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Pavement Management System Investigation in Case of Afghanistan

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Abstract. Afghanistan is encountering a massive compete in arrangement of old infrastructure. Specially for roads structure, it is found that many roads pavements built 30 to 40 years ago and now it is the end of their life. Other roads had been deteriorated because of misuse, overuse and mismanagement and also after more than 3 decades of conflict Afghanistan encountered keen challenges in rehabilitation and reconstruction of the roads. In addition, present and future threats influence the wished mission of these pavements for fast, safe and comfort transportation of people and goods. Moreover, the current management shows that the system is being used now is not flexible enough to consider on the changing conditions and is poor to assist in making decisions.

This study aims to initiate a Pavement Management System by providing an organized procedure of maintaining, reconstructing, and operating the roads pavements and to utilize in a better flexible strategy that can enable this research to perform better tasks, more economically, higher quality and do it such a manner to achieve a desired result.

A system has been also presented to help and make easier the decision making process. It is Micro PAVER pavement software. Micro PAVER is a Pavement Management System developed by the US Army Corps of Engineers. Micro PAVER provides pavement management capabilities to:

- Organize and develop the pavement list.
- Analyze the running condition of pavements.
- Develop methods to forecast future conditions report on past and future pavement execution; and
- Develop plots for pavement maintenance based on condition needs or budget.

Therefore, in order to have a good management system, this system will be preferred which provide an organized method of maintenance, reconstruction and operation of the roads pavements. And the system will be flexible enough and assists in making decisions.

***Keywords*:** Pavement management system, Micro PAVER, pavement maintenance, flexible strategy, pavement execution.

Afganistan'da Yol Kaplaması Yönetim Sistemi Araştırması

Özet. Afganistan, eski altyapı düzenlemesinde önemli bir sorunla karşı karşıyadır. Özellikle yolların yüzeyi sözkonusu olduğunda, birçok yol kaplamasının 30-40 yıl önce yapıldığı ve şimdi ömrünü tamamladığı görülmektedir. Bazı yollar da kötü kullanım, aşırı kullanım ve yanlış yönetim nedeniyle ve ayrıca 30 yıllık savaştan sonra Afganistan'ın yolların iyileştirilmesi ve yenilenmesi bakımından ciddi zorluklarla karşılaşılması nedeniyle kötüleşmiştir. Bunun yanısıra, mevcut ve gelecekteki tehditler de insanların ve ürünlerin hızlı, güvenli ve rahat ulaşımını sağlamak için arzu edilen bu yol kaplamaları işini etkilemektedir. Bunun yanısıra, mevcut yönetim şu anda kullanılmakta olan sistemin değişen koşullarını hesaba katmaya yetecek kadar esnek değil ve kararlar verilmesine yardımcı olmakta zayıf kalıyor.

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Araştırma, yol kaplamalarının bakımına, yeniden yapımına ve işletilmesine ilişkin bir organize prosedürün sağlanmasına yönelik bir Yol Kaplama Yönetim Sistemi başlatmak ve daha iyi görevleri daha ekonomik şekilde ve daha yüksek kaliteyle gerçekleştirmemizi ve bunları arzu edilen sonuca ulaşacak şekilde yapabilmemizi sağlayacak daha esnek bir stratejiyle kullanmayı amaçlamaktadır.

Ayrıca, karar verme sürecine yardımcı olacak ve bunu kolaylaştıracak bir sistem de sunuldu: Micro PAVER yol kaplama yazılımı. Micro PAVER, ABD Mühendisler Kolordusu tarafından geliştirilen bir Yol Kaplama Yönetim Sistemidir. Micro PAVER:

- Yol kaplama listesini organize etmeye ve geliştirmeye;
- Yol kaplamalarının çalışma koşulunu analiz etmeye;
- Geçmişteki ve gelecekteki yol kaplama icraatına yönelik gelecekteki koşulları tahmin etmeye yönelik yöntemler geliştirmeye ve
- Koşullara, ihtiyaçlara veya bütçeye dayalı olarak yol kaplama bakımına planlar geliştirmeye yönelik yol kaplama yönetimi becerileri sağlıyor.

Bu nedenle, iyi bir yönetim sistemine sahip olmak için yol kaplamalarının bakımına, yeniden yapımına ve işletilmesine ilişkin bir organize yöntem sağlayan bu sistem tercih edilecektir. Bu sistem, yeterince esnek olacak ve kararlar alınmasına yardımcı olacaktır.

***Anahtar Kelimeler*:** Yol kaplama yönetim sistemi, Micro PAVER, yol kaplama bakımı, esnek strateji, yol kaplama icraatı.

1. INTRODUCTION

A Pavement Management System (PMS) is an important tool in order to manage a road system appropriately. AASHTO regulations are used by road agencies which are dealing with maintenance and evaluation of road systems in a long service condition. PMS analyzes the most advantageous maintenance strategies and aids to apply and execute them. It relates to all occupations involved in a procedure of making a great road system. These occupations are such as, planning, initial information acquisition, maintenance, rehabilitation and construction [1].

Maintenance for the pavement network is one of the most significant and a vital duty to ensure that goods and people are carried and transported in a safe, fast, relax, and economic way. Witnesses in improved countries has proved that lack of proper maintenance would cause into a serious increasing vehicle operating cost, travel period and untrustworthy road transportation service.

It is known that the quality and effectiveness of roads boosts the health of social system quality of life and the durability of business and economic activities. Reasons for collapse and baleful failure of these roads may happen due to overuse, aging, and wrong management. Therefore, the maintenance and protection of such roads can take a great national notice [2].

Engineers and Managers, who have created and used pavement technology, can feel that pavement management has a matter of “Pay less now” or pay much more later [3]. All agencies working in this field find it out that they may not afford to pay later; it is more costly to reconstruct and rehabilitate badly damaged pavements. Unfortunately, there are agencies not paying attention to the pavement infrastructure maintenance, however, when the pavement is in the failure stage due to deterioration, large amount of money are spent for restoration. Agencies blessed with a good pavement infrastructure need to start a pavement management system as soon as possible. They have to make a complete list of the pavement infrastructure, evaluate its current and projected condition and specify the budget required to maintain the pavement condition higher than acceptable level. They must clarify the

condition for the work requirements, concentrate on projects, and maximize spending of maintenance funds [4].

In Afghanistan, pavement infrastructure plays an important role in the development of the country and therefore, Afghanistan pavement projects and their threats are chosen in this research to be investigated. [1].

- **Current Threats**:

Afghanistan's infrastructures reach to their end of economic life and challenges with old structure. In particular, there are road pavements found that were built 30 or 40 years ago and some are recently built with low quality, which are already about reaching to the end of their service life. [5] Afghanistan pavements have the below current threats:

- Increased rate of failure. (pavements damages fast)
- Vehicles overloading on the pavement.
- Fast traffic increase.
- Poor maintenance. (improper and not standard materials, wrong implementation)
- Bad design and implementation.
- Taliban (Terrorist groups who put the bombs beside the road or under the bridge)
- Restricted resources (funds, equipment, materials ...)
- Not enough data to make decision.
- Improper management system.

The traditional maintenance system which is currently used in Afghanistan municipality indicates:

- Lack of documentation. (no Maintenance Repair and Reconstruction (MRR) history, no periodic inspections ……)
- Lack of usage of structured set of data to save and process the system data in the Required Minimum Distribution (RMD).
- Systems being used are not enough flexible in setting work plans and timetables in order to monitor variable conditions.
- System is substandard in how to make decisions.

From above mentioned matters, the lack of extensive Pavement Management System (PMS) is considerably felt [6].

- **Future Threats:**

Future economy growth and the need to have fast, secure and relax transportation in order to move people and goods can put further pressure on already stressed pavement system. Adding to the equation, the growth of weighty loading generation and the shadow of continuing conflicts is not forecasting a bright future at this section.

The aim of this study is to expand a Pavement Management System that makes a regular procedure of protecting, rehabilitating, raising and utilizing Afghanistan's pavements. This is to facilitate a better and more flexible approach in making decisions, which are required to earn the wishes of road user's. To achieve this aim, the fallowing points should be considered:

- Building up a satisfactory data to maintain road pavements.
- Choosing and constructing an evaluation system for pavements.
- Developing computer program to facilitate the management process of road pavements.

In the following sections, we will define the pavement distresses, the index of international roughness and pavement conditions. It will be followed by the elaborating the maintenance strategies and highlighting the ones that are specifically applicable to the Afghanistan's roads requirement.

2. PAVEMENT DISTRESSES

Pavement distress involves distortion, disintegration, rutting, cracking, and other kinds of surface damages that shows a devaluation in the pavement's surface condition.

The deterioration of pavements is a result of weather or environmental factors, traffic, pavement and some other reasons [7]. The factors mentioned result in an increase on the shear in sub base, surface and subgrade, surface fatigue and

consolidation. Traffic factors are acceleration and deceleration which is done by heavy axle load repetition, while pavement factors include excess asphalt, poor subgrade drainage and insufficient particle interlock. Temperature changes and rainfall are types of climatic factors that may result deterioration to pavements [3, 8].

3. INTERNATIONAL ROUGHNESS INDEX (IRI)

International Roughness Index is used to determine the quality of the running lengthwise profile of a passed track and organize a systematize roughness scale. Often units used are millimeters per meter (mm/m) or meters per kilometer (m/km) [9, 10]. The IRI is found in the average corrected slope (ACS), that is a filtrated proportion of a typical vehicle's gathered pendency movement (in m, inch, etc.) apportioned by the distance passed by the carrier with the measurement (mile, km, etc.). IRI is then equal to ACS times 1,000. as shown in Figure 1

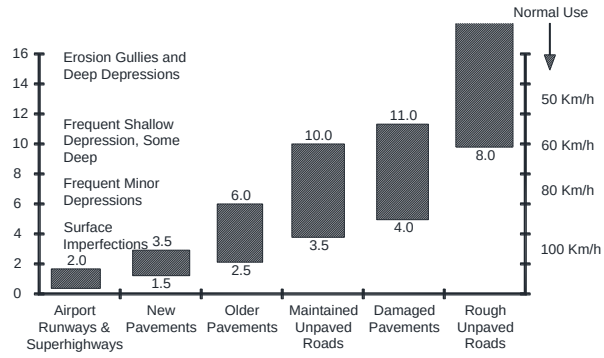


Figure 1. International Roughness Index.

4. PAVEMENT CONDITION INDEX (PCI)

The PCI arranges a numerical rating for the situations of road branches of road network, which 0 represents the worst condition and 100 represents the best condition [11]. This process is used worldwide to create a measurement of the condition of pavements which are taken into account for the functional performance beside the structural performance [12, 13]. The PCI measures two conditions:

1. Type, severity of pavement surface distresses and extent (like distortion, cracks and rutting).
2. The fluency and drive comfort of the road.

The PCI explains to public works organizers,

- The current condition of the road segments
- The size and rate of deterioration of the road segment and network by passing the time.

A PCI benefit;

- Determine maintenance and rehabilitation requirements
- Observe pavement condition over the time.
- Provide a strategy for the network preventive maintenance
- Develop budgets for the road maintenance.
- Analyze pavement design and materials

Figure 2. Pavement Condition Index (Cost Saving + Higher Service Level).

There are some steps to perform the condition and identifying the PCI rating criteria manually as described below: [14]

Road Pavements are divided into branches and sections.

- Every pavement section also is divided into units.
- Units are evaluated where distress conditions, severity and density are specified.
- Deduct value is specified for each type of distress.
- Total Deduct Value (TDV) should be computed.

- Total Deduct Value is computed to obtain Corrected Deduct Value (CDV).
- Pavement Condition Index for each sample unit evaluated is computed from the bellow equation.

$$PCI = 100 - CDV$$

The PCI of the total section is computed by taking the average of PCI's of all sample units.

5. MAINTENANCE STRATEGIES

Engineering scientists specified strategies for the different levels of pavement deterioration and condition [15]. Whenever the pavement is in its good condition, inexpensive preventive maintenance therapies are cost-effective, but when the pavements reach to the end of their design life, relatively expensive reconstruction will be needed [16]. Maintenance types versus pavement conditions are shown as Figure 3

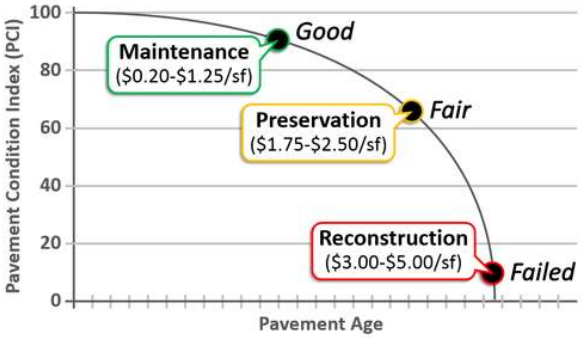


Figure 3. Maintenance Strategies.

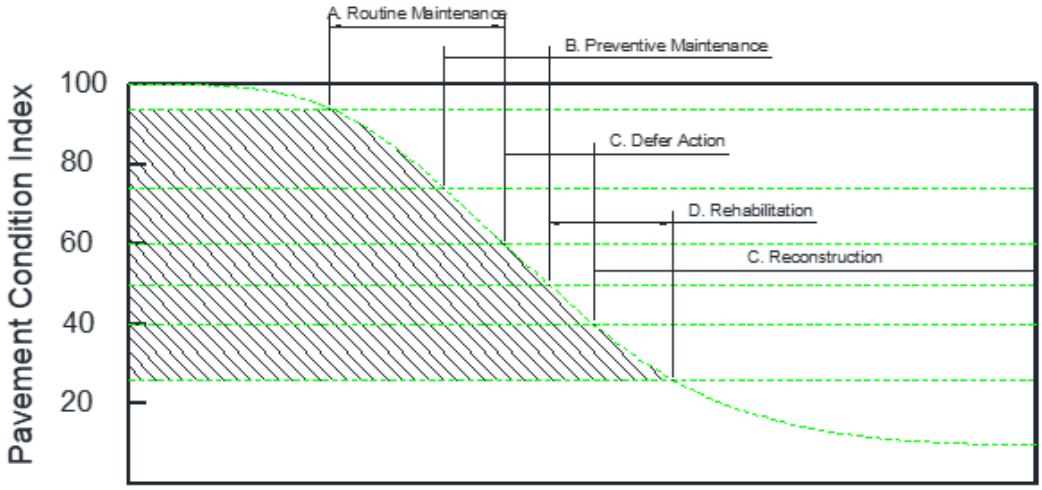


Figure 4. Five Strategies of the Paved Surfaces.

5.1. Determining Strategies

At first pavement condition data should be collected. It has to be evaluated to determine the rehabilitation and maintenance requirements [17, 18]. This evaluation should use special standards, with engineering arbitration. The induction must look at the determined status of sections and specify the cause of the detected distress and how it could be best corrected [12].

There can be are five strategies that considered for paved surfaces:

A- Routine Maintenance
B- Preventive Maintenance
C- Deferred Action
D- -Rehabilitation
E- Reconstruction

Typical Actions

The appropriate maintenance and repair strategies are best chosen using a life-cycle cost analysis. This action can be time consuming if attempted for every decision on every pavement section [19]. If a detailed economic analysis is not used, the most proper strategy can be selected using a logic scheme as suggested in Table 1 and Table 2. Such a scheme, of course, can be refined with a life-cycle analysis using average costs for typical actions, then using the resulting decision criteria as the standard for all sections. If such an approach is taken, different criteria for each pavement type can be chosen [8].

It should be considered that there is considerable overlap of possible strategies on the PCI performance curve [20]. In the example shown in Table 1, there are two or three possible strategies for any PCI value from 25 to 15. This leads to a realistic approach because the collapse of pavements is a gradual process. A change in just a few PCI points will not usually make one strategy preferred over another.

Within specific ranges of condition, one must look at the factors that went into the overall condition rating [21]. Predominately surface distress such as weathering, raveling, or bleeding would show a need for preventive maintenance over other strategies. On the other hand, if most of the condition rating is a result of structural distress such as alligator cracking, potholes, or failed patches, then it may be best not to expend preventive maintenance funds and plan a rehabilitation effort. Roughness can also help specify strategy decisions [13].

Table 1. Typical Actions Flexible Pavements.

Strategy	Recommended Actions
A-Routine Maintenance	1- Crack sealing 2-Skin patching 3-Local repairs 4-Strategy C actions as necessary
B- Preventive Maintenance	1-Strategy A and C actions as necessary 2-Surface seals 3-Thin overlays
C-Deferred Action	1-Patching of high severity potholes, shoving, corrugations and rutting
D- Rehabilitation	1- Strategy A, B, and C actions as necessary 2- Removal of a portion of the surface if necessary 3- Structural overlay
E- Reconstruction	1- Strategy D actions as necessary 2- Removal and replacement of the entire Pavement structure 3- Geometric, safety and traffic improvements as necessary

5.2. Comparing Condition Assessment and Strategy

The all rating, actual distresses and their causes, and performance of the surface over a time should be examined to determine the most proper strategy [22, 23]. A strategy should be thought of as an overall approach at this point rather than specific decisions about where to patch or how many inches of overlay to apply [24].

Table 2. Matching Condition Assessment and Strategy.

PCI	Other Consideration	Strategy
76-95	None (Excellent / Very good)	A
61-75	Normal or Small Amount of Surface distress	A
	Mostly Surface Distress	B
51-60	Mostly Surface Distress	B
	Distress Evenly Balanced	C
	Mostly Structural Distress very Rough (PSI < 2.0)	D
41-50	Relatively Smooth (PSI ≥ 2.5)	C
	Rough (PSI < 2.5)	D
26-40	Relatively Smooth to Rough (PSI ≥ 2.5)	D
	Very Rough (PSI < 2.5)	E
0-25	None(Very Poor / Failed)	E

A- Routine Maintenance
B-Preventive Maintenance
C-Deferred Action
D-Rehabilitation
E-Reconstruction

5.3. Evaluation the condition of Herat pavement

Evaluating the condition of Herat pavement network will be based on detailed visual inspection survey. It deals with the identification of pavement distress type, its extent and the level of severity of each type and it is also based on PCI criteria. Although, other methods including automated data collection, hand held computers, tablet computers or pocket inspectors may be developed to facilitate inspection and to eliminate data entry errors.

Table 3. Major Branch Data in Herat Pavement Network.

Branch ID	Branch Name	Number of Sections	True Area (SM)
100	Walayat Str	8	8832
150	64 Metra Str	9	25920
200	Spin Adi Str	6	10065.6
250	Farqa Str	14	34904.8

A pavement condition inspection form was prepared for this purpose. This form containing for example the condition data of Walayat Street is shown in Table 5.

Not all parameters need to be inspected every year, but an inspection scheduling procedure should be developed to assist in determining which sections should be re-inspected. There are commended pavement condition inspection policies minimizing the overall inspection effort of the city. A 2-3-year inspection interval at maximum is recommended.

Table 4. Part of Section Data in Herat Pavement Network.

Branch ID	Branch Name	Section ID	Inspection Date	Surface	Lanes	True Area (SM)
100	Walayat St	A/100	10/12/2015	AC	4	1104
100	Walayat St	B/100	10/12/2015	AC	4	1104
100	Walayat St	C/100	10/12/2015	AC	4	1104
100	Walayat St	D/100	10/12/2015	AC	4	1104
100	Walayat St	E/100	10/12/2015	AC	4	1104
100	Walayat St	F/100	10/12/2015	AC	4	1104
100	Walayat St	G/100	10/12/2015	AC	4	1104
100	Walayat St	H/100	10/12/2015	AC	4	1104
150	64 Metra St	1L/150	3/10/2015	AC	2	2880
150	64 Metra St	2R/150	3/10/2015	AC	2	2880
150	64 Metra St	3L/150	3/10/2015	AC	2	2880
150	64 Metra St	4R/150	3/10/2015	AC	2	2880
150	64 Metra St	5L/150	3/10/2015	AC	2	2880
150	64 Metra St	6R/150	3/10/2015	AC	2	2880
150	64 Metra St	7L/150	3/10/2015	AC	2	2880
150	64 Metra St	8R/150	3/10/2015	AC	2	2880
150	64 Metra St	9L/150	3/10/2015	AC	2	2880
200	Spin Adi St	AR/200	5/11/2011	AC	2	1677.6
200	Spin Adi St	BR/200	5/11/2011	AC	2	1677.6
200	Spin Adi St	CR/200	5/11/2011	AC	2	1677.6
200	Spin Adi St	DR/200	5/11/2011	AC	2	1677.6
200	Spin Adi St	ER/200	5/11/2011	AC	2	1677.6
200	Spin Adi St	FR/200	5/11/2011	AC	2	1677.6
250	Farqa Str	1R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	1L/250	4/8/2012	AC	2	2493.20
250	Farqa Str	2R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	2L/250	4/8/2012	AC	2	2493.20
250	Farqa Str	3R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	3L/250	4/8/2012	AC	2	2493.20
250	Farqa Str	4R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	4L/250	4/8/2012	AC	2	2493.20
250	Farqa Str	5R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	6R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	7R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	8R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	9R/250	4/8/2012	AC	2	2493.20
250	Farqa Str	10R/250	4/8/2012	AC	2	2493.20

Table 5. condition data of Walayat Street.

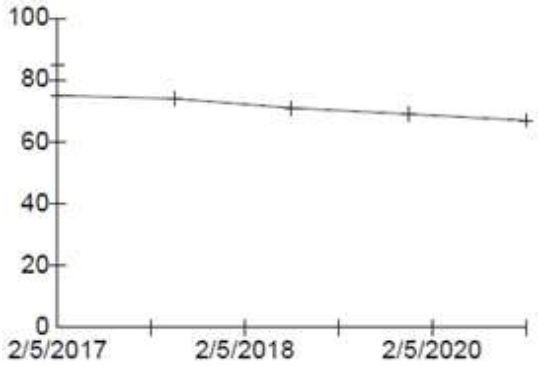
INVENTORY INFORMATION		Date: 12.02.2017						
Street Name : Walayat Str	Street ID : 100A		Section ID : 100/A					
From : Section 1	To : Section 2		Number of lanes : 0					
Section Length : 120 m	Zone : 01		Section Wide : 9.20 m					
Distress Information								
1- Alligator Cracking	8- Reflection Cracking		15- Rutting					
2- Bleeding	9- Lane/Shoulder Drop Off		16- Shoving					
3- Block Cracking	10- Long and Trance		17- Slippage Cracking					
4- Bumps and Sags	11- Patching & Util. Cut		18- Swell					
5- Corrugation	12- Polished Aggregate		19- Weathering & Raveling					
6- Depression	13- Potholes							
7- Edge Cracking	14- Rail Road crossing							
Distress Type		1	7	12	17	3	13	10
Severity		6 L	22 M	11	7 M	14 L	2	16 M
		13 L	16 L	8		11 L		
		6 M	14 L	29				
Total Severity	Low	19	30			25	2	
	Medium	6	22	48	7			16
	High							
Comments:								
Notes: 1. Distress (13) is counted as number of potholes. 2. Other distress types are measured in m2 except (4 – 7 – 8 – 9 – 10) in m.								

consequently, the current condition can be identified. Table 6 shows the condition of the case study zone sections as calculated by Micro PAVER.

Table 6. The PCI Values of the Case Study Zone Sections.

Section Condition Report

Date: 02/04/2018		Pavement Database				Network ID : WS1		
Branch ID	Section ID	Last Construction date	Surface	Use	True Area (sqm)	Last Inspection Date	Age at Inspection	PCI
100A (Walayat Str	100/A	2/3/2016	AC	ROADWAY	1104	9/20/2017	1	75



Graph 1. Section Condition Plot (Year vs. PCI).

that predict how a certain type of pavement will perform based on its performance in the past.

6. REQUIRED ROAD MAINTENANCE IN AFGHANISTAN

The main aim of this research is to develop a methodology for analysis of maintenance needed for Afghanistan roads. In this research, some structural arrangements proposed for the condition analysis of roads to plan and preform effective maintenance remedy for the enhancement of roads in Afghanistan. Maintenance is serious phase of road activity to maintain the original finance. So this is important to develop strategies for road maintenance condition and the condition of roads depending upon sectional area condition and sectional area significance [25]. The condition itself depends on functional and structural condition and functional condition is heavily pertinent to the available traffic condition and safety of the roads.

6.1. Maintenance Types

The type of maintenance and terminology, which relate to the highway maintenance, differs for each country [26]. It also differs from each urban area to others and from one highway authorization to another highway authorization and also, time is considered as another critical factor for performance of maintenance [27, 28]. Therefore, according to the time of performing, the maintenance can be categorized as below;

- Routine Maintenance
- Periodic Maintenance
- Extraordinary Maintenance
- Emergency Maintenance (According to Condition in Afghanistan)
- Winter Maintenance (According to Climate in Afghanistan)

7. CONCLUSIONS AND RECOMMENDATIONS

The current PMS in Afghanistan is in its traditional method and even it is not considered in many pavements. This entails the lack of accurate decision making to optimize the maintenance activities in most cities to match the road user's expectations. In this research, we could identify a serious and strong gap for comprehensive PMS. It can be concluded by this research with the following recommendations:

1. A PMS should be launched to service and work for to maintain Afghanistan pavements and enhance the management process and optimize the benefits to the society through a concentrate PMS.
2. Future enhancement should be considered to include all elements of roads maintenance management system.
3. Pavement Condition Index (PCI) to be chosen as a tool for Afghanistan pavements network condition analysis.
4. Micro PAVER caters for developing the management process of Afghanistan Pavement Roads Network.
5. Micro PAVER can be also utilized to help and find an easier way for the decision making process to manage Afghanistan Road Pavements.
6. In Afghanistan Maintenance Department staff have to be educated and trained to know the correct ways of carrying out the PMS tasks and the department should be equipped with the updated tools.

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