Article

Administrative Problems on Asphalt Road Pavement Maintenance and Rehabilitation: A Case Study in Kabul City Road Authority

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Abstract

Pavement Management System (PMS) is a tool for data collection, analysis, maintaining, and making reports, to help decision-makers and to find out best strategies for pavement Maintenance and Rehabilitation (M-R) due to pavement serviceability status and lowest cost. The main aim of this study is to evaluate and identify the current administrative problems of M-R in Kabul City Road Authority (KCRA). KCRA lacks appropriate pavement maintenance strategies which have resulted in the loss of a huge value of the investment in previous years. After a detail review of scientific papers and international experience in managing asphalt M-R, based on pavement evaluation, maintenance, and PMS questionnaire was developed and an interview was conducted. Through interview and questionnaire survey of professionals; the present M-R practice of KCRA is evaluated. Responses are graded by the average index method. In conclusion, the finding of this study implies that KCRA didn't conduct adequate pavement condition evaluation that can be sound input for recommending maintenance options, and the maintenance work is limited to overlay and pouching and performing maintenance without adequately defining the road cause of distress. Moreover, this study identifies the greatest challenges for road M-R in KCRA which is the absence of well-established PMS, lack of skilled manpower, lack of supervision and quality control, lack of budget, lack of proper machinery and equipment, and political influence respectively. The study recommended that KCRA must evaluate and apply alternative pavement assessment and maintenance techniques. Moreover, KCRA has to establish PMS to manage maintenance activities for better and optimum utilization of the resource. Further research is also suggested which includes the development of PMS and pavement treatment selection alternatives for KCRA.

Keywords: Pavement Assessment, Pavement Management System, Pavement Maintenance Management System, Pavement Deterioration

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Introduction

Pavement engineering is a branch of civil engineering and determines the pavement design, M-R, and optimization of Life Cycle Cost (LCC). Pavement engineering includes roads, runways, driveways, parking lots [1]. PM was first defined in 1980 at the first conference of Pavement Management (PM) in North America and in 1985 at the second conference of PMS in Canada. It is a tool for devolving the quality and performance of roads and controlling the cost based on a top management technique. Also, PMS is a tool for data collection, data analysis, maintaining, and making report. It also helps decision-makers to find out best strategies for pavement M-R due to pavement serviceability status and lowest cost [2]. PM works were divided into two phases; network phase and management phase. The maintenance budget for all road networks is related to the network phase and project implementation, treatment techniques, monitoring, inspection, and investigations are related to management phase of project [3].

Pavement Maintenance Management System (PMMS) "consists of a comprehensive, coordinated, set of activities associated with the planning, design, construction, maintenance, and evaluation. Thus, PMMS can be used in directing and controlling maintenance resources for optimum benefits" [4]. Thus, maintenance engineers based on his skill select the M-R approach with little regard given to life-cycle costing or initially analyzing the other part of road network demands [5]. When the road distress occurred, it is related to pavement deterioration while opening the highway for traffic at the beginning, very slowly after a period going to faster rate the deterioration of pavement and demand requires/needs more budget for treatment [6]. Although the amount of road deterioration directly depends on existent distress on pavement surface and after inspection to know the types and severity level of distress. Pavement distress is measured with square mater and liner mater to understand the intensity level; low level, moderate level, and high level, and at the end, surveying can suggest a treatment alternative for pavements [7]. Histories of road engineering have given us important detailed information about ancient times of road. In the beginning, a road was constructed in Italia "Rome" by the slave but it has not improved equipment for construction but it was found many directions to assist military activities due to this issue, Rome was the first pioneering pavement creation overall in the world.

1.1. Highlighting the Problem

Afghanistan lacks appropriate pavement maintenance strategies which have resulted in the loss of a huge value of the investment in previous years.

The government of Afghanistan and foreign donors emphasized on the development of the new pavement without concentrating on maintenance capability and budget. Though the government of Afghanistan and foreign donors invested six billion USD in pavement assets, this investment is likely to be lost. Thus, the Afghanistan government needs to develop a maintenance strategy for pavement [8].

Pavements are playing a significant role in social-economic both at the local and national level. The road is a key element of the pavement infrastructure. The causes of pavement deteriorations are mainly related to factors, such as traffic volume, traffic load, environmental factor-like (climate and moisture), use of poor materials during construction, quality process, weak maintenance, pavement age, and subgrade. Due to these causes the pavement functionally and structurally deteriorates like localized of depression, potholes, cracking, rutting, and texture loss [9].

While the road deterioration is increasing and the pavement demands more budget for treatment, the insufficient resource allocation is creating more challenge for maintenance activities. The highway or any type of pavements that are newly opened for traffic typically has top quality and performance, but after a period, the deterioration in pavement starts. The previous studies showed the pavement deterioration has a limit, which is 60% of pavement that will deteriorate before this level. The pavement surface functionally fails in 20 years, but when PMMS is applied, the road quality and performance will increase [10].

1.2. Purpose of Study

The main aim of this study is to evaluate and identify the current administrative problems of M-R in *KCRA*. It reviews the strategies, policies, and critical problems of PMS in *KCRA*. Scientific and different experiences from developed and developing countries are reviewed to identify the best asphalt pavement maintenance management. This research focuses on how to increase and improve the road and pavement management practices in Kabul, Afghanistan. The following are the major key points in achieving the aims;

- The literature of the M-R and pavement management processes of many developed and developing countries and succeeded in international experience were reviewed.
- The current condition of M-R management procedures of *KCRA* is evaluated and examined.
- Compare the international practice with KCRA'S experience and forward recommendations based on the findings.

1.3. Research Question

- What are the main administrative problems in the assessment and execution of pavement M-R activities in Kabul city?
- What are the main administrative problems hindering the establishment of PMMS in Kabul city?

2. Literature Review

Pavement deterioration causes are important factors that can effect on-road deterioration such as environment, material characteristics, traffic volume, type of design standards, pavement age, pavement construction quality which are discussed further in the following [11]:

2.1. Traffic volume and loading

One of the critical factors that directly affects pavement performance is traffic volume and traffic load. Even though while designing the pavement structure, it is considered that it should carry and insist against the expected traffic load, traffic loads are harming the roads which is the result of vehicle loads and their volumes [12].

2.2. Environmental factors (humidity and water)

A significant decrease in strength of the subgrade and gravel materials is happening from the penetration of the Moisture, humidity, or dampness. It simply enters the cracks through holes on the surface into the subgrade and although from the capillary section with water on that part of the structure. Swelling and shrinkage are from environmental factors. It is clarified in reflective cracking [13].

2.3. Subgrade

The subgrade is the other impactful factor of pavement failures. It is feasible with the wheel loads via the underlying soil. The sensitivity of the subgrade helps the wheel loads if it could not do this, the pavement will deform extendedly and of course this is the reason for pavement failures. The pavement performance will be different and various if the natural alliteration for the subgrade aggregate is not properly and precisely provided in the pavement design structure [10, 14, & 15].

2.4. Pavement Age

Aging in the pavement is a matter of fact which the road will show distress in the surface after more than 30 to 40 years. When the traffic is growing larger and the time passes the road begins accumulation, for instance, solidify increase hardness of asphalt gradually with its aging, though it improves the sensitivity of thermal cracking [14, 15].

2.5. Quality of Construction

Several factors are included in the quality of construction. For instance, materials quality, distress for good compaction, moisture conditions, and thickness of layers after compressions are affected considerably the road pavements [6]. The above issues justify the need for trained staff and good control and monitor procedures during the construction.

2.6. Material Properties and Composition

Materials selection is critical in pavement layers construction, it can easily cause the deterioration of the pavement. Considerably, it is due to the different conditions of the soil which affect the type of materials to be used. It affects the strength of the pavement or bearing capacity, mix properties, flexibility degree, and elasticity. Though material selection directly increases or decreases the performance of the pavement based on our design [17].

2.7. Road Maintenance Standards

Maintenance is the other element to keep the pavement well and standard. Maintenance standards defining the deterioration of the roads by treatment of road defects. A standard gives a limit for the deterioration level which the roads allow. The low-level standards are the reason for the fast deterioration of the pavements [10, 14, & 15].

2.8. Pavement Distress

The most visible flaw or defect in the road surface is pavement distress which is one of the deterioration factors. Organizations nowadays collect periodic distress data with PMMS in their surveys. Mostly the surface distress is categorized into 4 sections which are illustrated in Table 1. They are disintegration potholes, surface deformation, cracking, and surface defect bleeding [18].

No	Cracking	Surface deformation	Disintegration pothole	Surface defect bleeding
1	Fatigue	Rutting	Pothole	Raveling
2	Longitudinal	Corrugation	Patches	Bleeding
3	Transvers	Shoving		Delamination
4	Slippage	Depressions		
5	Reflective	Swell		
6	Block			
7	Edge			

Source: (Hafizyar & Mosaberpanah, 2018).

Table 1: *Types of asphalt pavement distress [18]*

2.9. Pavement Failure

The asphalt pavement failure is a more complicated issue which resulted in a series of interacting process. It might happen as an outcome of road deterioration due to the accumulation of distresses and pavement failure is divided into two parts; functional and structural [19].

> **Structural failure:** a pavement collapse includes structure or breakdown of some part of the road element due to which the pavement becomes incapable of taking the load on its surface [14].

> **Functional failure:** the surface pavement roughness ratings are highly dependent on the functional failures. Causes of road functional failures are related to distress in road surface outcome in depressions, cracks, poor riding quality, and rutting formation [15].

2.10. Pavement Assessment

The main objective of road assessment is principally to determine "why the present pavement is overcome so that the appropriate rehabilitation measures can be identified. Pavement evaluation involves detailing appropriate methods for road investigations, relating the symptoms of distress to their cusses and design using appropriate design methods"[18].

There are three methods available in the American United States for road assessment which are visual rating, destructive test, and non-destructive test [20].

> **Visual Rating (VR):** this method is the most popular in the entire world and generally used for the data collection on their road according to visual condition surveying [14].

> **None-Destructive Test (NDT):** Generally, this method is used in the phase of project information for improving the VR. It is able to evaluate the" overall pavement structural load-carrying capacity" and the thickness of overlay and the most common types of NDS are Falling weight Deflect-meter, and Road Rater. The advantages of the NDT method are: "provides on-site information about physical properties of the pavement, does not damage the pavement and minimizes laboratory tests, and NDT can be accomplished in a timely and efficient manner" [19].

> **Destructive Testing (DT):** It used to support the design analysis of pavement structure capacity why the pavement is failing and taking sample or coring from pavement structure to understand the causes of deterioration [21]. The test was based on" Laboratories such physical properties, and chemical properties (gathering from coring, and

trenching, and Shelby tubes), and Visual inspection of pavement layers from trenching and coring [15].

2.11. Pavement Condition Index (PCI)

Recently, most maintenance organizations used the PCI surveying technique for the assessment of pavement distress and it was developed by Corps Engineers US Army. PCI can measure only the road surface operational condition and ride quality so PCI rate is different started from zero to hundredth and 100 mean is an excellent condition and described the PCI rate by [10, 13].

2.12. Road maintenance, and Management Practice in Development Countries

To learn lessons and to have deep insights into the topic, the past experiences of the countries need to be reviewed of course. In this era of development, most of the countries have faced this challenge, by getting insights from them let's see how they overcome these challenges. Which methods have been used by them and what are their strengths and weaknesses which led us to select a proper way of selecting best methods for Kabul, Afghanistan and will not repeat mistakes that have been made by other countries while dealing maintenance and rehabilitation of their pavement networks [22]? And finally, to provide sustainable and efficient pavement maintenance. Table 2 illustrates the main points and strengths and weaknesses of many countries in this regard.

No	Country	Experience Details
1	New Zealand	• Road Controlling Authorities are the owners of the local road networks • RCAs specify outcomes of the community every 6 years • Road Asset Maintenance Management (RAMM) system being used in New Zealand which contains road conditions and maintenance history of the networks • RAMM stores drainage, road structure, condition data like rutting, cracks, etc., surfacing. It also contains TSA • Treatment Selection Algorithm (TSA) contains which tasks and works should be done in the coming year • This PMS also prioritize road maintenance using PCI • A routine of six weak cycles conducting using a video record to specify the defects • They use Performance specified maintenance contract, Hybrid, and Measure and value contract • One-third of the roads are outsourced with the PBSMC method.

2	Singapore	• Singapore is a small city-state which the roads are 12 percent of the lands in the country • Road damage is mostly by climate events, poor quality, and traffic load • Annual network condition survey and road inspectors are done by machine to collect data and riding quality of the roads like SCRIM for skid resistance and IRI • They do Preventive maintenance to avoid structural maintenance • The maintenance tasks are carrying out by contractors like maintenance term contracts • Singapore focuses on highway road maintenance because of the effects including users and residents nearby. • Timing of the maintenance depends on the community and conditions like night works etc.
3	Australia	• Australia has a 10-year financial plan on a local level which also contains plans for pavement networks such as construction cost, maintenance cost, operation cost, reconstruction cost, and disposal cost. • There are asset management programs with prioritization models and cost-benefit analysis. • Different pavement management systems deployed in rural and urban areas to measure rutting, roughness, skid resistance, wide network, etc. • Decision support tools being used in district levels, some developed their own like Queensland, and some used commercial applications available. • Western Australia has contracted 90 percent of its maintenance tasks • A variety of contract models are being used such as performance-specified, Conventional, hybrid of them, and alliance contract models.
4	Ethiopia	• Ethiopian Roads Authority (ERA) "carries out a road condition survey two times a year through ten districts road network directorate using visual condition survey method. ERA has Survey Equipment (Vehicle) that can cover 80km per hour but they usually used the output for planning purpose". • District road directorate measure and identify defects according to the condition survey and send the report to ERA for budget allocation. • ERA has a construction firm which is called Ethiopian Road construction Corporation (ERCC) who is responsible for maintenance and construction except some labor works which are being given to private companies. • ERCC did not bring any innovation in the maintenance delivery system. • Districts use a spreadsheet as an inventory for asset data. They gather visual condition survey data for every 5kms.

Source: Author's Compilation.

Table 2: *Different Experiences of Countries in Road Maintenance.*

3. Research Methodology

This research was based on a descriptive exploratory strategy through which administrative problems related to M-R, maintenance management, and PMS of Kabul City Road Authority can get solved.

The qualitative approaches seek to gain insight and to understand people's perceptions whether as individuals or groups. The research strategy adopted for this study is quantitative research

3.1. Data Collection

This research was utilized the data sources to generate subsequent principal documents: archival documents and respondent's documents. The archival documents provided most of the data through maintenance reports and bills. Respondent documents are questionnaires from different stakeholders including; university students, municipality employees, contractors, and consultants composed the source for data collection that were essential for specifying current asphalt pavement maintenance and management practices in Kabul city.

3.2. Sample Size

It was estimated the population parameters that he/ she used in sample statistics based on previous studies as used "SLAVIN'S FORMULA" for obtaining the sample size [23]. Denoting by n the sample size, Slovin's formula is given by:

$$n = \frac{N}{1+Ne^2}$$ **Eq-1**

N= number of populations   e = margin in error 0.05

The research was designed to obtain data through top 3 universities just from civil engineering, 3 contractors, 2 consultants, and 1 Kabul municipality department of maintenance. The total number of participants was 250 at different age ranges.

n = 250/ 1+ 250*(0.05) ^2= 153 Sample size

The participants of each organization were chosen according to the purpose of the study. The total number of the questionnaires distributed was 153, 27 to contactors, 30 to consultants, 45 to university students, and 50 to Kabul City Road Authorities. 95 questionnaires (22+18+25+30) were returned. The data were collected from contractors, consultants, university students, and municipality employees respectively.

3.3. Data Analysis Strategy

The answer specified by every respondent was assessed and summarized then utilizing the pursuing average index formula based on [19];

$$\text{Average index} = \frac{\Sigma \, ai \, Xi}{\Sigma_{Xi}} \qquad\qquad \textbf{Eq-2}$$

For this study, the Ordinal Scale was suggested. An ordinal scale is a position or rating information that typically utilizes the whole number in climbing or diving requests. The numbers as allocated for the settlement or grade of effect (1, 2, 3, 4, and 5) did not show the interval among scales for equivalency, but showed absolute magnitudes. They are exclusively numerical labels. The The5-Likert scale is as shown in Table 3 below;

Chances of occurrence	Very Important	Important	Average	Least Important	Not Important
Scale	5	4	3	2	1

Table 3: Incidence Scale.

3.4. Questionnaire Design

The questionnaires were improved to evaluate the present challenge on pavement assessment, pavement management practice, and pavement M-R, in Kabul city pavement networks and also how to reduce and eschew these challenges for best pavement maintenance operations, the observed and evaluated factors relevant to the literature review. The draft questionnaires were designed by researchers and finalized with 7 questions related to pavement assessment, 8 questions related to pavement M-R, and 4 questions related to pavement maintenance management.

4. Result and Discussion

According to respondents' results, KCRA did not apply the destructive and non-destructive test method which have a great role in recognizing the causes of pavement failure. Most of the respondents (almost 87.55 %) admitted stating that KCRA did not have any sound strategies for pavement M-R due to cost-effectiveness. Most of the respondents believe PMS is the best tool for road maintenance. KCRA only used distress survey for road M-R in Kabul city. They did not use roughness, structural capacity, and skid resistance. Chart 1 as showing, the result of respondents in part two.
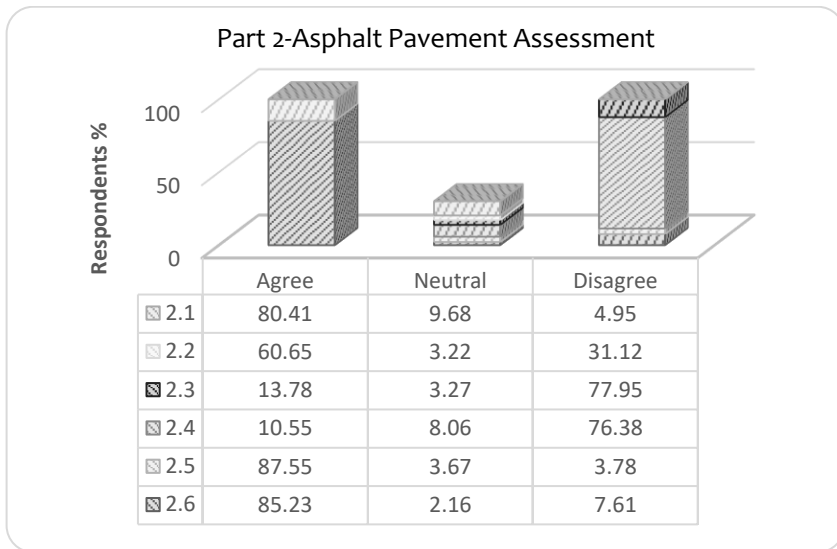
	Agree	Neutral	Disagree
2.1	80.41	9.68	4.95
2.2	60.65	3.22	31.12
2.3	13.78	3.27	77.95
2.4	10.55	8.06	76.38
2.5	87.55	3.67	3.78
2.6	85.23	2.16	7.61

Chart 1: _Showing the Result of Respondents in Part Two._

Q. 2.7: What are the main administrative problems in the assessment of pavement M-R activities in Kabul city?

It was specified that the maximum supreme ranked and the minimum supreme ranked factors that illustrated the main administrative problems for assessment of pavement M-R activities needed to be listed and considered as well demonstrated in Chart 2. The major significant administrative problems in asphalt pavement M-R activities in KCRA is the lack of proper PMS, limited qualified manpower, lack of inspection and quality control, lack of equipment and machinery, and lastly lack of a sufficient budget.
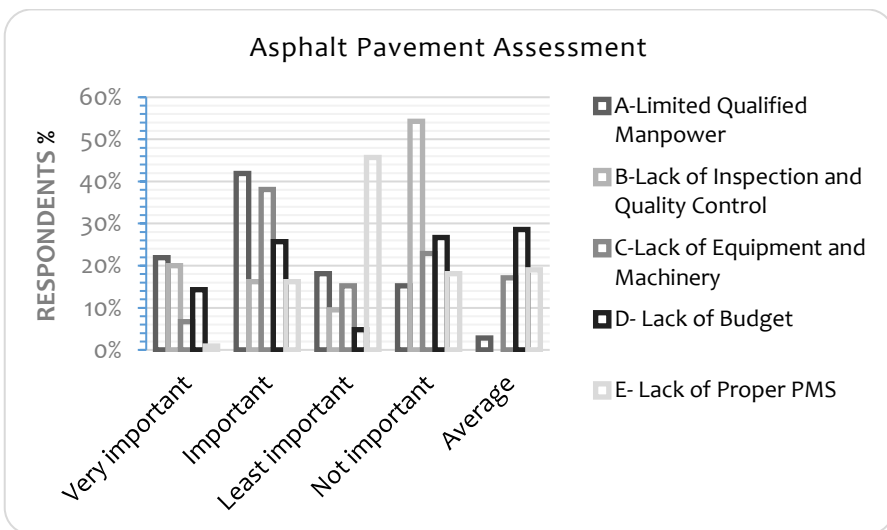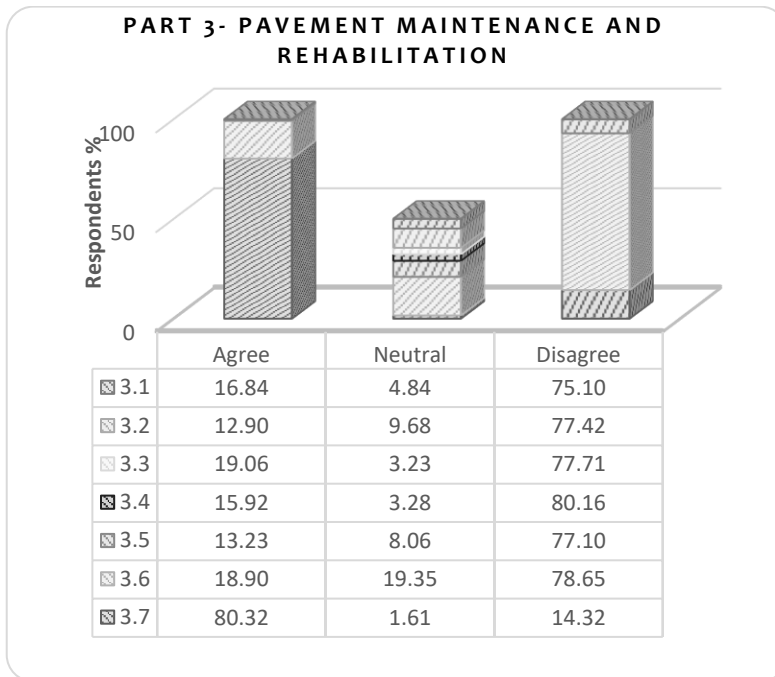

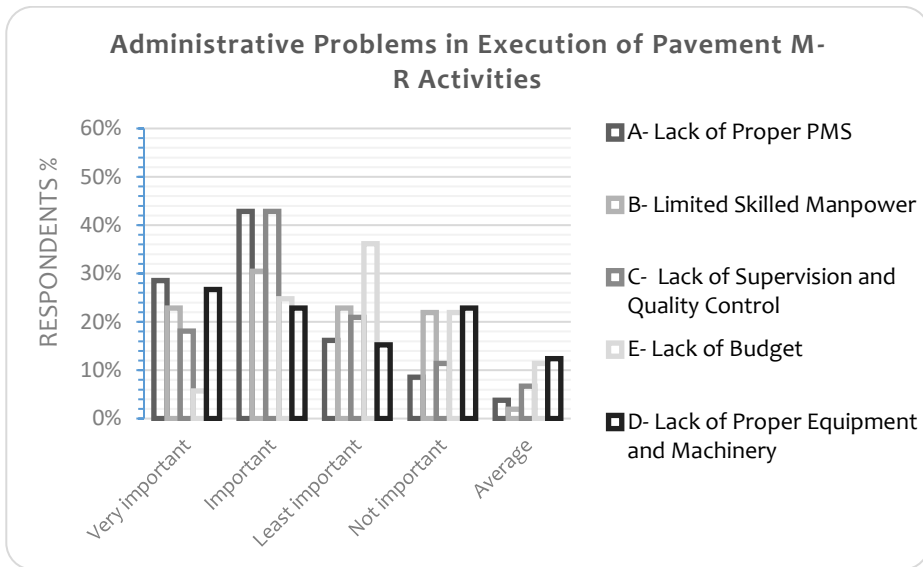**Chart 2:** _Administrative problems in the assessment of pavement M-R activities._

The respondents agreed that KCRA currently do patching and overlying treatment, they didn't apply other treatment alternatives. These treatment strategies are not sufficient for road treatment. There is no methodology in pavement treatment material design. Both treatment types of maintenance such as the design of overlays and path thickness are decided on the site of construction works and also there is no suitable quality control for M-R activities in KCRA demonstrated in Chart 3, the result of respondents in part three.

PART 3- PAVEMENT MAINTENANCE AND REHABILITATION

	Agree	Neutral	Disagree
3.1	16.84	4.84	75.10
3.2	12.90	9.68	77.42
3.3	19.06	3.23	77.71
3.4	15.92	3.28	80.16
3.5	13.23	8.06	77.10
3.6	18.90	19.35	78.65
3.7	80.32	1.61	14.32

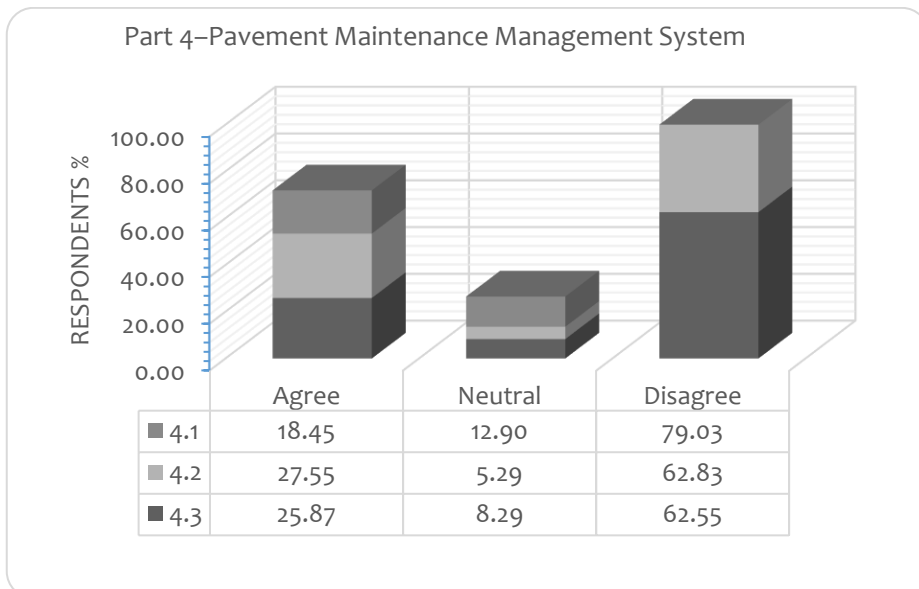*Chart 3: Showing the result of respondents in part three.*

Q. 3.8: What are the main administrative problems in the execution of pavement M-R activities in Kabul city?

According to the respondents grading the main administrative problems for the execution of pavement M-R activities, the answers are ranked respectively lack of proper PMS, limited skilled manpower, lack of supervision and quality control, lack of budget, and lack of proper machinery and equipment as shown all the result in Chart 4 at the bellow.

Chart 4: *Administrative problems in execution of pavement M-R activities.*

Most of the respondents believe that KCRA can't establish PMMS for proper planning of road maintenance in Kabul city road networks, neither can they apply alternative treatment approaches because of limited resources. The respondents also expressed that the KCRA did not have outsources for M-R activities by private construction companies. Recently, M-R activities by KCRA are carried out as well demonstrated in Chart 5, the result of respondents in part four.

	Agree	Neutral	Disagree
■ 4.1	18.45	12.90	79.03
■ 4.2	27.55	5.29	62.83
■ 4.3	25.87	8.29	62.55

Chart 5: *Showing the result of respondents in part four.*

Q. 4.4: What are the main administrative problems hindering the establishment of PMMS in Kabul city?

The respondents graded the low and high-rate factors in administrative problems in establishing PMMS activities and ranked answers respectively; lack of awareness of benefits and cost PMMS, limited skill manpower, political influence, and lack of equipment and machinery as shown in Chart 6 the bellow.
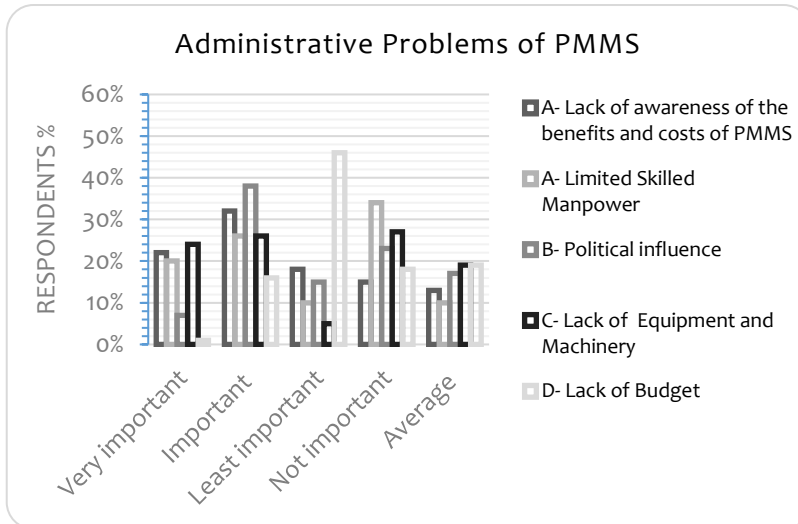
Chart 6: *Administrative problems hindering the establishment of PMMS.*

5. Conclusion

This study described administrative problems in asphalt pavement maintenance and rehabilitation in Kabul city. The road condition surveying conducted by KCRA and used visual inspection only, KCRA not applying destructive and non-destructive test methods which have the best role in recognizing the causes of pavement failure.

It is found out that the M-R activities carried out by KCRA are only overlaying and patching without specifying the real causes. Therefore, the KCRA used traditional M-R techniques such as simple treatment without defining the real causes of distress. This is a waste of resources that will fail to serve and the pavement surface will need repair soon.

Based on the result finding KCRA cannot establish PMMS which is essential due to effective cost and particular maintenance strategies at the project stage and administratively. The KCRA cannot define quality assurance and control for data collection, data analyses, and maintenance activities.

The research found out the main administrative problems of pavement M-R in Kabul city as lack of PMS, skilled manpower, budget, equipment, and quality control. As for political and security problems, there is no effective information management system for collecting and analysis of data due to

maintenance activities. These results show that without PMS maintenance activities are not effective.

Acknowledgment

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