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IMPROVING PAVEMENT MAINTENANCE DECISION SELECTION FOR THE MINIA ROAD NETWORK IN EGYPT BY USING PAVER AND GIS PROGRAMS

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Abstract— A lot of efforts have focused on eliminating the annual cost lost in random maintenance decisions by applying the Pavement Maintenance Management System (PMMS). The PMMS is a systematic approach for achieving effective management of maintenance decision selection. This study aims to clarify the extent of the difference between PMMS and the traditional aspect of maintenance decision-making. Therefore, a visual inspection survey was conducted for a length of 8.25 km of the Cairo-Aswan Agriculture Highway, Minia City, Egypt. Data was collected from one branch that was divided into two sections, 1 and 2 in right and left directions respectively. A total of 41 samples were surveyed per section, which was stored in a database file using GIS software. The PCI was calculated to determine whether maintenance or rehabilitation (M & R) decisions should be applied in sections one and two. The appropriate M & R for section 1 was "Thin Overlay without Milling," and for section 2 was "Milling and Overlay." These results were different than the decision taken by the responsible authorities, as they decided to do Milling and Overlay for the two sections.

KEYWORDS*: Pavement Management System; Pavement Maintenance Management System; pavement condition index (PCI); PAVER5.2.3 system; GIS.*

I. INTRODUCTION

Transportation agencies' priorities have shifted from constructing additional networks to maintaining the existing ones that already exist [1]. As a result, transportation agencies recognized the value of implementing Pavement Management System (PMS) tools to assist decision-makers in determining the most cost-effective strategies for providing, evaluating, and maintaining pavement in serviceable conditions over a given period [2]. It develops a systematic method for collecting, managing, analyzing, and summarizing pavement data to aid in selecting and implementing cost-effective pavement construction, rehabilitation, and maintenance programs [2].

A. *Pavement Management System (PMS)*

A pavement management system (PMS) must be applied to keep the road at a high functional level. A PMS is a set of tools or methods that assist decision-makers in finding optimum strategies for providing and maintaining pavements in a serviceable condition over a given period. Pavement management, in its broadest sense, includes all the activities (Figure 1) involved in the planning and programming, design, construction, evaluation, maintenance, and rehabilitation of the pavement portion of a public works program. [3]. The PMS was designed to improve decision-making quality, provide feedback on the consequences of decisions, and facilitate activity coordination within the agency. Also, ensure the consistency of decisions made at different management levels within the same organization. Highways, airports, and other agencies can provide several benefits to pavement management systems at both the network and project levels.

At the network level, agency-wide programs of new construction, maintenance, or rehabilitation are developed which will have the least total cost, or greatest benefit, over the selected analysis period. At the project level, detailed construction is given to alternative design, construction, maintenance, or rehabilitation activities for a particular section or project within the overall program, as shown in Figure 1 [3].

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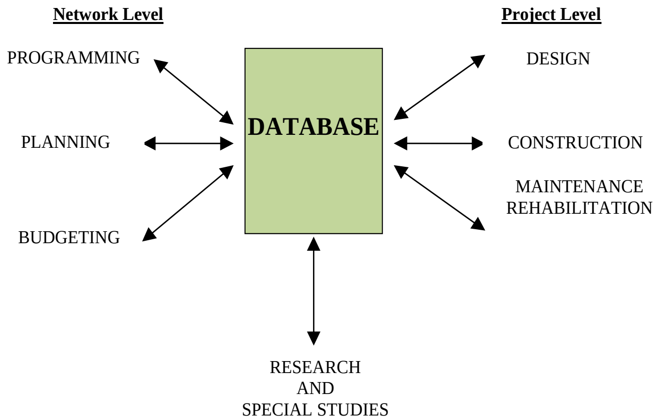


Fig. 1. The Main Components of a Pavement Management System [4].

This is a process for managing a roadway system efficiently and cost-effectively. It is built on a systematic, consistent approach to data collection and analysis, as well as providing recommendations and reports; so that those in control of road maintenance budgets can make informed investment decisions. This process depends first on collecting pavement network inventory for the database and then evaluating the pavement condition. PMS systems rely on computer software to store and analyze this data[5]. Maintenance is a part of the pavement management system called the Pavement Maintenance Management System (PMMS). A PMMS should not be confused with PMS, as shown in Figure 2. PMMS is a component of the PMS program, which means they overlap instead of replacing one another [6].

Pavement maintenance is the preservation and preservation of the pavement structure as close to its original condition as constructed or as subsequently improved, as well as any additional work required to keep traffic moving safely. This includes both periodic maintenance (patching, filling ruts, repairing surface corrugation, refilling cracks, and repairing the surface bleeding area) and corrective maintenance (reconstruction of asphalt layers, reconstruction up to subgrade, rehabilitation such as overlays)[7]. The goal of the PMMS system is to determine the required maintenance activities for the inspected roads through the available resources, information, and target evaluations to increase maintenance effectiveness. This system consists of some components, including recognizing the road sections and recording and collecting data about the pavement.

The PMMS system starts with network classification and moves through data collection, data analysis, and pavement condition evaluation. After evaluating the pavement condition, selecting the activities of the maintenance, identifying the priorities and future programs of the maintenance, and selecting final maintenance decisions. Finally, the maintenance department's staff manages and supervises the execution of those decisions [6].

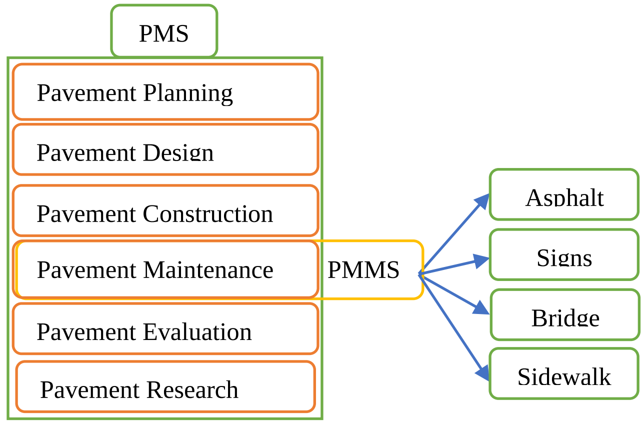


Fig. 2. Pavement Maintenance Management System Versus Pavement Management System [6, 8].

The PMMS is a valuable tool that can make the best possible use of the resources available. Hence, PMMS can direct and control maintenance resources for optimum benefits. By predicting future pavement conditions, PMMS provides a systematic method for selecting maintenance and rehabilitation needs and can be used to determine priorities and the optimal time of repair [9]. Figure 3 shows how early detection of pavement deterioration can result in significant savings in maintenance costs before the start of the sharp decline in pavement condition.

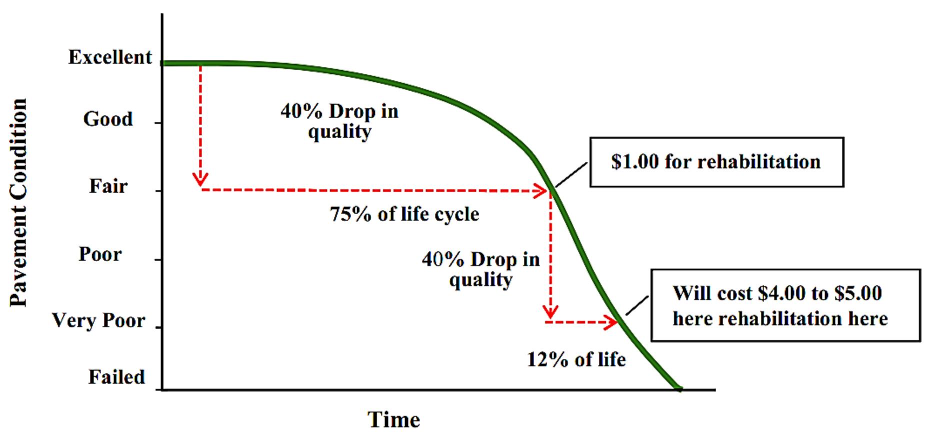


Fig. 3. Typical pavement life cycle [9].

B. Pavement Condition Assessment

Pavement Condition, both functional and structural evaluations are used to determine the pavement's current state or performance. The structural evaluation of pavement is based on its structural capability or adequacy[10-12]. There are four characteristics of the structural and functional assessment of the road [13]: pavement roughness, pavement distress, pavement deflection, and skid resistance. There are several indices used to evaluate pavement condition: for example, the Pavement Condition Index, and Pavement Condition Rating as shown in Table 1. All of this is depending on field measurements such as pavement distresses. There are many techniques used for collecting data depending on the available tools.

Many highway agencies rely on the Pavement Condition Index (PCI) to select the ideal pavement maintenance decisions to keep the roads in good condition. The traditional process for pavement management recommended that a road must be reconstructed if significant deterioration has occurred [14-16]. This process Certainly will lead to safe conditions but also will be more expensive than maintenance or rehabilitation decisions.

Table 1. Pavement Condition Indices Depend on Pavement Distresses [17].

CODE	***INDEX/DESCRIPTION***		***SURVEY METHOD***	***SCALE\SCALE DESCRIPTION***	
1	PCI	Pavement condition index	Visual inspection	0–100	Failed - Excellent
2	PCR	Pavement condition rating		0–100	Very Poor - Very Good
3	PDI	Pavement distress index		0–100	V. Poor – V. Good
4	RSI	Remaining service life index		0–100	Good–Fair–Poor
5	CCI	Critical condition index		0–100	V. Poor–Excellent
6	RI	Rutting index		0–5	Acceptable – Unacceptable
7	CI	Crack index		0.2-5.1	Uncracked, Slightly, And Moderately Cracked
8	PPI	Pavement performance index		0–5	V. Poor – V. Good
9	SDI	Surface distresses index		0–5	Poor - Good
10	DMI	Distresses manifestation index		0–10	Poor – Excellent
11	UDI	Urban distresses index		0–100	Poor – Excellent
12	PSC	Pavement structural condition		0–100	Poor – Excellent

C. Pavement Condition Index

The PCI rating represents the pavement condition on a scale that ranges from 0 to 100, as shown in Figure 4. A rating of zero indicates that the pavement has completely failed, while a rating of 100 indicates that the pavement is in outstanding condition. This rating does not directly indicate structural capacity or road roughness, but it has the capability of determining a roadway section's maintenance and rehabilitation needs[18].

PCI rating is used to evaluate a pavement condition by relying on the pavement surface distress survey by collecting the distress type, quantity, and severity. According to the PAVER system, this rating depends on nineteen distresses (Table 2). This number of distresses varies depending on the system and considerations followed in the PCI calculations. The evaluation process begins with a field survey for each sample of sections in the study area.

Pavement distress is an indicator of pavement surface condition and rides comfort. The ideal state for any pavement is a level surface that doesn't have any distress points. However, some of the pavement distress doesn't affect the pavement's structural efficiency if it is treated correctly within optimal time. There are some distresses with little effect on pavement condition at the time of their appearance, but over time, the effect increases, which may lead to function and structural failure, certainly this is depending on the type, severity, and quantity of the distresses.

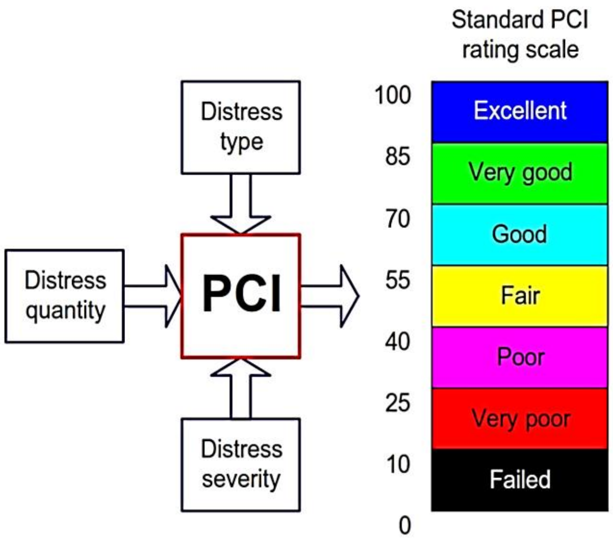


Fig. 4. Pavement Condition Index (PCI) Rating Scale [19-21].

Table 2. Asphalt road and parking lot distress classification using the PAVER system [19, 22].

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

The pavement condition index can be calculated by using a mathematical equation depending on some charts also it can be evaluated easily by Micro PAVER 5.2.3 software.

D. PAVER Software

PAVER 5.2.3 software was developed in the 1970s by the U.S. Army Corporation of engineers to help the Department of Defense manage the maintenance and repair of its vast inventory of pavements. This software uses inspection data and a pavement condition index (PCI) rating from zero (failed) to 100 (excellent) to consistently describe a pavement's condition, in addition, to predicting its maintenance and repair needs many years into the future.

It classifies pavement networks into branches and sections before performing condition analysis, as the inventory button provides tools to view, edit, and define pavement networks. It can also determine M & R needs, determine current and future pavement conditions, and analyze the effects of various budget scenarios [23]. The PCI can be calculated easily by PAVER 5.2.3 software using the data of a visual inspection such as the type, severity, and quantity of distress, as shown in Figure 4.

The advantages of new spatial technologies such as Geographic Information System- GIS have recently greatly enhanced PMS development and implementation efforts. GIS is used to create the PMS database, which stores, queries, retrieves, and reports on pavement management data. Furthermore, highway management agencies frequently use GIS to spatially display the network and display specific network characteristics. The visualization feature is typically used to assist decision-makers in determining what, where, and when any course of action should be taken with the system [2].

A. *Geographic Information System (GIS)*

A GIS is the most used software" ArcMap" in the PMMS system. It is a computerized database management system used to store, retrieve, analyze, and display spatial data. A GIS contains two types of data: geo-referenced spatial data and attribute data. Geo-referenced spatial data defines objects in two or three dimensions that have an orientation and relationship. A street segment's attributes may include its width, number of lanes, construction history, pavement condition, and traffic volume. A topological relationship should be maintained between spatially geo-referenced geometric entities (points, lines, or polygons) that have a position somewhere on the earth's surface.

The application of such sophisticated visualization and analysis techniques in PMS has been described in the literature by many researchers [24-28]. These studies' findings have proven useful in improving and supporting PMS.

The advantages and disadvantages of GIS and PMS integration were researched. The benefits of such integration include the simplicity of editing the roadway database, the capability to visualize results, the display of database queries and statistics on maps of the highway network, and the ability to view the network's condition by using highway sections' color coding for data access [29]. Also, among the most important GIS-PMS utilization advantages is the applicability of GIS to each component of pavement management. GIS can be used to display the results of the PCI for any roadway branches in different colors, which are calculated from PAVER software.

II. GENERAL AIM OF THE STUDY

Several studies, according to the review, have demonstrated the importance of PMMS implementation and its role in determining pavement maintenance decisions. Also, recent efforts have focused on keeping the existing road network at a high functional level by using PMMS. Despite this, some road institutions in Egypt and specifically, in Minia Governorate, depend on personal experiences in selecting the maintenance decisions and not on a management system such as PMMS. This study aims to clarify the extent of the difference between the traditional aspect of decision-making and the scientific aspect, which may reduce wasted budgets on random maintenance decisions. So, this study focused on applying the simplest concepts of the PMMS system using PAVER and GIS software to a Cairo-Aswan Agricultural Highway in Minia, Egypt, which is currently being maintained using the traditional concept of paving maintenance "personal decision." Before the current maintenance process, a section with a total length of 4125m in each direction was surveyed to evaluate the PCI to achieve the objective.

III. CASE STUDY

The study was conducted in the city of Minia, which road network consists of 3,675.945 km of paved roadways with the flexible pavement type. The determination of the network inventory data is considered one of the requirements for developing PMS. For this purpose, the city of Minia divided the road network into two categories: rural and urban. The first category belongs to the General Authority for Roads, Bridges, and Land Transport (GARBLT), which divides the Egyptian main road network into 12 districts. District 7 is in the Assiut governorate, and it is responsible for all main roads in Minia and the Assiut governorate. There are 15 main roads in the Minia governorate belonging to the GARBLT, and the total length of these roads is 1205 km. The second institution is the Roads and Bridge Directorate, Minia Governorate, which divides the road network in Minia into paved roads with a total length of 2470.945 km and unpaved roads with a total length of 163.65 km.

A manual survey is performed on a section of 8.25 kilometers of the Cairo-Aswan Agricultural Highway selected in Minia city according to the ASTM (D6433) [21]. Cairo – Aswan Agricultural Highway is the main road that begins north of Minia and extends to the city's south. It is a two-lane road in two directions, and it was constructed in 1996's by General Authority for Roads & Bridges and Land Transport (GARBLT) Figure 5 shows the general location of the study area. The studied section length was 4.125km per direction and 20.5m total road width.

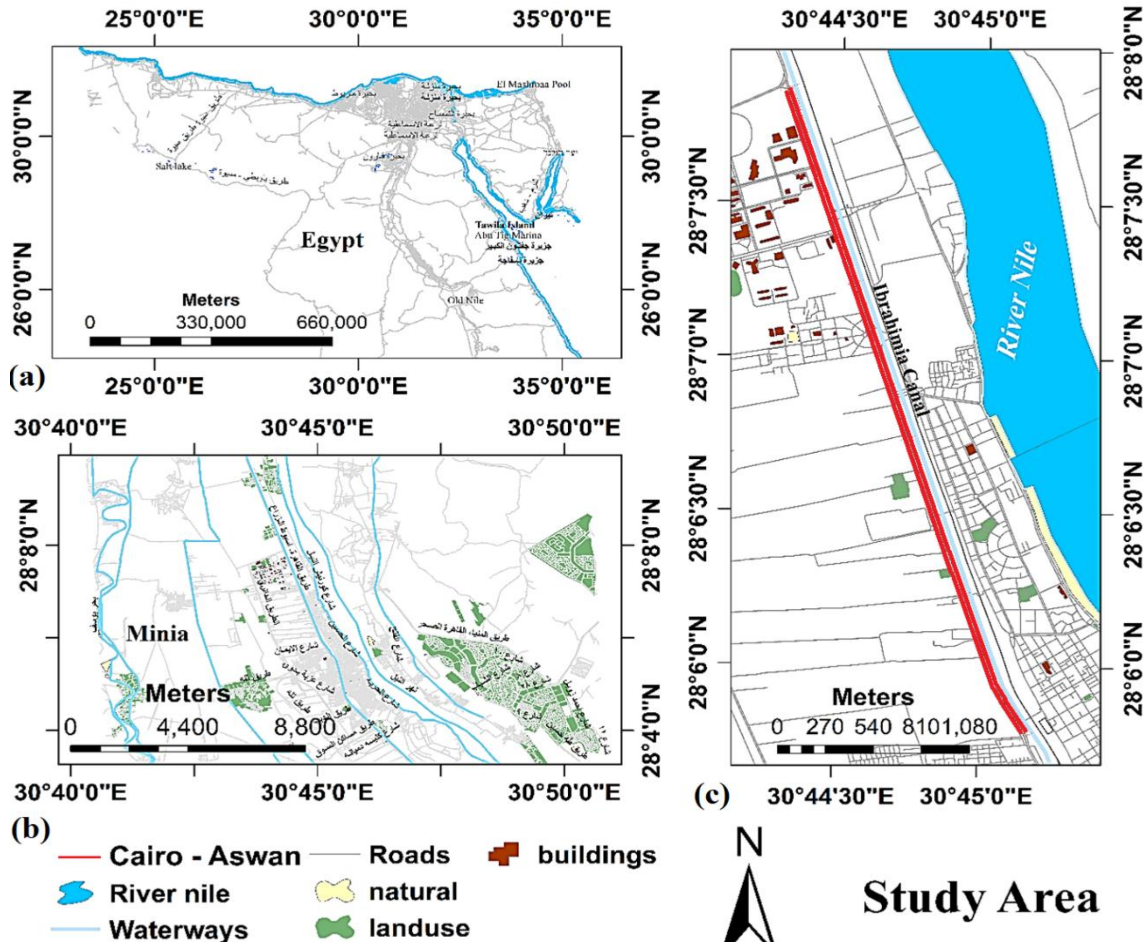


Fig. 5. Map of the study area showing the studied part location: (a) Egyptian Topographic Map; (b) Minia Topographic Map; (c) Cairo – Aswan Agriculture Road location in Minia, Egypt.

IV. RESEARCH METHODOLOGY

A. The pavement network inventory

Because the roadway does not have consistent characteristics and may not require the same maintenance and rehabilitation treatment throughout its length, therefore, it was divided in this study into branches at a length of 4.125 km, instead of taking the whole road. Also, every branch is divided into smaller, manageable sections. Sections are defined so that the pavement within their boundaries is consistent in terms of physical and functional characteristics, which were taken as each roadway direction in the defined branch. In addition, each section is divided into sample units. A sample unit is defined as a length of 100m for asphalt-surfaced roads.

These sections of roads must be identified on-site by using location referencing methods (LRM). Then collecting the pavement Inventory data such as; Pavement type, structure, construction history, functional categorization (or traffic), and present condition are all important factors to consider when defining the pavement inventory [19]. Table 3 summarizes the inventory data for each direction.

Table 3 The inventory data for the selected segments.

Road Name	**Cairo-Aswan Agricultural Highway**	
Section No.	1	2
Direction	Right	Left
Construction date	1996	1996
Pavement type	HMA*	HMA*
Length (m)	4125	4125
Width (m)	10.5	10
Section length (m)	100	100
Samples/100m	41	41
Section Area (m2)	1050	1000
Total Section Area (m2)	43312.5	41250

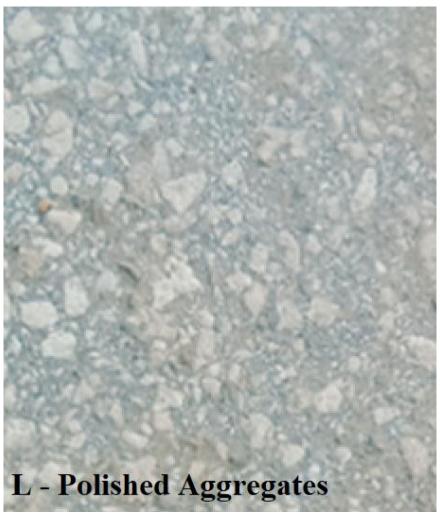
HMA Hot Mix Asphalt*

B. Pavement condition survey

PCI calculations process begins by going into the field and compiling a worksheet of all pavement distresses with their severities and quantities for road sections. Data collection tools can simplify the inspection task. Each sample's location is determined using handheld GPS units.

Also, there are other tools used to collect the pavement distress data, such as a camera, steel ruler, tape, 1.5 m straight edge, and datasheet. The steps of inspection used to find PCI are as follows:

1. Surface distresses in the samples were measured as area, length, number, or width and evaluated based on type, quantity, and severity level. Using the Pavement Distresses Identification Manual (PDIM) developed by the US Corps of Engineers, the type, quantity, and severity of distresses were determined.
2. For each sample, the location of distresses was pinpointed.
3. A digital photograph of each section of roadway records the distresses with different severity surveyed through this work. Figure 6 shows samples of pavement distresses with different severity surveyed through this work.



C. PCI Calculations

Because Micro PAVER software can perform pavement condition analysis, it has been utilized to assess pavement condition by determining the current PCI and to predict future pavement conditions, which has been relied upon in selecting maintenance and rehabilitation needs at the optimal time and according to the priorities. The inspection information of the pavement sections has been entered to estimate the pavement.

An evaluation of the pavement condition index was conducted by classifying the Cairo–Aswan Agricultural Highway into branches and sections before performing a condition analysis. One branch was chosen as a case study, and it was categorized into two sections, with each direction as a section. Every direction is 4.125 km in length, with a varying width range from 10 m to 10.5 m. Every section was divided into small, manageable samples, each measuring 100 m in length, with a total of 41 samples for each branch. PCI was calculated for all samples in the two sections, and the final PCI for any section was taken as the average value for all samples in the section.

Fig. 6. Type and severity of some pavement distress in the study area.

V. Results and discussions

After a visual survey was conducted on the study area, it was found that there were 15 distresses, including cracking, rutting, potholes, patching, raveling, slippage, etc. The depth and the area covered by each distress found in the roadway sections were measured and documented in Excel as a first step in building the distress database. The relationship between distress types and quantities (Figure 7) in section 2, shows that the longitudinal and transverse cracks have a high quantity at the low, medium, and high severity levels. Also, edge cracking represents the second highest quantity in low and high severity levels, while lane/shoulder has the third highest quantity in high and low severity levels. While the weather has a second quantity in high severity levels, Also, block cracks and swelling cracks represented the lowest quantity, which resulted in no damage to the base and subbase layers.

From the relationship between distress types and quantities (Figure 8) in section 1, it shows that the longitudinal and transverse cracks have a high density at low, medium, and high severity levels, but block cracking represents the second highest density without medium or high severity levels. However, lane drop-off represents the third highest density at low severity levels and the second highest density at medium severity levels. In high severity levels, alligator cracking has a third density. Also, block cracks and swelling cracks represented the lowest density, which resulted in no damage to the base and subbase layers.

After inputting each point of distress type that is found for each road section in Micro PAVER, the program will display the PCI value directly corresponding to the condition rate. The results of the field inspection and PCI calculations for samples are shown in Figure 9 for two sections 1 and 2. The average PCI of road sections for section 1 is better than section 2 because the average PCI of section 1 is 59% which means good condition, while the average PCI of section 2 is 48% which means Fair condition. Both sections are suffering from a lack of routine maintenance.

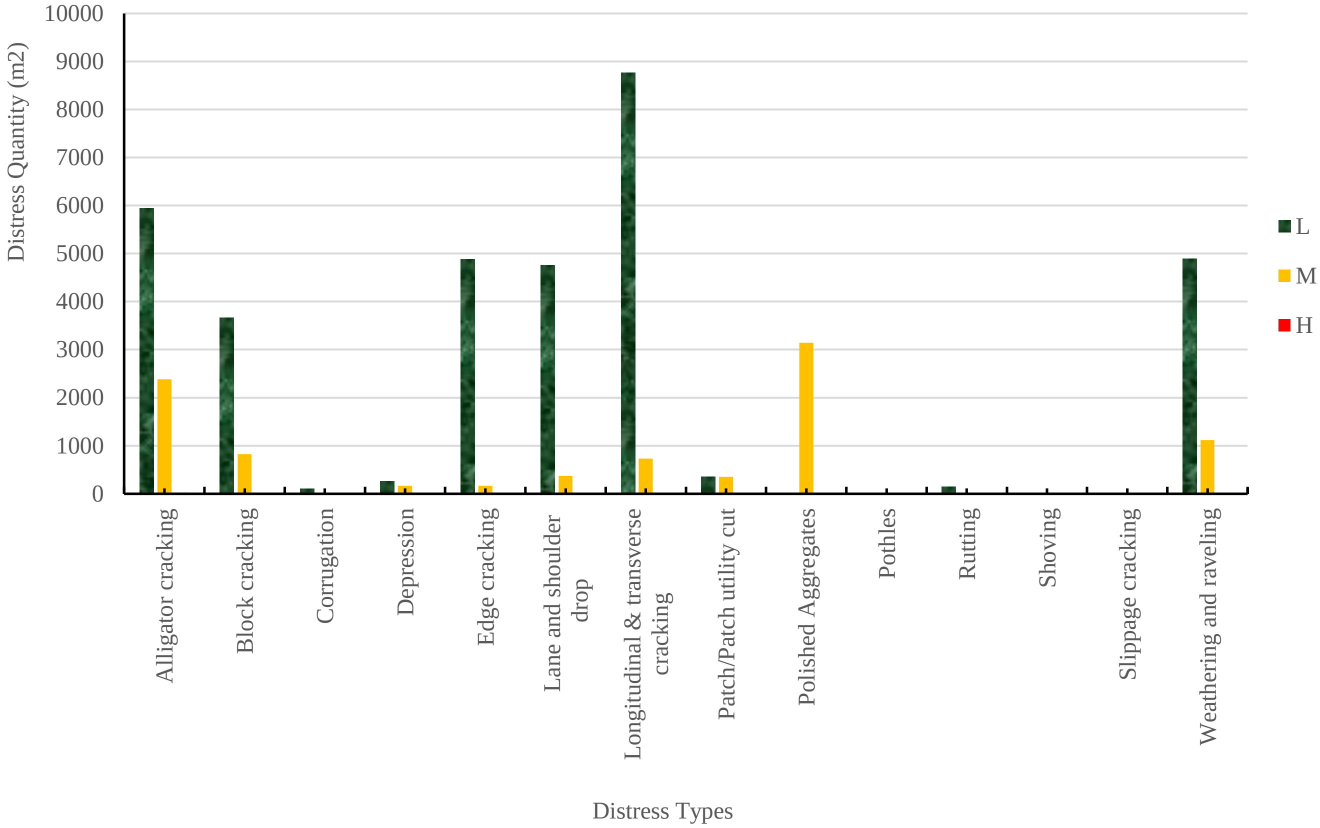


Fig. 7 Distress types and their quantity in section 2.

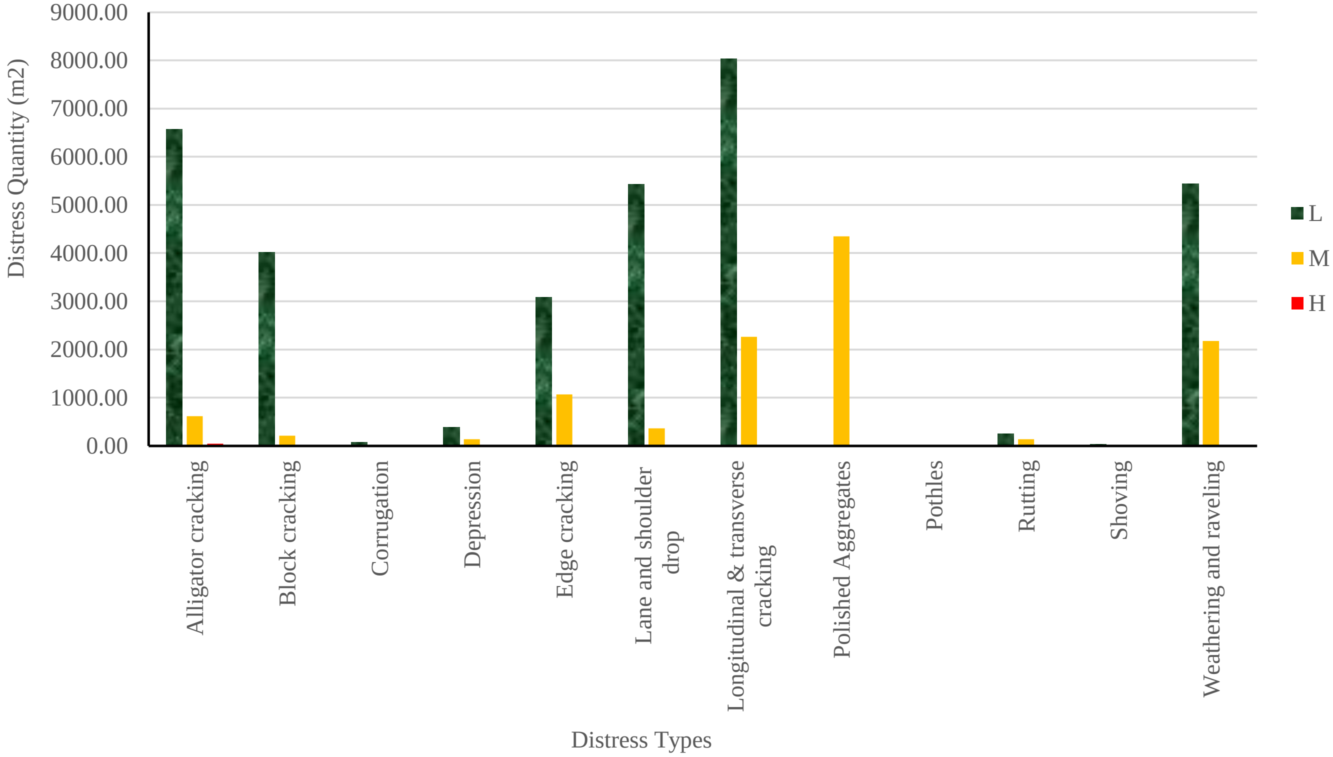


Fig. 8 Distress types and their quantity in section 1.

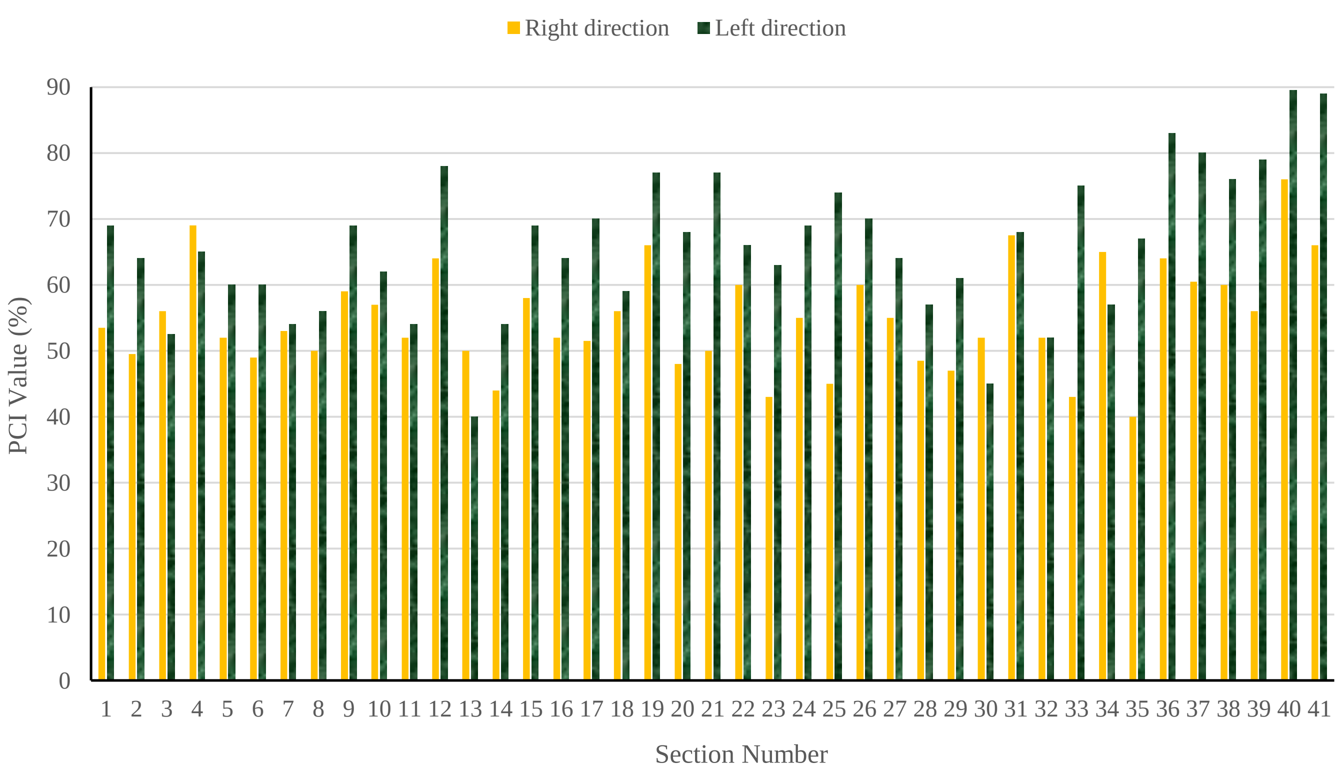
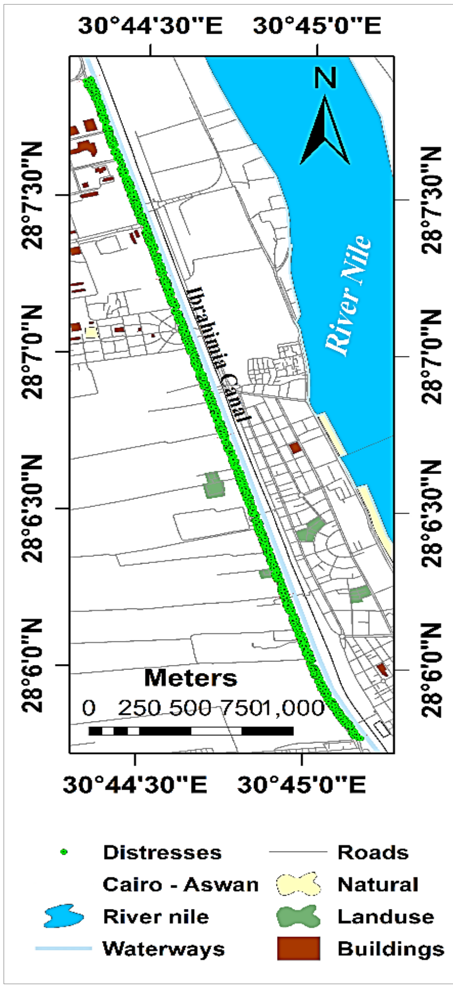


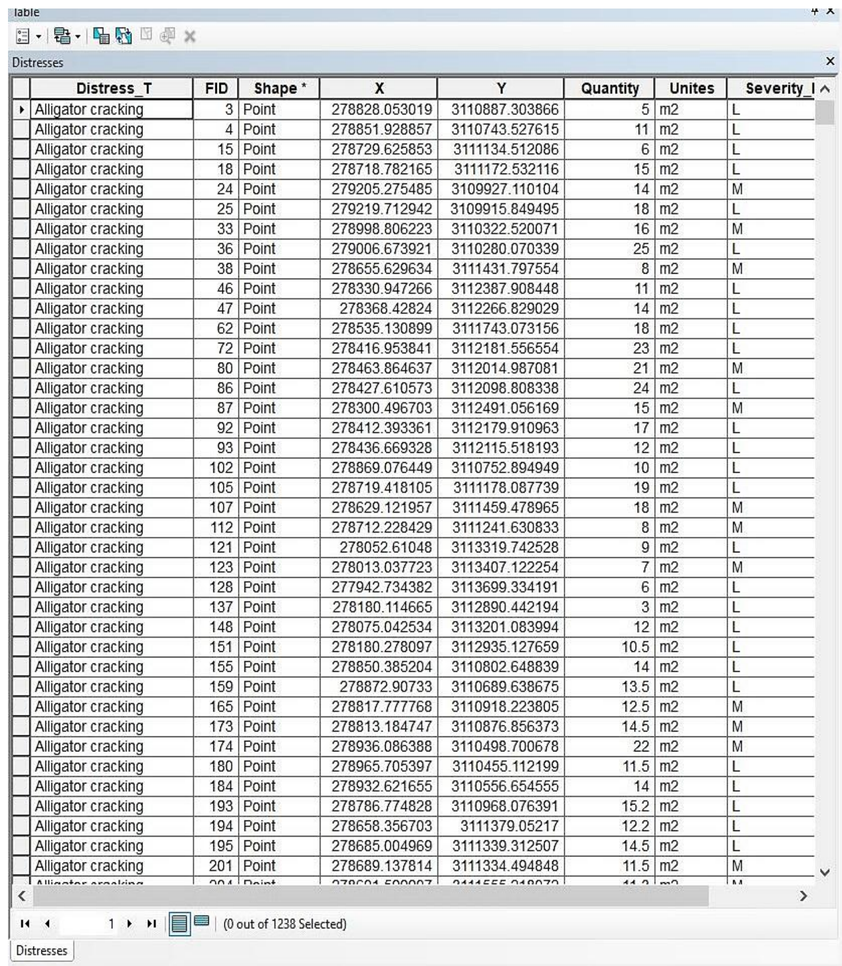
Fig. 9. PCI values of road sections for two-lane direction.

The causes of pavement deterioration may be divided into the following three general categories: Load Related, Climate-Related, and Other. The results of Micro PAVER software depict the primary causes of pavement deterioration as shown in Figure 10.

Fig. 10. Reasons for distresses for the selected road pavement.

To accomplish the implementation of GIS with PMS, all the collected data can be easily transferred into GIS. The road data is typically collected on a spreadsheet. This spreadsheet was then exported to the GIS database. The attributes considered included inventory data, distress data, and traffic data. Figure 11 shows the GIS database for the selected branch on Cairo-Aswan Agriculture Road in the City of Minia, including inventory and distress data. Also, figure 12 shows the ability to display any pavement distress photo by using hyperlink tools in ArcMap. Every distress point can be displayed by clicking on the point. Figure 13 shows PCI for every section of Cairo Aswan Agriculture Road on a GIS map.





Table

Distresses

	Distress_T	FID	Shape *	X	Y	Quantity	Unites	Severity_l
▸	Alligator cracking	3	Point	278828.053019	3110887.303866	5	m2	L
	Alligator cracking	4	Point	278851.928857	3110743.527615	11	m2	L
	Alligator cracking	15	Point	278729.625853	3111134.512086	6	m2	L
	Alligator cracking	18	Point	278718.782165	3111172.532116	15	m2	L
	Alligator cracking	24	Point	279205.275485	3109927.110104	14	m2	M
	Alligator cracking	25	Point	279219.712942	3109915.849495	18	m2	L
	Alligator cracking	33	Point	278998.806223	3110322.520071	16	m2	M
	Alligator cracking	36	Point	279006.673921	3110280.070339	25	m2	L
	Alligator cracking	38	Point	278655.629634	3111431.797554	8	m2	M
	Alligator cracking	46	Point	278330.947266	3112387.908448	11	m2	L
	Alligator cracking	47	Point	278368.42824	3112266.829029	14	m2	L
	Alligator cracking	62	Point	278535.130899	3111743.073156	18	m2	L
	Alligator cracking	72	Point	278416.953841	3112181.556554	23	m2	L
	Alligator cracking	80	Point	278463.864637	3112014.987081	21	m2	M
	Alligator cracking	86	Point	278427.610573	3112098.808338	24	m2	L
	Alligator cracking	87	Point	278300.496703	3112491.056169	15	m2	M
	Alligator cracking	92	Point	278412.393361	3112179.910963	17	m2	L
	Alligator cracking	93	Point	278436.669328	3112115.518193	12	m2	L
	Alligator cracking	102	Point	278869.076449	3110752.894949	10	m2	L
	Alligator cracking	105	Point	278719.418105	3111178.087739	19	m2	L
	Alligator cracking	107	Point	278629.121957	3111459.478965	18	m2	M
	Alligator cracking	112	Point	278712.228429	3111241.630833	8	m2	M
	Alligator cracking	121	Point	278052.61048	3113319.742528	9	m2	L
	Alligator cracking	123	Point	278013.037723	3113407.122254	7	m2	M
	Alligator cracking	128	Point	277942.734382	3113699.334191	6	m2	L
	Alligator cracking	137	Point	278180.114665	3112890.442194	3	m2	L
	Alligator cracking	148	Point	278075.042534	3113201.083994	12	m2	L
	Alligator cracking	151	Point	278180.278097	3112935.127659	10.5	m2	L
	Alligator cracking	155	Point	278850.385204	3110802.648839	14	m2	L
	Alligator cracking	159	Point	278872.90733	3110689.638675	13.5	m2	L
	Alligator cracking	165	Point	278817.777768	3110918.223805	12.5	m2	M
	Alligator cracking	173	Point	278813.184747	3110876.856373	14.5	m2	M
	Alligator cracking	174	Point	278936.086388	3110498.700678	22	m2	M
	Alligator cracking	180	Point	278965.705397	3110455.112199	11.5	m2	L
	Alligator cracking	184	Point	278932.621655	3110556.654555	14	m2	L
	Alligator cracking	193	Point	278786.774828	3110968.076391	15.2	m2	L
	Alligator cracking	194	Point	278658.356703	3111379.05217	12.2	m2	L
	Alligator cracking	195	Point	278685.004969	3111339.312507	14.5	m2	L
	Alligator cracking	201	Point	278689.137814	3111334.494848	11.5	m2	M

(0 out of 1238 Selected)

Distresses

Fig. 11 Distresses database for Cairo Aswan Agriculture Road using ArcMap.

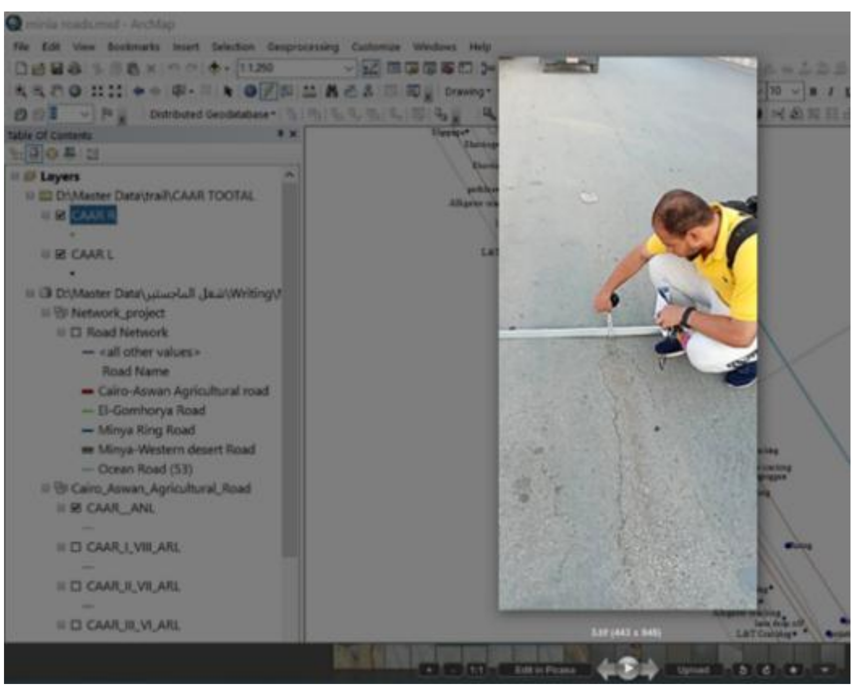


Fig. 12. The ability to hyperlink images and display them on the map.

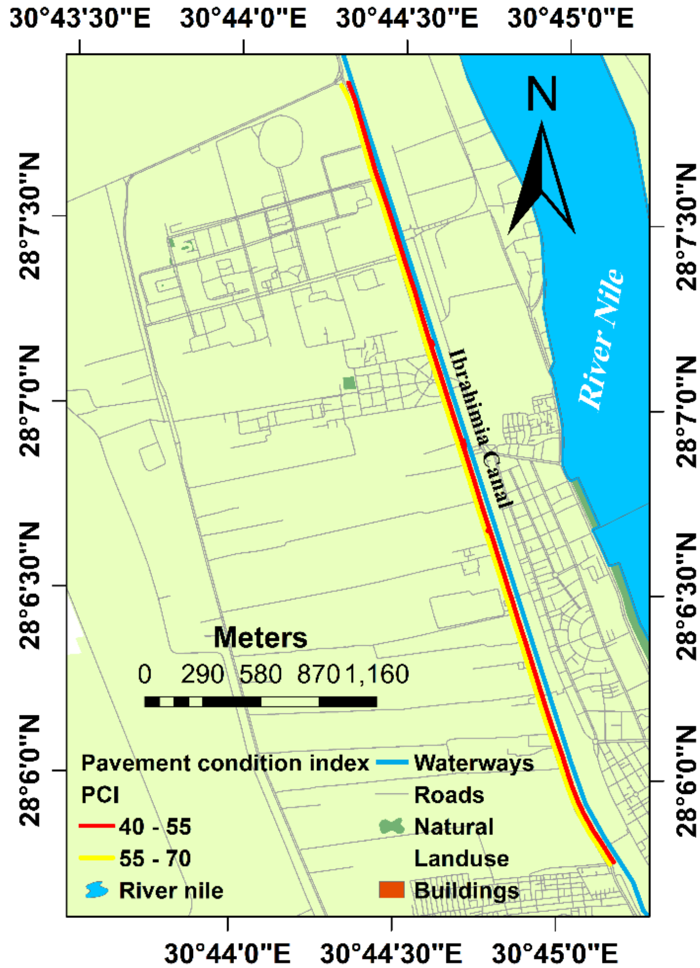


Fig. 13. PCI Distribution in the study area of Cairo Aswan Agriculture Road.

Determination of suggested treatment for the maintenance of road sections is depended on the condition of the pavement. PCI values are categorized into 7 classes with the suggested maintenance treatment shown in Table 4.

Table 4. Suggested maintenance treatment based on PCI [30, 31].

PCI Values	***Rating***	***Suggested Maintenance Treatment***
100 -85	Excellent	No maintenance required
71-80	Very Good	Routine maintenance or Emergency maintenance
56-70	Good	Preservative treatments (seal coating or thin non-structural overlay)
41-55	Fair	Milling & Overlay
26-40	Poor	Needs patching and repair before major overlay Milling and removal of deterioration extend the life of overlay.
11-25	Very Poor	Needs reconstruction of asphalt layers with the extensive base repair
0-10	Failed	Total Reconstruction (Reconstruction up to subgrade)

VI. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were obtained after field measurements and visual inspection of the road under study, as well as an analytical study of the types of distresses and the causes of their occurrence, and identifying the causes of distresses:

- The pavement condition index calculated by the PAVER software application for section 1 is 59, indicating that Preservative treatments (seal coating or ***thin non-structural overlay***) are the best alternative for repairing.

- The pavement condition index calculated by the PAVER software application for section 2 is 48, indicating that ***milling and overlay*** is the best alternative for repairing.
- According to the statistical analysis of the data and the results of the PAVER software, the major factor causing distresses is repeated traffic load.
- The currently applied maintenance decision was based on traditional methods in selecting the pavement maintenance decision, which was the opposite of the approach of PMMS in terms of the final maintenance decision and thus led to a loss in budget.

The authors recommended the following points for decision-makers:

- This study should be circulated on all roads, not only in the Minia government but also throughout Egypt, to maintain the current road network.
- After the circulation of the study and the establishment of a database of road networks, the pavement maintenance management system must be implemented to select the best decision in time and be suitable for the available budget.

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تحسين اختيار قرار صيانة الرصف لشبكة طرق المنيا في مصر باستخدام برامج PAVER وGIS

الملخص العربي — في الآونة الأخيرة، تركزت جميع الجهود على التخلص من التكلفة السنوية المفقودة في قرارات الصيانة العشوائية من خلال تطبيق نظام إدارة صيانة الرصف (PMMS). يعد PMMS نهجًا منظمًا لتحقيق الإدارة الفعالة لاختيار قرار الصيانة اعتمادًا على مؤشر حالة الرصف (PCI)، والذي يمكن حسابه باستخدام برنامج PAVER 5.2.3 اعتمادًا على الفحص البصري لعيوب الرصف. تهدف هذه الدراسة إلى توضيح مدى الاختلاف بين PMMS والجانب التقليدي لاتخاذ قرارات الصيانة. لذلك، تم إجراء مسح بصري بطول 8.25 كيلومتر من طريق القاهرة - أسوان الزراعي، مدينة المنيا، مصر لفحص أنوع ومستويات الخطورة وكميات جميع العيوب في جميع العينات، والتي تم تخزينها بعد ذلك في ملف قاعدة بيانات باستخدام برنامج GIS. تم حساب PCI لتحديد ما إذا كان ينبغي تطبيق قرارات الصيانة أو إعادة التأهيل (M & R)، وكانت النتائج للقطاعين 1 و2 هي 59 و48، على التوالي. وفقًا لهذه النتائج، فإن M & R المناسب للقطاع 1 هو " Thin Overlay without Milling"، وM & R المناسب للقطاع 2 هو " Milling and Overlay". كانت هذه النتائج مناقضة لما يتم إجراؤه حاليًا من خلال الجوانب التقليدية، حيث كان القرار المتخذ هو " Milling and Overlay" للقطاعين، وهو بالتالي أكثر تكلفة.

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