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# Development of an Urban Non-pavement Management System

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**Abstract:** The urban roads network in any country is a huge network that was established during different periods of time, the fact that requires a special attention in order to preserve the good functional condition, and reach its expected performance during the assumed design life, that means we should inspect the pavement and non-pavement element at period time to reach to the perfect maintenance decision. In view of the great development and economic importance of this raised issue, we should implement a Road Asset management System (RAMS), based on scientific principles, allowing the estimation of Urban Road Networks size and the elaboration of maintenance programs and relevant budgets in an accurate and efficient method that ensures goals achievement. Budge of maintenance contracts depend on maintenance decision and its cost for pavement and non-pavement elements like median and sidewalks, but only some of PMS contents non-pavement elements evaluation, maintenance and cost. So that, we developed a Road Asset Management System (RAMS) which contents pavement and non-pavement elements management system. The aim of this paper is to provide an overview of the benefits of the Urban Non-pavement Maintenance Management System (UNPMMS) in general and presents the methodologies adopted for developing a UNPMMS for median and sidewalks.

**Key words:** *Non-pavement Management System, Maintenance and Repair, Priorities, Asset Management Systems, Decision Tree, Maintenance Materials.*

## INTRODUCTION

The non-pavement elements which located on the road means complementary to the function of the road and its goal of serving the road users and pedestrians and help them to reach their goals quickly and easily and safety, so it had to be of interest in these elements and maintenance of damage so keep the road in good condition and safe at the same time.

The preservation of existing roads and streets has become a major activity for all levels of government. Deteriorating urban roads and reduced funding are major problems for local governments. One proven method to obtain maximum value of the available funds is through the use of an Asset management system (AMS) (Lee, H. and W.R. Hudson, 1985).

Transportation asset management is a set of concepts, principles, and techniques leading to a strategic approach to managing transportation infrastructure (AASHTO, 2011). Transportation asset management enables more effective resource allocation and utilization, based upon quality information and analyses, to address facility preservation, operation, and improvement (AASHTO, 2011).

Traditionally, a PMS is defined as a set of decision support tools used in the pavement management process to help make systematic decisions about pavements in a structured manner (Smith, R.E. and J.P. Hall, 1994).There are three main components for any pavement or non-pavement management system to be reliable, an efficient decision policy, and an appropriate optimization method (Abdulwahed, H., 2010).

### *2. Methodology:*

A methodology was developed to integrate different subsystems into a systematic non-pavement management system. These subsystems are non-pavement features coding, visual evaluation, maintenance and repair strategy selection, maintenance priority ranking, and reporting as shown in figure (1). The system is customized computer software that is a knowledge-based. The UNPMMS was tested and implemented. The implementation activities included a review and evaluation of data collection procedures, a development of evaluation manual, and preparation of the software documentation.

Several information was collected about all pavement and non-pavement elements, needs and expectations in addition to the network size. Consequently, a questionnaire was prepared and distributed to all municipalities. These data include the following:

- Pavement and non-pavement elements.
- Coding and definition system.
- Distress and evaluation methods.

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- Available material and maintenance techniques and its related cost,
- Methodologies of the network pavement condition evaluation, and
- Available PMS, UNPMMS and its concepts.
- Organization Structure of the Maintenance Departments and its capabilities.

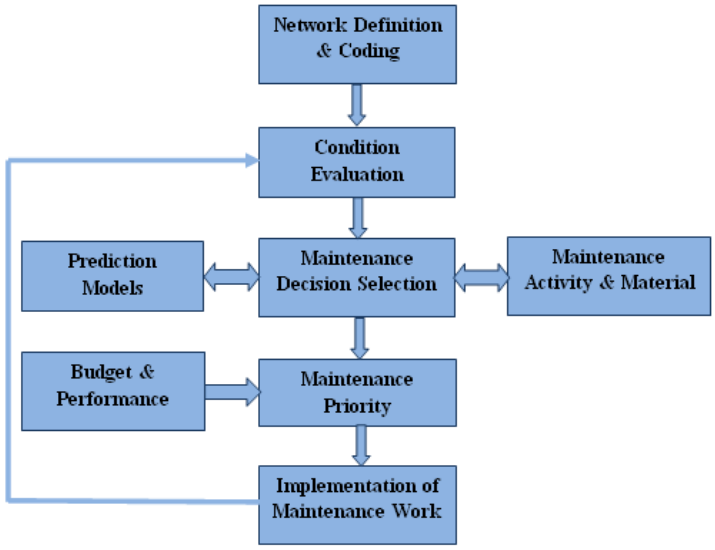



**Fig. 1:** Non-pavement Maintenance Management System Methodology.

***3. Development of Non-Pavement Management System:***

The following requirements were considered during the development of the suggested non-pavement management system:

1. The system should be comprehensive and easy to implement for data collection,
Entry, processing, and report generation.
2. The system should be implemented and capable to integrate with other existing systems.
3. The system should be modular and upgradeable for new addition of capabilities in the future.

Based on these requirements, network coding and definition, condition evaluation method, maintenance activity selection procedure, maintenance priority ranking procedure, and other system activities were reviewed and developed. A computer program was coded and compiled using the Visual Basic language and customized as Windows-based software. The software was fully developed as Windows-based application using a full-featured graphical user interface. The following paragraphs explain the suggested UNPMMS parameters.

***3-1. Coding:***

Is defined data of any kind, in order to link such data be placed on the road, we have to define the elements of non-pavement of reference of the sections on the road no. distinguishes these elements from each other and help in the recovery of such data or information required by item number. We have been to identify those non-pavement elements and identify them by adding two-digit code (as feature code) next to the numbering of the private section as shown in Figure (2). For a section code each city is divided into different areas. Roads in each area are also divided into uniform sections. A pavement section is further divided into features that specify the portion of the pavement segment to be considered for condition survey. Each feature in the pavement network is given an identification code (i.e. each municipality, city, area, section and sample given an identification code). Table no (1) shown Features code descriptions.

**Table 1:** Features Code Descriptions.

| Group Description | Feature No | Feature Short Name | Feature Description |
|---|---|---|---|
| Median | 01 | MC | Median Center |
| | 02 | ML | Median Left |
| | 03 | MR | Median Right |
| | 04 | MI | Median Intersection |
| Sidewalks | 05 | SWR | Sidewalk Right |
| | 06 | SWL | Sidewalk Left |
| | 07 | SWI | Sidewalk Intersection |

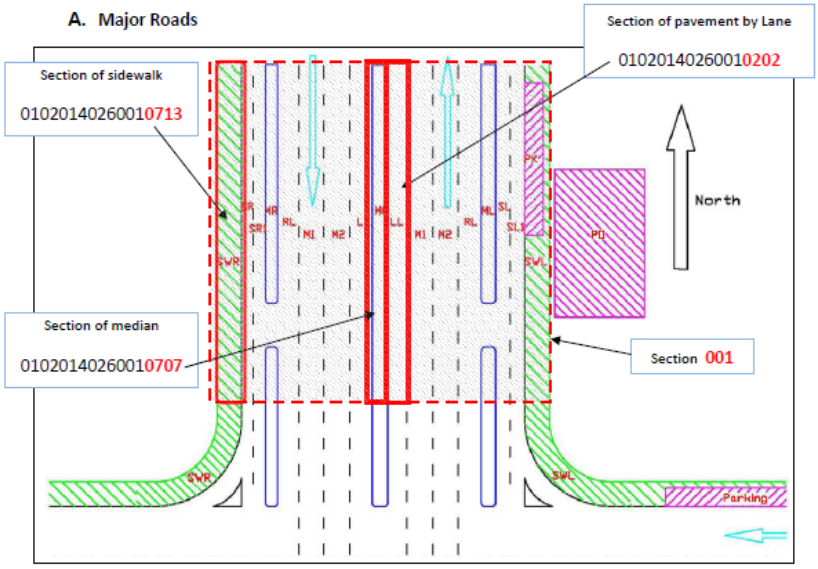



**Fig. 2:** Non-Pavement Definition and Coding System.

***3-2. Evaluation Methodology:***

Development of PMS depends on the methodology of how to obtain the decision of maintenance. So, the main activity in any PMS is the pavement evaluation to determine the appropriate maintenance type. The PMS has several ways to get the maintenance decisions based on field measurements available for each system (Hass, R., 1994). In this study, we developed a method to develop the methodology to evaluate the median and sidewalks and determine its appropriate maintenance decision based on visual inspection of them. The following include the definition of distress that appears non-pavement elements and how to measure and calculate the condition index of median and sidewalks.

- ***Median and Sidewalk Distress:***

Definition of distress is the first step to evaluate and determine the maintenance decisions. So, we took and evaluated many sections to determine the common distress which appear at non-pavement elements. Table no (2) shown the definition of the distresses that appear at median and sidewalks and its unit.

- ***Survey Procedures:***

Section of the sidewalk will be linked to the pavement section; section of the median will be linked to pavement section in the major direction. The whole section will be inspected. Figure no 3 shown median and sidewalk section and Figure 4 shown field surveying form

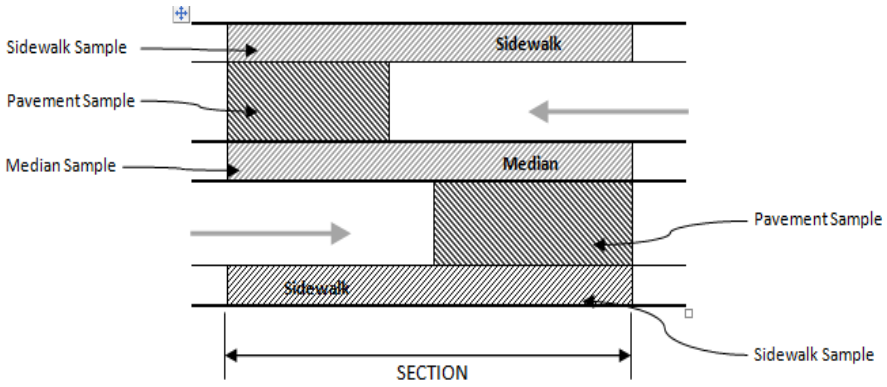



**Fig. 3:** Median and sidewalk section.

**Table 2:** Definition of median and sidewalks distress and its units.

| Distress No | Distress Description | Distress Photo | Distress Measurement Unit |
|---|---|---|---|
| 1 | Settlement = a localize portion of the median or sidewalk flooring is slightly depressed or level lower than the surrounding area. No severity considered |  | SQ. M |
| 2 | Damage/Broken = a portion of median, sidewalk, gutter are severely cracks, disintegrated or broken |  | SQ. M |
| 3 | Not Painted / Obliterated = no paint at all, paint flaking or less visibility |  | Meter Length |
| 4 | Swelling Base = A localize upward bulge in the tiles surface |  | SQ. M |
| 5 | Kerbstone Damage = Any Portion or partly of kerbstone broken |  | Meter Length |
| 6 | Kerbstone Disaligned = Kerbstone not in its original position |  | Meter Length |

- ***Median and Sidewalk condition Index Calculation:***

First, we calculate the distress density which calculate based on the values of distress and section area, as follows:

$$\textbf{Settlement Density (ST)} = \frac{Settlement\ Area}{Section\ Area} * 100 \quad (1)$$

$$\textbf{Swelling Density (SW)} = \frac{Swelling\ Area}{Section\ Area} * 100 \quad (2)$$

$$\textbf{Tile Damage Density (TD)} = \frac{Tile\ Damge\ Area}{Section\ Area} * 100 \quad (3)$$

$$\textbf{Kerbstone Damage Density (KDA)} = \frac{Damaged\ Length}{Section\ Length} * 100 \quad (4)$$

$$\textbf{Kerbstone Disaligned Density (KDS)} = \frac{Disaligned\ Length}{Section\ Length} * 100 \quad (5)$$

$$\textbf{No Paint Density (NP)} = \frac{No\ Paint\ Length}{Section\ Length} * 100 \tag{6}$$

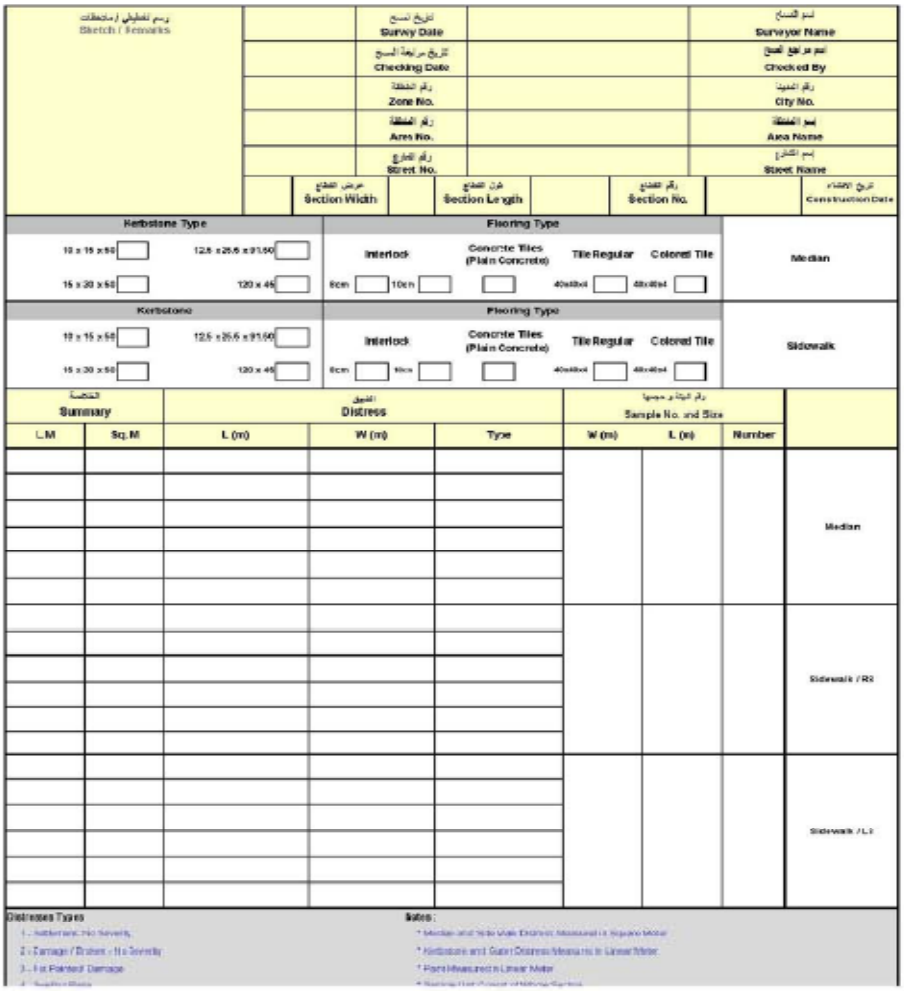


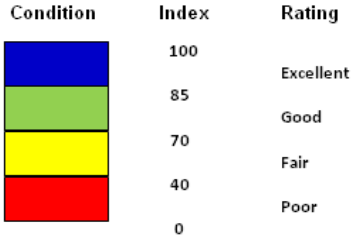

**Fig. 4:** Field Surveying Form.

- ***Section Condition Index (SCI):***

After calculating distress density and according to distress weight which was obtained from surveying questionnaire, we calculate the Section Condition Index (SCI) as shown in the following equation:

$$SCI = 100 - [0.2(ST) + 0.2(SW) + 0.4(TD) + 0.1(KDA) + 0.05(KDS) + 0.05(NP)] \tag{7}$$

Finally, we obtain the non-pavement rating according to the condition index as mention below



***3-3 Maintenance Activities:***

M&R treatments are generally considered for pavement and non-pavement maintenance based on the presence of distresses. Table (3) shows suggested M&R type. In M&R selection procedure each non-pavement distress is usually corrected by one or more M&R treatments based on its severity and extent levels. Based on M&R-distress matching adopted by different non-pavement maintenance methods (FHWA Pavement Management CATALOG, 2002) and based on the locally adopted procedures (Ministry of Transportation, 2004), a general matrix that matches the pavement distress with a specific M&R according to the severity and extent levels was prepared and shown in Table(4). The system allows the user to update the M&R selection strategies for any specific distress by selecting the specific non-pavement distress and updating its corresponding M&R treatments.

**Table 3:** Suggested M&R type.

| No. | M&R Type |
|---|---|
| 1 | Do Nothing |
| 2 | Repair Tiles |
| 3 | Replacing Tiles |
| 4 | Repair Kerbstone |
| 5 | Replacing Kerbstone |
| 6 | Painting Kerbstone |
| 7 | Repair Flooring |
| 8 | Replacing Flooring |

**Table 4:** Decision Matrix.

| Distresses | ≤ 10 | > 10 - 30 | > 30 - 60 | > 60 |
|---|---|---|---|---|
| SW/Median | | | | |
| Settlement | 1 | 7 | 7 | 8 |
| Damage | 2 | 2 | 2 | 3 |
| Paint | 1 | 1 | 1 | 6 |
| Kerbstone | | | | |
| Disaligned | 2 | 4 | 4 | 4 |
| Damage | 2 | 5 | 5 | 5 |

After determination the maintenance decision, if M&R density is more than certain number, it is circulated to all section. The maintenance global rules is shown in table (5).

**Table 5:** Maintenance Global Rules.

| IF M&R | IS GREATER THAN (% OF THE SECTION AREA)* | THEN APPLY M&R TO THE WHOLE AREA OF SECTION |
|---|---|---|
| 7+8 | 70 | 8 |
| 7 | 70 | 7 |
| 6 | 60 | 6 |
| 5+4 | 70 | 5 |
| 4 | 60 | 4 |
| 2+3 | 60 | 3 |
| 2 | 70 | 2 |

- This certain number is different from agent to other

May be there is many M&R section may require more than one type of maintenance at the same time, according to widespread distresses. The system was developed for the selection of the final maintenance that could serve other types of maintenance; some types of maintenance must be done at the same time simultaneously. Table (6) shows the method used to determine the final maintenance and which are sequentially until reaching the maintenance of one or more of a general need for any section.

**Table 6:** Maintenance Overriding Matrix.

| | M&R1 | M&R2 | M&R3 | M&R4 | M&R5 | M&R6 | M&R7 | M&R8 |
|---|---|---|---|---|---|---|---|---|
| M&R1 | 1 | | | | | | | |
| M&R2 | 2 | 2 | | | | | | |
| M&R3 | 3 | 3 | 3 | | | | | |
| M&R4 | 4 | 2+4 | 3+4 | 4 | | | | |
| M&R5 | 5 | 2+5 | 3+5 | 5 | 5 | | | |
| M&R6 | 6 | 2+6 | 3+6 | 4+6 | 5+6 | 6 | | |
| M&R7 | 7 | 7 | 7 | 4+7 | 5+7 | 6+7 | 7 | |
| M&R8 | 8 | 8 | 8 | 4+8 | 5+8 | 6+8 | 8 | 8 |

***3-4 Priority Evaluation:***

Practically, several constraints are considered during the distribution of budget. Techniques of formal optimization will be necessary to identify the most cost-effective strategies that meet all the specified constraints. The optimization models will also provide the ability to perform systematic sensitivity analysis to address what if questions – What if available budgets change or what if the desired performance goals for different facilities change.

For our system, we make the non-pavement maintenance priority related to pavement section priority. The composite maintenance priority index was the method selected for pavement maintenance priority ranking procedure. This method is relatively simple and gives close to optimal results (Shahin M.Y., 2005), and has been adopted by many PMS systems. The composite index method considers several factors that affect the priority ranking. Each of these factors has a specific weight of importance to the priority ranking.

***4. Conclusion & Recommendation:***

In this study, a Non- Pavement Management System was developed to manage the urban non pavement roads network (median and sidewalks), and provide an overview of the benefits of the Urban Non-pavement Maintenance Management System (UNPMMS) in general. The system includes non – pavement element coding, Evaluation Methodology, and Maintenance Activities

Also, the following can be recommended:-

1. The developed system has to be tested during implementation for further improvement.
2. The definition of distress has to be updated according to every zone.
3. The maintenance activities have to be updated to include all new materials and applied techniques.
4. The non-pavement maintenance priority has to be developed and not to be related to pavement section priority.
5. The maintenance cost has to be developed to make comparison between maintenance decisions.

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