

# Assessment of Flexible Pavement Condition Using PCI: A Case Study

## Evaluación del estado del pavimento flexible mediante PCI: un estudio de caso

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### Abstract:

*The pavement condition index (PCI) is an inexpensive and simple method to evaluate pavement distresses. The main purpose of this study is to identify and evaluate pavement distress of Jalalabad highway using pavement condition index (PCI) to find a practical solution of road distress by suggesting different alternatives of treatment. The evaluation of pavement condition index (PCI) is carried out by visual survey pursuing ASTM D 6433. The highway is divided into A and B two sections, each section is divided into sample units, and the intensity of distress is evaluated in each sample unite. The results show that section A is in good condition with 70 PCI value and section B is in good condition with 59 PCI value. Based on the PCI values of the road sections, the necessary maintenance or rehabilitation procedure is suggested.*

**Keywords:** Asphalt pavement, visual survey, classification and severity level of distress, PCI value, pavement maintenance.

### Resumen:

El índice de condición del pavimento (PCI) es un método económico y sencillo para evaluar el deterioro de las superficies pavimentadas. El objetivo principal de este estudio es identificar y evaluar el deterioro del pavimento de la autopista Jalalabad mediante la aplicación del PCI, con el fin de encontrar una solución práctica al deterioro de la carretera, sugiriendo diferentes alternativas de tratamiento. La evaluación se realizó mediante un reconocimiento visual según la norma ASTM D 6433. Para este fin, la autopista se dividió en dos secciones, A y B, cada una de las cuales se divide en unidades de muestra, en las cuales se evaluó la intensidad del deterioro en cada unidad de muestra. Los resultados muestran que la sección A se encuentra en buen estado, con un valor de PCI de 70 y la sección B con un valor de PCI de 59. Con base en los valores de PCI de las secciones de la carretera, se sugiere el procedimiento de mantenimiento o rehabilitación necesario.

**Palabras claves:** Pavimento asfáltico, reconocimiento visual, clasificación y nivel de gravedad del deterioro, valor de PCI, mantenimiento del pavimento.

## 1. INTRODUCTION

Pavement Management System (PMS) is an international method to help transportation agencies to evaluate the current condition of pavements, collect data, analyze, maintain and report to help decision makers in finding optimum strategy to be suggested as an alternative treatment for pavements because of serviceability status of pavement and least cost (Shahin, 2005).

When the pavement distress happens, road deterioration starts after opening the road for traffic. At the beginning, it starts slowly after a period of time and the deterioration of pavement becomes faster and then the pavement surface fails (Zumrawi, 2015). The quality of pavement deterioration is directly related to existing distress on pavement and after evaluation it will help us understand the types and severity level of distress. Pavement distress can be measured with square meter and linear meters to know the severity level; low level, moderate level and high level. At the end, condition survey can be suggested as a repair method (Cafiso, Di Graziano & Battiato, 2006). Whenever an effective maintenance system is implemented, it will reduce the maintenance cost of pavement. Preventive maintenance process has a very necessary role to play in maintaining of road network for a longer period of time (Hafizyar & Mosaberpanah, 2018). However professional maintenance can maintain the pavements which always have safety, and pavement user can be comfortable (Bashir 2006). Delay of road maintenance is directly or indirectly connected to costs of pavement. If the road distress is treated early the cost will be always low. While postponing the maintenance of the lead to failure of the pavement sections based on South African National Road Agency Ltd (SANRAL, 2013). The key element of pavement condition survey to be identifying different types of distress and determine the causes of distress to suggest appropriate maintenance repair to be applied. The Survey was conducted from Sarkhab bridge

of Jalalabad highway to the city of Jalalabad and encountered different types of distress. This study has recommended the treatment of distress.

This study is limited to the present condition of study on selected Jalalabad highway; therefore, it may differ from other results in previous studies and in peculiar cases different approaches may be required to analyze pavement conditions.

### 1.1 Problem statement

Pavement deterioration immediately starts after opening the road for traffic. This process starts slowly at first, and in due course it worsens. And the result of pavement deteriorations becomes a complex distress. Under traffic loading and environmental factors, deformation of road structure occurs through shearing, and material disintegration, while chemical or mechanical bond is fragmented through infiltration, weathering, or traffic loading. Sub-base structure, characteristics of traffic, and environmental factors, are issues that have impacts on efficiency of pavement networks (Gary, Hao & Qingbin, 2009).

### 1.2 Aim of the research

The main purpose of this study is to identify and evaluate pavement distress and find Pavement Condition Index (PCI) in order to evaluate the distress rate. Furthermore, initial assessment on the performance of asphalt pavement to find a practical solution for road distress of Jalalabad highway by giving different treatment alternatives.

### 1.3 Research question

- What are the most serious causes of asphalt pavement distress on highways in Jalalabad?
- What are the most important alternative treatments solution to pavement distress on highways in Jalalabad?

## 1.4 Research significance

Delay of road maintenance is directly or indirectly connected to costs of pavement. If the road distress is treated early the cost will be always low. While postponing the maintenance of the lead to failure of the pavement sections based on South African National Road Agency Ltd (SANRAL, 2013). Evaluation of treatment costs rise to 6 times maintenance costs but after 3 years of neglect the rise goes to 18 times. Road maintenance postponement takes more costs, and increases the vehicle operation cost (more renovation, more fuel use).

## 1.5 Scope and limitations

This study is centered on selected roads in Jalalabad city of Afghanistan, emphasizing the deterioration and its causes using visuals condition surveying to identify the PCI value as the particular method for this analysis, and is carried out using the ASTM D6433 standard. This study is limited to the present condition of study on selected Jalalabad highway; therefore, it may differ from other results in previous studies and in peculiar cases different approaches may be required to analyze pavement conditions.

## 2. LITERATURE REVIEW

Flexible pavement structures are “constructed with various layers of material with high quality materials at the top where the intensity of stresses from high traffic and low-quality materials at the bottom layer where the stress intensity is low. Flexible pavement has been analyzed as a several-layer mechanism under loading. Flexible pavement structures are structures that include the surface course, binder course, base course, sub base course and compacted subgrade or natural ground” (Hafizyar & Mosaberpanah, 2018). The causes of road deterioration are the impact of physical environment, traffic, material properties, standard design, quality of

construction process, and pavement age (Adlinge & Gupta, 2013).

Pavement layers are typically built for long term performance and to tolerance traffic loads. Traffic loading is an important factor which impacts the road performance. The vehicle loads have higher impact on the road. (Zumrawi, 2016). Moisture can weaken the stability of pavement structure, specifically the subgrade. Moisture may enter the layer of road from cracks and holes, and then goes to subgrade. Environmental causes are; “shrinkage, swelling and shrinkage which are the outcomes as shown in reflective cracking” (Ngxongo & Allopi, 2017). Some studies show that “the pavement age is between 35-45, and this will show in the pavement distress and typically, coupled the experience of traffic repetitions, roads begin to accumulate stress and over time the hardness of the asphalt increases, which develops the sensitivity and results as shown in thermal cracking” (Hafizyar & Mosaberpanah, 2018). Pavements need proper compaction; if it is not properly compacted during construction, moisture can penetrate the pavement and destroy the pavement layers (Okigbo, 2012). This condition straight forwardly identifies with the expertise of staff and the most vital best examination and quality control amid the development of the road. The choice of material is vital for the development of road structure and is one of the causes of road deterioration. It is good to make basic adjustments to the materials where necessary with respect to the soil properties or the desired properties needed. For example, the quality or load bearing limit, blend properties, modulus of versatility and level of adaptability. The poor materials with low properties when used in pavement construction have an incredible impact on the consistency of the asphalt layers and performance (Oguara, 2010).

The concept of ground investigations is to evaluate the asphalt insufficiencies, for example, patches, cracks, and used trench cut. These distresses go into the PMS da-

tabase which computes (PCI) for every section. PCI rate begins from zero (failed or unsatisfactory) to 100 (excellent or adequate) (Weil, 2009). The main objective of maintenance is the extension of service life of pavement design by reducing magnitude of deterioration of pavement. By maintenance, we can create smooth surface to traffic and prevent overcast. Maintaining the pavement can help the transportation services as it is very important to economic of the country. In inspection pavement distress two factors are needed to be examined: the first one is the severity and the second one is density stage of distress (David, 2006).

### 3. DEFINITION OF STUDY AREA

The survey was conducted on Jalalabad Road in Nangarhar province. This highway is the most important highway in Afghanistan as it connects many provinces of Afghanistan with Pakistan and is a crowded area in Nangarhar. It has two carriageways and each carriageway is divided into two lanes. This highway is used for transportation and public movement. PCI condition surveys have been done for inspection of road surface distress. Based on the research propose, it is essential to choose a pavement section because. It should cover all pavement conditions such as (excellent, good, fair, and poor condition).



Figure 1: Location of study Area

### 4. STUDY METHODOLOGY

The procedure introduced by PAVER (1982), American Society for testing and materials (ASTM) D6433-09 (2009) and Shahin (1997) has been used in this research. During PCI condition surveying, visual indications of pavement deteriorations were recorded in condition sheet and then analyzed. Finally in computing

PCI values, they starts from 0 to 100; 100 shows that the road is in excellent status. The road condition values are specified through correlation which existing road condition rating as function of the PCI value. The asphalt road status ranking is an explanation of road status as a component of the PCI rate that differs as of failed to excellent (Seiler, 2009). Table 1 illustrates the PCI ratings.

**Table 1: PCI rating**

PCI	Rating
85-100	Excellent
70-85	Very Good
55-70	Good
40-55	Fair
25-40	Poor
25-10	Very Poor
00-10	Failed

Source: (ASTM) D6433-09

For investigation, road network must be divided into branches like (streets, parking area and so forth), and all branches must be divided into sections. road section must be divided into sample units. At this stage carrying out the condition survey and specifying the PCI value will be conducted as per literature review (PAVER 1982; ASTM D6433-09 2009;) as follows.

- Evaluate the sample unit, specifying types of distress and severity phase and measure the intensity.
- Identifying the Deduct Value (DV) is specified through DV curves to any types of distress and intensity.
- The found total deduct values (TDV) are calculated with summing whole particular DV.
- The total deduct values are calculated Correct Deduct Value (CDV) should be specified via correction curves.
- If a CDV and particularly DV are higher from the CDV, the CDV are tantamount to the highest particular DV.
- The PCI is calculated by using this relation  $PCI = 100 - CDV$ .

Following tools are required for collecting data from the selected area.

- Asphalt road condition sheet
- Digital camera
- Hand odometer wheel
- Layout plan
- Safety equipment

## 5. DATA COLLECTION

Jalalabad road is divided in two (A and B) Sections and every section is divided into sample units. Each sample unit is surveyed by researcher and team. The sample size has chosen properly. The road is including four lanes with a width of “14m” and the length of each sample is 30m. The size of sample can be calculating by multiplying the width of highway 14m with the length of sample 30m which is equal to 420 square meters ( $14m * 30m = 420m^2$ ). Next the sample number should be selected for inspection; we assume 2 section (A, B) in this branch with the same length 3,500m. The total number of samples in the branch can be acquired by dividing the length of the section by length of the samples.

$$N = \frac{(\text{length of section})}{(\text{length of the sample})}$$

$$N = 3,500 / 30 = 116 \text{ samples}$$

To select the numbers of minimum samples to be inspected, we select 116 on the N scale (Figure 2), and proceed vertically to proper curve “PCI range 25 for flexible pavement” and read 14 on the n scale. It means 14 sample units must be inspected.



Section A which is started from Sarkhab bridge have 14 samples. The collected data of Section A are as follow.

Table 2: PCI values of Section A

N.º	Sample no	Sample unite area m²	Correct deduct value	PCI
1	2	420 m²	55	45
2	10	420 m²	50	50
3	18	420 m²	52	48
4	26	420 m²	40	60
5	34	420 m²	22	78
6	42	420 m²	22	78
7	50	42 m²	23	77
8	58	420 m²	28	72
9	66	420 m²	23	77
10	74	420 m²	21	79
11	82	420 m²	24	76
12	90	420 m²	20	80
13	98	420 m²	19	81
14	106	420 m²	20	80

Average PCI= 70 being good Condition

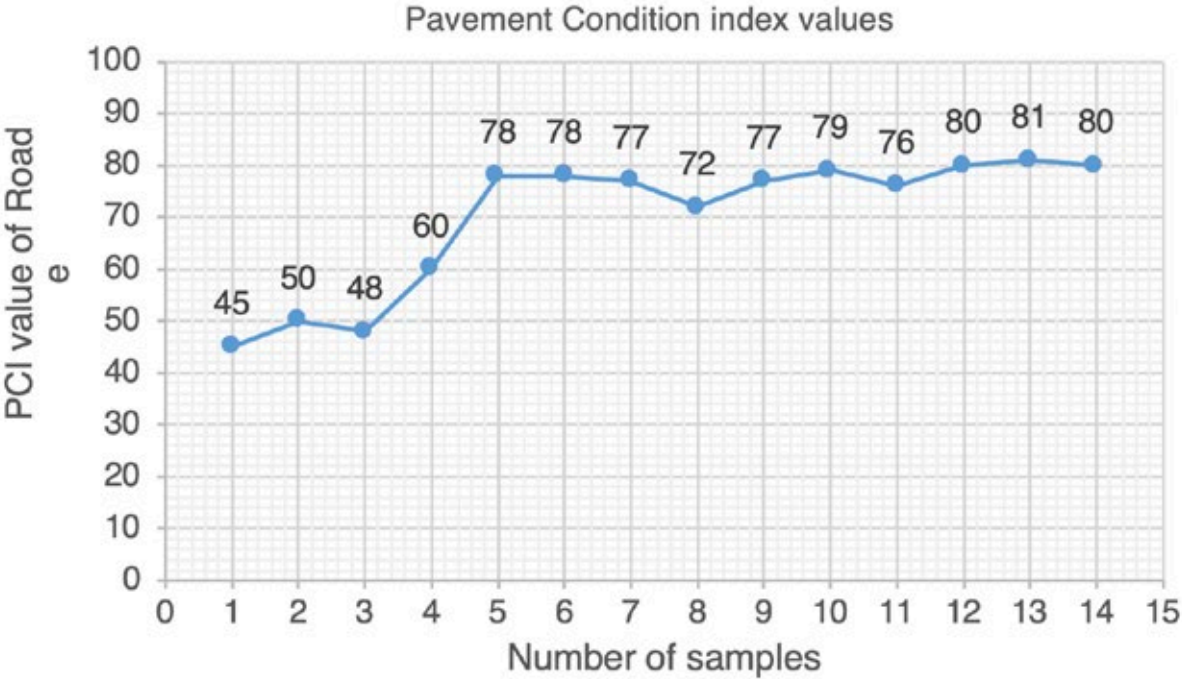


Figure 4: PCI values of Section A

Section B which is started from Bagرامي have 14 samples. The collected data of Section B are as follow:

Table 3: PCI values of Section B

N.º	Sample no	Sample unite area m <sup>2</sup>	Correct deduct value	PCI
1	2	420 m <sup>2</sup>	42	58
2	10	420 m <sup>2</sup>	43	57
3	18	420 m <sup>2</sup>	40	60
4	26	420 m <sup>2</sup>	37	63
5	34	420 m <sup>2</sup>	45	55
6	42	420 m <sup>2</sup>	39	61
7	50	420 m <sup>2</sup>	37	63
8	58	420 m <sup>2</sup>	38	62
9	66	420 m <sup>2</sup>	45	55
10	74	420 m <sup>2</sup>	51	49
11	82	420 m <sup>2</sup>	50	50
12	90	420 m <sup>2</sup>	40	60
13	98	420 m <sup>2</sup>	32	68
14	106	420 m <sup>2</sup>	35	65

Average PCI= 59 being good Condition

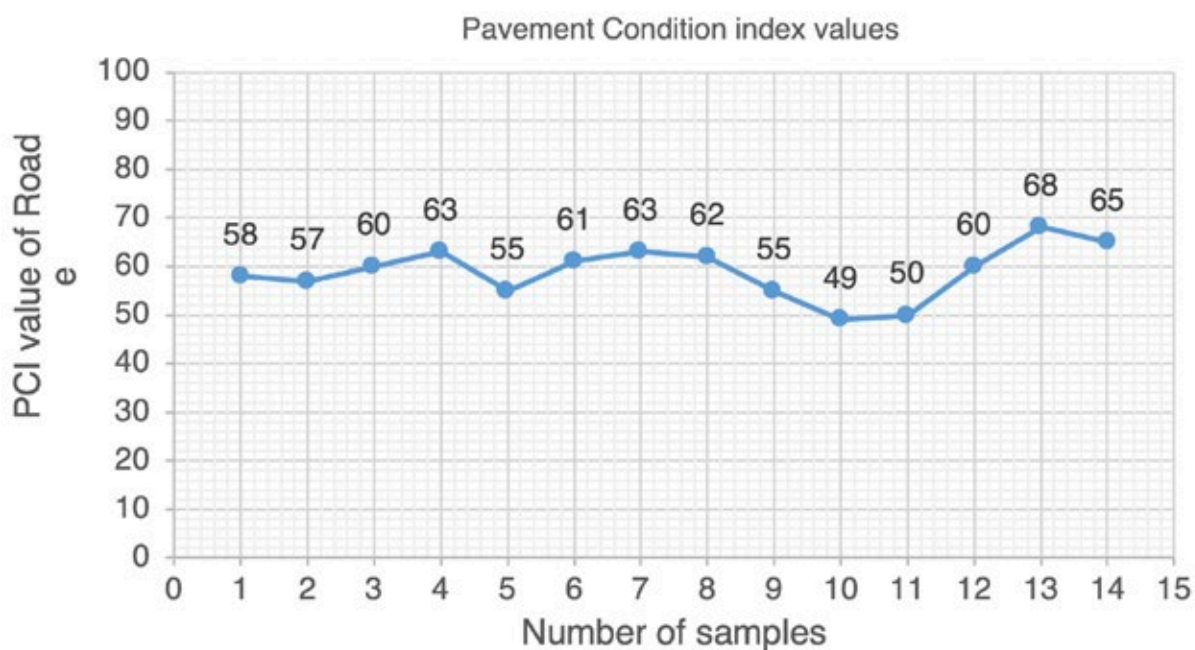


Figure 5: PCI values of Section B

## 6. RESULTS AND DISCUSSIONS

Both A and B sections of Jalalabad Road surveyed and PCI values were calculated. There was Alligator cracking at the beginning of Section A. Besides, potholes also recorded in Section A. The PCI values of first three samples of Section A were lower than other samples. The average PCI value of Section A is 70 being in good condi-

tion. Section B is starting from Bagرامي with 3,500 m length. The volume of traffic is high in this section which is one of the big reason of distresses in this section. The main distresses in these sections are longitudinal cracks, potholes, alligator cracks and patching. The average PCI of this section was 59 being in good condition.

Following graph shows the comparison of both A and B Sections.

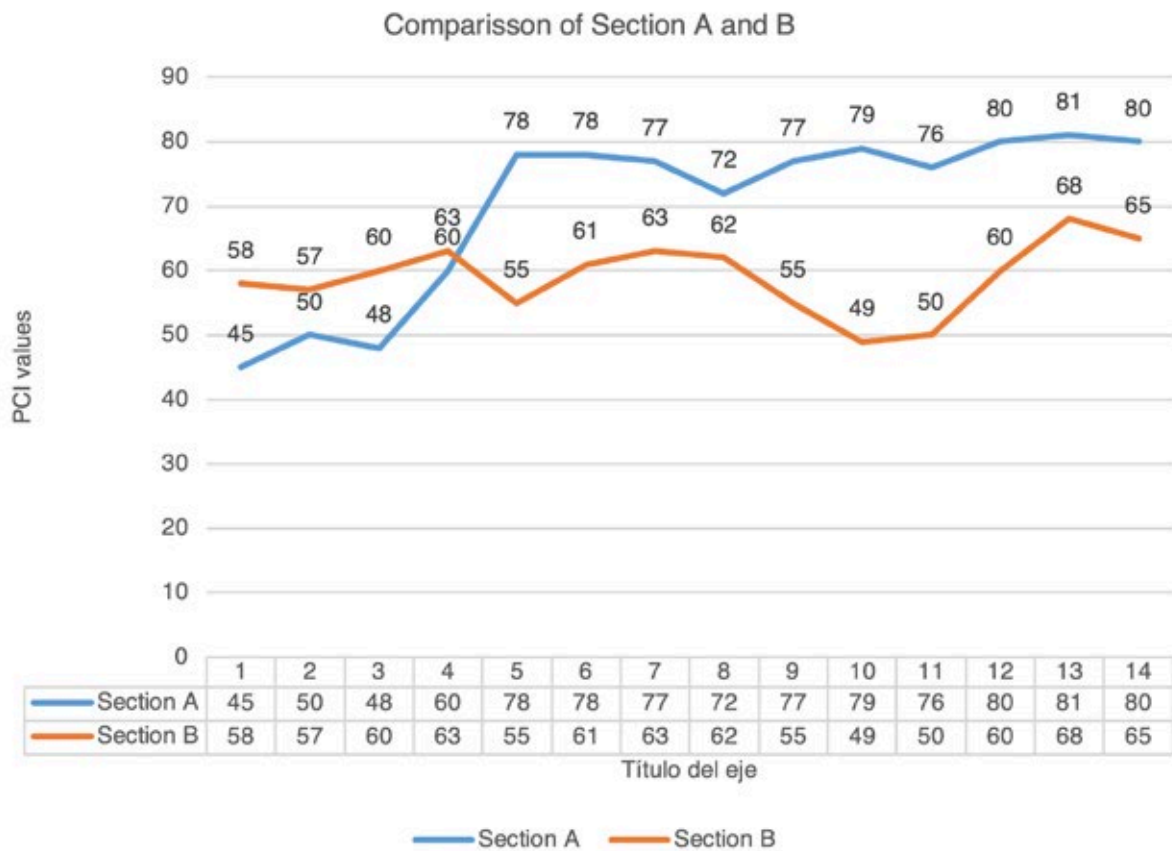


Figure 6: Comparison of PCI values of Section A and B

Table 4: Summary of PCI of two Sections of Jalalabad Road

N.º	Section	Section Length	Branch Name	PCI	Rating
1	A	3,500 m	Jalalabad	70	Being Good Condition
2	B	3,500 m	Jalalabad	59	Being good Condition
Average PCI= 64 being in good condition					

The result shows that the overall condition of Jalalabad highway is better than Hamid Karzai airport road with (45-67) PCI value (Hafizyar & Mosaberpanah, 2018).

Pavement researchers believe that if pavement condition is poor, the cost of maintenance is 4 to 5 times higher. Pavement cost for maintenance is minimized when it is in good condition (Haas, Hudso, & Zaniewski, 1994).

The first three sample units of Section A (2, 10, 18) have low PCI values (45, 50, 48). The survey results show that there are potholes and alligator cracks in these sample units with moderate and high density. Based on the types of distress the HMA overlays and chip seal repairing are suggested as treatment alternatives based on (GTC, 1998).

Overlay doesn't include wide redesign of structure; it can just contribute little. Overlay can remove pavement surface such as surface course and binder course. Generally, the thickness of non-structure overlay is between 12.5mm to 37.5mm (Hoffman, 2009). The utilization of HMA overlay on an existent road surface; usually determining the preventive maintenance repair (National Academies of Sciences, 2011).

For cracks in both A and B Sections the crack filling is suggested as treatment alternative.

Crack filling is the most popular treatment of cracks and is used widely in maintenance. Crack sealing is an inexpensive procedure in the maintenance mechanism. Today every country use crack filling and sealing (Lavin, 2003).

## 7. CONCLUSION

The pavement condition index of Jalalabad highway has evaluated pursuing ASTM D6433-09. It has been found that the average PCI value of Jalalabad highway is 64 be-

ing in good condition with some samples rated as fair condition. Most of the pavement deterioration in Jalalabad highway are alligator, block, edge, longitudinal, and transverse cracks as well as pothole and patch deterioration. The main causes of pavement deterioration in Jalalabad highway are environmental factors (poor drainage system), lack of maintenance, traffic loads (no vehicle load controlling system at the entrance of the road), poor materials and age of pavement. Based on the PCI value, the treatment options are HMA overlay crack filling and sealing treatment since PCI value of samples are in good and fair condition.

## 8. RECOMMENDATION

Based on the research findings, the following recommendations are suggested for developing the current condition of road maintenance and rehabilitation workout to Jalalabad highway in Afghanistan.

1. During this research some problems of drainage has seen. It is recommended that the maintenance agency must be careful about drainage system to lead the water on drainage way away from surface of pavement.
2. It is recommended to provide important equipment for maintenance activities in order to improve the stage of maintenance performance.
3. It is recommended to study the current traffic volume that is so important for future pavement conditions.
4. The total quality management must be performed in whole stages of pavement condition surveying to raise awareness of pavement management system.
5. Controlling and supervising each section of pavement before distress happens must be implemented to find out the defect causes of pavement.

6. Maintenance workers must be trained by special teams to have experience about pavement maintenance.
7. Periodic evaluation is important to collect data and help decision makers to suggest alternative maintenance option and it is also recommended that the data should be updated yearly.

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