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Comparing Different Equipment and Applications in Pavement Data Collection as Part of Road Management System

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Abstract

National roads are the main arteries in road transport infrastructure. Therefore, all agencies or authorities responsible of road infrastructure, pay attention to road management systems. Albania is experiencing an increase in road infrastructure investments and maintenance of this road network. There have been some attempts to establish national and secondary road management systems. These systems attempt to achieve different objectives, such as the provision of an adequate level of service, the preservation of the road infrastructure, etc. A good **R**oad **A**sset **M**anagement **S**ystem (RAMS), helps to carry out all the actions of inventory, storage and maintenance of road assets as well as, supports the decision-making process. At present, there are several data collection devices and applications that carry out the job efficiently. The purpose of this paper is to present the analysis of the use and comparison of some equipment and Cell Phone Based Systems (MiniROMDAS, PaveProf-V2 and RoadLab_Pro) used for the road pavement data collection, necessary in the calculation of the International Roughness Index (IRI), along the national road network in Albania. The comparison is made, by analyzing the data and results obtained along a 20 km long road segment in Albania, using the various above-mentioned technologies. Also, an overview of the currently available technologies providing information that could assist managers in establishing an appropriate data collection program is given.

Keywords: MiniROMDAS, PaveProf-V2, Road Lab_ Pro, IRI.

Introduction

The national road network in Albania is about 4,000 km length and maintained by Albania Road Authority. The secondary and local road network is about 9500 km length and maintained by 61 municipalities of Albania. In Albania, too, there have been some attempts to establish both national and secondary road management systems. These systems combine several objectives, such as provision of an adequate level of service, preservation of the facility etc. At present, there are several data collection equipment and systems that carry out the job efficiently. ROMDAS, PaveProf-V2 and RoadLab_Pro are some of those systems, which are widely used to collect pavement data with different cost and quality. Different systems are used to evaluate pavement quality. All methods of evaluation are based on IRI (The **I**nternational **R**oughness **I**ndex). The International Roughness Index (IRI) is the roughness index most commonly obtained from measured longitudinal road profiles [1]. This study aims to assess the pavement road conditions in the Maminas – Shen Pjeter road, using different tools and system of data collection and to make a comparison between the results obtained.

METHODOLOGY

The pavement road conditions are assessed by the use of International Roughness Index (IRI) via different systems, such as ROMDAS, PaveProf-V2 and RoadLab_Pro. These systems are used in the pavement data collection in several important projects in Albania. The results are compared with the purpose of providing some recommendations regarding the tools to be used as function of the established evaluation requirements.

Raw Data Collection and Data Processing

Data collection in this study was carried out in Maminas – Shen Pjeter national road in Albania region with 21km length. Roughness data was recorded with 100 meters interval using ROMDAS, Pave Prof-V2 and RoadLab_Pro systems. Raw data collections are processed by each software to get the final product of this survey. In order to have the same data collection conditions, an almost constant velocity of 40 km/h was maintained.

MiniROMDAS

ROMDAS is a cost effective and modular system designed to collect road and pavement data using any vehicle. The MiniROMDAS, was used in road pavement data collection on about 385 km of the Albanian national road network in the frame of the Project "**O**utput and **P**erformance based **R**oad **M**aintenance **C**ontracts (OPRMC)", funded by Government of Albania and the World Bank. A schematic presentation of data collection process using the Mini ROMDAS is shown in the Figure 1.

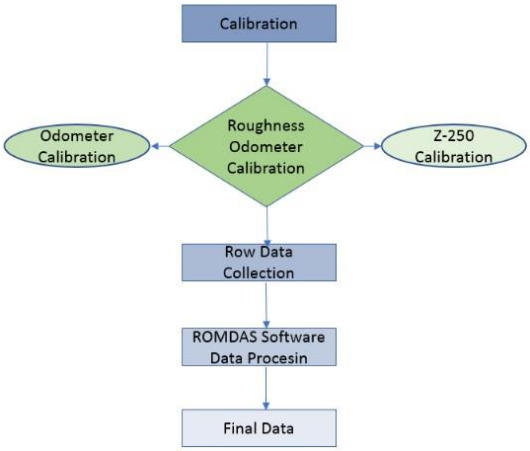

Figure 1.Framework of Data Collection Process

Before performing the data collection, the system needs to be calibrated. The MiniROMDAS calibration system is divided into three parts, as follows: 1) Z-250 reference profiler calibration, 2) odometer calibration and 3) roughness meter calibration.

Z-250 reference profiler was calibrated at the beginning in office, while odometer and roughness meter calibration were carried out in the certified service of the deliverer. Table 1 lists the data entered, necessary for providing the Z-250 calibration equation shown in Figure 2. Therefore, the slope adjustment factor (1,039) found from the analysis is entered into the profiler tab of data logger.

Z-250 Start Elevation: -0.09					
Shim Placements		Elevation (mm)			
Foot A	Foot B	Shim	Mean Elevation	Test 1	
				Display	Corrected
2	-	2	1.92	1.83	1.83
10	6	4	3.73	3.64	3.64
6	-	6	5.92	5.83	5.83
8	-	8	8.06	7.97	7.97
10	-	10	10.10	10.01	10.01
15	-	15	14.88	14.79	14.79
-	2	-2	-2.07	-2.16	-2.16
6	10	-4	-3.82	-3.91	-3.91
-	6	-6	-5.47	-5.56	-5.56

-	8	-8	-7.22	-7.31	-7.31
-	10	-10	-9.41	-9.50	-9.50
-	15	-15	-13.88	-13.97	-13.97

Table 1.Data Entry Component of Z-250 Calibration

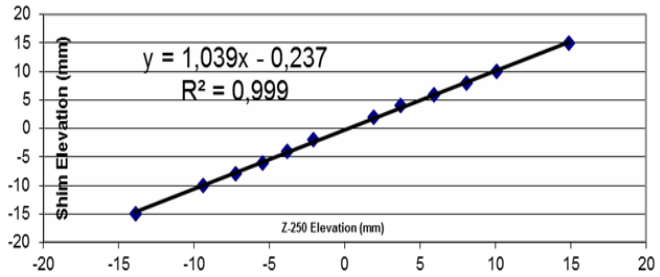

Figure 2.Regression Analysis for the Determination of Slope Adjustment Factor

Installation and calibration of the odometer are also necessary for the roughness meter calibration. The odometer, used for the accurate determination of the length and the speed, was calibrated in a 200-meter section using four runs as shown in the Table 2.

Table 2. Lists the data entry component of Odometer Calibration

Odometer Calibration Factor								**Error Tolerance:**			0.10%	
Run Number				**Sample**	**Mean**	**Sdev**	**S.Error**	**S. Error**	**Beta**	**Beta**	**Pass/Fail**	**Pass/Fail**
1	**2**	**3**	**4**					**(%)**	**90%**	**95%**	**90%**	**95%**
930	930	931	930	4	930.250	0.50	0.25	0.03	0.59	0.80	Pass	Pass

The Bumper Integrator BI, was installed in a vehicle having a Solid Rear Axle, measuring the so-called the 'Half-Car' roughness as shown in figure 3. [2]

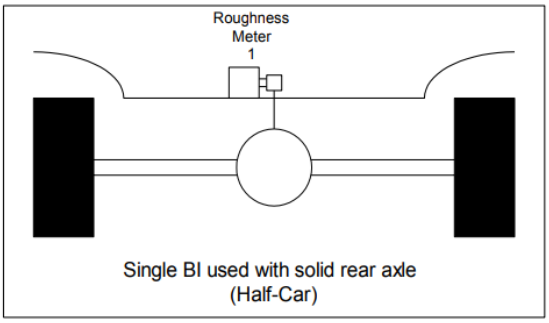

Figure 3 Single BI used with Solid Rear Axle (Source: ROMDAS user guide)

The roughness meter calibration in ROMDAS system was done using the calibrated Z-250 reference profiler. Seven different sections of 300 m length were used to measure the

reference profiles. The output of BI is generated in terms of count per km, representing the cumulative number of bumps in one kilometer, as shown in table 3.

Table 3 Roughness of the seven Different Sections Roughness

Calibration Site Number	Site IRI (m/km)	Site Length (m)	Calibration Speed (km/h)	ROMDAS Raw BI Count Number 1	2	3	Number of Runs	Run Mean Raw BI Count	Raw BI count /km	Sdev	S.Error	S. Error (%)	Beta 90%	Beta 95%	Pass/Fail 90%	Pass/Fail 95%
1	4.09	300	40	1273	1355	1136	3	1255	4182	111	64	1.5	186.52	274.88	Pass	Pass
2	4.5	300	40	1173	1170	1179	3	1174	3913	5	3	0.1	7.73	11.38	Pass	Pass
3	3.75	300	40	980	939	962	3	960	3201	21	12	0.4	34.65	51.06	Pass	Pass
4	3.09	300	40	866	882	889	3	879	2930	12	7	0.2	19.88	29.29	Pass	Pass
5	1.92	300	40	607	591	618	3	605	2018	14	8	0.4	22.89	33.73	Pass	Pass
6	2.25	300	40	708	699	709	3	705	2351	6	3	0.1	9.29	13.68	Pass	Pass
7	5.11	300	40	1491	1485	1490	3	1489	4962	3	2	0.0	5.42	7.99	Pass	Pass
1	4.09	300	60	1282	1342	1342	3	1322	4407	35	20	0.5	58.40	86.06	Pass	Pass

The ROMDAS software was used for the calculation of the Roughness Calibration Equation Coefficients, shown in figure 4. The R-squared value is above 0.9, showing a good repeatability and therefore good reliability of the BI results. The slope and the intercept respectively the coefficients a1 and a2 of the Calibration Equation are used in the calculation of IRI of the road segment under study.

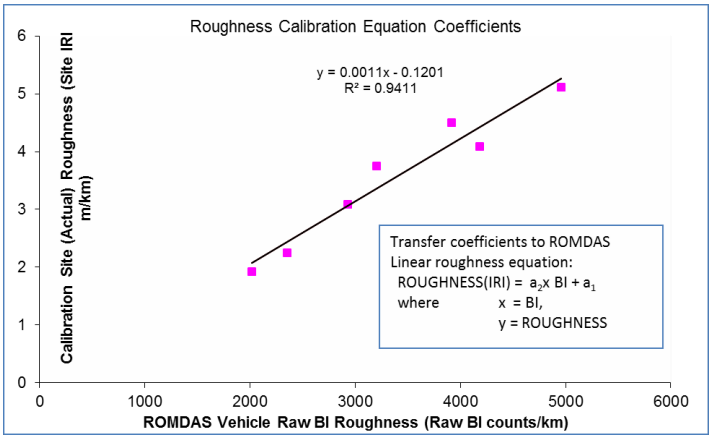

Figure 4 Calibration Equation Coefficients Worksheet

The miniRODMAS assembly is given in pictures of the figure 5.

Figure 5 Assemble and calibrate the ROMDAS equipment

PaveProf-V2

*Pave*Prof-V2 is a modular system that uses laser sensors to measure pavement profiles for applications such as highways and runways [3]. A single laser and accelerometer system were used to collect road data on the Albanian road network in the frame of "**O**utput and **P**erformance based **R**oad **C**ontracts (OPRC)" Project. We had the opportunity by the contractor to use this system for collecting pavement data for Maminas-Shen Pjeter Road.

RoadLab_Pro

RoadLab_Pro, is designed as a data collection tool for engineer by the World Bank in collaboration with Beldor Center, SoftTeco and Progress Analytics LLC [4]. With accelerometers on Smartphone's, this app evaluates road conditions, map road networks, detects major road bumps, and reports road safety hazards [4].

The Road lab Pro is used on data collection in two important Projects in Albania, the "Technical Assistance for monitoring, communication and visibility of Transport Sector with Focus on Roads" and "Regional and Local Roads Connectivity". The RoadLab_Pro app was downloaded on the Smartphone, mounted in a vertical position. The data collected was emailed and the IRI values for every 100 m length are obtained. Accompanied by the coordinates of each point the app allows the mapping of the IRI values and consequently the road conditions.

RESULTS AND DISCUSSION

The average every 100 m IRI values obtained using three different data collection systems (PaveProf-V2, ROMDAS and RoadLab_Pro), for Maminas – ShenPjeter road, are presented in the figure 6 and figure 7.

PaveProf of Maminas-Shen Pjeter					BI_ROMDAS_Maminas_Shen Pjeter					RoadLab_roP Shen r-pjeter Maminas					
Distance/m	Distance/m	Speed	IRI L1	GPS	CHAINAGE	LRP_FROM	LRP_TO	SPEED	C_ROUGH_1	latitude	longitude	length	speed	roughness	condition
0+000	0+100	44.05	3.365	41.378575N:19.606010E	100	0	100	38.7	3.08	41.533833	19.516491 67	110.13	39.62	2.8	Good
0+100	0+200	44.16	1.263	41.379123N:19.604657E	200	100	200	42.1	1.32	41.533033	19.517023 33	112.13	49.69	1.38	Very Good
0+200	0+300	44.32	1.487	41.379512N:19.603562E	300	200	300	42	1.41	41.532044	19.517225	117.41	39.98	1.34	Very Good
0+300	0+400	39.2	1.822	41.379898N:19.602393E	400	300	400	41.5	1.59	41.531144	19.517878 33	100.15	40.07	1.35	Very Good
0+400	0+500	38.6	1.646	41.380618N:19.601680E	500	400	500	41.2	1.57	41.530355	19.518488 33	107.57	40.54	1.5	Very Good
0+500	0+600	37.7	1.721	41.381428N:19.601367E	600	500	600	41.6	1.47	41.5295	19.51907	104.1	40.62	1.21	Very Good
0+600	0+700	39.3	2.068	41.382363N:19.601030E	700	600	700	40.9	1.75	41.528588	19.51945	106.66	44.05	1.44	Very Good
0+700	0+800	37.05	1.353	41.383198N:19.600595E	800	700	800	42.5	1.31	41.527711	19.519913 33	111.36	44.16	1.26	Very Good
0+800	0+900	35.12	1.635	41.384042N:19.600175E	900	800	900	42.6	1.56	41.526766	19.520368 33	112.55	44.32	1.48	Very Good
0+900	1+000	35.27	2.589	41.384898N:19.599903E	1000	900	1000	41.9	2.19	41.525799	19.520796 67	108.55	46.85	3.97	Fair
1+000	1+100	42.76	1.071	41.385798N:19.599670E	1100	1000	1100	41.6	1.31	41.524233	19.521903 33	107.68	40.54	1.55	Very Good
1+100	1+200	43.91	1.343	41.386907N:19.599433E	1200	1100	1200	41.1	1.40	41.523699	19.52294	111.84	40.62	1.46	Very Good
1+200	1+300	43.94	2.694	41.387602N:19.599302E	1300	1200	1300	39.5	2.12	41.523233	19.524151 67	112	44.05	1.55	Very Good

Figure 6.Processed Roughness Data

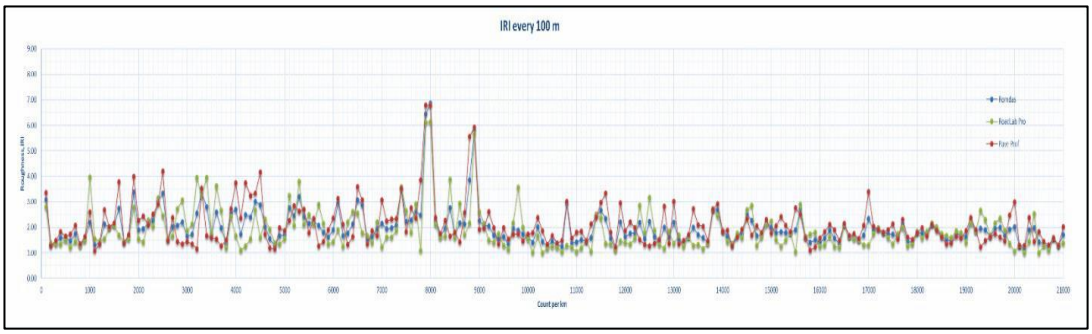

Figure 7.Chart of IRI every 100m for each system

The quality of the road pavement, for all systems used, was evaluated by the use of IRI (International Roughness Index), using the same scale of road conditions classification. The road pavement conditions are qualified as Very Good if the IRI are less than 2 m/km; Good if the IRI values are between 2 m/km and 4 m/km; Fair if the IRI values are between 4 m/km and 6 m/km; Poor if the IRI values are between 6 m/km and 8 m/km and Very Poor if the IRI values is larger than 8 m/km.

In the table 4 are summarized the road conditions based on IRI, related to the data collection system used in the survey.

Table 4. Road pavement classes based on IRI values in Maminas-ShenPjeter road based on different systems of data collection

Road pavement quality	Number of IRI values relative to road classes			Road class percentage		
	PaveProf	ROMDAS	RoadLab_Pro	PaveProf	ROMDAS	RoadLab_Pro
Very good (IRI<2)	125	134	144	59.52	63.81	68.57
Good (2<=IRI<4)	79	72	63	37.62	34.29	30.00
Fair (4<=IRI<6)	4	2	1	1.90	0.95	0.48
Poor (6<=IRI<8)	2	2	2	0.95	0.95	0.95
Very poor (IRI>=8)	0	0	0	0.00	0.00	0.00
Total	210	210	210	100	100	100

Based on the above table, regardless of the data collection tools or system used, the Maminas-Shenpjeter road pavement conditions are generally good. Taking into account the IRI scale chosen, about 60% of the road segment under study are classified as very good conditions, 35% as good and the rest as fair condition.

Differences between data collection tools are observed for IRI values less than 2 m/km, corresponding to very good road pavement conditions. In this case the PaveProf-V2 system is the most rigorous. The differences decrease with the increase of the IRI values, becoming equal for IRI values greater than 6 m/km, corresponding to poor road conditions.

In the following figure 8 is enlarged a segment which reflects the same degree of road condition classification for all three data collection systems used. The figure shows that for IRI values larger than 4 the results are similar.

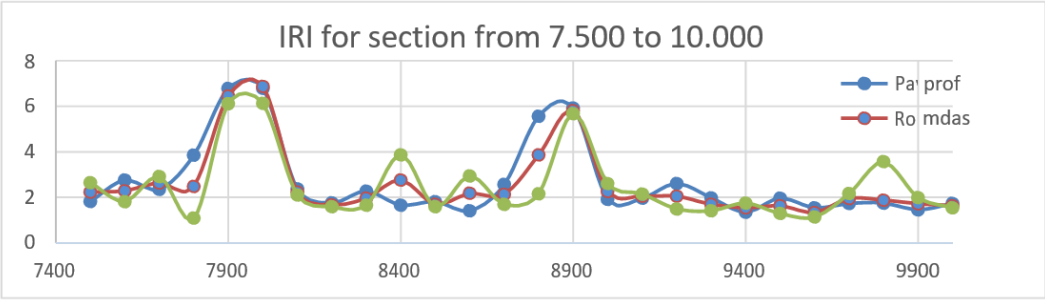

Figure 8.Chart of IRI from km 7+500 to km 10+000 for each system

The results of the study are also mapped showing the geographic location of each road condition class in GIS environment as shown in the figure 9, below.

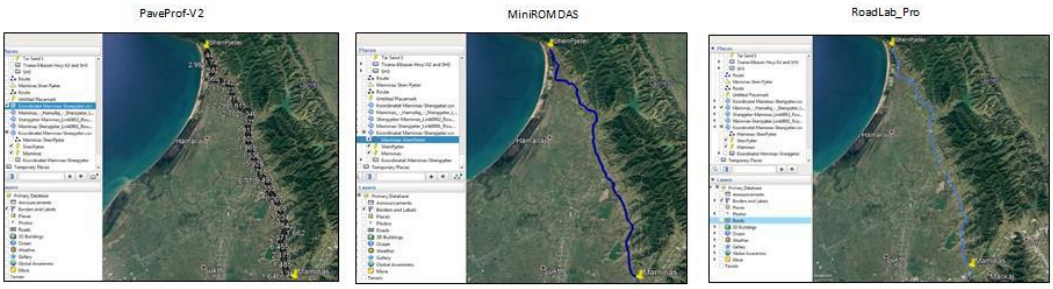

Figure 9. Map of road Maminas – Shen Pjeter for each system

Conclusion

The road pavement conditions in Maminas-Shenpjeter road are generally good, with small exceptions representing about 1.5-3 % of the total length, depending on the data collection system or tool used.

For good and very good conditions the use of PaveProf gives better results, while for IRI values higher than 4 the results are similar. In these terms the data collection system selection to be used depends on the road conditions to be assessed. In case of poor road conditions, a most convenient economic system can be used depending also in the project requirements. The RoadLab_Pro, representing the most economically convenient system, can be used in the assessment of roads in poor pavement conditions in Albania.

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