

Development of Distress Management System for Asphalt Concrete Roads in Kenya

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Abstract

Developing Countries are losing road networks as a result of deterioration and disintegration due to traffic loads and harsh climate conditions. Roads network are highly characterized by; under maintenance, series of defects, and are impassable,

A times cost of restoring pavement is above the cost of maintenance. The proposed system is a game changer as it; aids in timely maintenance of the asphalt concrete roads; significant improvement in service delivery; saves resources for other investment; prolonged roads service life amongst others, more so its developed using visual basic programming language as it's easy to learn and use.

The data base captures; name and number of road segment, distresses available, nature, maintenance measures on each distress, cost of maintenance, and the maintenance contractor.

The developed system is tested and validated by evaluating the Asphalt pavement surface condition of Bombolulu –Kisauni loops code BU15-MBS in Mombasa County.

It is expected that the developed system will be of great importance in management of Asphalt concrete by reducing paper works, bringing in efficiency and timely repairs of the networks in Kenya, hence added knowledge to asphalt concrete roads management approaches.

Keywords–Asphalt Concrete Roads (ACR), Distress Management (DM), Distress Management System (DMS), Visual Basic (VB), Present Conditioning Rating (PCR), Crack, Pavement distress, road maintenance, Pavement deterioration, Hot Mix Asphalt (HMA)

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I. Introduction

Asphalt concrete roads inevitably need to be resurfaced to avoid users endure poor conditions. Maintenance of road transportation infrastructure has become an increasingly important issue [1]. Traditional asphalt pavement maintenance approach adopts manual method, which has disadvantages, such as potential for mistakes to be made and the difficulty in transferring information digitally. In view of lack of effective real-time maintenance works, only commence after the tendering process is successfully complete [2]. In most cases the process takes a lot of time resulting to massive variations of works hence the government losing a lot of resources which would have been used to provide other key services. Which leads to the shortened service life of asphalt concrete pavements [3]. Distress management system is designed to manage maintenance and rehabilitation of Asphalt Concrete roads to optimize condition with each road segment assigned to a contractor given biannual maintenance contract or more. The contractor undertakes the maintenance immediately when distress in the asphalt road has been identified and the system has given out the remedial measure to be undertaken and the costings. The use of Pavement Management System is becoming increasingly more prevalent due to benefits achieved [4].

II. Development of Distress Management System

The objective is to develop computer distress management system in asphalt concrete roads.

This system automates the process of roads maintenance by capturing the necessary field data for the system to compute and give results.

The system also generates report such as bills of quantities for maintenance works to be carried on the asphalt concrete roads data.

2.1 Programing Language used.

The system is developed using visual basic 6.0 language with Micro Soft Access database, this is because the structure of the basic programming language is very simple and compatible with all operating systems both windows and Linux operating systems. More so; Visual Basic components can be integrated using with other systems; visual Basic is a programming language offering general ease of use and combined with ease of implementing a graphical user interface; it is relatively simplistic and therefore limited in function compared to more advanced programming languages and it is particularly easy to develop graphical user interfaces and to connect them to handler functions provided by the application [5].

2.2 System flow chart

System uses visual basic programming language. System flow chart diagram is presented in figure 2.0.

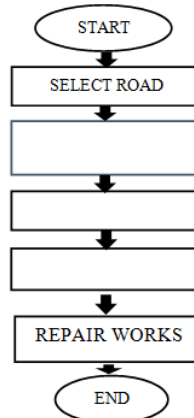


Fig.2.0 System flow chart diagram

2.3 System Modules

The system is made up of the following modules; roads definition module; contractor details; bid rates definition module; survey data capturing module; bills of quantities generating module; reporting module and system administration module.

2.3.1 Road defining module

This module entails capturing road information, including road name, width of the road, length of the road, start and end town etc. All this information has been shwon in the form below. Figure 2.3.1

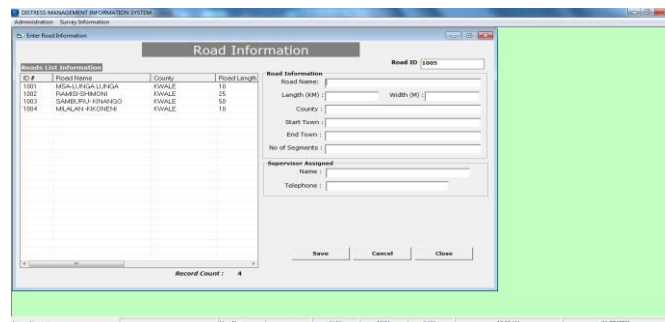


Figure 2.3. Road defining module

2.3.2 Adding new road details

To add new road details follow the following steps.

1. Click Survey information>Add New Road.

The form above will pop up.

2. Enter all the required information,
3. The click save button. The information of the road will be saved.

2.3.3 To edit road information.

To edit road information the following steps will be followed.

1. Click Survey information>Add New Road.
2. Select road to make changes from the list above.

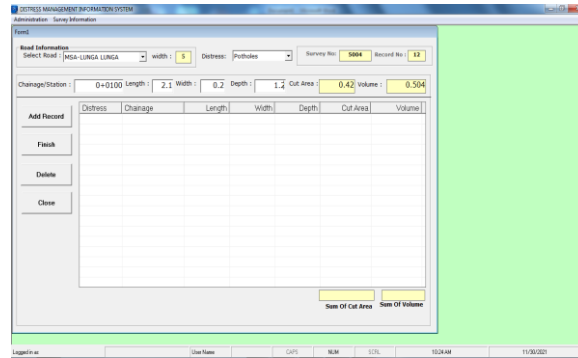


Figure 2.5.1 step 2, 3, 4, 5 of Road survey data capturing

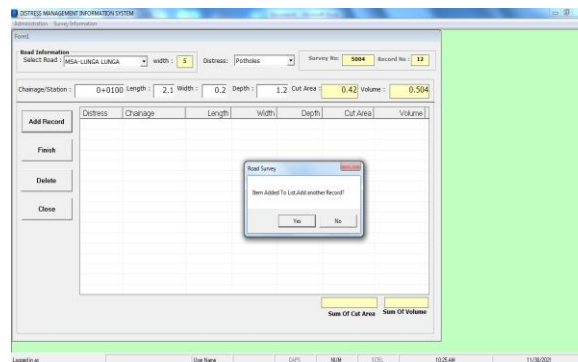


Figure 2.5.2 step 6 of Road survey data capturing

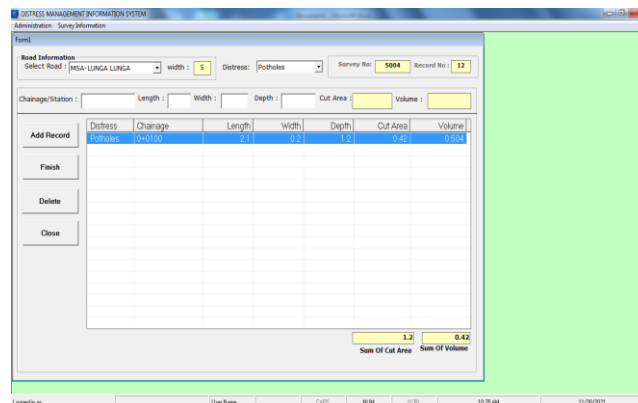


Figure 2.5 step 7 and 8 of Road survey data capturing

2.6. Contractors Details

The module is mainly used for giving details of a contractor who would be maintaining a particular road segments under biannual maintenance contract.

Figure 2.6 shows the content of the contractor’s details module.

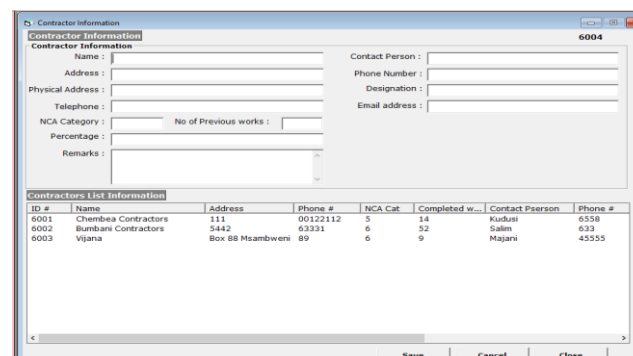


Figure 2,6 Contractors Details Module,

2.7 BQ Generating Module

This module is mainly for generating the BQ from the results survey data captured.

To access this module, follow the path below.

1. Click Survey information>BQ Generating
2. Select Road from the drop down
3. Enter the survey no and click **filter button**
4. The grid list will be populated with distress data collected.
5. Double click on each distress line.
6. Select DISTRESS from the drop down.
7. Select ITEM NO.
8. The system will compute the treatment value for each ITEM selected.
9. Click Add Item Button
10. Repeat the step 7 to 9 for the same distress, then start afresh for another distress type selected from step 5.

Once all distresses have be completed a BQ will be generated and displayed on the next tab.

The BQ can be printed as a report as shown in next page.

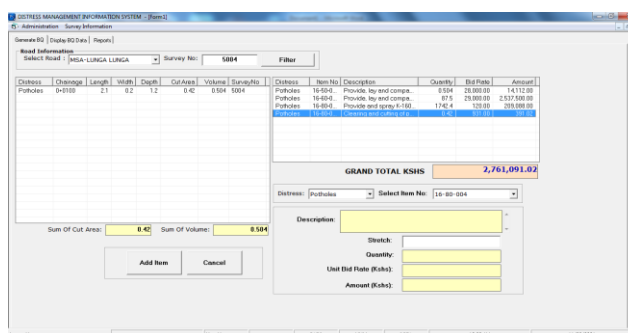


Figure: 2.7 BQ Generating Module

2.8 Reporting module

The system is capable of computing the survey data and generate Bills of quantity as per distresses noted and the Items for remedial measures.

1. Select Road
2. Enter Survey No
3. Click filter
4. Select contractor from the dropdown
5. Enter supervisor details
6. Click Generate report and print.

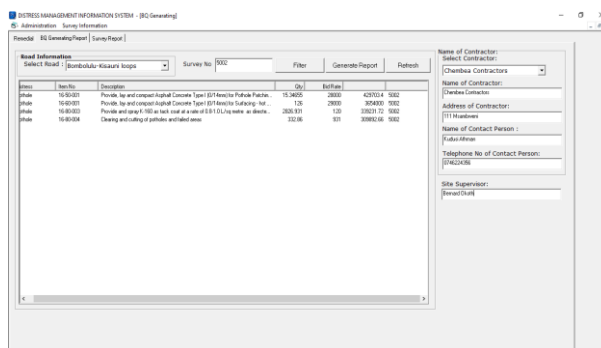


Figure: 2.8 Reporting Module

2.9 System Administration Module

This module is mainly granted user access and authorization to the system. Creating system users i.e., granting username and password.

To access this module, follow the path below.

1. Click Administration>User Account.
- The form shown below will pop up.
1. Enter the user information then click Add User

2. *The user details will be saved and displayed in the grid list.*
3. *User account is already created and can be used to login in the system.*

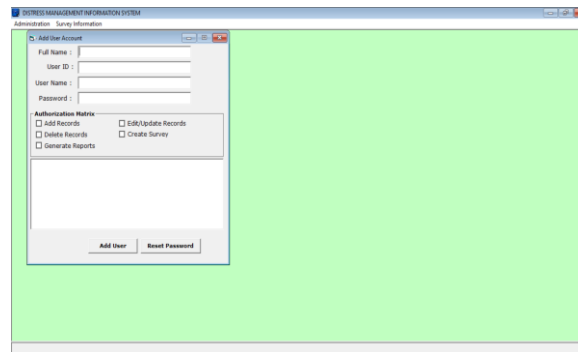


Figure: 2.9 System Administration Module

III. System Validation

The system was validated by carrying out asphalt concrete road assessment survey using two methods and compare the results. The two methods are the developed distress management system and the manual method.

3.1 Tools and equipment's.

The following tools and equipment were used to validate the developed system.

1. Developed distress management system
2. Measuring Tape
3. Note book
4. Flat rule
5. Asphalt concrete road Assessment forms.
6. Traffic cone
7. Reflective jackets
8. Safety gears
9. Permit from Kura/ County Government

3.2 Procedure

Distress assessment in asphalt concrete was carried along the Bombolulu – Kisauni loops code BU15-MBS in Mombasa County. The data on asphalt concrete distress is collected and recorded as follows in figure 3.3, more so typical distresses along the surveyed are as shown in figure 3.1 and 3.2 below.



Figure 3.1 Distresses along the surveyed road



Figure 3.1 Distresses along the surveyed road

3.3. Data Analysis and reporting

Data collected was analyzed and presented in figure below. 3.3 below.

CHAINAGE/ STATION	LENGTH	WIDTH	DEPTH
0+000	4	3	0.05
0+022	7	5	0.05
0+025	5	3.2	0.03
0+028	3.1	3.1	0.03
0+032	4.2	2	0.04
0+035	2.5	2.1	0.04
0+080	5	2	0.05
0+185	0.5	0.5	0.04
0+190	3	3	0.05
0+220	4	2	0.04
0+360	2	1	0.05
0+465	5	2	0.045
0+470	15	4	0.05
0+485	8	3	0.05
0+490	3	3	0.05
0+500	5	3	0.05
0+508	3	3	0.05
0+510	2.5	2	0.04
0+515	2	1	0.042
0+712	4	3	0.04
0+720	1	1	0.03
0+732	1.5	1.5	0.05
0+750	1.5	1.5	0.05
0+752	3	1.2	0.05
0+755	4	2.5	0.05
0+760	4	2	0.045
0+765	3	2	0.05
0+770	5	1	0.05
0+775	3.5	2.5	0.045
0+780	1	1	0.03
0+785	2	1.5	0.04

0+920	2	1.5	0.05
0+935	1.5	1	0.04
0+990	1	1	0.03
0+990	1	1	0.03
0+990	0.5	0.5	0.02
0+990	0.5	0.5	0.03
1+300	1.5	1.5	0.042
1+305	2	2	0.03
1+360	2	1.5	0.05
1+380	2.5	1.5	0.05
1+480	0.5	0.5	0.03
1+480	0.5	0.5	0.03

Figure 3.3 Chainage data collected

4.0 Data Analysis

4.1 Analysis and Reporting using the Arithmetic Method

Data collected on site was analyzed and a bills of quantity was prepared after one week as shown below Figure. 4.0 Below. [6].

Item No.	Description	Units	Quantity	Unit Bid Rate(Ksh)	Amount
16-50-001	Provide, lay and compact Asphalt Concrete Type I (0/14mm) for Pothole Patching - hot mix	M³	11.7	28,000.00	326,202.80
16-60-001	Provide, lay and compact Asphalt Concrete Type I (0/14mm) for Surfacing - hot mix	M³	151.2	29,000.00	4,384,800.00
16-80-003	Provide and spray K-160 as tack coat at a rate of 0.8-1.0 L/sq metre as directed by the Engineer	L	3257.0	120.00	390,840.24
16-80-004	Clearing and cutting of potholes and failed areas	M³	332.9	931.00	309,892.66
TOTAL					5,411,735.70

Figure 4.0 Bills of quantities for maintenance of Bombululu-Kisauni loops code BU15-MBS in Mombasa County.

4.1 Analysis and Reporting using Distress Management System

Data collected on site was analyzed and report generated as shown in Figure 4.1 below.

Bills Of Quantity

Road Name: MSA-LUNGA LUNGA Road ID: 1001 Survey No: 5002
Contractor: Chembea Contractors Address: 111 Msambweni Contact Person: Kudusi Athman Telephone: 0746224356
Dated: Wednesday, March 23, 2022

Distress	Item	Treatment/Remedial	Qty	Bid Rate	Subtotal
Pothole	16-60-001	Provide, lay and compact Asphalt Concrete Type I (0/14mm) for Pothole Patching - hot mix	15,34655	28,000.00	429,703.40
Pothole	16-60-001	Provide, lay and compact Asphalt Concrete Type I (0/14mm) for Surfacing - hot mix	126	29,000.00	3,654,000.00
Pothole	16-80-003	Provide and spray K-160 as tack coat at a rate of 0.8-1.0 Litre/metre as directed by the Engineer	2826,931	120.00	339,231.72
Pothole	16-80-004	Clearing and cutting of potholes and failed areas	332.86	931.00	308,892.66
Grand total Amount					4,732,827.78

Supervisor Name: Moses Kamau
Signature: _____ Date: _____

Figure 4.1 DMS Report for maintenance of Bombululu-Kisauni loops code BU15-MBS in Mombasa County.

The report was generated by the system immediately, and captures the name contractor to undertake the works. More so captures the name of Road inspector to supervise the works as required.

IV. Discussion

The Distress Management system provides timely reports, and instantaneous commencement of works hence there is saving of time, efficiency in maintenance and repairs of asphalt concrete road segments, hence resulting to cost cutting and savings as compared to Arithmetic approach.

In Arithmetic method the bills of quantities are prepared after a week or so depending on office workload. After the bill of quantities are proposed works are advertised and after successful process which is time consuming the works are awarded to a winning bidder for implementations. The works might be subjected to various amendments as the implementations of works is done later after the assessment of the road infrastructure is done. Hence the maintenance and repair works proves to be very expensive under taking compared to earlier projections projected after assessment of works. This results to un timely completion of works leading to continuous degradation of road segments.

V. Recommendation and Conclusion

The developed system is a game changer and can impact positively the management of Asphalt concrete roads infrastructures in Kenya as it has competitive edge over the Arithmetic method.

The Distress Management System can be piloted by various urgency and its benefits is enormous, from time saving in; preparation of bid documents, identification of contractor to undertake the works. Effective maintenance and repairs of Asphalt concrete roads as works are carried out in time as required hence saving costs, increase life span of the road segments and minimize wastefulness which characterizes the Asphalt concrete roads sector.

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