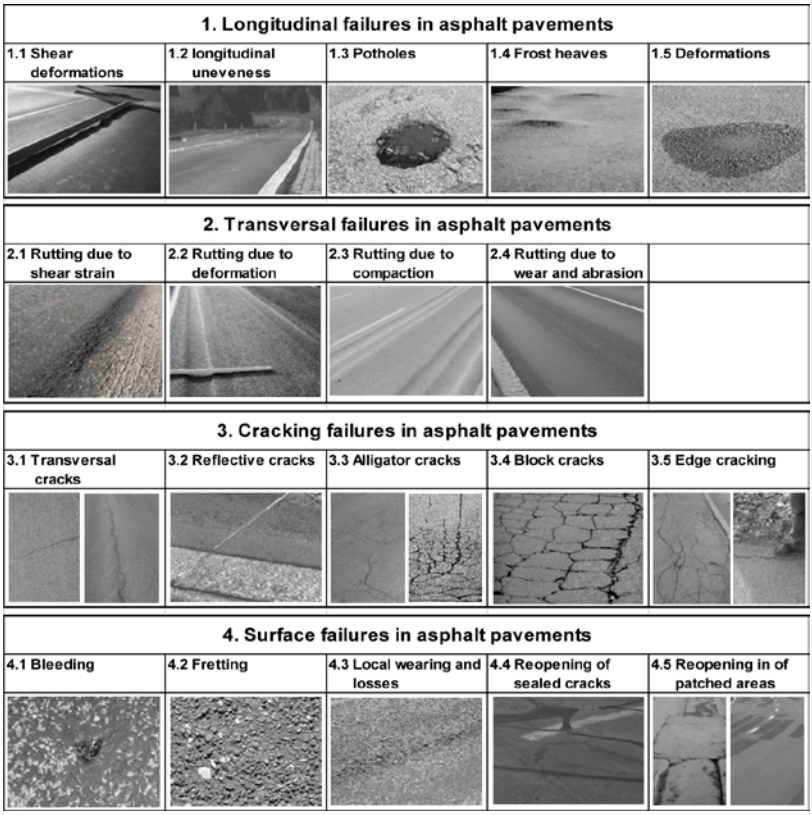

Figure 1 Overview of typical failures in asphalt pavements

The road inventory and the road condition data in each road section is usually recorded in standardized sheets which contain all the necessary information on the road and can be enriched by comments or photos. In Figure 2 such a standardized sheet from the condition survey in the city of Weiz is presented. It contains the inventory data and map of the surveyed road in the upper section, the information on the road condition in the middle and additional comments on local specifics and the overall condition on the bottom [3].

PMS WEIZ

Inventory data and condition survey

TU Wien - ISTU
ZT Jereb
City of Weiz
Province of Styria

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Goethegasse | Assessment | 07.05.2009
24761755 | Editor | HO

inventory data of assessed road

Region	Bezirk Weiz
Community ID	61755
Community Name	Stadt Weiz
Road ID	24761755
Roadname	Goethegasse
Road lenght [m]	500
Road category	III (paved, low)
Starting at road	Kapruner Generator Straße
Ending at road	Schillerstraße
Average daily traffic	
Date of survey	07.05.2009
Surveyor	Ing. Herbert Stern

Road section [lfm]	short	from	0	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475
		until	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500

road condition (input)

Road width	B	[m]	4	4	4,5	4,5	4,5	4,5	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1	5,1
Surface layer (asphalt, concrete, stone)	FB	[-]	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Slope	ST	[%]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deflection	TF	[mm/100]	60	60	60	60	85	85	30	30	100	100	70	70	60	60	75	75	70	70	60	60	
Longitudinal & transversal cracks	LR	[lfm]	0	20	60	50	50	80	15	20	20	2	12	20	15	10	0	0	20	20	30	1	
Alligator cracks	NR	[m²]	0	10	80	80	70	50	10	5	5	5	30	30	25	0	15	25	20	10	15	10	
Fretting	AM	[m²]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Shoulder damages and slides	RU	[m²]	0	10	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Deformation	VD	[m²]	0	0	70	70	10	5	0	0	0	0	0	20	0	0	3	20	10	2	0	0	
Potholes	SL	[m²]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
Others																							

sidewalk, gutter, drainage

Shoulder left condition grade	Ba-li	[-]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Sidewalk left (width)	Geh-li	[m]	0	0	0	0	0	0	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	
Sidewalk left condition grade (1,3,5)	Note	[-]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Drainage condition grade (1,3,5)	Note	[-]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Shafts and installations (Number)	SE	[Stk]	0	2	3	2	0	1	2	4	2	3	6	3	3	4	3	3	4	5	6	2	
Sidewalk right (width)	Geh-re	[m]	1,5	1,5	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Sidewalk right condition grade (1,3,5)	Note	[-]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Shoulder right condition grade	Ba-re	[-]	1	1	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Others																							

comments and disclaimer

General: Length 500 Meter; Temperature: 19°C; Parking: from 250-270 m on the right side, from 280-310 on the left side, from 340-350 on the left side; from 370-420 on the left side, from 445-470 on the right side

Condition assessment: Serious structural damage in the asphalt surface in many sections and potholes in from 425 - 450 m

Condition Assessment: The road shows a poor condition of the pavement. From a user perspective, the potholes are problematic.

Recommendation: Because of the bad condition and the low priority at least a restoration of the potholes from 425 - 450 is mandatory in the short-term construction program. In medium to long-term the asphalt concrete should be reconstructed.

Disclaimer: All measures are based on recommendations of the state of art at the time of collection, but can change over time and, therefore, particularly before the implementation of chosen measures in the medium and long-term construction program should be reviewed locally. The cost estimates are based on unit costs in the measures sheet and shall be updated annually based on the actual costs encountered in the previous year and the construction price index, as well as the actual construction costs from previus projects. In summary, this Pavement Management System (PMS) is a decision-empowering tool and not the decision itself, the ultimate responsibility lies, therefore, primarily with the user itself ...

Figure 2 Standard sheet for inventory data and condition survey with example data from the survey in the city of Weiz in 2009 [3]

3 Maintenance and rehabilitation measures

For the selection of an optimal treatment of pavements, the available maintenance and rehabilitation options and their effects on different failure conditions are a crucial element [4]. While preventive maintenance measures to a certain extent are always considered economic, the applications of rehabilitation measures have to be considered more carefully due to their high costs [1].

3.1 Typical maintenance & rehabilitation measures

In Figure 3 the commonly used standard measures in a Pavement Management System (PMS) for construction, maintenance and rehabilitation of roads are listed. The prices are based on the year 2009 for the province of Styria in lower Austria. The annual costs are calculated for a interest rate of 4%. Furthermore a short description of the typical application of the measures is given [1],[3],[4].

PMS WEIZ	Short description of standard measures				TU Wien - ISTU
					ZT Jereb
©DI. Dr. Markus Hoffmann - TU Wien - ISTU	Prices year	2009	Calculation	2009	City of Weiz
	Interest rate	4%	Editor	HO	Province of Styria

	Measures	Application	Unit [-]	Service life [a]	Total costs [€]	Annual costs [€/a]
Measures for roads with asphalt pavements	**Maintenance measures**					
	Crack repairing small	Longitudinal & transversal cracks (thin)	[lfm]	2,5	€ 2,50	€ 1,07
	Crack repairing big	Longitudinal & transversal cracks (wide)	[lfm]	3,5	€ 4,00	€ 1,25
	Patching	Local damages, potholes	[lfm]	7,5	€ 22,50	€ 3,53
	Resurfacing	Surface damages (fretting)	[m²]	4,0	€ 3,50	€ 0,96
	Rehabilitation measures					
	Milling & cold thin overlay	Surface damages (Fretting, rutting...)	[m²]	8,0	€ 4,50	€ 0,67
	Milling & hot thin overlay	Surface damages (Fretting, rutting...)	[m²]	10,0	€ 5,50	€ 0,68
	Milling & new asphalt layers	Structural damages (Alligator cracks...)	[m²]	14,0	€ 16,00	€ 1,51
	Milling, grading & new subbase/asphalt	Structural & subbase damages	[m²]	18,0	€ 30,00	€ 2,37
	Renewal (unfixed surface level)	Subbase damages (not town areas)	[m²]	23,0	€ 40,00	€ 2,69
	Renewal (fixed surface level)	Subbase damages (town areas)	[m²]	28,0	€ 45,00	€ 2,70
	New construction of roads					
	New construction (existing track)	Structural damages, widening	[m²]	35,0	€ 60,00	€ 3,21
	New construction (non existing track)	New route or connection	[m²]	40,0	€ 70,00	€ 3,54
	Asphalt to gravel road	Downgrading priority and costs	[m²]	25,0	€ 10,00	€ 0,64
	New construction gravel road	Low priority roads with very little traffic	[m²]	25,0	€ 15,00	€ 0,96
Other measures sidewalk, drainage & shoulders	**Sidewalk rehabilitation**					
	Small repairs	Longitudinal & transversal cracks	[lfm]	4,0	€ 6,50	€ 1,79
	Structural local patching	Local damages, potholes	[m²]	12,5	€ 25,00	€ 2,58
	New construction sidewalk	Requirement due to pedestrian traffic	[m²]	28,0	€ 50,00	€ 3,00
	Drainage construction & rehabilitation					
	New dirt troughs	During new or reconstruction	[lfm]	8,0	€ 5,00	€ 0,74
	Repair dirt troughs	Trough damages, landslides	[lfm]	4,0	€ 2,00	€ 0,55
	New drainage pipes	During new or reconstruction	[lfm]	36,0	€ 25,00	€ 1,32
	Repair drainage pipes	Drainage damages, landslides	[lfm]	18,0	€ 10,00	€ 0,79
	New asphalt gutters	During new or reconstruction	[lfm]	35,0	€ 15,00	€ 0,80
	New cobble stone gutters	During new or reconstruction	[lfm]	40,0	€ 50,00	€ 2,53
	Repair gutters	Gutter damages, deformation, slides	[lfm]	10,0	€ 8,50	€ 1,05
	Shoulder rehabilitation					
	Small shoulder rehab	Small erosion damages	[lfm]	12,0	€ 10,00	€ 1,07
	Big shoulder rehab	Big erosion damages	[lfm]	15,0	€ 15,00	€ 1,35

Figure 3 Overview and short description of standard measures in a PMS [1],[3]

3.2 Cost calculation and optimization of treatment options

For the optimal treatment selection of pavements, the available maintenance and rehabilitation options and their effects on different failure conditions are a crucial element. Before choosing an optimal treatment the possible choices have to be selected based on technical criteria (amount of failure, different failure types, applicability, local restraints etc.). The choice between the remaining options is then usually based on economic criteria [1], [4].
With the data of the condition assessment and the standard measures, the costs for different treatment options of single road sections are derived via a multiplication of the unit costs with the application length or area. The optimized treatment can then be found through suitable solitary measures or a combination of measures with the lowest annual costs. In general the best strategy is a strong dimensioning combined with preventive maintenance measures. If rehabilitation measures are necessary usually the strategy of the least interfering treatment is the optimal cost efficient solution if the expected service life of the measures is achieved [1].

4 Results of the PMS

4.1 Score sheet and project summary

For the decision making each maintenance and rehabilitation measure on individual road sections has to be condensed into a project. In order to reach a transparent and fast decision about the priorities in the construction program the crucial information for each project has to be summarized. One possible way to achieve this goal is the presented score sheet (Figure 4). The score sheet contains the results of the condition assessment for each failure type and the selected measures and road section for their application. Based on the amount of damage, the priorities and the road category, the measures can be checked and activated for the short, medium or long-term construction program. After checking and releasing the individual projects, the PMS results and selected maintenance and rehabilitation programs are presented in the form of lists and maps which allow further coordination with other departments (Figure 5, 6).

4.2 Budgeting and Implementation

The average budget needed for maintenance and rehabilitation of roads amounts to 1.5 to 2.0% of the costs of a new construction. Based on a PMS the actual costs can be estimated more accurately as the sum of the annual costs of all maintenance and rehabilitation projects of the road network. The operating costs depend on the road category and can be estimated with 1000 to 2500 €/km road per? year for asphalt paved roads and 300 to 500 € for gravel roads [1].
With sufficient budget the selected maintenance and rehabilitation projects can be tendered and implemented. The data and experiences of the finished projects are entered allowing a comparison with the previous calculations. Thus the gained experiences are leading to more accurate estimations over time.

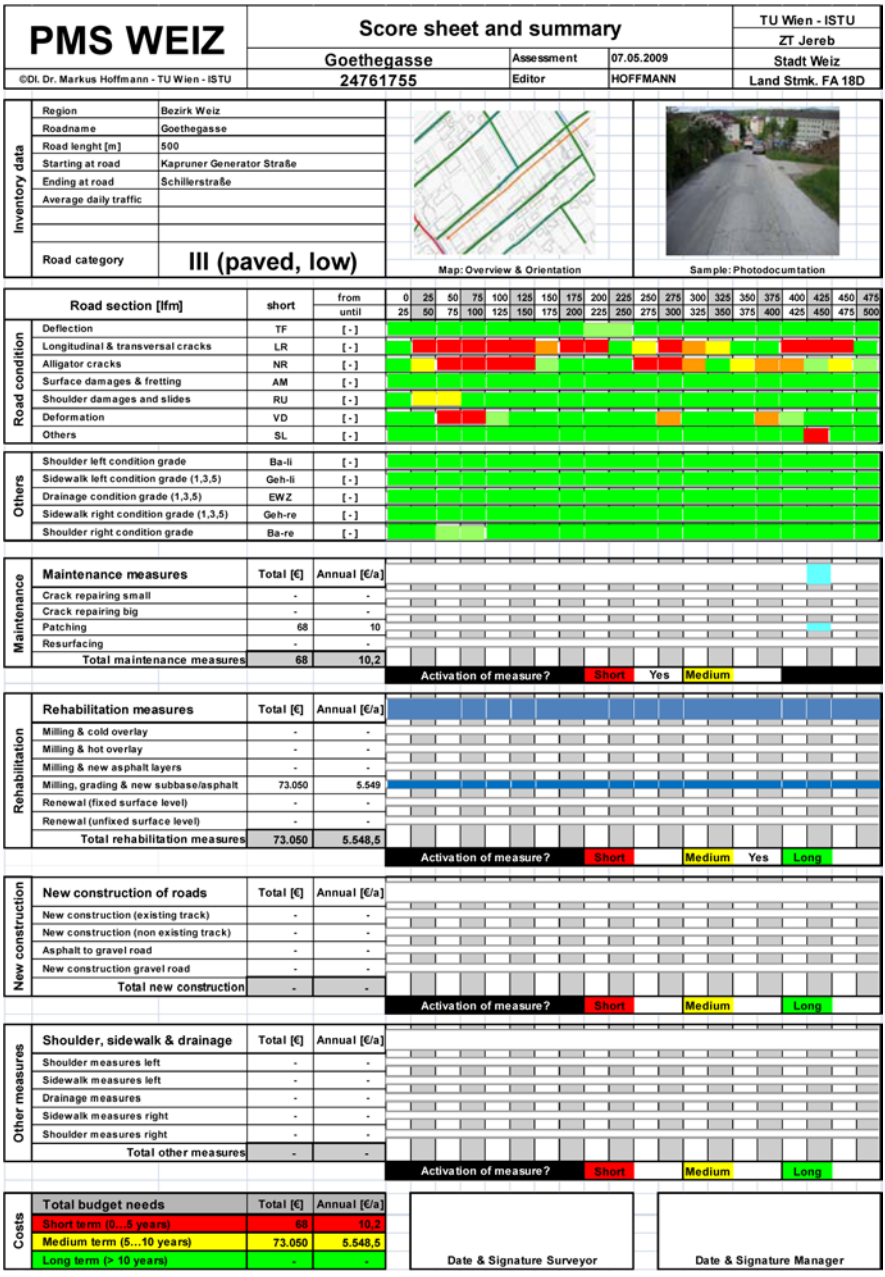

Figure 4 Score sheet with condition assessment, selected maintenance & rehabilitation measures and cost estimates for budgeting purposes [3]

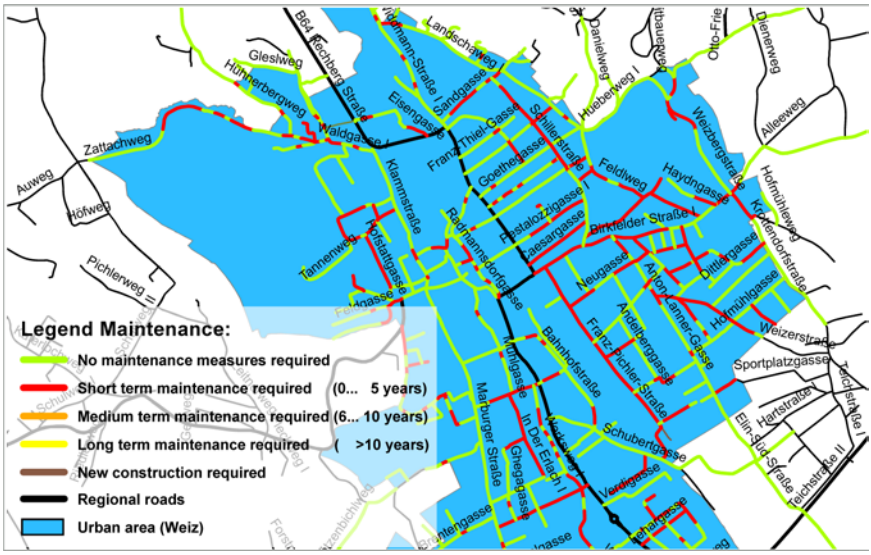

Figure 5 Excerpt of the required road maintenance measures in the Pavement Management System (PMS) of Weiz [3]

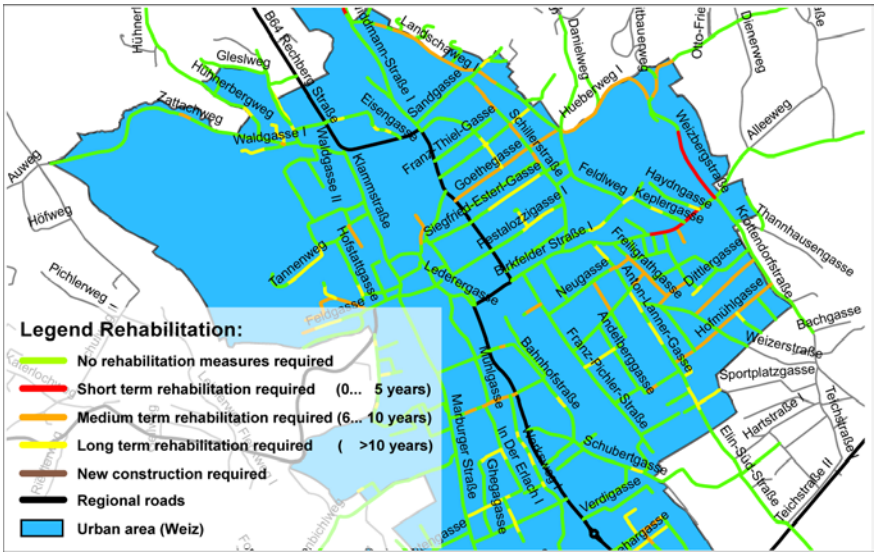

Figure 6 Excerpt of the required road rehabilitation measures in the Pavement Management System (PMS) of Weiz [3]

5 Conclusions and outlook

The ongoing maintenance and rehabilitation of roads causes enormous costs and usually requires a considerable amount of expertise and experience. The authorities in small structured municipalities in Austria have to master these tasks with decreasing budgets and manpower. The public and local economy on the other hand demands highly accessible and safe roads. In order to meet these requirements as well as achieve considerable savings and legal certaintywithin the legal framework? a Pavement Management System (PMS) is needed.
With well defined steps such as the establishment of road categories, the assessment of road conditions, the assignment of standardized maintenance measures and decision making, the requirements for a modern PMS are met. The acquired information about costs and urgency of measures helps not only to make better decisions but also to communicate them more effectively.
The presented framework is based on many years of experience & research and contains only the key elements of a comprehensive PMS. The practical implementation has shown that these key elements may be sufficient for the needs of most communities in Austria allowing a systematic, easy and cheap management of the maintenance and rehabilitation of roads.

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