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Development of Pavement Management Model for Ranya Urban Street Network

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ABSTRACT

The Paved roads are one of the most important and basic infrastructure, and there management is a significant issue for pavement organizations and engineers. Pavement Maintenance Management System (PMMS), which is a part of the Pavement Management System (PMS), consists of scheduled activity to obtain powerful management and cost-effective maintenance based on the Pavement Condition Index (PCI). The purpose of this research is to evaluate the pavement condition and provide a systematic plan for preventive maintenance, rehabilitation, and reconstruction of pavement roads to preserve it at an allowable level of serviceability. In this study, PAVER 7.1.3 and ArcGIS 10.8 were used to develop pavement management models for the Ranya urban network. A total of 17 roads with a combined length of 27.84 km and an area 478,750 m² were selected. The road network includes three arterial roads two collector roads and twelve local roads that compose 33% and 25% and 42% of the total roads respectively. To assess the type, severity, and quantity of distresses, visual inspection is carried out. Moreover, by using PAVER 7.1.3, the collected data are inventoried and assessed for calculation of PCI, prediction deterioration model, and PCI prediction. PAVER 7.1.3 is integrated with ArcMap to develop (PMMS) for the Ranya urban street network and layout the outputs like PCI, rehabilitation, and maintenance priority. The outcomes shows that the PCI of the total study area, have Fair condition 67.16, including 24.5% have Good, 20% have Satisfactory, 31.5% have Fair, 20% have Poor, and 4% have Very Poor condition. This indicates that roads in Poor and Very Poor condition require immediate maintenance. Maintaining Fair-condition roads can slow deterioration, while priority repairs should address poor areas to prevent costly reconstruction. Roads in Good to Satisfactory condition can be preserved through preventive maintenance.

1.Introduction

Road networks are one of the most vital components for the development of countries; therefore they need continuous rehabilitation and maintenance structurally and functionally. The condition of roads should be evaluated to execute the most suitable and economic maintenance and rehabilitations (Abdulmajeed & Alaswadko, 2023). Keeping roads in good condition will facilitate connection between regional and rural communities, contribute in reducing poverty and, ultimately, boost the socio-economic growth and development of any country (Ali & Sadeq, 2022; Khahro et al., 2021). Because after opening the road to traffic, the pavement deterioration will begin due to many reasons, such as traffic-related, environmental causes, quality of materials, design, construction shortages, and lack of maintenance. The deterioration starts very slowly, so may not be detectable, and it accelerates at faster rates over time. It is necessary to use the best practice method of planning, design, construction, and maintenance of the roads to minimize the risk of premature deterioration (Zumrawi, 2013). The pavement distresses can be classified into two main types of failure: Functional and Structural; the first one occurs when the road does not have enough quality of ride and safety, which is mainly measured by level of roughness. The second one occurs when one or more of the components of pavement structure collapse, like surface, base course, sub-base, and subgrade; therefore, they are no longer able to support loads that are applied to the surface (Subramanyam, 2017). Furthermore, the roads require the best techniques to keep safe and comfortable riding for a long time (Hall et al., 2003; Mouratidis et al., 2019). The U.S. Army Corps of Engineers created a rating system to evaluate the condition of pavements. This guided to the development the PAVER system, a (PMMS) that is a part of PMS, see (Fig.1). Also, the (PMMS) usually contain modules for network recognition, evaluation, distress forecasting models, maintenance tasks, and economic evaluation. Purposes of (PMMS): Carry out the most suitable Maintenance and Rehabilitation (M&R) by the most suitable treatment at the exact time to

increase pavement service life economically (Issa Sarsam, 2016).

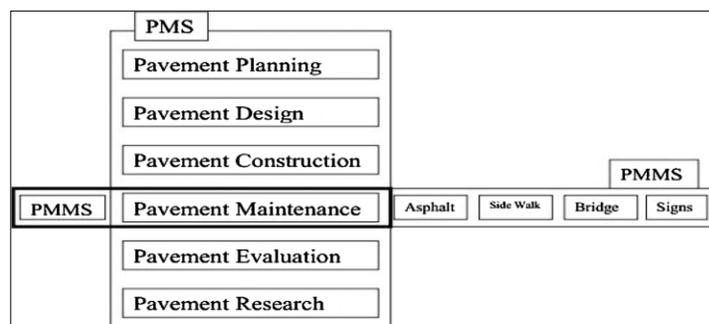


Figure 1: PMS and PMMS. (Almuhanna et al., 2018).

Moreover, integrating the PAVER and Geographic Information System (GIS) is more powerful for enhancing pavement maintenance management systems. This combining system has many benefits, which may include ease in collecting and analyzing data, planning and managing the activities, renovating and archiving, and identifying zones that require maintenance (Taleb Obaidat et al., 2018). Pavement evaluation is one of the most critical processes that rates the structure and functional condition of roads to ensure performance and safety. This process can be carried out by many methods, like: Field and laboratory testing: by taking and analyzing core samples for tensile strength and moisture sensitivity (Rajkumar et al., 2023). Connected vehicles: conducted by installing sensors on the vehicle to gather data on pavement conditions (Samie et al., 2024). Image processing and AI: using drones for taking pictures, then processing those pictures by deep learning models improves the precision of evaluations (Ramachandraiah et al., 2023). The evaluation process can be determined by lots of indicators like Pavement Condition Index (PCI), Present Serviceability Rating (PSR), Ride Number (RN), International Roughness Index (IRI), Present Serviceability Index (PSI), Mean Panel Rating (MPR), Pavement Condition Rating (PCR) and Profile Index (PI) (Wang et al., 2020). But PCI is the most commonly used indicator in Iraq; it is also utilized in this study. It is a suitable, basic, easy, and low-cost method that can be utilized to assess pavement condition and create a strong management strategy. The (PCI) is a

quantitative measure displaying the overall circumstance of pavement surfaces by assessing various types of distresses, their density, and severity that varies from 0 to 100, where 0 is the latest desirable circumstance named "Failed" and 100 is the best condition named "Good." To assist with maintenance planning, various models predict the Pavement Condition Index (PCI) for future years. These include AI-based techniques (machine learning, neural networks), probabilistic models (Markov chains), and deterministic models (regression analysis). The selection of a model depends on data availability, pavement properties, and accuracy requirements (Ali & Milad, 2023; Lin et al., 2024; Shtayat et al., 2022; Sidess et al., 2021). Soft computing techniques, for instance, neuro-fuzzy approaches using subtractive clustering and grid partitioning, have shown better performance compared to traditional models like the Markov chain model (Kaur & Datta, 2007). For short- and long-term prediction, Artificial Neural Networks (ANNs) models are very accurate in forecasting pavement condition; meanwhile, Group Method of Data Handling (GMDH) models show limited success (Ziari et al., 2016). One of the common methods is PAVER software for forecasting pavement condition and how the quality of pavement declines over time, based on several factors, including age of construction and last maintenance of pavement, distress types and severities, traffic volume, environmental factors, and pavement layer condition (Sidess et al., 2021). And the input data in PAVER include age, distress type, distress severity, road type, and road rank. Because the prediction modeling process identifies and groups pavements of similar construction, that are subjected to similar traffic patterns, weather, and other factors that affect pavement life. (Shahin et al., 2021). This study was conducted in the Ranya urban street network to help the Municipality of Ranya establish a regular program of road maintenance. First collecting data manually, then determining PCI by Paver and creating a model of deterioration in the next few years, after that, by integrating GIS with Paver software and providing a plan for maintenance, somehow which branch road needs to be fixed immediately.

2. Methodology

2.1. Study Area

The study area of this research is the Ranya urban street network, which is a densely populated district in the Sulaymaniyah Governorate, with a population of (201,795) people, according to the last census in 2024, situated in the Kurdistan Region, Iraq, with latitude and longitude of $36^{\circ}15'14''$ N and $44^{\circ}52'59''$ E, respectively, see (Fig. 2). It lies in the northwest of Sulaymaniyah, with a driving distance of about 145 km. The current situation of roads is different due to their age, function, and location, but there are common challenges that require a solution as soon as possible: lack of budget since the last 13 years, the relevant agency, which is the presidency of Ranya municipality, has a limited budget for roads; they have not done any repairs to the roads, only built new roads because the city continued to expand during that time. But now many roads need to be maintained; some of them require reconstruction, some of them require maintenance, and some of them are narrow, which led to traffic congestion, specifically in old areas of the city, also inadequate drainage, which led to flooding, specifically during heavy rain, and this water remains on the surface of the roads for several days, which affects the quality of the roads and causes damage to the road.

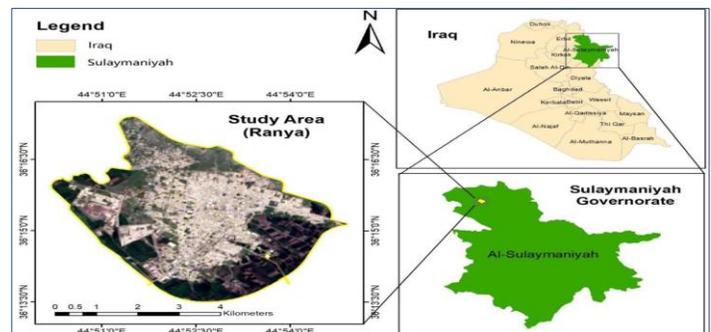


Figure 2: Study area - Ranya city (Chomani & Manguri, 2024)

2.2. Inventory Definition

The network contains different types of road: Arterial roads provide high mobility, connecting major trip generators with long trips and heavy traffic. Collector roads link local roads to arterials and manage intermediate traffic flow. Local roads

focus on land access, featuring low traffic volumes, low speeds, and short distances(Chakraborty & Gates, 2023). Arterial roads make up %33, collector roads %25, and local roads %42, see (Fig.3). In this study, the distress data are collected manually from selected roads, and the condition of the pavement has been evaluated using Paver. The total length of selected roads to be investigated is 27.84 km for data collection. The selected roads were divided into manageable smaller sections for a total of 61 sections; each section was subdivided into sample units to assess the pavement condition, with a total of 623 samples see (Fig.4), and an area of 478,750 m² in both directions (forwards and backwards) because the two-way roads have different characteristics in some places.



Figure 3: Selected roads of the study area.

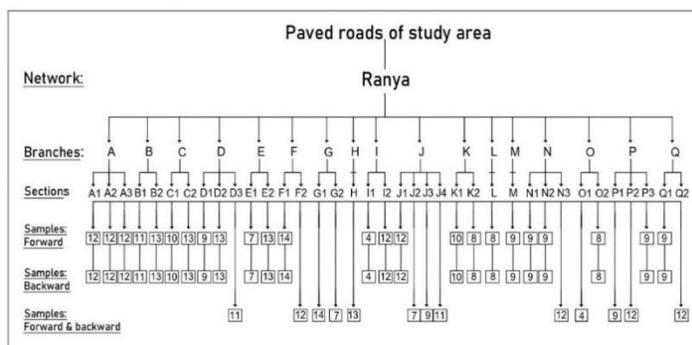


Figure 4: Divided network of study area.

2.3. Calculating Number of Unit Samples

Sample unit area is (225± 90 m²) for asphalt surface roadways due to the American Society for Testing and Materials (ASTM) standard. Those factors that were obeyed during determining section boundaries include: (a) an unexpected variation in traffic movements or

density; (b) any variation in the number of traffic lanes; and (c) natural or artificial boundaries, such as bridges, road intersections, and previously completed construction projects (ages, designs, different projects display variety materials, and other properties (Shahin M.Y, 2005). The most important factors relevant to this study have been considered, particularly the history of maintenance and road construction, the number of traffic lanes, and natural or artificial boundaries such as bridges, road intersections, and previously completed construction projects. These factors are sufficient to classify the roads.

The data collection details include:

1. Information about the section, including its name, width, length, and type of road (one-way or two-way), if it is arterial, collector, or local.
2. Pavement data for each segment, including type of surface, detail of distresses (type, density, and severity). Due to financial and lack of resources, the sampling strategy was carried out to determine the PCI for pavement evaluation condition (Shahin M.Y, 2005a).

According to ASTM standards for the highways and airfields D6433-09 (ASTM, 2009). The first step is to figure out how many sample units (n) must be surveyed in order to obtain a 95% confidence level estimate of the PCI of the section that is statistically accurate, use

$$\text{equation(1)} \quad n = \frac{Ns^2}{\left(\frac{e^2}{4}\right)N-1+s^2} \dots\dots\dots(1)$$

Where: N: exact number of units; where: N = area of section/sample unit area n: indicate the minimum number of sample units for the selected pavement section s: PCI value where N is the total number of units and N is the section's or sample unit's area. For the chosen pavement section s: PCI value standard deviation (often s = 10), provide the minimum number of sample units. e: a satisfactory inaccuracy in the PCI's estimated value, which is typically equal to 5. In accordance with ASTM D6433-09 (ASTM, 2009) interval (i) sampling for the units to be chosen was established; **equation (2)** was applied and rounded to the closest whole integer

$$i = \frac{N}{n} \dots\dots\dots(2)$$

For more clear if , $i = \frac{N}{n} = \frac{18.18}{9} = 2.02 \sim 2$

The selected sample units to be inspected were 2, 4, 6, and so on. $i=2$, see (Fig. 5) explain the sampling process.

22 units at 22 m									
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22								

Figure 5. The systematic sampling process.

2.4 Data Collection

Pavement management systems strongly depend on the precision of collecting data for successful decision-making. The quicker and more efficient method for collecting data is automated data collection technologies (Alyami et al., 2012). But in the Kurdistan region, the least attention has been given to pavement management systems, and these technologies have not been available yet. So the data was manually collected. The data collection was conducted according to the following procedures and using tools:

Step1: The history of construction, maintenance, road types, and road structure, provided by the Presidency Municipality of Ranya.

Step2: The length and width of roads were measured using a measuring wheel and laser tape measure.

Step3: Using GIS Arc Map and Google Earth Pro for diving the network into branches and sections.

Step4: All observed types of distresses within the sample units were measured and recorded on a pre-designed datasheet and recorded in audio; they have also been photographed using a smartphone, tape measure, wheel measure, and ruler. The inspection was carried out through a visual survey by walking through all roads; subsequently, the distress type, severity level, and quantity were identified in (number, m, m²).

Step5: According to the Pavement Identification Distress Manual (PIDM) issued by the US Army Corps of Engineers and ASTM D6433-07, the distresses were identified and classified, and the type and severity of each distress were determined during field inspection see (Fig.6). These manual contain details about asphalt-

surfaced distresses, photos, how to measure pavement distresses standardly, and the severity level of distresses.

Step6: The pavement distresses were identified and measured for their various severity levels (low, medium, and high) along the selected roads, and then the quantity and severity level of distresses were recorded in audio and a designed datasheet.



Figure 6: Distress type of study area.

2.5 Using Micro Paver and ArcGIS

Moreover, In this research, Micro PAVER and ArcGIS applications software were employed to develop a model for managing pavement issues in the urban network of Ranya. The Paver has the capability of calculating PCI, developing prediction models for the next years, family modeling, which is grouping the sections that have similar specifics, and the (M&R) model, which is useful in predicting of (M&R) for each section of roads and (M&R) work planning, which helps pavement managers in scheduling, and prioritizing of maintenance and rehabilitation.

3. RESULTS and Discussion

3.1 Pavement Condition Evaluation

This procedure is executed to calculate the current situation of paved areas. The PCI is a numerical unit of measure from 0 to 100, which is developed by the U.S. Army Corps of Engineers.

This rating process relies on pavement surface characteristics, type, quantity, and severity of the distresses to evaluate the pavement in the sections of selected roads, see (Fig.7).

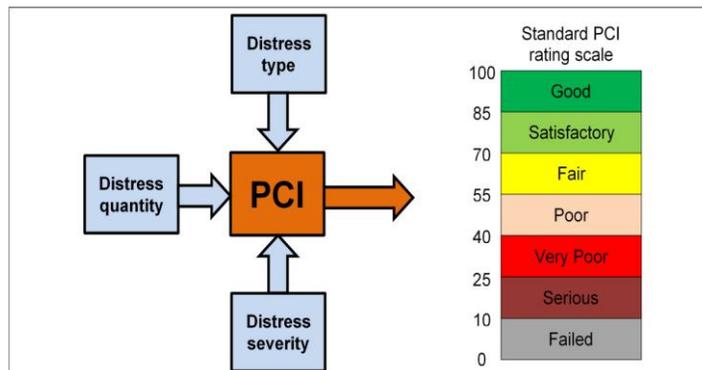


Figure. 7 Standard pavement condition index rating scale

3.2 PCI Calculation Using Paver and Hand Method

3.2.1 PCI Calculation Using Paver Method

After inputting the collected data, the length, width, and last maintenance or construction date of the roads, and the type, quantity, and severity of distresses into PAVER 7.1.3, the PAVER automatically calculates the (PCI) for each sample unit and section through scanning PCI of each sample, because the PCI of each section is equal to the total PCI of each sample unit. Twenty distresses types for paved-surface roads are known by code and categorized by it is unit measure, defined severity level, and main cause, see (Table 1), (Shahin M.Y, 2005a).

Table 1: Distress types

Code	Distress	Severity Levels	Cause
1	Alligator Cracking	Yes	Load
2	Bleeding	Yes	Other
3	Block Cracking	Yes	Climate
4	Bumps And Sags	Yes	Other
5	Corrugation	Yes	Other
6	Depression	Yes	Other
7	Edge Cracking	Yes	Load
8	Joint Reflection	Yes	Climate
9	Lane/Shoulder Drop-Off	Yes	Other
10	Longitudinal And Transverse Crack	Yes	Climate
11	Patching And Utility Cut Patching	Yes	Other
12	Polished Aggregate	No	Other
13	Potholes	Yes	Load
14	Railroad Crossings	Yes	Other
15	Rutting	Yes	Load
16	Shoving	Yes	Load
17	Slippage Crack	Yes	Other
18	Swell	Yes	Other
19	Raveling	Yes	Climate
20	Weathering	Yes	Climate

3.2.2 PCI Calculation Using Manual Method

Calculation of PCI by manual method was explained as below:

1. Calculate Deduct value (DV)

$$\text{Distress density} = \frac{\text{Total quantity of distress}}{\text{Area of sample}} * 100 \dots (3)$$

Unit Sample 1 at (L-N) section Alligator crack= 5 m2

$$\text{Distress density} = \frac{5}{250} * 100 = 2\%$$

By inserting this density value into the distress deduct value curves, see (Fig.8) to determine the deduct value for each distress.

2. Calculate corrected deduct value (CDV)

The Total Deduct Value (TDV) can be calculate by summing the deduct values of all individual distresses. Then, determine the Corrected Deduct Value (CDV) using the correction curve

based on q and TDV, see (Fig.9). Reducing the smaller individual deduct value that is >2 to 2, (for paved roads). Repeat these steps until q is equivalent to 1, see Table 2.

3. Calculate PCI

$$PCI = 100 - CDV \dots\dots\dots(4)$$

$$PCI \text{ (for unit 1)} = 100 - \text{The maximum CDV} = 100 - 52 = 48$$

Average PCI

$$= \frac{48 + 56.2 + 59 + 60.5 + 40.2 + 43 + 61 + 45}{8} = 51.6$$

The PCI scores obtained by PAVER software (51.7), see (Fig.10), and manual calculations (51.6) are practically identical, differing by a minuscule amount of 0.1, which is likely a result of rounding or differences in measuring distress. This close similarity is testimony to the reliability and validity of both the software and manual testing tools.

The values of PCI for various branches in the selected roads of the study area, and the PCI is affected by various causes involving PCI Climate, PCI load, and PCI Others. These factors collectively calculate the whole pavement condition, see (Table 3).

PCI Climate relates to environmental factors like moisture and temperature, which substantially affect the pavement durability. PCI Load characterizes the rate of loads that affect the damage to the pavement; higher PCI load values increase the rate of stress and possible fatigue damage (Park et al., 2023). PCI Others represents any factors not correlated to climate and load, such as construction shortcomings, lack or wrong maintenance, and drainage issues (Pérez et al., 2024).

Arterial and Collector branches have PCI values of 63.74 and 66.56, respectively; these values fall into the “Fair” category, and this shows that the pavement is in moderate condition, which indicates that the pavement needs rehabilitation activities, such as surface seal or surface treatment to stop further deterioration. The local branch has a higher PCI value of 71.18 and is in a better situation; that is, it falls into the “Satisfactory” category, and the local roads require preventative maintenance such as crack sealing and patching to preserve roads.

The factors of climate, load, and others participating in pavement condition deterioration are highlighted, but load and climate are more effective than others across the branches. Specifically, arterial roads are affected by load, while local roads are more affected by climate.

Moreover, the study area contains 61 sections, of which 2 sections are in “Very poor” condition and constitute 4%; 14 sections are in “Poor” condition and constitute 20%; 20 sections are in “Fair” condition and constitute 31.5%; 11 sections are in “Satisfactory” condition and constitute 20%; 14 sections are in “Good” condition and constitute 24.5% of the entire selected roads, see (Fig. 11).

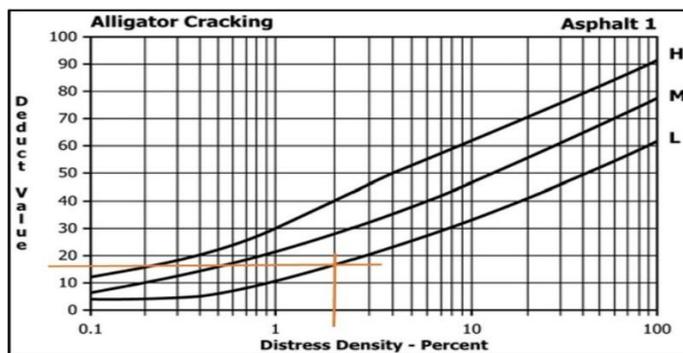


Figure 8: Alligator crack deduct value curve

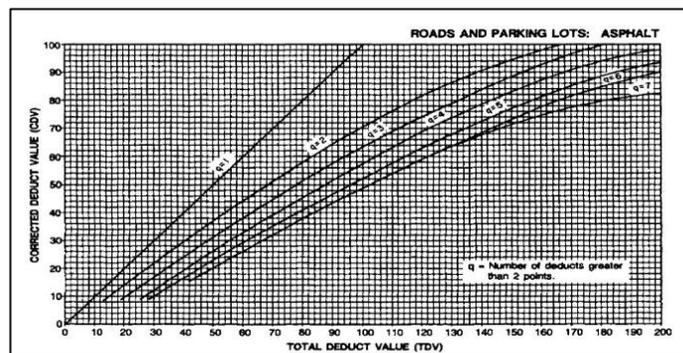


Figure 9: The correction curve for asphalt surface road pavements

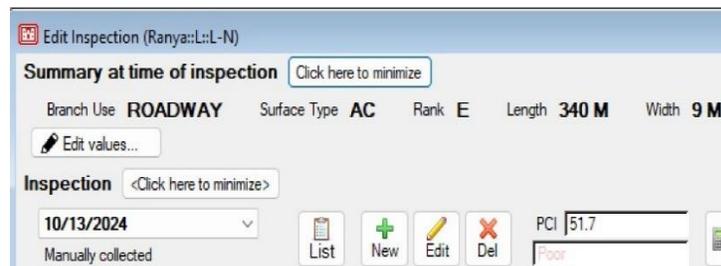


Figure 10: PCI value result using Paver

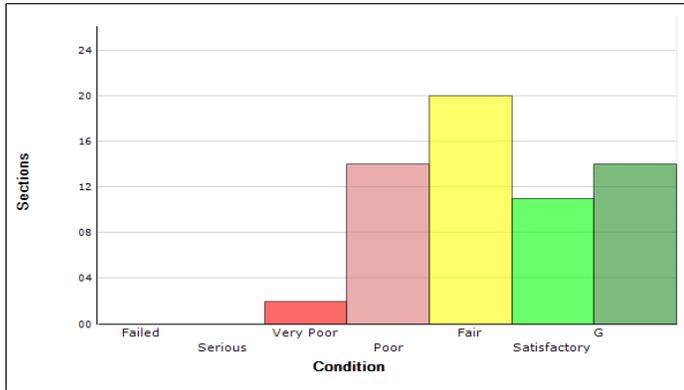


Fig 11. Number of sections with pavement condition

Table 2: The hand-calculated PCI results for the L-N section

Unit	Deduct value				TDV	q	CDV	Max CDV	PCI
1	37	25	16	13	91	4	52	52	48
	37	25	16	2	80	3	51		
	37	25	2	2	66	2	48		
2	37	2	2	2	43	1	43	44	56
	37	7	5	1	50	3	31		
	37	7	2		46	2	33		
3	37	7			44	1	44	41	59
	37	13	3		53	3	35		
	37	13	2		52	2	38		
4	37	2	2		41	1	41	40	61
	37	15	1		53	2	39		
	37	2			39	1	40		
5	46	37			83	2	60	60	40
	46	2			48	1	58		
6	37	33	21		91	3	57	57	43
	37	33	2		72	2	52		
	37	2	2		41	1	41		
7	37	12			49	2	36	39	61
	37	2			39	1	39		
8	37	37	9		83	3	54	55	45
	37	37	2		76	2	55		
	37	2	2		41	1	41		

Table 3: PCI results for all branches in current condition

Network ID	Branch Category	PCI	PCI Category	PCI% Climate	PCI% Load	PCI% Other
Ranya	Arterial	63.74	Fair	32	41	27
	Collector	66.56	Fair	37	32	31
	Local	71.18	Satisfactory	41.5	26.4	32.1

3.3 Using Paver Software for Developing Pavement Deterioration Model

A set of pavement sections subjected to similar weather conditions, traffic patterns, and other factors affecting pavement life is known as a 'deterioration family.' And pavement condition deterioration over time is influenced by various factors, including traffic volume, environmental conditions, structural design, and material properties. (Shahin et al., 2021; Llopis-Castelló et al., 2020).

Comprehension of these factors is significant for the success of pavement management and maintenance policy. After calculating the PCI, the future pavement condition deterioration has been predicted based on the data's of distress that was gathered for the study area.

The equation of this model is a nonlinear polynomial that is created by PAVER software based on the independent variable (Age). The coefficient of correlation of the model is 0.957, which means a strong positive correlation between the true data points and predicted PCI value, and 91.6% of the variability of PCI value can be explained by the model because R² is 0.916, which means high accuracy of the model for predicting the pavement condition in the future. The total data points of the model are 61

of which 8 data points were outliers and 53 were valid. The slope line of the model is the decline of the PCI value annually, which is equal to -1.3, which means the PCI value decreases by 1.3 every year. The prediction green curve shows that the PCI value reaches the critical value (PCI=55) after 17 years (Fig. 12).

The critical PCI is the PCI value at which the cost of performing localized preventive maintenance rises significantly, or the rate of PCI deterioration accelerates over time. The critical PCI typically ranges between 70 and 55, with 55 being the threshold between 'Fair' and 'Poor' pavement conditions. Below this critical value, pavement deterioration speeds up, leading to increased repair costs (Shahin M.Y, 2005b).

$$PCI = 100 - 11.5479 X^1 + 4.7464 X^2 - 0.8810 X^3 + 0.07361 X^4 - 0.0029 X^5 + 4.2050 X^6 * 10^{-5} \dots (5)$$

were x: is age of pavement.

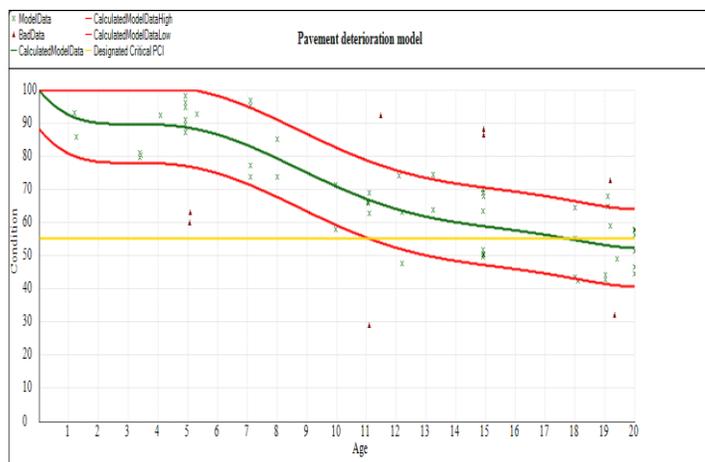


Figure 12: Pavement deterioration model for study area

3.4 PCI Forecasting for The Next Decade

The predicted PCI for the next ten years for all branches in the study area was created by the PAVER program (Fig. 13).

This bar chart prediction model gives an expensive forecast of pavement condition for the next ten years. The current average PCI value in 2024 is close to 67, demonstrating that the pavement of the study area is in sufficient condition relatively. In 2033 the average PCI value will reach approximately 44, showing a significant decrease in pavement condition; this demonstrates that without any rehabilitation and

maintenance, the quality and life of the roads will not extend and will not be in acceptable life service. (Fig. 14) shows the expected annual rate of decrease in pavement condition over time.

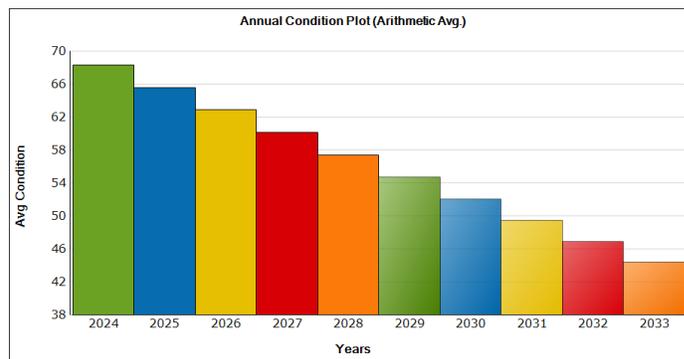


Figure 13: Prediction of Pavement condition for next ten years

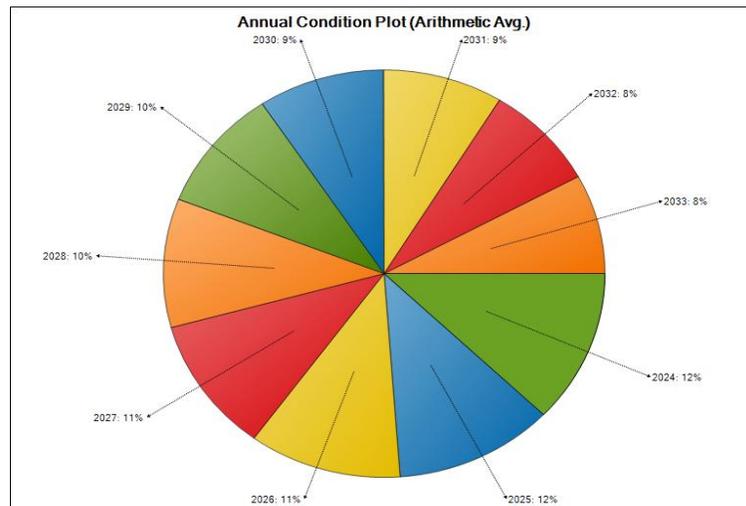


Figure 14: Decline the rate of PCI value for each year

3.5 Linking Paver with ArcGIS

For effective PMMS, the integration of PAVER with Geographic Information System (GIS) has been examined in several studies. Numerous universities execute research on small roads, or university campuses, using these techniques. To develop a pavement maintenance system, these universities are in collaboration with the local administration roads, such as in Arizona and North Carolina; these systems have been created and applied in several districts by the universities and federal government (Zagvozda et al., 2019). This technique joins GIS software like ArcGIS with PAVER. These led to enhanced display data, analyses, and decision-making

(Taleb Obaidat et al., 2018). Also, the integration allows the display of a color-coded map of pavement condition networks(Khidr & Khalil, 2025) (Fig. 15).

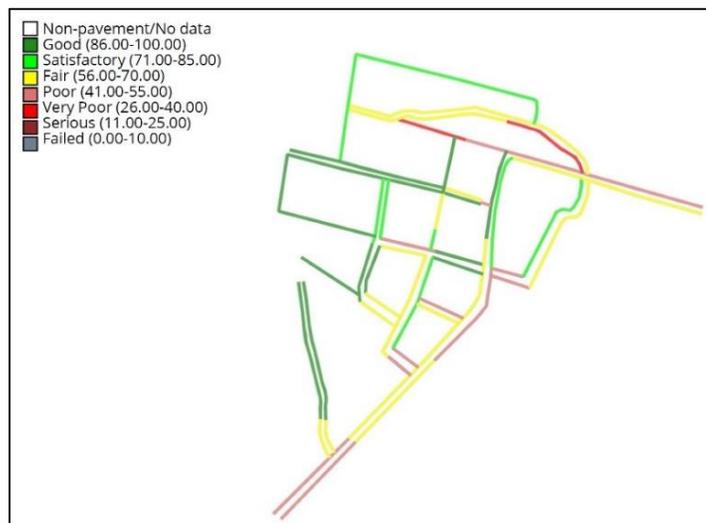


Figure 15: PCI layout of study area using ArcGIS and PAVER 7.1.3

3.6 Maintenance Priority

Generally, it is not possible to carry out maintenance for all sections of low PCI because of restricted financial resources. Available budget less than required budget. In this case, to prepare a maintenance and rehabilitation (M&R) program, one of the methods of prioritization will be needed.

There are a large number of methods that can be used to conduct (M&R), but the proposed method in this study is **Simple Ranking by PCI measure**, which depending on pavement condition rules, provides a prioritized list of projects (Ewadh et al., 2018). First, the PCI is calculated for all sections based on distress types numerically scored from 0 to 100. Then, based on PCI value, the pavement sections are then ranked, from lower value 0 indicating a poorer situation to higher value 100 indicating the best situation.

Finally, maintenance was conducted from the lowest PCI value to the highest. In the urban Ranya street network, **48.8%** of branches require preventive maintenance (e.g., crack sealing and patching), while **50.2%** require rehabilitation (e.g., overlay). These are illustrated

in (Table 4) and (Fig.16), with respect to the PCI level vs. M&R type (Service, 2011), see (Fig.17).

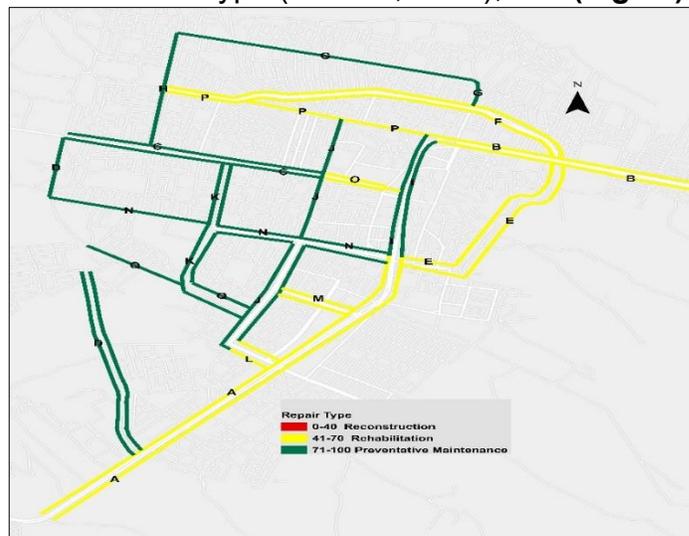


Figure 16: Priority of M&R for sections in study area

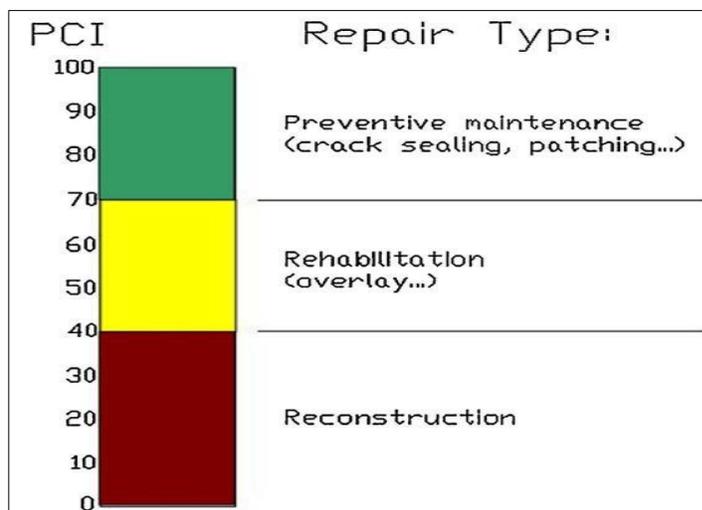


Figure 17: PCI level vs. M&R type (Service, 2011)

Table 4: Illustrate the maintenance type and activity.

Branch ID	PCI	PCI Standard	Types of Repair	Rank	Type of treatment
L	51	40-70	Rehabilitation	1	Overlay
B	51.2			2	
P	51.2			3	
A	52			4	
F	53.5			5	
E	54			6	
M	55.5			7	
O	67			8	

J	72.5		9
H	73		10
I	74		11
Q	74		12
N	77	70-100	13
G	79	Preventative maintenance	14
D	81		15
K	85.5		16
C	90.5		17

Crack sealing, Thin overlays, Patching, Milling

4. CONCLUSIONS

1. Overall, the PCI of the total study area has a Fair condition of 67.16; so 24.5% have Good, 20% have Satisfactory, 31.5% have Fair, 20% have Poor, and 4% have Very Poor condition.
2. PCI of the Arterial sections have a Fair condition of 63.74, the Collector sections have a Fair condition of 66.56, and the Local sections have a satisfactory condition of 71.18.
3. PCI prediction outcomes display that there is a decline in PCI value from 67.16 in 2024 to 44 in 2033.
4. Load and Climate are the most influential factors in pavement condition deterioration.
5. A pavement deterioration model was developed based on age and indicates that after 17 years, the overall condition of pavement will reach a critical (PCI=55).
6. The integration of PAVER with ArcGIS improves data display capacities as well as enhanced analysis tools that enhance the decision-making process.
7. A maintenance priority method based on PCI measure is proposed.
8. Repair types including: 48.8% of branches require preventive maintenance (e.g., crack sealing and patching), while 50.2% require rehabilitation (Overlay).

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