GIS as a tool to Study Pavement distresses Distribution in Irbid city – Jordan

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Literature Review-In the past pavements were maintained but not managed. Pavement engineers experience tended to indictate the selection of maintenance and rehabilitation (M&R) techniques with little regard given to life-cycle costing or to priority as compared to other pavement requirements in the network, pavement distress information is needed to assess maintenance requirements. (GHUZLAN, 1998).The distresses of asphalt concrete pavement are any defects or deterioration in the pavement and they can be grouped into the general categories: cracking, distortion, disintegration and skid hazard defects. Many traditional systems were used to evaluate and classify pavement surface distresses, they used operations characterized by: manual operations, time consumption, and not following up technology trends. (AL-MISTREHI, 2011). The research work presented in this paper focuses on the use of GIS, and GPS in order to collect and analyze different distress data, arterials of Irbid-Jordan city were taken for the prototype study. Spatial analyst extension provided tools to create, query, analyze and map cell-based raster data and to perform integrated vector-raster analysis using feature-based and grid-based themes. The following spatial analysis options could be performed when utilizing the GPS-elevations database: like mapping contours, grid interpolation, slope deriving, and hill shade computation. (LEE et al., 2010). The developed system could provide users with numerous advantages including: a scheme for distributing maintenance priorities based on priority indices values and available budget criterion, a scheme to estimate flexible pavement maintenance costs, and various spatial and analytical query GIS tools for roadway inventory, pavement condition, severity levels, PI, traffic volumes, contours mapping, grid interpolation, slope deriving, aspect deriving and hill shade computations (SHUBINSKY, 2009). The integration of GPS, GIS systems was anticipated to open the door to fully automated technology applications for distress data collection and pavement surface road conditions, mapping, classification, prediction.

Abstract-The main objective of this research work was to investigate the potential Geographic Information Systems (GIS) and Global Positioning Systems are common techniques for spatial distribution studies. This study aims to use these techniques on pavement distresses distribution in the city of Irbid with the help of GPS it was very easy to located pavement distresses samples units and sections in Irbid city. GIS desktop was also helpful in establishing the database attributes tables of the information. Obviously, It is recommended to make several studies related to the topic in order to maximize the benefits of utilizing GIS and GPS in such fields of study particularly in the growing cities

like Irbid – city. Therefore, GIS system has been used in this research work for the purpose of data analysis and archiving.

Keywords-Geographic Information Systems (GIS), Global Positioning Systems, pavement distresses

1. Introduction

The distribution of pavement distresses in Irbid city is one of most important issues for the society because there is a rapid increasing in number of the pavement distresses in Irbid- city. There are many factors affects on the existence of distresses in the roads of Irbid city such as pavement condition , construction history, traffic volume, road class (arterial, collector, local) and pavement age which defined as the number of years since construction or last overlay. The spatial analysis of distresses samples units and sections in Irbid city could be done using (GIS and GPS) in order to display the basic data and location utilizing Arc View software .

1.1. Significance of the study

❖ The Pavement Management System (PMS) is a set of tools or methods that can assist decision makers in finding cost effective strategies for providing, evaluating, and maintaining pavements in a serviceable condition to provides the information necessary to make these decisions.

❖ The PMS consists of two basic components. The first component is a comprehensive database, which contains current and historical information on pavement condition, pavement structure, and traffic. The second component is a set of tools that allows us to determine existing and future pavement conditions, predict financial needs, and identify and prioritize pavement preservation project .

❖ The Fact that the use of GIS and GPS adds more significance for the study.

1.2. Objectives of the study

This study has the following objectives relating distresses distribution in Irbid city:

❖ To establish a database attributes reference about distresses distribution in Irbid city.

❖ To recognize the spatial distribution of the Locations of distresses Sections in Irbid city using ArcVeiw software .

❖ To explain the spatial pattern of density of the distribution of distresses and make proximity and Query to sections distresses .

1.3. Study area

- Irbid city was being selected to be the study area.
- Irbid city which is located Longitude 35º 45̃ and 36º 00̃ east and between Latitudes 32º 30̃ and 32º 45̃ north, as shown in figure 1.1

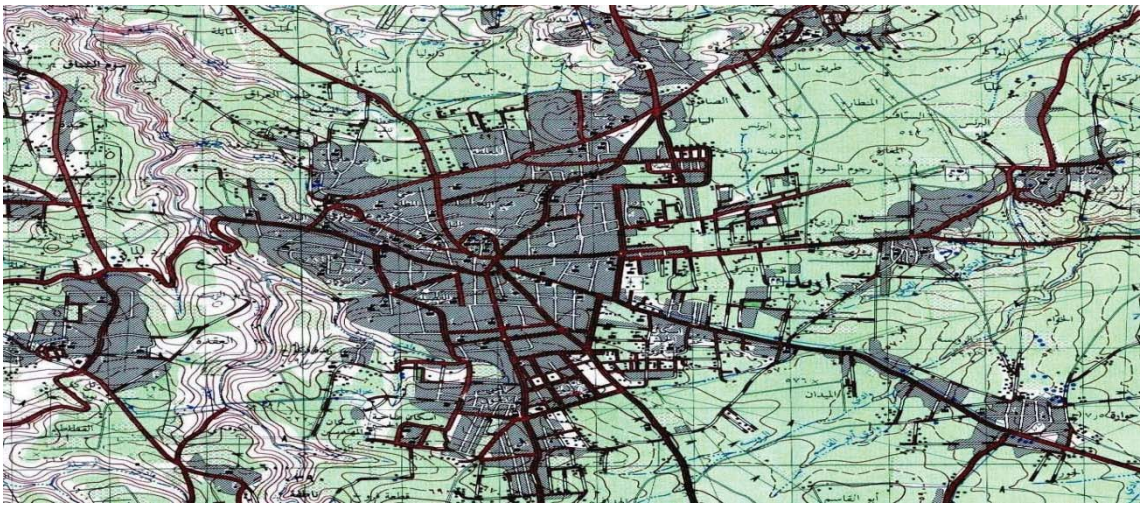


Figure 1.1: Irbid Study area.

2. Research data and Methodology

The research data and methodology can be divided into components:

- Data acquisition and collection.
- Spatial distribution.
- Analysis and Display the data to solve problem.

2.1. Data acquisition and collection

- Taking the base map of study area.

- Collecting the database for this study by using hand- odometer to measure distresses Length and area , a straight edge and ruler were used to measure the depth of ruts or depression.

- The distresses inspection was conducted by walking over the sample unit measuring the distress type and severity according to PCI distress manual, and recording the data on the flexible pavement survey sheet as following :

- Calculation of the PCI and pavement condition rating using PAVER system as following :-

1) Defining the pavement inventory (network , branches , sections),

as shown in figure 2.1

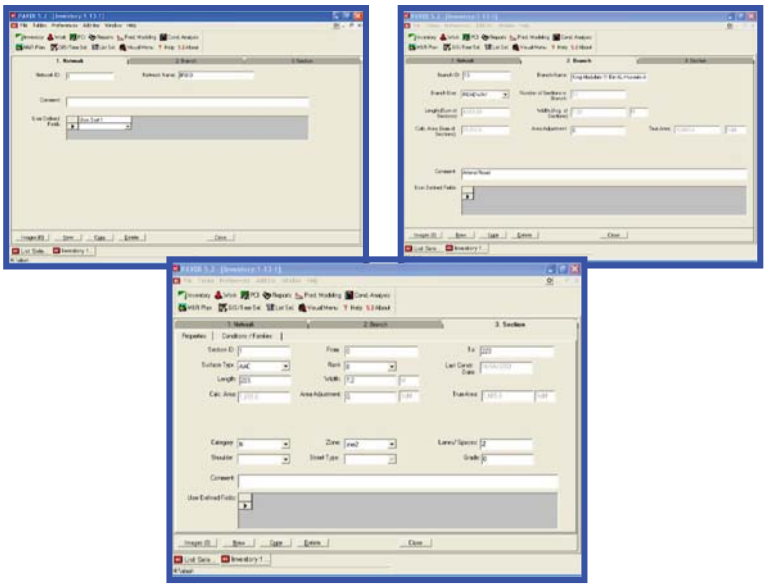


Figure 2.1: Selection Networks, Branches, and Sections

2) Entering the dates and samples information:

A. Click on the (edit inspection) to enter inspection dates as shown in figure 2.2 :

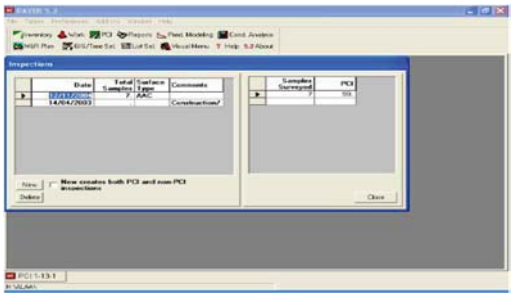


Figure 2.2: Defining the dates

B. Click on the (edit sample unit) to enter survey information, as shown in figure 2.3

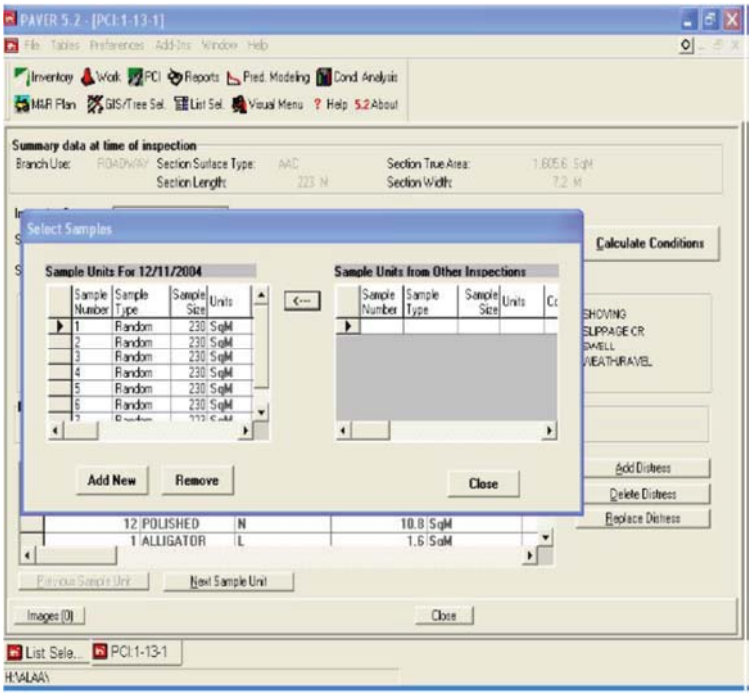


Figure 2.3: Survey Information for Sample Unit.

3) Entering information on distress (Type , Severity , Quantity) as shown in figure 2.4

4) Calculating the pavement Condition index (PCI) as shown in figure 2.5

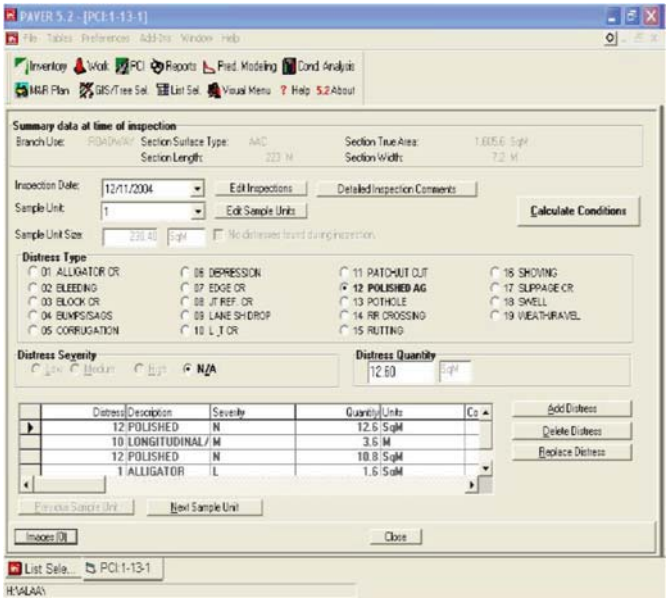


Figure2.4: Distress information.

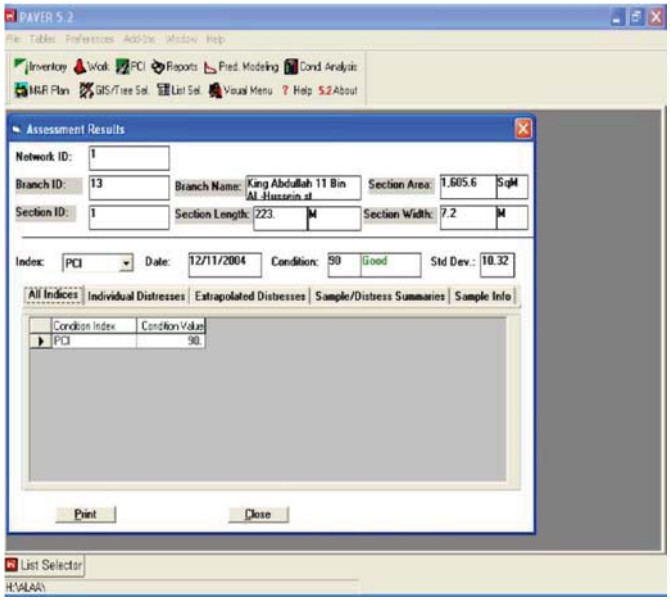


Figure 2.5: Pavement Condition Results

5) Determining the rate condition according to (PCI), as shown in figure 2.6

Figure 2.6: Pavement Condition Index Concept

6) Calculating Present Serviceability Rating (PSR) which provide us a measure of the smoothness or roughness of the pavement, as shown in figure 2.7.

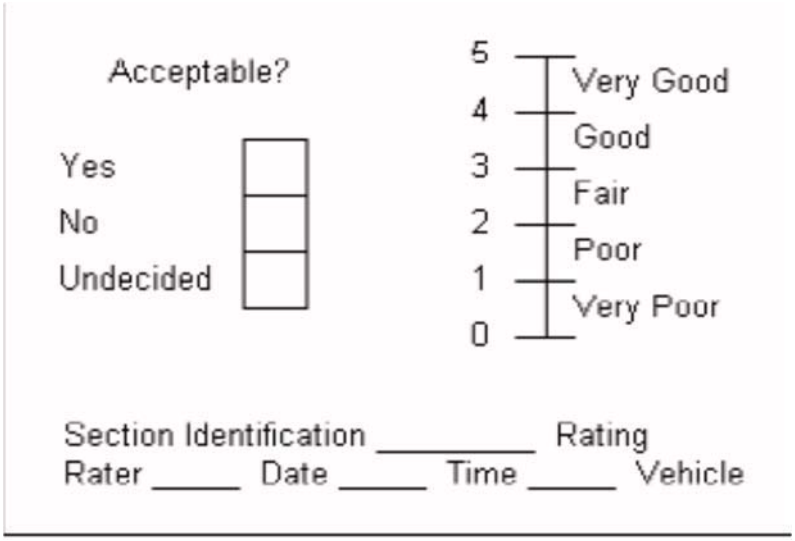


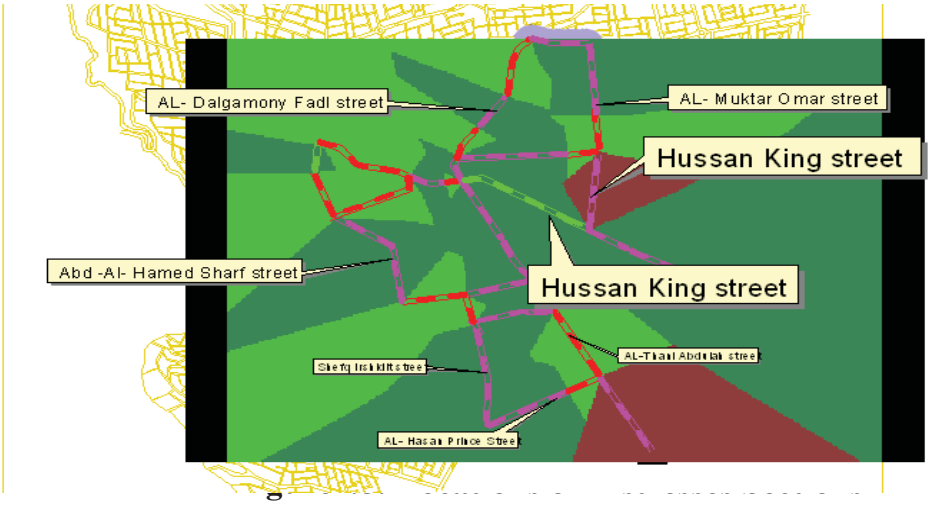
Figure 2.7: Present Serviceability Rating

2.2 Spatial distribution

❖ Locating distresses sections and samples units using the universal transverses mercator (UTM) projection system and (WGS 84) datum for locating distresses in the study area .

❖ Digitizing the Locations on Arc View software Like (distresses samples units as point. Distresses sections as polyline) using UTM projection system.

❖ Editing database , and Edge matching between features, as shown in figure 2.8



❖ Establish database attributes tables for Irbid polyline , distresses sections , and distresses samples units as following in table 2.1

Table 2.1

Data base Attributes Table

ArcView GIS 3.2

File Edit Table Field Window Help

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Attributes of Samples distresses .shp

Shape	Id	Distress_d	Distress_s	Distress_q	Distress_u
Point	1	Alligator Cracking	L	43.0	SqM
Point	2	Alligator Cracking	H	16.0	SqM
Point	3	Alligator Cracking	M	7.0	SqM
Point	4	Bleeding	L	7.0	SqM
Point	5	Bleeding	H	49.0	SqM
Point	6	Block Cracking	H	43.0	SqM
Point	7	Block Cracking	L	10.0	SqM
Point	8	Block Cracking	M	7.0	SqM
Point	9	Bumps/ Sags	H	10.0	M
Point	10	Bumps/ Sags	M	16.0	M
Point	11	Depression	L	7.0	SqM
Point	12	Depression	H	31.0	SqM
Point	13	Edge Cracking	L	31.0	M
Point	14	Edge Cracking	M	71.0	M
Point	15	Edge Cracking	M	28.0	M
Point	16	Lane Shoulder Drop off	H	7.0	M
Point	17	Lane Shoulder Drop off	L	7.0	M
Point	18	Polished Aggregate	N	47.0	SqM
Point	19	Pothole	M	6.1	Count
Point	20	Pothole	L	18.3	Count
Point	21	Weath / Ravel	H	13.0	SqM
Point	22	Alligator Cracking	L	20.0	SqM
Point	23	Alligator Cracking	M	14.0	SqM
Point	24	Alligator Cracking	H	5.0	SqM
Point	25	Bleeding	L	5.0	SqM

2.3Analysis and Display the data to solve problem

❖ (Density , Assign proximity , Reclassify , Query , and Histogram by zone) analysis of samples units distresses and sections distresses to determine where the distresses locations, as shown in figure 2.9 and figure 2.10, respectively.

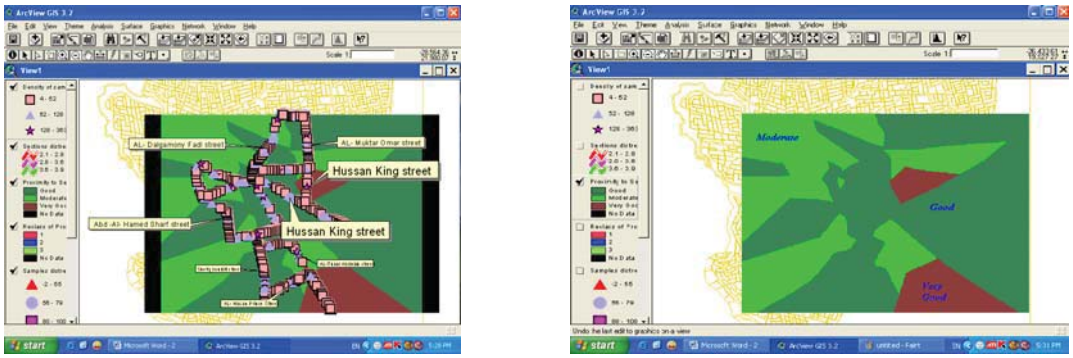


Figure 2.9: Density and Assign Proximity of Distresses

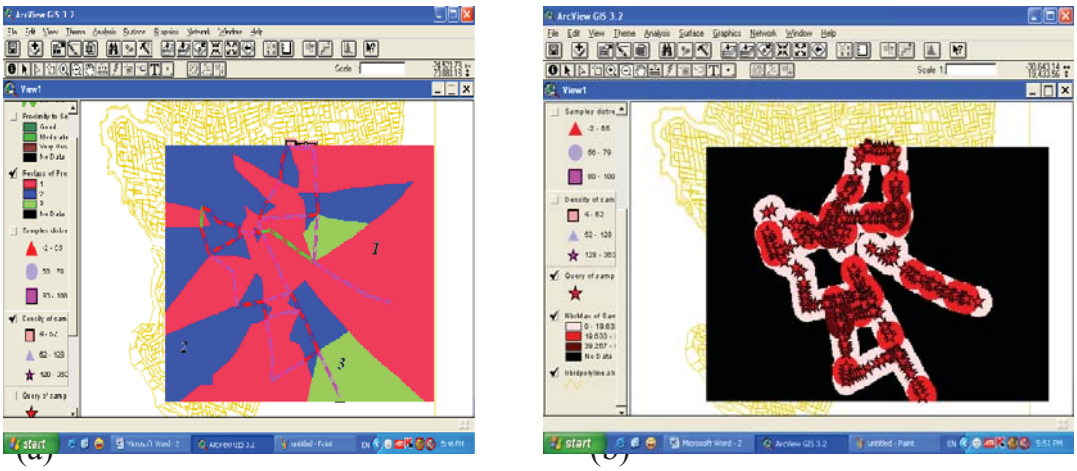


Figure 2.10: Reclassify and Query of Distresses

3. Discussion & Analysis of the results

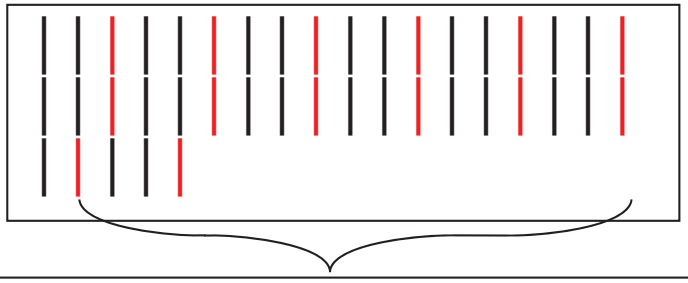
❖ The basic criteria that used in the study was applying density technique using (GIS) to distresses Locations.

❖ The resulting analysis showed that the spatial distribution of distresses is widely spread in Irbid city particularly potholes, Alligator cracking, polished aggregate and ravel \ weathering in addition to longitudinal and transverse cracking, as shown in figure 3.1.

❖ Analysis and sample calculation for example section between AL-Naseem signal and AL- Eskan signal using PAVER procedure as following :

- ✓ Length of section =819m
- ✓ Width of section = 12m
- ✓ Area of street=(L*W) =9828 m^2
- ✓ Area for each sample unit =230m^2
- ✓ Total number of sample unit =(9828/230)=42 sample unit
- ✓ Number of samples units to be surveyed=12 sample unit

- ✓ (42/12) = 3.5 →



14 random sample unites to be surveyed

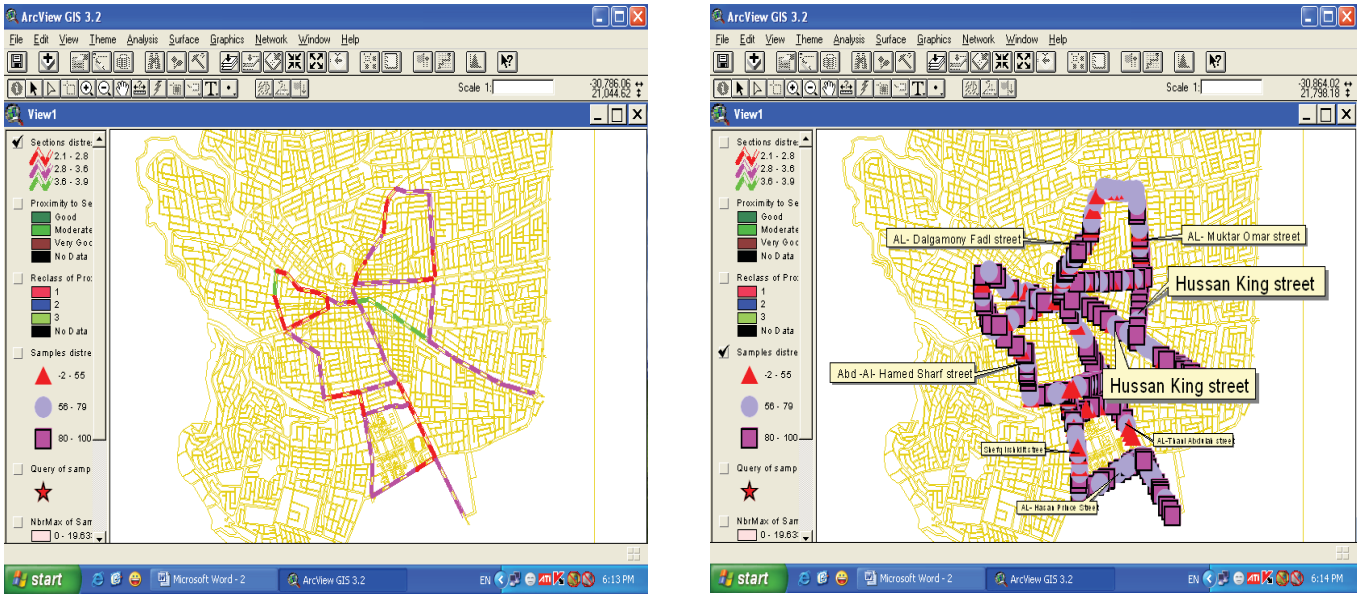


Figure 3.1: Final Sections and Sample units Distresses

4. Conclusions and Recommendations

❖ The analysis dealt with issues related to the objectives mentioned in this study. This study will help both government related to pavement maintenance and people who concern in order to take right decisions about this problem & its relationship to transportation issues in society of Irbid city and other factors .

❖ Also it was clear that there are a lot of distresses in Irbid city roads as following in table 4.1 below :

Table 4.1

Type and distresses associated curing and treatment

Type of distresses	Curing & Treatment
Alligator Cracking	Crack Seal , Overlay , Excavation & rebuilding , Total reconstruction , improvement of drainage .
Longitudinal and Transverse cracking	Crack seal , chip seal , thin overlay
Slippage Cracking	Excavation , seal coating & rebuilding , and overlay
Block Cracking	Seal coating , Overlay , and Reconstruction
Raveling	Crack sealing , ship sealing , thin overlay
Potholes	Excavation & rebuilding of HMA layer , Excavation &rebuilding of entire pavement including sub base & sub grade layer .

❖ It is recommended to make several studies related to the topic in order to maximize the benefits of utilizing GIS and GPS in such fields of study particularly in the growing cities like Irbid – city.

REFERENCES

Books:

Al-MESTAREHI, B.: *Integration of GIS, and PAVER Systems to award Pavement Maintenance Management System (PMMS)*. VDM Verlag Dr. Müller GmbH & Co. KG publishing house Itd, Saarbrücken, 2011.

Journal articles:

GHUZLAN, K.: *A Stereometric Knowledge-Based System for Maintenance of Street Network in Urban Areas.* M.Sc Thesis. Civil Engineering, Jordan, University of Science and Technology, not published, December 1995.

HOWE, R., CLEMEA, G.: *Feasibility of an Automated Pavement Distress Survey System Incorporating Digital Image Processing.* Full report, the media Team, VTRC Report No. 98-R1, 2009.

JASELSKIS, E.: *Field Data Acquisition Technologies for Iowa Transportation Agencies.* Iowa DOT Proj HR-366, ISU-ERI-Ames-94409, Pagination: p.193, 2009.

LEE, H., LEE, N., JITPRASITHSIRI, S., SORCIC, R.: *Development of Geographic Information System-Based Pavement Management System for Salt Lake City*. Transportation Research Record, Issue: 1524, 2101 Constitution Avenue, NW, Washington, DC, 20418-USA, p. 16-24, 2010.

SHAHIN, M.: *Pavement Management for Airports, Roads and Parking Lots*. Klluwer Academic Publishers Group, 101 Philip Drive, Assinippi Park, Norwell, Massachusetts 02061, p. (233-270), 1998.

SHAHIN, M., CLINE, G., BURKHALTER, J.: *Automated Data Collection for Pavement Condition Index Survey*. Fourth International Conference on Microcomputers in Transportation. Published by American Society of Civil Engineers, 345 East 47th Street, New York NY 10017-2398, USA, p. 572-583, 2010.

SHAHIN, M., WALTHER, J.: *Pavement Maintenance Management for Roads and Streets Using the PAVER System*. USACERL Technical Report M-90/05, p. 280, 2009.

SHUBINSKY, G.: *Visual and Infrared GIS Imaging for bridge Inspection*. Northwestern University, BIRL Basic Industrial Research Laboratory, 2009.

SMITH, D.: *Advanced Technology and the Highway Maintenance*. Transportation Research Circular, 12th Equipment Management Workshop Conference, p. 4-14, 2007.

THEODORAKOPOULOS, D., CHASSIAKOS, A., MANARIOTIS, I.: *Improvements in Highway Maintenance Management in Greece*. Ninth, AASTHO/TRB Maintenance Management Conference, Published by Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC, 20418 USA, p. 11, 2007.

UDDIN, W.: *Microcomputers in Transportation for a maintenance Management System for Highways and Urban Streets*. Fourth International Conference on Microcomputers in Transportation, Published by American Society of Civil Engineers, 345 East 47th Street, New York NY 10017-2398, USA, p. 572-583, 2006.

WAUGH, J.: *Data Collection and Analysis Techniques*. XÍÍÍth World Meeting of the International Road Federation, 525 School Street, SW, Washington, DC, 20024, USA, 2007.