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Utilizing GIS Application to Evaluate Pavement Condition Index: Case Study In Nasiriya City

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Abstract

In all Countries, road pavements are recognized as one of the most critical structural components. Attention must be paid to the management of maintenance work and its timely execution in order to keep the pavement in good conditions and acceptable service level. Pavement distress check is very beneficial to the capabilities of Pavement Management Systems (PMS). The objective of this research is to connect the PAVER software database to A GIS software in order to perform spatial analysis of pavement condition and develop location-related heat distress maps based on Pavement Condition Index (PCI) values. A visual survey of the research area was conducted to evaluate the type, level, and amount of defect. The PAVER 6.5.7 software was used to calculate the PCI values for each sample unit based on the data collected from the visual survey. The data obtained by the PAVER program was integrated with ArcGIS software 10.4 in order to create heat maps utilizing spatial analysis tools .

The heatmap shows the type maintenance for the study region based on PCI values, with each category of PCI values represented by different colors. Each color on this map represents a different sort of maintenance, with red indicating that the pavement requires rebuilding, yellow indicating rehabilitation, and green indicating preventative maintenance. PCI values over 85 indicate that the pavement is in excellent condition and does not need to be maintained. Using the heat map . In general, the selected roads in Nasiriya city is quite and in acceptable conditions, although there is some patching and weathering practically everywhere, and the road needs to be covered with overlay asphalt layer.

Keywords: PAVER, Pavement Condition Index(PCI),Geographical Information System(GIS), Maintenance

1. Introduction

Provides integration of ArcGIS and PAVER systems possibility to use fully automated technology to collect distress and data analysis. The popularity of this technology has grown as a result of its critical role in conducting a wide range of cost-effective and safe research projects. Pavement Maintenance Management System PMMS is a set of tools and procedures that may assist the making of decisions to designing cost-effective ways to present, evaluate and maintain acceptable sidewalks. PMMS enables a system, consistent approach to pick maintenance and repair needs, in addition, calculate the optimum repair time based on the future condition **[1].** This PMMS is known as the PAVER system and has evolved into an approved PMMS for airports, cities, and counties, to improve funds for paving Maintenance and Rehabilitation **[1]** However, in order to implement the paving management system, PAVER may require time-consuming data collection methods. End users should also have professional experience. It is expected that ArcGIS will be combined with PAVER and will be a useful tool in studying PMMS to address some vulnerabilities previously identified. Implementation of this hybrid system will have a number of Benefits, including practicality, follow-up capabilities, and ease of digital use capabilities and skills to record, plan, manage and access activity a variety of activities, update and archiving [**2**].

2. PAVER and Micro PAVER

PAVER and Micro PAVER were developed to supply engineers with a methodical technique for assessing maintenance and rehabilitation. PAVER is the mainframe version, while Micro PAVER works on a small computer. PAVER was created to make the largest usage of costs allocated to the maintenance and rehabilitation of the sidewalk. Micro PAVER was utilized to managing streets, roads, parking lots, and airport docks. Surveying and Classification Using the Pavement Condition Index (PCI). The technology serves as the basis for the PAVER system. To accomplish grid and project analysis, users can learn about future paving conditions, budgets, and project priorities using network analysis for long-term estimation maintenance and rehabilitation needs. PAVER system is built-in FORTRAN and ++C programming, which is designed to run on IBM or other compatible PCs. PAVER's inventory management is based on a hierarchical structure of network, branch, and section, with section

being the smallest censored loneliness'. This structure allows users to easily manage their inventory by storing sidewalks information in various fields and levels. that it decision-making tool used to determine the most economical repair and maintenance choices for roads, parking lots, streets, and airports **[3]**US Army Corps of Engineers, 2011. PAVER gives users the flexibility to customize PCI. Status rating ratings, plus other features. As shown in Figure (1).

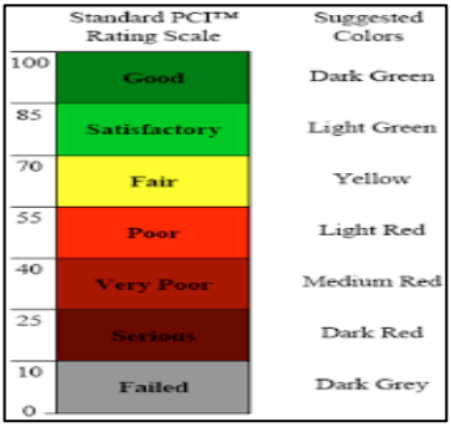

Fig.1 The scale of PCI with condition rating

3. Pavement management

The management of pavement is a successful approach for examining and fixing the pavement conditions of the road network. It is a valuable gadget that alerts road management to an impending emergency in the highway's life cycle. The ability to infer present road network circumstances and estimate future state is a crucial element of the (PMS). A suggested (PMS) is a worldwide approach used to help making decisions in "finding the optimal option" for road repairs. There are two major components to road failure. The first is functional failure, which occurs when the highway is unable to execute its intended function without creating a nuisance to passengers and significant damage to cars. The cause of functional failure is the distress of pavement surface, which manifests itself as depressions, fractures, rutting development, and poor ride quality. The second kind of failure is a structural failure, which results in the collapse of the pavement layer or the fracture of one or two pavement layers, rendering the pavement unable to withstand stresses on the pavement surface. Pavement control includes, among several other tasks, their preservation. Controlling a pavement involves an understanding of its status, which determines the need for the optimal duration of maintenance. When specific information about a road system is implemented, determining the objectives for maintenance or failure becomes much easier.

4. Geographical information system (GIS)

A GIS is a database management system for storing, retrieving, analyzing, and displaying geographic data. In GIS, two types of data exist: the first one is the geo-referenced spatial data and the second one is the attribute data. Geo-referenced spatial data represents objects that have a direction and relationship in two or three dimensions. A street segment's attributes might include its breadth, lanes number, installation age, paving status, and density of traffic **[4].** GIS is employed to improve management information of pavement through offering standard features such as a graphical depiction of the highway network and the existing and future paving conditions of the chosen paving sections. GIS also provides strong geographical query and analysis potentials for identifying degraded pavement portions that expect rapid repair **[5],[1].**

5. Pavement management system (PMS)/Geographical information system (GIS) integration

The use of GIS and the ability to spatial assessment of road networks is seen as one of the best tools for process improvement paving management, with features such as visual paving put another. GIS is quickly used by government organizations as a result of technological advances in computers hardware and software, there is a growing trend to integrate PMS data in ArcGIS. Researchers investigated the benefits with the negatives GIS and property management system integration, the benefits of this group include the capability to visualize Results and display database queries and statistics on highway maps Network to assess the state of the network through the use of highways Color coding section for data access via graphic interface map **[6].** Moreover, the ability of GIS is one of the most important benefits of using GIS - PMS to be used in all aspects of pavement management. Defects were not considered **[7]** Some of the benefits of integrating GIS and PMS maybe it boils down as follows **[8]:**

1. The ability to study pavement management data geographically relies.
2. Plots the database results for queries on a network map and performs pavement management research.
3. Show the condition of the pavement on the road network map forecasting action plans.
4. The ability to update and modify the pavement network map.
5. Using a framework, can help paving management information through the use of an easy-to-understand structure of managers.

The perfect integral can be used to complete the integral, since then. Uses the PMS becomes a component of GIS, and the PMS data is exported to match GIS or export the map to the PMS map view/query module. The benefits and drawbacks of this integration can be analyzed, but in a format in order to highlight the best use of the GIS application for each of them pavement Management Section, Downsides **[9].**

6. Spatial analysis

Analysis of locations and forms of geographical features, In addition to their common relationships, is known as spatial analysis. My place the analysis is useful for determining the appropriateness and generation predictions, along with gaining an adequate understanding of how to do it positioning and geographic events and dispersal. Spatial the analytical tools used to generate the heat map in this research are Inverse Distance Weighted (IDW) **[10].**

7. Research area

The Pavement Maintenance Management System (PMMS) was examined in the study field. The chosen research region is in Nasiriya city. The road going to Thi-Qar University was included in the examination. Figure (2) illustrates the length of the road is 4022 meters. During scanning, data was collected, which included identifying defects, measuring distress, and photographing existing problems in the research region. Using the Index of Road Distress, it was possible to assess the level of severity, which were then grouped into three categories: low, medium, and high severity. Paving is poor when the level of severity is high. A low severity level, on the other hand, suggests that the pavement is in good condition. The database that has been developed is exported and shown on the Arc GIS program.

Fig.2 Aerial photo of chosen roads in the research area

8. Methodology

To meet the study's goal, the following activities were completed:

1. A visual assessment of all sample units in a specific research region was undertaken to determine the defect type, amount, and severity.
2. The X and Y coordinates of each fault, in addition to the center of each unit, were recorded using GPS.
3. Each section of road was photographed digitally. .
4. PAVER 6.5.7 application is utilized to calculate the value of PCI for each visually collected unit on examined highways.
5. Connecting the PAVER program's outputs to the GIS database directly.

9. Analysis and results

In this research, Micro PAVER and ArcGIS applications were utilized to enhance road site management pavement issues system in the city of Nasiriya, Iraq, after entering the distress data in PAVER6.5.7, the software automatically determine the PCI for each sample unit scanned thought total PCI for a section, plus distress amounts shown in Figures (3 and 4).

Fig.3 PCI value by using PAVER program.

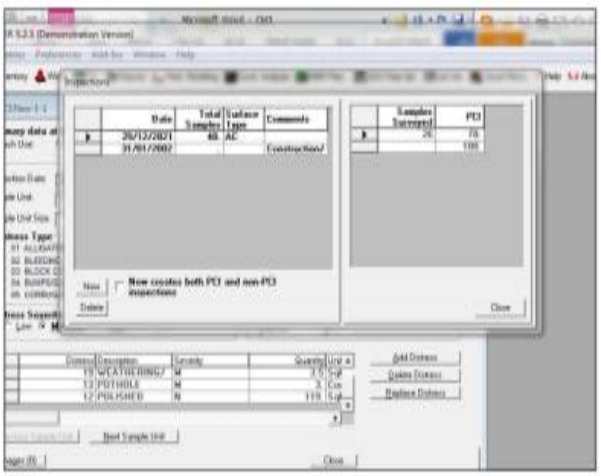

Fig.4 Number of Samples by using PAVER Program.

10. Drawing heat map using ArcGIS software

The primary tools used in this research to create a heat map for road defects were Inverse Distance Weighting. A heat map of road defects was created by combining the X and Y coordinates of the defects obtained by GPS with the PCI value of each unit. This map can rapidly determine the precise location of the defect. Additionally, data collection could be presented in an excel work-sheet form. In addition to getting the locations of defects, the GIS program can also help to classify the severity level of defects occurring on Thi-Qar university road. This map, created with ArcGIS software, displays the present condition of the road, including road defects.

10.1 Heat map for road using inverse distance weighting (IDW)

This includes the PCI for each unit, in addition to the X and Y coordinates located at the center of each defect. are all listed on the Excel page. Then, insert the Excel worksheet into the GIS program for spatial analysis utilizing Inverse Distance Weighting (IDW). In accordance with the value of PCI, the hue of the heat map indicates the degree of degradation in pavement condition. The PCI value is transformed to a color gradient depending on the severity of the defect. The condition using Inverse Distance Weighting in Figure (5). Green indicates the optimal condition of the pavement, while the color red denotes the worst potential state of the pavement. A popup emerges when the user selects this map, displaying the PCI value of the sample unit, the position of the distress, the street name, and the sample number. The PCI levels are classified in Table (1) into five stages of deterioration, which are further split into subcategories. Each level has a different color allocated to it.

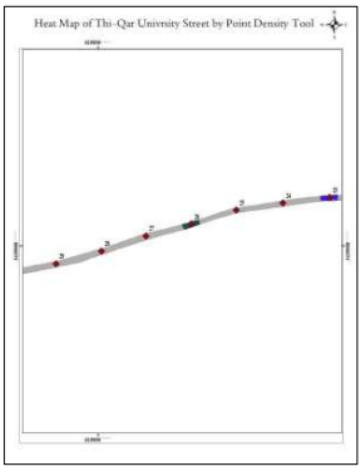

Fig.5 Section of Heat Map of Thi-Qar University Street by (IDW) Tool

Table 1 Classifying levels of distress based on color with the IDW tool

Levels of PCI	Type of region within the location	Using color to determine PCI
1	Distress level is very low	
2	Distress level is low	
3	Distress level is average	
4	Distress level is high	
5	Distress level is very high	

Conclusions

To determine the levels of danger along the roads in the research area, a spatial analysis was performed on the sites. The chosen road in Nasiriya is rather good, but it must be covered with overlay asphalt layer. Use geographic data and a GIS to create a heat map that accurately identifies fault locations. From collecting data to prioritizing road repair options, this map will aid in the road maintenance management process. The following conclusions were drawn based on the current research:

1. There are no difficulties, except for the repair of the facilities, which are in good condition. There may be many from weathering.
2. It is necessary to use GIS software as a database to locate each distress point with complete information during the survey and in order to determine the rate of pavement deterioration, allowing early detection of maintenance and rehabilitation needs.
3. Users can evaluate the condition of the pavement and choose the appropriate maintenance according to the coloring of the heat map. Starting with red, indicating that the pavement is deteriorated and requiring rebuilding, and ending with dark green, indicating that the pavement is in good condition and requires no maintenance.
4. The heat map shows users everything they need to know, including the location of the defects, the PCI value of each unit.
5. These maps are cost effective and useful for making the best research maintenance decisions. best research maintenance decisions.

References

[1] Obaidat, M. T., and Bara'W, A.-M. (2012). Integration of Geographic Information Systems and Paver System to Award Efficient Pavement Maintenance Management System (PMMS)–Case Study–Irbid City–Jordan. *Journal of Advanced Science and Engineering Research*, 2012, 2, 279.

[2]Bemanian, S., Polish, P., and Maurer, G., Pavement management system based on financial consequence. *Transportation Research Record*, 2005, 32.

[3] Ismail, N., Ismail, A.,and Atiq, R.. An overview of expert systems in pavement management. *European Journal of Scientific Research*, 2009, 30, 99.

[4] Jain, N., Nanda, P. K., Durai, B. K., and Rao, I. P. . Geographical Information System for Pavement Management System. *Map Asia conference, New*

Delhi, India, 2003.

[5] Niju, A. GIS based Pavement Maintenance and Management System (GPMMS), 2006, 105.

[6] Parida, M., Aggarwal, S., & Jain, S. S. Enhancing pavement management systems using GIS. *Transport*, 2005, 158, 107.

[7] Hadidi, T., Naghawi, H., Kilany, O. Al, Sharief, A. Al, and Accepted. Utilizing Geographic Information System as a Tool for Pavement Management System. *International Journal of Applied Mathematics, Electronics and Computers*, 2016, 4.

[8] Broten, M., Local Agency Pavement Management Application Guide, *The Northwest Technology Transfer Center*, 1996.

[9] Weber, L. Uses GIS for Pavement Management. *Esri News*, 2002.

[10] Johnston, K., Ver Hoef, J. M., Krivoruchko, K., & Lucas, N. Using ArcGIS geostatistical analyst. In *Analysis jornal*, 2001, 300, 300.