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Assessment of Bridge Management System in Iran

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Abstract

The road and railroad networks are the most important elements of the infrastructure system and bridges are the main connective parts. Moreover, bridges are considered as important points in critical arteries. If the bridges deteriorate, because of aging, fatigue, loading, weather conditions, natural disaster and etc. repair works will be more expensive than maintenance works. The available budget for rehabilitation and maintenance usually is not enough for holding the system in a certain condition level its whole life. In our country bridge maintenance isn't important as their construction. Bridge maintenance authorities haven't any serious view towards prevention maintenance, and while there isn't any structural failure, they don't take any effective measures. Nowadays, in developed country and even some developing countries, all of the bridges are evaluated and maintained by Bridge Management System (BMS). Bridge management system has a specific principle and plenty of developed software for it. Hence, for deployment of this system, it's necessary to plan a specific program with reasonable time table in order to prevent the disadvantages of these national assets. In this paper, a study has been conducted about implementation of BMS in IRAN that present accomplished activities and then evaluate the process and finally significant strategies and executive suggestion have been mentioned.

Keywords: bridge management; bridge management system; BMS.

1. Introduction

Bridges are important links in any national road or rail network, and the fund required to build them is high. If their carrying capacity is impaired or if they collapse, the resulting cost as a result of road closure and rehabilitation could double.

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Unfortunately many politicians seemed more interested in bridges when they found that so many of them were structurally deficient. It is a major problem when funds are requested to repair them since the bridge engineer has to explain why the deficiencies have occurred. There are many contributory agents that affect the nature and degree of degradation as the atmospheric environment, scour, fire, fatigue, earthquake, floods, weather and the nature and intensity off the imposed traffic loading. Bridge management is the means of which a bridge stock is cared for from conception to the end of its useful life. Many politicians and bridge authorities throughout the world whist acknowledge the need for regular inspection and maintenance during the service life of their bridges, failed to appreciate the need for forward planning at the end conception and design stages to ensure that sound principles were applied which would maximize their long term durability. Consequently the present generation of bridges engineers has inherited a legacy of badly bridge management system deteriorating bridges which now have to be repaired, strengthened, replaced, propped or have a weight restriction posted on them. According to recent reports, there are nearly 333000 bridges in Iran just in road network which the total length of them is 1258 Km (Annual Transportation Statistics Report, 2010).

Most of these bridges have been in service for more than 30 years on average and so many of them have been deteriorated due to heavy traffic and severe conditions and require repair or retrofit. Nowadays, in many developed and developing countries "Bridge Management System" has been applicable, but in Iran there is no systematic method to maintain the bridges yet. In this study, implementation of BMS in Iran has been evaluated and eventually some practical strategies for solving problems and launching Bridge Management System have been presented.

2. BMS Components

A bridge management system or BMS is a means for managing bridges throughout design, construction, operation and maintenance of the bridges. As funds available become tighter, road authorities around the world are facing challenges related to bridge management and the escalating maintenance requirements of large infrastructure assets. Bridge management systems help agencies to meet their objectives, such as building inventories and inspection databases, planning for maintenance, repair and rehabilitation interventions in a systematic way, optimizing the allocation of financial resources, and increasing the safety of bridge users (Guideline for Bridge Management System, 2004). There are a number of basic components which comprise a BMS in order to make it a fully integrated system able to analyse the database and then interact with other components together with incoming information. The output should ideally be in the form of a limited schedule listing the ailing bridges in priority of need (which requires some form of condition rating) followed by a prediction of the costs of various maintenance strategies. Figure (1) illustrates the stages in the whole life of the bridges.

2.1. Inventory Components

This component stores information about the bridge in terms of its name, location, tie of construction etc. and provides the starting point for the system. It requires reviewing drawings, maintenance records and a walkover survey to familiarize the user with the bridge.

2.2. Inspection Components

This component stores the information from the inspection preforms and reports, which includes information about the general condition of the bridge, the specified treatment, the priority given to past remedial works and the cost.

2.3. Maintenance Component

In order to keep abreast of the condition of a bridge, maintenance records are essential. They will inform the bridge owner of the nature of the maintenance carried out and exactly what is being spent on any given bridge.

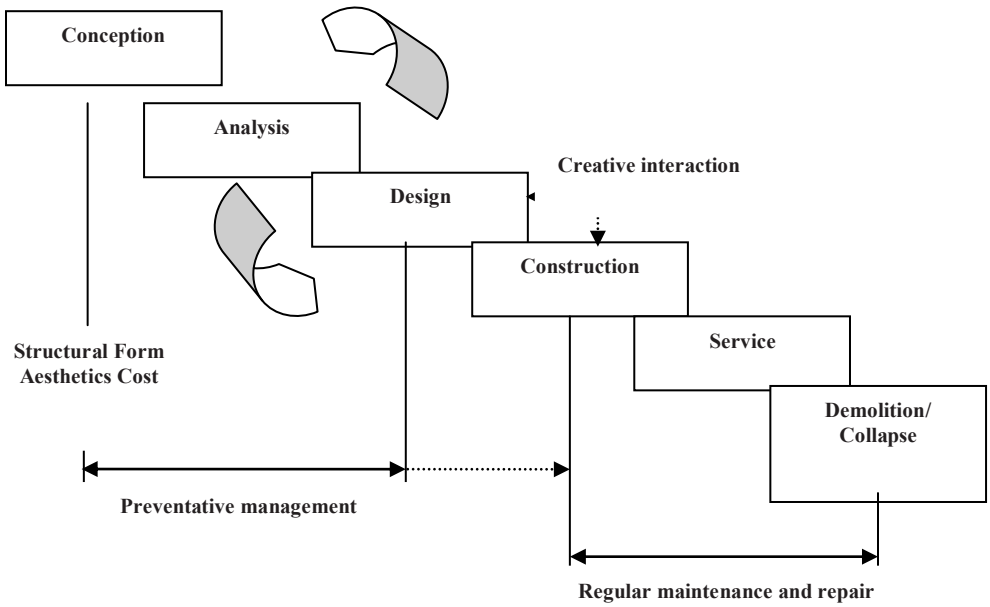

Figure 1. The stages in the life of the bridges (M, J.Ryall 2001).

2.4. Financial Component

This component processes all of the cost information from past and present projects and should be able to produce regular and reliable financial reports.

2.5. Management Component

This is considered to be the brain of the system and analyses all of the information from other modules together with costs and budgetary constraints and attempts to prioritize both the bridges and the maintenance work required.

2.6. Database

The database is basically a store containing all of the information about the bridges in a particular network. It contains details of a technical nature as well as administrative and financial information. It draws from the four inner modules and the outer management module. Table (1) presents some famous BMS in developed countries and figure (2) shows an overview of the COWI – BMS Modules.

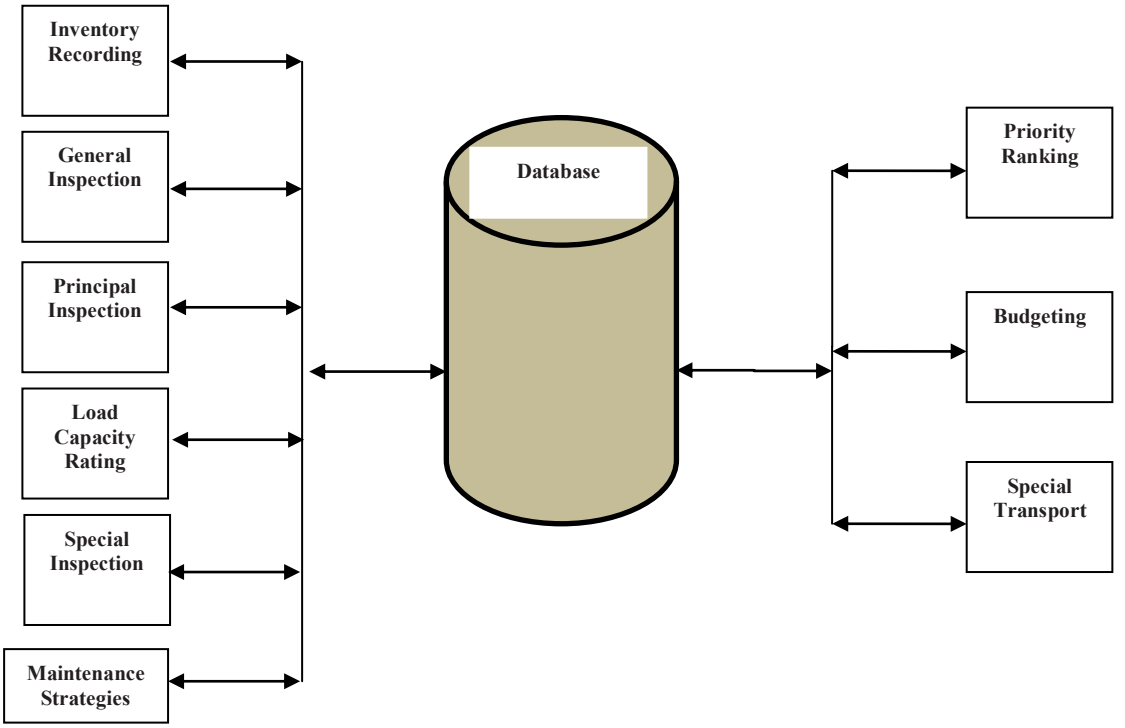

Figure 2. Overview of the COWI – BMS Modules (Gholami and Rezaee 2009).

Table 1. Some famous BMS in developed countries (M, J.Ryall 2001).

-DANBRO (Danish Bridges and Roads)	Denmark
-FinnRABMS (Finnish National Roads Administration Bridge Management System).	Finland
-DISC -COWI	Netherland
-SAMOA (Surveillance, Auscultation and Maintenance of structures)	Italy
-MICHI (Ministry of Construction Highway Information Database)	Japan
-BMS.NRA (National Roads Authority) -SIHA	South Africa
- BSM (Lindblath, 1990)	Sweden
- STEG (Structures Register) - HiSMIS (Highway Structures Management Information System) - BRIDGEMAN (BRIDGE Management system) - COSMOS (Computerized System for the Management of Structures)	England
- PONTIS (Preservation, Optimization and Network information System) - BRIDGIT (Bridge Information Technology) - PENBMS (Pennsylvania Bridge Management System)	USA

3. Activities Carried Out

In IRAN, the Ministry of Roads and Transportation (MRT) has been custodian for utilizing and maintaining of bridges from nearly 100 years ago. Indeed, there are 33 affiliated provincial departments which are responsible for bridges. But, there is no systematic framework or approved regulation for this issue yet and therefore, reactions have been done in critical situation only. Unfortunately inspection forms are often incomplete and don't cover the necessary information about various bridges. Most of these forms are identical in all types of inspections and obtained information cannot be processed in computer programs and this is a great weakness. In addition, these forms are not the basis of maintenance planning and funds allocation. Moreover, in most conventional Bridge Management Systems in the world, quantitative numbers are assigned to deteriorated members to simplify the process, while in current forms, this issue is not considered. However, considering the facilities and manpower available, the activities carried out are appreciable.

Although many regulations and guidelines about maintenance of bridges developed in the world, but Iran has not yet provided a complete set. Recently some efforts have been done and a guideline about maintenance of bridges has been prepared by Transportation Research Institute (Road Maintenance General Technical Specification-2004). But this also requires further evaluation to implement it as an obligated instruction. Additionally, no appropriate training courses have been designed yet and consequently executed courses have not useful results. So it is necessary to notice seriously to the technical training courses especially for experts and inspectors.

Actually, first steps for establishing BMS in Iran were conducted by Technical Supreme Council of Infrastructure (TSCI) in 1998 (Gholami and Rezaee 2009).

According to this Council it was approved to set up special software for BMS. The first software was provided during a study conducted in the Research and Education Center of Roads and Transportation in 1999. Actually this software was a guideline to maintain and repair of bridges and didn't deal with categories such as economic evaluation, prioritization and financial issues. Thus, TSCI organized a committee to investigate about existing and conventional BMS in the world. The committee evaluated many software such as DANBRO (Denmark), COWI (Denmark), Bridge-ASYST (Australia), BRUTUS (Norway), LAGURA (France) and BMX (UK) and finally, with regard to technical and managerial aspects, COWI software system was selected for implementing in IRAN. In conclusion, it was approved by TSCI to purchase COWI software in 2002. After that, the Road Maintenance and Transportation Organization (RMTO) was the responsible of formation the contract and deployment of BMS. After several expert meetings RMTO form the contract to COWI (Denmark). In fact, this system had already been implemented in many countries like Denmark, Malaysia, Singapore, China, Spain, Uruguay, Laos, Bulgaria and Kosovo. Although this project faced lots of lateral problems (such as inadequate support of principals and managers and also political argument between Iran and Denmark), different stages of commissioning and application of software including software installation, translation of instructions and manuals to Persian, system configuration, technical workshops and several field inspection have been carried out. Practically after around six years the contract finished the project in 2008 but, due to economic problems, data entry has just been started nearly six month ago. In the future, it is necessary to create or complete the existing inventory database which is basically the most important part in the system. Experimental implementation in one or more provinces which have suitable situation is also helpful to resolve discrepancies and problems.

According to recent reports, there are nearly 333000 bridges in Iran (without railroad bridges) which the total length of them is 1258 Km. In 2008, as the BMS had not been executed yet, the maintenance and management of bridges department decided to apply a different temporary method to prioritizing allocation of funds. This method which named Bridges Health Degree (BHD) only covered large and important bridges. In fact, BHD comprised the bridges which had minimum one span larger than 20m or the total length was more than 30m and so the number of bridges for maintaining limited to 2890. Table (2) presents the number of major bridges in each province. Otherwise, BHD was a number between 0 and 100 and had been computed by BHD summation of elements and so this method would have been a suitable criterion to evaluate the situation of bridges rapidly. However, BHD for these bridges computed in 2008 and the average was 79.9 which illustrated rather good health degree (Annual Transportation Statistics Report, 2010). The actions had been done in this time are as followed:

- Simple forms were developed to inspect the bridges.
- Inspections have been done by experts and the relevant forms were completed.
- BHD was computed for each member.

- Appropriate weight factors were defined for each member.
- BHD of bridge was computed considering BHD of members and their weight factors.

The next year in 2009, they continued to this procedure but unfortunately the average BHD of bridges decreased to 79.5 and it showed that the maintenance had not been adequate. Really, the bridges need more consideration and fund allocation to be alive and service this increasing traffic and it depends on supporting of relative managers. BMS have not been practically executed yet and BHD method also is not perfect and precise. Besides, the cost of executive of BMS had been estimated only 2 million dollars for the first year, whereas, damages to the bridges in this time evaluated nearly 56 million dollars.

Table2. Number of major bridges in each province (Annual Transportation Statistics Report, 2010).

	ecnivorP	**egdirB**		**ecnivorP**	**segdirB**
1	najyabrazA.W	271	18	nivzaQ	36
2	najyabrazA.E	117	19	moQ	15
3	libedrA	74	20	natsedroK	107
4	nahafsI	106	21	namreK.S	37
5	rhahsnarI	127	22	namrK.N	52
6	malI	64	23	hahsnamreK	53
7	rehsuB	83	24	damhareyuB	130
8	narhT	120	25	natseloG	54
9	iraithkaB	40	26	naliG	122
10	nasarohK.S	59	27	natseroL	116
11	nasarohK.C	136	28	natseraL	15
12	nasarohK.N	54	29	naradnazam	310
13	natsezuhK	157	30	izakraM	60
14	najnaz	80	31	nagzomroH	89
15	nanmeS	16	32	nademaH	64
16	natsiS	11	33	dzaY	52
17	sraF	63	**Total**		**2890**

Therefore considerable issues are as follow:

- There are more than 333000 bridges in road network which the total value of them estimated to around 18 billion $
- There are 2890 major bridges in road network only with estimated value of 3.7 billion $
- Economic losses to the bridges for a 20 percent drop in their quality is 900 million $

- Financial losses incurred by the bridges over the past 10 years due to not implementation BMS is 562.5 million $
- The amount of economic losses every year due to the damage to bridges is 56.2 million $
- BMS implementation costs for major bridges
  - In the first year : 1.9 million $
  - Other years : 0.63 million $
- Financial required for the maintenance of bridges based on the experiences in developed countries is between 2 to 6 percent of bridges so it is almost 90 million $
- Annual funding needed to reach optimal health for bridges during 10 years is 90 million $
- Therefore, funding needed annually to reach optimal health and current maintenance is 180 million $

Table 3. BHD quantities related actions (Annual Transportation Statistics Report, 2010).

	BHD	ACTIONS
1	0-25	Bridge is not useable-The traffic must be stopped
2	25-50	Traffic must be limited-Repairing must be done Immediately
3	50-75	Bridge need to be repair basically
4	75-90	Bridge need to be repair
5	90-100	Normal maintenance – proper condition

4. Weaknesses and Deficiencies

Despite several large bridges have been constructed during the past fifty years and a huge number of bridges that are building at present, we have no specific instructions regarding to management of bridges in IRAN. Additionally, there is no defined and clear plan for training of experts yet. However, as it was mentioned earlier other countries have already prepared these guidelines. Actually, in IRAN most of the existing guidelines concern on the management of roads and pavements and only small part of them concentrate at bridges maintenance. Recently, more efforts have been done to translate and prepare guidelines in this issue.

Besides, lack of unreliable data has caused lots of problems for the municipalities and the Ministry of Roads and Transportation to take decision about repair, maintenance and management of bridges. Totally, the deficiencies of implementation of bridge management system in Iran could be classified as follow:

- Most of Bridges have no technical document (such as identity certificates, periodic inspection forms, calculating booklets, maintenance reports, soil mechanics and hydraulics reports, as built drawings etc.). In many cases, even the

time of design and construction and the name of consultant and contractor are unspecified.

- Inspection forms have many defects and most of these forms are similar in all types of inspections.
- Evaluation of deteriorated members is qualitative and there is no rule or method to assign numbers to deficiencies in inspection forms. so obtained information cannot be processed in computer programs
- Procedure of inspections have not been compiled and specified.
- Suitable processor systems or software have not been applied yet.
- There is no economic evaluation in the analysis.
- Major expenses such as user costs have not been considered.
- Methods of maintenance and repairing of bridges are often traditional and non-technical.
- Priorities and budget allocation system, which is the most important function of the bridge management system, currently does not exist.
- The appropriate attention to the special transportation has not been taken.
- Comprehensive research about the cost of maintenance and construction of bridges does not exist in the country.

Overall, the Ministry of Roads and Transportation and Municipalities have not followed a systematic method to maintenance and management of bridges. Thus, despite the many activities carried out so far, the bridge management system is still not operational in the country. Therefore bridge owners spend a large amount of annual budget for bridges without technical justification. In conclusion, it is necessary to establish the system as soon as possible to prevent spending non-essential costs.

5. Practical Strategies

Absolutely, government support is one of the most important factors for implementation of BMS. On the other hand, administrators and specially the minister of Roads and Transportation as the owner of bridges, have an impressive effect to develop the project. This support should include employing professional human resources, disposing necessary equipment and facilities and financial aids during implementation the project. For this purpose, the planning can be performed in four main stages: introduction, training, pilot implementation and calibration the software.

Introducing the advantages of this system and justifying the necessity of application is the first step. Create information Website, preparing brochures and posters, translating and publishing references, guidelines, books and technical reports, producing training films are some actions that could be done in this direction.

The next step is training of human resources. Furthermore, the teaching methods would be verbal or virtual (using multi media) and also workshops could be very useful as well as seminars and conferences. Besides, COWI–BMS have been already purchased and so it should be trained to all relevant experts and staffs and consultants. Thus, it is very important to begin this step for experts of road and railroad sectors and municipalities in addition to private sectors as soon as possible.

Pilot implementation and calibration the software are the next steps which help to appear executive difficulties and consider the condition of Iran. It is need to calibrate the software to adapt country conditions. Strictly it is advised to Pilot the software in 2 or 3 provinces before main performance. Provinces which have more appropriate conditions and are candidate for this issue are preferred surely. Obviously, this would be done in cooperation with private companies and specialist consultants to carry out the inspections and fulfill relevant forms and provide technical reports. Sometimes administrators believe that gathering initial information is so easy and they intend to perform this phase with only their few experts. In fact, this method cannot be effective and quick and therefore, they waste the time and cost without suitable result. Otherwise, governments always avoid to increase the numerous of employees and intend to activate private sectors and so it means that cooperation with specialist contractors would be beneficial for both of them.

Overall, regarding to extent of Iran and existence of more than 333000 bridges in the country, it is essential that local experts and consultants would be trained and technical information and reports provided and enter the software immediately. These data would be the basis of prioritizing and budget allocating which after minimum 3 years would be calibrated and close to reality.

6. Conclusions

Indeed, assessment of bridge management system in Iran illustrates that serious efforts need to implement this system in the near future. However, repeating mentioned stages for all of provinces and process the collected data altogether conclude to BMS. This method is approximately implemented in all developed countries while they begin to apply it. Totally, considering Iran conditions there are some important agents that strictly suggested improving the process:

- Management support at the major level
- Serious intent in middle management and relevant experts
- Provide an executive development plan and a defined timetable

- Appoint a powerful and effective manager (person or committee) to overcome the problems
- Offer full authority to manager includes required funds or facilities and power of take decision
- Controlling all of the phases and monitoring the actions in detail to avoid any mistake.

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References

M.gholami, N. Rezaee Mehr (2009). Documentation Bridge Management System Activities in IRAN, Bureau of Technology and Safety Studies Technical Report, Ministry of Roads and Transportation of IRAN.

Annual Transportation Statistics Report (2010). Road Maintenance and Transportation Organization of IRAN.

Multi-Objective Optimization for Bridge Management Systems (2007). NCHRP Report 590.

H.Shim, H.George (2007), Bridge Management System with NDE, Journal of Civil Engineering, Vol. 11, No. 5, pp253-259.

M.J.Ryall, Bridge Management (2001), Published by Butterworth-Heinemann, 2001.

Guideline for Bridge Management System (2004). Austroads (AP-R252).