PROPOSAL FOR LIBYA’S BRIDGE MANAGEMENT SYSTEM (BMS)

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الملخص

تعتبر الجسور من أهم المكونات الرئيسية لشبكة الطرق حيث تنفق وزارتي المواصلات الإسكان والمرافق في ليبيا الكثير من الأموال للحفاظ على قوام هذه الجسور وعملها بطريقة فعالة وسلسة للاستعمال. من جهة أخرى لا تعتمد الأجهزة المسؤولة عن تشغيل وإدارة الجسور في ليبيا إجراءات محددة أثناء تقييمها لحالة الجسور سواء من ناحية تأهيلها للصيانة أو إعادة ترميمها أو إستبدالها بعناصر إنشائية أخرى. لذلك يجب اعتماد وتطوير نظام جديد لإدارة الجسور لدعم خطط التطوير والصيانة من قبل الجهات ذات العلاقة فضلا عن اتخاذ القرارات لتعمل الجسور بكفاءة عالية وبطريقة منظمة كما يساعد هذا النظام على تحديد وتقدير الإصلاحات اللازمة للحفاظ على الجسور لتعمل على نحو فعال إلى جانب ترتيب أولوية الجسور حسب الحاجة للصيانة أو إعادة التأهيل أو الاستبدال.

لخصت هذه الدراسة بتجميع أغلب البيانات المهمة والأساسية لتأسيس قاعدة بيانات للجسور الواقعة في مدينة طرابلس كنواة لتطبيق نظام إدارة الجسور في ليبيا وتم فحص وتجميع بيانات جسرين للمفاضلة بينهما وترتيبهما أولويا من ناحية معالجتها أو صيانتها أو إعادة تأهيلها وفي بعض الأحيان إستبدالها.

ABSTRACT

Bridges can be considered the main important components of the road network and represent a very large investment. Libyan transportation authority’s spends large amount of funds to keep bridges operate in an efficient way. The agencies responsible for Libya’s bridges have no procedure for ranking bridges for maintenance, rehabilitation and replacement. The proposed Bridge Management System BMS is expected to provide Bridge Owner’s/ Engineers with a reliable tool to help in managing and prioritizing bridges according to their needs for rehabilitation. This making sure that the available financial resources (Funds) has been spent wisely while keeping bridge safe and functional.

By adopting and developing a new BMS which supports the relative authorities in Libya by assisting maintenance planning as well as decision making of bridges to operate efficiently in a systematic way, also helps to identify and estimate the repairs required to keep bridges operate effectively besides ranking them to priority of work, and performing optimal maintenance and replacement actions. The objective of this paper is to collect all important data to establish a database of bridges located in Tripoli. The data of two bridges were collected and they are inspected to compare and rank them in the priority of work. The results showed that one bridge is qualified for government replacement funding and the other for rehabilitation funding.

KEYWORDS: Bridge Management System; Bridge Inventory; Inspection Report; Pontius.

INTRODUCTION

Bridges are considered to be the most important component of the road network and represent a very large investment. Many of bridges need strengthening and treatment or replacement and this will cost a lot of money.

This valuable investment needs to be managed properly to minimise the total cost of the road network, this has increased the requirements for a proper and an effective management tools to operate the infrastructure in an efficient way and to minimise the total costs of the road network.

There is a way for improving efficiency and effectiveness of the present inspection and maintenance programmes for bridges and to apply a more organised and uniform standard for the bridge stock in Libya. We can achieve all these improvements by adopting and developing a new Bridge Management System (BMS), which has become increasingly important to support the development of the country.

This proposed BMS is expected to provide Bridge Owner's/ Engineers with a reliable tool that supports the relative authorities policies by assisting maintenance planning as well as decision making of bridges to operate efficiently in a systematic way, also it helps to identify and estimate the repairs required to keep bridges operate effectively besides ranking them to priority of work besides help in managing and prioritizing bridges according to their needs for rehabilitation. and performing optimal maintenance and replacement actions. In general the proposed BMS should consist of following components:

- Database system.
- Inspection system.
- Decision making system which based on maintenance policy and deterioration prediction.

RESEARCH OBJECTIVES

The purpose of BMS proposed in this dissertation is to establish a unified database for the existing bridges in Libya, this database contains all necessary information such as bridge identifying information, bridge type and classification, age and service, Geometry data, condition data, appraisal data and inspection data. These information's will be primary for the analysis and the evaluation for the operating bridges and will finally help in making the right decision regarding the maintenance and the associate cost. The proposed Libya's BMS provide the relative authorities with the following:

- Provide a record of all bridges in national road network.
- Keeps the available stock of bridges safe and functional.
- Minimise bridge funding to a minimum level.
- Provide a tool to rank and prioritise bridges which need to be maintained or replaced.
- Provide a cost estimate of repair over time.
- Make standard procedures for all bridge service.

EXISTING BMSs

BMS consists of formal procedures for analyzing bridge data for the purpose of predicting future bridge conditions, predicting maintenance and improvement needs, determining optimal policies, and recommending projects and schedules within budget and policy constraints [1]. In most of the countries, the BMS is used to manage bridges on the National Highway Network and all main roads. A review is made to some of BMSs used around the world. Many countries worldwide are using bridge systems Canada, Japan and USA known to be well advanced in BMS [2]. More than 20 BMSs used in 16 countries around the globe is summarised in Table (1).

Table 1: Twenty one Bridge Management Systems used worldwide

No.	Country	System Name	System abbreviation	First version
1	Canada	Ontario Bridge Management System	OBMS	2002
2	Canada	Quebec BMS	QBMS	2008
3	Canada	EBMS	EBMS	2006
4	Canada	PEIBMS	PEIBMS	2006
5	Denmark	DANBRO BMS	DANBRO	1975
6	Finland	The Finish BMS	FBMS	1990
7	Germany	Bauwerk Management System	GBMS	N/A
8	Ireland	Eirspan	Eirspan	2001
9	Italy	Autonomous Province of Trento BMS	APTBMS	2004
10	Japan	Regional Planning Institute of Osaka BMS	RPIBMS	2006
11	Korea	Korea Road Maintenance Business System	KRBMS	2003
12	Latvia	Lat Brutus	Lat Brutus	2002
13	Netherland	DISK	DISK	1985
14	Poland	SMOK	SMOK	1997
15	Poland	SZOK	SZOK	2001
16	Spain	SGP	SGP	2005
17	Sweden	Bridge and Tunnel Management System	BaTMan	1987
18	Switzerland	KUBA	KUBA	1991
19	USA	Bridgit	Bridgit	1993
20	USA	Pontis	Pontis	1992
21	Vietnam	Bridgeman	Bridgeman	2001

Pontius is the most recognised system throughout the world, this software is currently licensed through the American Association of State Highway and Transportation Officials (AASHTO) to over 46 state Departments of Transportation and other agencies [3] also it's been licensed internationally to some countries e.g. Kuwait, Hungary and Estonia [4].

IMPLEMENTING A NEW BMS IN LIBYA

The agencies responsible for Libya's bridges have a random process with no strategy considering ranking bridges for maintenance, rehabilitation and replacement. Since our country lacks any history of bridge data records, this has lead to disordered maintenance and rehabilitations without giving priorities to the bridges which needs work the most.

In order to fill this gap and to bring radical changes in transportation management we highly demand to establish a BMS that operates the infrastructure of bridges in an efficient way.

Establishing a BMS that will enable planning to be carried out in a systematic way and provides uniform procedures for all bridge activities at all levels [5]. This will lead to protecting the significant investment in bridges, save resources and direct them to be spent on the bridges of most need.

The main objectives of this system are to setup a database for every bridge, identify bridges for treatment, to provide an efficient management tool for all aspects of decision making, and to rank bridges in a priority order for work's programming.

With applying BMS it will assist maintenance management planning and decision making of work, plus it will help optimizing the use of funds available for bridge works, and enables to identify and prepare treatments needed to keep bridges functioning [6].

Libya's Bridge Inventory (LBI)

A Bridge Inventory is a collection of key information used to identify and characterize the type, usage, size, location, and condition of each bridge [7]. This inventory is developed to have a unified database for including the identification information, bridge types and specifications, operational conditions, and bridge data including geometric data, functional description, inspection data, etc [8].

After reviewing some of the coding guides, the FHWA's recording and Coding Guide [9] & Illinois Highway Information System [10] are taking as a main guide for LBI coding, this is due to its large collected data from each bridge also for future considerations this guide will ease up implementing a comprehensive computerised BMS. The proposed LBI consists of three major reports each report contains information regarding the bridge condition from different prospects:

- Inventory / Status Report.
- Route / Construction Information Report.
- Inspection Report.

These three reports displayed in Table (2). Each item on these three reports are not explained due to the restricted limited page length for the paper.

Table 2: The three proposed reports for collecting Bridge Data

Inventory / Status Report			
Structure Number:		Bridge Name:	
Facility Carried:		Longitude:	
Feature Crossed:		Latitude:	
Location:		Parallel Designation:	
District:		Deck Width:	
Service On/Under:		Deck Type/Thickness:	
Structure Length:		Longest Span Length:	
Bridge Roadway Width:		Number of Spans Main / approach	
Bridge Median Type:		Main Span Material/Type:	
Bridge Median width:		Approach Span Material/Type:	
Sidewalk Width Right:		Type of Wearing Surface:	
Sidewalk Width Left:		Substructure Material:	
Sidewalks Under Structure:		Number of Culvert Cells:	
Guardrails On (Right):		Culvert Cell Width:	
Guardrails On (Left):		Culvert Cell Height:	
Replaced By Structure:		Culvert Opening Area:	
Replaces Structure Number:		Design Load:	
Approach Roadway Width:		Inventory Rating:	

Route / Construction Information Report			
Year:		Sufficiency Rating:	
Construction Remarks		Bridge Status Date:	
Bridge Remarks:		Bridge Status:	

Key Route On		**Key Route Under**	
	Municipality:		
Functional class:		Functional class:	
Number of lanes:		Number of lanes:	
One or Two way traffic:		One or Two way traffic:	
Max Single Roadway width:		Max Single Roadway width:	
ADT/ Year:		Vertical clearance	
Detour Length:			

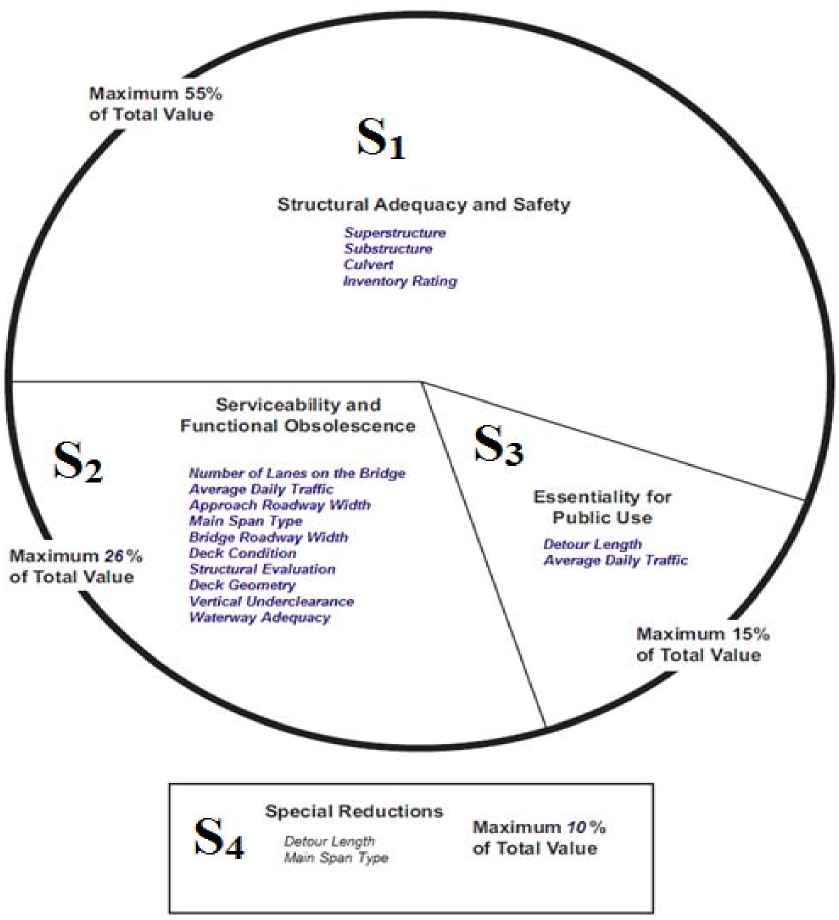
Inspection Report	
Inspection Date:	
Inspection Temperature (Celsius):	
Inspector Name:	
Deck Condition:	
Superstructure Condition:	
Substructure Condition:	
Culvert Condition:	
Waterway Adequacy:	
Structural Evaluation:	
Deck Geometry:	
Underclearance:	

Sufficiency Rating Formula

The sufficiency rating formula is a method of evaluating bridge data by calculating four separate factors to obtain a numeric value which is indicative of bridge sufficiency to remain in service which is essentially an overall rating of a bridge's fitness for the duty that it performs [11]. Figure (1) shows summary of sufficiency rating factors.

The sufficiency rating helps determine which bridges may need repair or replacement, not which bridge could collapse also it doesn't necessarily indicate a bridge ability to carry traffic loads.

A sufficiency rating of a bridge affects its eligibility for government funding for maintenance, rehabilitation, or replacement activities. For bridges to qualify for government replacement funds, they must have a rating of 50 or below. To qualify for government rehabilitation funding, a bridge must have a sufficiency rating of 80 or below.



$$\textbf{Sufficiency Rating} = \left[\frac{(S1 + S2 + S3)\times 100}{96} - \frac{S4\times 13}{10}\right]$$

Figure 1: Summary of Sufficiency Rating Factors

1. Structural Adequacy and Safety (55% maximum):
a. Only the lowest rating code of (Superstructure Condition) (Substructure Condition) (Culvert Condition) applies:

If (Superstructure Condition) or (Substructure Condition) is:			
	≤ 2	then	A=55%
	= 3		A=40%
	= 4		A=25%
	≥ 5		A=10%
If (Superstructure Condition) and (Substructure Condition) = N.A and (Culvert Condition) is:			
	≤ 2	then	A=55%
	= 3		A=40%
	= 4		A=25%
	≥ 5		A=10%

b. Reduction for Load Capacity:

Calculate using the following formulas where IR is the Inventory Rating (MS Loading) in metric tons:

$B = (32.4 - IR)^{1.5} \times 0.3254$ or

If $(32.4 - IR) \leq 0$, then $B = 0$

"B" Shall not be less than 0% nor greater than 55%.

$\mathbf{S_1 = 55 - (A+B)}$

S_1 shall not be less than 0% nor greater than 55%.

2. Serviceability and Functional Obsolescence (26% maximum):
a. Rating Reductions (11 maximum):

If (Deck Condition) is	≤ 3	then	A= 5%
	= 4		A= 3%
	≥ 5		A= 1%
If (Structural Evaluation) is	≤ 3	then	B= 4%
	= 4		B= 2%
	≥ 5		B= 1%
If (Deck Geometry) is	≤ 3	then	C= 4%
	= 4		C= 2%
	≥ 5		C= 1%
If (Underclearance) is	≤ 3	then	D= 4%
	= 4		D= 2%
	≥ 5		D= 1%
If (Waterway Adequacy) is	≤ 3	then	E= 4%
	= 4		E= 2%
	≥ 5		E= 1%

$J = (A + B + C + D + E)$

J shall not be less than 0% nor greater than 11%.

b. Width of Roadway Insufficiency (15% maximum)

Use the sections that apply:

(1) Applies to all bridges;
(2) Applies to 1-lane bridges only;
(3) Applies to 2 or more lane bridges;
(4) Applies to all except 1-lane bridges.

Also determine X and Y:

$$X\ (ADT/Lane) = \frac{(ADT)}{(\text{number of Lanes})}$$

$$Y\ (Width/Lane) = \frac{(Bridge\ Rdwy.Width)}{(number\ of\ Lanes)}$$

(1) Use when (Main Span Type) is not a Culvert:

If (Bridge Roadway width+0.6 meters) < (Approach Roadway Width) then F= 5% else F=0%

(2) For 1-Lane bridges only, use the following:

If (number of Lanes) are equal to 01 and

$Y < 4.3$	then	G = 15%
$5.5 > Y \geq 4.3$		$G = 15\left[\frac{15-Y}{1.2}\right]$ %
$Y \geq 5.5$		G = 0%

(3) For 2 or more lane bridges. If the limits below apply, do not continue on to (4) as no lane width reductions are allowed.

If	number of Lanes = 02	and	$Y \geq 4.9$,	G = 0%
If	number of Lanes = 03	and	$Y \geq 4.6$,	G = 0%
If	number of Lanes = 04	and	$Y \geq 4.3$,	G = 0%
If	number of Lanes $\geq$ 05	and	$Y \geq 3.7$,	G = 0%

(4) For all except 1-lane bridges, use the following:

If	$Y < 2.7$	and	$X > 50$	then	G = 15%
	$Y < 2.7$	and	$X \leq 50$		G = 7.5%
	$Y \geq 2.7$	and	$X \leq 50$		G = 0%
If	$50 < X \leq 125$	and			
	$Y < 3.0$	then			G = 15%
	$4.0 > Y \geq 3.0$				G = 15(4-Y)%
	$Y \geq 4.0$				G = 0%
If	$125 < X \leq 375$	and			
	$Y < 3.4$	then			G = 15%
	$4.3 > Y \geq 3.4$				G = 15(4.3-Y) %
	$Y \geq 4.3$				G = 0%
If	$375 < X \leq 1350$	and			
	$Y < 3.7$	then			G = 15%
	$4.9 > Y \geq 3.7$				$G=15\left[\frac{4.9-Y}{1.2}\right]$ %
	$Y \geq 4.9$				G = 0%
If	$X > 1350$	and			
	$Y < 4.6$	then			G = 15%

$4.6 \leq Y < 4.9$ $\qquad$ $G = 15\left[\frac{4.9-Y}{1.2}\right]\%$

$Y \geq 4.9$ $\qquad$ G=0%

F + G shall not be less than 0% nor greater than 15%.

$\mathbf{S_2 = 26 - (J + F + G)}$

S_2 shall not be less than 0% nor greater than 26%.

3. Essentiality for Public Use (15% maximum)

a. Determine:

$$K = \frac{S1 + S2}{81}$$

b. Calculate:

$$A = 15\left[\frac{(ADT)\times(Detour\ Length)}{320{,}000\times K}\right]$$

"A" shall not be less than 0% nor greater than 15%

$\mathbf{S_3 = 15 - A}$

S_3 shall not be less than 0% nor greater than 15%

4. Special Reductions (Use only when $S_1 + S_2 + S_3 \geq 48\%$)

a. Detour Length Reduction, use the following:

$A = (\text{Detour Length})^4 \times (7.9 \times 10^{-9})$

"A" shall not be less than 0% nor greater than 5%.

b. If (Main Span Type) is "Cable Stayed" ; then

B = 5%

else B=0%

$\mathbf{S_4 = A + B}$

S_4 shall not be less than 0% nor greater than 10%.

$$\therefore \textbf{Sufficiency Rating} = \left[\frac{(S1 + S2 + S3)\times 100}{96} - \frac{S4\times 13}{10}\right]$$

The Rating shall not be less than 0% nor greater than 100%

Inspection Forum

There are five basic types of bridge inspections [12]:

1) Initial inspections:
The first inspection of a bridge to determine baseline structural conditions.

2) Routine inspections.
This type of inspection is conducted almost every two years.

3) Damage (emergency) inspections:
Unscheduled inspection to evaluate structural damage resulting from environment or human actions.

4) In-depth inspections:
A close up inspection of one or more members to identify deficiencies.

5) Special inspections:
Used to monitor a known or suspected deficiency.

To do an initial inspection to determine the baseline of every bridge condition a bridge inspection report forum is created Table (3) using rating Tables (4) & (5) which they have been established by FHWA [9].

Table 3: Bridge inspection report forum

Bridge Inspection Report

Structure Number: ________________ Bridge Name: ___________

Temperature: _____ C^0 Inspection Date: ___/____/___

Insp. Team Leader: _________________

Inspector Names: __________________ ______________________

		Rating weight:	Comments:
Deck			
Deck Condition:		10	
Wearing Surface* :		5	
Parapets / Bridge Railings* :		5	
Curbs* :		5	
Median* :		5	
Sidewalks * :		5	
Drain System * :		5	
Expansion Joints * :		5	
Superstructure			
Superstructure Condition:		10	
Bearing * :		5	
Girders / Beams / Stringers * :		5	
Diaphragms / Braces * :		5	
Trusses / Portals / Bracing * :		5	
Rivets / Bolts * :		5	
Paint * :		5	
Substructure			
Substructure Condition**:		10	
Abutments:		10	
Piers:		10	
Paint* :		5	

* Use General element ratings table 3 ** Use the minimum rating between Abutments and Pier

Table 4: General condition ratings [9]

Description	Code
N.A	**NOT APPLICABLE**
9	**EXCELLENT CONDITION**
8	**VERY GOOD CONDITION** - no problems noted.
7	**GOOD CONDITION** - some minor problems.
6	**SATISFACTORY CONDITION** - structural elements show some minor deterioration.
5	**FAIR CONDITION** - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4	**POOR CONDITION** - advanced section loss, deterioration, spalling or scour.
3	**SERIOUS CONDITION** - loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	**CRITICAL CONDITION** - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	**"IMMINENT" FAILURE CONDITION** - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.
0	**FAILED CONDITION** - out of service - beyond corrective action.

Table 5: General element ratings [9]

Rating	Condition
5	New
4	Good
3	Fair
2	Poor
1	Needs Replacement
N.A	Not Applicable

CASE STUDY

A database was collected for more than 60 Bridges located in Tripoli, only two bridges will be taken as a case study in which the information of these bridges is gathered using the three reports in the proposed LBI after filling the inspection forum report Table (6) and (8), these rank and priorities which of these two bridges needs to be maintained or replaced first, Figures (2) and (3) show the two bridges from different views.

Since the information of design loads is unknown the Inventory Rating was assumed to help calculate the Sufficiency Rating Table (7) and (9).

Figure 2: A lower side view of Al Khazanat Bridge

Figure 3: A side view of Al Mahary Bridge

1- Al Khazanat Bridge

Table 6: Al Khazanat Bridge collected Inspection Report

Bridge Inspection Report

Structure Number:	001-024	Bridge Name:	Al Khazanat
Temperature:	17 C^0	Inspection Date:	28/12/2013
Insp. Team Leader:	Dr. Omran Kensheal		
Inspector Names:	Majed Aduwaeb	Eshbean Garib	

		Rating weight:	Comments:
Deck			
Deck Condition:	9	10	
Wearing Surface :	3	5	
Parapets / Bridge Railings :	3	5	
Curbs :	4	5	
Median :	4	5	
Sidewalks :	N.A	5	
Drain System :	4	5	
Expansion Joints :	3	5	
Superstructure			
Superstructure Condition:	8	10	
Bearing :	N.A	5	
Girders / Beams / Stringers :	4	5	
Diaphragms / Braces :	N.A	5	
Trusses / Portals / Bracing :	N.A	5	
Rivets / Bolts :	N.A	5	
Paint :	4	5	
Substructure			
Substructure Condition:	8	10	
Abutments:	9	10	
Piers:	8	10	
Paint :	4	5	

Inventory / Status Report			
Structure Number:	001-024	Bridge Name:	Al Khazanat
Facility Carried:	Brega gas tanks road	Longitude:	13° 8'46.65"E
Feature Crossed:	Airport Highway	Latitude:	32°47'19.53"N
Location:	0.5 km SW. of Brega Gas Company	Parallel Designation:	N.A
District:	23	Deck Width:	26.04m
Service On/Under:	Other/Highway	Deck Type/Thickness:	
Structure Length:	77.89m	Longest Span Length:	21m
Bridge Roadway Width:	25.3m	Number of Spans Main / approach	4/0
Bridge Median Type:	2	Main Span Material/Type:	Prestressed/ Box Beam
Bridge Median width:	0.74m	Approach Span Material/Type:	N.A
Sidewalk Width Right:	0	Type of Wearing Surface:	Asphalt overlay
Sidewalk Width Left:	0	Substructure Material:	Concrete
Sidewalks Under Structure:	On both sides	Number of Culvert Cells:	N.A
Guardrails On (Right):	Steel Plate Beam	Culvert Cell Width:	N.A
Guardrails On (Left):	Steel Plate Beam	Culvert Cell Height:	N.A
Replaced By Structure:	N.A	Culvert Opening Area:	N.A
Replaces Structure Number:	N.A	Design Load:	Unknown
Approach Roadway Width:	15.62m	Inventory Rating:	19.8 (Assumed)

Route / Construction Information Report			
Year:	Unknown	Sufficiency Rating:	58
Construction Remarks	-	Bridge Status Date:	14/11/2013
Bridge Remarks:	-	Bridge Status:	Open

Key Route On		**Key Route Under**	
	Municipality:	Tripoli	
Functional class:	Minor Arterial	Functional class:	Principal Arterial
Number of lanes:	4	Number of lanes:	8
One or Two way traffic:	2 Two-Way	One or Two way traffic:	2 Two-Way
Max Single Roadway width:	12.65m	Max Single Roadway width:	12.65m
ADT/ Year:	26100/2014	Vertical clearance	5.65m
Detour Length:	6 km		

Inspection Report	
Inspection Date:	28/12/2013
Inspection Temperature (Celsius):	17 C°
Inspector Name:	Dr Omran Kensheal
Deck Condition:	9
Superstructure Condition:	8
Substructure Condition:	8
Culvert Condition:	N.A
Waterway Adequacy:	N.A
Structural Evaluation:	5
Deck Geometry:	9
Underclearance:	9

2- Al Mahary Bridge

Table 8: Al Mahary Bridge collected Inspection Report

Bridge Inspection Report

Structure Number:	001-057	Bridge Name:	Al Mahary
Temperature:	25 C^0	Inspection Date:	9 / 02 / 2014
Insp. Team Leader:	Dr. Ali Etarhoni		
Inspector Names:	Eshbean Garib	Majed Aduwaeb	

		Rating weight:	Comments:
Deck			
Deck Condition:	4	10	
Wearing Surface :	2	5	
Parapets / Bridge Railings :	4	5	
Curbs :	4	5	
Median :	N.A	5	
Sidewalks :	4	5	
Drain System :	N.A	5	
Expansion Joints :	N.A	5	
Superstructure			
Superstructure Condition:	4	10	
Bearing :	4	5	
Girders / Beams / Stringers :	N.A	5	
Diaphragms / Braces :	N.A	5	
Trusses / Portals / Bracing :	N.A	5	
Rivets / Bolts :	N.A	5	
Paint :	3	5	
Substructure			
Substructure Condition:	6	10	
Abutments:	6	10	
Piers:	N.A	10	
Paint :	3	5	

Table 9: Al Mahary Bridge collected data

Inventory / Status Report			
Structure Number:	001-057	Bridge Name:	Al Mahary
Facility Carried:		Longitude:	13°12'2.08"E
Feature Crossed:	Ash Shatt Street	Latitude:	32°53'48.91"N
Location:	100 metres NE. of Al Mahary Hotel	Parallel Designation:	N.A
District:	045	Deck Width:	23.78m
Service On/Under:	other/other	Deck Type/Thickness:	
Structure Length:	13.66m	Longest Span Length:	13.66m
Bridge Roadway Width:	12.5m	Number of Spans Main / approach	1/0
Bridge Median Type:	0	Main Span Material/Type:	Concrete/Mult i-beam
Bridge Median width:	0	Approach Span Material/Type:	0
Sidewalk Width Right:	6.65m	Type of Wearing Surface:	Asphalt overlay
Sidewalk Width Left:	4.6m	Substructure Material:	Concrete
Sidewalks Under Structure:	0	Number of Culvert Cells:	0
Guardrails On (Right):	Chain Link	Culvert Cell Width:	0
Guardrails On (Left):	Chain Link	Culvert Cell Height:	0
Replaced By Structure:	-	Culvert Opening Area:	0
Replaces Structure Number:	-	Design Load:	Unknown
Approach Roadway Width:	12.5m	Inventory Rating:	16.2 (assumed)

Route / Construction I	
Year:	Unknown
Construction Remarks	-
Bridge Remarks:	-

Key Route On	
Municipality:	
Functional class:	Minor Arterial
Number of lanes:	4
One or Two way traffic:	2 Two-Way
Max Single Roadway width:	12.15m
ADT/ Year:	12180/2014
Detour Length:	0.5 km

Inspection
Inspection Date:
Inspection Temperature (Celsius):
Inspector Name:
Deck Condition:
Superstructure Condition:
Substructure Condition:
Culvert Condition:
Waterway Adequacy:
Structural Evaluation:
Deck Geometry:
Underclearance:

Case Study Conclusion

By comparing the Sufficiency Rating of the three bridges the Mahary Bridge is ranked the most deficient bridge with a sufficiency rating of 23 and considered to be qualified for government replacement funding, then comes Al Khazanat Bridge with a sufficiency rating of 58% which qualifies it for government rehabilitation funds.

CONCLUSION AND RECOMMENDATIONS

Based on the work carried out in this dissertation the conclusion can be divided into two main parts:

1- Difficulties and obstacles

- There is no information regarding the design details of most bridges.
- Roads in Libya are not classified into standard types. The classification of roads is needed when calculating the Sufficiency Rating of bridge located in these roads.
- No record data are available about traffic and type of vehicle passing over these bridges.

2- Conclusion

- ❖ The proposed BMS established a unified database for most of the bridges located in Tripoli.
- ❖ Collections of key information of each bridge have been accomplished to identify and characterize the type, usage, size, location, and condition of each bridge in Tripoli municipality.
- ❖ Based on the proposed Libya's Bridge Inventory (LBI) a database has been collected, the LBI contains all the necessary information that is used for the analysis and evaluation for the bridges.
- ❖ The BMS identifies bridges for treatment and ranks them in a priority order for maintenance works to keep bridges in functioning status.
- ❖ Based on the case study the two bridges have been inspected and ranked in priority order of which bridge needs to be treated first.
- ❖ By comparing the Sufficiency Rating of the two bridges the results showed that the Mahary Bridge considered to be qualified for government replacement funding with a Sufficiency Rating of 23% then comes the Al Khazanat Bridge which qualifies them for government rehabilitation funds with a percentage of 58%.
- ❖ The proposed BMS assists maintenance management planning and help optimise the use of funds.

Recommendations

After the completion of this dissertation we recommend the following:

- The related agencies responsible for bridges should adopt this BMS.
- Use a computerised BMS to achieve all the major purposes of this system.
- Perform initial inspections for all the uncompleted bridges to determine baseline of every bridge condition.
- The relative authorities should collect all the unknown bridge information such as Load Designs, classification of the road network and the bridge elements material and type.

- Implement the LBI all over Libya and collect all the necessarily information in order to apply Libya's BMS.

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